Capital Delivery Alliance
Cynghrair Cyflawni Cyfalaf

Dŵr Cymru Welsh Water

Cardigan (Lower Town); St Mary's Street Relief CSO

NRW Solution Report

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Capital Delivery Alliance
Cynghrair Cyflawni Cyfalaf

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		Name	S. Appleby	S. Appleby	D. Hamer
		Signature			

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Teifi and North Ceredigion Management Catchment Summary, published in 2016 by Natural Resources Wales (NRW)

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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

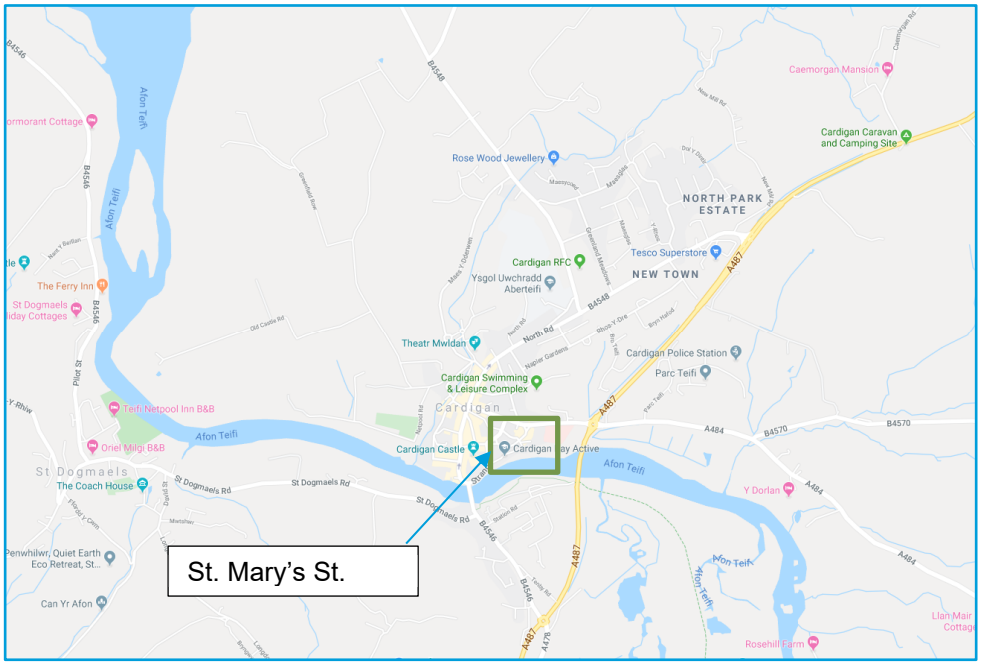


Figure 1: St. Mary's Street CSO Location Plan

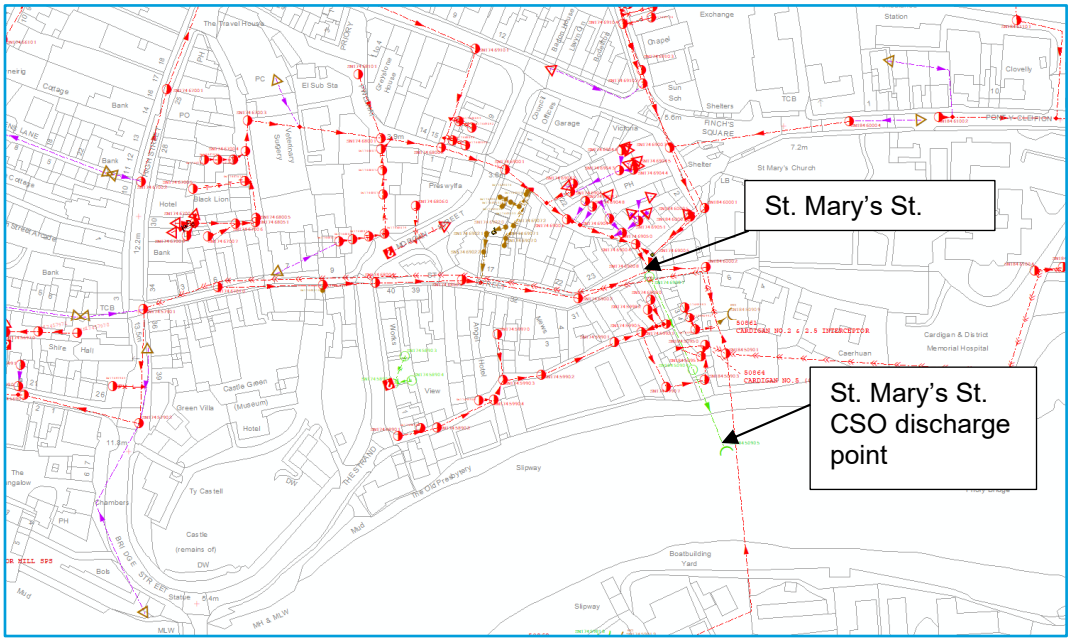


Figure 2: Sewer network around St. Mary's Street CSO

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 St Mary's Street CSO 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.

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:

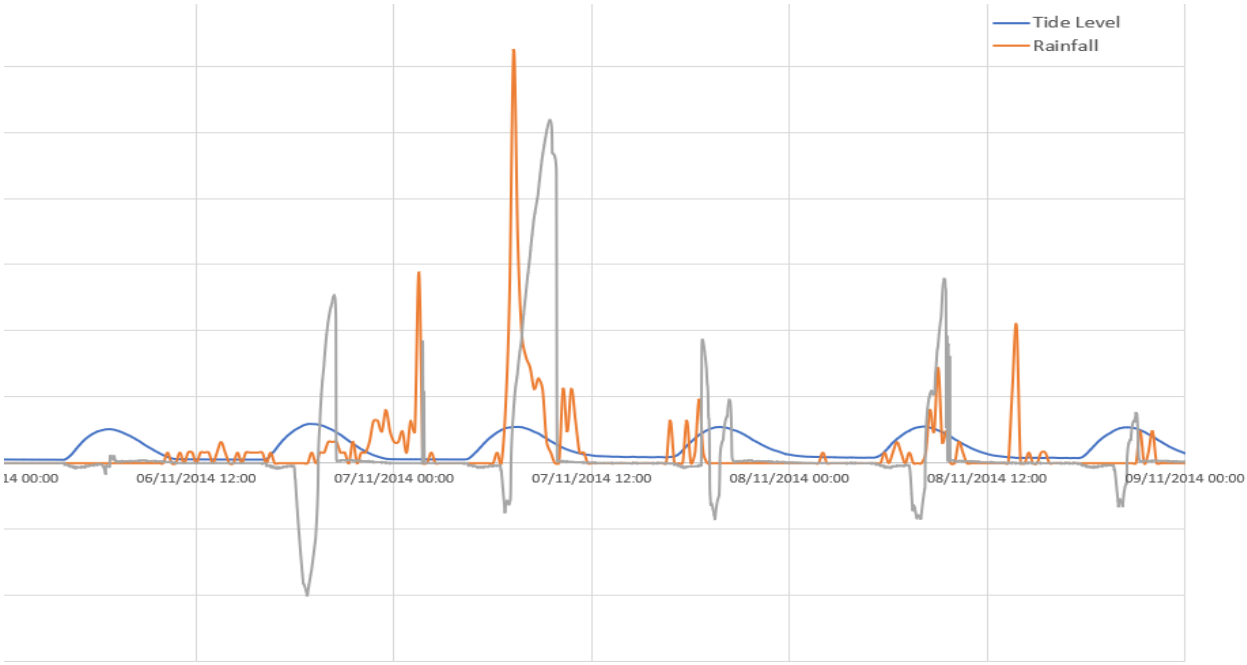


Figure 3: Tide, rainfall and sewer velocity comparison

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:

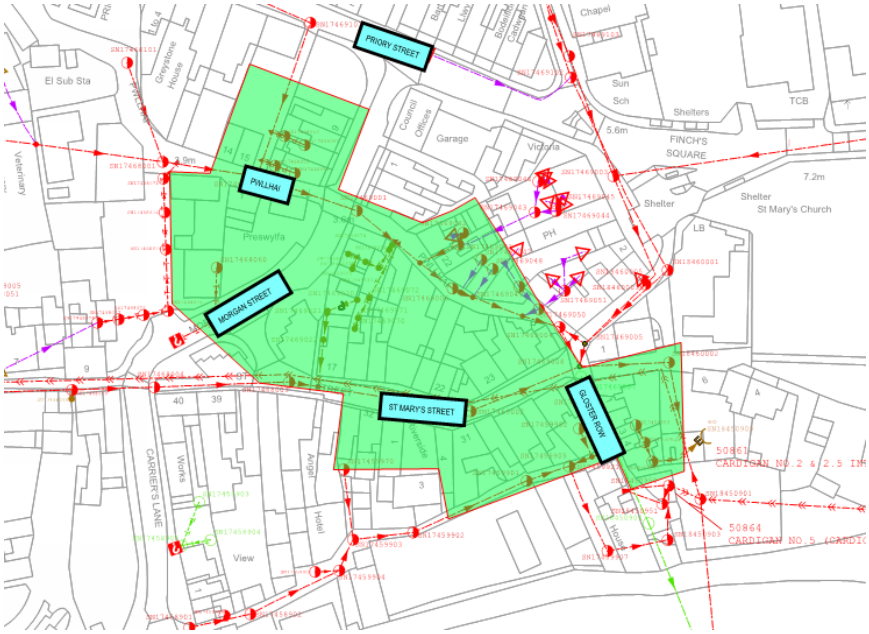


Figure 4: Flooded properties around St. Mary's Street and Pwllhai

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.

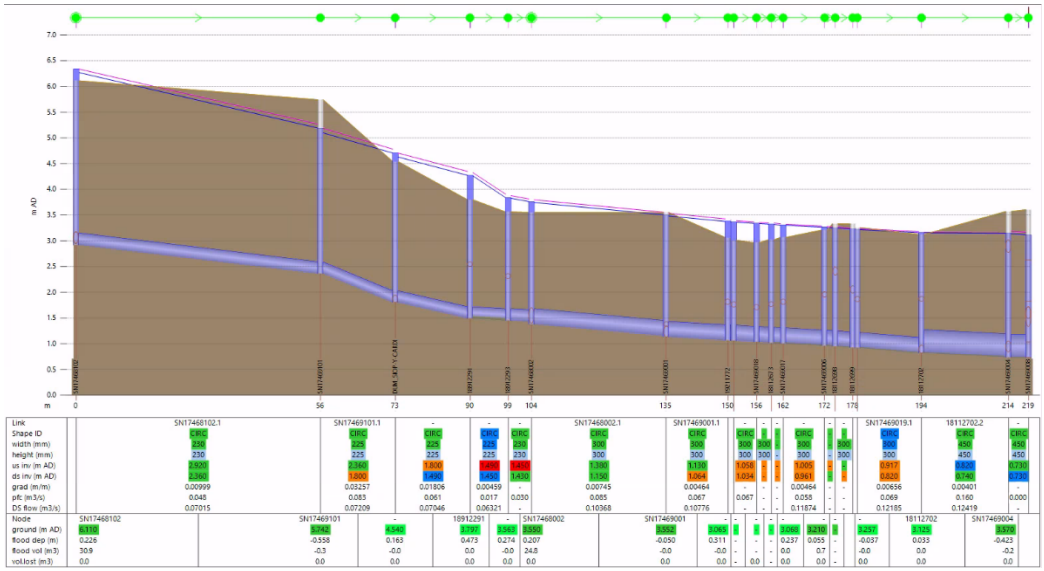


Figure 6: Longsection through Pwllhai – 1 in 1 year return period storm with tide locked outfall

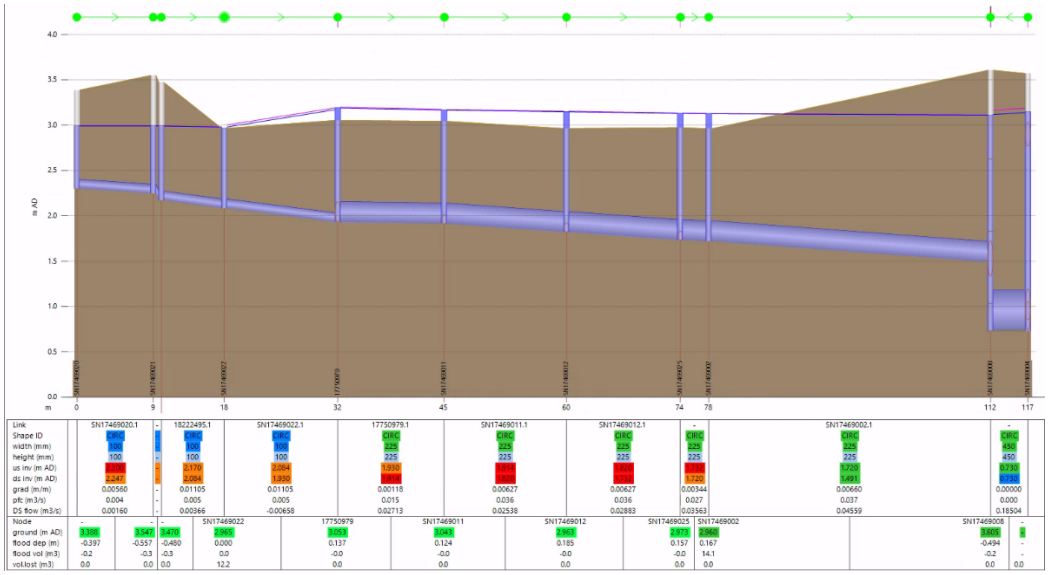


Figure 7: Longsection through St Mary's St – 1 in 1 year return period storm with tide locked outfall

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 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

Several different options were reviewed during the early stages of the design. These were rejected due to buildability constraints and impact of construction on the local community. These costed options included (See Appendix B for layout drawings):

1. Full network upsizing of Cardigan Lower Town and Feidrfair, including CSO pumping station in Gloster Row car park.
   - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St, Church St and Feidrfair
   - New CSO pumping station in Gloster Row car park
2. Full network upsizing of Cardigan Lower Town, including CSO pumping station in Gloster Row car park.
   - Upsize of sewers along St. Mary's St, Pwllhai, Morgan St and Church St
   - New CSO pumping station in Gloster Row car park
3. 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 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 CSO pumping station in Gloster Row car park
4. Redistribution of pumped networks to reduce flows to Gloster Row pumping station along with network upsizing and CSO pumping station at Gloster Row car park:
   - Diversion of existing network pumping stations to reduce flows at Gloster Row pumping station
   - New CSO pumping station at Gloster Row or upgrade of existing pumping station to incorporate CSO
5. Surface water removal (Rainscape):
   - Removal of up to 7Ha of surface water discharge to the sewer network across the catchment
   - Introduction of sewer upsize and/or new relief CSO pumping station.

   Rainscape: the removal of hardstanding areas which discharge to the sewer network, will not work as a standalone option to eliminate the flooding in Lower Town Cardigan. Hydraulically, the water levels which flood residents in the Lower Town are unaffected by the reduction in surface water in the upstream network, as they are flooded from tidal locking, rather than hydraulic overloading of sewers. Flooding volumes could be reduced but not prevented with any surface water area reduction within the network when there is a storm and a high tide.

The costs in Section 5.1 of the options identify the capital cost of the pumped CSO and associated Rainscape costs for differing hectarage 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 CSO 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 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/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

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

Table 2: Options not progressed plus Rainscape removal costs

The addition of Rainscape hectarage to each of the main scheme option to resolve internal flooding further erodes the BTKNEEC whole life cost ratio calculated as part of our internal Risk & Value exercise.

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

Figure 9 (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 relief CSO with pumped outfall. The location for the new CSO 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 relief CSO 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 relief CSO 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 Relief CSO, 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*

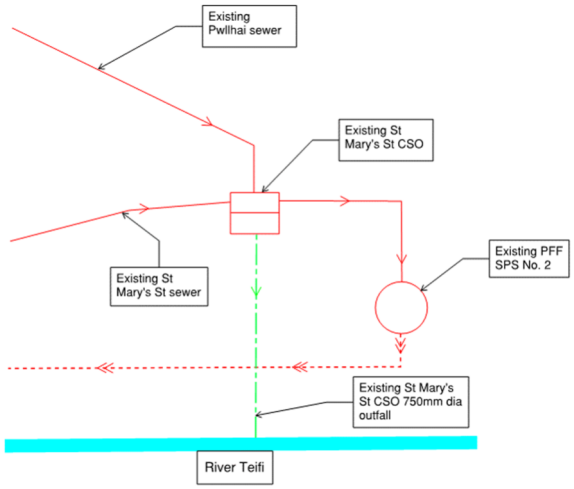
Table 3: Base scheme costs plus Rainscape removal costs

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.

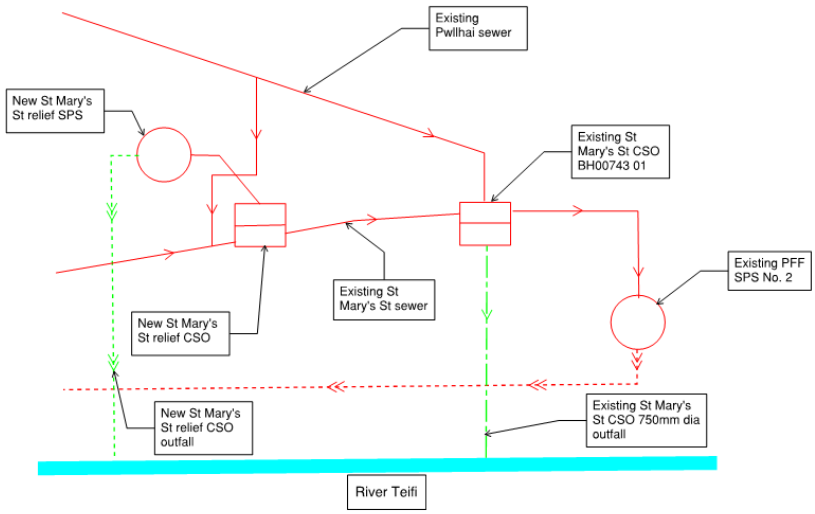
8. Intermittent Discharges – Existing and Proposed Performance

8.1 Asset Schematic

Asset Schematic Existing Scenario



Asset Schematic Proposed Scenario



8.2 Existing Performance

St Mary's St CSO is predicted to spill 157 times per annum and with a spill volume of 67,611m^3. 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 8,104m^3. This is a total volume discharging to the environment of 75,715m^3.

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.

8.3 Proposed Performance

The proposed relief CSO will only operate when St Mary's Street CSO is unable to operate due to tide locking of the outfall. The two CSOs will not operate together.

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 relief CSO, 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 the two CSOs.

The existing CSO spill volume from St Mary's Street will reduce from 67,611m^3 to 66,051m^3 per annum with implementation of the proposed design. The proposed relief CSO is expected to operate approximately 44 times per year, coinciding with high tides and storm events, with a total annual volume of 9,664m^3. A total of 75,715 m^3 of screened flow will therefore discharge to the environment.

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 >50m3		157	No. Spills >50m3		197
Spill Volume m3		67,611	Spill Volume m3		75,715
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 3: 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.

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.

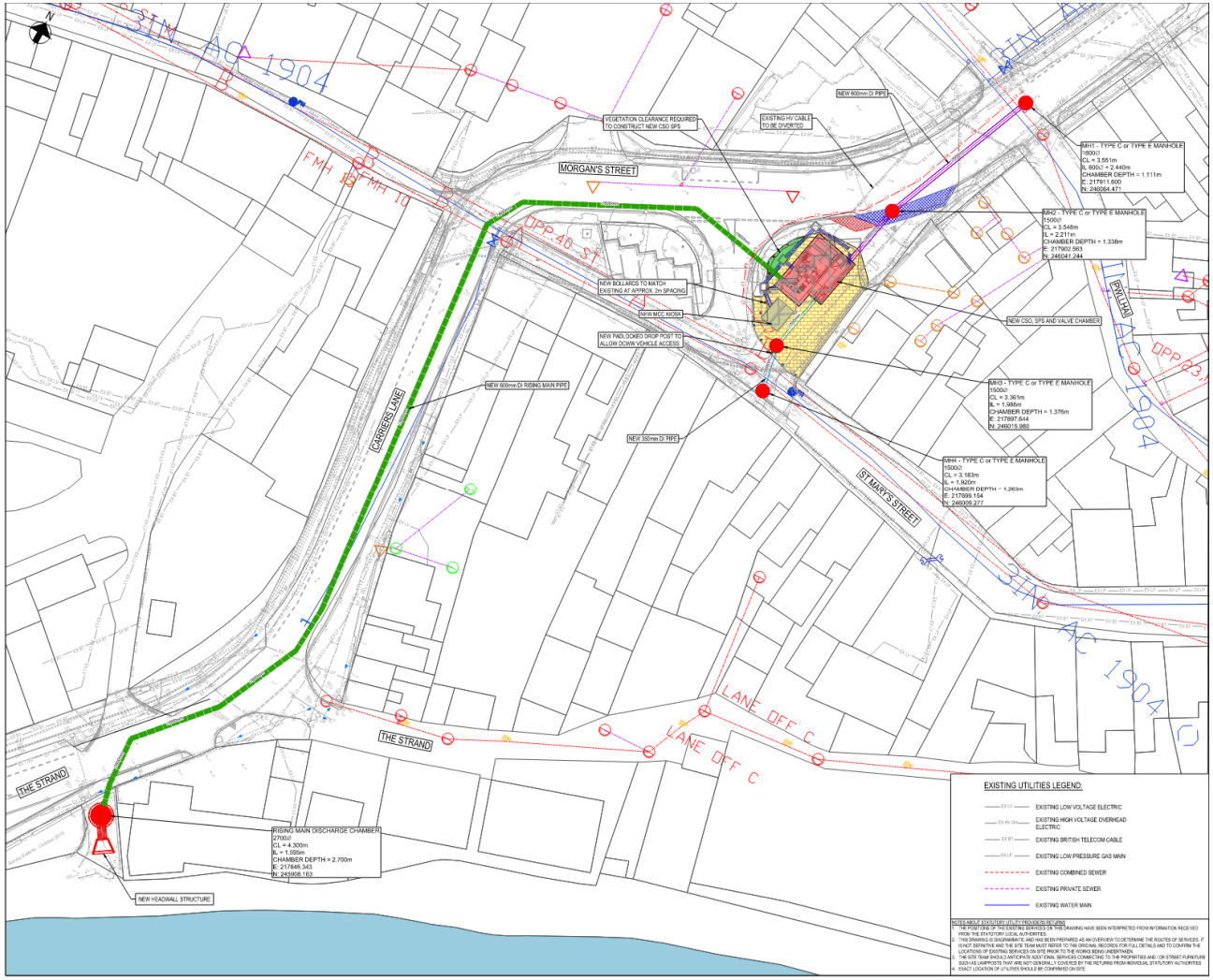
Pumping in the location of the existing CSO is not possible as it is in the middle of a small highway junction. Additionally, streets within Cardigan are very tight, so works within these areas would likely be very disruptive to local residents and there would be significant constructability issues.

A new relief CSO 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.

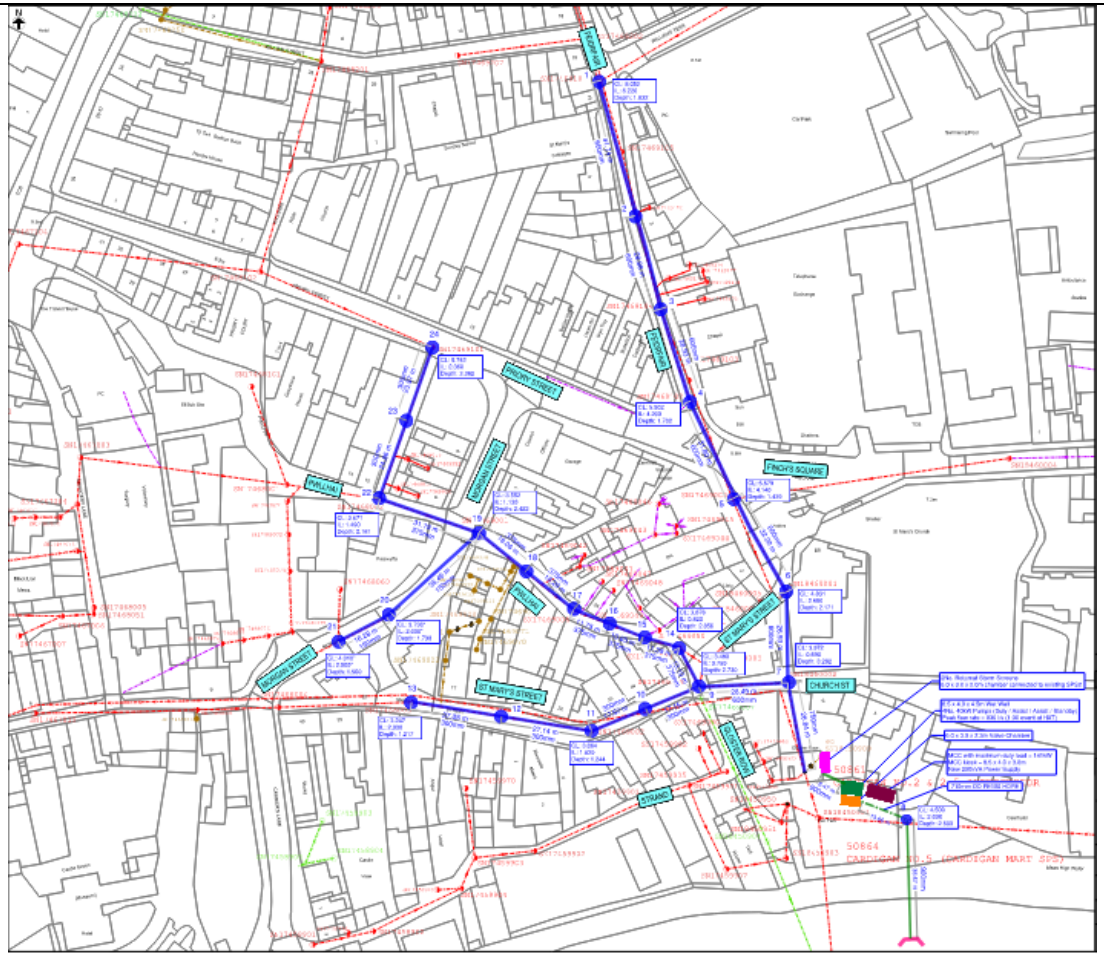
Appendix A

Proposed Solution

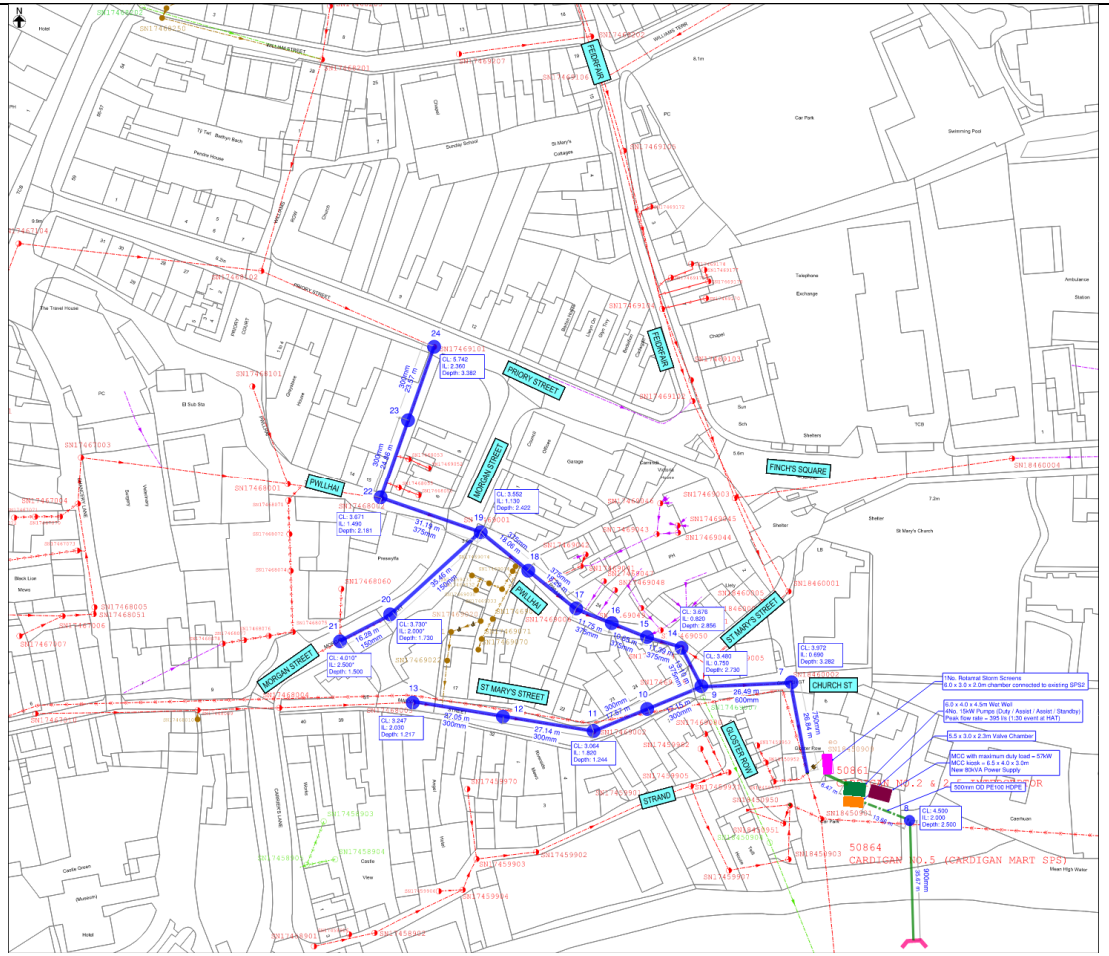

MORGAN'S STREET
CARRIGERS LANE
THE STRAND
ST MARY'S STREET
NEW 600mm DI PIPE
VEGETATION CLEARANCE REQUIRED TO CONSTRUCT NEW CSO SPS
EXISTING HV CABLE TO BE DIVERTED
NEW BOLLARDS TO MATCH EXISTING AT APPROX. 2m SPACING
NEW MCC KIOSK
NEW PADLOCKED DROP POST TO ALLOW DOWN VEHICLE ACCESS
NEW 600mm DI RISING MAIN PIPE
NEW 350mm DI PIPE
NEW CSO, SPS AND VALVE CHAMBER
MH1 - TYPE C or TYPE E MANHOLE
1800ø
CL = 3.551m
IL 600ø = 2.440m
CHAMBER DEPTH = 1.111m
E: 217911.600
N: 246064.471
MH2 - TYPE C or TYPE E MANHOLE
1500ø
CL = 3.548m
IL = 2.211m
CHAMBER DEPTH = 1.338m
E: 217902.563
N: 246041.244
MH3 - TYPE C or TYPE E MANHOLE
1500ø
CL = 3.361m
IL = 1.985m
CHAMBER DEPTH = 1.376m
E: 217897.844
N: 246015.980
MH4 - TYPE C or TYPE E MANHOLE
1500ø
CL = 3.183m
IL = 1.920m
CHAMBER DEPTH = 1.263m
E: 217890.154
N: 246009.277
RISING MAIN DISCHARGE CHAMBER
2700ø
CL = 4.300m
IL = 1.595m
CHAMBER DEPTH = 2.700m
E: 217846.343
N: 245905.183
NEW HEADWALL STRUCTURE
EXISTING UTILITIES LEGEND:
EXISTING LOW VOLTAGE ELECTRIC
EXISTING HIGH VOLTAGE OVERHEAD ELECTRIC
EXISTING BRITISH TELECOM CABLE
EXISTING LOW PRESSURE GAS MAIN
EXISTING COMBINED SEWER
EXISTING PRIVATE SEWER
EXISTING WATER MAIN

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.
  - New CSO pumping station in Gloster Row car park



- Full network upsizing and CSO pumping station at St Mary's St.
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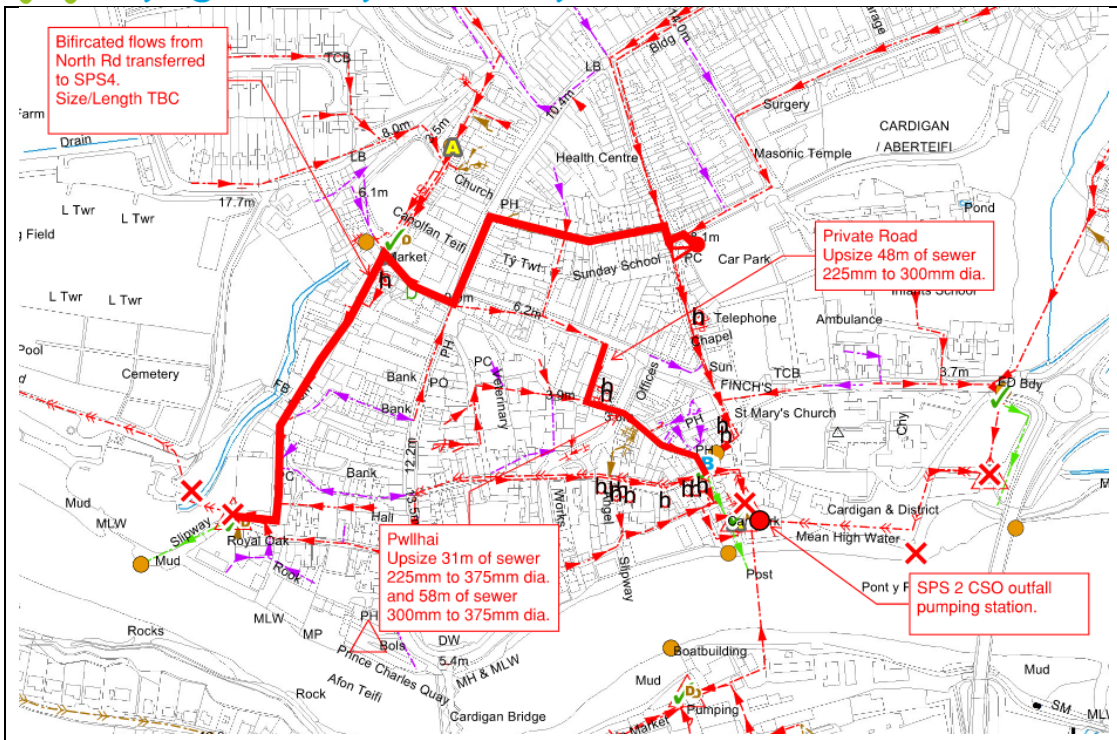
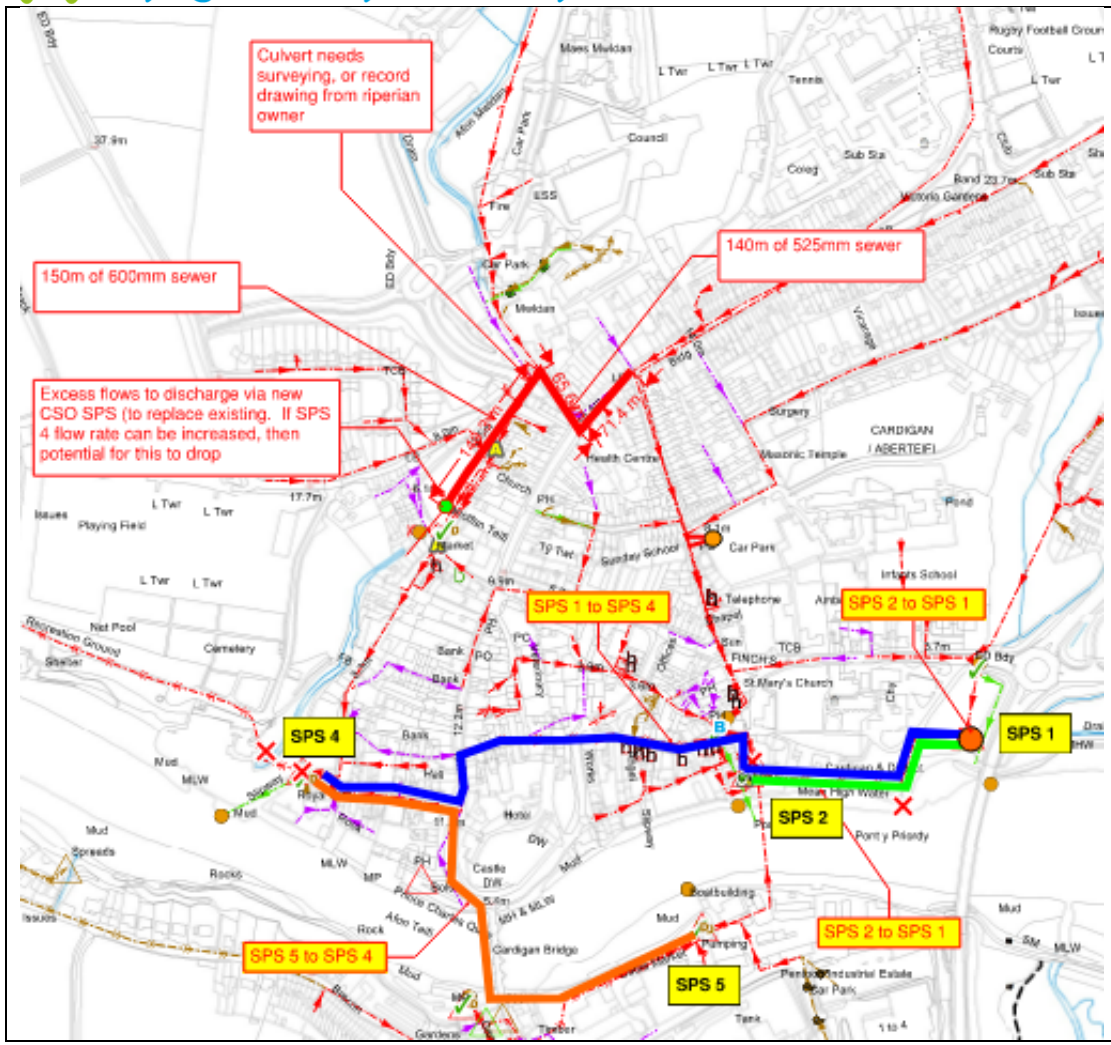
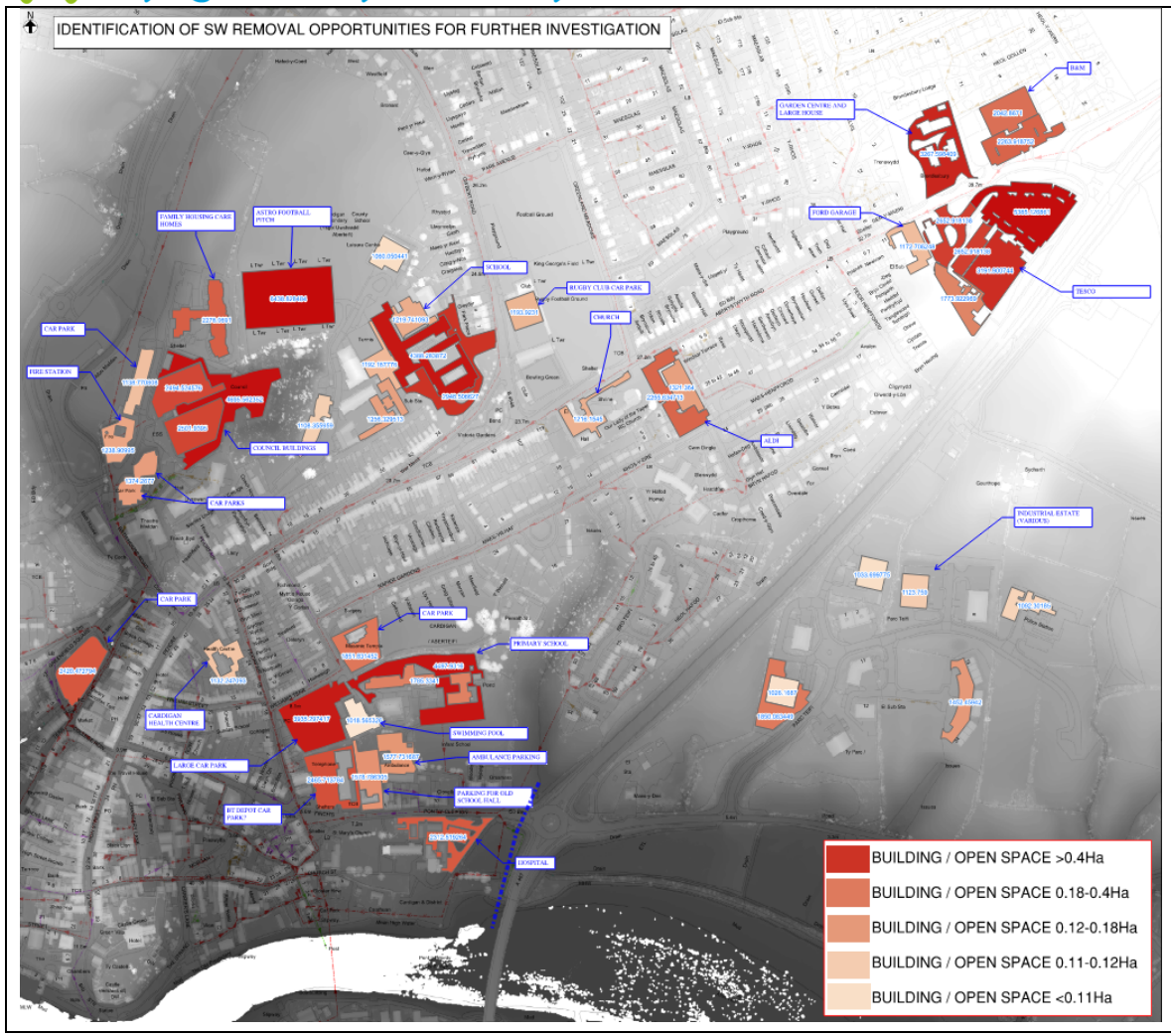


- Bifurcation of flows to divert from Lower Town area to Quay Street car park pumping station along with network upsizing and CSO pumping station at St Gloster Row
  - Bifurcation of flows from the top of Cardigan town and redirecting them to Quay Street pumping station
  - Sewer upsize along Pwllhai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

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


IDENTIFICATION OF SW REMOVAL OPPORTUNITIES FOR FURTHER INVESTIGATION
BUILDING / OPEN SPACE >0.4Ha
BUILDING / OPEN SPACE 0.18-0.4Ha
BUILDING / OPEN SPACE 0.12-0.18Ha
BUILDING / OPEN SPACE 0.11-0.12Ha
BUILDING / OPEN SPACE <0.11Ha

Appendix C

Agreed Solution Sign-off

Agreed Solution

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

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 Relief CSO	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: