Section 19 Flood Investigation

February 2020 – Storm Jorge

Sully Moors Road, Vale of Glamorgan

Version 3

March 2023

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Contract

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

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Purpose

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Executive summary

This report has been produced in-line with the duties placed upon The Vale of Glamorgan Council (VoCG) under Section 19 of the Flood and Water Management Act 2010. The Act states, "On becoming aware of a flood in its area, a lead local flood authority (LLFA) must, to the extent that it considers it necessary or appropriate, investigate:

a) which risk management authorities have relevant flood risk management functions and

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

This Section 19 investigation provides a factual report of the storm event which occurred on 28 and 29 February 2020 and the flooding that happened at Sully Moors Road, Penarth, Vale of Glamorgan, South Wales from 29 February to 2 March as a result. The investigation focuses on the area located on the roads and land around Sully Brook, Sully Drain and River Cadoxton to the northwest of Sully.

The Section 19 data analysis report identifies that due to a series of storm events which occurred throughout the month of February 2020, the soils were already saturated prior to the rainfall on 28 and 29 February 2020. During February 2020 the UK was hit by three named storms in quick succession, bringing sustained periods of heavy rainfall and widespread flooding across much of England and Wales. This meant that the Sully Moors Road area had already experienced very heavy rainfall before the onset of this storm event (Storm Jorge 28 -29 February).

The evidence gathered in this report demonstrates that the cause of the flooding was a result of heavy rainfall combined with already high water levels in the Sully Brook, Sully Drain and River Cadoxton, plus the highway drainage and surface water sewer systems were hydraulically locked and unable to discharge, resulting in flooding to Sully Moors Road and the surrounding areas.

Key recommendations of this report include:

- Review maintenance actions and frequency for the Sully Brook, Sully Drain and River Cadoxton.
- Consider catchment options further to reduce the risk of surface water flooding to Hayes Road
- Investigate the feasability of increasing the current frequency of cleansing to the Sully Moors Road highway drainage system
- Liaison between VoG and NRW on the areas of concern within the Cadoxton catchment

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Abbreviations

AEP	Annual Exceedance Probability
DCWW	Dŵr Cymru Welsh Water
FWMA	Flood and Water Management Act 2010
JBA	Jeremy Benn Associates Ltd
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LTA	Long Term Average
NRW	Natural Resources Wales
RMA	Risk Management Authority
SuDS	Sustainable Drainage System
S19	Section 19
VoGC	The Vale of Glamorgan Council

Definitions

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

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

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

1 Introduction

1.1 Background to investigation

As the Lead Local Flood Authority (LLFA) The Vale of Glamorgan Council (VoGC) has a duty to prepare and publish the results of investigations into significant flood incidents, as detailed within Section 19 (S19) of the Flood and Water Management Act 2010 (FWMA). The Act states, "On becoming aware of a flood in its area, a Lead Local Flood Authority (LLFA) must, to the extent that it considers it necessary or appropriate, investigate:

a) which risk management authorities have relevant flood risk management functions and

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

This report has been prepared for the purpose of meeting the LLFA S19 requirements by providing a detailed, factual account of the flooding that occurred on 29th February to 2nd March 2020 in the industrial area of Sully Moors Road and Hayes Road, Barry, Vale of Glamorgan, South Wales. During this event, Sully Moors Road (B4267), the main road linking Barry to Sully and Penarth, was flooded and closed over a length of approximately 800m between the roundabout at the junction of the Barry Dock link road (A4055) in the north and the Hayes Road roundabout in the south; Hayes Road was flooded west of this junction, but the total distance cannot be ascertained from the data supplied. Six business properties were reported to have flooded internally.

This report will focus on investigating the causes of the flooding in the Sully Moors Road area (Figure 1-1) as a result of the storm event.

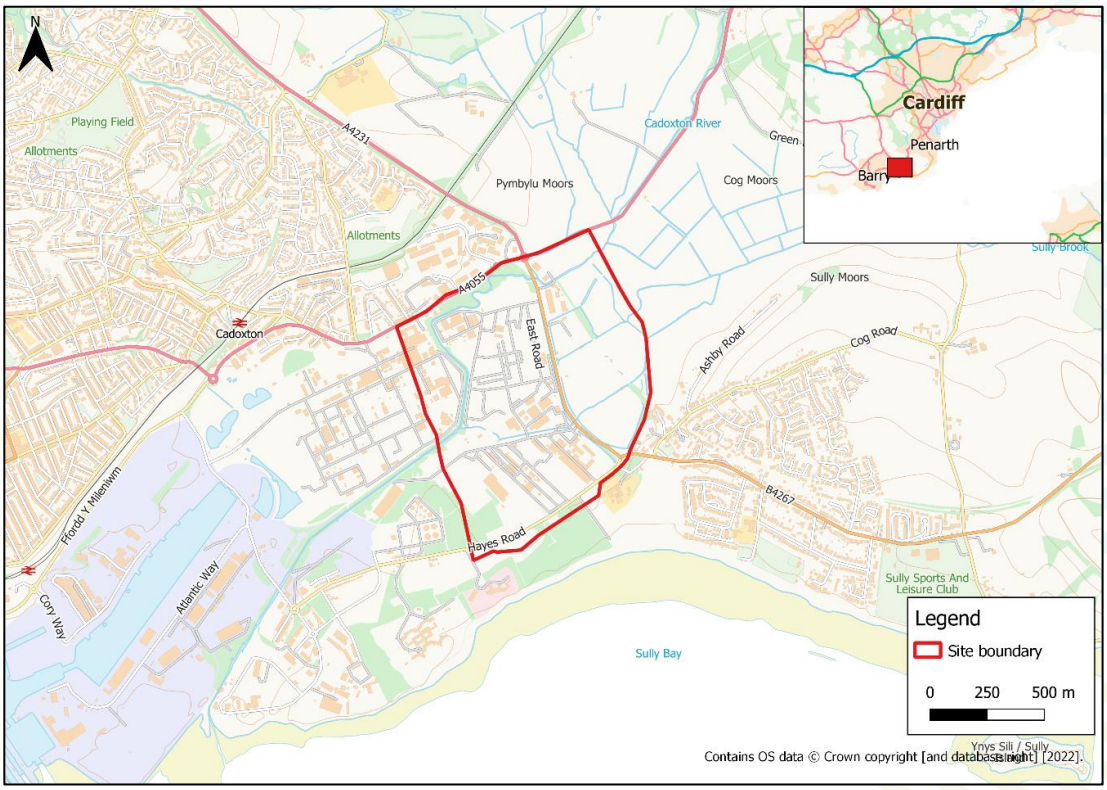

Figure 1-1: Overview map

To provide an accurate account of the flood event, this S19 Report for Sully Moors Road, Penarth will:

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

1.2 Site location

The Sully Moors Road area is a highly industrialised and commercial area approximately 1km east of Barry Docks. Sully Moors Road (B4267) runs in a north-south direction through the eastern part of the area of investigation from the roundabout at junction of the Barry Dock link road in the north to the Hayes Road roundabout in the south. Hayes Road runs along the southern edge of the area in a westerly direction from the Hayes Road roundabout. Sully Moors Road is the main link to the businesses in the immediate area and the industrial estates within the Barry Docks area and provides an essential link for Sully and Penarth. West of Sully Moors Road the area is predominantly industrial with North Road and Horton Way providing access into this area from Sully Moors Road, the large Hexion chemical site is located in the southern extent of the industrial estate. To the east of Sully Moors Road are commercial premises. Bordering the southeast edge of the investigation area is the large village of Sully.

The area is located within the Cadoxton River, Sully Coastal catchment. Three Main Rivers flow into the investigation area: Cadoxoton River; Sully Brook; and Sully Drain.

The Cadoxton River flows in a predominantly southerly direction through the investigation area, culverted beneath Sully Moors Road and bordering the northern and western boundaries of the investigation area, and the industrial units to the west of Sully Moors Road.

The Sully Brook flows in a westerly direction from Cosmeston, west of Penarth, to pass centrally through the area of investigation before joining the Cadoxton River on the western edge of the area of investigation. There is a network of drainage channels in the agricultural land to the east of Sully Moors Road, of which the Sully Drain is the principal drainage channel. The Sully Drain flows parallel to the Sully Brook into the area of investigation before turning south, and flowing in ditches along both sides of the Sully Moors Road to join the Sully Brook within the area of investigation.

Figure 1-2 shows the topography of the area using Opensource LiDAR data. Ground levels are shown to be relatively constant across the investigation area at approximately 6m above ordinance datum (AOD).

Sully Moors Road falls from a level of 7.12mAOD at its junction with Barry Docks Link Road at its northern extent, to a level of 6.1mAOD just south of the Sully Brook crossing. Ground levels rise to 8.1mAOD at the junction with Hayes Road. Hayes Road falls from a level of 8.02mAOD at the junction with Sully Moors Road to a level of 5.75mAOD at the western boundary of the investigation area.

Average ground levels across the Sully Moors within the investigation area is 5.7mAOD. Within the industrial area to the west of Sully Moors Road, average ground level is approximately 6.42m AOD - 6.14m AOD.

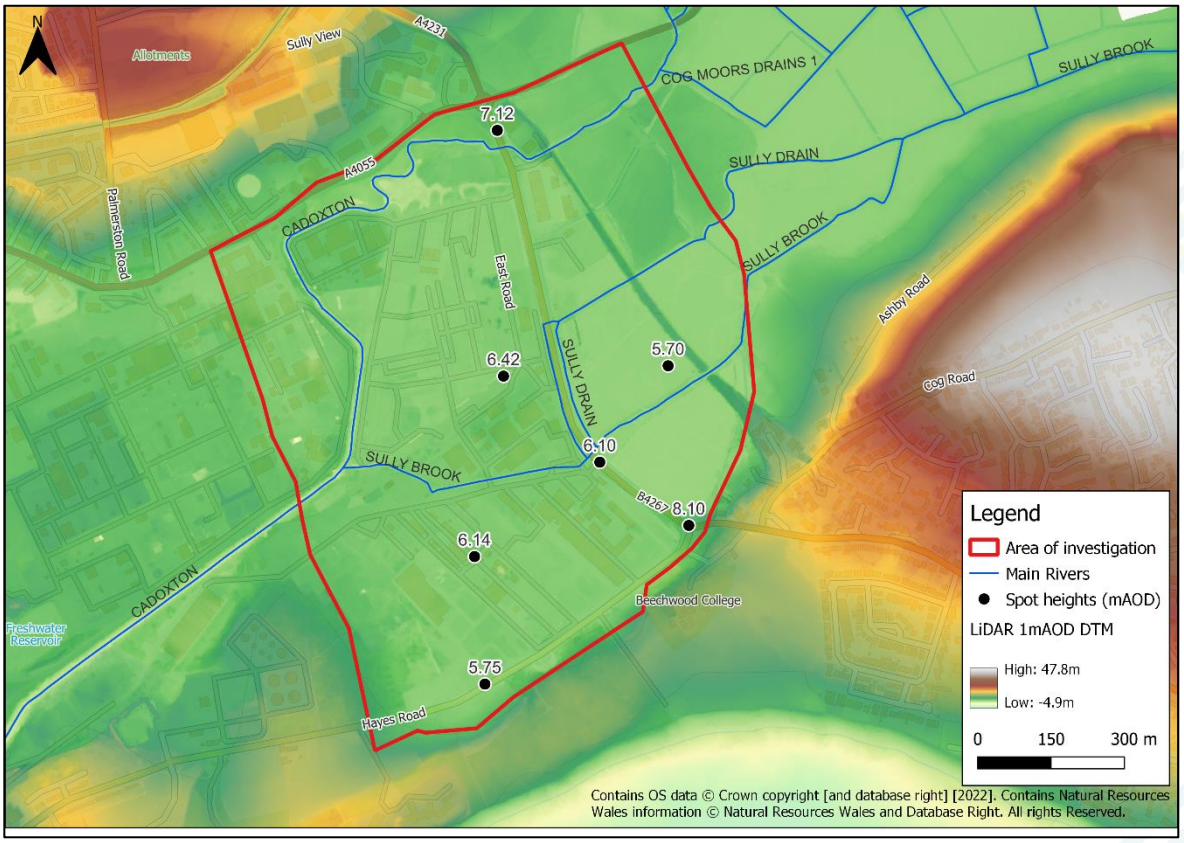

Figure 1-2: LiDAR

2 Roles and responsibilities

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

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

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

(a) which risk management authorities have relevant flood risk management functions, and

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

(2) Where an authority carries out an investigation under subsection (1) it must-

(a) publish the results of its investigation, and

(b) notify any relevant risk management authorities.

2.2 Risk Management Authorities

2.2.1 Lead Local Flood Authority

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

Additionally, the LLFA takes on role of the Sustainable Drainage Systems (SuDS) Adopting and Approving Body in which they are responsible for approving designs and adopting and maintaining finished SuDS.

As the LLFA, VoGC have statutory duties:

1 to prepare local flood risk management strategies;

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

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

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

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

6 to contribute to sustainable development; and

7 through consenting powers on ordinary watercourses.

2.2.2 Natural Resources Wales

Natural Resources Wales (NRW) has statutory duties and permissive powers, including:

1. Operational responsibilities for flooding from main rivers, the sea and coastal erosion.
2. Oversight responsibilities in relation to all flood and coastal erosion risk management in Wales.

NRW's powers to manage flood risk include the management and maintenance of Main Rivers, the construction of new flood risk management assets and maintaining existing flood assets. NRW assesses developers' flood assessments (and supporting documentation) to decide with developers have met the requirements of *Planning Policy Wales* and *Technical Advice Note 15:*

Development and Flood Risk in relation to the risks of flooding from main rivers, the sea and reservoirs. NRW is a statutory consultee in Local Authorities' planning processes and provides support to Welsh Ministers in their preparation of the National Flood and Coastal Erosion Management (FCERM) Strategy.

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

2.2.3 Highways Authority

The Vale of Glamorgan Council undertake the role of the Highways Authority, being responsible for the maintenance of all adopted highways in the Vale and their associated infrastructure. This includes ensuring the highway has a drainage system that controls the surface water that enters onto the highway, providing and managing highway drainage and roadside ditches to ensure they are clear of obstructions. The above duties and responsibilities of the Highways Authority are not applicable to Trunk Roads, which are the responsibility of the Welsh Government.

2.2.4 Dŵr Cymru Welsh Water

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

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

2.3 Other Authorities

2.3.1 Landowners and riparian owners

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

2.3.2 Residents and property owners

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

2.4 Permissive Powers

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

- Powers to request information.
- The ability to raise levies for local flood risk management works (NRW only).
- Powers to designate certain structures or features that affect flood or coastal erosion risk.

- The expansion of powers to undertake works to include broader risk management actions.
- The ability to cause flooding or coastal erosion under certain conditions.

3 Stakeholder Engagement

Following the flooding in February 2020, VoGC carried out interviews with businesses in the Sully Moors Road investigation area. 6 Flood incident reports were received collating information on the following:

- Date of flooding;
- Extent of flooding to private land and properties;
- Depth of flooding on private land and in properties;
- Perceived source/cause of flooding;
- Impacts and estimated costs of damages.

In addition, photographs and videos of flooding were provided by the residents and via news articles of the flooding incident and have been used in investigations for this report.

4 Catchment characteristics

4.1 Catchment overview

The site is located in the Cadoxton River and Sully Brook catchments. The Sully catchment drains into the Cadoxton catchment to the west.

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

The topographic characteristics of the Sully Coastal catchment are varied; higher land to the north and east of the site acts as a natural watershed, but the area of investigation is very low-lying and flat, consisting of floodplain. This floodplain is comprised of the large industrial area to the west of Sully Moors Road, a commercial area in the northeast of the area of investigation and to the east of Sully Moors Road the Sully Moors and Cog Moors, which are agricultural land.

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

4.2 River network

The River Cadoxton and its major tributary, the Sully Brook are both NRW Main Rivers and flow through the area of investigation. The source of the River Cadoxton is near Wenvoe, it then flows east and then south through Dinas Powys before flowing south-west through the northern edge of the area of investigation, and then along the western edge of the area. The Sully Brook's source is just west of Penarth and flows in a predominantly westerly direction. The Sully Drain branches off the Sully Brook as it flows across the low-lying area of the Sully Moors. Both the Sully Brook and Sully Drain flow south-west through the area of investigation, passing under the Sully Moors Road via bridges; the Sully Moors Drain flows south alongside both sides of the Sully Moors Road to join the Sully Brook next to this road within the area of investigation. The Sully Brook then joins the River Cadoxton on the western edge of the site before finally discharging into the Bristol Channel at Barry Docks (see Figure 4-1).

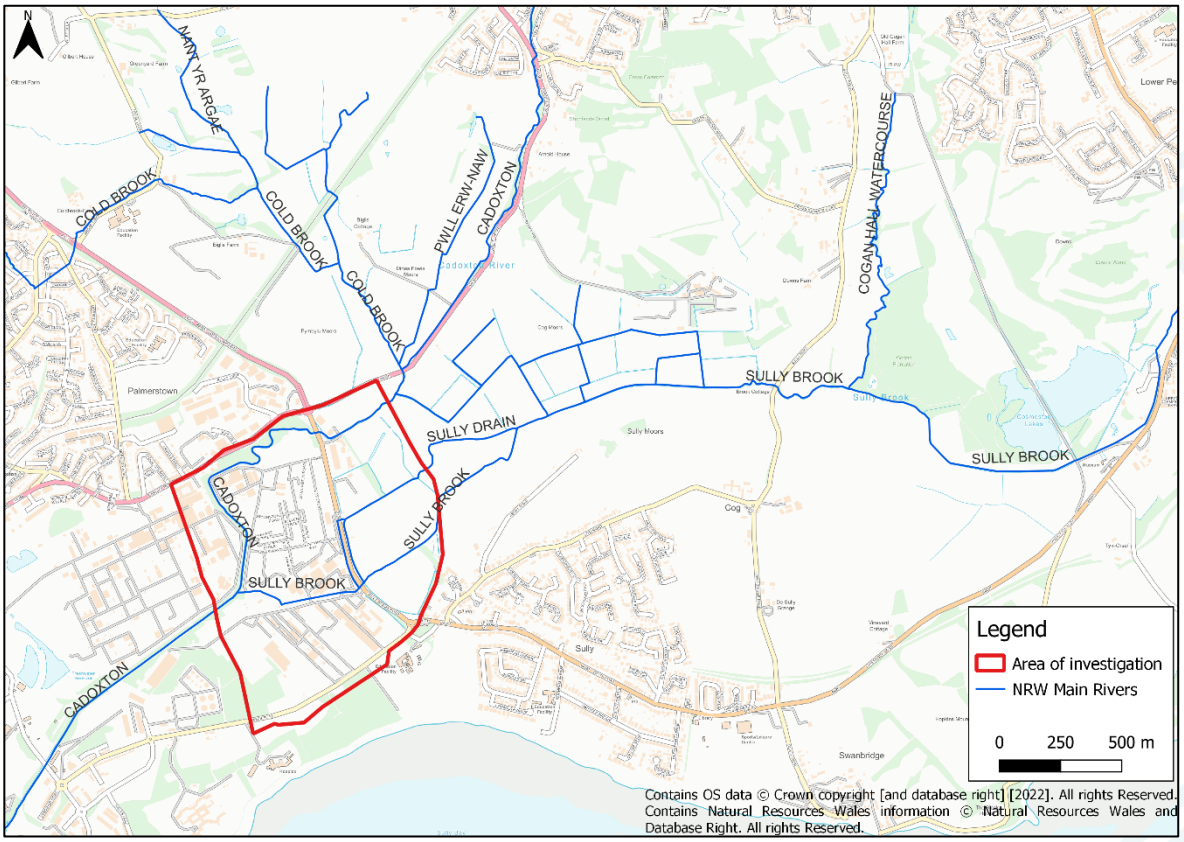

Figure 4-1: Map of NRW main rivers

4.3 Drainage system

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

The Sully Moors Road investigation area is served by surface water and combined public sewer networks, at least one non-DCWW network, as well as a highway drainage network.

4.3.1 Sewer network

The public sewer network in the study area is comprised of a combined system. Large areas of the industrial units to the west of Sully Moors Road are served by a private system, not present on DCWW asset maps. The combined sewer drains towards to Cog Moors Wastewater Treatment Works east of the investigation area. DCWW asset maps are shown for Sully Moors Road in Figures 4-3, 4-4 and 4-5.

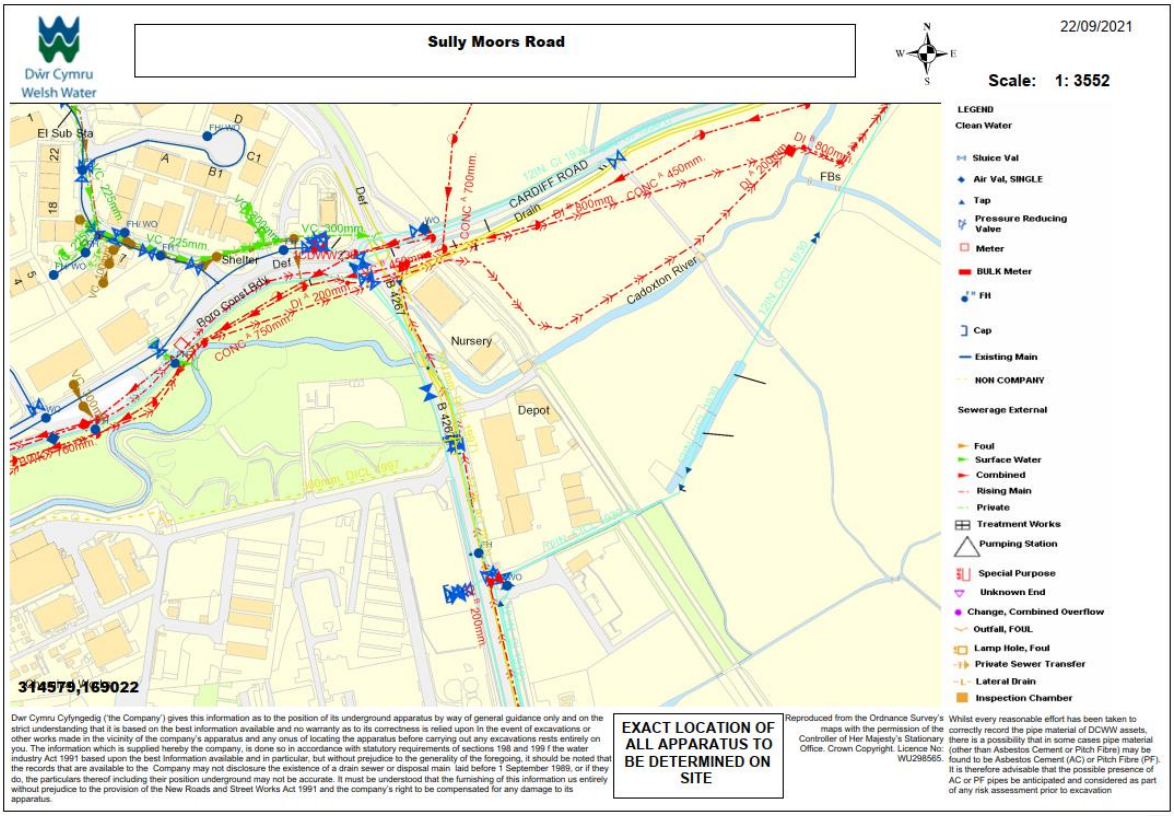

Figure 4-2: DCWW asset map - Sully Moors Road north

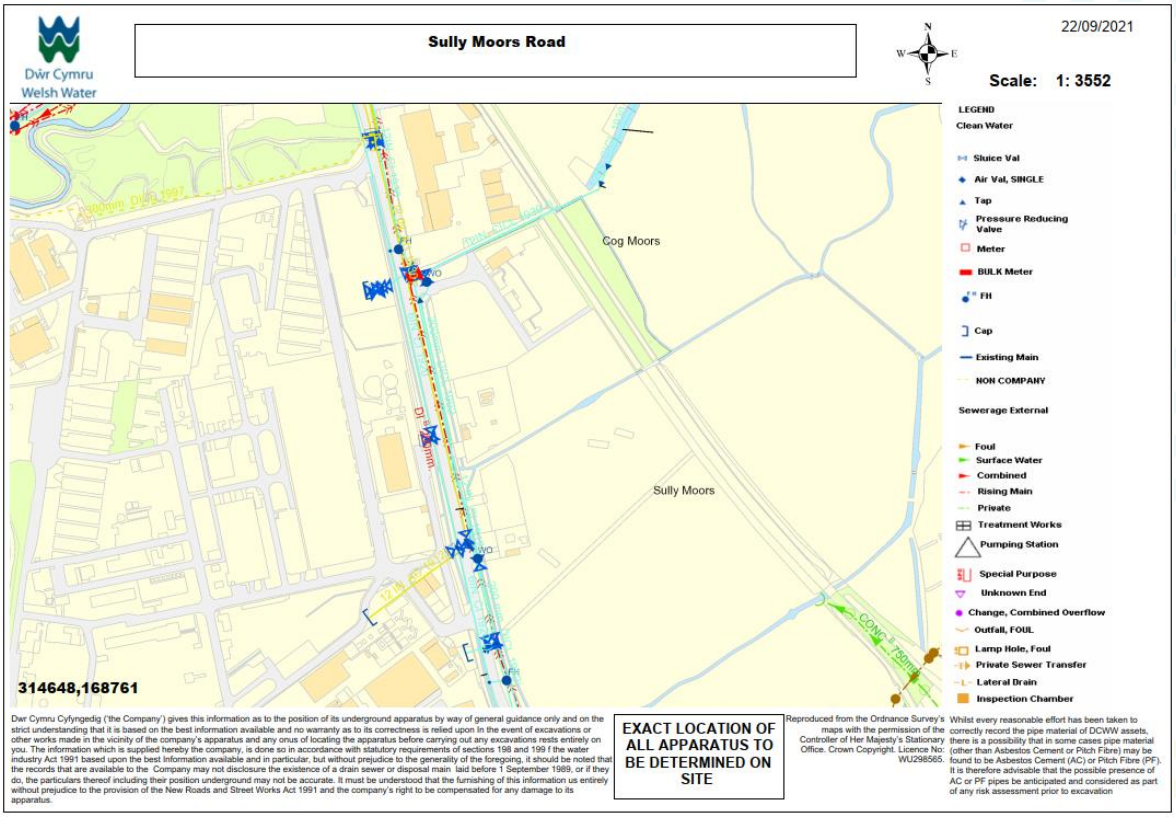

Figure 4-3: DCWW asset map - Sully Moors Road middle

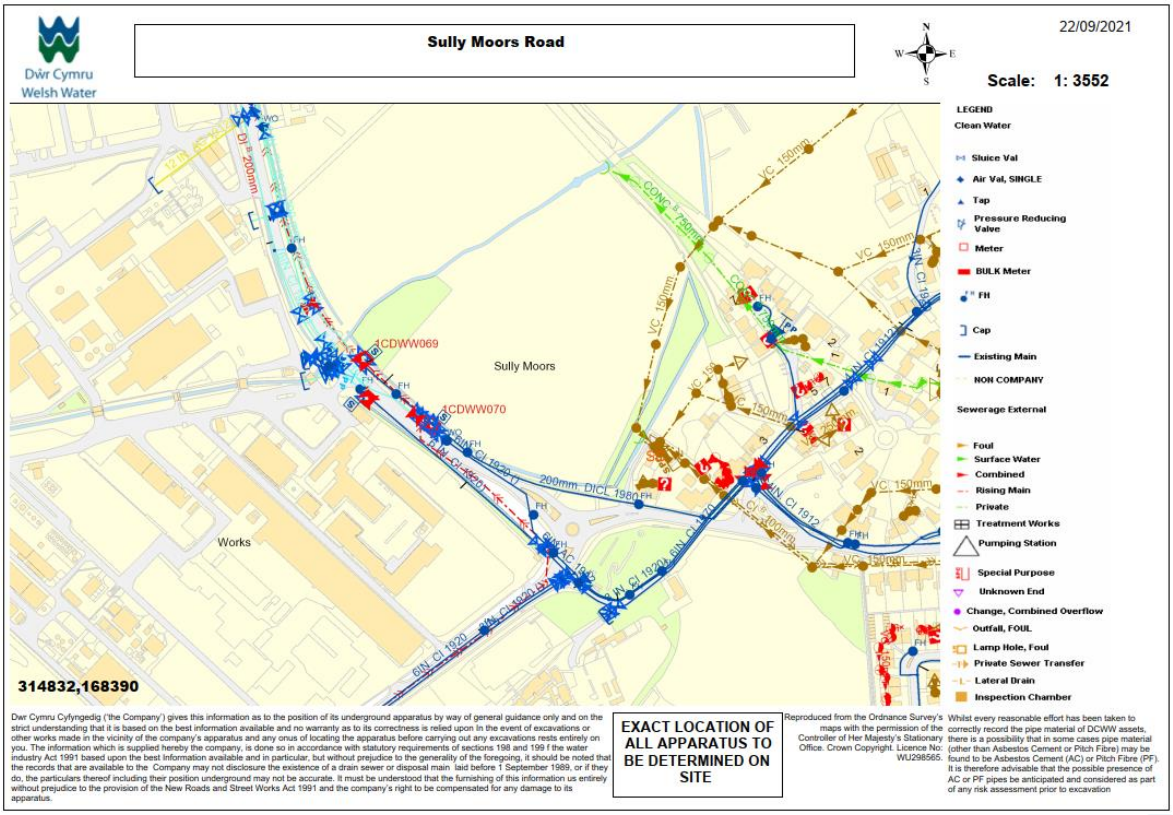

Figure 4-4: DCWW asset map - Sully Moors Road south

4.3.2 Highway drainage

Sully Moors Road is served by highway gullies that connect directly to the adjacent land drainage ditches and Sully Drain which conveys surface water to either the Cadoxton River in the northern extent of the investigation area or the Sully Brook to the southern extent.

Hayes Road drains via a piped and pumped system. The pumps are controlled by Hexion Chemicals, a large industrial site to the north of Hayes Road.

The highway gullies on Sully Moors Road and Hayes Road are reported to be cleansed on a 15 to 18 month average rotation.

5 Information gathering

5.1.1 Long-term flood risk information

5.1.2 Rivers

The NRW Flood Risk Assessment Wales map showing long-term flood risk from rivers indicates that Sully Moors Road is predominantly located within an area with a high risk of fluvial flooding, as shown in Figure 5-1. High risk of flooding means greater than 1 in 30 (3.3%) probability in any year.

The infrastructure of both Sully Moors Road and Hayes Road are at high to medium risk of flooding. Medium risk means between 1 in 100 (1%) and 1 in 30 (3.3%) chance of flooding in any year

The floodplains of the Sully Brook and Sully Drain are located both east and west of Sully Moors Road; the River Cadoxton's floodplain is located to the south of the river within the area of investigation, at high risk of flooding.

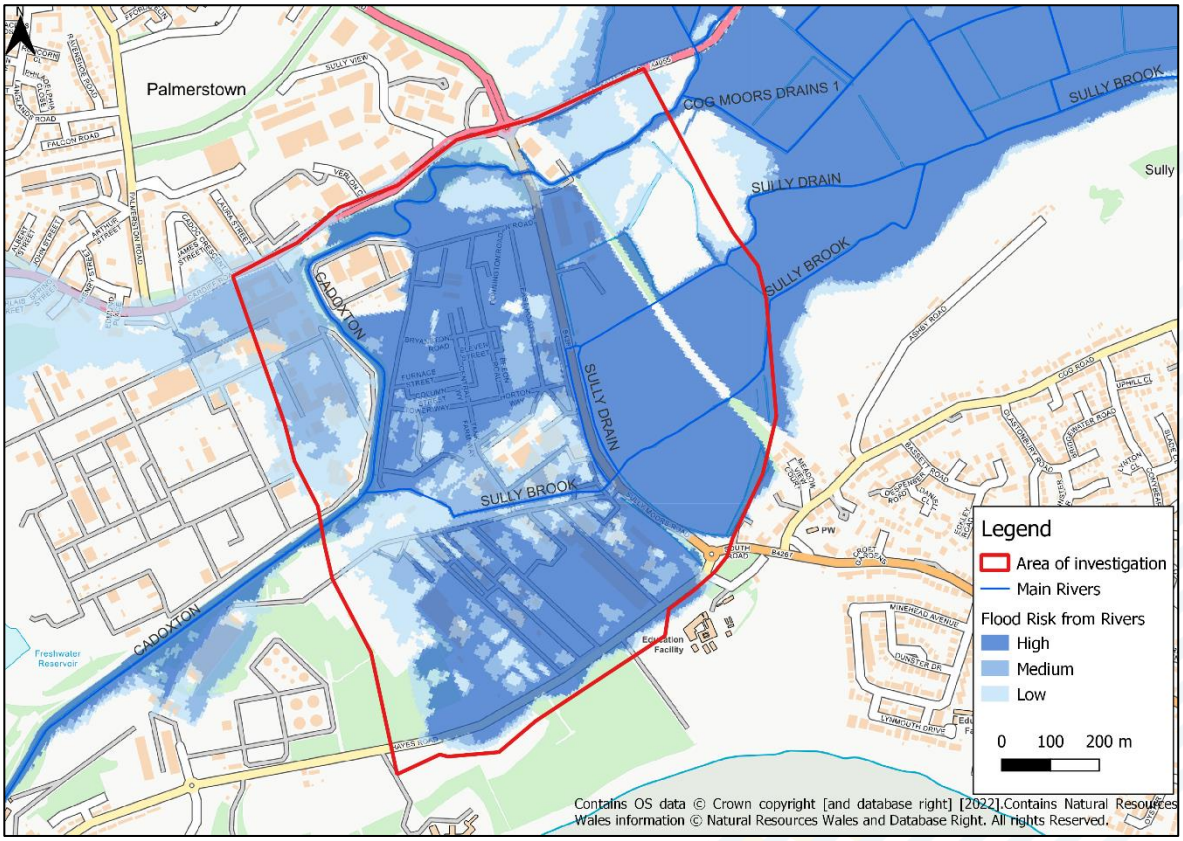

Figure 5-1: Risk of flooding from rivers (Flood Risk Assessment Wales (FRAW) map)

5.1.3 Tidal

The NRW FRAW map for flooding from the sea indicates that the entirety of the investigation area has a low risk of tidal flooding, as shown in Figure 5-2. A low risk of tidal flooding is equivalent to a chance of flooding of 0.1% and 0.5% in any given year.

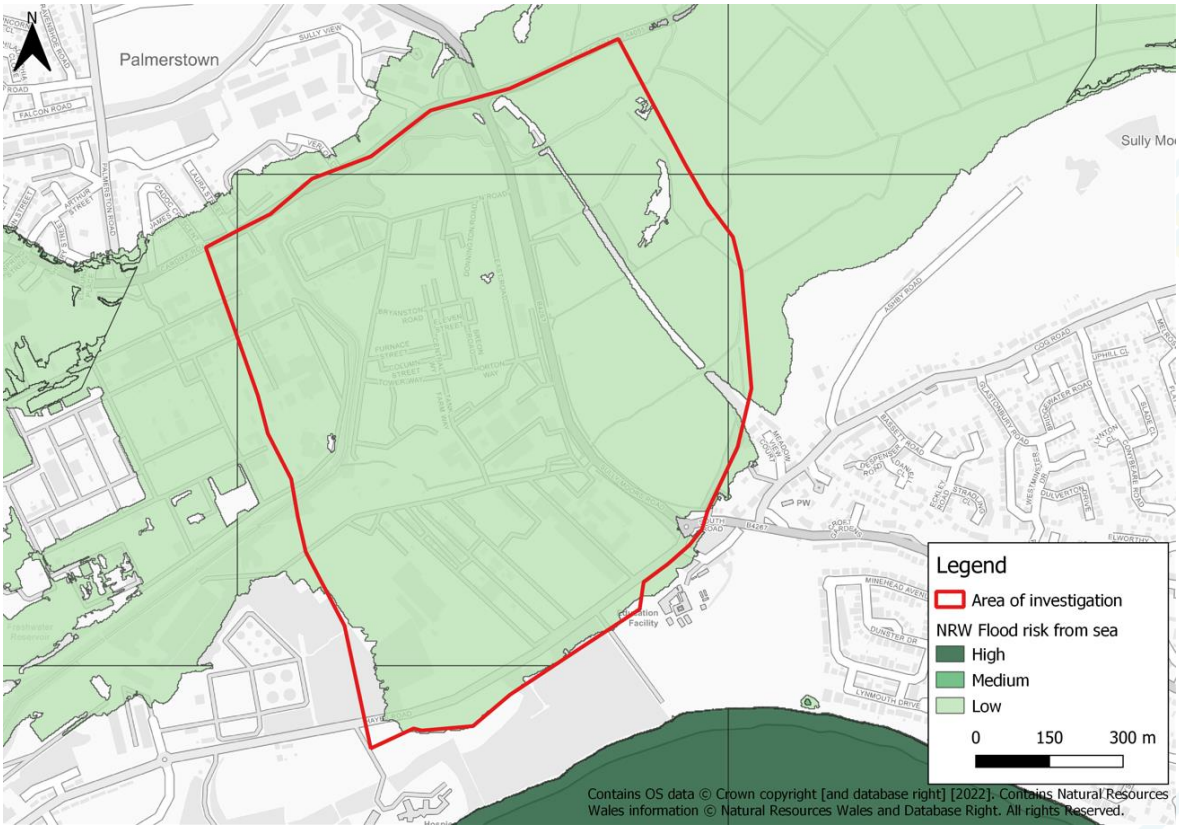

Figure 5-2: Risk of flooding from sea.

5.1.4 Surface Water

The NRW FRAW Map for Surface Water shows that small, localised areas of the investigation area are at risk of surface water flooding. See Figure 5-3.

The south-westerly section of Hayes Road has a high risk of flooding from surface water, defined as a chance of flooding of greater than 1 in 30 (3.3%) in any year as a result of rainfall.

The industrial units to the west of Sully Moors Road have a medium to high risk of surface water flooding. Medium risk equated to between 1 in 100 (1%) and 1 in 30 (3.3%) chance of flooding in any year.

A small number of ditches alongside Sully Moors Road have a low risk of surface water flooding. This is equivalent to between a 1 in 1000 (0.1%) and 1 in 100 (1%) chance of flooding in any year as a result of rainfall.

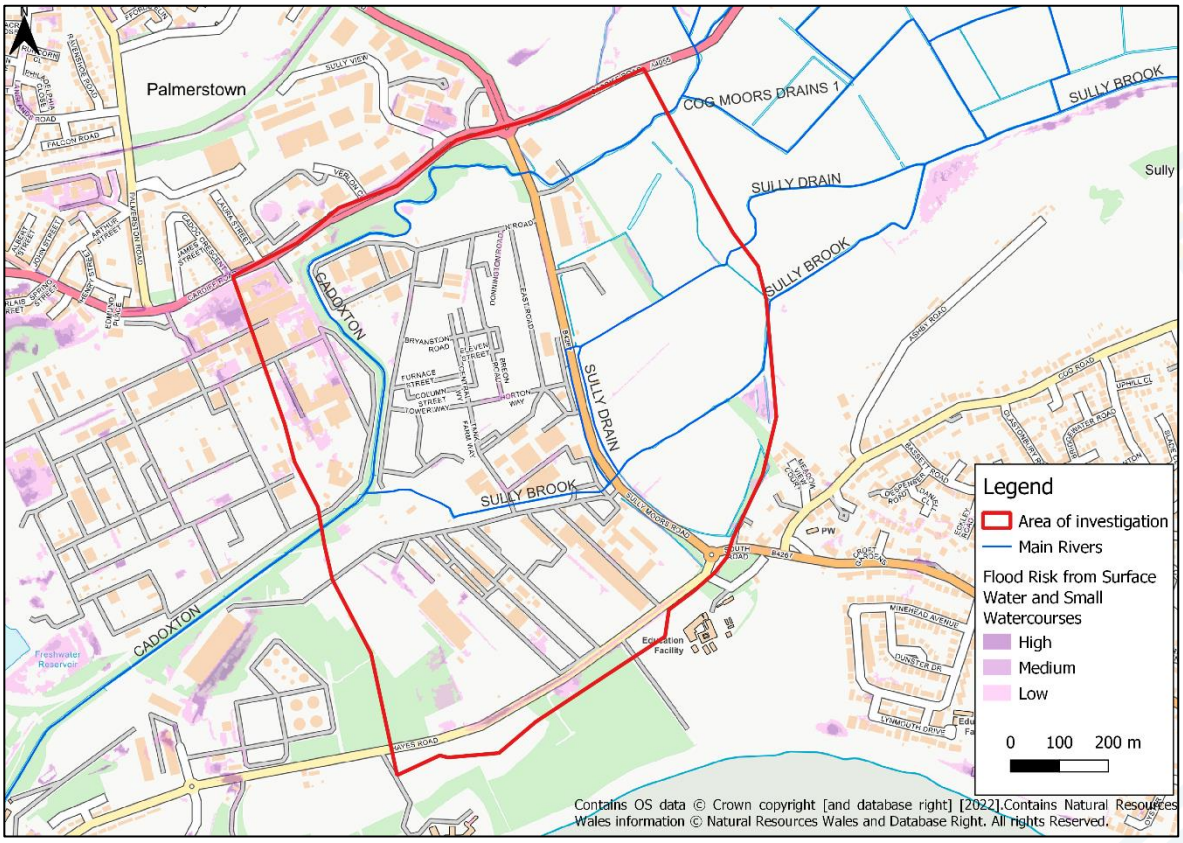

Figure 5-3: Risk of flooding from surface water

5.1.5 Groundwater

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

5.1.6 Flood history

The Sully Moors Road area has a history of flooding, with several businesses referring to this in interviews conducted for the VoGC Preliminary Flood Incident Report. One business reported flooding as occurring 4 times since 1985, another had experienced flooding approximately every 5 years since 1998. No official flood records have been received to further inform this report.

The Sully Flood Management Group meets twice annually to address flooding locally, including specifically on Sully Moors Road. The group includes representatives from NRW and VoGC Highways Department. The 28th-29th February 2020 Storm Jorge event was preceded by two large storm events: Storm Ciara (8th-9th February) and Storm Dennis (15th-16th February). Meeting minutes from the Flood Management Group February 2020 meeting confirm that there had been no reports of flooding to Sully Moors Road during either of the preceding storm events.

6 Source-pathway-receptor analysis

6.1 Source

6.1.1 River

Three NRW main rivers, run through the area of investigation: the Sully Brook and Sully Drain flow through the middle of the investigation area and the River Cadoxton flows along the northern boundary. The source of the River Cadoxton is near Wenvoe, flowing east and then south before flowing south-west through the northern edge of the area of investigation, then in a predominantly southerly direction before finally discharging into the Bristol Channel near Barry Docks; it passes beneath Sully Moors Road via a bridge.

The Sully Brook is one of the largest tributaries of the River Cadoxton. The source of the Sully Brook is located west of Penarth, and it flows in a predominantly south-westerly direction. The Sully Drain branches off the Sully Brook as it flows across the low-lying area of the Sully Moors. Both the Sully Brook and Sully Drain flow south-west through the area of investigation, passing under Sully Moors Road via bridges; the Sully Moors Drain then splits before turning south to flow in ditches along both sides of the Sully Moors Road to join the Sully Brook next to Sully Moors Road within the area of investigation.

The River Cadoxton and the Sully Brook are tidally influenced as they flow through the investigation area. The majority of the investigation areas is categorised as 'Area benefitting from flood defences from the sea' by NRW. The investigation area includes a small, 105m stretch of bund along the River Cadoxton at the north-eastern corner of the investigation area. This defence is classified as in 'Fair' condition by NRW.

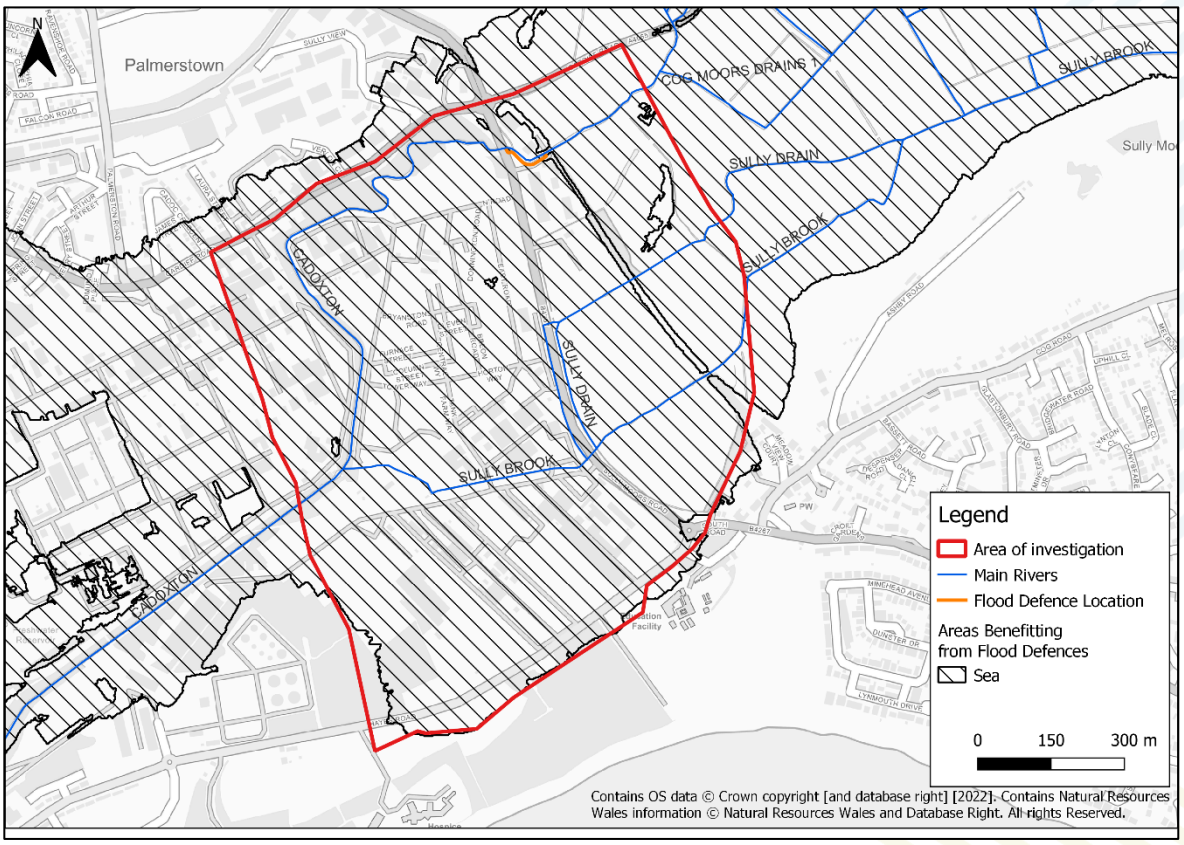

Figure 6-1: Areas benefitting from flood defences

6.1.2 Extreme rainfall

During February 2020 the UK was hit by three named storms in quick succession, bringing sustained periods of heavy rainfall and widespread flooding across much of England and Wales. This meant that the Sully Moors Road investigation area had already experienced very heavy rainfall during Storm Ciara (8th – 9th February) and Storm Dennis (15th – 16th February) which had rainfall levels at 130-180% of average across South Wales[1]. Storm Jorge (28th – 29th February) did not bring the quantity or intensity of rainfall seen over the previous storms, however the rain fell on already saturated ground and maintained the high river levels seen throughout February 2020.

6.1.3 Groundwater

Groundwater has not been reported as a source of flooding for this flood event. However, as groundwater levels rise in response to precipitation, groundwater could contribute to an increased level of surface water overland flow and a faster flow of water to river channels. The rapid onset and short duration of the flood event does not characterise groundwater flooding. Therefore, groundwater is not considered to be a direct source of flooding for this flood event.

6.2 Pathway

6.2.1 Fluvial

The main fluvial pathway is from exceedance of the channel capacity of the Sully Brook and Sully Drain. This resulted in floodwater overtopping the banks of these watercourses onto the Sully Moors to the east of the investigation area. Floodwater then flowed onto Sully Moors Road. It is understood that whilst the River Cadoxton may have also reached capacity and flooded into its functional floodplain, the flood defences retained water within the immediate river corridor, reducing the likelihood that flood waters from the River Cadoxton flowed onto Sully Moors Road or the adjacent commercial properties to the east.

Flood water from the Sully Brook and Sully Drain flowed in a westerly and northerly direction from the watercourse onto the moors and subsequently onto Sully Moors Road. Water flowed overland to the commercial premises located on the eastern side of Sully Moors Road, resulting in 6 properties flooding internally. Flood water flowed along Sully Moors Road onto North Road and Horton Way and an un-named road; all access roads of the industrial estate to the west of Sully Moors Road. From this location, flood water entered the wider industrial estate, resulting in widespread flooding. Flood water flowed into a southerly direction onto Hayes Road at the southern extent of the investigation area.

[1] JBA Risk Management, Storm Ciara, Dennis and Jorge, 2020: https://www.jbarisk.com/flood-services/event-response/storm-ciara-dennis-and-jorge/

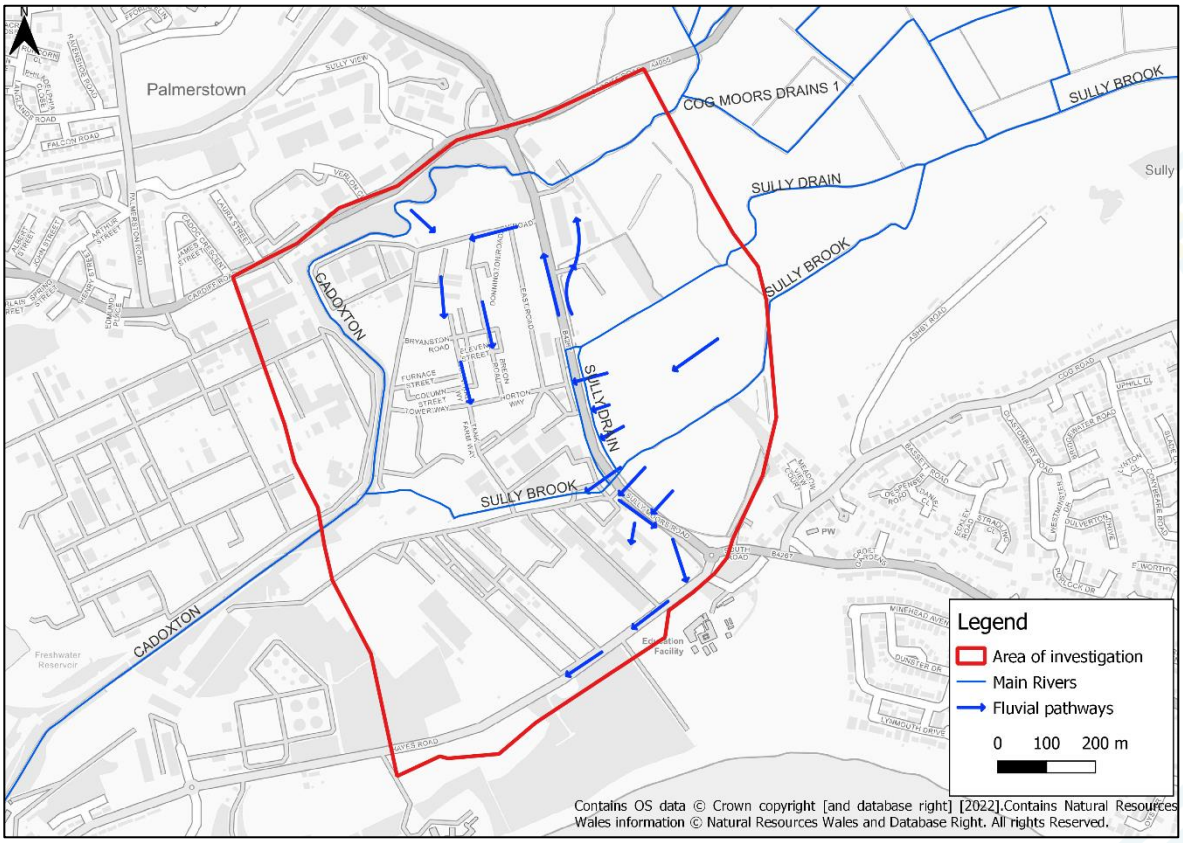

Figure 6-2: Flood water pathways

6.2.2 Surface water

Due to the high intensity of rainfall during the storm period, surface water pooled directly on impermeable surfaces, such as roads and pavements and the large industrial sites that occupy much of the western part of the area of investigation, where it normally discharges into the private surface water sewer networks. Due to high water levels in the surrounding watercourses, the private surface water sewer systems were hydraulically locked and unable to discharge, exacerbating flooding in the investigation area.

Sully Moors Road is served by highway gullies that connect directly to the adjacent land drainage ditches which discharge into either the Cadoxton River or Sully Brook. The highway network was hydraulically locked as a result of the high water levels within the watercourses during the rainfall event resulting in backing up of the system and surcharging of the highway network during the flood event.

There are no reports of flooding from the DCWW combined system during this flood event.

6.3 Receptor

6.3.1 People

No residential properties were affected in the area of investigation; however, businesses were affected by the flooding either directly or indirectly as access routes were blocked by the floodwater thus meaning businesses had to close for the duration of the flood. The floodwater blocking Sully Moors Road and Hayes Road resulted in disruption to journeys, therefore impacting the wider community.

The emotional impact of experiencing flooding and how it can have a harmful impact on mental health is well documented. This is true to business and property owners, with flooding resulting

in temporary (and sometimes permanent) business closure and unexpected costs for business recovery. Business owners in this area reported numerous historic flood events at this location, resulting in this event having the potential to add to existing unrest and anxiety surrounding flooding.

6.3.2 Property

A range of commercial property was directly flooded with 6 businesses reported to have flooded internally as a result of this flood event. Flood depths varied between 450mm and 900mm. Serious external property damage as a result of the flood event has also been reported. No information on the extent and cost of the damages is known to inform this report.

Figure 6-3: Flooding of commercial property in the north east of the study area.

6.3.3 Infrastructure

Sully Moors Road (B4267), the main road linking Barry to Sully and Penarth, was flooded and closed over a length of approximately 800m between the roundabout at the junction of the Barry Dock link road (A4055) in the north and the Hayes Road roundabout in the south; Hayes Road was flooded and closed west of this roundabout but the total distance cannot be ascertained from the data supplied. Indicative flood extents along Sully Moors Road and Hayes Road are shown in Figure 6-4. Flood depths have not been reported. Road closures remained in place from 29th February to 2nd March.

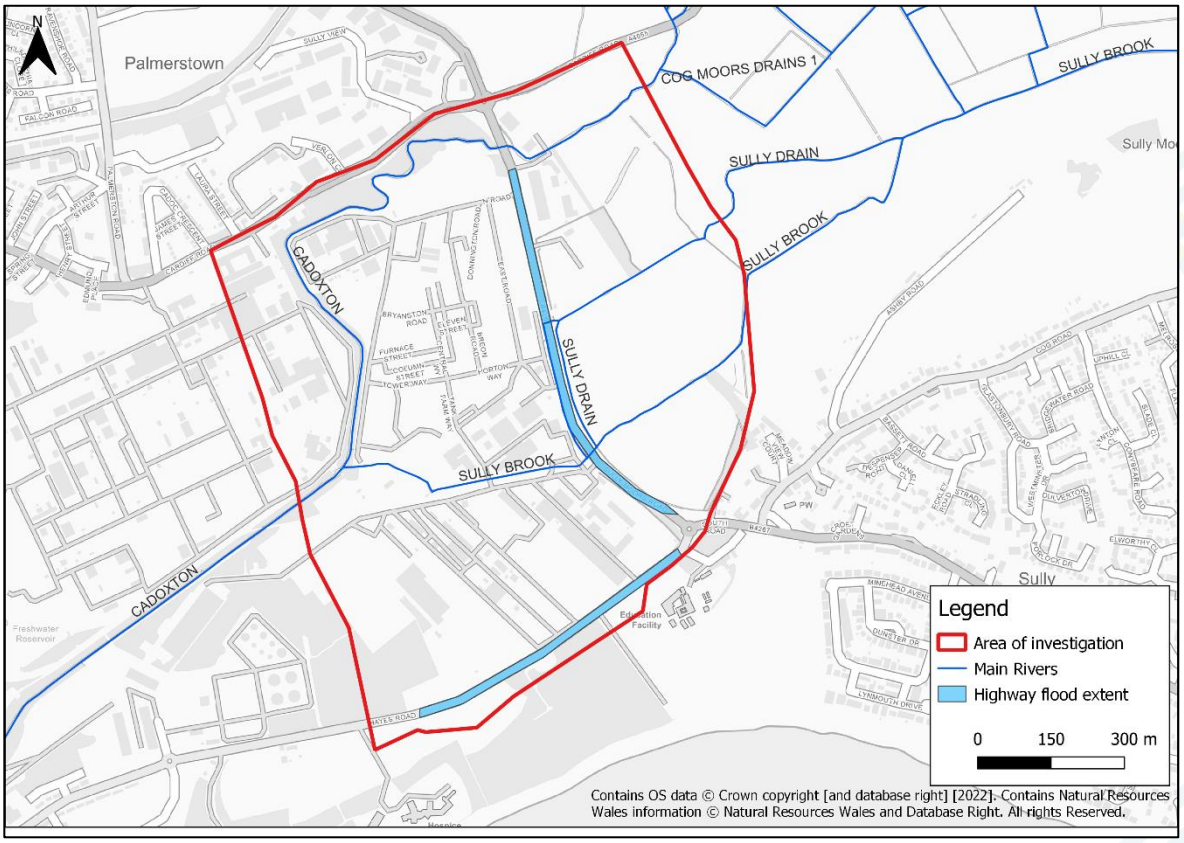

Figure 6-4: Highway flooding

Road access into Sully and to the industrial and commercial estates in the Sully Moors Road area was severely restricted due to flooding and closure of Sully Moors Road, resulting in loss of business and widespread traffic problems. Images of flooding to the area are contained in Figure 6-5 and Figure **6**-**6**.

Figure 6-5: Flooding of Sully Moors and Sully Moors Road in the south east of the study area, looking north west.

Figure 6-6: Flooding of Sully Moors Road and North Road, looking west.

7 Causal factors

Determining the exact cause of flooding is complicated and flooding often results from a combination of factors. Where location specific issues, such as blockages, are identified these will be described in the following section.

The primary cause of flooding to the Sully Moors Road area is limited channel capacity of the River Cadoxton, Sully Brook and Sully Drain resulting in overtopping of the river channels and floodwater spilling onto the floodplain. Fluvial flood water flowed in all directions, across the Sully Moors and along Sully Moors Road resulting in property and highway flooding across the investigation area. The extent of flooding correlates well to the 'high' flood risk extent on the FRAW risk of flooding from rivers map. High antecedent rainfall conditions as a result of Storm Ciara and Dennis resulted in initial conditions of a saturated catchment and high river levels.

Given the timing of the event, in winter, vegetation coverage in channel will have been at its lowest, and as a result the impact of any vegetation is likely to be minimal across most of the site. However, anecdotal reports raise concerns that vegetation arising from maintenance following the previous storm events remained in channel during the Storm Jorge event, limiting channel capacity. It is known that landowners, and NRW regularly undertake channel maintenance in this location, depositing material on the watercourse banks. Given the site location, volume and duration of flooding during this event, it is considered unlikely that vegetation within the channel would have significantly impacted on the extent of flooding during this event.

Hydraulic locking of the highway and private surface water sewers in the area resulted in surface water being unable to discharge into the Sully Brook, Sully Drain and River Cadoxton. Much of the western part of the area of investigation consists of industrial estate, with a large proportion of impermeable surfaces causing surface water runoff. High water levels in the receiving watercourses resulted in surface water systems being surcharged for the duration of the flood event. The NRW fluvial flood map is largely in line with the recorded flood extent for this event. Surface water flooding is not considered to be the main source of flooding for this event.

8 Conclusion and recommendations

8.1 Conclusions

This report has detailed the investigation into the flooding of the Sully Moors Road investigation area on 29th February to 2nd March 2020. This investigation has reviewed evidence provided by responders and businesses affected by the flood event.

Within the investigation area, the impacts from the storm event primarily occurred on the Sully Moors Road and Hayes Road, along with the neighbouring industrial/commercial estates.

The impact of the event was that 6 commercial/industrial properties experienced internal flooding, along with road closures to key highway links between Barry and Sully. Flooding resulted in damage to property and highway closures for 4 days, impacting on access to businesses and on the wider community travelling around the county.

The evidence gathered in this report demonstrates that the cause of flooding was due to heavy rainfall resulting in exceedance of channel capacity of the Sully Brook, Sully Drain and River Cadoxton. This was likely exacerbated by hydraulic locking of the surface water networks in the area, resulting in increased surface water flows.

The below actions are recommended in response to these findings.

8.2 Recommendations

Risk Management Authority/Stakeholder	Recommended actions
LLFA / Highway Authority (VoGC) / NRW	Assess the merits of installing a level gauge on the Sully Brook to assist with warning and informing of local businesses and highway users, and improved monitoring of extreme events.
Riparian Owner / Maintainer (Private Landowner/NRW)	Review maintenance actions and frequency for the Sully Brook, Sully Drain and River Cadoxton.
Highways Authority (VoGC)	Consider catchment options to reduce the risk and impact of surface water flooding to Sully Moors Road and Hayes Road
Highways Authority (VoGC)	Undertake an assessment of the condition and capacity of the local highway drainage system.
Property Owners	Consider flood risk to own properties; to install property flood resilience (PFR) where necessary in liaison with the appropriate RMAs.
Property Owners/ LLFA	Undertake an assessment of the condition and capacity of the private drainage network within the industrial estate, and review maintenance regime.
LLFA / Highway Authority / NRW / Local businesses / Local ward members	Continued engagement between local stakeholders and risk management authorities through Sully Flood Management Group.
VOGC (LLFA)	Consider adding Sully Brook and Cadoxton catchment as an area where new development requires specific hydraulic control within

	forthcoming updates to the Local Flood Risk Management Strategy

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