Drainage and Wastewater Management Plan

Falmouth Case Study

May 2023

South West Water

Contents

Introduction

We wanted to delve deeper into our catchment solutions to improve our understanding and aid the development of our strategy for other catchments across our region. This document explores our case study catchment, the Falmouth Level 3 catchment in Cornwall. The outputs of this study, alongside similar assessments in Sidmouth and Plymouth, have significantly improved the accuracy of our solution design and cost estimating process. This learning has been applied throughout the wider DWMP and has been used to inform our scenario planning approach.

Throughout this process we have worked closely with our internal and external stakeholders on proposed locations, solutions, impacts and identifying opportunities for partnership working. Notably, we have worked closely with the Environment Agency, Cornwall Council, Falmouth Town Council and Penryn Town Council to co-create and co-develop our strategy for the catchment and thank them for their input.

A combination of both desktop analysis and site visits has been carried out, and we have been able to identify several potential solutions. Our solution modelling unlocked a more complete holistic view of the catchment, providing the benefit of optimising solutions. In this catchment, hydraulic modelling has been extended to cover spill risk, updated using the latest climate change projections from the Met Office, and recalibrated to improve its alignment to observed Event Duration Monitoring spills.

In order to reduce overflow spills to 10 (or below) a year by 2040, Table 1 summarises the favoured option and the associated investment required in the Falmouth Level 3 catchment.

Storage (m^3)	Surface Water Separation (ha)	Network enhancement (km)	Sewer Upsizing (km)	FFT increase (l/s)	PFF increase (l/s)
2,820	11.9 (13%)	19 (12%)	11.6 (7%)	71	16

Table 1: investment required to reduce overflow spills to below 10 per year.

What are the risks?

Initially, we wanted to understand what the risks are in the catchment. Our detailed review and catchment modelling identified 17 storm overflows requiring intervention to reduce spills to meet the Government targets (10 spills or less per year) and identified the locations at risk of flooding in a 1:50 storm event (Figure 1).

Figure 1: Baseline 2050 1:50 flood risk locations (blue) and storm overflow sites with more than 10 spills (red). Storm overflows that are already compliant with the Government spill targets are shown in green.

Types of Solutions Considered

As outlined in our 'Green First' Framework document, we considered Green, Blue and Grey solutions to address flooding and spill risk. A summary of these categories can be found below:

- Green – Semi-natural spaces and assets that use ecologically driven processes to treat and slow or stop rainfall runoff. These options enhance the urban environment in a variety of ways. Green solutions can be applied upstream in the river catchment, in the sewer network (such as Sustainable Drainage Systems - SuDS), and downstream in areas like wetlands
- Blue – infrastructure includes the ponds, waterways, wet detention basins and wetlands within a drainage network
- Grey – Traditional engineering solutions such as tanks for storage of combined and foul flows

Our Green First approach means that we will always look for Green and Blue opportunities within our Falmouth Case study.

Green Solutions

Green Solutions – Upstream and Downstream

The potential for upstream and downstream nature-based solutions in the Falmouth Level 2 catchment was explored to identify opportunities to address issues associated with storm overflow discharges. This included:

- Nature based Solution (NBS) measures upstream of the sewer network, such as ponds, scrapes, woodland planting
- Wetlands downstream of the sewer network
- Coastal NBS approaches

Green Solutions – in the Sewer Network (SuDS)

As well as upstream and downstream solutions, we reviewed the opportunity for green solutions (SuDS) in the network. SuDS solutions will attenuate flows which will then discharge back into the existing pipe network. In order to simplify the range of network options across the Falmouth catchment and enable a similar assessment elsewhere, the SuDS considered were grouped by type as follows:

- **Rain gardens**: Shallow depressions with absorbent yet free draining engineered soil and planted with vegetation
- **Detention basins**: Shallow, open depressions that are normally dry, but in heavy rainfall provide capacity to store water for a short time. Designed to maximise infiltration into the soil
- **Swales**: Vegetated channels used to slowly convey run-off, whilst promoting infiltration and the filtering out of pollutants
- **Permeable paving**: A hard landscaping measure that stores surface run-off in underground cells before allowing infiltration into the ground and/or discharge to another drainage feature

SuDS are not as well developed in the industry compared to traditional grey solutions so there is more risk and uncertainty in delivery, effectiveness and maintenance. At their most beneficial, SuDS are nature-based solutions that mimic natural systems and provide us with a green approach to drainage and wastewater management. SuDS can provide multiple benefits to the community and the environment as well as to the sewer network in attenuating flows and improving the water quality of the flow that is discharged.

Blue Solutions (SWS and Network Enhancement)

In urban locations most surface water is collected from roofs, hardstanding areas and roads and transferred either by surface water pipes to an outfall or via combined sewers to a WwTW. Most storm overflow spills are caused by heavy rain overwhelming the combined sewers. Storm overflows act as safety valves that help prevent properties flooding by discharging diluted excess flows into the local watercourse.

Surface Water Separation (SWS) is therefore a solution that targets the root cause of storm overflow spills and flooding by removing the (blue) surface water from the combined sewer system. In a typical SWS scheme, a new surface water sewer network is installed to intercept run off from properties, convey it in a new surface water sewer in the road, picking up highway run-off and discharging it to a nearby watercourse.

In addition to SWS solutions, network enhancement has been considered to reduce inflow from other sources that do not require treatment at the WwTW, such as misconnected land drains, overland flow of surface water, groundwater and tidal flow. These schemes have been targeted at three key sites within Falmouth where additional inflow has previously been investigated or modelled as part of previous investment programmes.

The option of water butts filling with rainwater from roofs provides a Blue Green option and can slow flows from entering the combined system. When there are hundreds or thousands of these across a catchment, they could make a significant difference to the flow arriving to the sewers and therefore help reduce SO spills and flooding if they are not full before it rains. There are two ways of ensuring they have capacity: 'Smart' water butts have a computer which automatically empties the water butt when rain is forecast and 'Leaky' water butts which have a small hole in the bottom so that they are always slowly emptying. Water butt solutions would be targeted in areas where SWS and SuDS schemes may be less practical due to local site constraints. An additional benefit of water butts is the reuse of rainwater for garden watering which supports our drive to improve clean water efficiency as outlined in our Water Resources Management Plan.

Grey Solutions (Storage, Upsizing, Full Flow to Treatment)

Combined sewer storage tanks hold excess flows from heavy rainfall, then return them when downstream pipes have the capacity to convey the flows to the WwTW, protecting the system from spills and flooding. Storage is a well-established option; the impact is easily quantified, and it is often cost-effective so as a result there is less perceived risk and more confidence in delivery. However, storage does have some limitations:

- Storage does not address the root cause of problem (excess surface water)
- If future needs change, they are difficult to extend
- Some locations do not have enough space to construct a large enough tank
- They have a high carbon impact

In some cases, pipe upsizing might be necessary to remove hydraulic restrictions and convey additional flows to the WwTW so they don't back up and cause flooding or spills. This can also be expensive and cause disruption, particularly on longer lengths of larger diameter sewers in main roads.

Finally, as more flow is passed to the WwTW to reduce spills and flooding, there are two options to prevent additional storm overflow spills once it arrives. Firstly, if there is space, it can be stored in a tank until after the storm event and the works has sufficient capacity to treat the flow. Secondly, to expand the WwTW process capacity so that a higher flow rate can be treated. Treating additional flows or increasing flow to full treatment (FFT) is expensive because it requires investment in land, equipment, energy and chemicals. It is more sustainable to reduce flow to the WwTW as much as possible by keeping the inflow from rainfall and other sources that do not need wastewater treatment separate from the foul water upstream of the WwTW.

Methodology

The catchment planning process used for the case studies has been summarised in both Figure 2 and the below bullet points:

- Modelling - The Phase 1 outputs from the draft DWMP were reviewed and the modelling updated to include the latest climate change projections and calibrated against recent Event Duration Monitoring of spill data.
- Optioneering - Green, blue and grey options were then developed at individual sites to produce high level solutions which were fed back into the model to further understand their catchment wide impact. This stage was carried out in collaboration with the stakeholders in the catchment.
- Recommendation - Finally, the recommendations consider the combined impact of the solutions together with the estimated costs and benefits.

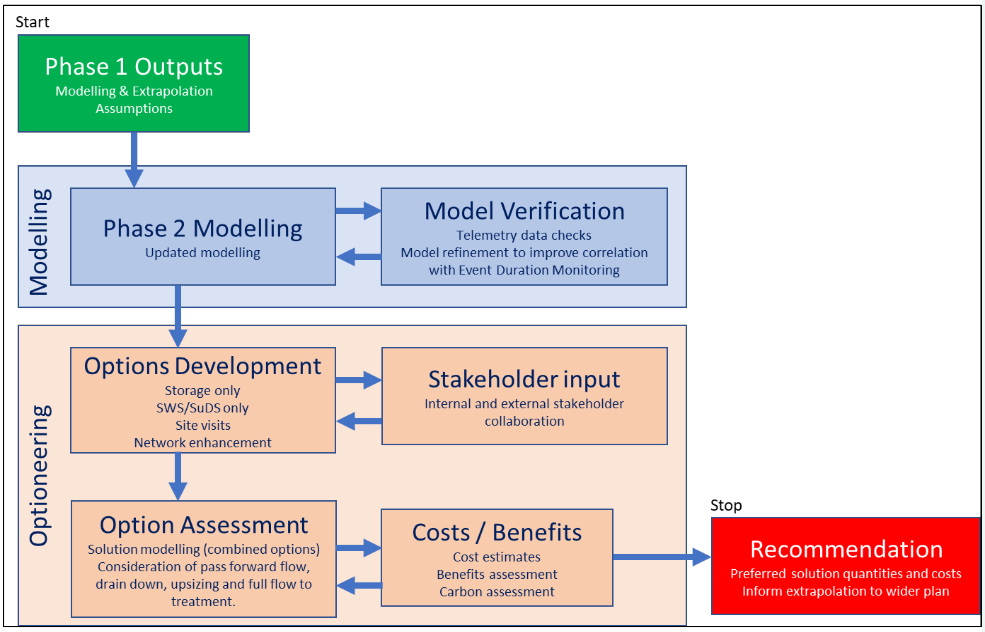


Figure 2: Catchment Planning Process

We used set data, hydraulic model information and mapping to outline solutions that could be employed to meet our goals. The proposed SuDS and SWS sites were all visited to get a better assessment of potential implementation. We consulted with our key stakeholders throughout this process to get feedback on risks, constraints, and opportunities. For example, we explored the potential opportunities for partnership working, especially for SWS and SuDS locations. Stakeholders consulted were:

- Falmouth Town Council
- Penryn Town Council
- Cornwall Council

- The Environment Agency

Green, Blue and Grey solutions were developed and costed separately to individually assess cost and benefit and in total:

- 11 storage solutions have been identified covering 14 SOs
- 17 SWS and SuDS solutions were developed and costed

Solutions Development

Green Solutions – Upstream and Downstream

To explore the potential for Green solutions upstream and downstream, we carried out opportunity mapping using a data-led approach, which created a replicable and scalable method that can now be used elsewhere.

Inland, several locations were identified where NBS intervention could attenuate peak flow through the sewer network. Proposed measures include offline runoff attenuation, leaky barriers and Blue-Green infrastructure. Rainwater harvesting, alongside SuDS, was also identified as a potential option to ease pressure on part of the sewer network. One of the level 3 catchments within Falmouth also has the opportunity for treatment via a wetland. We will continue to explore this opportunity and review its feasibility, considering its proximity to a SSSI and productive agriculture land.

Opportunities on the Falmouth catchment coastline identified for coastal NBS include seagrass beds, native oyster beds, blue mussel beds, algae beds and seaweed farming. Native oyster beds could be sited near storm overflows for nutrient mitigation, while the other NBS provide more general benefits to the catchment including carbon sequestration, sediment stabilisation, nutrient storage and biodiversity support. The coastal region has great potential for partnership working, in part due to the variety of benefits that could be realised.

A key outcome of our upstream and downstream study was to inform the considerations we would need to take into account to implement upstream and downstream solutions across our region. These considerations have fed back into our process: for example, an approach to group storm overflows into clusters to understand their collective environmental impact, as well as the inclusion of wider drainage and wastewater issues.

Green Solutions – in the Sewer Network (SuDS)

Our review of sewer network green solutions identified 17 locations for SWS and SuDS. High level designs have been produced for locations, for which we have reviewed the costs and benefits of each SuDs feature, as well as for the entire scheme as a whole. This included a review of the maintenance and operational requirements. A summary of one of these designs is shown in Figure 4.

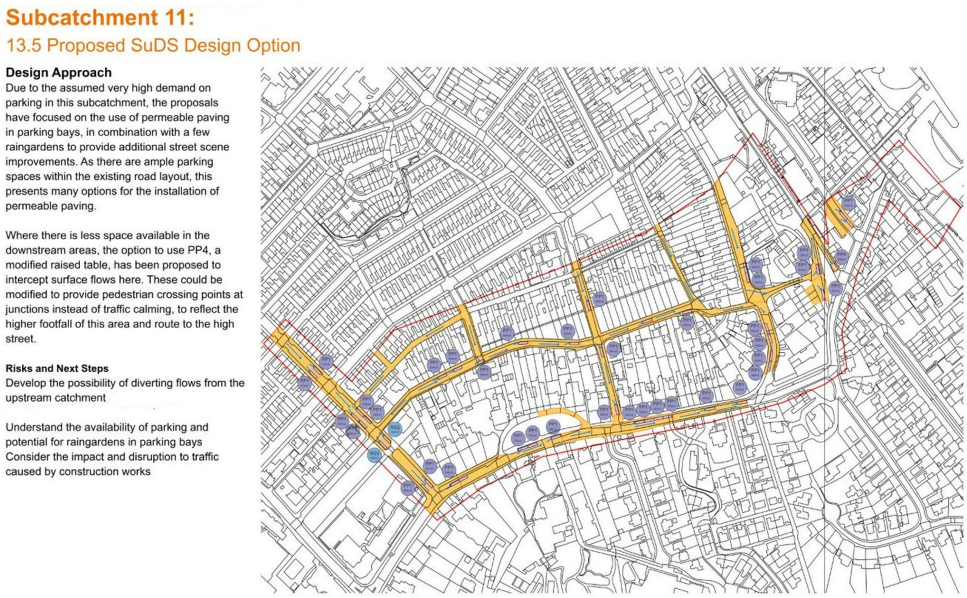


Figure 4: Example SuDS high level design showing locations of features and contributing road area

Blue Solutions (SWS, Network Enhancement)

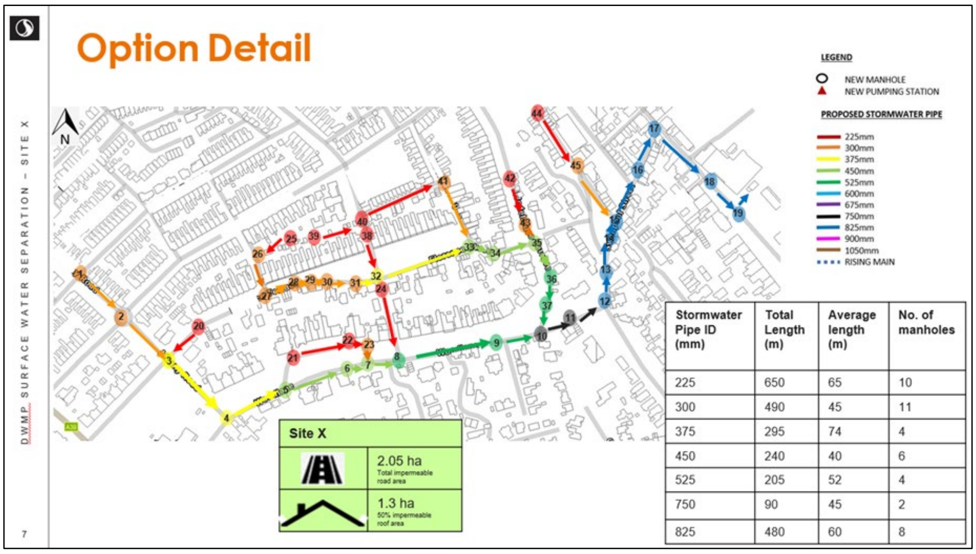
Surface Water Separation (SWS) was focused on collecting flows from the front of properties. This is because work on private property and in back gardens can be difficult, disruptive to customers and expensive. As such, we assumed that that surface water could be separated from half of the total roof area, front gardens and driveways, plus highways where there is not already a separate highways pipe.

Where possible, impermeable area surveys and highways records were used to confirm connectivity to the combined system and contributing area. Most areas were not believed to have separate highways pipes, but where thought to be present, it was assumed they had insufficient capacity for additional flow so a new pipe will still be required. In future design phases, we will explore the potential to lay a new foul sewer and convert the existing combined sewers to surface water pipes.

It was assumed that new outfalls and permissions will be required to discharge flows to a watercourse or the sea for all areas, although detailed design may reveal the potential to use existing outfalls. To protect the receiving watercourses from water quality issues, particularly pollutants from road run-off, provision was made in all cases for oil and solids separators. To provide further quality protection and prevent deterioration in flood risk, we propose that new outfalls to rivers and designated Bathing Waters will include SuDS schemes to attenuate flows and remove pollutants.

17 potential locations were identified for blue interventions upstream of predicted flooding and problem storm overflows, totalling 32 ha of surface water contribution. These 17 schemes provided separation of 30% of the contributing area.

An assessment was made of the sewer flows, pipe sizes, manhole configuration and outfalls for a new surface water system to enable separation from the combined network. The system was designed to a 1:30 return period storm. An example of a proposed layout of a separated network is shown in Figure 5 below.



Stormwater Pipe ID (mm)	Total Length (m)	Average length (m)	No. of manholes
225	650	65	10
300	490	45	11
375	295	74	4
450	240	40	6
525	205	52	4
750	90	45	2
825	480	60	8

Figure 5: Example SWS high level design showing locations of new surface water network pipes, manholes and pumping stations

The 17 locations were then ranked according to the following criteria: proximity to risk areas, their likely impact on flooding and storm overflow spills and construction risk. Schemes that scored the least were removed to produce a 20% separation option. A 10% option was also established, utilising the schemes that scored the highest in the ranking criteria.

Grey Solutions (Storage, Upsizing, Full Flow to Treatment)

Hydraulic modelling estimated the storage volumes required to meet the 10-spill target at 11 sites covering 14 storm overflows (one storage tank was the solution for four storm overflows which combined in the same screening chamber). Storage only solutions were developed by assessing flows, volumes, available space, pump returns and calculating the size of the storage tank required. As it is anticipated that a range of solutions will be implemented, the storage volumes used were deemed worst case. These volumes were then refined after model recalibration and subsequent hydraulic modelling.

As well as this, we have been working with our partners, the Environment Agency and Cornwall Council, on the Falmouth Integrated Urban Drainage Management (IUDM) scheme. This partnership project investigated the causes of flooding around the Prince of Wales Pier from all sources.

The Environment Agency and Cornwall Council are supportive of SWS and SuDS and see them as the most sustainable long-term solutions that deliver the most additional benefits and least carbon impact. We know that we need to challenge ourselves to deliver more SWS and SuDs using our Green First approach.

Benefits Assessment

Benefits of the potential schemes were assessed using three different tools:

- Stantec Benefits Assessment Tool (BAT) v5.2, developed for the Water Industry National Environment Programme
- Construction Industry Research and Information Association (CIRIA) SuDS Benefits Estimation Tool (B£ST) version 5 - Coarse Assessment
- PR24 Carbon Accounting Tool developed for the Water Industry National Environment Programme and enhanced to include SWS and SuDS

The Benefits Assessment Tool was applied to all schemes to capture and estimate the value of additional benefits under:

- Natural environment - biodiversity, air quality
- Net zero - climate regulation
- Catchment Resilience - flooding regulation, water quality
- Access, Amenity and Engagement - Recreation, Education and Volunteering

The B£ST coarse assessment tool was applied to Green SuDS solutions. The tool covers similar benefits as the Benefits Assessment Tool, but is designed specifically for SuDS and covers additional elements:

- Impact on properties at risk of flooding
- A wider assessment of river quality improvements.

The PR24 Carbon Accounting Tool was used to calculate the total embodied carbon, operational carbon and whole life carbon of the Green, Blue and Grey solutions.

The benefits assessment found that the benefits were higher for SWS solutions than storage, and higher still for SuDS solutions reflecting the increased value of more Blue and Green solutions. However, the costs for these options were also higher, so consideration needs to be made to balance cost and benefit between solution options (storage v SWS) and SWS approaches (traditional v SuDS).

Similarly, the total embodied carbon was highest for the storage only solutions with an average of 336.9 tCO2e, SWS was an average of 124 tCO2e and SuDS considerably lower at an average of 16.7 tCO2e. The main reason for this was the need to pump in the majority of storage solutions, both to return flows back to the sewer, and to retain pump and treat more flows than SWS. SWS was higher than SuDS due to the need to construct new surface water sewers.

These findings are in line with our understanding and have helped us to inform our Green First Framework, which is described in a separate document. As per the Green First approach, in order to maximise the benefits, Green solutions will be delivered in combination with Blue and Grey solutions. As well as reducing storm overflow discharges, this will enable us to deliver additional benefits such as mitigating flood risk and water quality impact, improving biodiversity and creating a better place for people to live.

Scenario Modelling

Once the potential solutions were developed, over 300 scenarios of different solution combinations were modelled using the Falmouth hydraulic model and the predicted outcomes of spill volumes and properties flooding were captured. All modelled scenarios required network enhancement to reduce inflow by 30% as well as increased flow capacity at three sites: Flushing SPS, Praze Tank, and Falmouth WwTW.

Combinations of separation at 10, 20 and 30% were explored, with a view that these solutions covered traditional Blue and Green SuDS solutions. As Falmouth is a coastal catchment, tides can impact the network and exacerbate flooding and reduce spills. Therefore, a combination of different tide levels with a 1 in 50 storm event was considered.

Six summary options were presented for assessment to align with the scenarios being considered for the wider DWMP programme:

- 1a. 10% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill target**
- 2a. 20% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill target**
- 2b. 20% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill & flood risk targets**
- 2c. 20% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill & flood risk targets, high mean water spring tide**
- 3b. 30% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill & flood risk targets**
- 3c. 30% SWS + Storage + 30% network enhancement + Pass Forward Flow
    - **Addresses storm overflow spill & flood risk targets, high mean water spring tide**

Collaborative Learning

The Falmouth scheme has shown that there is limited funding within the local councils and other risk management authorities. Most of the agencies involved would be looking for Grant in Aid funding through the Environment Agency and as such cannot commit to funding until later in the development process when these Grant in Aid applications are made. Whilst schemes could be supported out of the Grant in Aid allocations, these are limited and are more likely to be in the £10-100k arena. It is therefore likely that we are only likely to see 1-2% of financial contributions from third parties across the programme.

It has shown, however, that there is a willingness to support and that there are pockets of land available either for the construction of storage tanks or SuDs (although these are not necessarily in the right locations hydraulically). Stakeholders are keen to continue to work with us to co-create and co-develop solutions in order to provide beneficial outcomes in their local area.

Results

All scenarios required network enhancement to reduce inflow by up to 30% at key locations. In addition, storage was not feasible at three sites due to the excessive volumes predicted to be required by the hydraulic model. As such, flow increases to Pass Forward Flow (PFF) or Flow to Full Treatment (FFT) will be needed:

- Flushing SPS requires a reduction in inflow from the catchment and estuary, so provision was made for relining 1.2km of sewers and sealing assets at an estimated cost of £1m. Increases in PFF, which varied by scenario, would be achieved by uprating pumps.
- Praze Tank, Penryn requires a reduction in inflow from a large upstream catchment, so provision was made for relining 9.2km of sewers at an estimated cost of £7m. It is assumed the increase in PFF can be achieved easily by controlling the automated penstock although downstream impact would need detailed modelling.
- Falmouth WwTW requires a reduction in inflow in the upstream subcatchment, so provision was made for relining 1.2km of sewers at an estimated cost of £1m. An increase in FFT was required, without which it was not possible to meet the < 10 spills target for the works. It is assumed that the required rates for different scenarios are achievable but would need expansion of the works beyond its existing footprint. The cost is estimated to be approximately £35m

17 surface water separation schemes totalling approximately 30% of the impermeable area were identified. Approximately 10% were considered high confidence of delivery, 10% medium confidence and 10% lower confidence.

Surface water separation delivers a marked improvement in spill and flooding performance and reduced the amount and size of storage required. The average unit cost of traditional blue SWS was £2.2m and all were new network installations. Unfortunately, no lower cost solutions, such as being able to connect to an existing surface water system, were identified. However, water butts would be incorporated into the solution.

SuDS options were possible for all 17 locations at a unit cost of £2.6m/ha. When the need for SuDS to attenuate flows and improve water quality mitigation was considered alongside the best combination of SWS and SuDS, the unit cost increased to £3.5m/ha.

The flood risk modelling revealed that in addition to SWS as the main solution, a considerable length of sewers would require upsizing to cope with predicted increases in flows and achieve a 5% property flooding target. For 8.2km of sewer upsizing, this would cost £11.9m.

With the mix of solutions recommended from solution modelling, notably SWS and FFT increase, the number of sites at which storage was required reduced from 11 to 4 and total storage reduced significantly, compared to a storage only option.

With regards to the partnerhship Prince of Wales Pier Integrated Urban Drainage Management scheme, the modelling indicates a storage tank of 1,100m^3 in the 10% SWS option. If we were to carry out 20% SWS, this reduces to 900m^3. However, in the other options, the storage required could be as much as 4,500m^3.

Table 2 below summarises the options for potential blends of solutions in the six different summary options.

Option No	1A	2A	2B	2C	3B	3C
SWS level	10%	20%	20%	20%	30%	30%
Network Enhancement	30%	30%	30%	30%	30%	30%
Storm Overflow spills	Yes	Yes	Yes	Yes	Yes	Yes
1:50 flooding <5%	No	No	Yes	Yes	Yes	Yes
1:50 flooding <5% High tide	No	No	No	Yes	No	Yes
Storage (number of sites)	4	4	4	4	4	4
Storage Volume (m^3)	2820	2360	5190	7190	4680	6180
SWS (number of sites)	7	10	10	10	17	17
SWS (Ha)	11.9	26.2	26.2	26.2	32.61	32.61
PFF Increase - Praze (l/s)	9	7	7	7	4	4
PFF Increase – Flushing (l/s)	7	6	10	10	10	10
FFT Increase (l/s)	71	61	58	58	45	45
Sewer Upsizing (km)	0	0	8.2	9.8	7.5	9.2

Table 2. Summary of potential solutions by summary option.

Our focus for the DWMP is Option 1A. This is because it aligns to our Best Value preferred scenario in the wider DWMP, which is explained in the Our Regional Plan document. Whilst not tackling flooding directly, the work at storm overflows will deliver additional benefits for flooding. We know that we may need to adapt in the future, should flood risk become more prevalent.

In the meantime, we will continue to go further in areas where there is a potential for collaborating with other stakeholders and delivering partnership schemes; for example, our contribution to the Prince of Wales Pier Integrated Urban Drainage Management scheme will go beyond that required of Option 1A. This is because we believe it is important to ensure that we maximise on opportunities to deliver better and more efficient outcomes for our customers and communities.

Accelerating Delivery

We know how important the issue of storm overflows is to our customers and stakeholders. As part of our WaterFit 2040 initiative, we will deliver improvements to storm overflows in line with Government targets by 2040, 10 years earlier than required. In Falmouth, we are going even further by accelerating delivery at nine overflows:

- 24 NORTH PARADE_CSO_FALMOUTH_SW 7989 3392
- FALMOUTH STW_SO_FALMOUTH_SW 8264 3206
- GREENBANK GARDENS_CSO_FALMOUTH_SW 8054 3343
- GROVE PLACE NO. 1_CSO_FALMOUTH_SW 8131 3245
- NORTH PARADE_CSO_FALMOUTH_SW 7989 3392
- OLD HILL SPS_PSCSOEO_FALMOUTH_SW 7973 3371
- PR OF WALES PIER SPS_PSCSOEO_FALMOUTH_SW 8083 3302
- SWANVALE SPS_PSCSOEO_FALMOUTH_SW 8048 3056

This will mean that we can start delivering improvements sooner, completing the associated schemes by 2028, rather than 2030.

Conclusion

This case study has demonstrated that in order to maintain and improve the performance of the sewage network to 2040, a blend of different solutions is required. The most effective solutions require a reduction of inflows to the network, such as SuDS, SWS and network enhancement to reduce inflow together with Grey solutions, such as storage tanks and, in some cases, an increase in treatment capacity at the WwTW.

Green and Blue interventions will provide additional benefits, particularly regarding a reduction in flooding and reduced pumping and treatment of surface water runoff. These benefits will be seen in all rainfall events, even beyond the 1 in 50 design criteria. In addition, Green and Blue solutions will have wider environmental and societal benefits.

SuDs interventions provide the most additional benefits and have the least impact in terms of embodied carbon, with SWS offering slightly lower benefits, and storage providing the least. However, those options that provide additional benefits are also higher in cost, can take longer to deliver, and carry higher uncertainty in terms of their outputs. As such, a combined approach to solutions is preferred, following our 'Green First' framework.

The case study has provided significant detailed information about tackling storm overflows, the learnings from which we have been able to utilise in the production of the storm overflow investment programme across the other catchments.

It has also helped us continue to expand our co-creation and co-development approach, identifying opportunities for partnership working in order to deliver better outcomes in an efficient way.

Accelerating delivery at nine overflows will also enable us to start sooner on our journey and provide critical learning for us and our delivery partners to utilise across the wider storm overflow improvement programme.