Drainage Strategy Framework

For water and sewerage companies to prepare Drainage Strategies

Good practice guidance commissioned by the Environment Agency and Ofwat

Environment Agency

OFWAT
Water today, water tomorrow

May 2013

Halcrow
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Document history

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Appendices

Appendix A Glossary

1 Introduction

1.1 Background and Purpose

Water for Life[1] recognised that longer term planning for water and sewerage company drainage infrastructure has had less focus than water supply infrastructure. It set out a commitment to ensure a more strategic approach to drainage planning. This is important, to demonstrate that economic growth is supported, the environment continues to be protected and that climate change adaptation[2] is planned for appropriately.

Since privatisation, water and sewerage companies have invested to achieve significant improvements to the environment and the service customers receive, notably reducing the number of properties known to be at risk of flooding. This investment has been a reaction to the issues inherited at privatisation. It is now appropriate to look forward to ensure that water and sewerage companies, working together with other partners, are able to deliver the outcomes that customers need and want.

For the next price review water and sewerage companies will propose a number of high level outcomes that they will deliver. An outcome should reflect their customers' priorities, identified through appropriate customer engagement, and deliver the best long-term, sustainable solution for customers and the environment. An outcome may not be bound by a single price control period and should be set in the context of customers' and the environment's long term needs.

Outcomes are likely to be framed at a high level for each water and sewerage company's area. However, the way in which these outcomes are delivered in a particular drainage catchment will depend on the characteristics of that catchment and the partners that the water and sewerage companies work with.

Companies will set out the measures they will use to demonstrate delivery of outcomes. An UKWIR study[3] has described example measures that include: the number of properties which experience sewer flooding; the number of properties at risk of flooding; the number of properties at risk from sewerage asset failure; risk indices that capture both the probability and consequence of failure; customer satisfaction with regards to clean rivers and beaches; the number of pollution incidents; the frequency of combined sewer overflow operation; and compliance with discharge permit conditions[3]. Most measures are likely to be meaningful at a catchment scale, as well as at the overall company level. This Drainage Strategy Framework illustrates good practice in how to prepare a Drainage Strategy for a particular catchment that is in line with it delivering its outcomes in that location. It is based around established planning approaches and emphasises six key principles. It has been designed to be informative and flexible so that it can be applied in different circumstances to suit companies' needs and customers' expectations. Most of the elements of the framework are taken from existing good practice in water and sewerage companies. However, articulating and communicating a clear Drainage Strategy for an area is not yet common practice. By adopting the

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[1] http://www.defra.gov.uk/environment/quality/water/legislation/whitepaper/

[2] Ofwat has published research illustrating the predicted scale of increased sewer flooding risks due to climate change and growth http://www.ofwat.gov.uk/sustainability/climatechange/rpt_com201106mottmacsewer.pdf

[3] UKWIR has published guidance on Defining and Incentivising Outcomes and Measures of Success http://www.ukwir.org/ukwirlibrary/96066

Framework principles and developing Drainage Strategies, water and sewerage companies will be better able to provide greater confidence to all stakeholders that outcomes can be achieved in the long term.

A Drainage Strategy should help customers and other stakeholders understand how a water and sewerage company intends to deliver its statutory functions over the long term within a particular area in a sustainable and economic manner. The Drainage Strategy should explain how a water and sewerage company will do this in conjunction with other organisations (e.g. The Environment Agency, Natural Resources Wales, local authorities, highways authorities, housing developers)[4] and how the company, in turn, will support these organisations in delivering their own responsibilities as well. For example, the Drainage Strategy should signal to housing developers and other interested parties how sewerage infrastructure will develop so that they are able to plan accordingly and contribute to economic growth.

The Environment Agency, Natural Resources Wales and Ofwat expect that Drainage Strategies will be developed (following a risk based approach) in accordance with the six principles in a way that suits local circumstances and customers' expectations. In England, Defra has described[5] the requirement for companies to continue their investment in Drainage Area Plans for the period 2015 to 2020 and subsequent planning cycles so that these can be used as the basis for the development of Drainage Strategies. The Environment Agency, Natural Resources Wales and Ofwat believe that companies completing Drainage Strategies will be well placed to deliver their long term outcomes.

1.2 Attributes of a Drainage Strategy

A Drainage Strategy should be accessible and understandable to customers, local authorities, developers, the Environment Agency (in England), Natural Resources Wales and other stakeholders that may be interested in what the water and sewerage company intends to do in the future. It will give confidence to all stakeholders that the water and sewerage company will deliver their duty of providing a public sewerage system that will deliver stated outcomes. The Drainage Strategy will encourage a more strategic approach that is less reactive and more proactive in providing what customers and environment requires.

A Drainage Strategy should normally cover the drainage area containing public sewers serving a single wastewater treatment works, although in large cities it may be prudent to sub-divide into smaller areas. Adjacent drainage catchments, impacting on the same receiving water, ought to be considered together. When planning to accommodate growth, allow for climate change and maintain or improve water quality (in rivers and the sea) it will often be necessary to consider the interaction of public sewers and wastewater treatment works.

A Drainage Strategy should be developed by the water and sewerage company with a primary focus on its network of foul, combined and surface water sewers. However, the company should work with other organisations so that their role in controlling the demand on sewers is confirmed and the company plays its part in the resolution of wider drainage, surface water flooding and water pollution issues in the catchment.

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[4] The Environment Agency and Natural Resources Wales already collaborate with local authorities to undertake strategic planning for flood risk management from rivers and the sea. (e.g. through the control of development in floodplains)

[5] http://www.defra.gov.uk/publications/2012/10/05/pb13829-statement-obligations/

The following section (1.3) is provided as a generic illustration of how companies might choose to communicate the process of developing, selecting and delivering a Drainage Strategy in a location. Full technical analysis and documentation demonstrating how the six principles have been followed needn't be made publically available as this may contain confidential, complex and sensitive information. It is envisaged that a Drainage Strategy could be communicated within up to 20 written pages depending on size and complexity.

1.3 Suggested Elements of a Drainage Strategy for Sharing with Partners and the Public

The following is provided as an example of the type of information that could be shared publically to communicate the Drainage Strategy for a catchment.

1. Provide a catchment description and map illustrating principal drainage and related water infrastructure (e.g. larger sewers, combined sewer overflows, wastewater treatment works, rivers and ordinary water courses). Explain how wastewater and stormwater are collected and treated.

2. Describe company aims and outcomes and how these relate to the drainage system. Indicate the performance measures that will be used to monitor progress towards the achievement of outcomes. Report on current and historical patterns in performance measures for the catchment (e.g. number of flooded properties, number of pollution incidents, and frequency of combined sewer overflow operation).

3. Summarise the wider drainage issues in the catchment, their relation to the company's assets and the organisations consulted in the development of the Drainage Strategy (e.g. describe areas of significant surface water flooding).

4. Describe and quantify any pressures in the catchment that will affect the achievement of outcomes – e.g. population change, urban creep, new development, climate change, asset deterioration, water consumption and environmental legislation.

5. Describe how the pressures identified will influence predicted future performance measures (a do nothing scenario). Show the rate of change over time and discuss any uncertainties.

6. Describe a short-list of alternative strategies that are technically feasible and result in the achievement of outcomes for the catchment. Explain the strengths, weaknesses, opportunities and threats of alternative strategies considering societal benefits, whole life costs, programming, uncertainties, and the role of other organisations. Consider the perspectives of customers and other organisations (e.g. with reference to Local Flood Risk Management Strategies or River Basin Management Plans).

7. Explain the selection of a preferred strategy (with reference to SWOT analysis) and illustrate this in more detail with plans, timelines and images so that stakeholders understand what might be involved and how it will impact on them. A full disclosure of strategy appraisal is not necessary. The roles of other organisations should be agreed and described.

8. Explain how progress towards delivery of the Drainage Strategy and the achievement of outcomes will be monitored and reported.

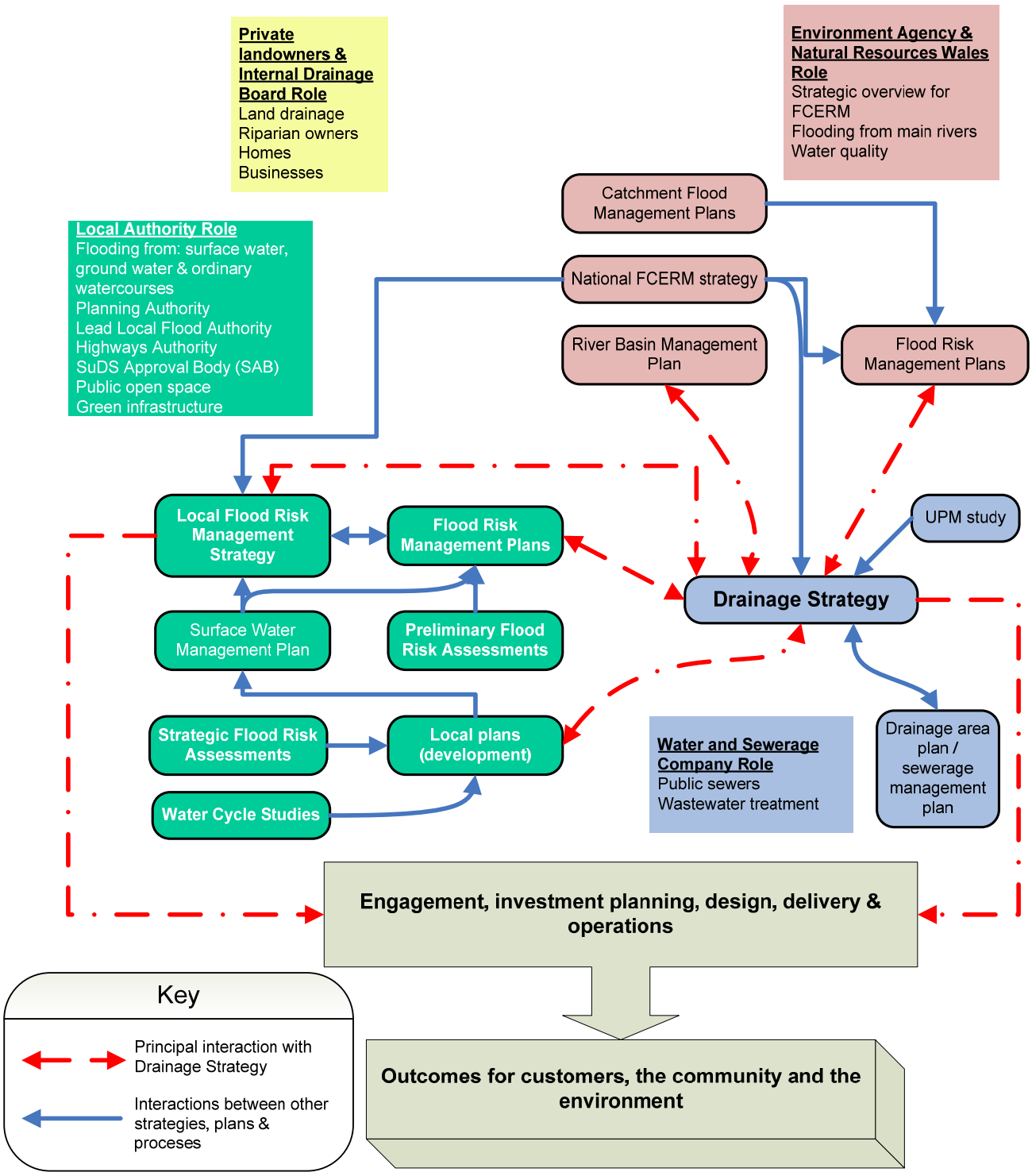

Figure 1 Water and sewerage company Drainage Strategy interactions with other strategies, plans and processes relating to flood and water quality management.

Figure 1 illustrates how a water and sewerage company produced Drainage Strategy relates to the strategies, plans and processes of other partner organisations in flood and water quality management. The principal external (to water and sewerage company) relationships are between Drainage Strategies and:

- Local Development Plans (of planning authorities);
- Flood Risk Management Plans;
- Local Flood Risk Management Strategies (of Lead Local Flood Authorities); and
- River Basin Management Plans (led by the Environment Agency).

A Drainage Strategy should be risk and evidence based and should lead to companies minimising whole life costs whilst still delivering outcomes for customers and the environment. It should recognise that population growth, new development, urban creep, climate change and changing customer behaviour all exert new pressures and demands on drainage systems.

A Drainage Strategy is there to facilitate both long and short term planning. While relatively few Strategies are likely to be complete in advance of 2015, we expect companies to adopt a risk based prioritisation approach to develop further Strategies in the coming years. Once complete, more detailed planning should be consistent with the long term Strategy both up to and beyond future price reviews (although it is recognised that competing priorities may affect the pace at which outcomes are delivered).

A Drainage Strategy is likely to contain a mixture of responding to current problems, pro-actively reducing risks for predicted problems, improving operational responses and acting to improve data and reduce uncertainty. An example structure for a Drainage Strategy is included in Section 1.3.

1.4 Links with Established Drainage Planning Processes

The Drainage Strategy framework encompasses and supplements established planning processes and technical guidance which have been applied selectively and adapted by water and sewerage companies (and Lead Local Flood Authorities) in recent years when planning for drainage systems.

These include:

- Common Framework for Capital Maintenance Planning[6]
- Sewerage Management Plans (Sewerage Risk Management 5)[7]
- Urban Pollution Management 3[8]
- Surface Water Management Plan technical guidance[9]
- Local Government Association Framework to assist the development of the Local Strategy for Flood Risk Management[10]
- Long Term/ Least Cost Planning for Wastewater Supply-Demand (to be superseded in 2013)[11]
- Water Cycle Study Guidance (2013 revision in print) [12]

These CIWEM[13] Urban Drainage Group (WaPUG) published technical guides are also in widespread use:

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[6] http://www.ukwir.org/ukwirlibrary/80474 (££- indicating that a charge is made to access this content)
[7] http://srm.wrcplc.co.uk/ (££)
[8] http://www.fwr.org/UPM3/
[9] http://www.defra.gov.uk/publications/2011/06/10/pb13546-surface-water-guidance/
[10] http://www.local.gov.uk/web/guest/local-flood-risk-management/-/journal_content/56/10171/3618366/ARTICLE-TEMPLATE
[11] http://ukwir.forefront-library.com/reports/07-rg-08-2/91714 (££)
[12] http://www.environment-agency.gov.uk/research/planning/33368.aspx

- WaPUG code of practice for the hydraulic modelling of sewers (3rd edition)
- WaPUG guide to quality modelling of sewer systems
- WaPUG integrated drainage modelling guide

The sewerage risk management and surface water management methodologies, in particular, share a common phased approach to understanding drainage problems and developing cost effective solutions. These phases are central to good practice in drainage planning and are central to the development of a Drainage Strategy.

Generically, these phases include:

- **Initialisation / Preparation phase**; where data are collated to understand current issues in the system and necessary partners are consulted with to agree success measures and objectives.
- **Risk assessment phase**; where predictive tools are used to quantify current problems and predict how these problems will change in the future.
- **Options appraisal phase**; where the costs and benefits of alternative remedies that meet agreed objectives are considered. This informs the selection of a preferred solution or solutions.
- **Implementation phase**; where drainage improvements are financed and delivered and the effectiveness of improvements monitored.

The process is cyclical, indicating that it is periodically revisited to confirm previous decisions, address uncertainties and adapt to a changing environment. Figure 2 and Figure 3 illustrate the Sewerage Risk Management and Surface Water Management Plan planning processes.

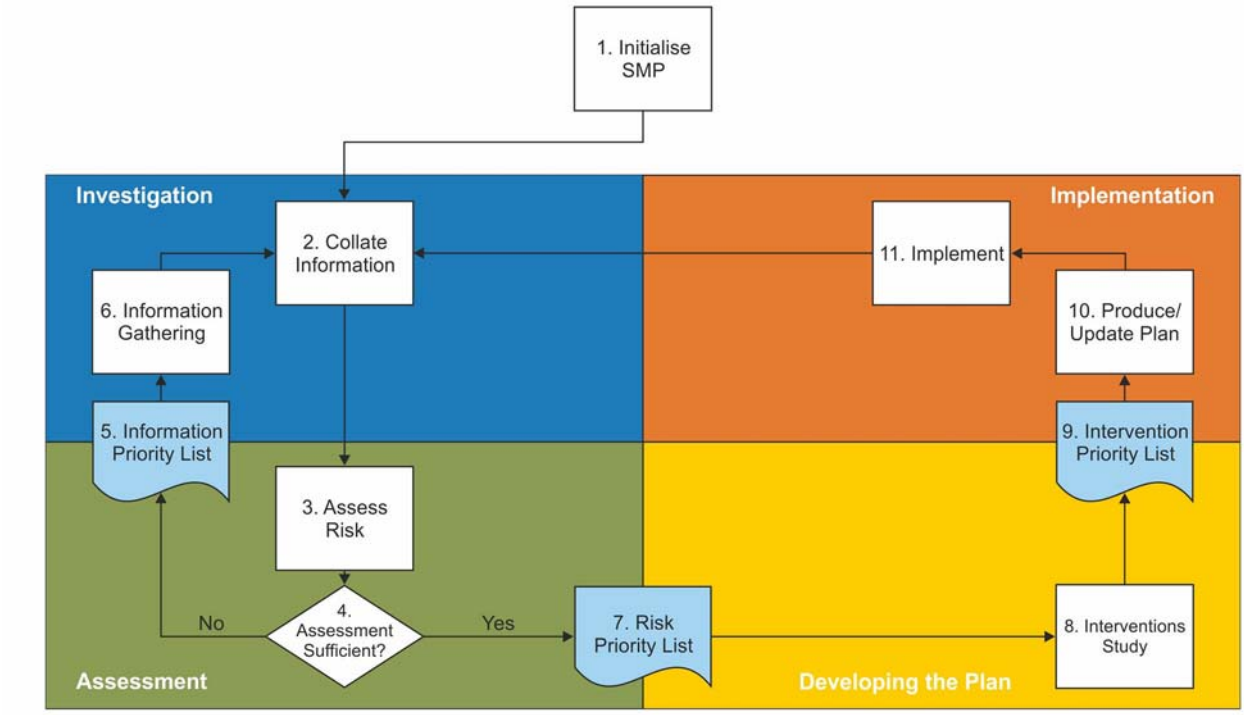

Figure 2 Sewerage Risk Management Approach (Copyright WRc plc http://srm.wrcplc.co.uk, used with permission)

13 http://www.ciwem.org/knowledge-networks/groups/urban-drainage/publications/modelling-guides.aspx

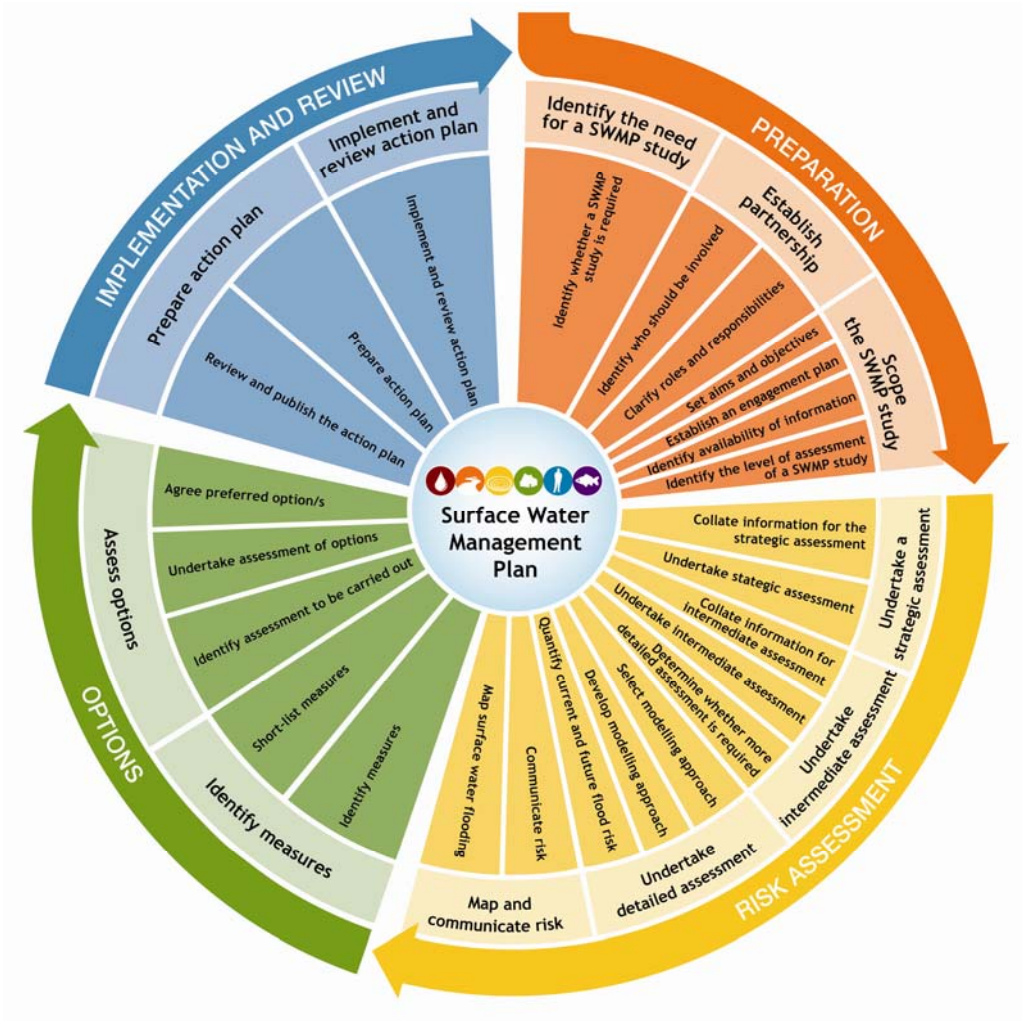

Figure 3 Surface Water Management Plan Approach

Ofwat has previously commissioned research[14] on current practice in sewerage planning and drainage area plans, concluding that traditional drainage area plans are no longer widely undertaken but that these activities are generally undertaken under different guises.

[14]http://www.ofwat.gov.uk/future/sustainable/drainage/rpt_com20111208drainage.pdf

1.5 Statutory Obligations and Regulatory Drivers

1.5.1 Government

Drainage planning is undertaken within a context established by a variety of Government policies and instruments. These are succinctly detailed in Defra's October 2012 Statement of Obligations[15] (for England) which is to be referenced by water and sewerage companies in the preparation of business plans for the 2015-2020 price review period. More specific guidance over priorities for 2015-2020 is provided in Defra's[16] strategic policy statement for Ofwat. A Water Strategy for Wales[17] will be consulted on in 2013.

The key legislative drivers and Government priorities relevant to drainage planning are summarised here:

- Section 94 of the Water Industry Act 1991[18] describes how every water and sewerage company is under a duty to 'provide, improve and extend … a system of public sewers … as to ensure that the area is and continues to be effectually drained'. This is relevant to drainage planning because it explicitly indicates that the sewerage system should be improved to keep pace with growing pressures over the long term; this requirement is assured if a long term Drainage Strategy is in place and implemented.

- The Urban Wastewater Treatment Directive[19] provides a further requirement to provide sufficient capacity in wastewater collection systems.

- The Governments in England and Wales are committed to taking an ecosystems approach to environmental management which accounts for the environmental, economic and social benefits that result from an improved water environment. Water and sewerage companies are encouraged to invest in natural as well as built infrastructure to deliver their desired outcomes. *The Natural Choice* [20] demonstrated how this type of investment can deliver a wide range of positive social, environmental and economic outcomes. Benefits can be determined using 'payments for ecosystem services' [21] methods. Water and sewerage companies are encouraged to consider these approaches where they can deliver cost beneficial outcomes for their customers. This is relevant to drainage planning because it encourages the use of retrofit sustainable drainage systems in place of more traditional sewer upsizing and storage. Ofwat has supported water and sewerage companies to investigate these approaches through pilot studies[22] in the 2010 to 2015 price review period.

- Water and sewerage companies may work in partnership with other organisations to jointly invest in shared outcomes and to discuss with customers their willingness to pay for wider

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[15] http://www.defra.gov.uk/publications/2012/10/05/pb13829-statement-obligations/
[16] http://www.defra.gov.uk/publications/2013/03/07/pb13884-sps-seg-ofwat/
[17]http://wales.gov.uk/topics/environmentcountryside/epq/waterflooding/publications/water-strategy/;jsessionid=235D11ADCC6EEC8EE88886DD69CE0784?lang=en
[18] http://www.legislation.gov.uk/ukpga/1991/56/part/IV/chapter/I
[19] http://archive.defra.gov.uk/environment/quality/water/waterquality/sewage/uwwtd/index.htm
[20] http://www.defra.gov.uk/environment/natural/whitepaper/
[21] http://www.defra.gov.uk/environment/natural/ecosystems-services/
[22] http://www.ofwat.gov.uk/future/sustainable/drainage

benefits. This is relevant to sewerage planning because it encourages water and sewerage companies to partner with local authorities to resolve complex storm water management problems (for flooding or pollution control) through the use of retrofit sustainable drainage systems. The wider benefits to citizens outside of the water and sewerage company's customer base can be accounted for.

- The governments of England and Wales are promoting a catchment-based approach[23] to River Basin Management Planning to meet the water quality requirements of the Water Framework Directive (WFD)[24]. The important aspect of the approach is that all interested parties should work together to build consensus about the best way to improve water quality and habitats. Water and sewerage companies should expect to be involved in the process of agreeing objectives and the apportionment of responsibility for delivering those objectives within the river basin districts they operate. The central requirements of the Water Framework Directive are to prevent deterioration in water quality, aim to achieve good chemical status and aim to achieve good ecological status. It additionally seeks to limit the discharge of priority substances. River Basin Management Plans will undergo consultation in the second half of 2014 and be published in December 2015; thereafter the programmes of measures included become statutory requirements and the Environment Agency (in England) and Natural Resources Wales will use permit and license conditions to ensure that water and sewerage companies deliver their agreed contributions. This is relevant to drainage planning because misconnections, blockages, mechanical failure, sewer flooding and combined sewer overflows (CSOs) can all contribute to the deterioration of water quality and the failure to achieve good ecological status or meet environmental quality standards for priority substances. Climate change and growth may increase these risks but water and sewerage companies are not the only polluters and need to partner to ensure that outcomes are met. Defra is consulting (closing February 2013) on developing its policies with respect to the control of diffuse urban pollution.[25]

- A revised Bathing Water Directive (2006/7/EC)[26] applies from 2015 and by then the Government's aim is for all bathing waters to achieve at least 'sufficient class'; this is approximately twice as stringent as requirements for the current Directive. Subsequent planning should aim to achieve 'good' or 'excellent' classifications. This is relevant to drainage planning because CSOs, other wet weather intermittent discharges, final effluent discharges and misconnections can all contribute to bathing water failures. Climate change and growth may increase these risks but water and sewerage companies are not the only polluters and need to partner to ensure that outcomes are met.

- Under the Flood and Water Management Act (2010)[27] water and sewerage companies (in England and Wales) must act in a manner consistent with the National Flood and Coastal Erosion Risk Management (NFCERM) Strategies[28] for England and Wales and have regard to

[23] http://www.defra.gov.uk/environment/quality/water/legislation/catchment-approach/
[24] http://www.defra.gov.uk/environment/quality/water/legislation/water-framework-directive/
[25] http://www.defra.gov.uk/consult/2012/11/20/water-pollution/
[26] http://www.environment-agency.gov.uk/business/regulation/107017.aspx
[27] http://www.defra.gov.uk/environment/flooding/legislation/
[28] http://www.environment-agency.gov.uk/research/policy/130073.aspx

Local Flood Risk Management Strategies[29]. NFCERM is based around six principles: community & partnership; catchment based approach; sustainability; risk based planning; beneficiary investment; and delivering multiple benefits. Companies should also co-operate with local authorities and the Environment Agency in the exercise of their functions in relation to surface water management and combined sewers under section 94 of the Water Industry Act 1991. The Flood Risk Regulations 2009[30] implement the Floods Directive and give particular responsibilities to Lead Local Flood Authorities. In 'Flood Risk Areas' Lead Local Flood Authorities and the Environment Agency are expected to prepare Flood Risk Management Plans that set out flood risk management objectives and measures to manage risk from local flooding. The Environment Agency is required to prepare Flood Risk Management Plans for the whole of England and Wales that cover flooding from main rivers, the sea and reservoirs. It is important for all risk management authorities to work in an effective way to plan to manage flood risk from all sources in a way that is well coordinated across catchments and coastal cells. These duties are relevant to drainage planning because of the vital (but not unlimited) role surface water and combined sewers play in reducing flood risk in urban areas. The Act also makes provision for the compulsory drainage of new developments through sustainable drainage systems (SuDS) and the 'right to connect' being conditional on SuDS being approved by the SuDS Approval Body of the Lead Local Flood Authority.

- The Climate Change Act 2008[31] created a legal framework to cut greenhouse gas emissions and build the UK's ability to adapt to a changing climate. Water and sewerage companies are expected to reduce carbon emissions and adapt to the impact of climate change over the next decades. The Government published its first UK climate change risk assessment in January 2012 and this will be updated every 5 years. This is relevant to drainage planning because of the carbon embodied in new drainage infrastructure, the carbon emitted during the pumping and treatment of sewage and the increase in flooding and pollution that will occur if climate change adaptations are not made. The Government expects Ofwat to work towards the targets of its Adaptation Report and to ensure that its regulatory approach explicitly supports companies in adapting to climate change

- From October 2011 the Water Industry (Schemes for Adoption of Private Sewers) Regulations 2011[32] transferred responsibility for existing private sewers and lateral drains to water and sewerage companies. Pumping stations will be transferred by October 2016. This is relevant to drainage planning because of the significant increase in assets now within the responsibility of the water and sewerage company and the need to understand and respond to risks therein.

1.6 Six Guiding Principles for a Drainage Strategy

This Drainage Strategy Framework describes good practice themed around six guiding principles. Adherence to these principles will help ensure a Drainage Strategy which meets the expectations of Defra, the Welsh Government, the Environment Agency, Natural Resources Wales and Ofwat and

[29] The Local Government Association has published guidance on Local Flood Risk Management Strategies http://www.local.gov.uk/c/document_library/get_file?uuid=a2538b94-d3c1-4cec-81b0-8aefd2996c5e&groupId=10171

[30] http://www.environment-agency.gov.uk/research/planning/125459.aspx

[31] http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx

[32] http://www.legislation.gov.uk/ukdsi/2011/9780111510933/contents

will be an essential means of communicating with customers and other partners. Further details on each principle are described in Section 2 of this document, along with examples of good practice.

The six principles are:

1.6.1 Partnership

Water and sewerage companies cannot develop optimal Drainage Strategies on their own and therefore partnership is key to developing and defining objectives, performance indicators and the milestones that will need to be achieved in order to achieve measures that will demonstrate the delivery of outcomes. Strategies should be developed and implemented in partnership with customers, developers, Lead Local Flood Authorities, planning authorities, the Environment Agency and Natural Resources Wales. Strategies should align with (informing and informed by) River Basin Management Plans, Local Flood Risk Management Strategies, Flood Risk Management Plans and local plans (from planning authorities).

1.6.2 Uncertainty

Strategies should explain the reliability of data and knowledge about current and future performance of drainage systems. They should explain what steps are planned to improve this understanding and how this will benefit customers. Where future performance is uncertain (e.g. because of sensitivity to climate change) they should explain how adaptive approaches will be used to ensure outcomes are met. The uncertainty in predictions of future risks should be recognised and accommodated within decision making.

1.6.3 Risk based

Strategies should be risk based. This means that planning, operational and investment activities should be based on consideration of the probability and consequence of inadequate drainage function (risks) as these relate to the achievement of measures that demonstrate delivery of outcomes. A risk based strategy ensures that investment is made where risks are the greatest.

To aid communication, risks should be visualised through maps and plans (Figure 10 is an example). To aid risk assessment, risks should be monetised, combined and predicted into the future. To aid options appraisal the impact of interventions on the level of risk should be predicted.

The approach to Drainage Strategy development should be risk based itself. The degree of detail included should be related to an understanding of the overall level of risks in the catchment, now and in the future.

1.6.4 Whole life costs and benefits

Strategies should be informed by consideration of whole life costs and benefits. They should promote a series of interventions which in view of the quantified uncertainties are most likely to result in performance indicators which demonstrate the achievement of outcomes at lowest cost to customers and the community more widely.

Costs relate to capital and operational expenditure to deliver interventions and the monetised impacts of drainage failures such as flooding and pollution.

Benefits relate to the reduction in risks from drainage failures such as flooding and pollution but should also include wider societal impacts such as those calculated using a ‘Payments for Ecosystems Services’ approach.

When considering the 'whole life', the strategy should consider climate, population and asset deterioration trends. These are likely to increase risks over the long term if no interventions are made. The strategy should state 'what' should be done but also broadly 'when' and in what sequence interventions should happen.

1.6.5 Live process

The Strategy should be adaptable and periodically reviewed. Whilst outcomes are expected to be relatively stable over time, the pace at which the strategy delivers outcomes will be linked to volatile influences (like climate and population change) and the decisions made at each price review about the priorities for the following period. The strategy should be reviewed at regular intervals to reflect investments already made, the changing priorities of the water and sewerage company and partners, and the presence of emerging risks. The review is also an opportunity to report drainage catchment performance relative to performance measures designed to monitor progress towards achieving outcomes.

1.6.6 Innovative and sustainable

The framework promotes the full evaluation of alternatives to traditionally engineered sewerage solutions to test whether these offer lower whole life cost options or better responses to uncertainty. It is anticipated that drainage solutions of the future will be different from the ones we are used to.

These should include (at least at a high level) real time control or active management, storm water retrofit techniques, education to enable customers to change behaviour, enhancing incentives for customers to reduce surface water flowing to sewers, and innovative permitting arrangements across drainage networks and wastewater treatment works. Water and sewerage companies should continue to review and develop other innovative solutions.

For example, where a company may historically have preferred to tackle sewer flooding or combined sewer overflow pollution by increasing its underground equipment to store more rainfall during storms, it might consider other options in future; such as working with customers to manage the rainfall close to source, preventing it from entering the sewer system.

1.7 Mapping the Framework to Current Planning Processes

We assume that practitioners will be following a broad and generic four-stage planning process common to the Sewerage Risk Management (SRM5) and Surface Water Management Plan (SWMP) processes when preparing Drainage Strategies.

Figure 4 is provided to guide water and sewerage companies in the development of Drainage Strategies. It identifies each stage of the drainage planning process and highlights the good practice principles (colour coded by theme) in the locations through the process where it is most important that they are adopted.

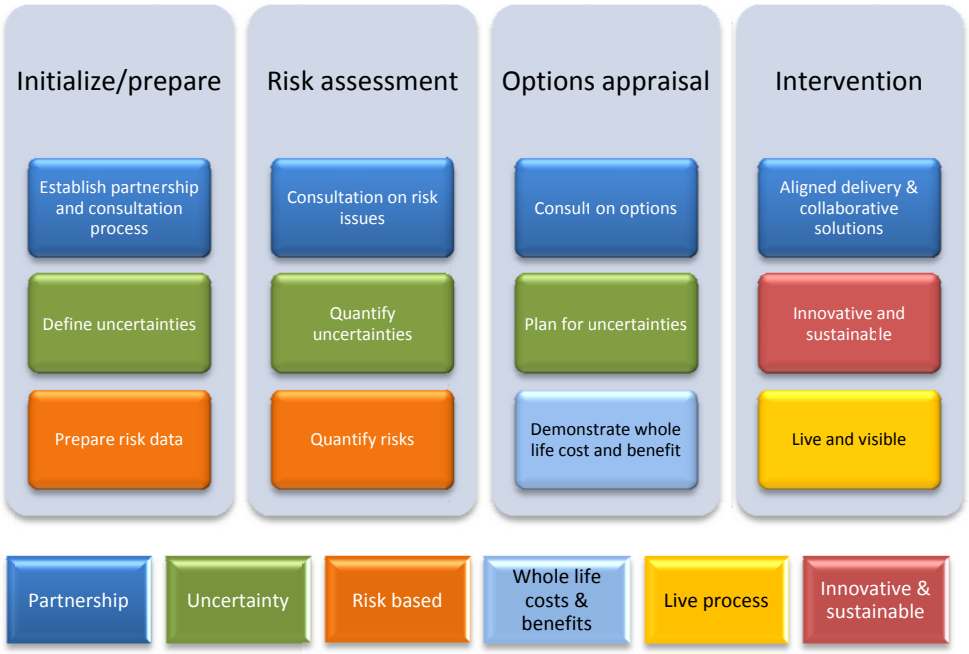


Figure 4 Drainage Strategy framework principles mapped to the drainage planning process

1.8 Who will benefit from the Framework?

The Drainage Strategy Framework will benefit:

- Water and sewerage companies looking to improve their company specific drainage planning approach and make it fit for purpose for the delivery of long term outcomes over multiple price review cycles. It will point them towards good practice and provide examples as inspiration and to promote innovation.
- Organisations and individuals looking to engage with the development of Drainage Strategies and scrutinise progress towards the achievement of outcomes associated with enabling growth, adapting to climate change, managing flooding and managing water pollution.

2 Drainage Strategy Framework

This section describes recommended good practice against each of the six key principles necessary to develop a Drainage Strategy. For reference, links are made to relevant and established planning processes and emerging guidance which drainage planners may find useful. These examples are provided for information and reference only.

Water and sewerage companies should work towards developing Drainage Strategies which apply these approaches in a way that is consistent with their needs and those of their customers and partners. Partners should take note of this advice and prepare to engage with water and sewerage companies on this basis.

The recommended good practice is organised, within each principle, as it would be approached chronologically in developing a Drainage Strategy following the planning processes already established in the Sewerage Risk Management and/or Surface Water Management Plan methodologies.

2.1 Principle One: Partnership

Water and sewerage companies cannot develop optimal Drainage Strategies on their own and therefore partnership is key to developing and defining objectives, performance indicators and the milestones that will need to be achieved in order to achieve measures that will demonstrate the delivery of outcomes. Strategies should be developed and implemented in partnership with customers, developers, Lead Local Flood Authorities, planning authorities, the Environment Agency and Natural Resources Wales. Strategies should align (informing and informed by) with River Basin Management Plans, Local Flood Risk Management Strategies, Flood Risk Management Plans and local plans (from planning authorities).

2.1.1 Recommended good practice

No.	Good practice	Example references
1	Engage with partners in a drainage catchment to: • Explain the purpose of developing a Drainage Strategy and partners' roles in its success & how each party will benefit from establishing a long term Drainage Strategy. • Explain what outcomes are and how progress towards achieving them will be measured. • Share data and information so that a shared understanding of risks and opportunities is developed. • Explain what current drainage system performance is and how this is expected to change in the future. Use risk visualisation tools to do this. • Explain significant uncertainties and how these affect how interventions are delivered.	Thames Water has demonstrated good practice through the development of its Counters Creek sewer flooding proposals. This website describes the engagement process and how customers have been kept informed.
2	Engage with the following partners in the development of the Drainage Strategy: • Lead Local Flood Authority (the drainage area may include more than one) because of its responsibilities for local flood risk management and SuDS approval. • Planning authority (the drainage area may include more than one) because of its role in determining the location and pace of housing development. • Highways Authority because of the connection of highway runoff to public sewer systems • The Environment Agency (in England) because of its responsibilities for flood risk management (strategic overview) and ensuring good ecological quality is met in water bodies. • Natural Resources Wales (in Wales) because of its responsibilities for flood risk management (strategic oversight) and ensuing good ecological quality is met in water bodies. • Regional Flood and Coastal Committees who help develop a mutual understanding of flood and coastal erosion risks in an area • Bodies representing customers (e.g. Consumer Council for Water, large local businesses, flood action groups, faith communities) • Bodies representing local environmental concerns (e.g. Wildlife Trusts, Rivers Trusts) • Water only companies and water and sewerage company departments planning and operating water supply systems. Water demand management practice can have an important impact on sewerage headroom.	SWMP guidance (Chapter 2) advises on the establishment of partnerships for urban flood management and how to agree and align local objectives.
3	Understand alignment of planning cycles and what this means locally (e.g. periodic review, River Basin Management Plan, Local Flood Risk Management Strategy, Flood Risk Management Plan, local plan).	

No.	Good practice	Example references
4	Be alert to opportunities for joint solutions and/or shared funding by understanding local plans for: new development; re-development; improving street furniture and public open space; improving parks and green infrastructure. Understand Lead Local Flood Authority and Environment Agency programmes for the management of flood and pollution risks.	A guide to joint funding of local flood risk management intervention has been published by Defra[33] and provides relevant advice to water and sewerage companies and other partners.
5	Consider water and sewerage company funded solutions which deliver third-party non-sewerage assets that result in the long term, least cost delivery of outcomes (e.g. water and sewerage company funding of household rain barrels and rain gardens to prevent surface water entering sewers).	
6	Use data and mapping from the Environment Agency and Natural Resources Wales to understand exposure of drainage infrastructure to extreme events (e.g. coastal, fluvial and surface water flood maps) so that network resilience can be understood and improved if this is cost beneficial.	UKWIR has completed a project in 2013 'Resilience: building a business case for PR14 and beyond'.
7	Work with LLFAs and the Environment Agency (or Natural Resources Wales) to understand the effectiveness of interventions at reducing risk and use this information to improve intervention planning.	The UPM3 manual (section 7) advises on post project monitoring needs for water quality driven improvements.
8	Share Drainage Strategies with partners and stakeholders so that there is transparency around challenges, opportunities and the roles expected of different organisations.	

2.1.2 Good practice example – South West Water working with local authorities

These examples from South West Water illustrate how the company has worked with local authorities to coordinate investments and to share resources and skills in the development of integrated urban drainage management studies and Surface Water Management Plans.

- South West Water approached Devon County Council (DCC) to pool resources in delivering two (of five) pilot integrated urban drainage management studies (IUDMs) for Exeter and Exmouth. South West Water took the lead role for Exmouth but DCC led in Exeter. This engagement shared costs across organisations and has facilitated the production of full Surface Water Management Plans. The collaboration has resulted in a shared understanding of the urban drainage challenges faced by both organisations and has opened dialogue around investment priorities.
- In Lyme Regis, South West Water supported extensive coastal erosion defence works being carried out by West Dorset District Council by accelerating a programme of sewer rehabilitation and targeting renovation of sewers in vulnerable areas.
- In partnership with Cornwall County Council (CCC) and the Environment Agency, South West Water has been working on a number of key drainage issues identified by CCC in its Preliminary Flood Risk Assessment (PFRA).

[33] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17085

- In Camborne, South West Water has taken the opportunity to invest in sewer separation works which align with the aims of the Camborne, Pool, Redruth urban regeneration group, supported by Cornwall Council, and to promote sustainable development, economic growth and a strategic aim of 'sewers for sewage'.

2.1.3 Good practice example – Northumbrian Water partnership working in Tyneside

Northumbrian Water has led a sustainable sewerage study for Tyneside[34] between 2010 and 2012. It is a good example of how partner organisations can collaborate to understand and resolve drainage issues in their urban area.

Its approach was informed by the fact that a shared urban drainage problem around flooding and pollution was best addressed by a shared response from all the relevant organisations. The project steering group involved representatives of Northumbrian Water, the Consumer Council for Water, the Environment Agency and five Lead Local Flood Authorities. The urban drainage system collects wastewater for a single wastewater treatment works serving a population of over 900,000.

Working together, the group studied the impact of growth, urban creep and climate change on future urban drainage issues. Figure 5 illustrates how a city-wide map of potential problem areas was generated by the project team sharing data on sewer capacity (from Northumbrian Water), population change (from the local authorities) and river flooding (the Environment Agency). It was predicted that future problems were more likely to occur in the darker shaded areas. These became focus areas for the project, where a range of traditional and novel drainage solutions were tested.

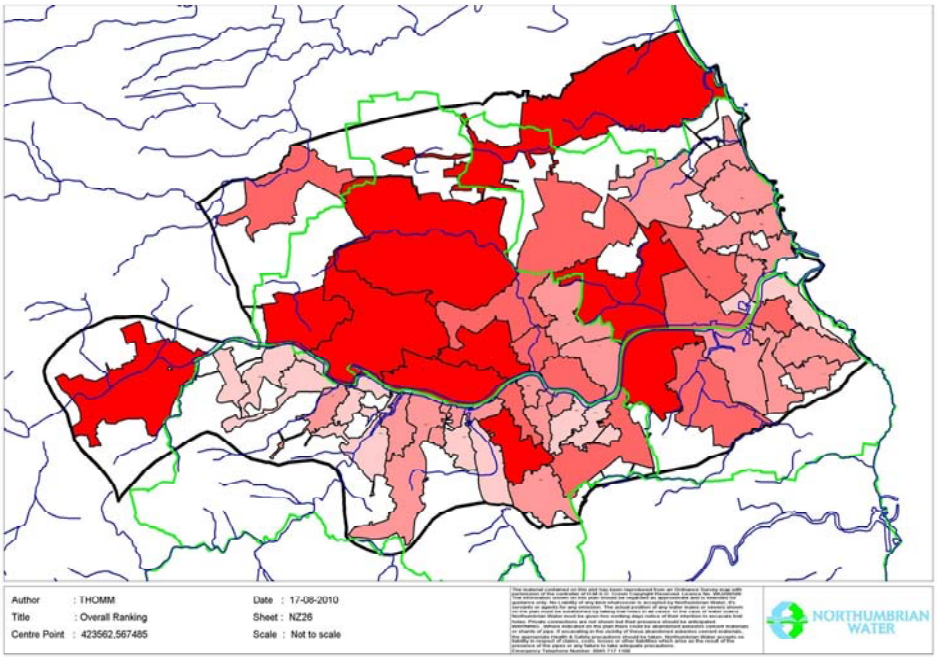
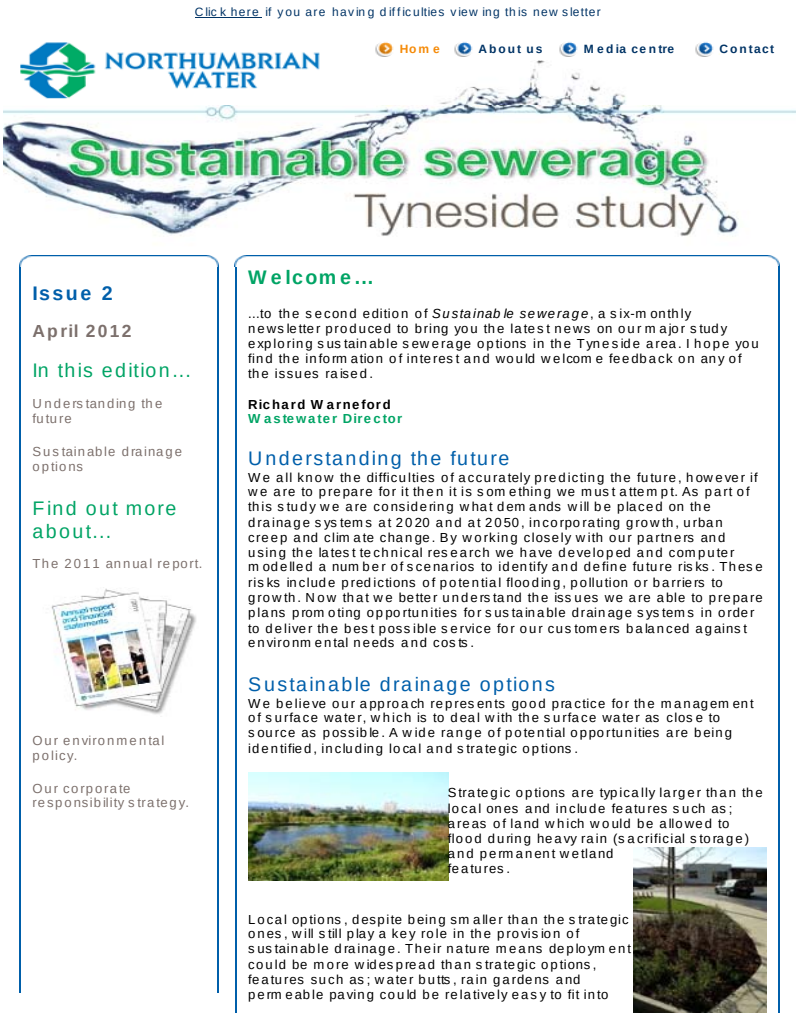


Figure 5 Future drainage problem areas indentified through data sharing

[34] http://communicatoremail.com/IN/fNLOjNRayfOA1rfrfYcdK-S7UwRcYcNo/WebView.aspx

The project team was keen to promote its work to customers and the community and prepared a series of newsletters updating interested parties on progress and issues. An example is illustrated in Figure 6.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NORTHUMBRIAN WATER

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Sustainable sewerage
Tyneside study

Issue 2

April 2012

In this edition...

Understanding the future

Sustainable drainage options

Find out more about...

The 2011 annual report.

Our environmental policy.

Our corporate responsibility strategy.

Welcome...

...to the second edition of *Sustainable sewerage*, a six-monthly newsletter produced to bring you the latest news on our major study exploring sustainable sewerage options in the Tyneside area. I hope you find the information of interest and would welcome feedback on any of the issues raised.

Richard Warneford
Wastewater Director

Understanding the future

We all know the difficulties of accurately predicting the future, however if we are to prepare for it then it is something we must attempt. As part of this study we are considering what demands will be placed on the drainage systems at 2020 and at 2050, incorporating growth, urban creep and climate change. By working closely with our partners and using the latest technical research we have developed and computer modelled a number of scenarios to identify and define future risks. These risks include predictions of potential flooding, pollution or barriers to growth. Now that we better understand the issues we are able to prepare plans promoting opportunities for sustainable drainage systems in order to deliver the best possible service for our customers balanced against environmental needs and costs.

Sustainable drainage options

We believe our approach represents good practice for the management of surface water, which is to deal with the surface water as close to source as possible. A wide range of potential opportunities are being identified, including local and strategic options.

Strategic options are typically larger than the local ones and include features such as; areas of land which would be allowed to flood during heavy rain (sacrificial storage) and permanent wetland features.

Local options, despite being smaller than the strategic ones, will still play a key role in the provision of sustainable drainage. Their nature means deployment could be more widespread than strategic options, features such as; water butts, rain gardens and permeable paving could be relatively easy to fit into

Figure 6 Newsletter promoting urban drainage partnership working

2.2 Principle Two: Uncertainty

Strategies should explain the reliability of data and knowledge about current and future performance of drainage systems. They should explain what steps are planned to improve this understanding and how this will benefit customers. Where future performance is uncertain (e.g. because of sensitivity to climate change) they should explain how adaptive approaches will be used to ensure outcomes are met. The uncertainty in predictions of future risks should be recognised and accommodated within decision making.

2.2.1 Recommended good practice

No.	Good practice	Example references
1	Data analysed and used in the development of the strategy related to asset location, dimensions, condition, failure and flood and pollution incidents should be assigned a confidence grading. The confidence grading should be related to its accuracy, completeness, compatibility, credibility and currency. Models used to predict blockages and collapses, flooding locations, polluting discharges and water quality impacts should be assigned a confidence grading based on their accuracy, completeness, compatibility, credibility and currency. Model predictions should be assigned a confidence grading depending on the confidence in the model and whether it is being applied outside of its verification range (e.g. for extreme events or for atypical geographies). The purpose of confidence grading data and model results used in strategy setting is to understand the likelihood that outcomes will be achieved in a cost efficient manner. Where the outcomes remain uncertain, knowledge of data confidence can be used to target improvement programmes.	SRM5 (S3-03-17) refers to Ofwat's method for recording the reliability and accuracy of regulatory data in bands A to D. The SWMP guidance (Section 3.19) describes an alternative system of grading data and model results.
2	Use the Drainage Strategy to justify data and model improvement programmes. This should be focussed on areas where risks are currently (or predicted to be) high and uncertainty in data or models reduces the ability to determine robust operational or capital solutions. Poor model verification in high risk areas would be an indicator that model improvements were required.	CIWEM's urban drainage group has published a series of guides on hydraulic and water quality modelling. They discuss model calibration, verification and uses. SRM5 (S3-04) describes how to determine where the current assessment of risk is sufficient to proceed or whether data and models should be improved.
3	Improve understanding of network performance (and improve models) by using long term flow and level monitoring on sewers and CSOs.	Yorkshire Water discusses its CSO monitoring programme here.
4	Demonstrate how the uncertainty in both the underlying data/models and in the future projections is addressed in options appraisal. Consider if this should be done implicitly (e.g. through choosing conservative assumptions) or explicitly through the use of sensitivity analysis or scenario testing.	Treasury Green Book supplementary guidance illustrates how to accommodate climate change uncertainties.

No.	Good practice	Example references
5	Population growth, new homes and businesses, climate change and urban creep combine to make the future highly uncertain but will almost certainly increase flooding and pollution risks from drainage systems. Use the Drainage Strategy to explore different scenarios (combining the impact of these drivers) for a near term (≤ 10 years) and future (≥ 30 years) epoch. For example, combine modest growth and slight climate change (a low impact case) and contrast with high growth and significant climate change (a high impact case). Where the location of significant new development is unknown, include scenarios accommodating different possibilities. Running multiple scenarios is time consuming and costly. A risk based approach should be adopted to focus efforts where flooding and pollution risks are especially sensitive to changes in demand.	UKWIR has published research on accounting for climate change[35] and urban creep[36] in sewerage planning together with more general advice on accommodating climate change in water asset management planning[37]. Ofwat has published research[38] predicting the combined impacts of climate change, urban creep and development on a national basis.
6	In the face of significant uncertainties about future demands on the drainage system and their consequences, the Drainage Strategy should identify low-regrets interventions (i.e. ones that are robust no matter what the future holds) and ensure that solutions can be adapted if greater certainty is achieved. For example, through quickening the pace of SuDS retrofit activities or using (previously identified and secured) land to extend underground storage facilities. Strategies which remove surface water from sewerage networks provide 'headroom' for unpredictable increases in demand from population and climate change.	Designing Resilient Cities A guide to good practice DR Lomardi et al, HIS BRE Press.
7	Post project appraisal and cost monitoring should be used to capture real costs and performance so that Strategies can be updated and improved with latest information. It is especially important to collate and understand the whole life costs of new technologies where industry understanding is currently poor.	

[35] http://www.ukwir.org/reports/03-cl-10-0/90427/94658/90179,90198/90198 (££)
[36] http://ukwir.forefront-library.com/reports/10-wm-07-14/93273 (££)
[37] http://ukwir.forefront-library.com/reports/12-cl-01-16/94816/90001/90155,90145,90140,94658/90155 (££)
[38] http://www.ofwat.gov.uk/sustainability/climatechange/rpt_com201106mottmacsewer.pdf

2.2.2 Good practice example – Severn Trent Water's MICAS

Severn Trent Water has developed a process to measure confidence in hydraulic models of sewer systems. Modelling Investment Confidence Assessment Scoring (MICAS) was developed to provide an objective evaluation of model confidence. It uses information stored in the hydraulic model about the provenance of each data element and the quality of model verification. Before the approach was developed, the assessment of 'fitness for purpose' of models was subjective and based on modellers judgment. This was not always reliable and certainly not repeatable and transparent. MICAS provides an objective assessment of hydraulic model quality which can be used to inform its use and prioritise improvements to input data and model verification.

Figure 7 and Figure 8 illustrate how an understanding of model confidence from the MICAS assessment (right hand side images) can be used to interpret predictions of flooding (left hand side images). In Figure 7 areas at predicted high risk of flooding (red in the left hand side image) are shown to be in high confidence areas of the hydraulic model (green in the right hand side image). In contrast, in Figure 8, areas at predicted high risk of flooding (red in the left hand side image) are shown to be in poor confidence areas of the hydraulic models (orange in the right hand side image). In the latter case, this information is used to identify where further model improvements would be beneficial.

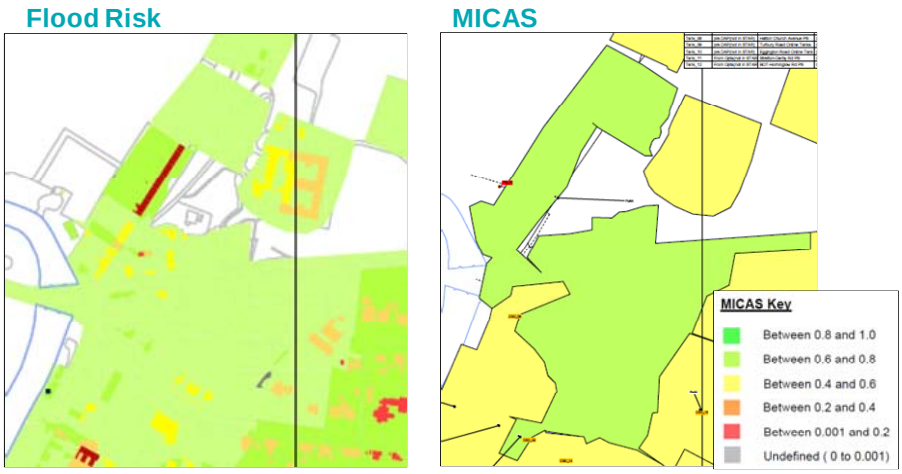

Figure 7 Modelled flood risk and MICAS confidence scores (high model confidence)

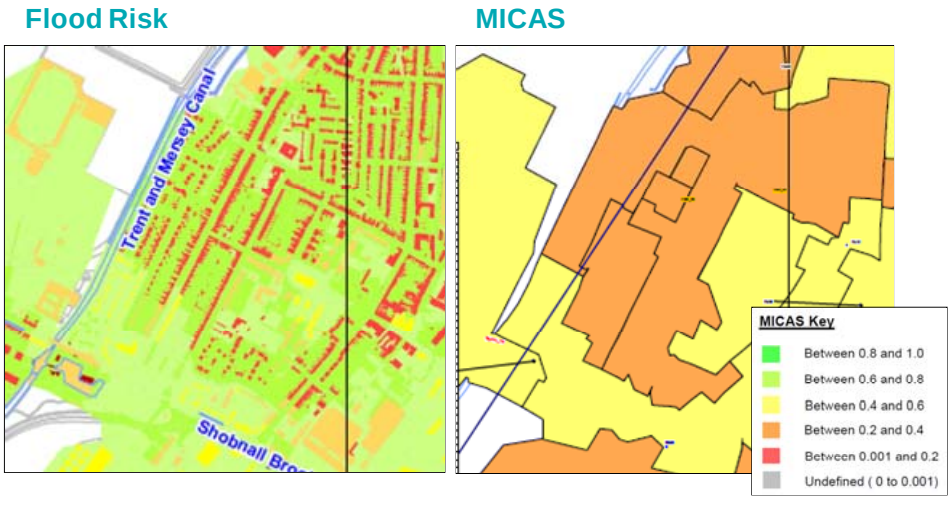

Figure 8 Modelled flood risk and MICAS confidence scores (lower model confidence)

2.3 Principle Three: Risk Based

Strategies should be risk based. This means that planning, operational and investment activities should be based on consideration of the probability and consequence of inadequate drainage function (risks) as these relate to the achievement of measures that demonstrate delivery of outcomes. A risk based Strategy ensures that investment is made where risks are the greatest.

To aid communication, risks should be visualised through maps and plans (Figure 10 is an example). To aid risk assessment, risks should be monetised, combined and predicted into the future. To aid options appraisal the impact of interventions on the level of risk should be predicted.

The approach to Drainage Strategy development should be risk based itself. The degree of detail included should be related to an understanding of the overall level of risks in the catchment, now and in the future.

2.3.1 Recommended good practice

No.	Good practice	Example references
1	Determine where a Drainage Strategy is required by combining current performance with external influences likely to result in deteriorating performance. This stage requires no modelling or detailed assessment. On a catchment-by-catchment (drainage area) basis, understand current risks by collating data on current performance: e.g. blockages, collapses, pumping station failures, pollution incidents, CSO spills, storm tank spills, internal flooding incidents, external flooding incidents and infiltration rates. Relate these risks to performance indicators and the achievement of outcomes. Combine with information about known growth rates, predictions of urban creep, quantity of newly adopted 'private' sewers, surface water flooding risks (e.g. from flood map for surface water), WFD water body status, and bathing water status. Prioritise catchments with high current risks and/or factors suggesting that risks are likely to worsen significantly in the future. Consider normalising scoring method for size of catchment (e.g. by unit area or unit length of sewer). Consult with stakeholders to confirm correct prioritisation. Commence with development of Drainage Strategies for the highest ranked catchments. Periodically revisit prioritisation (updating with new data) to check that priorities are still correct.	The initialisation stage of a Sewer Management Plan (SMP) (described in SRM5) considers how a risk assessment can be used to prioritise which spatial units (e.g. catchments) should be prioritised for a SMP study.
2	Visualise catchment risks (from 1) to illustrate and explain to partners the reasons for prioritisation. Accommodate their views & consider changing prioritisation to aid wider drainage planning requirements (e.g. increase prioritisation of a catchment with significant surface water flooding problems where close collaboration between water and sewerage company and LLFA will benefit the community).	

No.	Good practice	Example references
3	Clearly relate sewerage risks to the performance indicators that will be used to measure progress towards achieving outcomes. e.g. relate blockage rates to flooding and pollution incidents. e.g. relate increase in flows to increased CSO frequency, breaches of permit conditions and deterioration in receiving water quality Adopt a source–pathway-receptor model and workshop techniques to ensure that cause, effect and consequences are fully captured. Use performance indicators as the basis for a comprehensive risk assessment that considers likelihood (frequency) and consequence (extent, degree and duration of impact) of failure expressed as risk scores. Monetise risks in GBP (£) to align with principle four (whole life costs & benefits). Use (verified) predictive models to understand near term (<10 years) and long term (>30 years) risks. The latter to align with principle four (whole life costs & benefits). Align complexity of method with level of risk, recognising the needs of partners. e.g. use complex 2D flood routing models to ascertain (with greater certainty) flood mechanisms and damages where the quantity and frequency of flooding is high and interventions will be complex and costly. Elsewhere, more simple approaches are appropriate. e.g. use complex UPM3 water quality modelling methods where compliance with river standards or discharge consents is already failing or is expected to do so. Elsewhere, more simple approaches are appropriate. Combine risk scores from different risks to describe the total level of risk in a catchment. Use visualisation techniques to communicate combined level of risk. Combine analysis from hydraulic, blockage and asset deterioration models on a catchment basis. In hydraulic analysis, consider flooding performance for rainfall events beyond the usually provided standard of protection to understand performance in extreme events in support of partners (especially LLFAs) and in search of cost beneficial interventions at a higher standard than normal.	SRM 5 (S3-03) details approaches to simple and more complex approaches to risk assessment that are consistent with CMPCF guidelines.
4	Be alert to interactions between sewer networks and wastewater treatment plans. e.g. by modelling the impact of changing sewer flows on wastewater treatment works' performance and costs. Consider combined impact of different catchments on a single or linked water body (e.g. an inland river, bathing water or shell fishery).	UPM3 guidance discusses approaches to understanding these interactions and applying more complex water quality impact models.
5	Establish systems and apply methods to predict how interventions can reduce risks. e.g. how a targeted and pro-active maintenance can reduce the occurrence of sewer blockage and flooding from 'other causes'. e.g. how reducing infiltration can reduce CSO spills. e.g. how reducing connected impermeable area can reduce sewer flooding.	

2.3.2 Good practice example – United Utilities risk assessment

United Utilities has demonstrated a robust risk based approach in the development of sewerage management plans used for long term planning across their area of operations.

Hydraulic models were applied in 235 catchments and configured to look at future performance and to evaluate the consequences of inadequate capacity. Starting from a baseline of 2010, versions of the models were built for 2020 and 2036 epochs. The following model input parameters were adjusted: population, water consumption, infiltration, planned development, known sewerage improvement projects, urban creep, rainfall (for climate change).

Two-dimensional (2D) modelling was used to consider the consequences of sewer flooding resulting from the changes made to reflect the future operating environments. As well as the impact on homes and business (from internal and external flooding) the flood risk to critical infrastructure was also considered. The operation of CSOs was considered by computing the annual spill volume, duration and frequency.

Finally, predictions of the likelihood and consequence of sewer failure were added taking account of sewer material, age and the incident records relating to similar assets.

All these data were combined and weighted to generate a Sewer Management Plan (SMP) Risk Score for each length of sewer. The process is illustrated in Figure 9.

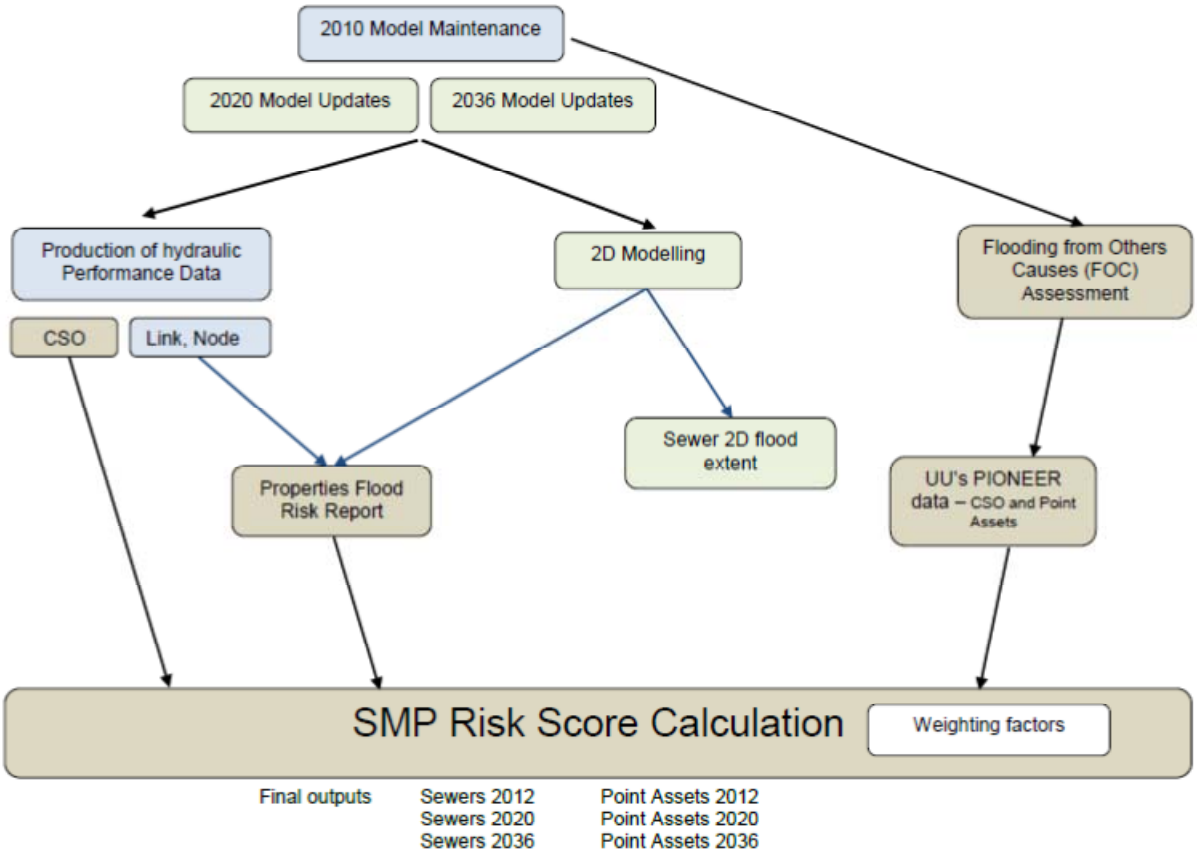

Figure 9 United Utilities' process for calculating risk score in sewerage catchments

Risk scores were summed spatially and monetised so that high priority locations could be identified. Mapping and visualisation were used to communicate the results of this assessment, priority areas for further investigation and how risks change through time (Figure 10).

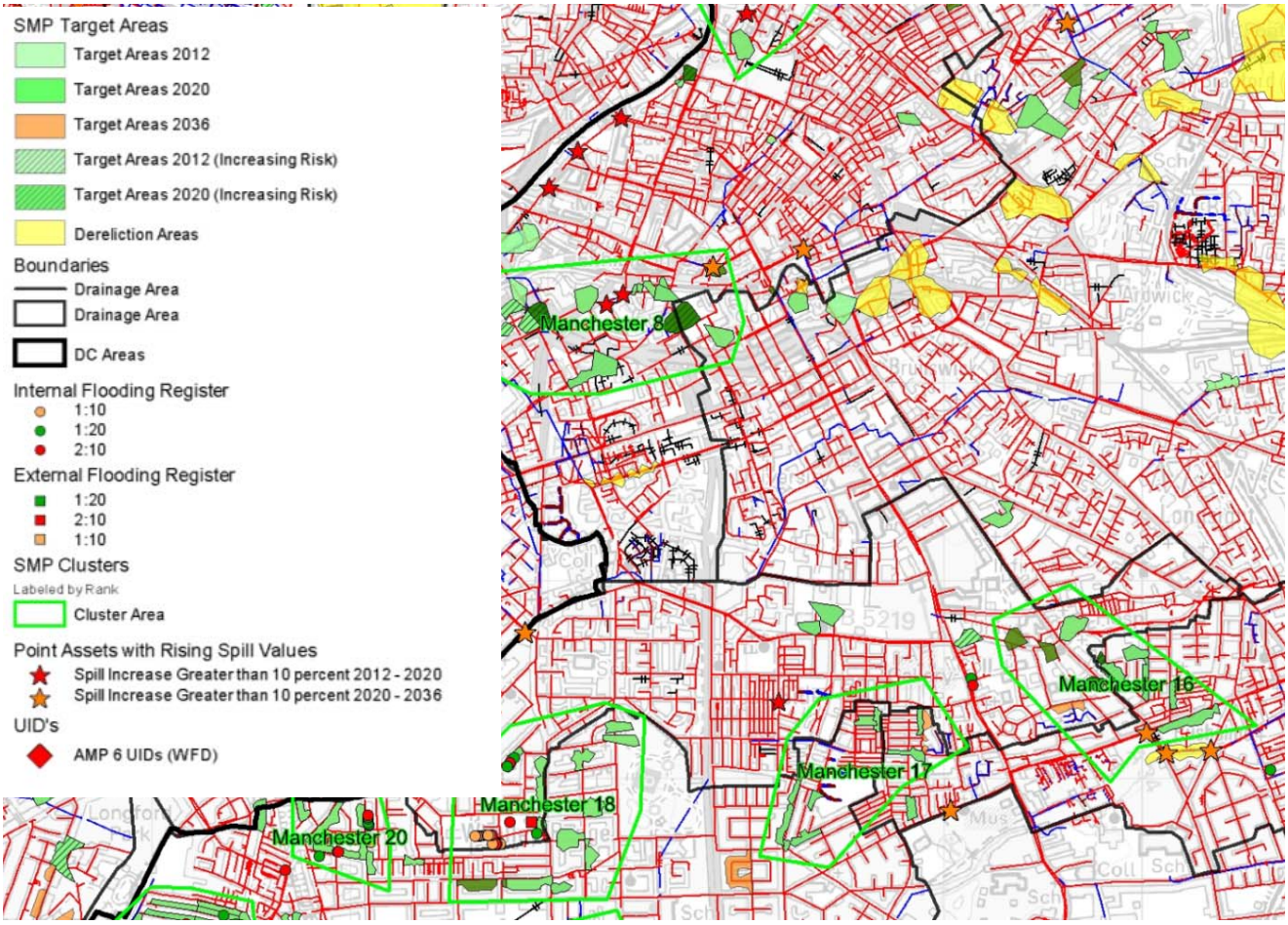

Figure 10 Visualisation of sewerage risks

2.3.3 Good practice example – Northumbrian Water risk assessment

Northumbrian Water completes an annual assessment of hydraulic capacity in its sewerage network at the drainage area scale. Its approach does not require hydraulic models to have been completed and yet can reliably highlight areas of under-capacity in need of further investigation through more detailed analysis, including hydraulic modelling. New and emerging risk areas can also be identified by applying data for population growth which occurs through development. 'What if' scenarios can be run to test when capacity limits may be overcome and flood risks potentially set to increase. It demonstrates good 'risk based' planning principles because it shows the drainage planner where more detailed analysis is warranted.

The approach uses the following data from company records: population connected to sewer P, water consumption rate G (l/h/d), trade discharge E (l/s), pipe diameter and gradient, pipe connectivity, CSO consent pass forward rate (l/s), pumping station rate (l/s), sewage treatment flow rate (l/s). A wastewater dry weather capacity map calculates pipe full capacity, dry weather flow (PG+E+I), and Formula A flow for fully combined (1360P+2E+DWF) and separate (4PG+3I+E) areas of the network. Infiltration (I) is assumed to be 50%* PG +E.

A theoretical assessment of network capacity is then calculated by comparing Formula A with pipe full capacity, flow consent values at CSOs and wastewater treatment works, and pumping rates. This determines areas of the network with a capacity shortfall, with a potential capacity shortfall and with no capacity shortfall.

When run across the whole company area, approximately 100 out of 500 drainage areas were found to be under capacity. Over 60% of these areas had recorded sewer flooding incidents. In over 300 drainage areas there was no forecast capacity shortfall. Only 7% of these drainage areas had recorded sewer flooding incidents. Overall, the system proved to be very reliable at predicting drainage areas likely to have sewer flooding problems because of sewer under-capacity.

In under capacity drainage areas an intermediate (hydraulic model based) assessment is then carried out. Figure 11 shows the results thematically mapped for an example drainage area. Red areas are predicted to have a very high risk of sewer flooding. Yellow and green areas are predicted to have a low risk of sewer flooding.

Figure 11 Example of a drainage area capacity map

2.4 Principle Four: Whole Life Costs and Benefits

Strategies should be informed by consideration of whole life costs and benefits. They should promote a series of interventions which in view of the quantified uncertainties are most likely to result in performance indicators which demonstrate the achievement of outcomes at lowest cost to customers and the community more widely.

Costs relate to capital and operational expenditure to deliver interventions and the monetised impacts of drainage failures such as flooding and pollution.

Benefits relate to the reduction in risks from drainage failures such as flooding and pollution but should also include wider societal impacts such as those calculated using a 'Payments for Ecosystems Services' approach.

When considering the 'whole life', the strategy should consider climate, population and asset deterioration trends. These are likely to increase risks over the long term if no interventions are made. The strategy should state 'what' should be done but also broadly 'when' and in what sequence interventions should happen.

2.4.1 Recommended good practice

No.	Good practice	Example references
1	Predict risks into the future for at least two epochs: ≤10 years (to understand what the company needs to do now and how this fits with longer term outcomes), and ≥30 years to understand long term needs in light of changing population and other pressures. Account for the following changes in demand: • Growth - new homes and businesses • Urban creep – uncontrolled addition of connected impermeable area • Climate change – affecting design events (flood predictions), time-series (CSO and treated effluent quantities), river flows and temperatures • Infiltration/exfiltration – through deteriorating sewer condition • Dry weather flows – through changes in water consumption rates	
2	Combining monetised risks (associated with sewerage failures), determine whole life costs for a 'do nothing' scenario (i.e. no interventions). Include costs associated with electricity consumption (in the network and at the wastewater treatment works) and CO2 emissions.	UKWIR will publish in 2014 a revision to their Long Term/ Least Cost Planning for Wastewater Supply-Demand guidance. This may provide tools and methods for expressing costs and benefits to support the development of a Drainage Strategy.

No.	Good practice	Example references
3	Test intervention strategies which keep performance indicators on track to deliver outcomes by adding capacity (supply), reducing flows (demand) or altering operational regimes. Include the costs of interventions and the benefits of reduced risks to inform selection of the most cost beneficial strategy over the whole life. Have regard to the timing of interventions, recognising that uncertainty may require low-regrets (insensitive to uncertainty) solutions and that delaying major interventions may be more affordable and attractive in the short term. Discounting should be used to compare the costs and benefits of interventions occurring at different times. Recognise that some interventions will be obligatory and defined (e.g. maintenance of a spill frequency standard at a CSO) whilst others will be more discretionary, focused on achieving outcomes rather than specific outputs.	SRM5 (Section 8) defines and contrasts cost benefit analysis, cost effectiveness analysis, whole life cost analysis, and risk cost benefit analysis. HM Treasury Green Book[39] sets out a framework for the appraisal of long term projects which can be applied to the development of a Drainage Strategy.
4	Don't, at first, be concerned with the distribution of costs and benefits between partners who may be sharing costs. Identify the most cost beneficial solution first, and then debate and agree an equitable sharing of costs. Give equal weighting to OPEX (operating expenditure) and CAPEX (capital expenditure) costs so not to cause bias towards capital intensive solutions. Properly consider the costs and benefits of pro-active maintenance regimes and campaigns to influence customers to reduce fats, oils and greases (FOG) build-ups and the misuse of sewers. Consider the affordability of solutions, the impact on customers' bills and the resources of other organisations to play their part.	UKWIR research outputs[40] in 2013 (SW01) will provide a framework for making a business case for separating storm water from combined sewers.
5	Where interventions include the provision of green space, public amenity and improved habitats then Payment for Ecosystem Services approaches should be used to identify further monetised benefits in the appraisal. Customers should be consulted to help value these benefits.	Supplementary Green Book[41] guidance describes methods for accounting for environmental impacts including the ecosystems approach.

[39] http://www.hm-treasury.gov.uk/data_greenbook_index.htm
[40] http://www.ukwir.org/publishor/system/component_view.asp?LogDocId=96116
[41] http://www.hm-treasury.gov.uk/d/accounting_environmental_impacts.pdf

2.4.2 Good practice example – Severn Trent Water making the case for surface water separation in Stoke-on-Trent

In this example[42] Severn Trent Water compared alternative ways of addressing sewer flooding problems by looking at a range of costs and benefits not all of which were directly associated with its specific responsibilities as a water and sewerage company. Whilst the example does not express a monetised value for all costs and benefits over the whole life, it does illustrate the types of factors which could be included in an appraisal of this type, scaled to address problems at a catchment level. It also demonstrates how working collaboratively can help identify solutions which are cost-beneficial for the community at large.

In an area of Stoke, served by a combined sewer system, five properties were at risk from sewer flooding in cellars for events equal to and less frequent than the 1 in 10 year probability. A conventional sewer pumping station based solution was presented as the standard option.

However, a nearby former hospital site was also undergoing re-development which would result in reduced runoff to the combined sewer. The new drainage regime in the redevelopment site was sufficient to remove the flood risk at the five properties (this was a do nothing strategy).

A third option completely separated the development site runoff from the combined sewer and also addressed local flood risk issues nearby. The solution required a new storm sewer and a network of swales and other SuDS features connecting with an ordinary watercourse.

Table 1 illustrates how costs and benefits were compared across the three alternative strategies. Each provided the same benefit in terms of the number of homes (5) relieved from sewer flooding. The novel SuDS and surface water management solution additionally gave local flood risk relief to 3 further properties. The separation/SuDS strategy came at a higher capital cost but delivered greater social cost benefits, savings in annual operating costs and a bonus improvement water quality (because of reduced CSO spill volume). Severn Trent selected the separation SuDS solution because the higher capital costs were offset by other benefits.

Table 1 Costs and benefits of drainage improvements in part of Stoke-on-Trent

	Do nothing	Standard option	SuDS
Sewer flooding benefits	5	5	5
Other flooding benefits	0	0	3
Change in runoff to combined sewer (m3/year)	0	0	-40,000
Estimated cost (£)	0	168,000	419,000

[42] http://www.ciwem.org/media/695460/Paper%203_Creating%20Sewer%20Capacity_Presentation%20by%20Mike%20Wood.pdf

	Do nothing	Standard option	SuDS
Social Cost Benefit (£)	16,000	5,000	51,000
Change in electricity costs (£/year)	0	+75	-525
Programme impact (years to deliver solution)	+ 4	0	+4
CSO spill volume (m^3 in 1year event)	+298	0	-397

2.4.3 Good practice example – New York City comparison of grey and green infrastructure drainage strategies

This example is taken from New York in the United States of America. It's an illustration of how whole life costs have been compared for alternative strategies to solve urban drainage issues on a mega-city scale. The key data are summarised in Table 2.

Table 2 Comparing drainage strategies in New York

	Grey Strategy	Green Strategy
CSO spill volume reduction (billion gallons /year)	10.1	12.2
Wider benefits over 20 years ($ million)	0	139 to 418
Whole life costs over 20 years ($ billion)	6.8	5.3

The information is taken from the New York City Green Infrastructure Plan[43] produced by the Mayor's Office in 2010. The Plan (and recent updates) provides a comprehensive evidence base around costs and benefits of different approaches to address the city's drainage problems. It is therefore an excellent example of how drainage strategies can be described in plain language for a non-specialist audience concerned with their environment and the cost of providing infrastructure to enhance it.

It is becoming commonplace for North American cities (e.g. Portland and Philadelphia) to address the issue of frequent combined sewer overflow (CSO) operation by using a combination of grey infrastructure (sewers) and green infrastructure (sustainable drainage systems). The wider health

[43] http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_plan.shtml

and ecological benefits of green infrastructure approaches, and the reduced reliance on materials and energy are attractive to utility planners and cities alike.

New York has 422 CSOs and an agreed Long Term Control Strategy to significantly reduce the impact wet weather discharges have on aquatic systems throughout the city. Annual discharges are currently (2010) estimated to be 30 billion gallons (114 million cubic meters) per year. Building on existing and committed new sewer plans, an agreed grey infrastructure based strategy to this problem is set to reduce these discharges to 19.8 billion gallons per year (a 34% reduction) by the 2030s. An alternative green infrastructure approach based around intercepting the first inch (25mm) of rainfall across 10% of the impermeable city area by 2030 is predicted to reduce CSO spills to 17.9 billion gallons per year.

Planners have calculated that the whole life costs after 20 years of the grey infrastructure solution will be $6.8 billion (2010 prices) compared to the green infrastructure whole life costs of $5.3 billion. The green infrastructure strategy reduces CSO spills by more than the grey alternative for $1.5 billion less in terms of whole life cost. Further, planners have calculated that New Yorkers will benefit by up to $418[44] million (accumulated over 20 years) in additional benefits associated with lower energy bills from control of urban heating, increased property values and improved health.

Based on this analysis, New York City has committed itself to an aggressive green infrastructure based runoff control strategy to provide long term reductions in CSO spills. The plan is to achieve interception of 1.5% of impermeable area by 2015, 4% by 2020, 7% by 2025 and 10% by 2030.

2.5 Principle Five: Live Process

The Strategy should be adaptable and periodically reviewed. Whilst outcomes are expected to be relatively stable over time, the pace at which the Strategy delivers outcomes will be linked to volatile influences (like climate and population change) and to the decisions made at each price review about the priorities for the following period. The Strategy should be reviewed at regular intervals to reflect investments already made, the changing priorities of the water and sewerage company and partners, and the presence of emerging risks. The review is also an opportunity to report drainage catchment performance relative to performance measures designed to monitor progress towards achieving outcomes.

[44] Estimated using methods from the New York Municipal Forest Resource Analysis (MFRA) prepared by the US Dept. of Agriculture.

2.5.1 Recommended good practice

No.	Good practice	Example references
1	Regularly repeat screening exercise to determine catchments requiring a Drainage Strategy and modify programme of Strategy development accordingly. Check for changes in measured rates of flooding and pollution incidents, blockages, collapses, pumping station failures etc. Check for changes in extent and location of new development. Check for activities being undertaken by partners (e.g. redevelopment, urban realm improvements, and flooding and pollution management activities).	SRM5 illustrates how improved and updated knowledge of system performance should be applied to establish Strategies.
2	In 'live Strategies', repeat risk assessment when data and models improve and adjust confidence scores accordingly. Confirm that Strategy will still achieve performance indicators and outcomes at least cost. Revise Strategy as necessary.	
3	Periodically refresh Strategy accommodating impact of interventions already delivered, using re-verified predictive tools as appropriate. Confirm that Strategy will still achieve performance indicators and outcomes at least cost. Revise Strategy as necessary. Triggers for a wholesale review of the Strategy are likely to be significant changes to the location or extent of planned development.	
4	Monitor, report and share (with partners) the measures used to demonstrate delivery of outcomes. Example measures may include: the number of properties which experience sewer flooding; the number of properties at risk of flooding; the number of properties at risk from sewerage asset failure; risk indices that capture both the probability and consequence of failure; customer satisfaction with regards to clean rivers and beaches; the number of pollution incidents; the frequency of combined sewer overflow operation; and compliance with discharge permit conditions.	

2.5.2 Good practice example – Thames Water live DAP

Thames Water has initiated a DAP (drainage area plan) Live approach. It's a good example of how companies are continuously monitoring and updating the status of drainage area risks. It provides a 'live' snapshot of the current health of all drainage areas in Thames Water's region, allowing real time planning as part of a strategic approach. It enables drainage planners to view the effectiveness

of intervention strategies and compare incident rates across varying geographies and development types in the Thames Valley.

DAP Live will be available for all catchments in the Thames Water area thus enabling:

- high level monitoring of risks across the business;
- a live and strategic review of catchment performance;
- prioritisation of catchments based on risk; and
- an ability to share data with partners collaborating in drainage planning and improvements

Figure 12 illustrates the types of data managed through the DAP Live system. These include: asset data, political and drainage boundaries, environmental data, operational data, property & growth data and modelling data. As new data become available the DAP Live system is updated so that drainage planners have the most current view on emerging risks and issues.

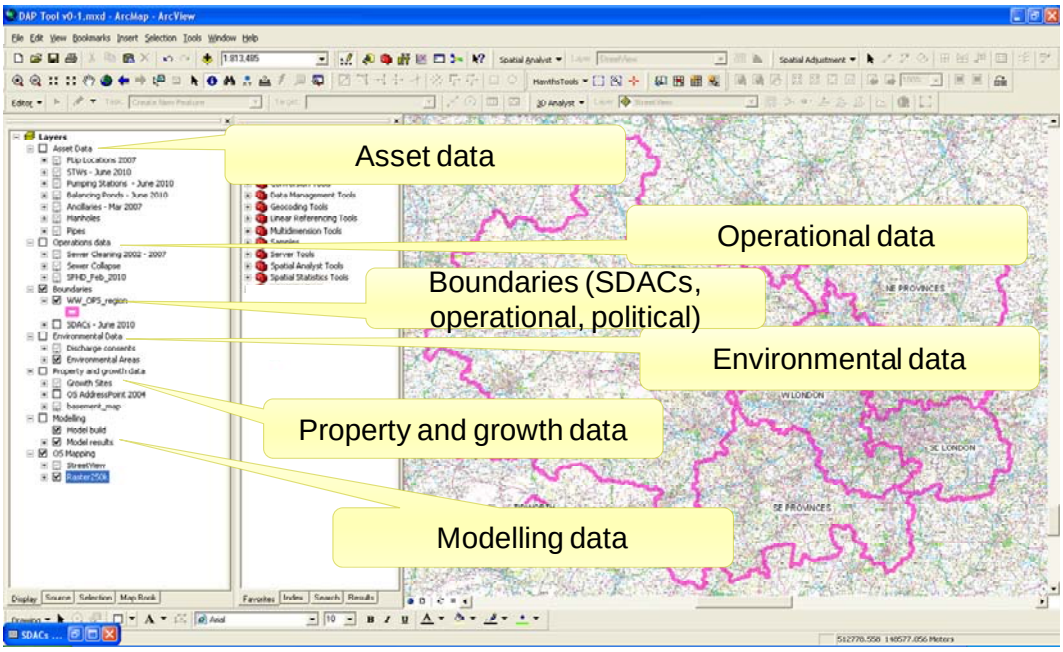

Figure 12 Data types held in the DAP Live system

Figure 13 illustrates how the system can provide analysis at a variety of scales from local authority boundaries, sewage treatment works catchments, drainage areas or a regular grid.

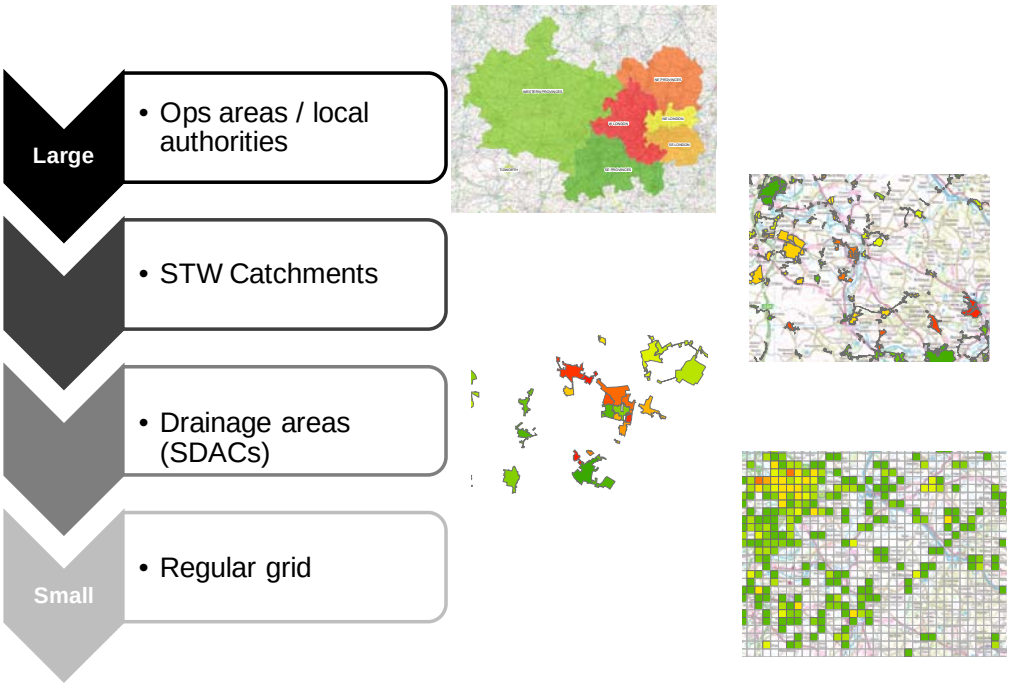

Figure 13 DAP Live reporting performance at different scales

2.5.3 Good practice example – Wessex Water Water live data

Wessex Water is regularly using data geospatially to proactively identify and respond to risk. Theirs is a good example of how data can be used to provide an adaptable approach that is regularly reviewed to plan investment.

The risk-based and live approach uses a set of likelihood and consequence models, which are built up from all currently available data; asset data (e.g. CCTV data, material, age), operational data (e.g. flooding and pollutions incidents) and information (e.g. locality near hospital or downstream of an overflow). All these data are collated for the entire Wessex region, updated regularly and analysed geospatially.

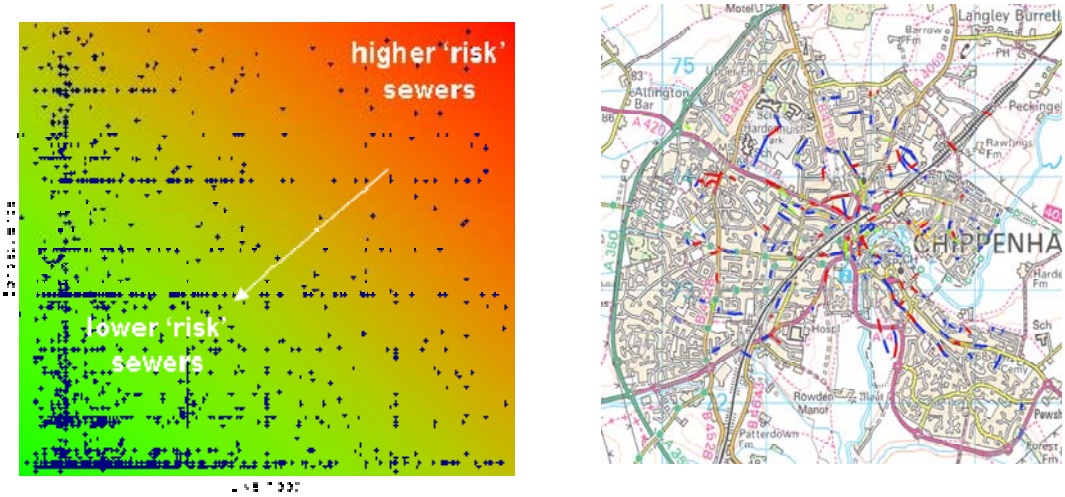

Figure 14 Sewer risk scores presented in a risk matrix and geospatially

This allows a risk score (Figure 14) to be calculated for each mapped sewer length, which directs investigation more efficiently by allocating each mapped sewer a planned CCTV inspection date.

This risk-based approach has been successful in targeting problematic sewers, increasing identification rates threefold. Density analysis is performed using asset failure and operational information, which allows planning of both proactive structural and operational investment.

Proactively found structural issues are far more cost effective to repair before failure and can also prevent serviceability issues.

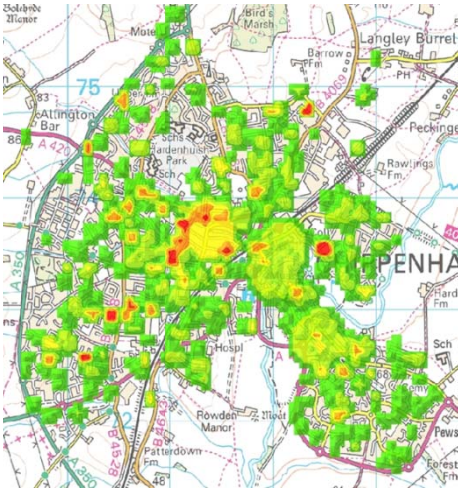

Figure 15 Hotspot analysis

The hotspot analysis (Figure 15) shows where operational clusters have been calculated. This hotspot analysis is made available on the Wessex Water corporate GIS, to allow operational staff to target their efforts to mitigate against further repeat incidents. Additional information from asset and operational activities can be added regularly to the databases which drive the models enabling risk scores to be kept as live as required.

2.6 Principle Six: Innovative and Sustainable Solutions

The Drainage Strategy Framework promotes the full evaluation of alternatives to traditionally engineered sewerage solutions to test whether these offer lower whole life cost options or better responses to uncertainty. It is anticipated that drainage solutions of the future will be different from the ones we are used to.

These should include (at least at a high level) real time control, storm water retrofit techniques, education to enable customers to change behaviour, enhancing incentives for customers to reduce surface water flowing to sewers and innovative permitting arrangements across drainage networks and sewage treatment works. Water and sewerage companies should continue to review and develop other innovative solutions.

For example, where a company may historically have preferred to tackle sewer flooding or combined sewer overflow pollution by increasing its underground equipment to store more rainfall during storms, it might consider other options in future – such as working with customers to manage the rainfall close to source, preventing it form entering the sewer system.

2.6.1 Recommended good practice

No.	Good practice	Example references
1	Use cost-benefit methods to demonstrate that innovative and sustainable solution types provide best value for customers and the wider community.	UKWIR will publish new research and guidance in 2013 addressing active control and storm water removal; demonstrating how these technologies can be justified and included within Drainage Strategies.
2	Consider integrated water resource management. Work with partners (especially developers and local authorities) to examine whether use of stored stormwater reduces potable water consumption AND need for capacity in sewers.	CIRIA has published a scoping study for water sensitive urban design[45] in the UK.
3	Consider a mix of conventional and new technologies, using more adaptive approaches as low-regrets responses to uncertainty, e.g. prevent current sewer flooding with underground tank storage but address future risks (worsened by climate change) with retrofit SuDS implemented progressively.	CIRIA has published 'Retrofitting to manage surface water'[46] ; a comprehensive guide to planning and delivering this type of project.
4	Use carbon accounting methods to compare embodied and emitted carbon in alternative intervention strategies so that these impacts are accounted for in whole life costs. Consider the benefits of surface water removal on the costs (including carbon) of pumping and sewage treatment	UKWIR[47] has and continues to publish detailed guidance on carbon accounting for water and sewerage company use.

[45]http://www.ciria.org/service/research_information/AM/ContentManagerNet/ContentDisplay.aspx?Section=research_information&ContentID=23581

[46]http://www.ciria.org/SERVICE/Home/core/orders/product.aspx?catid=5&prodid=1909

[47]http://ukwir.forefront-library.com/reports/08-cl-01-6/92341/90001/90269,90265,94658/90269

No.	Good practice	Example references
5	Where interventions include the provision of green space, public amenity and improved habitats then Payment for Ecosystem Services approaches can be used to claim further monetised benefits in the appraisal. Customers should be consulted to help value these benefits.	The Environment Agency will publish data in 2013 on costs and benefits of retrofit stormwater projects to promote understanding and uptake.
6	Share data within the industry on innovative solutions to increase knowledge of new technology and SuDs approaches.	EA retrofitting SuDs costs and benefits database[48] accommodating data from Ofwat AMP5 SuDS pilot initiative and other examples.

2.6.2 Good practice example – Welsh Water surface water reduction and removal strategy for Gowerton and Llanelli

Dŵr Cymru Welsh Water and partners are applying innovative storm water removal methods to address capacity problems in the sewer network in Gowerton and Llanelli[49] (population 140,000). Current under capacity leads to localised sewer flooding and excessive combined sewer overflow (CSO) spill to the Burry Inlet, a protected shellfish water and special area of conservation. The capacity problems in the system were a concern for the Environment Agency (Wales) and there was a risk of widespread restrictions to economic development being imposed. Dŵr Cymru Welsh Water, Carmarthenshire County Council, City and County of Swansea, Consumer Council for Water, Environment Agency Wales and the Welsh Government all worked in partnership to resolve the situation.

A brand new hydraulic model was built for the entire sewerage network with particular attention paid to accurately representing the sources of storm run-off and infiltration. The model was verified against data from flow monitors and observed CSO spill frequencies into the Burry Inlet.

To begin with, a traditional sewer storage solution was proposed that would result in an average 10 spills a year into the shellfish water from all 90 CSOs in the two catchments. Although this reduced spills and dealt with some of the flooding and growth issues, the storage requirements would have been unaffordable, provide no protection against long term climate change and would not tackle the fundamental problem of too much surface water getting into the combined network.

An alternative approach, based on the reduction and removal of storm water from the combined sewer system, was also developed. This was in accordance with Dŵr Cymru Welsh Water's Rainscape[50] (surface water elimination and reduction) strategy. To identify areas with the most

[48] http://evidence.environment-agency.gov.uk/fcerm/en/Default/HomeAndLeisure/Floods/WhatWereDoing/IntoTheFuture/ScienceProgramme/ResearchAndDevelopment/FCRM/Project.aspx?ProjectID=15515be8-bbed-4204-ae56-3e810ba47694&PageID=56bad68e-dcb1-4bf8-84cc-cbfd03ab63a2

[49] http://www.ciwem.org/media/674511/Paper%208%20Stephen%20Ollier.pdf

[50] http://www.dwrcymru.com/_library/leaflets_publications_english/

potential for effective storm water removal a flow/area/flooding thematic map was developed. This was used to focus attention on areas which would deliver the most benefit if storm water removal was carried out. These areas are coloured red in Figure 16.

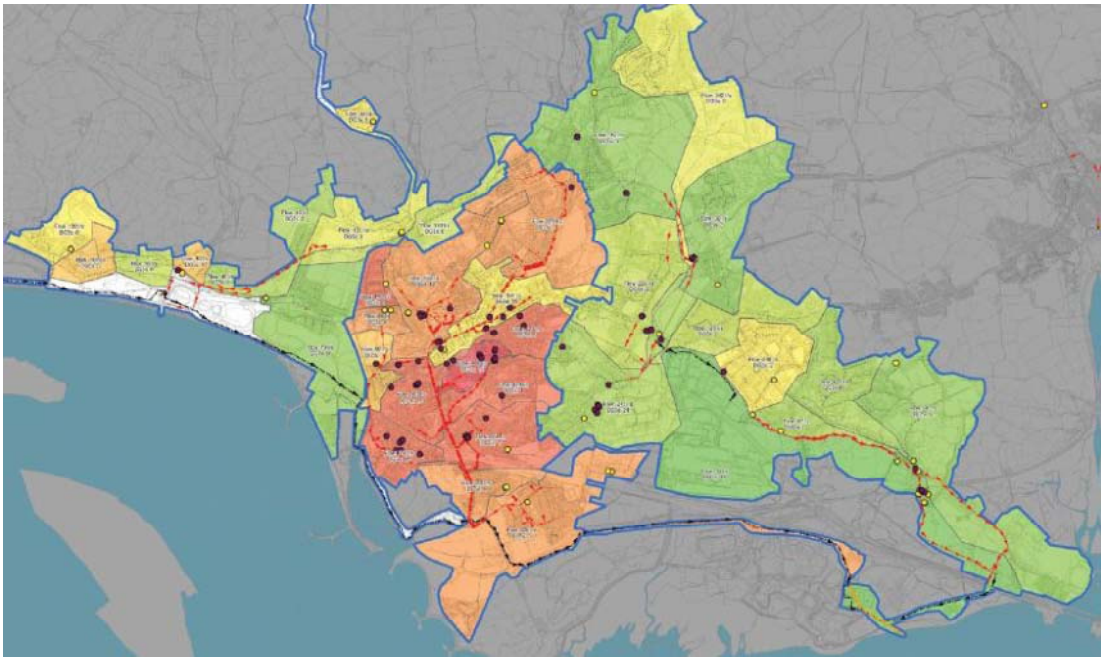

Figure 16 Thematic map showing areas of maximum potential for storm water removal

The following interventions (181 in total) were combined into single strategy to be delivered in phases by 2015, 2020 and afterwards:

- The management of surface water through swales, basins and soakaways rather than through combined sewers, resulting in new amenity and ecological areas within the built-up environment.
- Implementing smarter flow control to better use existing storage and conveyance assets
- Relining of sewers to prevent groundwater ingress
- Removal of land drainage connections to sewers
- Household rainwater harvesting retrofit schemes

surface_water_management_strategy.pdf

Figure 17 is an artist's impression of what one of the sustainable urban drainage system solutions may look like

Figure 17 Example retrofit SuDS solution proposed for Gowerton and Llanelli

Modelling has demonstrated that the alternative strategy will achieve the same CSO reduction benefit as the storage strategy together with flooding improvements and additional less tangible benefits at significantly lower cost than the traditional sewer storage solution.

Figure 18 illustrates the dispersed nature of solutions identified for central Llanelli.

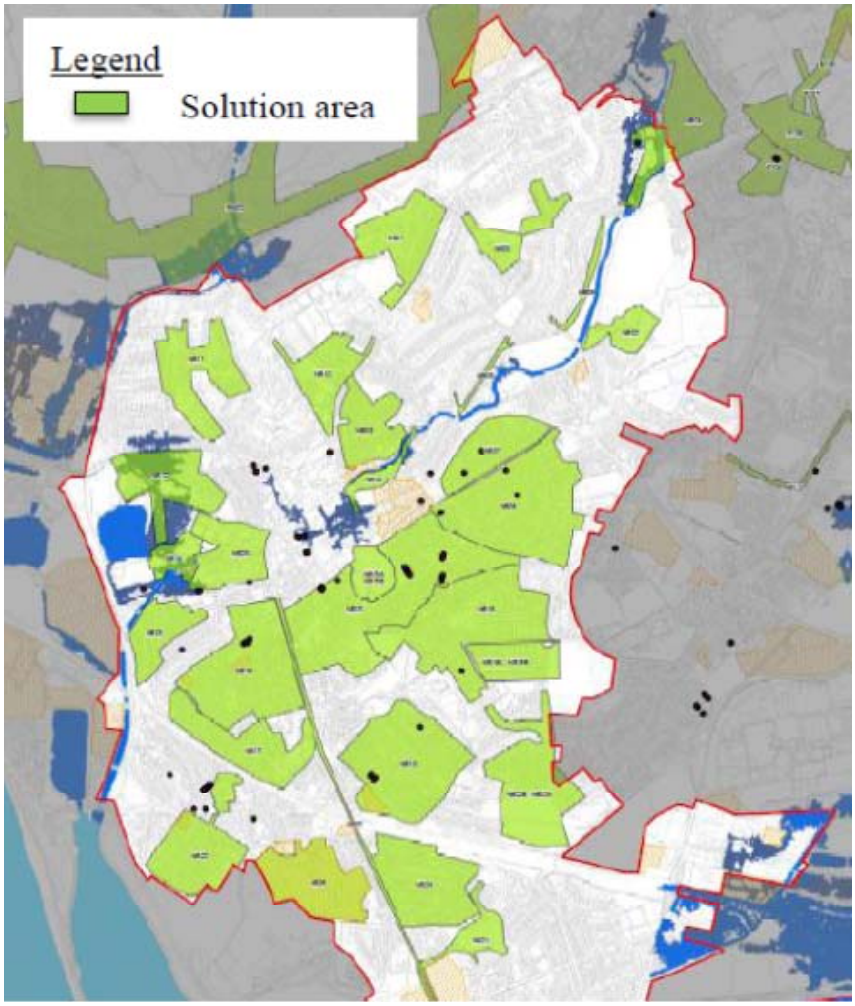

Figure 18 Water sensitive urban design interventions planned for central Llanelli

Appendix A

Glossary

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CAPEX	Capital expenditure. Appointed water and sewerage companies' spending on new, replacement or refurbished capital assets, such as construction or buying machinery.
CIWEM Urban Drainage Group (WaPUG)	A group of the Chartered Institution of Water and Environmental Management supporting professionals working in urban drainage.
Combined Sewer Overflow (CSO)	The discharge of untreated sewage diluted with storm water into rivers and the sea. CSOs occur during heavy rain and are necessary to reduce the risk of sewer flooding. The physical overflow structure is also called a CSO.
Common Framework for Capital Maintenance Planning	A planning approach developed for the water and sewerage companies in 2002 which provides a robust basis for assessing future capital maintenance needs. The approach is consistent with the needs of Ofwat.
Defra	The Department for Environment, Food and Rural Affairs. The Government Department with responsibility for water, flooding and water quality in England.
Drainage Area Plan (DAP)	A detailed plan for a drainage catchment that prioritises a list of interventions based on risk using an approach established in the WRc Sewerage Rehabilitation Manual. This approach has been succeeded by Sewerage Risk Management which guides the preparation of Sewerage Management Plans (SMP). Companies vary in how they prepare DAPs or SMPs (or their equivalents) following the general principles that have been established.
Drainage Strategy	Developed by water and sewerage companies to demonstrate how outcomes will be delivered in drainage catchments over the long term. Drainage Strategies will use the information developed in producing a DAP/SMP and if a drainage strategy has been produced, this should be the starting point in producing a more detailed DAP/SMP should this be required. It is likely that the activities required to prepare DAP/SMP and Drainage Strategies may overlap. Drainage Strategies might not refer to specific interventions but instead outline a general approach.
Drainage Strategy Framework	Guidance to describe the contents and intention of Drainage Strategies.

Flood Risk Management Plans	Required by the Flood Risk Regulations in Flood Risk Areas by December 2015.
Flood Risk Regulations	The legislative instrument used to implement the requirements of the Floods Directive in England and Wales.
Floods Directive	DIRECTIVE 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
Lead Local Flood Authority (LLFA)	The Shire County or unitary authority with responsibility for managing local flood risk.
Local development plans	Developed by planning authorities to explain where and what type of development (new homes and businesses) will occur within their area. They are required to explain water infrastructure needs to support this development.
Local Flood Risk Management Strategy (LFRMS)	Developed by the Lead Local Flood Authority to explain how local flood risk will be managed by the Authority and in partnership with others.
Natural Resources Wales	From 1 April 2013, Natural Resources Wales (NRW), a new body formed by the Welsh Government, will take over the functions previously carried out by the Environment Agency (EA) in Wales, alongside those of the Forestry Commission Wales and the Countryside Council for Wales.
Ofwat	The Water Services Regulation Authority – the economic regulator of the water and sewerage companies of England and Wales.
OPEX	Operating expenditure. Appointed water and sewerage companies' day-to-day spending on running the services, for example, staff costs and power. This is likely to include investment in joint projects that do not create or relate to an asset that the company solely or jointly owns.
Outcomes	Outcomes are the higher level objectives that a company's actions are intended to deliver. A company's outcome should reflect its customers' priorities, identified through appropriate customer engagement, and deliver the best long-term, sustainable solution for customers and the environment. An outcome may not be bound by a single price control period and should be set in the context of customers' and the environment's long-term needs.

Price Review	The process of setting appointed water and sewerage companies' price limits. The next price review will take place in 2014 for the period 2015-20. Ofwat currently sets price limits every five years.
Real Time Control (RTC)	Using actuated pumps, gates and weirs to actively control flow in sewers. Better use can be made of existing infrastructure and links can be made between network, treatment and receiving water systems for operational benefits. Sometimes referred to as Active Management.
River Basin Management (Plans)	River Basin Management is a continuous process of planning (to develop River Basin Management Plans) and delivery. The Water Framework Directive introduces a formal series of 6 year cycles. The first cycle will end in 2015 when, following further planning and consultation, the River Basin Management Plans will be updated and reissued.
Sewerage Management Plan	A risk based approach to indentifying investment needs in sewerage systems as described in the Sewerage Risk Management (SRM) approach developed by WRc plc.
Storm water retrofit	Releasing capacity in sewers by controlling stormwater at the surface using disconnection, swales and other sustainable drainage systems (SuDS).

We are the Environment Agency. We protect and improve the environment and make it a better place for people and wildlife. We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate. Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do. We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

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