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Beryl Road Section 19 Flood Investigation - Storm Dennis

Section 19 Investigation Report

Swansea Council

October 2021

5200249-10-DG-001

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Executive Summary

Storm Dennis caused widespread flooding across parts of South Wales on 15th and 16th February 2020. It was reported at the time that the resulting rainfall was unprecedented in places. One of the areas affected in Swansea was Beryl Road in Clydach, which suffered extensive flooding to the unadopted road and internal flooding to five properties.

This investigation into the flooding at Beryl Road has been undertaken by Swansea Council under Section 19 of Flood and Water Management Act. At the outset of the investigation, it was suspected that the majority of the flood water affecting Beryl Road originated from the Enid Stream which enters a long, culverted section to the east of the road.

Consultations

The following organisations and individuals were contacted for information relating to the flooding incident:

- Swansea Council Drainage Department
- Swansea Council Highways
- Dŵr Cymru Welsh Water (DCWW)
- Residents of Beryl Road – 9 households
- Pobl Housing Association – relating to property on Capel Road
- Canal and River Trust (CRT)
- Mid and West Wales Fire and Rescue Service (MWWFRS)
- Swansea Councillor Gordon Walker

Residents have provided details of the mechanisms of the flooding and feedback on the impacts on their lives through responses to a questionnaire and on-site interviews with Atkins' Engineers. It is noted that the residents have been active in investigating possible causes of the flooding. Their contribution to this investigation has been extremely valuable.

Rainfall analysis for rarity

Analysis of the rainfall data from the nearby Natural Resources Wales gauge at Trebanos has revealed that Storm Dennis had an estimated return period of 8 years (12.5% AEP or chance of occurrence in any given year). Consequently, in this area of South Wales, the rainfall during Storm Dennis cannot be considered to be unprecedented.

Drainage systems in the area

The land drainage, surface water and highway drainage systems have been investigated, based on available record information and with additional site investigation support from Swansea Council, to understand the mechanisms of flooding in Beryl Road and the locality. The drainage systems are complex, and some aspects remain unresolved; further investigation will be needed to understand how these systems may interact to influence flood risk in the area. These unknown aspects include:

- The condition and connectivity of a DCWW surface water sewer which carries surface water and road drainage south from Beryl Road to the Enid Stream just upstream of an inverted syphon under the Swansea Canal.
- The catchment, connectivity and levels of the highway drainage serving Park Road remain to be confirmed.
- The condition, connectivity, and levels of the Enid Stream from Capel Road via the inverted syphon to the eventual outfall to the canal.

Flood frequency and mechanism at Beryl Road

The investigation has identified a series of flooding incidents which have affected Beryl Road in the last 2 to 3 years. These followed a period of over ten years of little or no incidence of flooding. The rarity of the rainfall during these recent incidents, ranges from just over a 1 year return period (100% AEP or chance in any given year) to 7 years return period (14% AEP). Of these recent flood events, the Enid Stream contributed directly to the flooding in Beryl Road on only one occasion, the Storm Dennis event (8 years return period).

Flooding to Beryl Road is caused by water on the road being unable to drain into the gullies, which appear to be connected to a DCWW surface water sewer. Flooding in Beryl Road is exacerbated by overland flow from Park Road where the highway drainage is unable to deal with the volumes of water arriving on the road. During Storm Dennis the Enid Stream spilled out of bank from a culvert inlet east of Beryl Road. The resulting

overland flow exacerbated flooding to the already flooded Beryl Road, resulting in internal flooding to five properties and extensive flooding around the garden of one other property.

The subsequent flooding incident of 25th August 2020 was reported by residents to have only narrowly avoided entering properties. Water levels in the Enid Stream were elevated during this event but remained just within the stream banks.

Responses of the Risk Management Authorities to Storm Dennis

It is considered that the responsible Risk Management Authorities (RMAs), Swansea Council and DCWW, had both implemented appropriate planned actions prior to the arrival of Storm Dennis. During the flooding incident, they reacted to reports of flooding and provided support to the local community along with the MWWFRS. The actions taken by the RMAs includes surveys and cleansing of sewers and highway drainage prior to and following Storm Dennis. Investigation of the Enid Stream connectivity around Capel Road and the canal is ongoing.

Conclusions

This investigation has confirmed that there is an ongoing flooding problem affecting Beryl Road, and also Capel Road located further downstream. Incidences of flooding appear to be have become more frequent in the last 2 to 3 years. The rainfall analysis has shown that Storm Dennis was a high rainfall event, but it had a return period of 8 years and is not therefore considered to have been not an extreme flood event.

Further investigations are required to confirm the connectivity and condition of the Enid Stream, the DCWW sewers, and Park Road highway drainage system. This will inform assessment of the causes of the apparent under-capacity of the systems and the interactions between them.

The extent of such investigations will be agreed between the RMAs following sharing of the findings of this investigation.

1. Introduction

1.1. Legislative Background and Purpose of this Report

Under the Flood and Water Management Act 2010, Swansea Council is the Lead Local Flood Authority (LLFA) for the City & County of Swansea. As part of its responsibilities under Schedule 3 of the Act, the LLFA has a statutory obligation to investigate incidents of significant flooding. This report describes the investigation of the flood event that occurred at Beryl Road, Clydach on 15th and 16th February 2020 during Storm Dennis. Atkins was commissioned to assist Swansea Council with the investigation and to compile the information gathered into a Flood Investigation Report.

The purpose of this report is to present the results of the investigation into the circumstances of the flooding incident. The scope includes collating information from multiple sources with the aim of identifying the causes of the flooding incident and the actions taken by Risk Management Authorities. The report brings together technical information on the magnitude of the rainfall and the nature of the drainage systems with anecdotal accounts of the incident from local residents and public agencies who were in attendance during the event. The scope does not extend to assessing potential options for land drainage improvements; this may be undertaken in future studies at the discretion of Swansea Council.

1.2. LLFA Responsibilities

Under Section 19 of the Flood and Water Management Act 2010 (FWMA), Swansea Council as Lead Local Flood Authority (LLFA), on becoming aware of a flood in its area, must, to the extent that it considers it necessary or appropriate:

- Investigate the incident;
- Identify the Risk Management Authorities (RMAs) with relevant flood risk management functions;
- Establish if the relevant RMAs have responded to the flood event or are proposing to respond;
- Publish its findings; and
- Inform the relevant RMAs of its findings.

An RMA (as defined under Section 6, subsection 13 of the FWMA) has certain powers to manage, regulate, assess, and mitigate flood risk. The activities of the following RMAs have been examined as part of this Section 19 flood investigation for Beryl Road, Clydach:

- Swansea Council as the Lead Local Flood Authority (LLFA);
- Swansea Council as the Highway Authority (HA);
- Dŵr Cymru Welsh Water (DCWW).

1.3. Summary of the Event

Storm Dennis was the fourth named storm of the 2019/ 2020 winter season to bring heavy and persistent rain across much of the UK. The arrival of this storm over the weekend of 15th–16th February 2020 brought severe rainfall to Swansea and caused internal flooding of properties at Beryl Road, Clydach.

The intense rainfall resulted in flooding to the Beryl Road area affecting six properties, five of which suffered internal property flooding. Flooding associated with the same catchment also affected Capel Road, at a depression in the road, east of its junction with Vera Road. Here flooding affected the GMD Body Repairs garage south of the road, and flats at 14 to 18 Capel Road owned by the Pobl Housing Association.

Following the flooding incident Swansea Council officers determined that the criteria had been met as laid under Measure 19 of the Local Flood Risk Management Strategy, triggering the Duty to Investigate Flooding Incidents, specifically:

- Where there is internal flooding to one or more property on more than one occasion; or
- When more than five properties have been affected by flooding.

1.4. The Investigation

1.4.1. Scope of the Investigation

This investigation has addressed the following aspects to understand the cause(s), circumstances, and effects of the flooding incident.

1. Various sources of information on the land drainage and surface water drainage systems in the area have been reviewed to assess the characteristics and connectivity of open channel streams, surface water culverts and pipe networks. An un-named watercourse approaches the eastern end of Beryl Road from the north. This stream enters a culvert following a route along Enid Road and hereafter for the purpose of this report is referred to as the "Enid Stream";
2. Local rainfall records have been obtained from Natural Resources Wales (NRW) for Storm Dennis, and other recent storms;
3. Hydrological analysis has been carried out on the rainfall data to establish the return period of the storm and give an idea of the rarity of the event;
4. Local residents have shared their experiences of the flooding incident, which in turn has informed the understanding of the flooding mechanisms. This includes the timing and depth of flooding, and the influence of local features that may have affected the severity of flooding;
5. The responses of the Risk Management Authorities (RMAs), organisations, and the emergency services to the flooding incident during and after the incident have been collated.

1.4.2. Flood Investigation Report

The outcome of the study is the Section 19 Flood Investigation Report (FIR) with its key findings. This is a factual record documenting:

- what happened during the incident;
- the actions taken before, during and afterwards;
- the cause(s) of flooding or the probable cause(s) of flooding, so far as these can be ascertained; and
- identify any adjustments that may be needed to implementation of the Local Flood Risk Management Plan in relation to known flood risk at Beryl Road.

It is a legal requirement under the requirements of the Act that this FIR must be published.

Swansea Council offers the following advice to residents on its website with respect to the responsibility for flood protection of property:

> *Swansea Council, the emergency services and Natural Resources Wales will help where they can, but primarily you are responsible for protecting your own property. When flooding is widespread, it is not possible to respond to every call for assistance at once, and our priority will be to save lives.*
>
> (Flood advice on Swansea website at https://www.swansea.gov.uk/floodadvice)

1.5. Consultations

The following organisations and individuals were contracted for information relating to the flooding incident.

- Swansea Council Drainage Department
- Swansea Council Highways
- Dŵr Cymru Welsh Water
- Residents of Beryl Road – 9 households
- Pobl Housing Association – relating to property on Capel Road
- Canal and River Trust (CRT)
- Mid and West Wales Fire and Rescue Service
- Swansea Councillor Gordon Walker

1.6. Information Reviewed

A variety of information was obtained from the RMAs and other sources during the investigation. The following information was reviewed, and relevant details extracted to support the study:

- A series of CCTV surveys undertaken for Swansea Council:
  - CCTV survey of February 2015
  - CCTV survey of August 2016
  - CCTV survey of July 2020
- MWWFRS incidents log
- Dŵr Cymru Welsh Water (DCWW)
  - Call out records – February 2020
  - Maintenance and survey of sewer October and November 2019
- Swansea Council provided resources to undertake dye testing of the drainage system to determine connectivity where this was unknown

1.7. Rainfall Records Analysis

Rainfall records procured from NRW have been analysed to understand the magnitude of the rainfall and estimate the annual probability of Storm Dennis in the Clydach area. The results of this analysis are discussed in **Section 6.2**.

2. Site Description

This section contains a series of plans illustrating the area investigated in the study. The immediate location of the area of interest at Beryl Road is shown in wider context in Figure 2-1. The overall landform catchment draining towards Beryl Road is shown in Figure 2-2. The publicly available flood risk map produced by NRW is reproduced for convenience in Figure 2-3.

Figure 2-1 - Location of reported flood incidents - Beryl Road, 16 February 2020

2.1. Site Location

The residential Beryl Road is situated within the village of Clydach, approximately 6 miles north-east of Swansea city centre. The road is not an adopted public highway but forms a link between the public highways at Vera Road and Enid Road. Beryl Road is located adjacent to Waverley Park, which includes the Clydach cricket ground. The Swansea Canal is to the south-east of Beryl Road, and the Clydach Refinery known as 'The Mond' lies beyond the canal.

The general location of the affected area of Beryl Road in relation to Clydach is indicated by the red line boundary in **Figure 2-1**. The locations of the affected properties are shown within the figure inset.

The location of Beryl Road in relation to local areas predicted to be at risk of flooding from surface water is shown in **Figure 2-2**. The areas at flood risk are based on Natural Resources Wales' (NRW) Flood Risk Assessment Wales (FRAW) map.

The contributing surface water catchment to Beryl Road (i.e. the watershed) is shown in **Figure 2-3**; covers an area of 0.43km^2. In this figure the flows are directed from north to south down the contours. The contributing catchment extends for approximately 1km above Beryl Road to the highest part of the catchment above Gellionen Road.

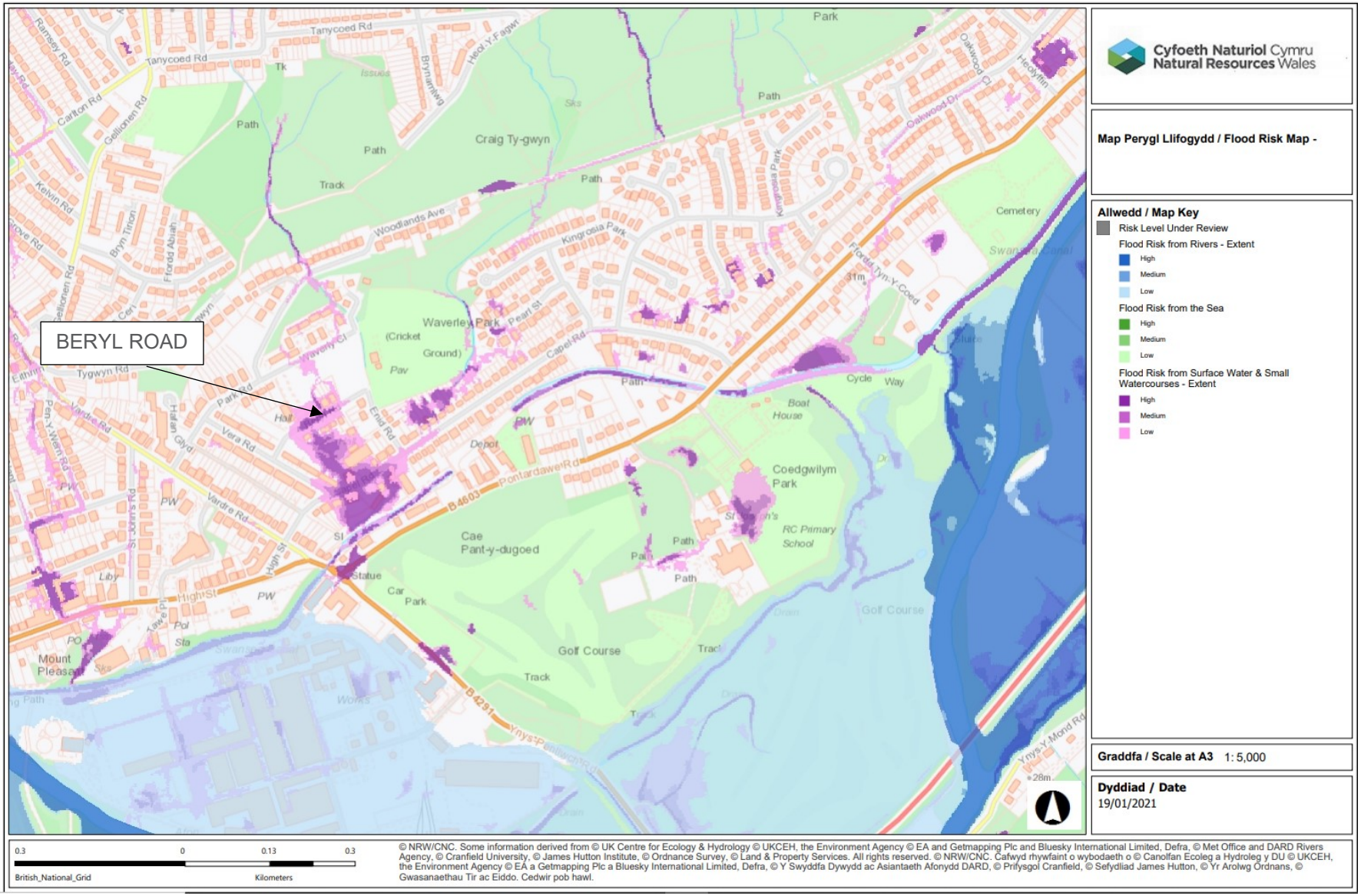

Figure 2-2 - NRW Flood Map for Surface Water and Small Watercourses.

Figure 2-3 – Landform and catchment boundary in area of Beryl Road; the numbers are the contour intervals given in metres above mean sea level.

2.2. Topography

Beryl Road is situated in a mainly residential area of Clydach. It lies at the bottom of a steep slope extending 1.17km from a high point to the north above Gellionnen Road. The fall in ground levels to the south-east of Beryl Road towards Capel Road and the Swansea Canal are very shallow.

Reference has been made to contoured LiDAR[1] data to derive the general falls in level in the different sections of the overall land drainage catchment in which Beryl Road lies (i.e. the red outline area on Figure 2-3).

The highest point of the catchment is at an elevation of approximately 190mAOD,[2] and there is a fall of 168m to Beryl Road, which is at an elevation of 22mAOD. In contrast to the steep fall in the upper catchment, the much shallower fall from Beryl Road to the eventual outfall of the Enid Stream to Swansea Canal at the Mond is only 2.5m.

The upland areas are characterised by moor and agricultural pastureland from Gellionen Road, sloping down approximately 100m in elevation to the urban residential areas around Penydre and Tanycoed Roads. The mid-section of the catchment sloping down to Woodlands Avenue comprises woodland area with some urban area at Gellionen School.

Woodlands Avenue intercepts surface runoff from part of the catchment to the north and diverts this away from the Enid Stream (which crosses this road in a masonry arch culvert). Woodlands Avenue slopes steeply down towards the west to its junction with Park Road, an overall fall of approximately 15m.

There is a significant break in slope at Park Road with the catchment becoming relatively flat. The change in ground levels is relatively slight from Park Road south towards Beryl Road across an area of green open space. The ground profile to the north-east of Beryl Road is such that out of channel flows from the Enid Stream are directed onto the road.

The road and houses at Beryl Road lie in something of a low-lying depression or shallow basin in the surrounding topography. The road itself has a low spot near the centre between high points at its intersections with Vera Road to the west and Enid Road to the east. The low spot in the road is at an elevation of approximately 22.3mAOD.

The low-lying nature of the area and the shallow fall in the land to the south are reflected in the extensive area of surface water flood risk indicated on Figure 2-2 above.

The land drainage systems draining the catchment are described in the following sections of this report.

[1] The term “LiDAR” stands for Light Detection and Ranging, which is a technique for collecting topographic information using aircraft or satellites.
[2] All height information is given as mAOD, i.e. metres Above Ordnance Datum.

3. Watercourse and Land Drainage System

The Enid Stream drains the majority of the land drainage catchment, largely in open channel down to the western side of Waverley Park cricket ground. It continues in alternating sections of culvert and open channel to its eventual outfall to the Swansea Canal, which are described in the following sub-sections.

Predominantly Open Channel Watercourse Section to the Cricket Pavilion

The sections of this watercourse in proximity to Beryl Road and Capel Road to its eventual outfall to the Canal are shown in the following three figures, Figure 3-1 to Figure 3-7 and described below.

Figure 3-1 - Open Channel sections of Enid Stream north of Beryl Road

The stream has a large masonry arch culvert crossing at Woodlands Avenue which appears to have been constructed for the old railway sidings; historic maps show that the railway sidings , which were located on this site up to the 1960s. The stream continues from here in open channel down to Waverley Park road, crossing this road and the access to the cricket ground from Park Road in two culverts (the latter is shown in Figure 3-2).

Figure 3-2 – Screen and headwall on short culvert under the Cricket Club access from Park Road/ Waverley Close.

As indicated on Figure 3-3 the stream course continues in open channel southwards along the western side of the cricket ground to a screened culvert inlet near the pavilion.

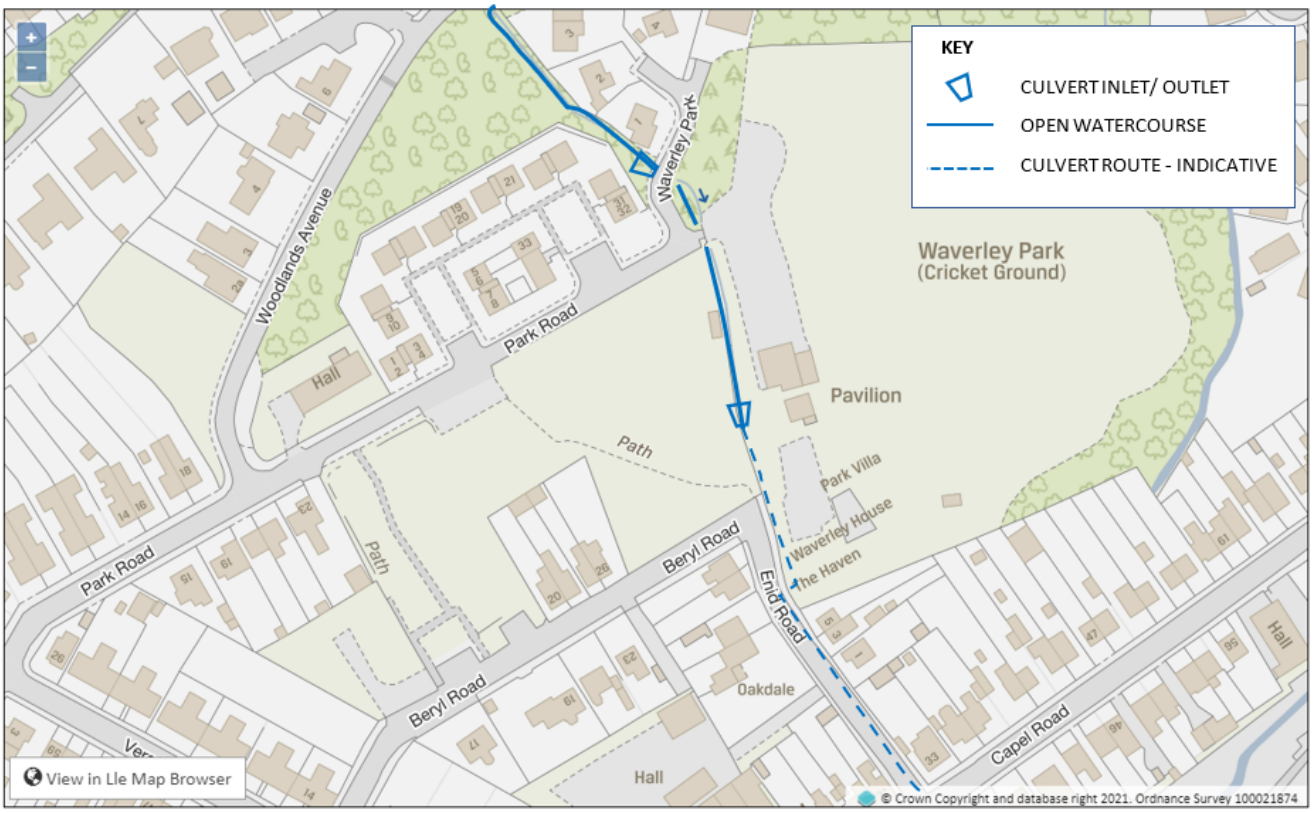

Figure 3-3 – Key culvert and open channel sections of Enid Stream north and east of Beryl Road.

Culverted section from Enid Road to Capel Road

From the cricket pavilion the stream enters a long, culverted section which follows a route along Enid Road and continues south-west along Capel Road (the route is shown on Figure 3-6 and Figure 3-7, below). The screened inlet and upstream channel are shown in Figure 3-4 and Figure 3-5.

Figure 3-4 – View of the Enid Stream upstream of the culvert screen.

Figure 3-5 – Screen at entrance to long culvert into Enid Road adjacent to the cricket pavilion.

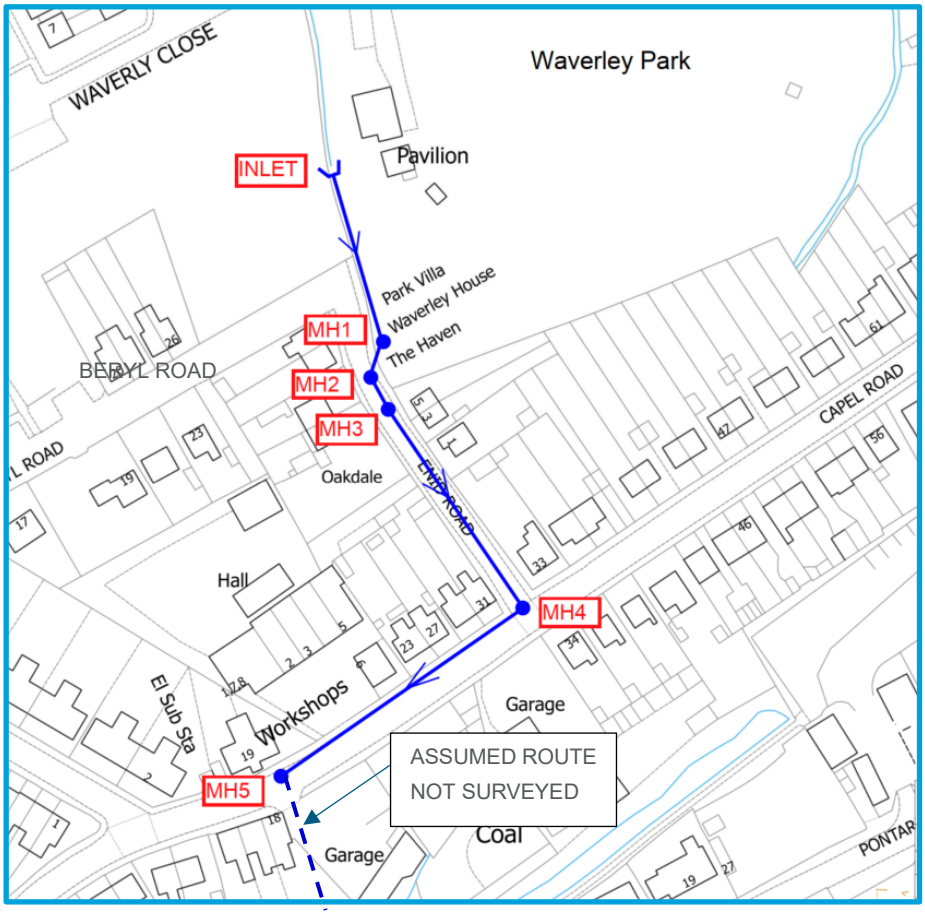

Figure 3-6 – The culverted section of the Enid Stream in Enid Road and Capel Road.

Records provided by the Council show that various sections of the culvert were CCTV surveyed and cleared in 2015 and 2016, and also in July 2020 after Storm Dennis.

CCTV survey information indicates that the culvert begins as a 450mm diameter concrete pipe. The pipe transitions to a 600mm diameter pipe at chamber MH1 (Figure 3-6). A dog leg in the route of the culvert to the centre of Enid Road (MH2) marks a new section which was replaced sometime between 2016 and 2020, due to the deteriorated condition of the previous arrangement. From the centre of Enid Road, the culvert continues as 600mm dia. pipe to the junction with Capel Road. Here it turns through a right angle and follows the highway in a south-west direction to MH5.

It is noted that from the records available at the time of writing, there is no evidence of this section within Capel Road having been surveyed completely. The survey records cite various reasons such as the line being surcharged or encountering debris blocking the pipe leading to termination of the surveys. Therefore, the exact route and condition of the culvert along the lower portion of Capel Road and south towards the canal is uncertain. There is good confidence in the chamber locations within Capel Road as all manhole covers are visible in the highway.

The route from Capel Road to the canal outfall is described in the following section and is shown on Figure 3-7 below.

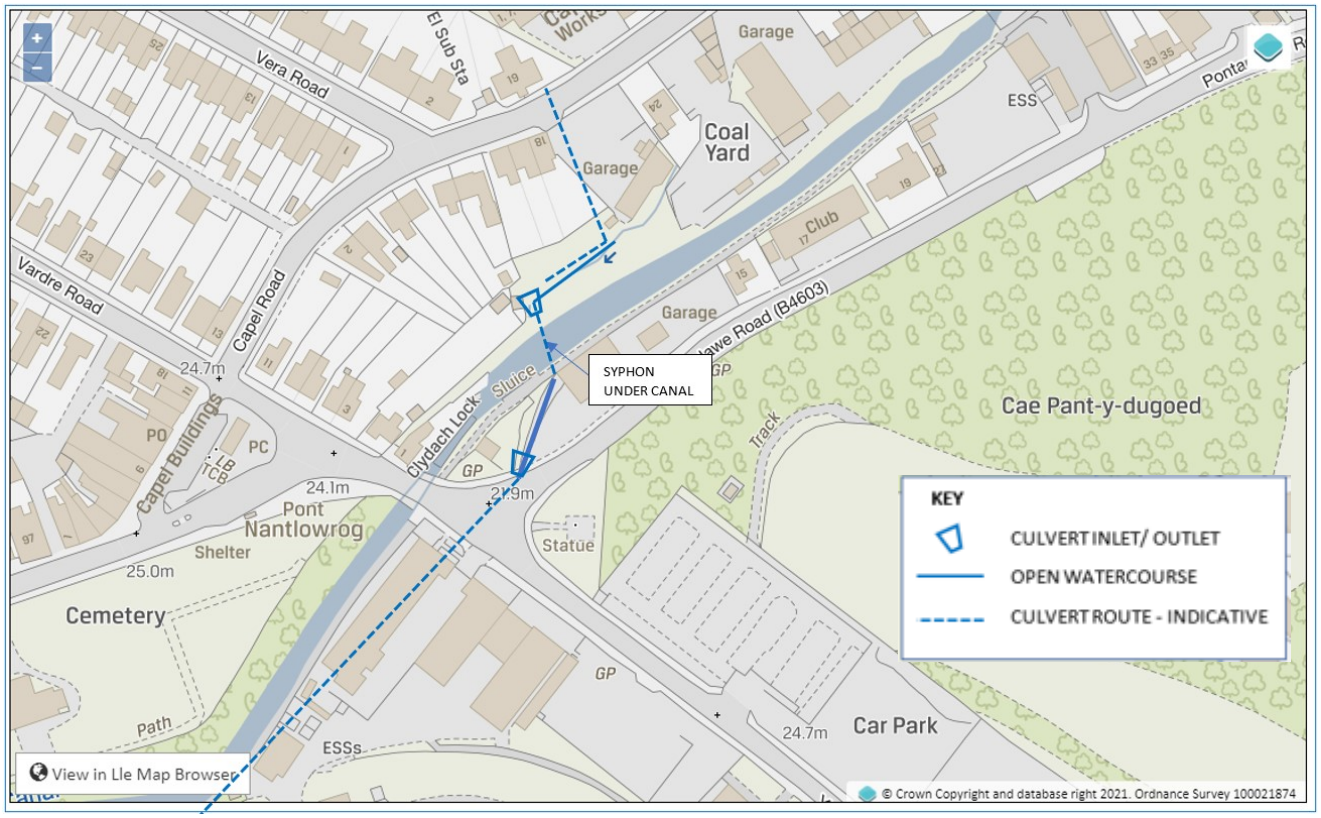

Figure 3-7 – Route of Enid Stream south of Capel Road via a syphon to the Canal outfall.

Enid Stream Section - Capel Road to the Canal Crossing and on to its Outfall

South of Capel Road the culverted watercourse seems to enter a short open channel ditch (Figure 3-9)

Internal photographs of chamber MH5 on Capel Road confirm that there is a 90-degree bend through the chamber. This suggests that the culvert is routed south from Capel Road between the GMD Body Repairs garage and No. 18 Capel Road, and flows towards an outfall (unlocated) to the open channel ditch.

The course of the ditch runs south-west, parallel to Swansea Canal, before turning through approximately 90 degrees to cross under the canal in an inverted syphon.[3] The headwall to this syphon is shown in Figure 3-10. The poor condition of the ditch channel and the significant debris at the inlet to the inverted syphon are shown in figures Figure 3-9, Figure 3-10 and Figure 3-12 below.

A separate surface water sewer also outfalls to this open channel section (the catchment of this sewer includes Beryl Road and is described further in Section 4 below).

As part of this investigation a chamber was identified near the ditch in an area of overgrown scrub south of No. 18 Capel Road (see Figure 3-8 and Figure 3-12). The route from this chamber to the stream was determined through dye tracing. Although the outlet position could not be located, the dye was observed to emanate into the stream at the location indicated on Figure 3-12 and is taken as evidence of a positive connection to the ditch.

Figure 3-8 - Chamber rear of No. 18 Capel Road.

[3] An inverted siphon (or sag culvert) is a conduit that allows water to flow beneath an obstruction and 'uphill' again without mechanical pumping. The flow is carried under a pressure head. Culvert, screen and outfall manual, (CIRIA C786), CIRIA 2019.

The condition of this section of Enid Stream from MH5 in Capel Road to the chamber and on to the unidentified outfall to the ditch is not known. Water levels in this section were high during site visits. Surveys provided by Swansea Council were not successful in surveying the interior of these sections of pipe.

Figure 3-9 – Ditch channel upstream view from syphon inlet north of the Canal.

Figure 3-10 – Headwall/ inlet to inverted syphon south of the canal (dye trace visible).

The syphon conduit under the canal is understood to be an asset belonging to The Canal & River Trust. The size and condition of the conduit remains to be confirmed.

Figure 3-11 – Outlet from syphon south of the canal (dye trace visible).

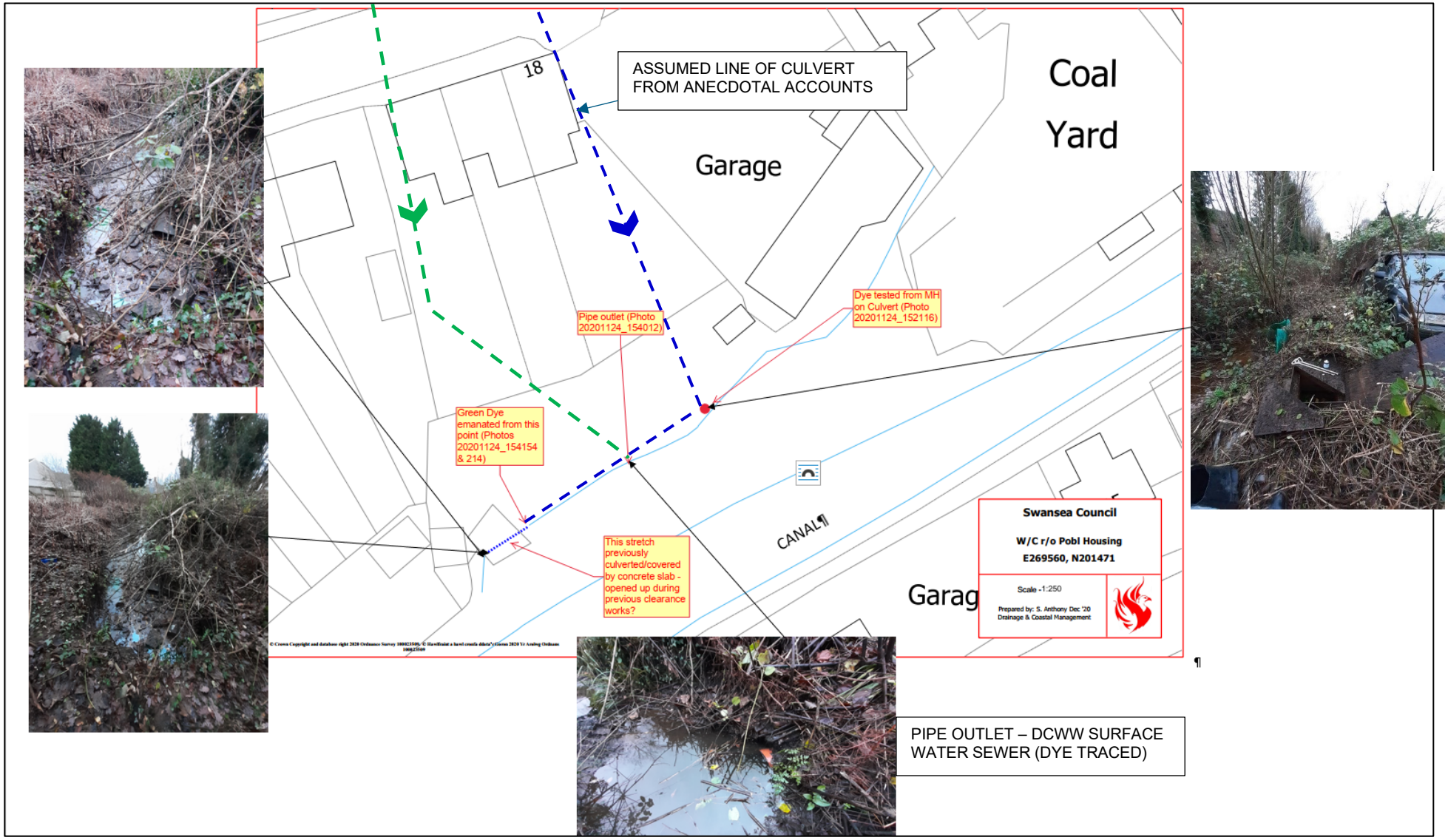

Figure 3-12 – General layout of sections of "Enid" Stream south of Capel Road to the Canal Syphon.

The stream is conveyed south from the canal syphon in approximately 18m of open channel to a culvert entrance at the B4603 Pontardawe Road (adjacent to an old building known locally as “the Men’s Shed”). This final culverted section runs south-west through the Mond works to an outfall to the Swansea Canal downstream of the lock.

It is believed that the land drainage system does not discharge directly to the canal in the vicinity of the syphon because the canal level is too high, and hence flow is directed through the syphon and to its eventual outfall to the canal downstream of the lock.

Figure 3-13 – B4603 Pontardawe Road (Men’s Shed) Screen – Culvert entrance to canal through Mond Works.

Figure 3-14 – Canal tow path at Mond Works – outlet from culvert approximately on bend.

4. Drainage System Details

This section describes the Public Sewer Networks and Highway Drainage Networks in the area as distinct from the Land Drainage Network described in the preceding sections.

4.1. Public Sewerage Network

The public sewerage system within this area of Clydach is owned and maintained by Dŵr Cymru Welsh Water (DCWW) and largely consists of combined sewers. These sewers take both foul and surface water flows to the treatment works.

However, a separate DCWW surface water sewer runs approximately north-to-south from Woodlands Avenue to outfall to the ditch feeding the inverted syphon under the Swansea Canal. DCWW's records show this to be a 150mm diameter surface water sewer indicated by the green line on Figure 4-1.[4] It crosses Beryl Road, picking up the road drainage, and continues south through the garden of No. 19. Although the record drawing indicates an outfall to the canal, dye testing has confirmed that it actually discharges to the ditch that runs parallel to the canal before syphoning underneath it (Figure 3-12 above).

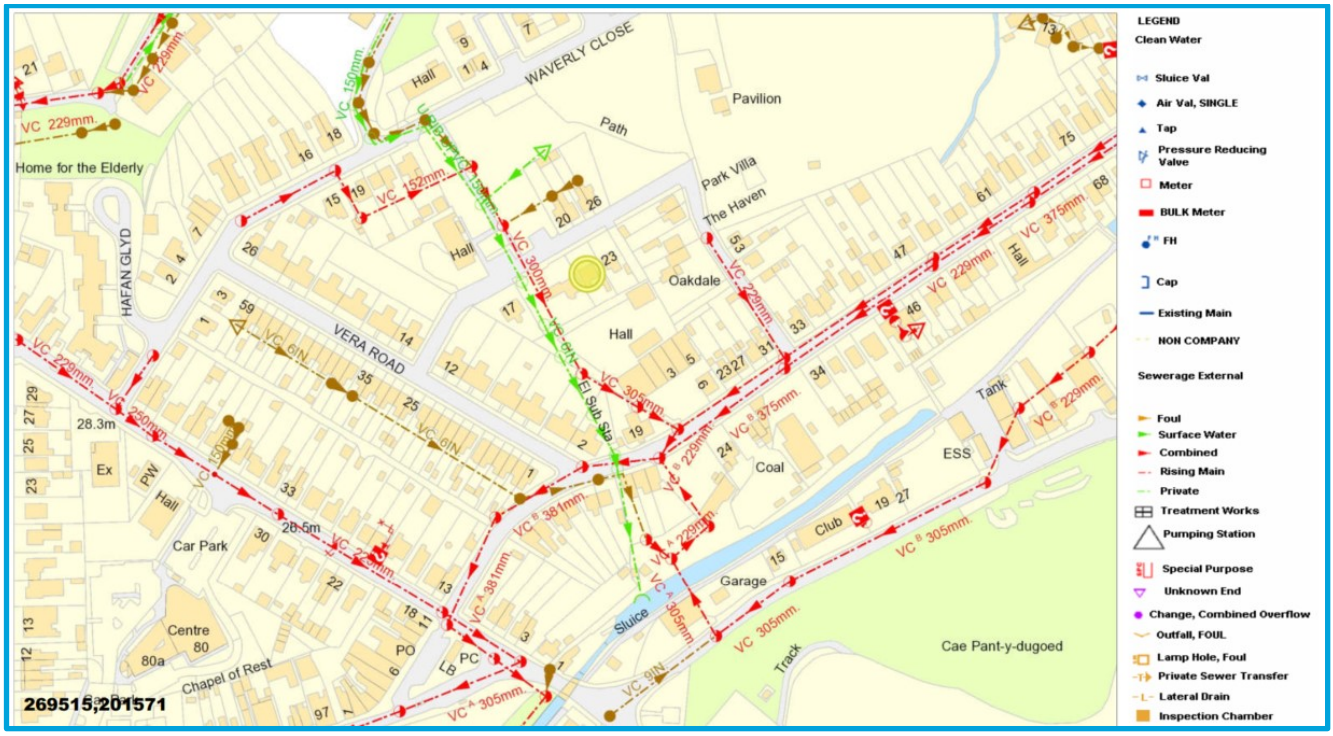

Figure 4-1 – Extract of DCWW's Sewerage Plan.

From enquires with residents and DCWW it is understood that in addition to property connections, a road gulley and informal pipe inlet outside No.19 Beryl Road also connect highway runoff into this DCWW surface water sewer. These features were observed during a visit to the site, and they are illustrated in Figure 4-2.

[4] There is some uncertainty based on variance between the sewer record plan and the cleansing report undertaken in November 2019 in response to flooding at No.19, which shows a 225mm/ 300mm diameter pipe.

Figure 4-2 – Photograph of gulley and inlet outside No.19 Beryl Road.

These non-standard connections would not normally be approved by DCWW, but it is understood from discussions with DCWW's representative that these connections were in place when DCWW became responsible for them, possibly at the privatisation of the water companies in 1989.

Condition of the Surface Water Sewer

DCWW has provided records of recent maintenance activities on its surface water sewerage assets.

A DCWW survey undertaken on 4th October 2019 indicates silt build-up of 25% in four access chambers from Capel Road to a chamber in the green communal space upstream of Beryl Road. This is a length of approximately 150m.

The line was jet cleansed and roots that had penetrated the sewer were cut on 14th November 2019. This maintenance followed a flooding incident reported to have caused internal flooding to No. 17 Beryl Road (Fire Service callout records to Beryl Road indicate flooding on 2nd November 2019). The survey report quotes a pipe diameter of 300mm which is at variance to the 150mm shown on the sewer drawings. Also, the report illustrates the remnants of what appears to be an old screen (Figure 4-3) within the system which may contribute to blockages. The conduit appears to be rubble masonry construction of poor condition in this location.

hoto: 1_1_21_A.jpg
2.87m, Finish node type, manhole reference number: SN69015509

Figure 4-3 – Condition of chamber in Drill Hall Grounds (ref SN69015509) 14th November 2019 (picture provided by DCWW).

The condition of the sewer upstream to Park Road and Woodlands Avenue, and downstream from Beryl Road to Capel Road and the outfall to the ditch and canal syphon, is unclear from the DCWW records. There is no further information available to confirm the size and material of this sewer down to and including its outfall/ connection to the canal syphon (see Figure 3-12, Section 3).

4.2. Highway Drainage Network

Beryl Road is not adopted as a public highway and consequently there are no Council owned drainage assets within the road. However, there are known assets within Park Road and Waverly Close which are understood to discharge at the headwall of the Enid Stream adjacent to the cricket pavilion.

Woodlands Avenue is of particular note. This road remains unadopted and the drainage gullies are raised relative to the unfinished road surface. Consequently, road runoff cannot enter the gullies and is instead directed as surface runoff down this steep road to the junction with Park Road. This surface runoff via Woodlands Avenue is reported by residents and Swansea Council drainage officers to contribute to ponding which occurs at a gulley outside No. 23 Park Road. The connectivity of this gulley and the local highway drainage on Park Road has, at the time of writing, not been confirmed. It is possible that this gulley is connected directly into the DCWW surface water sewer described in the preceding section.

The land drainage catchment which drains towards and is intercepted by Woodlands Avenue, in addition to the road runoff, will require further assessment to confirm the total runoff flows intercepted by the road and its connectivity. Reference to old maps show that this road is constructed on the site of railway sidings that stood on this site until the 1960s. Details of the drainage in the area are not known. The unadopted nature of the road serving housing development on Woodlands Avenue has only added to the uncertainty.

Runoff from Park Road contributes to overland flow paths and makes a significant contribution to the flooding at Beryl Road, as described in the following sections of this report. During a site visit on 18th December 2020, the slot drain serving the low-lying parking area on Park Road (refer to Figure 4-4) was observed to be completely silted up along the majority of its length. The connectivity of this drain with the main highway drainage has not been confirmed.

Figure 4-4 – Parking area on Park Road north of Beryl Road. Slot drain is located at the interface between the concrete and tarmac surfaces.

On Beryl Road itself, each of the four properties on the northern side has a single small gulley grating directly outside their boundaries. The discharge location is unclear but is assumed to be the DCWW surface water sewer. In addition to these property gullies, there are two additional large highway gullies (example shown in Figure 4-5) in the road with a connection to the DCWW surface water sewer.

Figure 4-5 - Gulley in Beryl Road

The highway drainage connections in Capel Road have not been investigated as part of this overall investigation. However, it is observed that the profile along this road falls from the Kingrosia Park area towards the low point at the Vera Road junction. Water draining from this highway will serve to exacerbate surface water flooding and this is reported to have occurred on 16th February 2020 (see agencies response, Section 7 below).

5. Background and Flooding History

5.1. Flood Risk

Reference to Natural Resources Wales' (NRW) online Flood Risk Assessment Wales (FRAW) map included in the site description (Figure 2-2) and the extract included in Figure 5-1 below, indicates that Beryl Road is anticipated to be at risk of flooding from surface water and small watercourses. It is not within an area affected by flooding from rivers, the sea or reservoirs.

The FRAW map (Figure 5-1) shows the flood risk to Beryl Road as 'high' which, based on the NRW definitions, means that each year the chance of flooding is estimated to be greater than 1 in 30 (3.3% Annual Exceedance Probability or AEP). It is noted that this map does not directly reflect the capacity of the piped drainage system.

The map extract indicates that during a flood of this annual probability, water is predicted to escape from the watercourse between Woodlands Avenue and Waverly Close, developing an overland flow path along the road and then flowing overland towards Beryl Road and further to the south. It is noted that the detail of the map is in error with respect to the point at which out of channel flow will originate. This reflects the digital terrain model on which the map is based, and it does not include the small stream channel marked by the blue line along the western boundary of Waverley Park. However, the map does illustrate that Beryl Road lies in the shallow valley formed by the surrounding landform, with the natural flow path for overland flows directed south towards Capel Road and the Canal, as commented in Sections 2.2 and 3 above.

It should be noted that the NRW flood maps are based on high-level assessments of flood risk. The maps are only available at small scale and do not represent the drainage infrastructure in the area. Therefore, they do not reflect the capacity of the surface water and highway drainage systems described in the preceding sections.

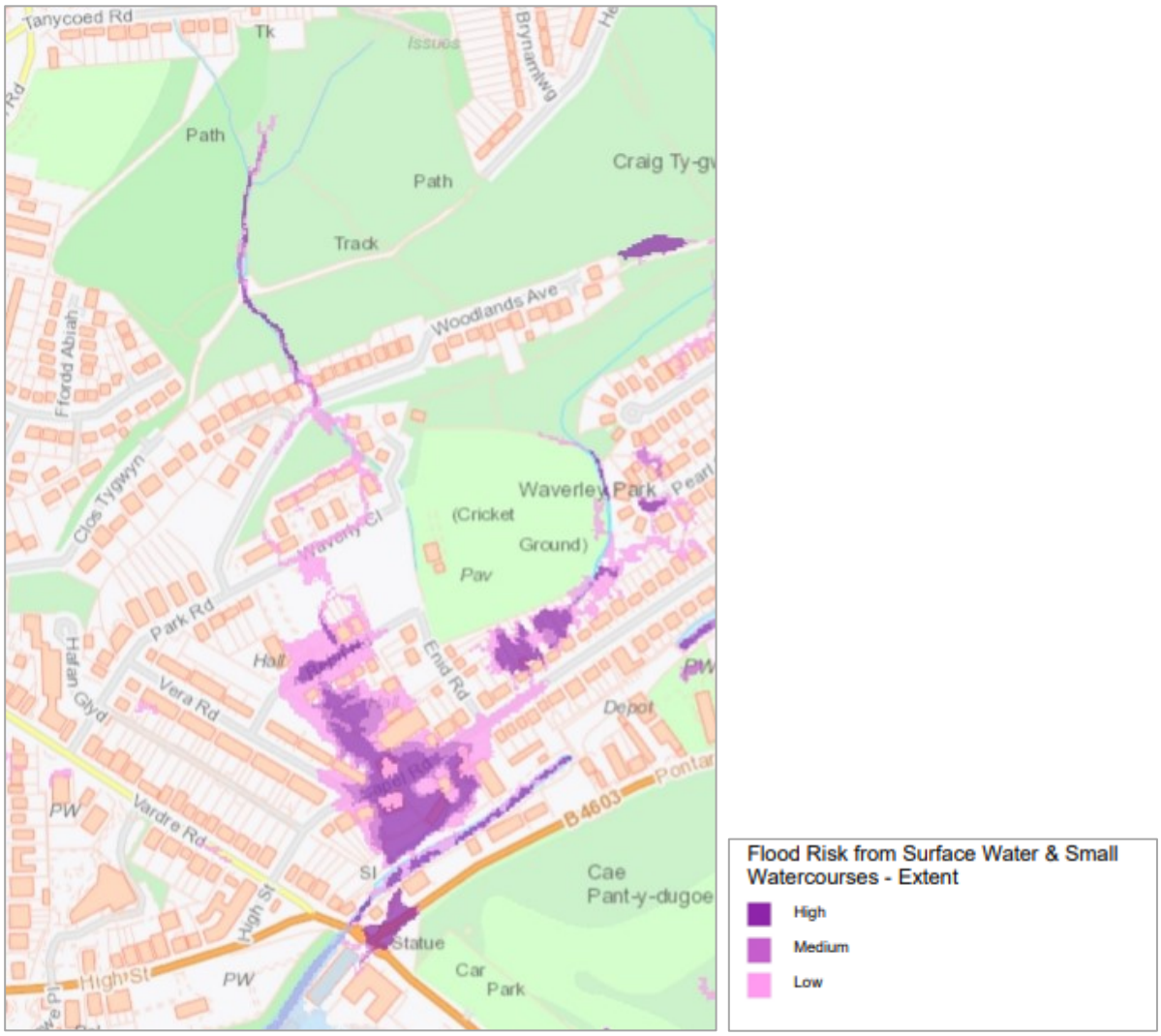

Figure 5-1 – Extract from NRW's FRAW map – Surface Water and Small Watercourses.

5.2. Previous and Subsequent Flooding incidents

This section provides the flood history in the local area as context to the Storm Dennis flooding incident of 16th February 2020. The main sources of information are Swansea Council as the lead local flood authority (LLFA) and the local residents. Cross reference of incidents has been made to MWWFRS and DCWW records. The specific details of the Storm Dennis incident are described in Section 6 below.

5.2.1. Lead Local Flood Authority Records

The LLFA has six recorded reports of historical flooding incidents at Beryl Road, including Storm Dennis.

In addition, there have been a number of recorded incidents of historical flooding of the highway in Park Road reported by the residents. Four incidents in the LLFA record are attributed to Park Road, but in light of residents' comments these are likely to have also impacted Beryl Road. The details of these incidents in the LLFA records are limited. Further information on flood events has been provided by residents as part of this investigation; such reports are gratefully received and will be added to the LLFA Flood Incident Record.

It is noted that the LLFA has only been recording flood events since 2011. It is therefore unlikely that the LLFA will be aware of flood events prior to this date.

Dates of incidents recorded by LLFA for Beryl Road are:

• 03 September 2016	• 25 October 2019
• 02 November 2019	• 16 February 2020
• 30 June 2020	• 20 January 2021 (from Park Road)

Dates recorded by LLFA for flooding incidents for Park Street are:

• 26 January 2014	• 15 November 2015
• 02 November 2019	• 20 January 2021

As part of this investigation, residents have provided records of incidents in and around Beryl Road through questionnaire responses and on-site interviews with Atkins' engineers (see Section 6.3 below). Their information on frequency and severity of flood events are described in the following sub-sections.

5.2.2. Residents Information

General comments on the frequency of incidents received include:

One resident who has lived in Beryl Road for 20 years reported that the road had flooded 5 or 6 times in the 28 months up to October 2020, requiring assistance from the fire service. Prior to this, there was a flood free period of approximately 10 years. The same resident reports that *"flooding of the road occurred many times when I first moved in but after the culverts were cleared it stopped"*. Other residents' comments broadly agreed with the records, as demonstrated by the following quotations:

> "*Road has flooded 6-8 times over the last 4 years."*
>
> "*We have lived at this address since 1974. First couple of years we had a few flooding incidents then it seemed to be ok until flooding started again about 2 years ago*"

An overall summary of the flooding to Beryl Road, compiled from the residents' responses and interviews is presented Table 5-1 below.

Table 5-1 – Summary of flood events reported by Beryl Road Residents in Questionnaire Reponses and on-site interviews.

Reported event date	Impact – areas flooded
November 1997	Extensive flooding – no details
18 July 2019	Garden of No. 19
08 August 2019	Garden of No. 19
09 August 2019	Road and Garden of No. 19. Fire Service pumped out.
09 September 2019	Garden of No. 19
24 September 2019	Road partially flooded and Garden of No. 19
28 September 2019	Extensive flooding of road, water within 1" of No. 20. Garden of No. 19
25 October 2019	Road flooded. Ponding from DCWW SW sewer
02 November 2019	Garden of No. 19
02 November 2019	Internal flooding to No. 17 from road
16 February 2020 (Storm Dennis)	Severe flooding of road, internal flooding to 5 properties and garden of another property.
25 August 2020	Severe flooding of road. Water level almost achieved the threshold of No. 20. Fire service pumped out. No. 17 protected by individual property protection installed following Nov 2019 event.

In addition to Storm Dennis, other notable/ severe events affecting Beryl Road for which information has been gathered are November 1997, 2nd November 2019 and 25th August 2020. These are described in summary as follows.

November 1997

Residents reported that this was the last time flows in the Enid Stream had caused out of bank flow into Beryl Road prior to the arrival of Storm Dennis. Residents' recollections were that this was associated with fly tipping blocking the channel and culvert entrance.

2nd November 2019

During this event extensive flooding affected Beryl Road and caused internal flooding to No.17. Although no photographic evidence is available, interviews with residents indicates that the Enid Stream did not contribute to the flooding. It is therefore inferred that water from the DCWW surface water sewer and overland flows from Park Road were the sources of the flood water. Analysis of rainfall records indicates that this event had a return period of slightly more than 3 years (33% AEP) with a storm duration of 4 hours.

Jetting of the surface water sewer by DCWW on 14th November 2019 followed this event (refer to Section 4).

25th August 2020

Extensive flooding affected Beryl Road during this event. Although water levels in the Enid Stream rose to the top of the cricket pavilion culvert inlet (Figure 5-3), no overland flow developed towards Beryl Road from this source. Water reportedly came up through the covers on the DCWW surface water sewer and ponded in the road. Overland flow from Park Road was also reported. Analysis of rainfall at NRW's nearby Trebanos rain gauge indicates that this was a 7 years return period event with 4 hours storm duration. The extent of flooding is shown by the following photographs provided by two of the residents.

Figure 5-2 **– Beryl Road – 25th August 2020, 06:02h.**

Figure 5-3 **– Culvert Inlet Cricket Pavilion, 25th August 2020, 06:51h.**

Figure 5-4 – View from No. 20 Beryl Road on 25th August 2020.

Figure 5-5 – Water 'bubbling-up' from surface water cover at 06:45hrs (video still).

Summary frequency of flooding

The reports of flooding incidents recorded by Swansea Council and recalled by residents indicate that flooding of Beryl Road was a rare occurrence until approximately 2 to 3 years ago.

The overall impression is that flooding to the road and the garden of No.19 has occurred with some regularity over the last 2 to 3 years. Anecdotal evidence from residents suggests that flooding has continued over the winter of 2020, associated it appears with surcharging from the DCWW surface water sewer and the overland flow from Park Road. Residents regularly move cars from the road when water starts to pond. The exact frequency is unclear as no records of such precautionary actions has been kept.

The investigation has revealed that the residents continue to combat overland flows from Park Road, which occur with some regularity. The most recently reported incident, which arrived after substantial completion of this investigation, was Storm Christoph in January 2021.

Property flooding has occurred on two occasions since November 2019 with one near miss in August 2020.

6. Assessment of the Flood Event of 16th February 2020

6.1. Summary of Flood Event – 15th to 16th February 2020

Storm Dennis was the fourth named storm of the 2019/ 2020 winter season and it brought heavy and persistent rain across much of the UK. Met Office data for this storm indicates that Clydach lies in an area where the total rainfall was between 25 and 50mm. This is the equivalent of 25 to 50% of the average rainfall experienced each year in February in the period 1981-2010. The UK national rainfall totals are presented in Figure 6-1.

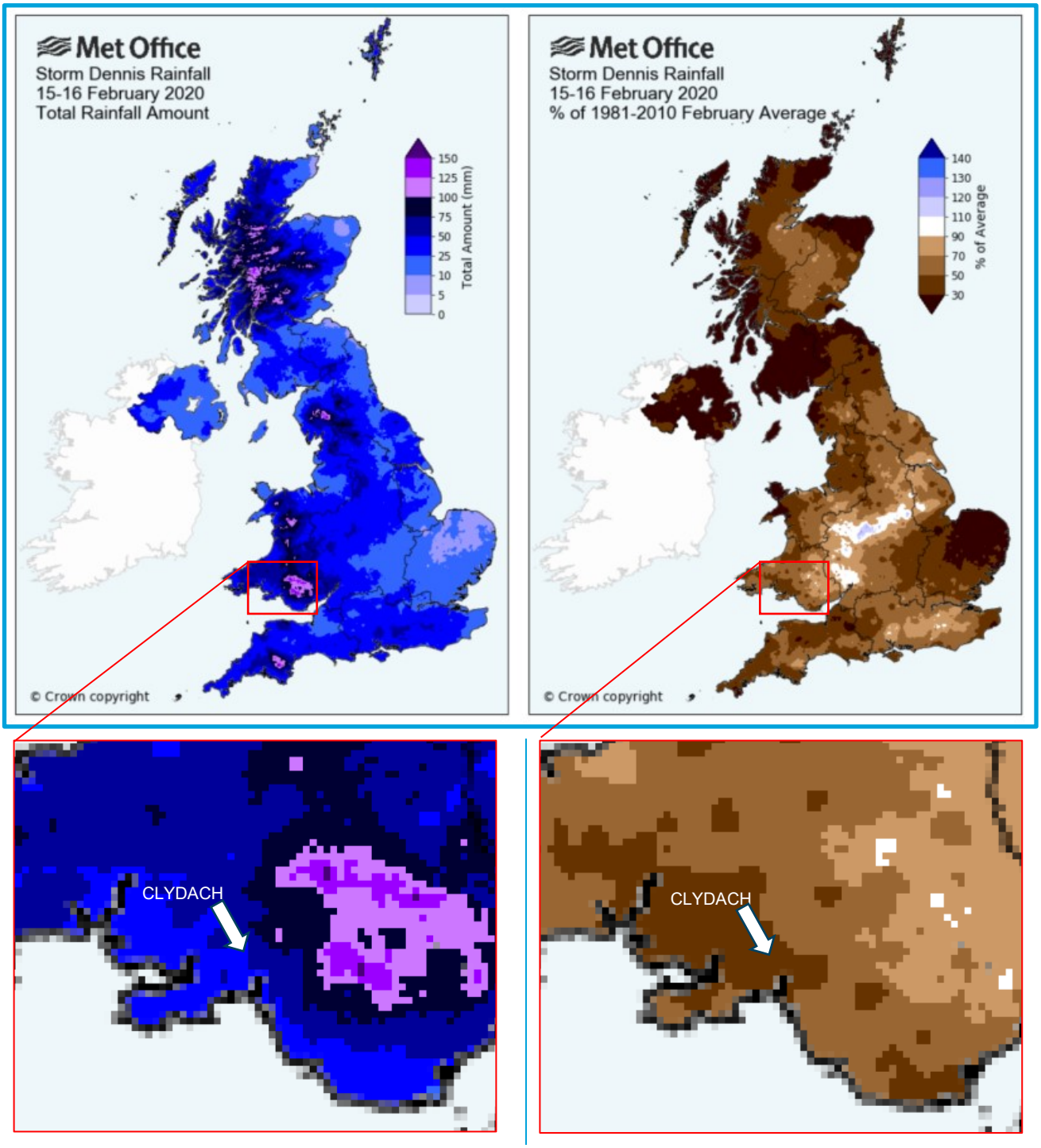

Figure 6-1 – Met Office rainfall data for Storm Dennis.

6.2. Rainfall Analysis

Analysis of rainfall gauge data has been carried out specifically for this flooding investigation to understand the severity and rarity of the storm affecting the catchment in Clydach. The distribution of rain gauges operated by NRW was assessed and rainfall gauge data was obtained for three rain gauges within the local region. The nearest of these gauges is at Trebanos, located 1.7km from Beryl Road and this gauge has a good quality data record. The other two gauges are farther away at Birchgrove 2.9km south-east and Spite 3.3km north-west of Clydach, respectively and each of these has some "suspect quality" data flags for the data records in the periods of interest. The final estimation of rainfall probability during Storm Dennis is therefore based on the Trebanos Rain Gauge due to its proximity to the site of interest and the good quality of the rainfall record. As a sense check the rainfall records for the other two gauges have been used for comparative purposes

Analysis of the gauge data shows that rainfall was heaviest between 00:00 and 02:00hrs on 16th February (see Figure 6-2 below). This corresponds with call out records from Swansea Council Highways emergency response team (Section 7 below).

Rainfall can be defined in terms of a return period or annual probability of occurrence in any given year (AEP[5]) as defined in the industry standard Flood Estimation Handbook methodology. Note that return periods are calculated based on the amount of rain falling over a duration of time. Therefore, the return period figure will vary depending on the assumed duration of the storm.

Analysis of the rainfall at the Trebanos gauge, which peaked in intensity in the early hours of 16th February 2020, produces an estimated return period of 8 years (12.5% AEP) for 24 hours storm duration in the Beryl Road catchment.

6.2.1. Interpretation of the Rainfall Analysis

The following table presents the assessed rarity of rainfall between October 2019 and August 2020.

The road is reported to have flooded on at least four occasions in this period (see Section 5.2). Road flooding in October 2019 coincides with rainfall estimated to have a return period of only slightly greater than 1 year event (70% AEP). Property flooding on 2nd November 2019 coincides with rainfall of a little over 3 years return period (30% AEP), which is not considered particularly rare in terms of rainfall. The rainfall during Storm Dennis itself only has an assessed return period of slightly below 8 years (13% AEP).

In view of the relatively high probability of such rainfall occurring, it is suggested that under-capacity in the drainage systems, possibly due to blockages, is contributing to the frequency of flooding reported in the area.

Table 6-1 – Rainfall – assessed return periods at Trebanos Rain Gauge October 2019 to August 2020

	Trebanos		
Rainfall event	Highest return period	Storm duration	Maximum depth (mm)
Mid Oct 19	1.4	12 hours	35.2
Early Nov 19	3.3	4 hours	28.8
Early Feb 20 – Storm Ciara	Common place **	N/A	Common place **
Mid Feb 20* - Storm Dennis	7.9	24 hours	74.0
25 Aug 20	7.3	4 hours	36mm

*Storm Dennis

** All rainfall highest return period is 1.0, therefore max. depth has not been reported as this is a common place event

[5] Annual Exceedance Probability (AEP) refers to the probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which may be calculated to have a 1% or 1 in 100 chance of occurring in any one year, is described as 1% AEP.

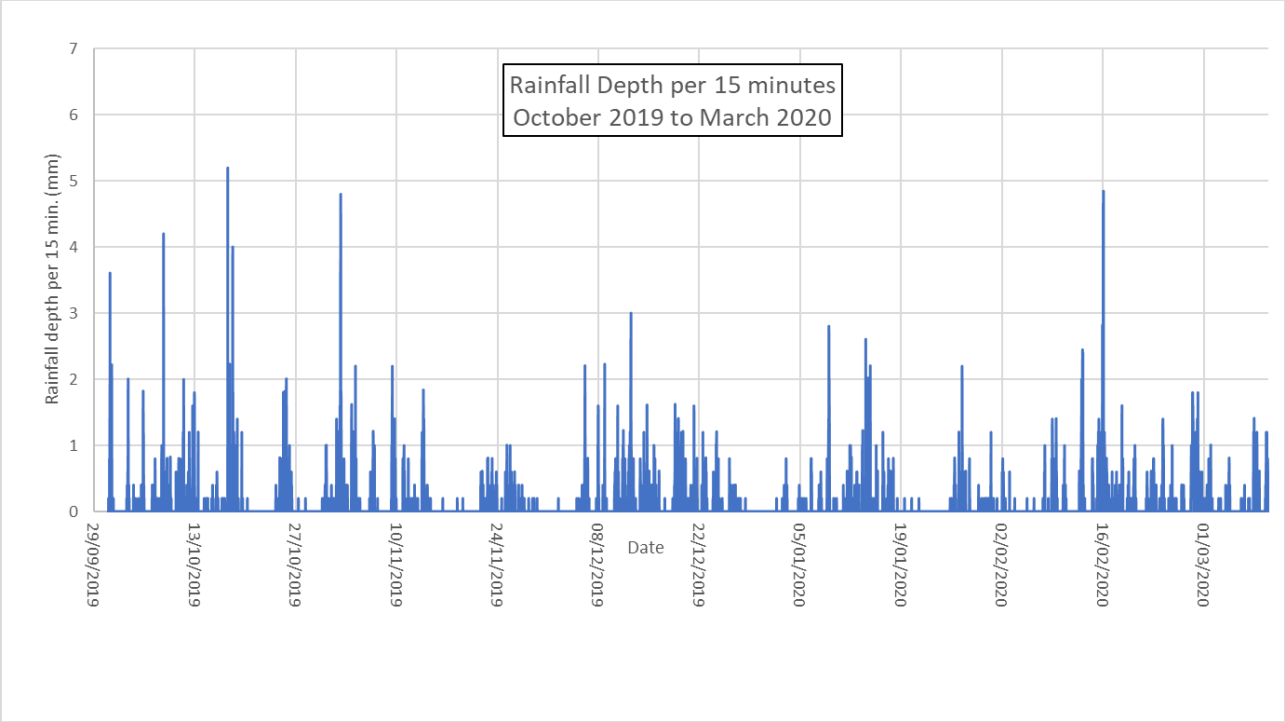

Figure 6-2 – Rainfall NRW Rain gauge at Trebanos. Storm Dennis in context September 2019 to April 2020.

There is potential that Storm Ciara which occurred on 8th to 9th February, whilst considered commonplace in terms of probability in Clydach, was sufficiently intense to fully saturate the catchment. Rainfall during Storm Dennis was possibly then unable to infiltrate into the ground and so resulted in a higher runoff rate than would otherwise be expected for a storm event of 8 years return period preceded by dry weather. conditions.

In summary, the short duration, highest intensity rainfall during Storm Dennis, was not especially unusual.

6.3. Flood Event Information – Residents' Experiences and Information

Questionnaire Survey

A questionnaire survey was sent out to all residents in Beryl Road who may have been impacted by or have knowledge of the flood event. This was conducted by Atkins on behalf of Swansea Council as the LLFA and sent to residents on 26th October 2020. The purpose of the questionnaire is to confirm the extent of the flood event, the number of properties impacted, and to gain an indication of the mechanisms that caused flooding to property or critical infrastructure.

The questionnaire was initially sent to residents who had contacted the LLFA with their concerns and subsequently further disseminated by these initial contacts to their neighbours.

The majority of the responses were completed in an online version of the questionnaire, but with one hard copy also provided to a single interested party. A copy of the questionnaire is appended to this report.

In total, nine responses to the questionnaire were received. This includes a property on Park Road affected by the same source of flooding, and which had not been identified prior to the investigation.

Direct extracts from the questionnaires are italicised where used in the following sections.

Site visit

An initial site and catchment familiarisation visit was undertaken by an Atkins engineer with LLFA drainage engineers on 24th August 2020.

Once responses to the questionnaire had been received, a further site visit was arranged for 11th November 2020 for Atkins engineers to follow-up with residents. Properties bordering Capel Road were also visited to gather information on the severity of flooding on this key overland flow path from Beryl Road towards the surface water syphon under the Swansea Canal.

In addition to the attention given specifically to Storm Dennis, information was gathered on other incidents of flooding to set the investigation in context. Observations and further relevant details provided by residents from the questionnaires and during the investigation have been very helpful in correctly understanding the sequence of events during Storm Dennis and the assessment of the most likely mechanisms and causes of flooding.

6.4. Flood Impact

Following heavy rainfall throughout the 15th February, residents of Beryl Road noticed ponding at gullies along the road. Their feedback suggests that this is not unusual during times of sustained heavy rainfall and the residents are accustomed to moving their personal vehicles to higher ground to ensure they remain accessible. However, in the early hours of the 16th February the water level on the road was observed to have risen sufficiently to begin entering properties.

The main impact of the flood event was the inundation of Beryl Road itself and subsequent internal flooding of five properties along the road; the properties that suffered internal flooding were Nos.17, 20, 22, 24 and 26. The internal water depth observed by residents varies due to several factors, such as time of discovery and variations in individual property threshold levels, but they generally range from 5cm to 15cm (reported as 2 to 6 inches). In addition to these properties, the gardens of Nos.19, 21 and 23 were also flooded with depths ranging from 10cm to 60cm (4 inches to 2 feet). The peak of the flooding occurred during the early hours of the 16th February when many residents were asleep; consequently, there is no photographic evidence of the peak flood levels. However, Figure 6-3 shows the state of the road once residents awoke.

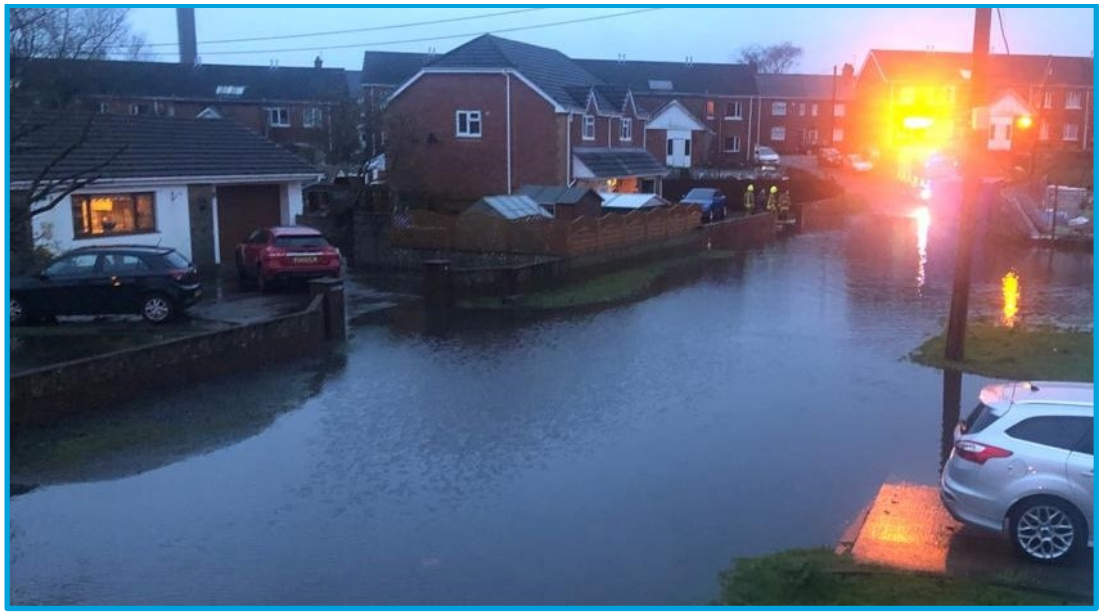

Figure 6-3 – Flooding of Beryl Road, 16th February, after the peak.

Away from the main area of flooding on Beryl Road, additional areas were also impacted including the garage of No.23 Park Road, the yard area behind the workshops on Capel Road, and the basement of the Drill Hall at this location (anecdotal evidence). Internal flooding is also understood to have occurred at No. 18 Capel Road, which is under the ownership of Pobl Group, where four ground floor flats were flooded.

6.5. Flooding Mechanism

A description of the event from one resident in their response to the questionnaire sets the scene:

"Drains were backing up on Park Road causing overland flood water to flow to Beryl Road. The culvert at the rear of the cricket club over-flowed and flowed to Beryl Road. Water was rising from the drains onto the road and garden of 19 Beryl Road and outside 17 Beryl Road....Several drain covers had lifted around Beryl Road causing uncontrollable water to enter properties. The drain outside No. 17 started to fail at 1am then water levels rose from 1am to 4am when the water actually breached my property. I had 25 sandbags across my driveway, 15 across my garage but still failed to keep the water out. I actively manoeuvred sandbags during the flooding to try and minimise damage but failed."

6.6. Sequence of events

Due to the timing of the flood event commencing after dark late on 15th February there is some uncertainty in the exact sequencing leading up to the internal flooding. However, the following sequence has been deduced from the compiled information:

- Initial flooding on Beryl Road appears to have resulted from the gullies being unable to deal with surface runoff and therefore causing ponding at the low point outside No. 19 as well as in the localised depressions in the unmade road surface;
- Uphill from Beryl Road, the area around the highway gulley outside No. 23 Park Road (location shown Figure 6-4) became inundated. Water levels here rose to overtop and spill over the kerb, resulting in an overland flow path developing across the green amenity area along the boundary with this property. This overland flow path was significant. Although no photos are available, this same flow path developed following heavy rain on 25th August 2020. The remnants of this path are shown in Figure 6-5.

Figure 6-4 – Ponding at gulley at No. 23 Park Road (left) and view towards Nos. 19 and 17 Beryl Road (right).

Figure 6-5 – Views of overland flow path looking upslope from Beryl Road towards Park Street.

- Water flooding from the top of the chamber on the DCWW surface water sewer in the green amenity area, between Park Road and Beryl Road (Figure 5-5, section 5.2 above), adding to overland flow onto Beryl Road.
- Overland flow extends to the footpath running between Park Road and Beryl Road.
- Water from the parking area at the low point of Park Road also began to overspill and flow across the green amenity area towards Beryl Road.
- Residents reported that the next stage was the observation of water 'bubbling up' from the gullies on Beryl Road. This suggests that water was backing-up from the surface water drains. This would be consistent with the head of water upstream within the DCWW sewer causing backflow and driving water out of the gullies when carry on flows in this sewer are restricted downstream of Beryl Road.
- The area between No. 19 Beryl Road and the Capel Road workshops to the south became flooded.
- Capel Road was flooded causing internal flooding to four ground floor flats at Nos. 14 to 18 Capel Road and extensive flooding to the GMD Body Repairs garage. The source of flooding to the latter is unclear because a ditch runs to the south of the garage, taking water from an unknown catchment, and this could have been the source of the flooding at that location.
- At some time during the night of 15th to 16th February the Enid Stream inlet, near the cricket club pavilion, was overtopped. Overland flow from the green amenity area adjacent to the stream began to weir over the dwarf boundary wall (Figure 6-6) at the north-eastern end of Beryl Road.
- Flooding to all four Victorian terrace properties comprising Nos. 20, 22, 24 and 26 Beryl Road report water coming up through their concrete floors. Air bricks to at least some of these properties had previously been blocked up. One resident reported water coming through "vents" and doors. It is unclear if air bricks contributed to water entering any of the other properties in this row.

Figure 6-6 – Water began to weir over this wall from the green amenity area east of No. 24 Beryl Road.

6.7. Causative Factors Affecting Flooding Identified by Residents

When discussing the Storm Dennis event with residents during the course of the investigation, a number of ideas were received on the causes of flooding at Beryl Road based on their local knowledge.

These are summarised here for reference in consideration of the possible causes of the flooding.

6.7.1. The Influence of the Canal on Flooding at Beryl Road

The water level in the canal has been observed to vary. Some residents have postulated a correlation between high levels in the canal and flood levels at Beryl Road. One particular example cited was an event on 25th August 2020 when Beryl Road was flooded, but which did not result in any internal property flooding. A dramatic drop in water levels in Beryl Road is attributed to sluices being operated by the CRT on that day. It is noted that the canal water level is normally above the surrounding ground level east of the lock at the B4291 Ynys Penllwch Road.

It seems unlikely that there is hydraulic connectivity between the Enid Stream watercourse and the canal at this location, and to date it has not been proven.

6.7.2. The Effect of Levels in the Open Channel Downstream of the Syphon to the Screen at Pontardawe Road

A resident has made the observation that during rainfall on 13th December 2020 clearance of debris from the screen at the B4603 Pontardawe Road (the "Men's Shed") resulted in a drop in water levels of approximately 250 to 300mm in the open channel downstream of the canal. This was reported to correlate with an observed drop in water levels at the cricket pavilion culvert entrance (OS NGR 269576, 201705) of a similar magnitude. This evidence may be useful for a subsequent hydraulic assessment of the Enid Stream to its canal outfall downstream of the Mond works culvert.

Figure 6-7 – B4603 Pontardawe Road Screen illustrating reduction in water levels following screen clearance on 13th December 2020.

7. Actions Undertaken by Risk Management Authorities

The following sections set out the actions that were completed or are in progress in the period leading up to, during and following Storm Dennis to January 2021.

7.1. Swansea Council as the Lead Local Flood Authority

The LLFA function in Swansea is fulfilled by the Drainage & Coastal Management team and the Highways department.

The Council has an operational procedure designed to minimise the risk of culvert blockage at culvert entrance screens. This includes carrying out routine maintenance to ensure screens remain clear of debris, and pre-emptive cleaning in response to weather forecasts prior to the arrival of heavy rain.

Four culverts on the Enid Stream in the area of Beryl Road are on the Council's "red list" of critical culvert screens. These are regularly inspected and cleared if there are any signs of blockage prior to forecast heavy rainfall. The "red list" screens include three screens between Waverley Park and the cricket pavilion screen, plus the screen on this same watercourse south of the canal at B4603 Pontardawe Road (adjacent to the "Men's Shed" (Figure 3-13, Section 3). The operational management of watercourses is carried out by the

Highways Department within the Council. The operational actions prior to and following Storm Dennis are described in the following Highways Authority section.

1. The Council as LLFA has produced a Flood Risk Management Plan which is reviewed periodically.
2. Following Storm Dennis, the LLFA has carried out an investigation using their powers under Section 19 of the FWMA 2010 (i.e. commissioned this report).
3. The extent of the flooding was confirmed through resident questionnaires and consultants were engaged to carry out a technical assessment of the area.
4. Draft Section 19 flood investigation report to be published to RMAs and residents of Beryl Road.
5. Investigations of the Enid Steam, the culvert connection from Capel Road and the open channel section to the canal syphon are ongoing.

7.2. Swansea Council as the Highway Authority

The following description of attendance at Beryl Road by the Council's maintenance teams during the event is derived from the Council's incident logging system.

1. The Council's Highways Maintenance out of hours team received multiple calls on the 15th to 16th February (once an area has been logged any further calls are not individually logged due to call volumes, and the number of calls received is therefore not recorded).
2. When Storm Dennis was forecast, all "red list" and other priority list watercourses including those in Waverly Park adjacent to Beryl Road were inspected and cleared of debris prior to the weekend of the 15th to 16th February. In addition to the standard two-man highway crew, three additional maintenance crews were mobilised. The "red list" watercourses were checked and cleared between 11.00 to 15:00hrs on 15th February and cleared again that evening between 19:00 to 23:30hrs.
3. The first call received by the Council in this area was from Capel Road at 01:00hrs on 16th February citing blocked culverts. These were checked and it was found that water was flooding from surcharged surface water manholes on Capel Road. The road was then closed for public safety.
4. The first call reported from Beryl Road was received at 01:35hrs on 16th February. The maintenance crews were already on site checking and clearing the watercourse. Gullies in Park Road were overwhelmed by water volumes resulting in water running down from Park Road onto Beryl Road adjacent to properties.
5. A second maintenance crew attended with sandbags (specific properties visited are not recorded). A crew attended again on Sunday. Significant material had been washed from the park into the gullies. These were cleaned and jetted (it is not recorded which gullies were jetted). The watercourses were checked and cleared again on the morning of 16th February.

Following Storm Dennis, the following measures have been undertaken or are ongoing.

6. Preliminarily review of the operation of the highway drainage in the area, notably Park Road.
7. Cleansing of the adopted highway drains in Park Road is an ongoing activity.
8. Connectivity Investigation is planned to determine causes of ongoing problem of surcharging of the adopted highway drainage in Park Road during heavy rainfall.

7.3. Dŵr Cymru Welsh Water

1. DCWW attended Beryl Road on 4th October 2019, surveyed the surface water sewer and noted siltation along the line from upstream of Beryl Road down to Capel Road.
1. DCWW attended Beryl Road again on 9th November 2019 following the flood event of 2nd November 2019. The staff on site identified sedimentation build up and root ingress into the sewer as contributing to the flooding.
2. Maintenance clearance of roots was carried out 14th November 2019.

If successful, the cleansing activity would have increased the available capacity in the sewers. Available survey reports indicate that only part of the line between Beryl Road and Capel Road was camera surveyed. No survey from Capel Road to the outfall to the canal syphon has been carried out. Hence, there remains the potential for residual blockages, sedimentation and root ingress along the un-surveyed sections of the sewers. If present, these would reduce the capacity of the sewers carrying surface water away from Beryl Road.

3. DCWW attended on 16th February to investigate the reported incident at Beryl Road. Although it is noted on the record that four houses had suffered internal flooding, it is unclear whether this included flooding from DCWW's foul or surface water sewers.
4. Reference is made in the DCWW records to the culvert at the end of the lane having been blocked and causing the pipe to back-up. This is assumed to be a reference to the overland flow path from the Enid Stream into Beryl Road.

5. Photographs were taken internally to properties at 20 to 26 Beryl Road and of the screen at the cricket pavilion culvert on the Enid Stream.

From CCTV survey information provided by DCWW there remains some uncertainty as to the connectivity of surface water to its sewers. There is some discrepancy between the sewer plans and the surveys with respect to the chamber numbers and pipe dimensions referenced.

Flood events affecting Beryl Road suggest surface water is overwhelming either or both the surface water and combined sewers. Both of the sewers run north-to-south from the green amenity area upslope of Beryl Road to Capel Road.

8. Emergency Services Response

8.1. Mid and West Wales (MWW) Fire and Rescue Service

1. The MWW Fire and Rescue Service attended on the 16th February following contact with three of the residents of Beryl Road.
2. Residents reported that pumping from Beryl Road appeared to have little effect on water levels. When the fire tender was moved to pump water from Capel Road the water levels in Beryl Road were observed to drop more dramatically.

It is noted that the drop in levels occurred after the peak of the storm had passed, but the precise time is not known.

"*Fire service attended approximately 6am and began pumping Beryl Road this was unsuccessful as they were only pumping onto Capel Road which was also flooded, when they moved and pumped Capel Road, Beryl Road water levels began to subside. Approximate levels in my back garden were 500mm.*"

9. Residents' Experience of Responses to the Incident

Local residents have provided a large quantity of information by answering the flood investigation questionnaire and engaging with staff representing Swansea Council and Atkins.

The following selected quotations reflect the broad range of responses received from the residents in relation to the incident itself, the degree of preparedness for dealing with flooding, and the actions taken by RMAs during and immediately after the flood event. The responses received will be shared with the RMAs and other organisations consulted as a means of reflecting on public perception of their activities.

"Sandbags were not available from council in February, so I sourced my own and bought sand. Fire service advise that they will not attend flood incident until the flood breaches your property which is crazy as that's what we try and avoid".

"Canal and river trust haven't been overly helpful with dealing with my concerns over the link between beryl road floods and the high water level of the canal. As I am affected badly by flooding I do personally feel all authorities can do more but that said I do appreciate financial and time restrictions. I hope that this investigation will be the start of major remedial works and resolve the problem."

"The Fire Brigade came out and the Water Board. The council provided sandbags which helped a little."

"We are disappointed with the response of the Council as they have been aware of flooding in this area for some considerable time and despite making previous complaints we have not been kept up-to-date in relation to our complaint. The Fire Service were also in attendance and assisted in pumping the water out of the road. Other than the Fire Service attending no action was taken to help us. I feel that the Council has let us down as they have been aware of the flooding in the area for some considerable time and as far as I'm aware no actions have been taken previously."

"Think they did the best they could in circumstances."

"Fire service was fantastic. Not aware of any other services in attendance."

"I only remember the fire service attending."

"Terrible response, I believe the only persons who came were local council workers with more sand bags after the event, no persons contacted us directly or called to property to help or offer support. Had no responses to emails or calls made to local councillors or Swansea council. I do believe relevant persons should have visited the individual flooded properties that had flooded to offer support and try to get to the bottom of the flood incident."

"Fire brigade have been out previously, but on this occasion they were called away and therefore the level continued to raise. There were numerous floods along Capel road too. Welsh water arrived the following morning to see if it was a sewer problem. They had a look in the sewage drain and said there would have been toilet paper etc if the water had come up from the drain."

10. Summary and Discussion of Findings

10.1. Key Findings

The investigation of the flooding at Beryl Road associated with Storm Dennis on 16th February 2020 has produced the following key findings:

1. The local catchment comprises a steep upper section and a relatively shallow section below the break in slope at Park Road. The area between Beryl Road and Swansea Canal is very flat.
2. The NRW flood map predicts a high annual probability of flooding at Beryl Road, i.e. each year, this area has a chance of flooding predicted to be greater than 1 in 30 (3.33% AEP[6]).
3. Flooding to the road itself appears to have become a relatively frequent occurrence particularly in recent years after a long period of more than ten years of little or no incidents. Residents report that flooding has become more frequent in the last two to three years up to January 2021 (the period end of this current investigation).
4. Apart from an incident in November 1997 associated with fly tipping on the Enid Stream, the only known flood event, during which the Enid Stream overspilled its banks is that of Storm Dennis. A subsequent flooding incident on Beryl Road of 25 August 2020 came close to entering property, but the Enid Stream remained in bank and therefore did not contribute to the incident.
5. Prior to Storm Dennis flooding on the 2nd November 2019 caused internal flooding to one property.
6. Analysis of rainfall records reveals that the historical flood events at Beryl Road from September 2019 up to Storm Dennis had low return periods, i.e. just over 1 year (71% AEP) to just over 3 years (30%) for October 2019 and 2nd November 2019, respectively.
7. Many of the reported lower severity flooding incidents to the road appear to have occurred during rainfall which is considered to have been of commonplace occurrence.
8. The analysis of Storm Dennis rainfall shows that the precipitation represented approximately 30 to 50% of the average February rainfall. The storm is estimated to have had a return period of just less than 8 years (12.5% AEP).
9. The subsequent storm of 25th August 2020 is estimated to have had 7 years return period (14% AEP).
10. The rainfall record indicates that Storm Dennis was preceded by Storm Ciara on 8th and 9th February, which meant that surface water runoff during Storm Dennis may have been exacerbated by rain falling on a catchment that was already saturated.
11. The flooding mechanism is complex:
    a. Flooding is initiated by water ponding on the surface because water is unable to enter the road gullies and the informal inlet to the surface water sewer outside No.19. This is followed closely by uncontrolled surface water runoff from Woodlands Avenue and Park Road flowing over the green amenity area immediately north of Beryl Road. Surface water also escapes from the DCWW manhole in this area upstream of Beryl Road and follows an overland flow path.
    b. The overland flow path from these sources is parallel to the footpath on the western side of property No. 20 Beryl Road.
    c. There is a low-spot on Beryl Road where excess surface water runoff begins to collect. As the basin fills with water, flooding spreads from the road into private driveways (16th February 2020 and 25th August 2020). In the most severe events, water floods into the properties themselves (16th February 2020 and 2nd November 2019, with a near miss on 25th August 2020).
    d. During Storm Dennis the intense rainfall caused the Enid Stream to overflow its banks into the amenity area to the eastern side of property No. 26 Beryl Road. Flood water formed an overland flow path via the footpath onto Beryl Road and subsequently also overtopped the low wall delineating the southern boundary of the amenity area.
    e. The rate of inundation appears to have increased rapidly once the Enid Stream overspilled its banks. Property owners reported flood water rising-up through the floor of their properties.
    f. During Storm Dennis there were five residential properties flooded at Beryl Road and at nearby Capel Road four flats and the GMD Body Repairs garage were also flooded.
12. The road drainage at Beryl Road, which is a private road, is not fully understood. There are several gullies believed to connect to the DCWW surface water sewer. However, the drainage provision is inadequate to

[6] Annual Exceedance Probability (AEP) refers to the probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which may be calculated to have a 1% chance to occur in any one year, is described as 1% AEP.

deal with the volume of water arriving at Beryl Road. There is a similar problem with surface water arriving at Park Road, where the drainage provision also appears to be inadequate.

13. Local property owners are proactive in responding to flood risk and attempting to prevent flooding of their homes.
14. There is a perception amongst local residents that the flooding problem may be related to the management of water levels in the canal and the trash screen adjacent to the "Men's Shed" at Pontardawe Road. The investigation has shown that the surface water and land drainage systems are separate from the canal. It is possible that the syphon under the canal and the trash screen at the "Men's Shed" have an influence on water levels at Beryl Road, and this could be a subject of further technical work.

10.2. Reponses of the Risk Management Authorities and Emergency Services

15. The risk management authorities, Swansea Council as both LLFA and Highways Authority, together with DCWW have taken positive action before, during and after Storm Dennis. The collated actions have been recorded as part of this investigation.
16. The available records indicate that the local trash screens on the Enid Stream were checked prior to the arrival of Storm Dennis.
17. Recent maintenance work was undertaken to the surface water sewer by DCWW following the flooding incident in November 2019.
18. MWWFRS attended during the event to assist residents. Efforts to pump water directly from Beryl Road were largely ineffectual in reducing levels. Pumping efforts were relocated to Capel Road, downstream of Beryl Road which coincided with levels dropping in Beryl Road.

10.3. Discussion

The reports of flooding incidents recorded by Swansea Council and recalled by residents indicates that flooding to the road and gardens of Beryl Road was a rare occurrence until the last 2 to 3 years. The frequency of flooding has increased in this period.

Only three significant flood events having occurred in the 23 years up to and including Storm Dennis. This suggests the NRW flood map (Figure 5-1) prediction of surface water flooding affecting Beryl Road with an annual probability of less than 1 in 30 years is broadly correct.

The analysis of rainfall records shows that the intensity of rainfall experienced during Storm Dennis was relatively high compared to typical rainfall amounts, but it was not in any sense unprecedented. The arrival of Storm Dennis a short time after Storm Ciara meant that the catchment was already wet, and this is likely to have exacerbated the surface water runoff. The near coincidence of these storms is thought to be more significant in explaining the flooding incident than the amount of rain that fell during Storm Dennis itself.

The investigation has revealed a series of issues concerning the local drainage system. As the development of Beryl Road is of considerable age and it is not an adopted highway, it does not benefit from a modern surface water drainage system using kerbs, gullies and associated pipework. The surface water sewer crossing Beryl Road falls within the ownership of DCWW, and other drainage features may be privately owned. Part of the downstream surface water sewer appears to be of historic masonry construction and its condition is uncertain; recent DCWW maintenance activities indicate that it may be prone to collecting silt and the ingress of roots, all of which will affect flow conveyance capacity. There is some uncertainty from the available information as to the condition, dimensions and connectivity of surface water drains into the surface water and combined sewers in the locality.

The drainage system upstream of Beryl Road could not be fully investigated as part of this study but it appears to be inadequate. The highway of the Woodlands Avenue development was never completed, resulting in surface water running off the highway and creating overland flows. Even if runoff from Woodlands Avenue could enter the gullies, based on present evidence it is unlikely that the DCWW surface water sewer could receive this flow without surcharging (assuming the gullies are connected to this system). The status of the Woodlands Avenue development as private or adopted highway and responsibility for the associated surface water flows being generated merits further investigation.

Efforts were made by Swansea Council to investigate the drainage system downstream of Beryl Road during the study. This was largely successful but some gaps in knowledge of the system remain. Importantly, the connectivity of the DCWW surface water sewer to the ditch immediately upstream of the canal syphon has been proven, but the location of the outfall has not been discovered. A local resident has made an important observation regarding the potential influence of the trash screen adjacent to the B4063 Pontardawe Road (near the "Men's Shed") on upstream water levels, which merits further investigation. Further work would be needed

by Swansea Council, DCWW and the Canal & River Trust to fully understand the surface water and land drainage systems.

The investigation has not highlighted any areas of weakness in the Local Flood Risk Management Plan with respect to the approach taken by Swansea Council to the management of flood risk.

11. Next Steps and Proposed Actions

11.1. Swansea Council as Lead Local Flood Authority and Highways Risk Management Authority

The following are suggested actions to be considered by Swansea Council in its capacity as LLFA:

1. The S19 Report should be published and shared with other RMAs and interested organisations.
2. Investigate the risk of blockage and potential benefits of upgrading trash screens on the culverted sections of the Enid Stream from Waverly Park.
3. Investigate the culvert on Capel Road for which the available CCTV surveys are incomplete.
4. Hydraulic investigation of the effects of screen blockage at Pontardawe Road on the upstream culverted length of the Enid Stream, and the potential effects on the risk of out of bank flow at the screened inlet at the cricket pavilion east of Beryl Road.
5. LLFA to work collaboratively with DCWW to investigate the flood risk from DCWW's surface water sewer at Beryl Road to the Canal (see below).
6. LLFA to work collaboratively with the Canal & Rivers Trust to investigate the syphon arrangement under Swansea Canal to fully understand its form and condition relative to the wider land drainage system.

11.2. Swansea Council as the Highway Authority

The following are recommended actions to be undertaken by Swansea Council in its capacity as Highways Authority:

7. Confirm the outcome of ongoing investigations into the connectivity and condition of the highway drainage in Park Road.
8. Investigate the potential effects of elevated water levels in the Enid Stream on the surcharging of the road drainage system.
9. Investigate the contribution of uncontrolled surface water from Woodlands Avenue to the ongoing under-capacity issues of the adopted highway drainage in Park Road.
10. Carry out hydraulic investigation of the effect of runoff from Woodlands Avenue (which cannot get into the unadopted drainage system) arriving on Park Road and the resultant risk to properties on Beryl Road. Quantification of the problem and the need for options to manage the flood risk to the road and properties should be considered.
11. Programme remedial action for any blocked or damaged highways drainage assets.
12. Investigate the feasibility of the options to upgrade of the drainage system within the investigation area.
13. Continue to monitor reported faults through the highway reporting system.

11.3. Dŵr Cymru Welsh Water

14. DCWW continue to monitor on a reactive basis with reports from the public.
15. Investigate the connectivity and condition of the surface water sewer which appears to take surface water from Beryl Road and areas upstream, to the unlocated outfall to the Enid Stream upstream of the inverted syphon under the Swansea Canal.
16. In light of the condition assessment, consider the need for hydraulic assessment of the flood risk to property from the surface water sewer/ and potentially combined sewer from Beryl Road to the Capel Road/ Canal area.

James Richards
Atkins Limited
West Glamorgan House
12 Orchard Street
Swansea
SA1 5ADWest Glamorgan House
12 Orchard Street
Swansea
SA1 5AD

Tel: +44 (0)1792 641172