

Dŵr Cymru Welsh Water
**Cardigan (Lower Town); St
Mary's Street Secondary Outfall**
NRW Solution Report

4392_S_216-ARP-07-XX-RP-XX-10040

Issue | P5 13 August 2021



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1 Introduction

1.1 Project Brief

The purpose of this document is to outline the scope requirement for relieving rainfall induced sewer flooding affecting 36 properties in the Lower Town area of Cardigan.

The properties are in a flat, low lying area of the town, to the north west of Cardigan Bridge. The area is characterised by terraced houses and narrow streets.

The purpose of this document is to outline and confirm the design parameters and scope of works required to protect these properties during a combination of high river levels and periods of heavy rainfall.

This report summarises the findings of the investigation and outlines the proposed modifications required to the CSO system in Cardigan in order to apply for a formal consent.

1.2 Asset Summary

Catchment Name: Cardigan

Asset Name: St Mary's Street CSO

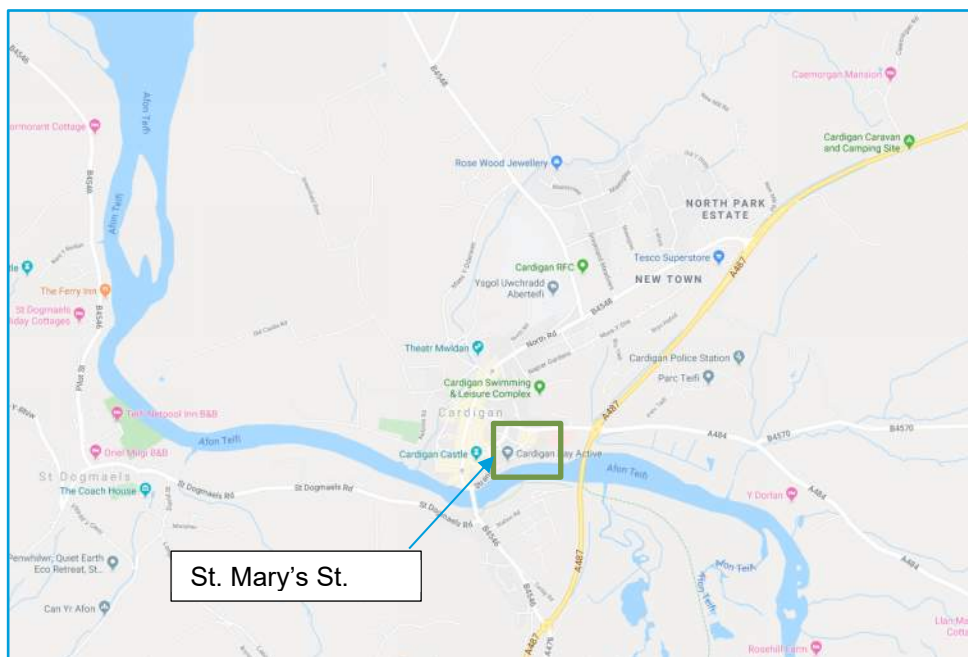


Figure 1: St. Mary's Street CSO Location Plan

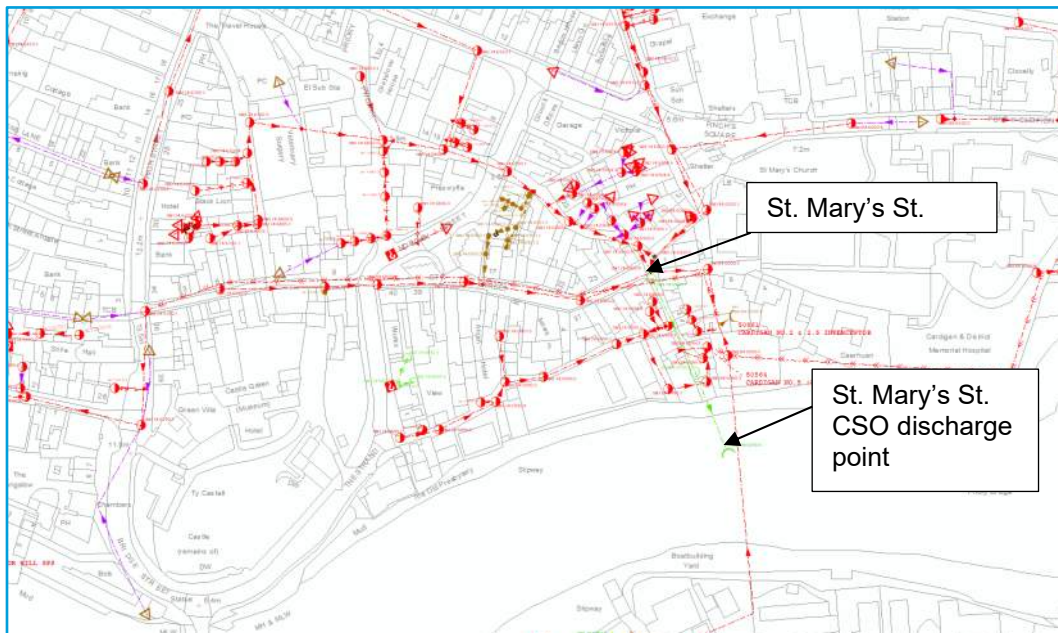


Figure 1: Sewer network around St. Mary's Street CSO

Cardigan is a town in Ceredigion, close to the border between Ceredigion and Pembrokeshire. The town has been built along the banks of the River Teifi, with properties constructed at low level, in close proximity to the watercourse.

The river opens into an estuary after passing through the town, before flowing into the sea at Poppit Sands some 5km downstream. The river is susceptible to tidal influence up to a distance of 2km upstream of the town. There are currently no flood defences within the town, which results in tidal flooding in Lower Cardigan.

The existing Gloster Row overflow - BH00743 01 (Referred to as St Mary's Street CSO for the remainder of the report), has a weir level which is lower than the average high tide; Weir level of 1.83mAOD and average high tide of 2.305mAOD. As such, it becomes tide locked during most high tide events, a twice daily occurrence. If a storm occurs during such a period, the CSO is unable to spill and property flooding can occur.

The existing CSO is located in the middle of a crossroads of St Mary's Street, Pwllhai and Church Street. The streets in this location are narrow and difficult to access and park. The chamber is an old, brick built, rectangular chamber.

St. Mary's Street CSO and the proposed secondary outfall are transitional waters assets, so they are not currently covered under SOAF and therefore don't have a Bathing or Shellfish driver. There is no impact assessment methodology for transitional waterbodies, although it is understood that a process is under development nationally.

2 Investigations

2.1 Hydraulic Model and Flow Survey

Flow Monitoring was undertaken in key locations on the network in order to produce a verified hydraulic model.

In total, twelve flow monitors and three rain gauges were installed. The information from these sites, as well as information gathered from previous RPS flow monitoring was used to produce the model. Flow monitors were installed for a total of 32 weeks due to the unprecedented dry summer of 2018.

The root cause of flooding was established from the hydraulic modelling work. This identified that excess network flows were unable to discharge via St Mary's Street CSO due to tide locking.

The model predicts that if the tide locks out the CSO at a level of 2.5mAOD and this coincides with a storm event, flooding will occur for as little as a 1 in 1 year event. The table below demonstrates this and gives the probability of a range of rising and high tide levels and rainfall occurrence:

Tide Level			1:1	1:2	1:5	1:10	1:30	<-- Storm Event
Name	mAOD	Exceedance Probability	Joint Probability (1 in ____)					
Lowest	0.556	100.0%	1	2	5	10	30	
Intermediate Level 1	1.336	33.3%	3	6	15	30	90	
Intermediate Level 2	1.984	16.7%	6	12	30	60	180	
Intermediate Level 3	2.506	6.7%	15	30	75	150	450	
Intermediate Level 4	2.765	3.3%	30	60	150	300	900	
Mean High Water Springs	2.987	1.6%	64	128	321	641	1923	
Highest Astronomical Tide	3.563	0.05%	2000	4000	10000	20000	60000	

Table 1: Tidal and rainfall joint probability assessment

The hydraulic modelling and analysis of rainfall and tide information also saw a direct correlation between the high tide occurrence and flooding. The following chart shows the rainfall in orange, the tide in blue and the velocity of discharge, the grey line shows velocity in the upstream sewer:

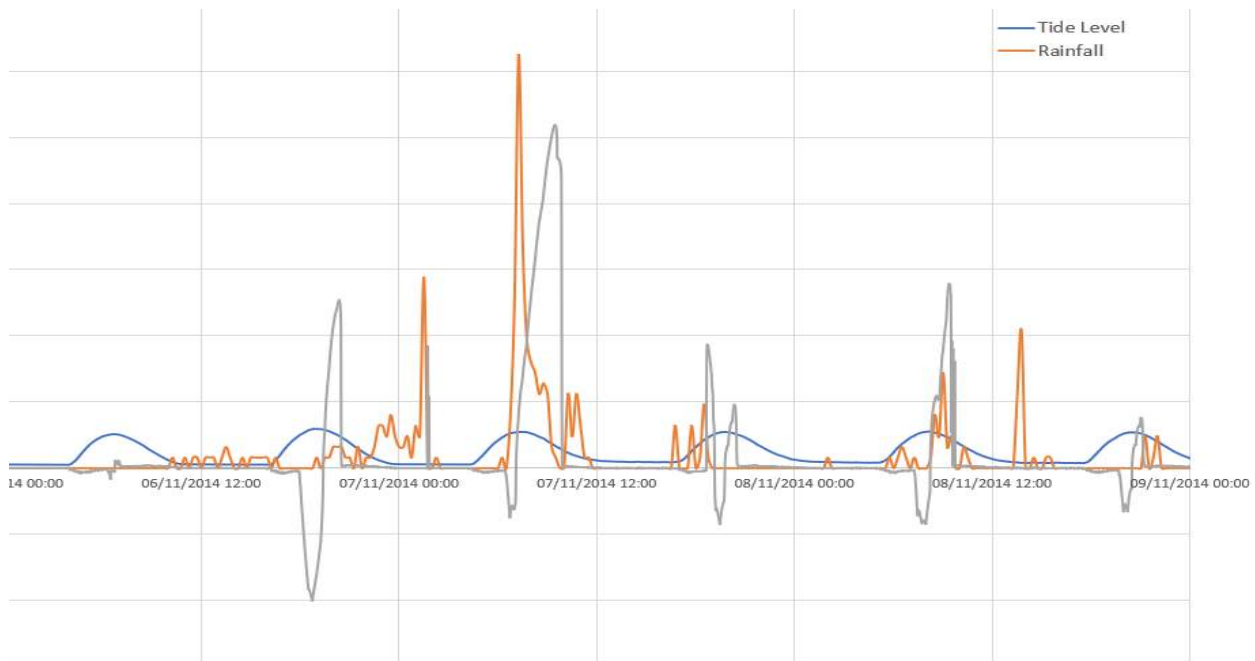


Figure 3: Tide, rainfall and sewer velocity comparison

The larger spike was the rainfall which occurred on 07/11/2014 and correlated with a high tide of 2.75mAOD. All of the identified properties in Cardigan flooded on this day. Incidentally, the day prior saw a higher tide of 2.98mAOD, however there was no flooding as the rainfall was considerably less than that which occurred on 07/11/2014.

2.2 Flooding properties

A total of 36 properties in the Lower Town area of Cardigan are at risk of flooding. These properties are clustered around St Mary's St and Pwllhai, where ground levels are lower than surrounding areas. The green highlighted area on the figure below shows the locations where properties have been subject to flooding:

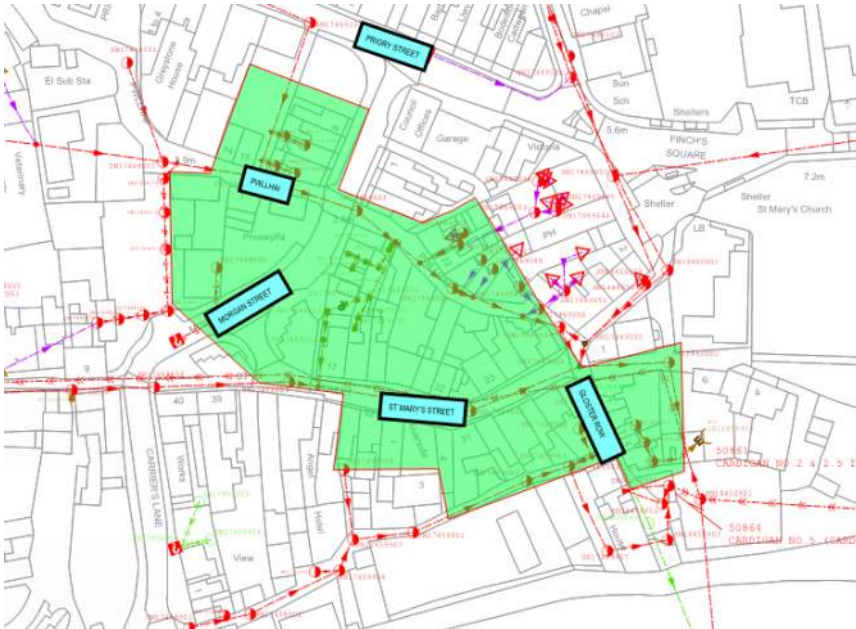


Figure 4: Flooded properties around St. Mary's Street and Pwllhai

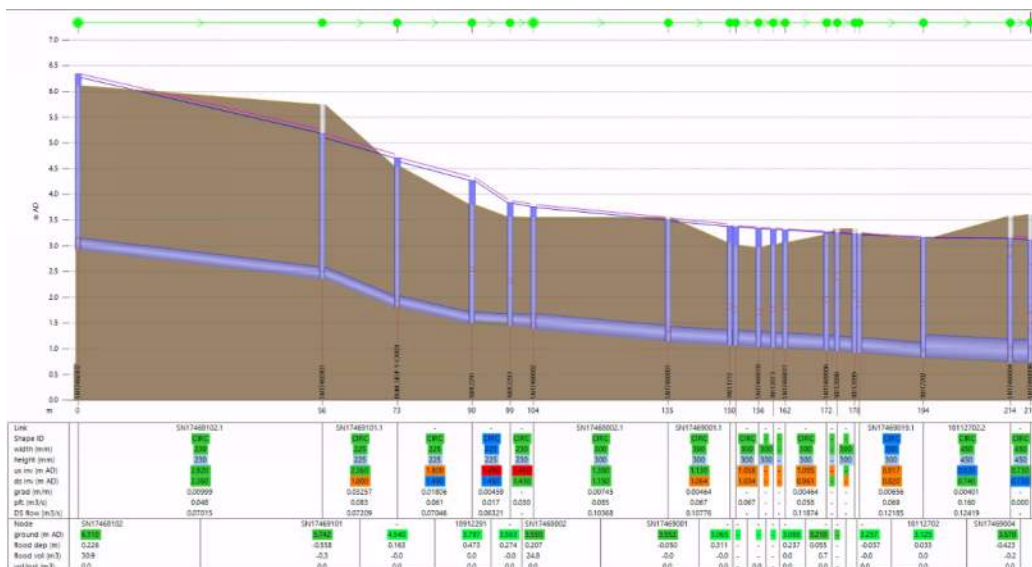
Flooding which occurred on 07/11/ 2014, affected much of the Lower Town. The photograph below, shows the impact of high tide with this 1 in 1-year flood event:



Figure 5: Flooded properties on St. Mary's Street on 07/11/2019

The longitudinal sections shown below in figures 6 and 7, show the level of flooding which is apparent during a tide locked outfall, when the rainfall is as low as a 1 in 1 year return period storm. The properties in these two streets are at a low point within the town and therefore become the pathway for flooding occurrence. The thresholds of all properties were surveyed as part of the investigation and compared against flood levels up to 1 in 30 year return period. Information relating to individual properties cannot be shared due to GDPR.

Introduction of a pumped CSO within the system, changes the pathway of the flows during high tide events. This pathway modification ensures flows are retained within the sewer system and prevents flooding to the properties in the Lower Town area of Cardigan.



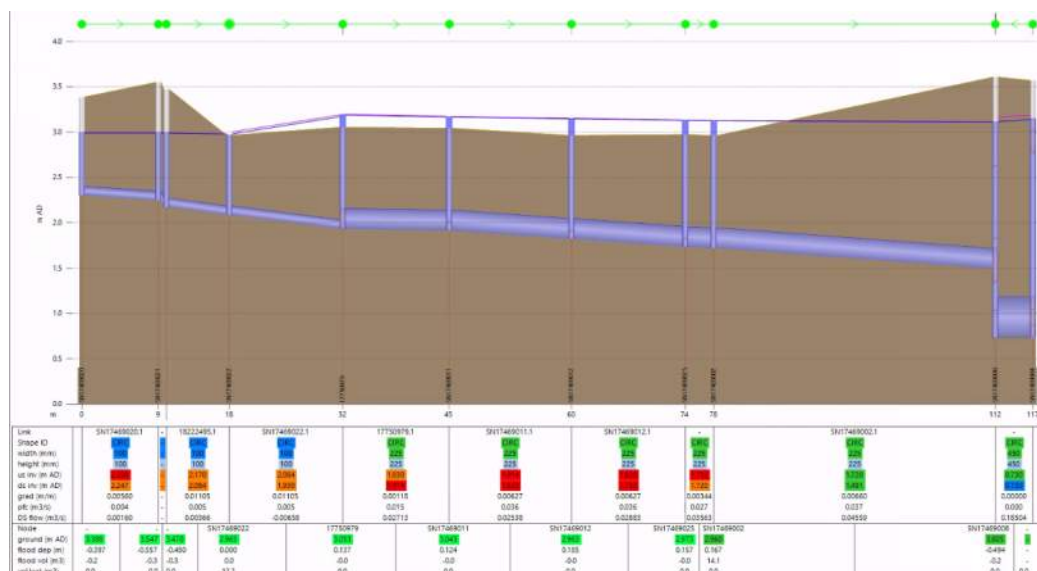


Figure 7: Longsection through St Mary's St – 1 in 1 year return period storm with tide locked outfall

3 Existing Consents

The existing CSO (BH00743 01) is consented to discharge only for flows in excess of 1,021,520 g.p.d, which equates to 53.7l/s

4 Summary of Receiving Waters

The CSO discharges into the River Teifi. A Teifi and North Ceredigion Management Catchment Summary published in 2016 by Natural Resources Wales (NRW), classified this area of the Teifi and the majority of the upstream catchment and the outgoing estuary, with an overall status of Moderate.

The vision for the Cardigan Bay Special Area of Conservation (SAC) is one of a high quality marine environment, where the protected habitats and species of the site are in a condition as good as or better than when the site was selected; where human activities co-exist in harmony with the habitats and species of the site and where use of the marine environment is undertaken sustainably.

The Welsh Water Alliance are undertaking further assessment work around the discharge point to establish any additional Environmental impact. Any mitigation work required will take place prior to work commencing.

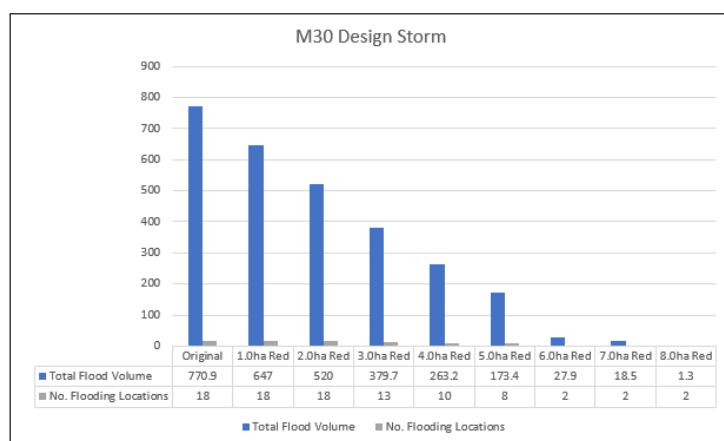
5 Options Not Progressed

In the early stages of the project, we looked at various options to alleviate the sewer flooding, these comprised of network upsizing, Bifurcation of flows, Re-distribution of the pumped network and surface water removal. It became evident that these options were either not deliverable, caused detriment elsewhere in the network and / or buildability constraints and impact of construction on the local community. It should also be noted that all of these options require a secondary pumped outfall, with the exception of option 5. These costed options included (See Appendix B for layout drawings). NOTE: The chosen option (option 3) is excluded from this list:

1. Full network upsizing of Cardigan Lower Town and Feidrfair, including secondary pumped outfall in Gloster Row car park.
 - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St, Church St and Feidrfair
 - New secondary pumped outfall in Gloster Row car park
2. Full network upsizing of Cardigan Lower Town, including secondary pumped outfall in Gloster Row car park.
 - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St and Church St
 - New secondary pumped outfall in Gloster Row car park
4. Bifurcation of flows to divert from Lower Town area to Quay Street car park pumping station along with network upsizing and secondary pumped outfall at St Mary's St.
 - Bifurcation of flows from the top of Cardigan town and redirecting them to Quay Street pumping station
 - Sewer upsize along Pwllhai and Church Street
 - New secondary pumped outfall in Gloster Row car park
5. Redistribution of pumped networks to reduce flows to Gloster Row pumping station along with network upsizing and secondary pumped outfall at Gloster Row car park:
 - Diversion of existing network pumping stations to reduce flows at Gloster Row pumping station
 - New secondary pumped outfall at Gloster Row or upgrade of existing pumping station to incorporate CSO
6. Surface water removal (Rainscape):
 - Removal of up to 8Ha of surface water discharge to the sewer network across the catchment
 - Introduction of sewer upsize and/or new secondary outfall pumping station for Rainscape removal of up to 8Ha.

Rainscape: Our preferred solution is always to tackle the root cause of the issue, in this case clean water entering the foul network. We have found that in order to remove sewer flooding at the properties we would need to remove in excess of 8 Hectares of impermeable area. We set out to identify these areas but were only able to identify 5.3 hectares. Hence this is not enough to alleviate the flooding.

Figure 8, below demonstrates the impact of surface water removal on flood volume:



- Verified Cardigan model includes approx. 10ha of impermeable area
- Removal of 80% of impermeable areas would be required to provide 30yr protection (< 2m³ residual flooding is predicted by the model)

Figure 8: Impact of varying degree of surface water removal on flood volume

The costs in Section 5.1 of the options identify the capital cost of the pumped secondary outfall and associated Rainscape costs for differing hectareage removal. Initial investigations into the catchment have highlighted areas where surface water can be removed from the network. These are recorded in Appendix B. Further investigations would be required to confirm cost and impact on volume of discharge.

The driver for this scheme is the prevention of internal flooding, rather than volume of discharge reduction.

A widescale review of the network to assess the potential for non-return valve (NRV) installation at effected properties: The flooding occurs in the worst affected areas at or above the property threshold level. A NRV solution would therefore not be suitable in this area.

5.1 Costings for options not progressed

A costing exercise was undertaken for Options 1 and 2 above, along with varying levels of surface water removal (Rainscape), from 1Ha, up to 7Ha:

	Scheme Cost	Total Carbon (kg/CO ₂ e)	+ 1Ha Rainscape*	+ 3Ha Rainscape*	+ 5Ha Rainscape*	+ 7Ha Rainscape*
Option 1	£3,094,626	227814	£4,094,626	£6,094,626	£8,094,626	£10,094,626
Option 2	£2,478,220	148655	£3,478,220	£5,478,220	£7,478,220	£9,478,220

*Costs based on approx £1M/Ha taken from historical DCWW schemes

Table 2: Options not progressed plus Rainscape removal costs

The addition of Rainscape hectareage to each of the main scheme options to resolve internal flooding, erodes the BTKNEEC. The baseline solution is required whether Rainscape is implemented or not. Rainscape removal in addition to the baseline solution does not therefore prevent flooding to these properties

The areas of surface water connections we have located following investigation isn't lost because this can be used by DCWW developer services function as forms or trade off when developers are requesting new connections. In Carmarthenshire for example, DCWW have signed into a memorandum of understanding where a developer wants to connect 1.0 l/s to the network, they need to remove 2.5 l/s, this may be an option for the future in Cardigan.

6 Restrictions and Limitations

There are several restrictions and limitations within Cardigan town, which have the potential to make construction extremely difficult and/or be overly disruptive to local residents. Options were therefore discounted because of these factors:

The streets in Cardigan are extremely narrow and were probably not designed for motor vehicles or construction wagons. Figure 6 shows the route down to Gloster Row Pumping station. Figure 7 shows upper St. Mary's Street. Residential properties open directly to the road on Gloster Row:



Figure 9 (left): Gloster Row down to the car park and River Teifi

Figure 10 (right): Upper commercial area of St. Mary's St.

7 Final Solution

The final solution was chosen on the basis that it provides a robust, constructible solution to alleviate sewer flooding to the lower town.

The tide-locking of the existing CSO means that all options would necessitate a new secondary outfall with pumped outfall. The location for the secondary outfall was chosen on the basis that it is close enough to the existing CSO to be effective, whilst also ensuring that it is both buildable and easily maintainable. The new secondary outfall needs to be fitted with a mechanically raked screen to ensure that it meets current CSO standards. Additionally, the pumps are approximately 1000kg each, so mobile lifting / low-loader access would be necessary.

The location for the secondary outfall is in an easily accessible area, which makes construction and maintenance more practical. This has the benefit of reducing time on site for both construction and maintenance activities and the Health and Safety benefits which reduced time on site brings.

The proposed CSO will not affect the performance/flows from the existing CSO and Gloster Row Pumping Station (pass forward flow). No other assets will be affected by the proposal.

The costing exercise, including surface water removal (Rainscape) was updated to include the preferred option, Morgan St Secondary outfall, Option 3:

	Scheme Cost	Total Carbon (kg/CO2e)	+ 1Ha Rainscape	+ 3Ha Rainscape	+ 5Ha Rainscape	+ 7Ha Rainscape
Option 1	£ 3,094,626	227814	£4,094,626	£6,094,626	£8,094,626	£10,094,626
Option 2	£ 2,478,220	148655	£3,478,220	£5,478,220	£7,478,220	£9,478,220
Option 3	£ 1,921,308	141143	£2,921,308	£4,921,308	£6,921,308	£8,921,308

**Costs based on approx £1M/Ha taken from historical DCWW schemes*

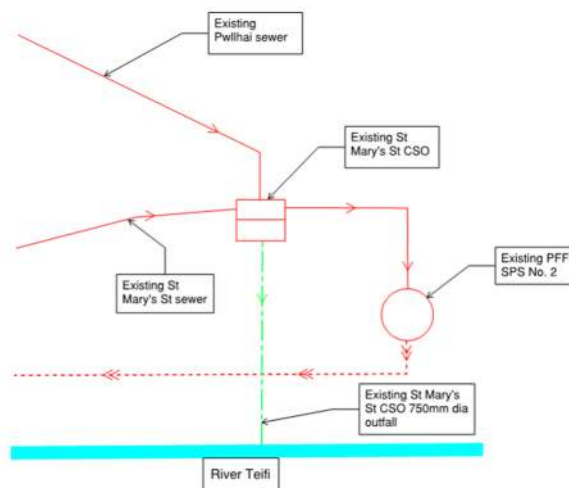
Table 3: Base scheme costs plus Rainscape removal costs

There is a net increase in operational carbon associated with the scheme, as a result of pumping operations necessary to overcome tide locking of the existing outfall. This does not however account for the carbon saving as a result of removing flood risk to these properties for a 1 in 30 year storm and the associated energy and carbon expended to remediate this. Due to the tide locking of the outfall, all of the options explored require a pumping station to prevent sewer flooding, even with the highest achievable area of Rainscape.

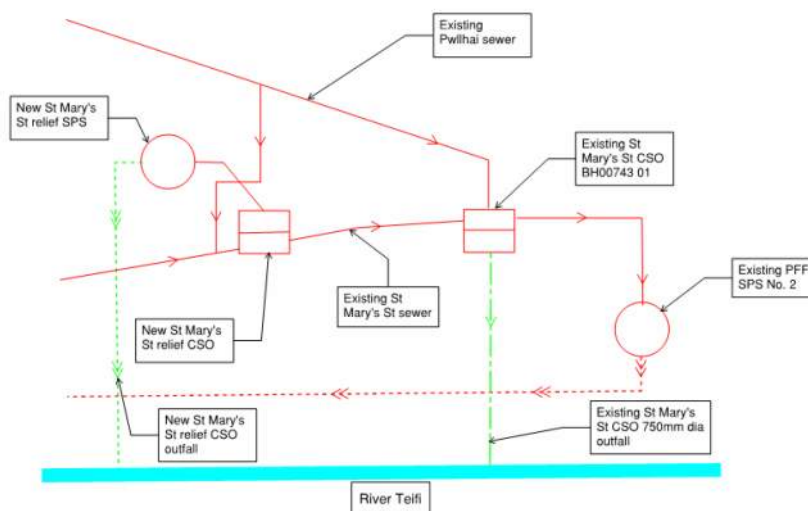
8 Intermittent Discharges – Existing and Proposed Performance

8.1 Asset Schematic

Asset Schematic Existing Scenario



Asset Schematic Proposed Scenario



8.2 Existing Performance

A verified hydraulic model has been used to calculate the predicted spills and flood volume on the catchment. 12 flow monitors were installed, and readings taken weekly for a 32 week period. Historic rainfall and tidal data was also used along with rain-gauge data taken at the time of the flow monitoring, to build an extremely accurate hydraulic model of the catchment. This has been used to predict spill volume and frequency and compared to actual spill data taken from St. Mary's Street CSO.

St Mary's St CSO is predicted to spill 157 times per annum and with a spill volume of 66,051m³. In addition to spills from the CSO, the volume of flood water which discharges into the highways at times of high tide and then drains via highway drainage to the Afon Teifi when the tide abates is 9,664m³. This is a total volume discharging to the environment of 75,715m³.

The existing Gloster Row SPS pumps the pass forward flow from the catchment, to Quay Street SPS; from here, flows are pumped to Cardigan Wastewater Treatment Works. The pass forward flow from Gloster Row SPS is consented at 53.7l/s, as noted in Section 3. It is not proposed to amend this as part of the scheme.

The primary root cause of sewage flooding is the existing St Marys Street CSO being unable to discharge due to tidal locking. The existing St Mary's Street CSO has a weir level which is lower than the average high tide. As such, it becomes tide locked during most high tide events, a twice daily occurrence. If a storm occurs during such a period, the CSO is unable to spill and flooding can occur within properties. Flood water / sewage effluent from flooded properties is discharged to the SAC via the sewer as the tide falls and the CSO become unlocked and operational. There is currently limited capacity for polluted flood water to infiltrate into the catchment due to the largely impermeable urban land use and the majority of flood water is delivered to the SAC via the sewer as the tidal valve becomes operational.

8.3 Proposed Performance

The proposed secondary outfall will only operate when St Mary's Street CSO is unable to operate due to tide locking of the outfall. The two discharge points will not operate at the same time.

The restriction on the network currently is and will remain, the pass forward flow (PFF) of Gloster Row pumping station. This pumps 53.7l/s, in line with the consent, ensuring no downstream detriment.

Once flow in the system exceeds 53.7l/s, it will back up to St Mary's St CSO initially. If this CSO is not tide locked, it will discharge, as it currently does. If it is tide-locked, flows will continue to back up in the network, along Pwllhai and St Mary's Street, to the new secondary outfall, from where discharge flows will be screened via a 6mm-2D screen and pumped to a new outfall point, approximately 160m downstream of the existing St Mary's Street CSO discharge point.

It should be noted that the discharge to the Afon Teifi will be from either of the two outfalls.

The existing CSO spill volume from St Mary's Street will reduce from 75,715m³ to 66,051m³ per annum with implementation of the proposed design. The proposed secondary outfall is expected to operate approximately 44 times per year, coinciding with high tides and storm events, with a total annual volume of 9,664m³. Therefore, the total annual spill volume to the SAC will remain the same.

CSOs are designed to operate during heavy rainfall when the downstream capacity has been exceeded and to prevent inundation of the sewage treatment works with storm flows. Flooding would not necessarily occur during each CSO spill event, however issues such as restricted toilet use, poor operational performance of the sewer, leading to the requirement for blockage clearance and odour issues can all occur as a result. The 44 No. spills expected to occur from the new secondary discharge therefore will reduce the risk of flooding to the 36 properties in the Lower Town area of Cardigan, and will also provide further benefits as noted.

The proposed solution therefore prevents sewer flooding whilst causing no net increase in volume discharged to the watercourse.

With the addition of a second screened overflow all flows will be screened and controlled thus providing an improvement to the current environmental discharge of unscreened flood water via the highway drains.

Inland Discharge Analysis					
Amenity Rating		Non-Amenity			
RQO		WFD – Moderate Status*			
Receiving Waters current performance d/s of discharge point i.e. RE			Moderate Status*		
Existing scenario			Proposed scenario		
No. Spills >50m ³		157	No. Spills >50m ³		157 (44 from the secondary outfall and 113 from St Mary's St CSO)
Spill Volume m ³		75,715	Spill Volume m ³		75,715 (9,664 from secondary outfall and 66,051 from St Mary's St CSO)
Annual Spill analysis %age (2012)		N/A	Annual Spill analysis %age (2012)		As Existing
Existing Water Quality 99%ile	BOD5	As Existing	Future Water Quality 99%ile	BOD5	As Existing
	NH4	As Existing		NH4	As Existing

Table 4: Discharge analysis information – existing and proposed.

*Based on "Teifi and North Ceredigion Management Catchment Summary" published in 2016 by Natural Resources Wales (NRW)

9 Summary of Environmental considerations and Approach

The nearest bathing water to the discharge point, Poppit Sands will not be adversely affected by the proposed discharge. The discharge volume will ultimately remain unchanged, however now instead of flooding properties in the lower town area of Cardigan before then discharging to the River Teifi, it will be mechanically screened and pumped to the River Teifi instead. A betterment to river quality is therefore expected and an advanced water quality assessment is deemed not necessary.

St. Mary's Street CSO and the proposed secondary outfall are transitional waters assets, so they are not currently covered under SOAF and therefore don't have a Bathing or Shellfish driver. There is no impact assessment methodology for transitional waterbodies, although it is understood that a process is under development nationally.

10 Solution Summary

The proposed solution is to provide a pumped relief for the CSO on St Mary's Street. The existing CSO becomes tide-locked and therefore unable to discharge during the majority of high tides. Consequently, flooding occurs to streets and nearby residential properties, causing significant short- and long-term disruption to a high amenity town area.

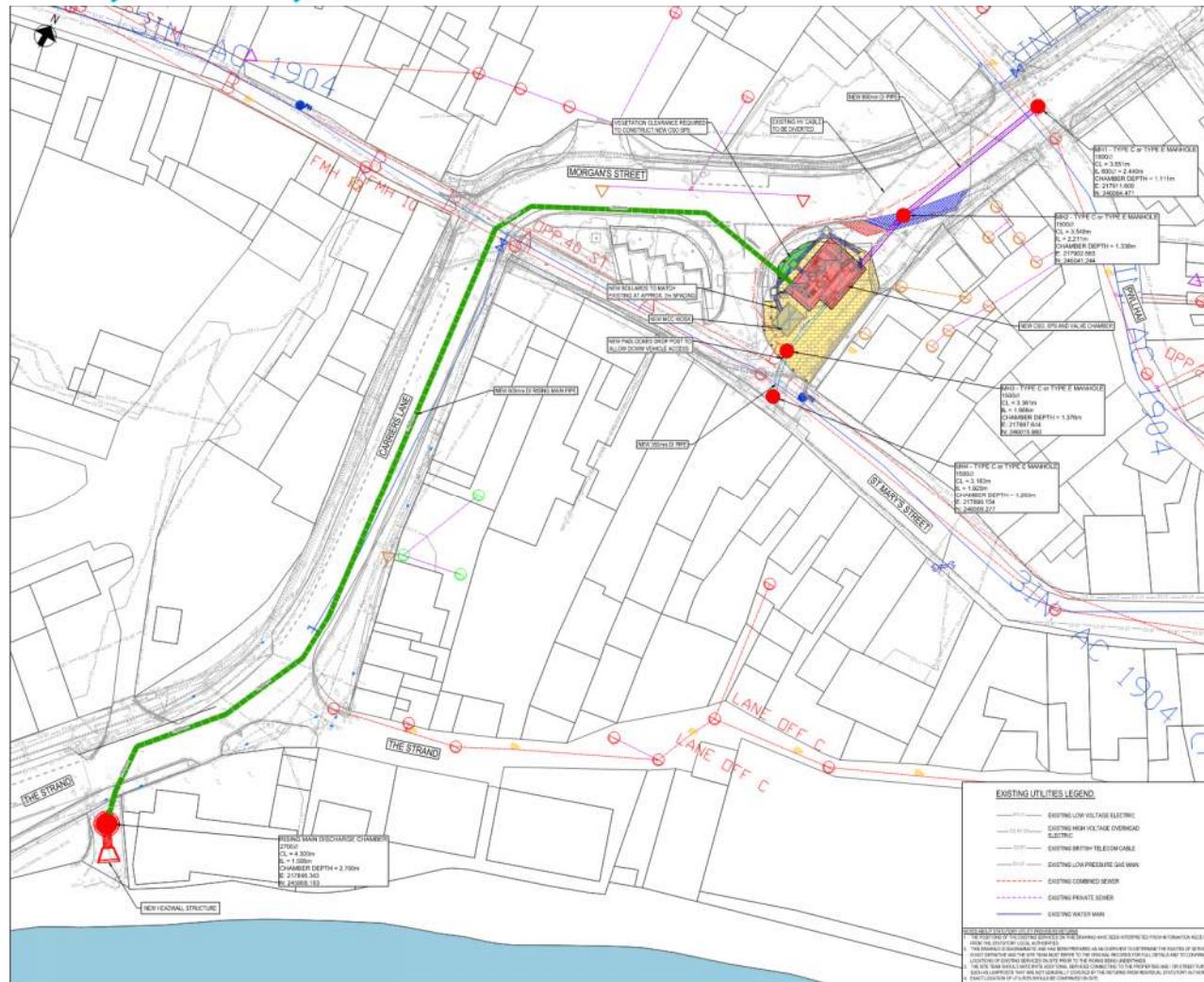
Pumping in the location of the existing CSO is not possible as it is in the middle of a small highway junction. Additionally, streets within Cardigan are very tight, so works within these areas would likely be very disruptive to local residents and there would be significant constructability issues.

A new secondary outfall is proposed in Morgan Street, in an accessible and maintainable location, approximately 90m from the existing St Mary's Street CSO.

Works are scheduled in collaboration with the Local Authority and NRW, who are also planning schemes in the area to reduce overland and tidal flooding respectively. This will minimise disruption to the local community and provide efficiency in design and construction activities.

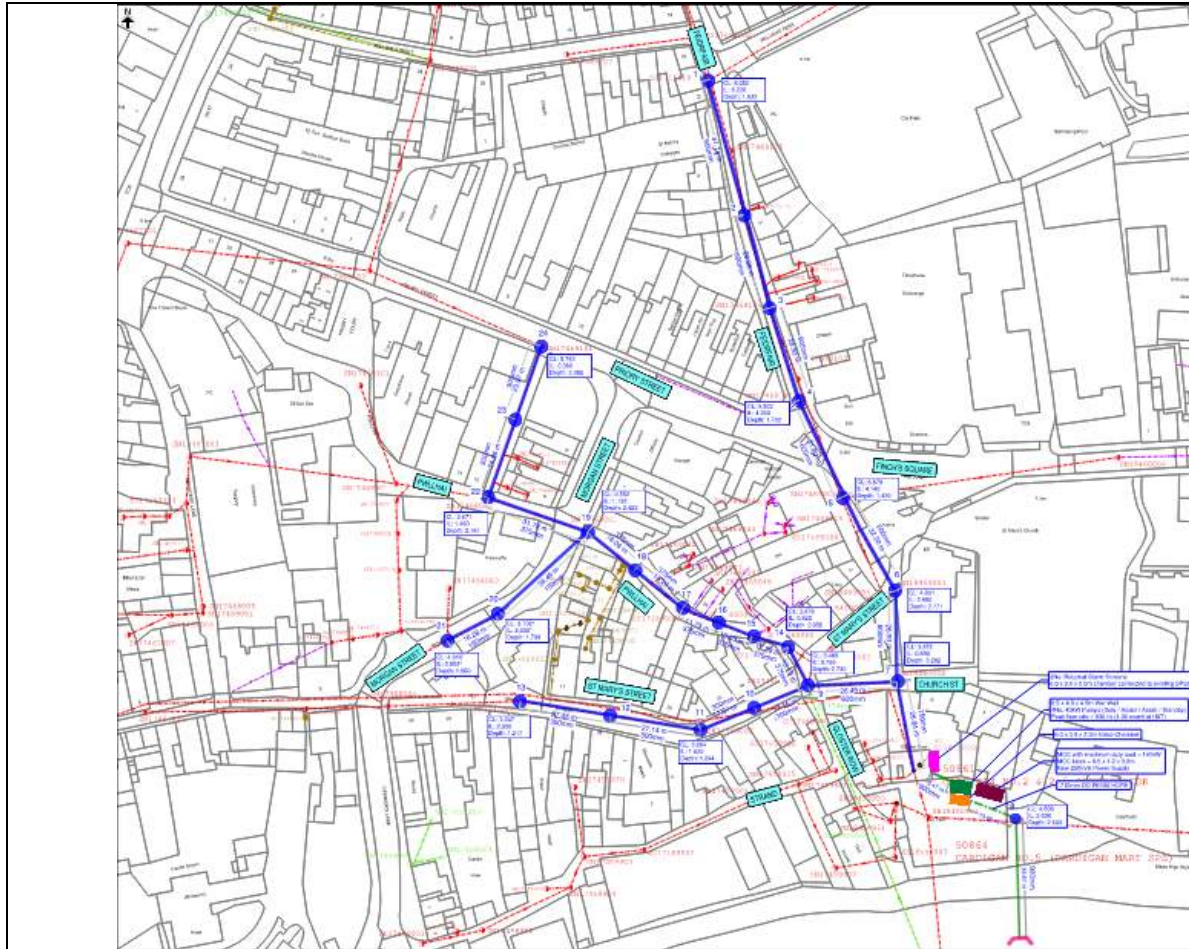
Appendix A

Proposed Solution

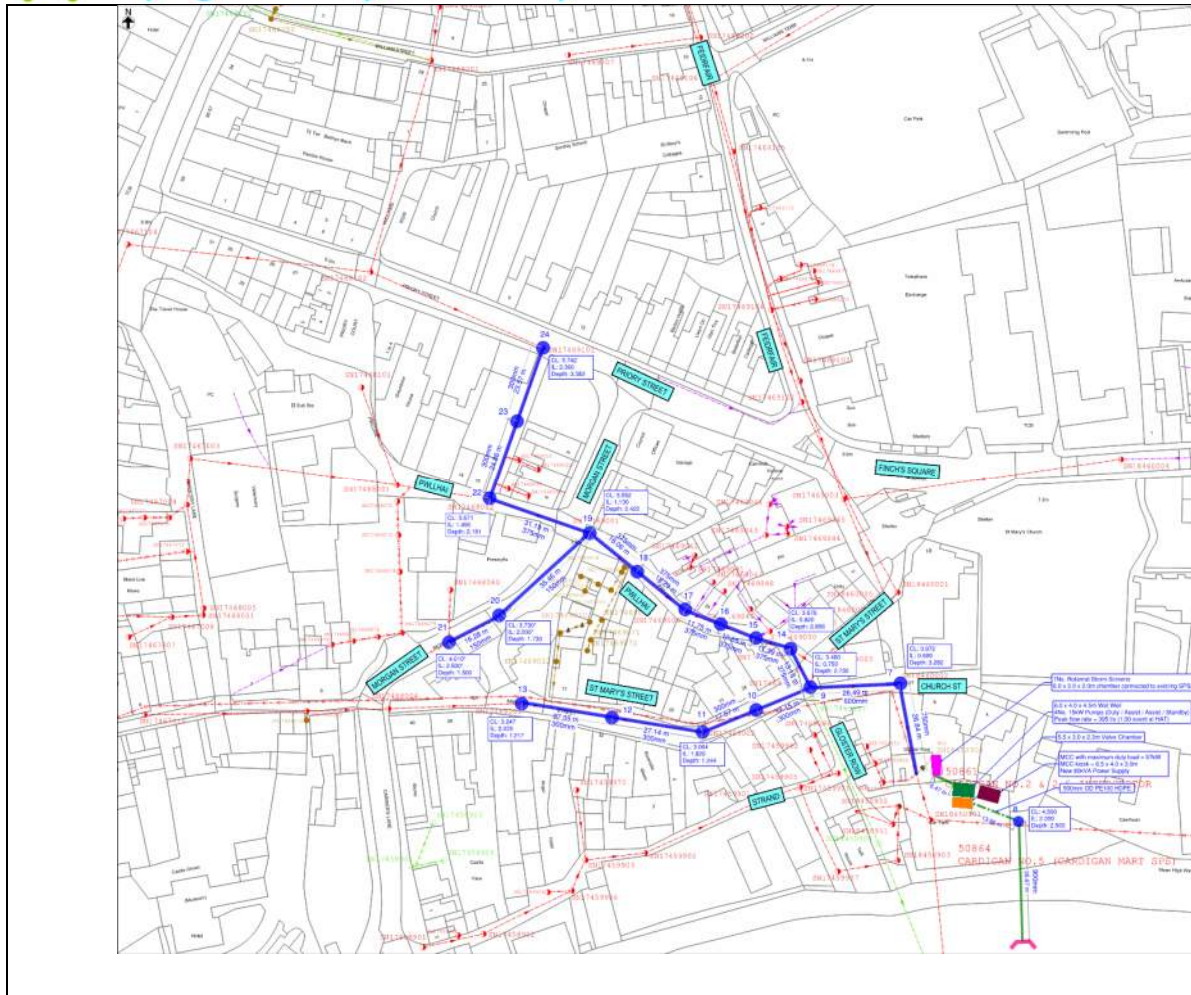


Appendix B

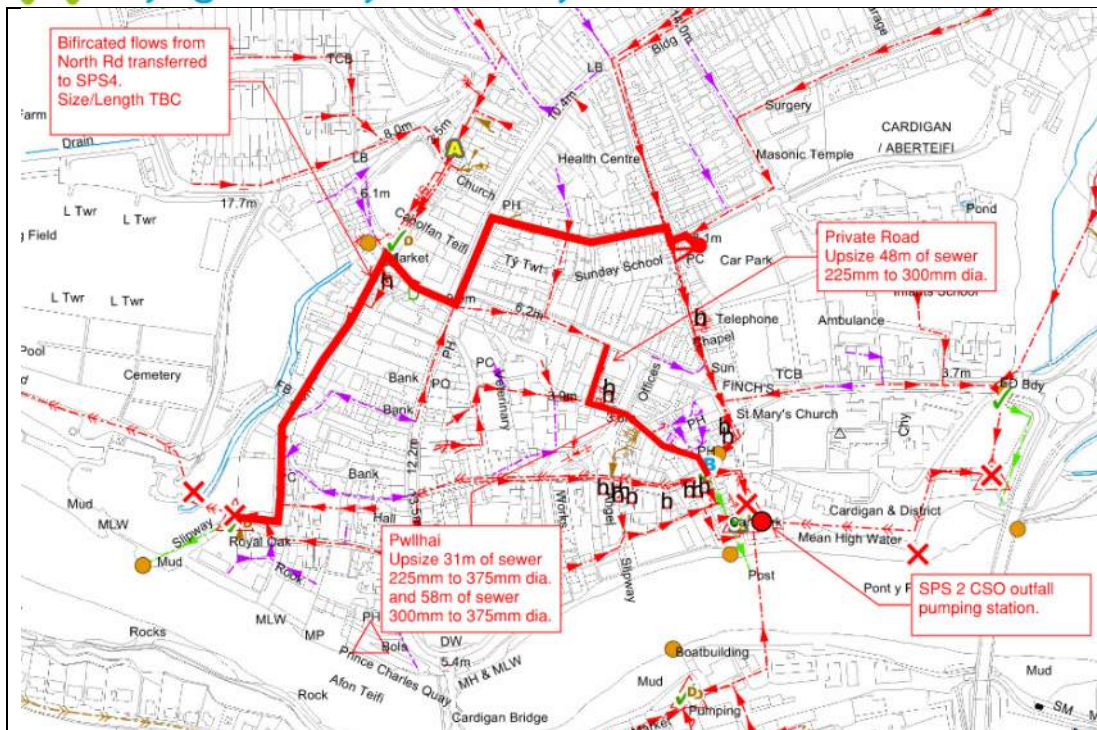
Options Not Progressed



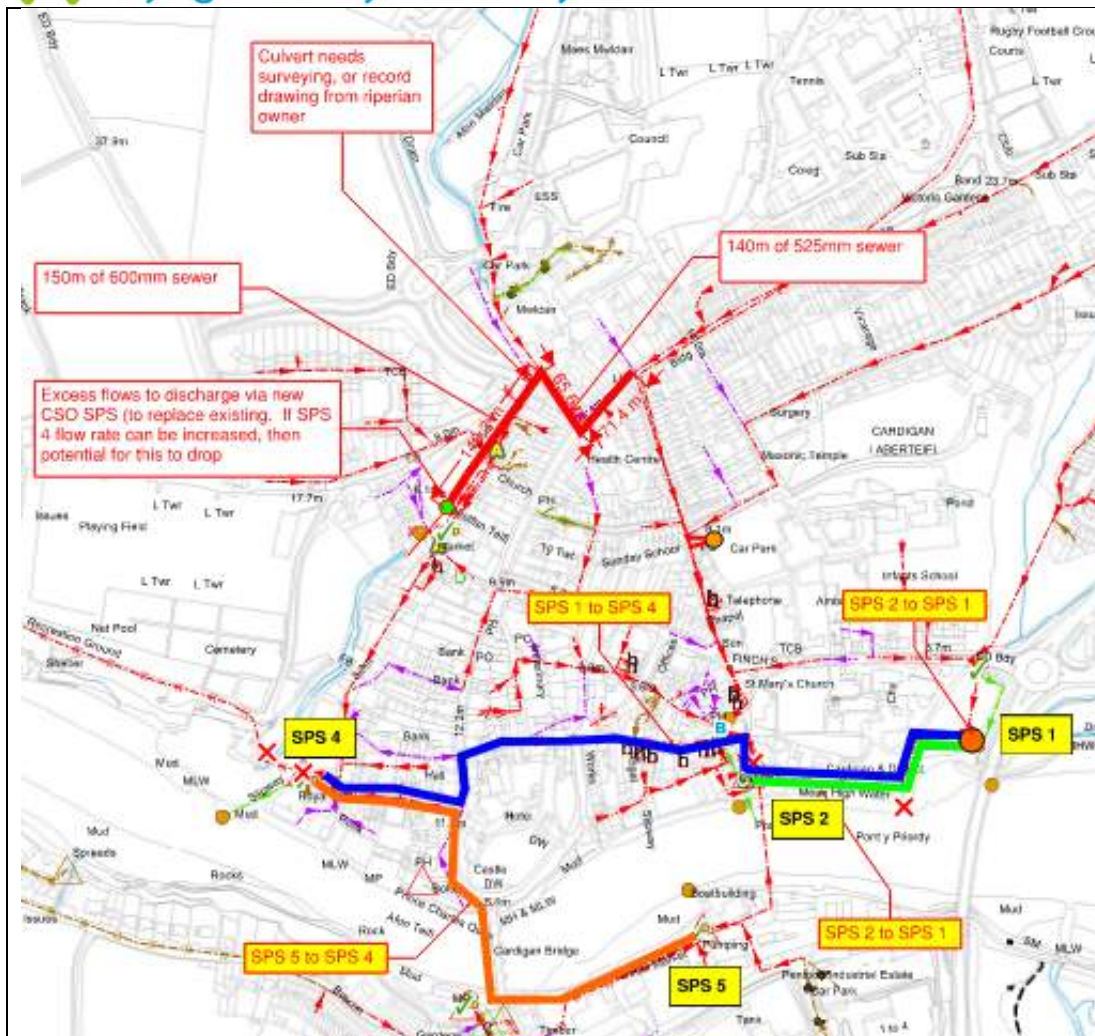
- Full network upsizing and CSO pumping station at St Mary's St.
 - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St, Church St and Feidrfair.
 - Secondary outfall pumping station in Gloster Row car park



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 - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St and Church St.
 - Secondary outfall pumping station in Gloucester Row car park

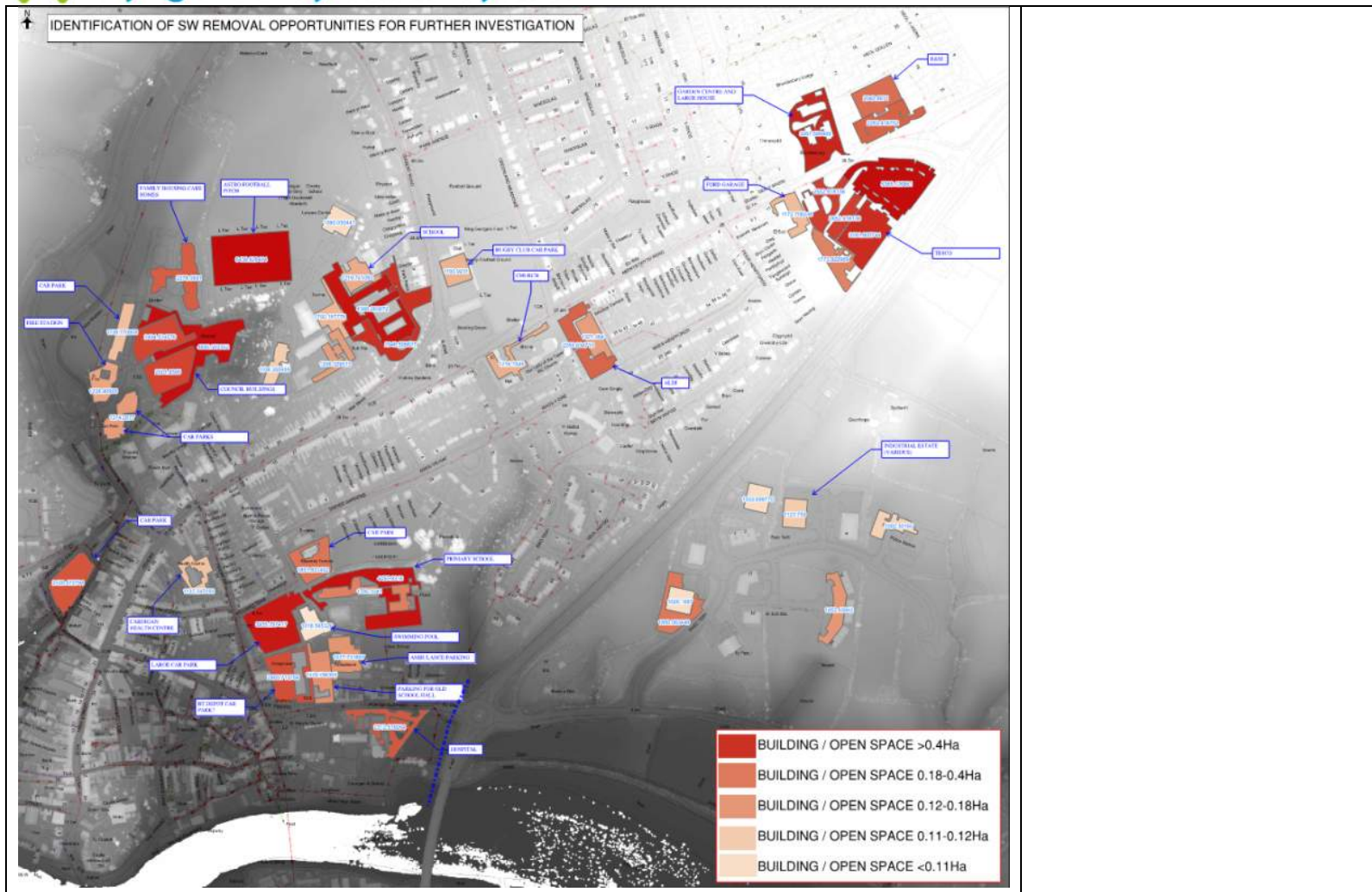


- Bifurcation of flows to divert from Lower Town area to Quay Street car park pumping station along with network upsizing and CSO pumping station at St Gloster Row
 - Bifurcation of flows from the top of Cardigan town and redirecting them to Quay Street pumping station
 - Sewer upsize along Pwllhai and Church Street
 - Secondary outfall pumping station in Gloster Row car park



- Redistribution of pumped networks to reduce flows to Gloster Row pumping station along with network upsizing and CSO pumping station at St Mary's St.
 - Diversion of existing network pumping stations to reduce flows at Gloster Row pumping station

Secondary outfall pumping station at Gloster Row or upgrade of existing pumping station to incorporate CSO



Appendix C

Agreed Solution Sign-off

Agreed Solution

Scheme Name: AMP7 Cardigan (Lower Town) – St. Mary's Street Secondary outfall

NOTE: THE DATA IN THE FOLLOWING TABLE WILL BE TAKEN AS THE INFORMATION EXPECTED ON THE CONSENT APPLICATION, UNLESS AN AMENDMENT IS PROVIDED AND SIGNED OFF BY NRW STAFF.

DC No	Consent No.	Name	Discharge NGR	Present	Proposed	Screens (type & size)	Storage (m3)	No. of spills (>50m3)		Emergency provision (if PS)	Comments (for NRW use)
				CSO setting (l/s)	CSO setting (l/s)			Current	Proposed		
N/A	TBA	St Mary's Street Secondary outfall	SN1789346029	new asset	53.7 l/s	6mm – 2D	0	0	44*	N/A	

*estimated annual spill frequency based on verified hydraulic model, should the existing St. Mary's Street CSO (Consent No. BH0074301) be tide locked.

ACCEPTED BY NRW

Name:

Date: