VALUING THE BENEFITS OF STORM DISCHARGE IMPROVEMENTS FOR USE IN COST-BENEFIT ANALYSIS

PRACTITIONERS' GUIDE

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PRACTITIONERS' GUIDE

Summary

The vision of the 21st Century Drainage Programme is to enable the UK water industry, in partnership with the UK's governments and regulators, to make plans now that will ensure the sustainability of our drainage infrastructure in the future.

The Programme recognises that storm overflows are an important part of our drainage system, providing protection to properties from flooding by alleviating surcharging of combined sewer systems that occurs in wet weather. However, they have the potential to impact on the receiving waters they discharge to, and can be sources of pollution if they are not controlled and managed effectively.

To help manage the environmental, reputational and other risks from storm discharges, the Environment Agency and the water industry has collaborated to produce the Storm Overflow Assessment Framework (SOAF). This is intended to address the problems caused by discharges from storm overflows considered to operate at too high a frequency.

Stage 3 of the SOAF requires an economic assessment of high spilling storm overflows that cause an environmental impact, or any overflow in a drainage catchment greater than the Urban Wastewater Treatment Directive (UWWTD) threshold of 2,000 pe (population equivalent).

This Practitioners' Guide accompanies the main project report, and is designed to support application of the framework that has been developed. It includes a methodology and step-by-step framework (with a recommended approach in each step) that enables the direct and indirect benefits of improvements to storm overflows to be assessed and valued in a robust, consistent and transparent way. It has been written for asset managers, investment planners and others involved in identifying and assessing improvements to storm discharges.

Details of the research undertaken to produce this Guide can be found in the main project report, which is provided separately.

For further information, please contact Water UK, 3rd Floor, 36 Broadway, London, SW1H 0BH quoting the report reference number

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Glossary

Aesthetic impacts	Changes to the visual appearance of a waterbody or area, either due to sewage litter, debris or options that include landscaping/greening.
Benefit-cost ratio	An indicator of the overall value for money of an option, project or proposal, used in cost-benefit analysis. A BCR is the ratio of the discounted present value benefits of a project or proposal, expressed in monetary terms, relative to its discounted present value costs, also expressed in monetary terms.
Benefits of SuDS Tool	Tool developed by CIRIA (Construction Industry Research and Information Association), which provides a structured approach to identifying and valuing a wide range of benefits associated with SuDS (sustainable drainage systems).
Cost-benefit analysis	A systematic approach to estimating the strengths and weaknesses of alternatives. It is used to determine whether a project or proposal represents a worthwhile (efficient) investment, and to select between different projects or proposals. In the context of this project, CBA incorporates wider (e.g. environmental and social) costs and benefits.
Combined sewer overflow	A structure on a combined or partially separate sewerage system that allows the discharge of flow in excess of that which the sewer is designed to carry, usually to a receiving surface water body.
Event Duration Monitoring	Monitoring of CSOs to determine the number of times and how long a CSO operates during a year.
Green infrastructure	An approach to managing wet weather impacts that is designed to be resilient and provide a range of financial, environmental and social benefits. It involves holding back water to reduce run-off and treating stormwater at its source.
Multi-Coloured Manual	A handbook and tool to support assessment of the impacts of flooding and coastal erosion.
Net Present Value	An indicator of the value for money of an option project or proposal, calculated by subtracting the discounted present value costs of a project or proposal, expressed in monetary terms, from its discounted present value costs, also expressed in monetary terms.
Option	A combination of measures/physical interventions that, taken together, are deigned to achieve a specific improvement or outcome in relation to stormwater discharges.

Storm Overflow Assessment Framework	An assessment framework, developed as part of the water industry's 21st Century Drainage Programme, which is intended to address the problems caused by discharges from storm overflows considered to operate at too high a frequency.
Sustainable Drainage	An approach designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges. Encompasses a range of measures including green roofs, permeable surfaces, ponds, wetlands and shallow ditches called swales.
TOTEX	The combination of capital expenditure (capex) and operational expenditure (opex) into a single measure of overall expenditure. Originally proposed to remove any potential bias towards capex in the water industry.
Willingness to Pay	The maximum amount an individual is willing to forego to procure a good or avoid something undesirable. Estimated WTP values for water, wastewater and environmental service improvements are generally derived from water company customer surveys and used to inform investment planning.

Acronyms

BCR	Benefit-cost ratio
BeST	Benefits of SuDS Tool
BTKNEEC	Best Technical Knowledge Not Entailing Excessive Cost
CBA	Cost-benefit analysis
CSO	Combined Sewer Overflow
EA	Environment Agency
GI	Green Infrastructure
MCM	Multi-Coloured Manual
NIEA	Northern Ireland Environment Agency
NPV	Net present value
NRW	Natural Resources Wales
PSG	Project Steering Group
SEPA	Scottish Environmental Protection Agency
SOAF	Storm Overflow Assessment Framework
SuDS	Sustainable Drainage
UWWTD	Urban Wastewater Treatment Directive
WaSC	Water and Sewerage Company
WTP	Willingness to Pay

1 Introduction

1.1 Background

The vision of the 21st Century Drainage Programme is to enable the UK water industry, in partnership with the UK's governments and regulators, to make plans now that will ensure the sustainability of our drainage infrastructure in the future.

The Programme recognises that storm overflows are an important part of our drainage system, providing protection to properties from flooding by alleviating surcharging of combined sewer systems that occurs in wet weather. However, they have the potential to impact on the receiving waters they discharge to, and can be sources of pollution if they are not controlled and managed effectively.

To help manage the environmental, reputational and other risks from storm discharges, the Environment Agency and the water industry have collaborated to produce the Storm Overflow Assessment Framework (SOAF). This is intended to address the problems caused by direct (e.g. from combined sewer overflows) and indirect (e.g. from surface water outfalls) discharges from storm overflows considered to operate at too high a frequency.

Stage 3 of the SOAF requires an economic assessment of those high spilling storm overflows that cause an environmental impact, or a high spilling overflow in a drainage catchment greater than the Urban Wastewater Treatment Directive (UWWTD) threshold of 2,000 pe (population equivalent).

1.2 Project objectives

The objectives of the project were to:

i. Identify the social, economic and environmental benefits of improving storm overflows;

ii. Review international practices for valuing benefits associated with storm discharge improvements within a cost-benefit analysis (CBA) framework;

iii. Develop a methodology to enable the marginal benefits of improvements to be valued; and

iv. Provide a CBA framework so future investment decisions can be made.

The key outputs of the project are:

- A benefit valuation methodology that can feed into the SOAF as part of the broader 21st century drainage programme of work; and

- A framework to support decisions on whether or not storm overflow improvements are required and how improvements should be prioritised.

1.3 The framework

An overview of the framework developed is provided in the main report. This Practitioners' Guide accompanies the main project report, and is designed to support application of the framework. It includes a methodology and step-by-step process that enables the direct and indirect benefits of improvements to storm overflows to be assessed and valued in a robust, consistent and transparent way.

For each step of the framework, there is a recommended approach and guidance on what to do and how to do it. Each step also allows for better or company-specific information (e.g. from willingness to pay surveys) to be used. At the end of each step, there is an example showing how the step can be applied in practice[1].

This Guide has been written primarily for water and sewerage companies (WaSCs), particularly asset managers, investment planners and others involved in identifying and assessing improvements to storm discharges. Ideally, assessments should draw on a range of expertise within a multidisciplinary team, including civil and environmental engineering, economics, ecology, planners and others.

Details of the research undertaken to produce this Guide can be found in the Project Report, which is provided separately (*NL5946 Final Report*).

1.4 Where to find more information

More detailed information regarding the approach adopted in developing the framework can be found in the Project Report. This describes the research undertaken to inform the approach, including its testing on ten case studies.

Further information on the 21st Century Drainage Programme can be found at http://www.water.org.uk/policy/improving-resilience/21st-century-drainage.

[1] Information to support the example is illustrative and has been kindly provided by Yorkshire Water.

2 Overview of the benefits assessment framework

The framework for assessing the benefits of storm discharge improvements is shown in Figure 1 and is designed to support an approach based on societal cost-benefit analysis (CBA). The aim of the framework is to ensure consistency in, and robustness of, assessments whilst allowing flexibility and ensuring the level of effort is proportionate to the decision to be made.

There are six key steps to follow, highlighted in orange ('Methodology') in Figure 1. Guidance relating to each step is included in the relevant section of this document (Sections 3 to 8). The process set out in Figure 1 should be followed for each overflow being assessed. To maximise consistency, robustness and transparency of assessments, each step includes a recommended approach to follow. However, the guidance is flexible and assessments can deviate from the recommended approach, e.g. where better or site-specific information is available. Where a WaSC wishes to deviate from the recommended approach, they should engage in an early dialogue with regulators and other key stakeholders.

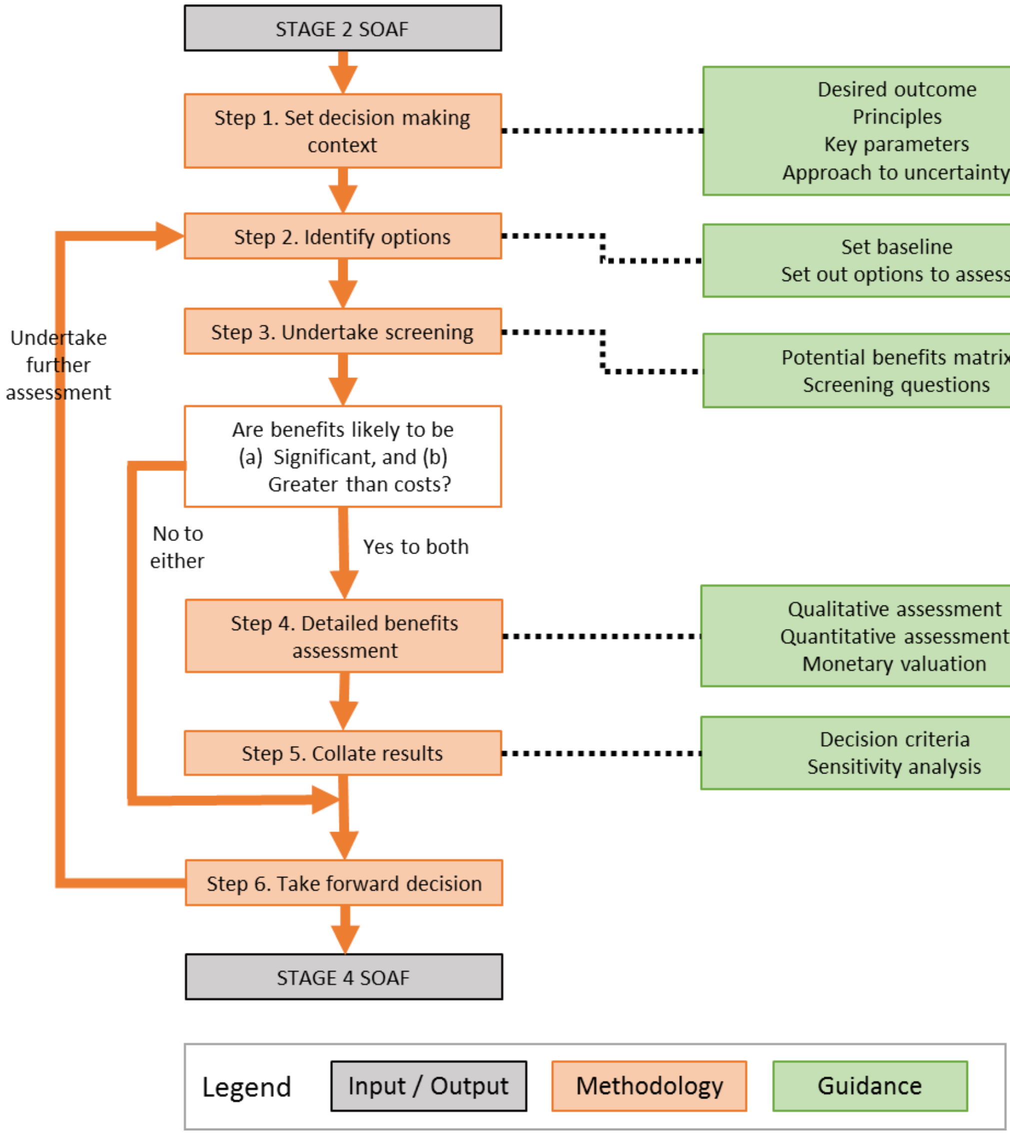


Figure 1 Overall framework

The approach adopted in the framework is sufficiently flexible to be applicable to both an individual overflow and a group of overflows (as part of a catchment-wide programme). It is consistent with government guidance (HM Treasury, 2011), principles set out by the Environment Agency (EA, 2016a), water industry approaches (UKWIR, 2010) and natural capital concepts (Natural Capital Coalition, undated).

At the beginning of each step is a blue shaded box. This sets out the purpose of the step and when it should be applied. At the end of each step is a pink shaded box. This highlights the expected outputs from the step.

2.1 Inputs to the framework

The key 'input' to the framework is the output from Stage 2 of the SOAF. This confirms that there is clear driver/justification for intervention, i.e. the overflow has been identified as a high spiller and causing an environmental impact, or that it is high spilling and above the 2,000 pe drainage catchment threshold.

A number of quantified or semi-quantified outputs from Stage 2 are expected, including:

- Number of spills;
- Details of aesthetic impact including amenity (e.g. litter) and public complaints (score and classification from no impact to severe); and *either*
- Details of invertebrate (biological) impact (score and classification from no impact to severe); *or*
- Water quality impact (based on dilution or modelled impact).

Stage 2 should also provide information about the watercourse itself and the surrounding environment close to the overflow.

In addition, the individual or team undertaking the assessment will need to consider what inputs are needed to ensure that the financial, social and environmental benefits of a range of potential options to improve overflows can be articulated, estimated and assessed. For this reason, assessments should draw on a range of expertise within a multidisciplinary team, including civil and environmental engineering, economics, ecology, planners and others. Guidance to support provision of these inputs is provided within this document.

2.2 Outputs from the framework

To facilitate consistent recording of outputs and reporting, an Appraisal Summary Table (AST) is provided (Table 1). This is the key outputs from the framework that should be taken forward to Stage 4 of the SOAF. A completed example AST is included in Appendix 1.

Table 1 Appraisal Summary Table

Scheme details: site, location, etc						
Baseline:						
Option name:						
Summary of screening:						
Detailed assessment						
Benefit category	Qualitative description	Quantitative assessment (1)	Value taken (2)	Monetary valuation (1x2)	Sensitivity	Assumptions
Results:						

3 Step 1: Set decision making context

The purpose of this step is to ensure the decision to be made is clear, agreed and recorded.

This step should be applied to all overflows that are assessed using Stage 3 of the SOAF.

We recommend that the principal aim of each assessment should be to identify the option that maximises benefits relative to costs, thereby maximising societal welfare. As such, the basis of the assessment process is cost-benefit analysis (CBA).

CBA requires the benefits of investments to be valued in monetary terms (UKWIR, 2010). Benefits that are typically relevant to CBA include 'gains' to customers in terms of improvements in service levels ('improved service'), avoided service losses, wider environmental and social benefits, and also avoided resource costs.

Valuing the benefits of investments in water, wastewater and environmental services in most cases requires the use of economic valuation methods. This is because these are generally 'non-market' benefits and their value cannot be inferred from the price paid for them (e.g. water and wastewater services), or because they are unpriced (e.g. environmental services).

Net present value (NPV) is the primary criterion for informing decision-making: for a project or programme to qualify on cost-benefit grounds the present value of its benefits must exceed the present value of its costs. The 'correct rule' for the CBA (in the absence of resource or investment constraints) is to undertake any investment with a positive NPV (that is benefits exceed costs) and to rank projects by NPV. CBA however is just one input to decision-making and other factors (e.g. affordability, distribution of costs and benefits) may justifiably be considered when determining investment priorities.

CBA permits the determination of the 'optimal' level of investment, which corresponds to the point at which net benefits are maximised. Alternative appraisal methods, such as multi-criteria analysis (MCA) and cost-effectiveness analysis (CEA), which express costs and benefits in different units, cannot define the optimal level of investment. The corollary is that CBA can determine if a project or programme should be undertaken at all, whereas MCA and CEA can only 'choose' between investment options and cannot address the question of whether *any* option should be chosen. This distinction stems from the expression of costs and benefits in different units in the latter approaches.

Accordingly, this stage should explicitly articulate the desired outcome of the intervention. This should be the optimal level of investment, i.e. that which provides best value for money for customers and society, but could also consider cases where CBA may be 'constrained', including:

- How benefits can be maximised, either relative to costs, or subject to a fixed budget or level of affordability;
- Whether a specific reduction in spills needs to be achieved;

- Whether a certain water quality, environmental or other standard needs to be met; and
- Ensuring no detriment to other drivers.

Identifying ways to achieve the desired outcome will involve the consideration of water quality, spill frequency, aesthetic issues (as defined in the SOAF) within the watercourse and other socio-economic factors.

This step should also set out and define any key parameters relating to the assessment. ***We recommend that these should include the timeframe for the assessment (note that the 21st century drainage programme of work is about taking a longer term approach, beyond the next few years), discount rate, geographical scope of benefits, and the beneficiary groups to be considered.***

Finally, this stage should set out the proposed approach to uncertainty. This is discussed further in Section 7 (Step 5 of the assessment). ***We recommend that, as a minimum, each assessment should utilise ranges for key metrics/values, and adopt sensitivity analysis around the results.***

To complete this step, you should record

- The aim of the assessment, including any constraints
- Key parameters
- The approach to uncertainty

Roundhay Park Example: Set Decision Making Context

Yorkshire Water investigated the potential of different options to reduce combined sewer overflow (CSO) spills in Roundhay Park in Leeds, as part of its plans for the 2014 Periodic Review. The aim was to compare the costs, immediate and wider benefits of a SuDS and conventional drainage approach.

The timeframe for the assessment was 40 years and the discount rate is 3.5%. All benefits within the water company operating area were considered.

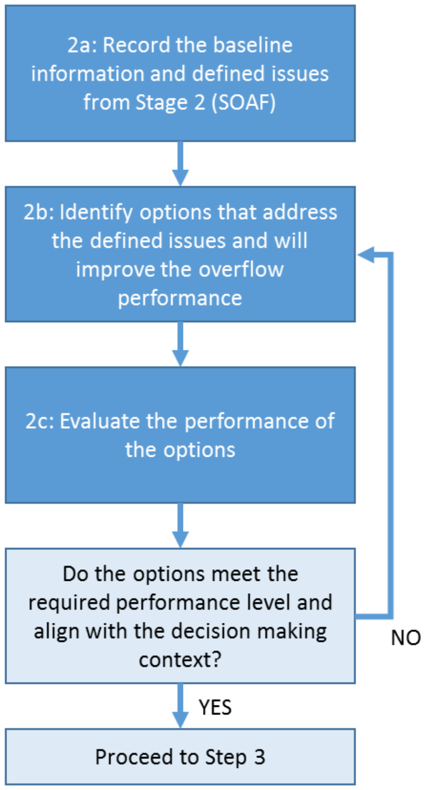
Uncertainty was managed using ranges for key values, along with confidence intervals based on the approach in BeST (Benefits of SuDS Tool) and sensitivity analysis of the results.

4 Step 2: Identify options

This stage should provide the basis for ensuring that all storm overflow interventions are assessed against a common baseline. ***We recommend that three key steps should be undertaken.***

> **The purpose of this step is to ensure that the options to be assessed (including the baseline) are clear, agreed and recorded.**
>
> **This step should be applied to all overflows that are assessed using Stage 3 of the SOAF.**

- ***Step 2a – Record baseline information***
- ***Step 2b – Set out the options***
- ***Step 2c - Evaluate options***



Step 2a – Record baseline information

The baseline ('business as usual' or 'do nothing' option) should be articulated and recorded. This includes the location of the overflow, drivers for intervention, reasons for failure (RFF), current spill frequency, water quality (generally based on measured data), EDM (event duration monitoring) data, WFD status and hydraulic capacity. Water quality modelling will also be necessary to confirm the baseline and potential change through the options. This may have already been started as part of the previous work under the SOAF to confirm the deficiency or may be required here where an environmental impact has been indicated through macroinvertebrate sampling. It is recommended that the UPM3 Manual (FWR, 2012) is used and the level of detail for the water quality modelling is commensurate with the context, scale and complexity being considered. **Note that if the overflow was not deemed to result in an environmental impact, then water quality modelling is not required i.e. in the case of the overflow in the drainage catchment with a greater than 2,000 pe.**

Where possible, external (e.g. climate change, growth) and endogenous (e.g. volume available for dilution) changes over time should also be considered, since projections of water quality (based on modelling) or other parameters may suggest deterioration if no action is taken.

The assessment framework is based on the evaluation of additional (marginal) changes in benefits. Therefore, any improvements expected as part of WFD-related schemes or other drivers should be included in the baseline/do nothing case.

Key information to capture in defining the baseline is shown in Table 2.

Table 2: Baseline information

Location	Description of information
Site information	• Location (e.g. postcode, grid ref.) • Location type (rural/urban) • Individual or group of high spilling overflows? • Catchment name • What information has been captured, and what assessment has been undertaken, as part of stages 1 and 2 in the SOAF? • Have any solutions to the problem been identified? Are these planned or already in place (assets previously improved)?
Overflow Information	• Overflow name and permit ref. number • Overflow type (CSO, pumping station overflow, treatment works), size and screening arrangements • Current and projected (over assessment timeframe) number of spills/ year (EDM or modelled) • Current and projected annual discharge, spill volume (measured/simulated) and if undertaken water quality river impacts.
Receiving water body	• Receiving water body name • Discharge location (e.g. postcode, grid ref.) • Amenity class (H/M/L/None) • Current & projected (over assessment timeframe) WFD Classification/RFF • Have any statutory or other drivers been identified in receiving water body? • Environmental assessment completed and results (e.g. UPM) • 95%ile low flow estimate

<u>Step 2b – Set out the options</u>

Once the baseline is established, the options for assessment should be set out. It is expected that the water and sewerage company will predominantly identify potential options for the assessment. However, in order to provide an indication of the likely scale and breadth of different costs and benefits, ***we recommend that a minimum of 2 options are considered, which should be varied in nature***.

Each option should include a description of the type, scale and other characteristics of the option and its component measures (which may differ in scale or timing). All options must be specified consistently in terms of their ability to achieve the desired outcome, e.g. an option to just reduce spills and tackle water quality through additional storage will have different impacts, costs and benefits to an option which also seeks to tackle flood risk (if a wider problem exists). Options should be assessed *relative to* the baseline.

Options can be considered in different locations. These will create different benefits through a combination of different types of measures (e.g. tanks, screens, SuDS) and where they are built. The measures may be either:

- At the overflow, where storage, a screen or treatment process is applied; and/or
- In the catchment upstream or downstream of the overflow through source control, disconnection, conveyance and or storage.

These are not definitive, but intended to illustrate the sort of options that may be appropriate, and which may deliver benefits of different types and at different scales. Table 3 provides further detail to the types of options that may be used to improve water quality, some of which will attract greater and wider benefits. For example, where:

- Grey infrastructure single point storage options are considered, these are likely to create benefits to the watercourse and dis-benefits in the sewer network (e.g. more pumping and treatment required).
- Distributed measures are considered in the sewer network, these are likely to create wider benefits to a wider range of beneficiaries.

Options can be amended or refined later (e.g. to ensure benefits are maximised relative to costs), and the framework includes a feedback loop to allow for this.

Step 2c - Evaluate hydraulic and water quality performance of the options

Options should be evaluated to understand their performance against the required need and the agreed decision making context. This will provide an indication of the likely hydraulic and water quality benefits that the options will create. Determining the length of water body improved will require water quality modelling of the options (as indicated in Step 2a) unless the overflow was not deemed to be causing an environmental impact.

If the options meet the required performance level and align with the decision making context, then proceed to Step 3. If not, return to Step 2b.

Table 3 Summary of the types of options that might be considered

Outcome	Option	Description
Reduce spills	Disconnection & source control (green infrastructure)	Runoff from impermeable area is disconnected from the combined system or slowed down through source control to reduce flow and volume. Uses vegetative (green) and water based (blue) SuDS.
	Disconnection and source control (grey infrastructure)	Runoff from impermeable area is disconnected from the combined system or slowed down through source control to reduce flow and volume. Uses 'grey' SuDS and conventional solutions
	Storage and transfer	Flows are held in storage tanks at or around overflows or diverted away from the location, possible as a larger network solution.
	Screening	Screens are used to prevent aesthetic impacts, by preventing sewage litter being discharged from the overflow chamber

Outcome	Option	Description
Improve discharge quality	Online treatment (green)	Flows being discharged from the overflow pass through a natural treatment system (e.g. reed beds) to capture and remove pollutants. This might result in a change in the type of permit.
	Online treatment (grey)	Flows being discharged from the overflow pass through a grey infrastructure physical / chemical / biological process to treat the pollutant load. This might result in a change in the type of permit.

To complete this step, you should record

- The baseline information
- The options to be assessed

Roundhay Park Example: Identify options

Four options were considered, all in relation to the current situation (baseline). These are described below. The assessment described later in this report is based on Option 3.

- Option 1: A conventional option to store water in concrete tanks at CSOs to limit the volume spilling to the watercourse and return it to the combined sewer after the storm.
- Option 2: A conventional (+) option that limited the volume spilling from the CSOs but also reduced predicted flooding in the catchment (giving similar hydraulic performance in the combined sewer network to Options 3 and 4 below). This option included a combination of storage tanks and pipe upsizing to manage flow in the combined sewer.
- Option 3: A SuDS approach in public areas to disconnect surface water from the combined system and pass it through the conveyance and storage SuDS. This used a combination of swales, detention basins, geocellular storage and connecting pipes.
- Option 4: A SuDS approach as in option 3 with measures added in residential private locations. These included water butts and residential rain gardens on properties of sufficient size


Option 3: SuDS in public spaces


Option 4: SuDS in public spaces and private spaces

Example photos courtesy of susdrain.

5 Step 3: Undertake screening

The purpose of this step is (a) to ensure the assessment is focused on those options most likely to be cost-beneficial, and (b) to ensure assessed options focus on benefits of greatest significance.

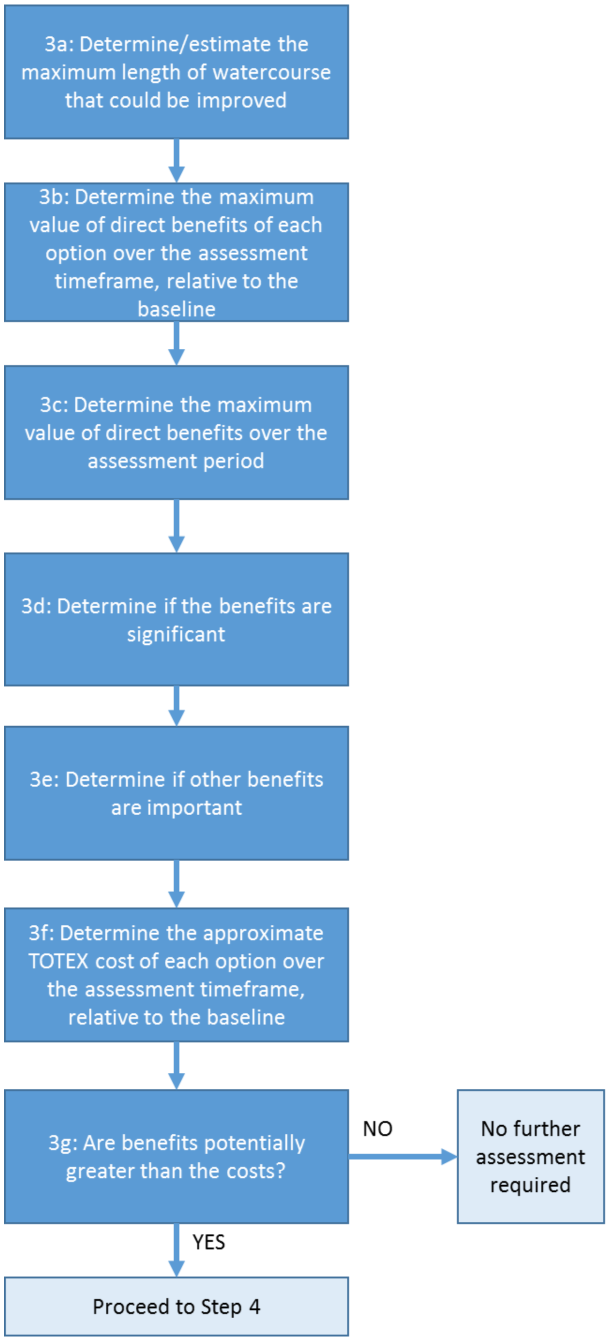
This step should be applied to all options identified in Step 2.

The purpose of the screening process is to remove infeasible options or identify a clearly favourable option (one which dominates all the others) based on the potential scale of net benefits (the difference between benefits and costs). This will help to ensure that the assessment is undertaken in a proportionate way and focused on those impacts of greatest likely significance. The approach set out here enables assessment of the potential scale of net benefits in monetary terms to be based either on default values or on a water company's own willingness to pay (WTP) information.

The screening process comprises a series of steps (see flow chart). These are described below and provide a means of determining whether or not a detailed assessment is needed and appropriate.

Based on responses to these questions, the assessment should record whether benefits are likely to be (a) significant, and (b) greater than costs. If the answer to either (a) or (b) is no, then a detailed assessment of benefits for that option is unlikely to be required.

To enable you to answer these questions, ***we recommend that you follow the process outlined below***.



Step 3a - What is the maximum length of improved watercourse?

Estimate the potential length of watercourse that might be improved by reducing the number of spills or improving discharge quality by considering the following principles:

- This should only be assessed where the high spilling overflow has been recorded as causing an environmental impact, i.e. not through the >2,000 pe drainage catchment route.
- Where water quality modelling (e.g. UPM) has taken place, use this to indicate the length of river which is deficient and could be improved by amending the discharge frequency. Where appropriate, initial options may also be modelled to demonstrate their level of improvement (Step 2b). Note that it may be necessary to increase the definition of the river modelling in assessing the water quality impacts to enable the length of improvement to be determined.
- Where water quality modelling has not taken place (due to invertebrate survey taking place that demonstrates a deficiency):
    - It may be possible to estimate the length of river that could potentially be improved through engineering judgement or by using the dilution calculation in Stage 2 of the SOAF. Through the latter, identify the length of the watercourse where the dilution is less than 8:1 (Q95 river flow:sewer DWF). Review key physical characteristics of the river reach that could shorten the likely improved length – for instance, a ponded reach providing significant attenuation can dissipate wet weather impacts sufficiently so that they do not persist further downstream (e.g. beyond a weir or confluence with another watercourse).
    - It may be necessary to undertake water quality modelling, following the guidance in UPM3 to determine the length of reach improved at this stage.
    - If in doubt, assume that improving 1 overflow will (depending on size of overflow, dilution, etc) improve a maximum 1km of watercourse (consistent with selecting the highest amenity class in the SOAF).

> To complete this step, you should record the length (km of watercourse) improved for each option.

Step 3b - What is the maximum value of direct benefits per year?

To support the maximum potential value calculation of benefits each year, Table 4 provides approximate monetary values for improvements in the quality of water bodies, linked to the WFD classification of ecological status. These values come from the Environment Agency's National Water Environment Benefits Survey (NWEBS) and provide an indication of the benefit typically expected from storm overflow improvements (EA, 2016a; Metcalfe et al, 2012).

This survey is based on a national study funded by the Defra-led Collaborative Research Programme, which elicited WTP values from around 1,500 people for improvements in the water environment with respect to WFD.

NWEBS values are used as, based on the literature review (see Main Report), they appear to represent the most appropriate means of monetising the various impacts of overflow improvements in a relatively simple way.

We recommend that you select the value from Table 4 that most closely reflects the location and potential improvement provided by the option. Note that more detailed, catchment-specific values, are also available and can be applied where appropriate (e.g. as part of a detailed assessment (Step 4) or where a decision is likely to be contentious or borderline), although these may need to be updated for inflation.[2]

Table 4 Values from NWEBS to inform maximum value of benefits per year

River Basin District / Country	Average benefit by status change (£000/km/yr)[3] (2016 prices)				
	Bad to Poor	Poor to Moderate	Moderate to Good	Good to High	Bad to High
Anglian	18.7	21.5	24.9	0.0	65.1
Dee	16.8	19.2	22.1	0.0	58.1
Humber	19.3	22.2	25.8	0.0	67.3
North West	20.3	23.4	27.2	0.0	70.9
Northumbria	15.9	18.2	21.0	0.0	55.2
Severn	17.2	19.6	22.8	0.0	59.6
Solway Tweed (also use for Scotland and N. Ireland)	11.8	13.2	15.0	0.0	39.9
South East	23.4	27.2	31.9	0.0	82.4
South West	14.8	16.8	19.3	0.0	50.9
Thames	33.1	38.9	45.9	0.0	117.9
Western Wales	13.8	15.5	17.7	0.0	46.9
England & Wales	18.9	21.8	25.2	0.0	65.9

Of course, linking benefits to change in WFD class is challenging. This is because most water bodies will only have one ecological monitoring point and a maximum of three water quality sampling points, so the recorded classification could be quite different from what is found at a specific overflow location. In addition, most water bodies have multiple causes of failure, the circumstances where an overflow improvement would result in a change in class are

[2] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291464/LIT_8348_42b259.pdf

[3] Values have been updated from 2012 to 2016 prices using the Consumer Price Inflation figures from the Office of National Statistics.

limited. In reality, most improvements are likely to lead to a change in one or more WFD element rather than an entire class.

To allow for this, it is possible to adopt a pragmatic approach to 'break down' the values in Table 4 according to the type and scale of improvement expected. Respondents to the NWEBS questionnaire considered six equally weighted ecosystem components when making their assessment (EA, 2016b). These components were:

1. Fish
2. Other animals such as invertebrates
3. Plant communities
4. The clarity of water
5. The condition of the river channel and flow of water
6. The safety of the water for recreational contact

Table 5 links the environmental impact expected (based on stage 2 of the SOAF) to the six components above. Based on this mapping, the last column of Table 5 sets out the proportion of the value from Table 4 that should be applied. Using this approach, the improvement from any given option will result in a minimum of one-sixth and a maximum of five-sixths of the appropriate value from Table 4. This is advisory and based on a precautionary approach. It is a simplified approximation and you should consider whether the proportions to apply are sensible for the option being assessed, and adjust them using sensitivity analysis (see Step 5e, e.g. by applying confidence scores) if considered appropriate.

Table 5 Linking Stage 2 SOAF to NWEBS

Environmental impact	**NWEBS component(s) to which improvement relates**	**Proportion of value from Table 4 to take**
Aesthetic (moderate to severe)	Clarity of water	One-sixth
Invertebrate (moderate to extremely severe) ***or*** water quality (moderate to severe)	Fish Other animals such as invertebrates Plant communities	Three-sixths
Any high amenity receiving water	The safety of the water for recreational contact	One-sixth

We recommend that the appropriate proportion of the value from Table 4 is taken forward, based on the approach described above.

Of course, the values from Table 4 can be replaced with a company's own values if these are available (e.g. from WTP surveys), although these are company specific and, depending on the attributes considered and valued, would need to be mapped to the outputs from Stage 2 of

To complete this step, you should record the maximum value (£) of benefits per year for each option.

the SOAF in a similar way to that described above for the NWEBS values. In addition, it should be noted that the values from such surveys are designed to be applicable to generic service improvements, and not for site-specific application.

Step 3c - What is the maximum value of direct benefits over the assessment period?

Once the most appropriate annual value, based on Table 4, has been selected, the maximum potential value of benefits over the assessment period (the present value) should be calculated, so a decision can be made on whether benefits are likely to be (a) significant and (b) greater than costs. Where other values are used, such as WTP, a similar present value calculation should be completed.

To calculate the maximum value of present value benefits, we recommend that the following equation should be used:

$$PV\ (Benefits) = L \times A \times\ NWEBS\ Fraction \times Discount\ factor$$

Where: L is the *km improved (from 3a above)*

A is the annual value (from 3b above)

NWEBS Fraction is the proportion of NWEBS components improved (between one-sixth and five-sixths, from b above)

Discount factor has a default value of 22.17 for a 40 year discount period[4]

The last element of this equation (discount factor) reflects the impact of discounting future benefits over the timeframe of the assessment period. Over a 40-year assessment period, a discount rate of 3.5% per year (declining to 3% after 30 years, as recommended in the Treasury Green Book) would give a discount factor of 22.17 (i.e. the present value over 40 years would be 22.17 times greater than the annual benefit). Where there is likely to be a time lag before benefits are realised, or where a different discount rate is used, the discount factor may vary.

To illustrate present value benefits, Table 6 provides a set of indicative 'look up' values that enable a quick estimate of likely present values to be calculated, based on a discount factor of 22.17. The table shows the present values for a change from poor to moderate in each river basin district assuming three-sixths (i.e. half) of the total value is taken.

[4] Additional guidance on, and default values for, discount values over different time periods is available from the Government's Impact Assessment Calculator (https://www.gov.uk/government/publications/impact-assessment-calculator--3, 'EANDCB Calculations' tab). This may be particularly useful for sensitivity analysis (see Step 5).

Table 6 Calculating present values based on NWEBS (2016 prices)

River Basin District / Country	(£000/km/yr) poor to moderate	(£000/km/yr) (half of value)	(£000/km) (PV) poor to moderate
Anglian	21.5	10.7	229.1
Dee	19.2	9.6	204.8
Humber	22.2	11.2	237.2
North West	23.4	11.7	249.9
Northumbria	18.2	9.1	194.4
Severn	19.6	9.9	209.5
Solway Tweed (also use for Scotland and N. Ireland)	13.2	6.6	141.2
South East	27.2	13.7	290.4
South West	16.8	8.5	179.5
Thames	38.9	19.5	415.4
Western Wales	15.5	7.8	165.5
England & Wales	21.8	10.9	232.6

To complete this step, you should record the maximum value (£) of benefits over the assessment period for each option.

Step 3d - Are benefits significant?

To provide an initial indication of whether benefits are likely to be significant, ***we recommend that significance is defined as PV benefits greater than £100,000 for any given option.*** For the majority of options, PV benefits is likely to be in excess of this.

To complete this step, you should record whether the maximum value (£) of benefits over the assessment period is significant for each option.

Step 3e - Are other benefits important?

For some options (e.g. where there is no environmental impact from the overflow, or WFD status is already good), it may be that no valued benefits are identified from steps a to c. However, other potential benefits (e.g. relating to health, air quality, flows or flood risk) could still be important.

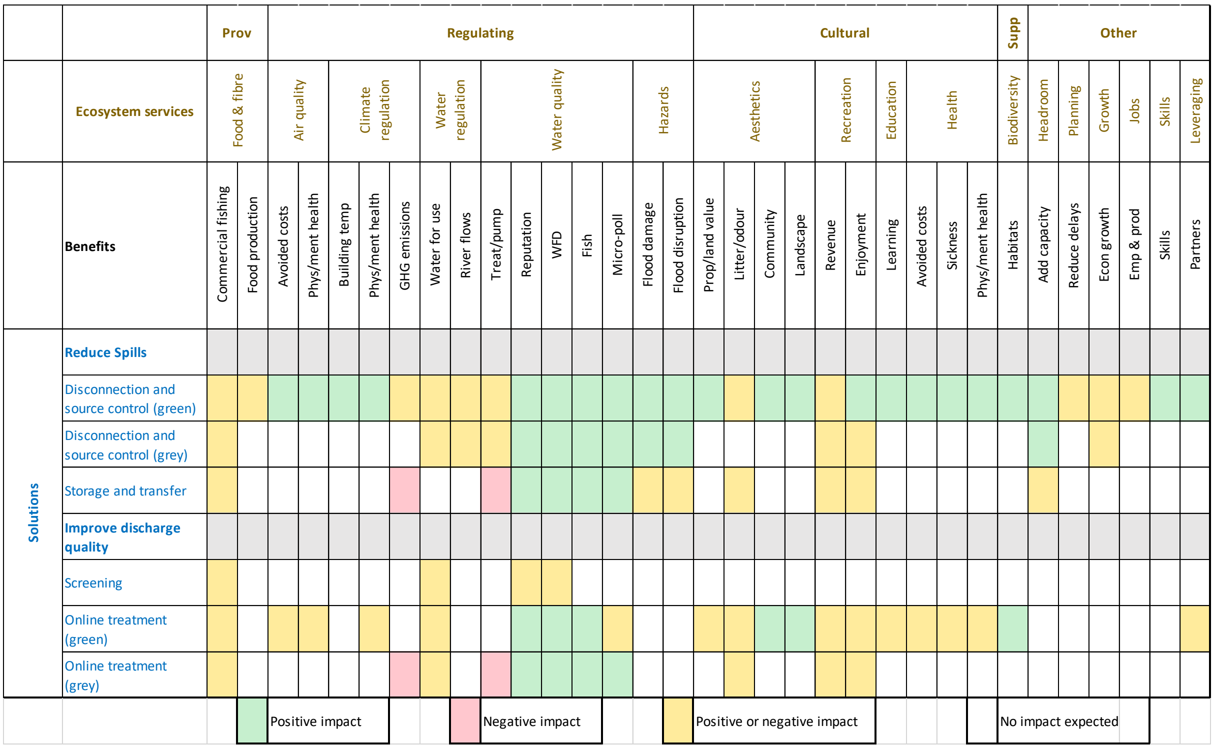
Figure 2 is a matrix which provides an initial indication of the potential scope and extent of benefits associated with different options. This helps to identify which other benefits might be important for a given option. Other benefits are likely to be particularly important for catchment based options (see Step 2b) that include green infrastructure or that also consider other 'issues' in the catchment simultaneously. Further information on when benefits in each of the categories shown in Figure 2 are likely to be important is provided in Appendix 2.

Of course, overflows are always context specific, so this guidance can only ever provide a general view of potential benefits or disbenefits (i.e. negative benefits). Nevertheless, it provides a starting point and an indication of which benefits may subsequently be worth assessing in more detail for each option.

Where an option consists of more than one specific intervention or measure, then the option with the greatest indicative impact shown in Figure 2 should be considered. For example, if an option includes screening the overflow and some disconnection and source control (green), then there could well be a positive impact on air quality.

We recommend that you should make a judgment about whether such additional benefits will be sufficient to mean that total benefits over the assessment period are likely to be significant (i.e. over £100,000). This may require these key benefits to be valued using the approaches outlined in Step 4.

Figure 2 Matrix of potential benefits



To complete this step, you should record whether the maximum value (£) of benefits over the assessment period, taking other benefits into account, is significant for each option.

Step 3f - What is the approximate cost of each option?

To enable present value benefits to be compared to costs, ***we recommend that you estimate the approximate TOTEX (capital and operating) cost of each option, relative to the baseline, over the assessment period, in present value terms***.

This should be based on in-house cost databases, best estimate engineering estimates or external sources of cost information.

> To complete this step, you should record the approximate value (£) of costs over the assessment period in present value terms for each option.

Step 3g - Are benefits potentially greater than costs?

To provide an initial indication of whether benefits are potentially greater than costs, ***we recommend that that you calculate, based on the preceding steps, the indicative benefit cost ratio (PV benefits divided by PV costs).***

To allow for uncertainty in the assessment, ***we recommend each option is subject to a sensitivity analysis of -25% for costs and +25% for benefits. Options with a benefit cost ratio greater than 0.5 under any sensitivity analysis scenario should then be taken forward to Step 4.***

> To complete this step, you should record the benefit cost ratio for each option.

Based on responses to steps 3a to 3g, the assessment should record whether benefits are likely to be (a) significant (i.e. greater than £100,000 in PV terms), and (b) potentially greater than costs (i.e. with a benefit cost ratio > 0.5). ***If the answer to either (a) or (b) is no, we recommend that a detailed assessment of benefits for that option is not required.***

> **Roundhay Park Example: Undertake screening for Option 3**
>
> The maximum length of improved watercourse is 2.5km and the potential improvement expected is 'moderate' to 'good'. The relevant value for the Humber is £23,800 per km. The option is expected to have an impact on aesthetics, macroinvertebrates and water quality, in a high amenity receiving water body. Therefore, PV benefits = 2.5 x 25,800 x 5/6 x 22.17 = £1.19 million. PV costs are expected to be £9.3 million. Therefore benefits are expected to be (a) significant, but (b) less than the benefit cost threshold of 0.5. However, other benefits are expected to be important (an earlier assessment suggested these could be several million pounds). Therefore, a detailed assessment is required.
>
> Based on the earlier assessment, a number of other benefits are expected to be important: Water quality (WFD status, water treatment), Natural hazards (flood damage), Aesthetic values (property value), Recreation (enjoyment), Biodiversity (habitats).

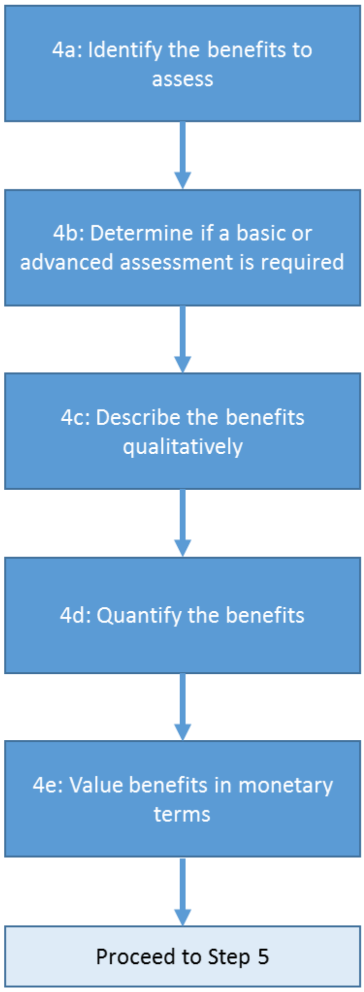
6 Step 4: Detailed benefit assessment

The purpose of this step is to develop a detailed, robust and auditable assessment of the direct and indirect benefits of those options which have been carried forward from the screening process.

This step should be applied to all options that are carried forward from the Step 3 screening process.

If the screening indicates that benefits are likely to be (a) significant and (b) greater than the benefit cost threshold of 0.5, then a detailed assessment is required.

In this step, ***we recommend that a more detailed investigation and assessment of the direct and indirect benefits in each relevant benefit category is undertaken***. The overall approach to assess benefits is shown in the flow chart.



Step 4a - Identify the benefits to assess

The benefits to be assessed for a given option will vary depending upon the option identified in Step 2. The range of benefits to consider is shown in both Figure 2 and Appendix 2. For all options, it is likely that benefits in the water quality category will, if identified for improvement by Stage 2 of the SOAF (i.e. not through the >2,000 pe route), be relevant. In addition, benefits in the aesthetics category may also be relevant. Other benefit categories to assess in Step 4 should be identified using the process outlined in Step 3e, based on Figure 2 and Appendix 2.

We recommend that you determine which benefit categories are likely to be relevant to each of the options taken forward for detailed assessment.

To complete this step, you should record, for each option, the benefit categories that will be considered in the detailed assessment.

Step 4b – Determine if a basic or advanced assessment is required

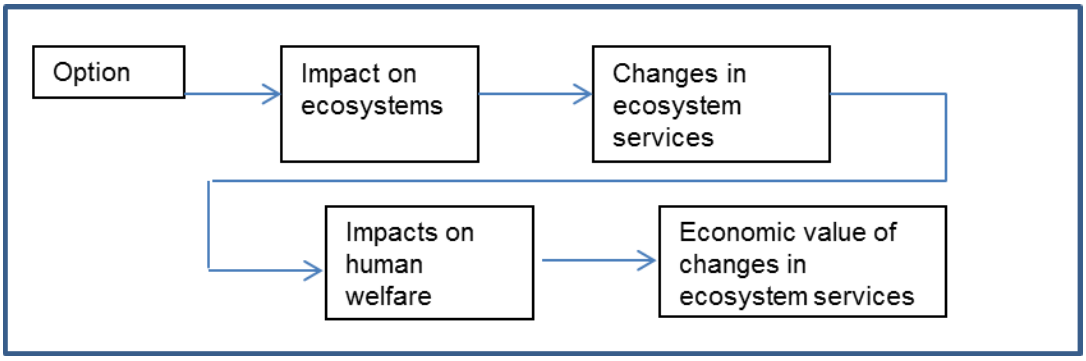
Guidance relating to each specific benefit category is provided in Appendix 3. For each benefit in each category, Appendix 3 includes a table, which provides information to support either a *basic* or *advanced* assessment of a benefit. A basic assessment requires a lower amount of effort and information than an advanced assessment. Of course, it is likely to be associated with greater uncertainty, but should be sufficient for most benefits associated with most options.

As a minimum, ***we recommend that a basic assessment should be undertaken for all 'screened in' benefits*** (identified in Step 4a). ***For those benefits likely to be particularly important or significant, we recommend that an advanced assessment should be considered***. This can be undertaken in an iterative way. For example, benefits identified as individually constituting more than 20% of total benefits using the basic approach can subsequently be subjected to an advanced assessment if required.

To complete this step, you should record, for each benefit associated with each option, whether a basic or advanced assessment will be undertaken.

Step 4c - Describe the benefits qualitatively

This step sets out how the options (or individual measures within options) are likely to link to create a benefit. This reflects an 'impact pathway' approach (see flow chart below) and helps to determine the extent to which any given benefit is likely to accrue.



Appendix 3 provides guidance to enable you to complete this step for each benefit category. This applies equally whether you apply the basic or advanced approach.

Importantly, in terms of improvements to overflows provided by the options, the *existing* benefits provided by the overflow (e.g. reduced flood risk if it was not there, sustaining river flows) are not relevant (and should be considered as part of the baseline). It is only any new benefits or any change in benefits provided, as a result of the option that should be considered. These may be positive or negative.

We recommend that you use Appendix 3 to help describe each impact (benefit) associated with each option.

To complete this step, you should describe the expected benefit in each category for each option.

Step 4d - Quantify the benefits

Quantification is important and necessary to enable valuation to subsequently take place. Guidance on how to quantify the benefit, using either the basic or advanced approach, is included in Appendix 3. This refers to relevant resources and tools (e.g. BeST, CIRIA, 2016), which can help. In general, the basic approach is based on estimated changes in the relevant outcome associated with each benefit. The advanced approach is based on consultation or modelling. In both approaches, assumptions may need to be made.

Whilst recommended quantities are provided in Appendix 3, both the basic and advanced approaches are sufficiently flexible to enable better or more specific, local information to be used. Such relevant information may be obtained from:

- Map-based websites that provide an indication of conditions, amenities and populations in an area (for example, https://gridreferencefinder.com/, http://environment.data.gov.uk/catchment-planning/);
- Local groups, for example sports clubs and hobby groups;
- Local councils, who may for example have information on visitor numbers, car parking, etc; and
- Online databases (for example, MENE – Monitor of Engagement with the Natural Environment).

Note that, whilst some benefits may materialise as soon as the option is in place, other benefits may take time to accrue (e.g. because of time lags in the natural environment) or may vary over time. In general, options with benefits occurring well into the future are less likely to be favoured than those with near-term benefits. ***We recommend that, as part of this step, you consider when benefits are likely to start, and how long they may last.***

We recommend that you use Appendix 3 to quantify each benefit of each option.

To complete this step, you should quantify the expected benefit in each category for each option.

Step 4e - Value the benefits in monetary terms

Guidance on possible ways to value each benefit in monetary terms (including examples of monetary values that may be appropriate to apply), using either the basic or advanced approach, is provided in Appendix 3.

Note that the impact of options on fines, compensation payments, regulatory penalties or rewards are not relevant to the valuation process. This is because these are transfer payments, i.e. a redistribution of income or wealth between two parties. They do not directly absorb resources or create value. As such, they are private costs of failure and relevant to internal financial analyses only (UKWIR, 2010).

We recommend that you use Appendix 3 to value each benefit of each option in monetary terms.

To complete this step, you should value the expected benefit in each category for each option in monetary terms.

Roundhay Park Example: Detailed Benefit Assessment for Option 3

The assessment for 'Water Quality (WFD status)' is shown here. Full details of the assessment in all benefit categories are shown in Appendix 1.

Qualitative description

Estimated improvement (mod to good, Humber region) is slightly greater than that under the conventional option due to improvements to other CSOs downstream, and cleaner, more balanced flow being discharged over the year.

Quantitative assessment

2.5km of watercourse improved

Value taken

£25,800 per km

Monetary valuation

£595,819 PV after confidence applied (2.5 x 25,800 x 5/6 x 22.17) x 50% (to take account of confidence)

Sensitivity

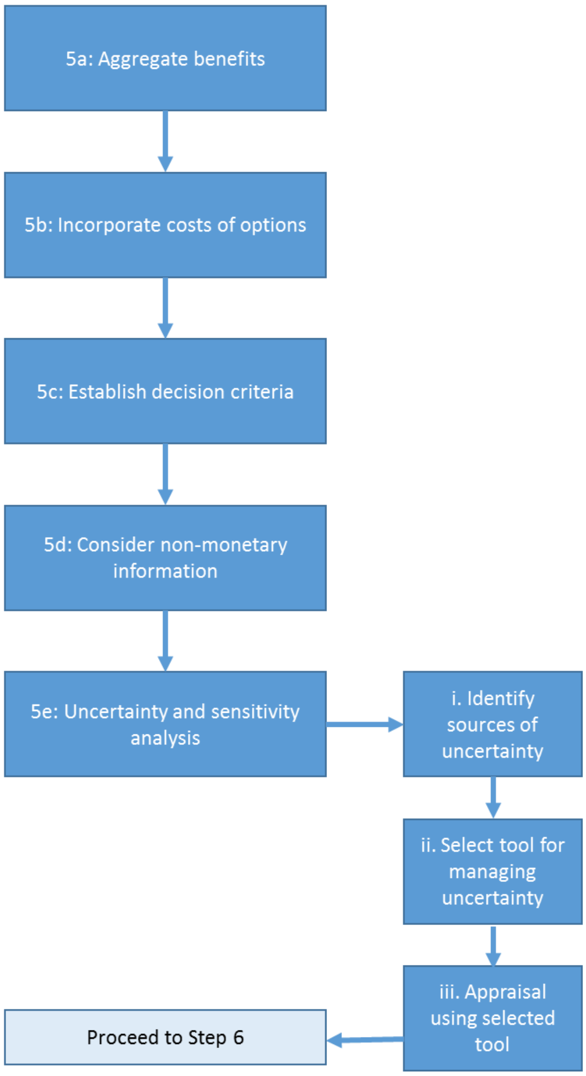
50% confidence applied to quantity, 100% to monetary value (based on guidance provided

7 Step 5: Collate results

The purpose of this step is bring together and present the results of each option.

This step should be applied to all options that are carried forward from the Step 3 screening process and subject to a detailed assessment in Step 4.

There are a number of key steps to consider when collating the results of the assessment. The overall process is shown in the flow chart.



Step 5a – Aggregate benefits

The first step is to aggregate the estimates of benefits of each option that has been subject to a detailed benefits assessment.

Step 4 automatically ensures that benefits in each category are aggregated over the relevant beneficiary population. The other main consideration is to aggregate benefits over time. To ensure consistency in the monetized benefits assessed, ***we recommend that those occurring in the future should be discounted***. Note that, whilst most benefits are expected to occur annually, some (e.g. 'increased property/land values') are 'one-off'.

Discounting is based on the principle that more importance is placed on benefits that occur now than those that arise in the future, although be aware that benefits may change over time.[5]

For all public policy related economic appraisals, the social time preference rate (STPR) rate is set by the Treasury.

[5] Note that inflation related to future benefits can be ignored, since in economic appraisal the valuation of costs or benefits should be expressed in 'real terms' or 'constant prices' (i.e. at 'today's' price level) (HM Treasury, 2013).

Currently, this is 3.5%. For long-term projects (over 30 years), the discount rate actually declines gradually.

In the water sector, the ‘weighted average cost of capital’ (WACC) is set by the financial regulator and water companies will apply this in developing their future investment plans. The WACC is used to calculate the revenue required by companies to provide a return to investors.

Generally, the most appropriate approach to adopt in CBAs where costs fall to firms to be financed but benefits accrue to consumers and/or society more widely is to discount all costs (including financing costs as calculated based on a WACC) and benefits at the STPR. This is known as the Spackman approach (JRG, 2012) and takes explicit account of firms’ financing costs. In practice, this is done by converting the firm’s investment cost into annual payments (an annuity akin to a corporate bond) using the firm’s WACC; the resulting flows of costs and benefits should then be discounted at the STPR.

There are some important implications of discounting in the analysis of environmental and social benefits. The higher the discount rate used, the lower the importance placed on future costs and benefits. At any positive discount rate, benefits that accrue more than 50 years into the future will have a very small present value. At a rate of 3.5%, benefits occurring in 25 years will have only 42% of the value of those occurring today. Hence, schemes with benefits occurring well into the future are less likely to be favoured than those with near-term benefits.

To complete this step, you should ensure that all benefits are discounted over time and aggregated for each option.

Step 5b – Incorporate costs of options

Estimates of costs are exogenous to this assessment process but may include both financial costs (e.g. capital equipment, operating expenditure and opportunity cost of providing land for storm overflow improvements) and other costs (e.g. social or environmental costs such as embodied carbon in materials). Cost information may come from a range of sources, including engineering estimates, past experience, proprietary information provided by suppliers/contractors and cost databases.

Crucially, ***we recommend that cost information is presented in the same format as the benefits. This means that the base year and timescales should be equivalent with the same discount rate used.*** If this is not the case, the costs and benefits will not be comparable.

Cost estimates may be the same as those derived in the screening process (Step 3), or may be refined/specified in greater detail.

To complete this step, you should ensure that cost estimates for each option are prepared and presented in the same format as benefits.

Step 5c – Establish decision criteria

The decision rules used in economic appraisal are based on the concept of economic efficiency. A proposed action is deemed cost beneficial, providing an efficient allocation of resources (and therefore justified) if the discounted benefits of the action are greater than the discounted costs. Each WaSC will have its own approach to determining efficiency based on the balance of costs and benefits. ***We recommend that, for every option, you should calculate both NPV and BCR, the most commonly used decision criteria in economic analysis***.[6]

- *Net Present Value* (NPV): used at a policy or project level to identify the optimal solution out of a set of mutually exclusive options. NPV is calculated as:

  NPV = PV of benefits - PV of scheme costs

  A positive NPV indicates that a project is justified as it yields a rate of return which is greater than the discount rate. When comparing alternative options, that with the highest NPV becomes preferred (as the greater the NPV, the greater the benefits to society). In the (unlikely!) case of an unlimited budget for high spilling storm overflow improvements, it would be economically desirable to undertake all of the projects for which the NPV is greater than zero. When the budget is limited, such that only one or a few projects can be undertaken, investment funds are scarce (because there are still projects yielding a rate of return in excess of the discount rate). In these cases, project selection includes the use of the BCR.

- The *Benefit-Cost Ratio* (BCR): used at the programme/project level to determine whether or not an option is justified and which can also be used to determine the best allocation of limited funds amongst a set of competing projects.

  The BCR is calculated as: BCR = PV benefits / PV costs

  The BCR demonstrates which scheme provides the largest benefit per pound of expenditure. This is valuable information when trying to prioritise between schemes when the overall budget is constrained. Because of the revenue competing character of the decision, it is typically important to obtain the largest benefit for every pound of money spent.

[6] Note that, depending on the decision criteria used, different options could be preferred/selected. For example, if option 1 has benefits of 100 and costs of 10, the NPV is 90 and the BCR is 10. If option 2 has benefits of 500 and costs of 100, the NPV is 400 and the BCR is 5. If NPV was used as the decision criteria, option 2 would be selected, but if BCR was used, then option 1 would be chosen. Therefore, to ensure both absolute and relative costs and benefits are considered, both NPV and BCR should be calculated.

It may also be useful to consider other non-monetary decision criteria, e.g. distribution of benefits (although note this relates to equity rather than economic efficiency).

To complete this step, you should calculate NPV and BCR for each option.

Step 5d – Consider non-monetary information

It is likely that some of the benefits are not amenable to valuation (as identified in Step 4). However, these could be important and non-valued effects should remain part of the decision making process. There may also be other potential benefits that are not currently captured by the framework. Finally, there may also be benefits of wider initiatives of which high spilling storm overflow improvements form a part but are not the principal component. This may include programmes to develop sustainable transport or to green urban areas. In these cases, it may be possible and appropriate to allocate a certain proportion or percentage of the benefits of the whole programme to the storm overflow component or reduce the costs through partnership funding.

We recommend that you should develop a qualitative ranking score (low, 1 to significant, 5) for key non-monetised benefits. Where this score is 4 (high benefit) or 5 (significant benefit), we recommend that you should consider explicitly bringing these into the assessment. There are two possible ways of doing this:

- Calculating 'switching values' or 'implied values. For example, for a scheme costing £10 million with valued benefits of £9 million, any non-valued benefits would need to have an implied value of at least £1 million to switch the NPV to positive and make it worthwhile for the scheme to go ahead. It may be necessary for a group of key stakeholders to determine whether such implied values are realistic and whether any further investigation or assessment is required; or
- Formal use of non-quantitative assessment techniques. There are several methods of formally scoring and weighting non-valued impacts, the most notable of which is multi-criteria analysis. The government has provided detailed guidance on this (Defra, 2011a, 2011b). The use of such techniques may be appropriate if non-valued impacts are considered to be particularly important or significant, or of specific concern to some stakeholders.

To complete this step, you should identify any key non-monetised impacts and bring them into the assessment for each option.

Step 5e – Uncertainty and sensitivity analysis

Information used to inform CBA is inherently uncertain as it is to do with future events. Ideally, a range of foreseeable/expected outcomes needs to be considered and represented through scenario analysis and CBA results should present changes in investment outcomes (e.g. NPV) related to different states of the world that could materialise, i.e. distributions of NPVs for an assessed investment.

In practice, to deal with uncertainty affecting the analysis there are three key steps to undertake (UKWIR, 2010). The first is to identify the sources of uncertainty; the second to use a tool that allows representing and considering these in the decision making; the third is to take into consideration risk and uncertainty in the decision making.

i. Identify sources of uncertainty

First, the key sources of uncertainty should be identified, and the extent to which the economic decision (i.e. whether the investment is economic and therefore should proceed or not) can be affected should be assessed. There are a number of causes of potential uncertainty, including:

- Will the planned water quality improvements be delivered?
  - Inherent uncertainty in model predictions (input, calibration and structure) related to before improvement & after improvement state (e.g. UPM studies differentiate uncertainty from levels 1 to 4)
  - How will benefits be phased in time and space?
- Will other benefits be delivered? If so, when and will anyone notice?
- Is the monetary valuation of benefits robust?
- How sensitive is my conclusion to uncertainties in decision variables?

ii. Select tool for managing uncertainty

Second, the tools used to assess the impact of risk and uncertainty on the decisions need to be selected.

Water companies have been provided with guidance previously on this (see for example UKWIR, 2010). The tools that can be used are principally:

- Sensitivity analysis: how appraisal results change because of changes in the variables used in the assessment of costs and benefits;
- Switching analysis: the extent to which variables used in the assessment of costs and benefits have to change for the NPV of the project or programme to switch from positive to negative or vice versa;
- Monte-Carlo Analysis: used to show the expected results and range of possible outcomes due to the combined uncertainty of variables used in the assessment of costs and benefits; and
- Real options analysis: used to identify whether an option should be implemented now, or whether it should be deferred, abandoned, expanded or staged.

iii. Appraisal using selected tool

Third, using the selected tool, companies should:

- Make initial investment decisions based on the most plausible or expected values;
- Identify and justify the key assumptions – identifying the confidence intervals around the expected values and any further sources of bias or uncertainty;
- Perform sensitivity analysis on key assumptions; and
- Finalise investment decisions given the sensitivity analysis results ensuring the business case fully documents the findings.

A useful approach is that adopted in BeST, which considers uncertainties through the application of a simple user defined estimate of confidence. This confidence score approach is built into the tool, and follows a number of standard approaches. It considers and accounts for the two key aspects of potential uncertainty in the tool:

- The quantified performance data, i.e. for the outcomes of whatever option is under consideration, e.g. numbers of properties for which flooding has been reduced or avoided; and
- Monetising these outcomes, e.g. how to assign monetary values to reduce flooding.

For each of these, the tool asks the user to apply a confidence score of 25% (low likelihood of delivering intended outcome), 50%, 75% or 100% (certain to deliver intended outcome).

To ensure proportionality of effort, ***we recommend that a relatively simple and pragmatic approach to managing uncertainty, based on the use of ranges and sensitivity analysis, should be applied.***

Ranges for the values of key parameters can be developed and applied throughout the assessment process. Sensitivity analysis involves testing the robustness of the result by changing one or more of the key parameters in the assessment. When undertaking sensitivity analysis, it is important that you carefully consider which parameters are having the most impact on the results of the assessment, and whether there is a justification for adjusting these to test the robustness of the result.

We recommend that, as a minimum, you undertake a high level sensitivity analysis by considering low and high estimates of quantities and assessed benefits.

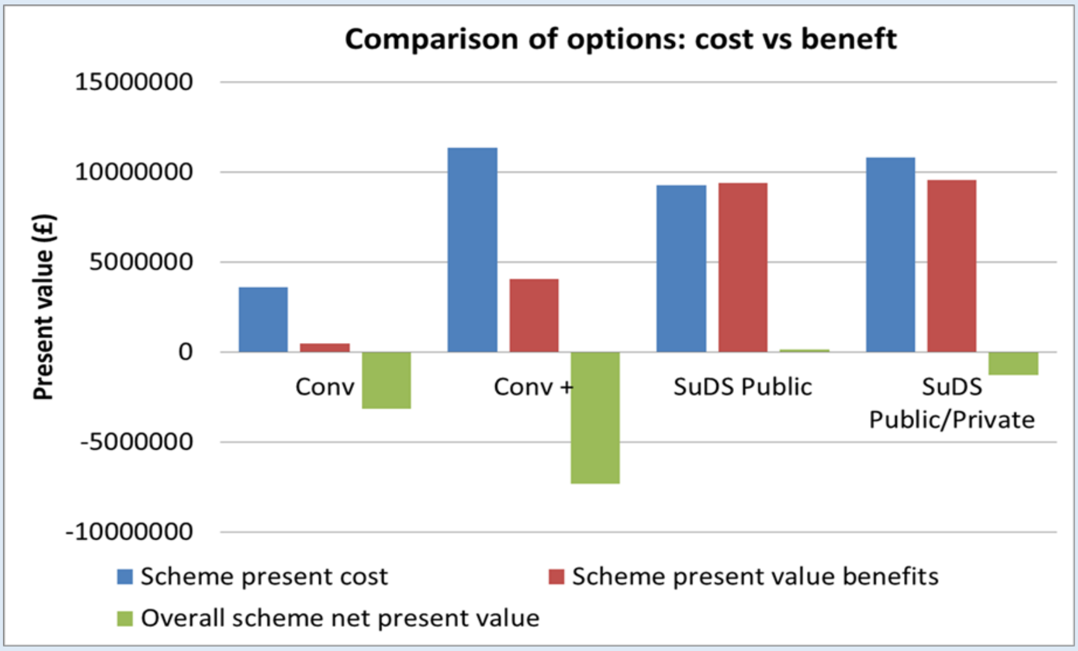
Where more detailed sensitivity analysis is required, we recommend that the assessment is re-run and the results used to consider a wider variety of changes, including to:

- the discount rate - (for comparability, the discount rate used should be applied throughout the assessment, i.e. to all monetised benefit categories and to all costs)
- the assessment period (when benefits start and end)
- quantified estimates of impacts
- monetary values
- cost estimates

To complete this step, you should consider uncertainty and apply sensitivity analysis to the assessment of each option.

Example: Collate Results

The graph below shows a comparison of the PV costs and PV benefits for all 4 options.



For option 3, the estimated benefits are marginally higher than the costs, and the central estimate after confidence is applied gives a benefit cost ratio if 1.0. The main benefits are associated with amenity, flood risk and water quality. Amenity benefits relate to creating a park with a detention basin and general street greening, replacing grass verges with bio-infiltration swales.

Further details, including the distribution of benefits, impact of uncertainty (through application of confidence intervals) and sensitivity analysis, are available on the susdrain web site

http://www.susdrain.org/files/resources/BeST/best_case_study_roundhay_v2.pdf

8 Step 6: Take forward decision

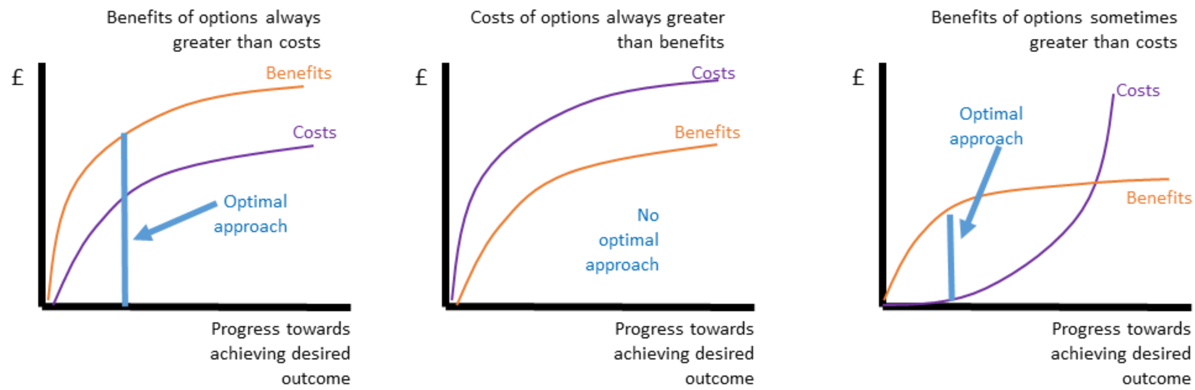
The purpose of this step is to (a) refine and improve options to enhance their cost-benefit justification, and (b) to ensure the most economically efficient options are taken forward.

This step should be applied to all overflows that are assessed using Stage 3 of the SOAF.

The economic case for some options is likely to be clear-cut, e.g. where the BCR of option A is always positive and always greater than options B and C. At other times, the case for an option may not be obvious, e.g. where the BCR of option A is sometimes <1 and/or sometimes < option B and C. In all cases, the optimal approach (the best or most efficient option) is that for which the difference between benefits and costs is greatest. This is shown in Figure 3. In practice, the assessment process is likely to be applied to a limited set of options. Therefore, the option with the greatest BCR should be selected.

Note that the detailed assessment of benefits (Step 4) is likely to give a different result to the screening assessment (Step 3). This is to be expected and is due to the more detailed consideration against a wider range of benefit categories in Step 4.

Figure 3 The Economic Case for Options



The framework includes a feedback loop at this stage, back to Step 2 (Identify options). This is because the outputs of the benefits assessment should inform the options considered. It may be possible for example to increase benefits by bringing in additional detail or information, by tweaking options, or by considering radically different options. It may be necessary and appropriate to go through the benefits assessment cycle twice or more to refine and bring in greater detail and improved information.

In all cases, the outputs of the benefits assessment should be taken forward to Stage 4 of the SOAF.

We recommend that WaSCs should develop and implement an investment case for all options where benefits are greater than costs, starting with the option with the highest BCR, until either (a) the objective has been achieved, or (b) budget or other constraints have been met.

Roundhay Park Example: Take Forward Decision

The different options are associated with a large range in net present value. Option 1 reduced the CSO spills, was lowest cost but offered limited other benefits. Option 2 provided similar levels of drainage performance in the sewer network as option 3 and 4, but created fewer benefits having underground infrastructure only, and was also less resilient to climate change. Options 3 and 4 included distributed SuDS features across the catchment, creating a second drainage network to manage surface water, in turn creating wider benefits to the community and environment. These options had similar costs and benefits. Overall, only the 'SuDS public' option 3 generated a positive NPV (benefits greater than costs).

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Appendix 1: Completed appraisal summary table (AST)

Scheme details: Yorkshire Water investigated the potential of different options to reduce combined sewer overflow (CSO) spills in Roundhay Park in Leeds, as part of its plans for the 2014 Periodic Review. The aim was to compare the costs, immediate and wider benefits of a SuDS and conventional drainage approach.

Option name: A SuDS approach in public areas to disconnect surface water from the combined system and pass it through the conveyance and storage SuDS. This used a combination of swales, detention basins, geocellular storage and connecting pipes.

Screening:

1. **Screening questions**

The maximum length of improved watercourse is 2.5km and the potential improvement expected is 'moderate' to 'good'. The relevant value for the Humber is £25,800 per km. The option is expected to have an impact on aesthetics, macroinvertebrates and water quality, in a high amenity receiving water body. Therefore, PV benefits = 2.5 x 25,800 x 5/6 x 22.17 = £1.19 million. PV costs are expected to be £9.3 million. Therefore benefits are expected to be (a) significant, but (b) less than costs. However, other benefits are expected to be important (an earlier assessment suggested these could be several million pounds). Therefore, a detailed assessment is required.

2. **Potential benefits matrix**

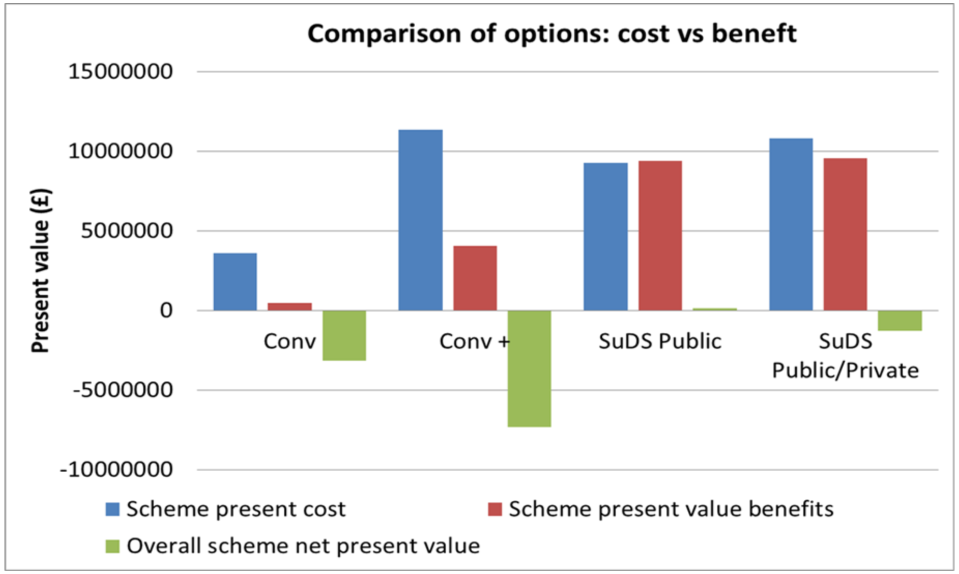
Based on the earlier assessment, a number of benefit categories are expected to be important: Water quality (WFD status, water treatment), Natural hazards (flood damage), Aesthetic values (property value), Recreation (enjoyment), Biodiversity (habitats).

Benefit category	Qualitative description	Quantitative assessment (1)	Value taken (2)	Monetary valuation (1x2)	Sensitivity	Assumptions
Water quality (WFD status)	Estimated improvement (mod to good, Humber region) is slightly greater than that under the conventional option due to improvements to other CSOs downstream, and cleaner, more balanced flow being discharged over the year.	2.5km	£25,800 per km	£515,819 PV after confidence applied	50% confidence applied to quantity, 100% to monetary value	
Water quality (water treatment)	Reduction in flow reaching works as a result of option	Modelling suggests a reduction of 49,770 m^3/yr flow, (and we assume	Values in BeST for operating, energy and	Using BeST, PV benefit is £25,481	75% confidence applied to quantity, 100%	Large (cat 6) urban works UWWTD

		75% using the confidence values) passes through combined sewer system for treatment.	carbon cost savings		to monetary value	
Natural hazards (flood damage)	Protection of properties from flooding as a result of additional natural storage	32 properties. Given that there is some slope across the area, we assume that 50% of properties will benefit from reduced flood risk.	Based on outputs from assessment using MCM	£345,152 per year (£3.6 million PV after confidence applied)	For low sensitivity, assume 25% (16 properties) and for high, assume 75% (48 properties).	Annual weighted damage used for residential properties with 10cm of flooding, including disruption, blight, distress etc.
Aesthetic values (property value)	Improvements to local park, as option will turn unused green space into amenity location that is attractive and can be used.	Using BeST, 74 detached houses, 840 other houses and 73 flats will benefit. Use average house prices of £300K (detached), £220K (other houses) and £110K (flats)	Use % property premium from BeST	Using BeST, one-off benefit is £4,718,135	50% confidence applied to both quantity and monetary value	Mix of planting anticipated but low (conservative) value selected from range of monetary values. Assumed well looked after.
Recreation (enjoyment)	General recreation improvements around Roundhay Park due to WQ leading to increase in visitors. Also small increase in (coarse) fishing as a result of the option (angling more sensitive to water quality/quantity than say general recreation).	10,000 additional general recreation visits per year, 365 additional coarse angling trips	£5.36 per visit for general recreation, £4.59 per visit for angling (using BeST)	£279,641 PV after confidence applied	50% confidence applied to both quantity and monetary value (general recreation), and 75%/100% applied for fishing	Very difficult to find estimates of current recreation in residential areas or likely increase associated with SuDS measures. However, recreation may increase in Roundhay Park, so assume approx 1% increase in number of visits from current situation (in region of 1 million visits per year). Only 1% because most visits not dependent on, and not sensitive to small improvements in, water quality/quantity. For angling, assume 10% increase in number of

						visits per year as a result of the option (angling more sensitive to water quality/quantity than general recreation).
Biodiversity (habitats)	Improved quality of habitat to suburban area - domestic gardens, grass verges, some open space	1.3 ha improved	£1,684 per ha per year	£11,420 PV after confidence applied (general recreation), £26,244 (angling)	50% confidence applied to both quantity and monetary value	Habitat quality is Medium - Provides good potential habitat for range of species. Connectivity is Poor - surrounded by hard-standing areas (concrete, paths, roads). No 'green space' present.

The graph (right) shows a comparison of the PV costs and PV benefits for all 4 options.



For option 3, the estimated benefits are marginally higher than the costs, and the central estimate after confidence is applied gives a benefit cost ratio if 1.0. The main benefits are associated with amenity, flood risk and water quality. Amenity benefits relate to creating a park with a detention basin and general street greening, replacing grass verges with bio-infiltration swales.

Further details, including the distribution of benefits, impact of uncertainty (through application of confidence intervals) and sensitivity analysis, are available on the susdrain web site

http://www.susdrain.org/files/resources/BeST/best_case_study_roundhay_v2.pdf

The different options are associated with a large range in net present value. Option 1 reduced the CSO spills, was lowest cost but offered limited other benefits. Option 2 provided similar levels of drainage performance in the sewer network as option 3 and 4, but created fewer benefits having underground infrastructure only, and was also less resilient to climate change. Options 3 and 4 included distributed SuDS features across the catchment, creating a second drainage network to manage surface water, in turn creating wider benefits to the community and environment. These options had similar costs and benefits. Overall, only the 'SuDS public' option 3 generated a positive NPV (benefits greater than costs).

Appendix 2: Benefit categories

Category	Benefits	Benefit only likely where
Provisioning Ecosystem Services	Food & fibre	• The watercourse supports food production or there are freshwater commercial fisheries within the watercourse (or these could develop if water quality improves) • Water quality likely to improve such that dissolved oxygen levels will be maintained at all times above lowest acceptable levels (warm water fish 5 mg/l, cold water fish 6 mg/l, spawning season 7 mg/l) • Reduced overflows lead to improved sludge production and availability as a soil conditioner (this will depend on the wet weather capabilities of the plant)
Regulating Ecosystem Services	Air quality	• Option is within an air quality management area • Option involves green infrastructure (e.g. trees, green roofs) • Option is in a populated area or a transport corridor?
	Climate regulation	• Option involves green infrastructure (e.g. tree planting, green roofs) • Option includes measures that involve embedded carbon in construction or operational carbon in ongoing use • Option involves significant pumping (e.g. of oxygen into river) that is linked to energy use
	Water regulation	• Option includes demand management measures (e.g. rainwater harvesting) that will significantly reduce water demand • Option is expected to deliver a significant change (increase or decrease) in flows in the watercourse • Option will lead to a change in the amount of wastewater pumped to treatment
	Water quality	• Stage 2 SOAF assessment indicates overflow is non-compliant with Fundamental Intermittent Standards (FIS) • Stage 2 SOAF assessment indicates 'moderate' or worse invertebrates impact • Improvements in water quality mean abstractors will be able to reduce treatment applied or amount of water treated
	Natural hazards	• There are properties, buildings, areas or infrastructure (including transport) at risk of flooding currently (not necessarily connected to the overflow, which may indeed be helping to reduce flood risk) • Growth or climate change is expected to change the risk of flooding from storm overflows in the area • The option is expected to increase (although an unlikely acceptable outcome) or reduce local flood risk
Cultural Ecosystem Services	Aesthetic values	• Option involves new/improved water bodies, landscaping or greening • Option is in a populated area, or an area used for recreation, work, commuting, tourism, etc • Option involves components that will be visible to those living nearby or passing by • Option could lead to inconvenience/disruption to residents or others (e.g. during construction or loss of car parking)

Category	Benefits	Benefit only likely where
	Recreation	• Area is currently used for formal or informal recreation • Option is expected to improve facilities or opportunities for formal or informal recreation
	Education	• Option could lead to an increase in number of children engaged about drainage and its role in the environment, whilst supporting the science curriculum • Option could lead to improved awareness and more educational visits/talks • Option could lead to an increase in the number of community events or open days
	Health	• Option will encourage residents or others to spend more time outdoors or participating in physical activity/exercise, e.g. as a result of increased green infrastructure • Option could improve health by reducing the potential for high temperatures in summer and cold temperatures in winter • Option will lead to reduction in sickness/illness for employers, schools and others • Option involves green infrastructure (e.g. tree planting, green roofs) that will lead to an increase in number of people having a view over green space from house or regular place of work
Supporting Ecosystem Services	Biodiversity	• Option will impact on a designated site (e.g. SSSI, SAC, SPA), Habitats of Principal Importance (BAP priority habitats), a site of local importance for nature, or a non-designated site of local or regional value • Option involves components that may improve these sites, or create new sites
Other	Headroom	• Option is likely to create additional drainage capacity, deferring or delaying investment in piped systems or treatment works
	Planning	• Population growth is currently occurring or expected in the future • Storm overflows are a barrier to this growth or development
	Growth	• Option could play a part in regeneration programmes, tourism or other types of economic development
	Jobs	• Option could lead to <u>new</u> jobs or training opportunities (e.g. green economy)
	Skills	As above
	Leveraging	• Option involves green infrastructure (e.g. tree planting, green roofs) that will lead to an increase in number of people having a view over green space from house or regular place of work
	Construction	• Option involves construction in a populated area that could lead to traffic (e.g. road closure) or other disruption

Appendix 3: Guidance for detailed assessment of benefit categories

The approach and values included here are recommended only. Companies are able to utilize alternative approaches and better, site-specific information if appropriate. However, significant deviations from the recommended approaches included here should be discussed with key stakeholders at the earliest opportunity.

Food and Fibre

All types of storm overflow improvements have the potential to impact on food and fibre, arising for example from improvements to water quality or increases in water available for use. As such, improvements have the potential to impact on food and fibre in two main ways:

- New/improved opportunities for commercial fishing; and
- Impacts on food production (e.g. via improved soils, pollination)

<table>
<tr><th>Commercial fishing</th><th>Description of impact</th><th>Quantification</th><th>Valuation</th></tr>
<tr><td>Basic</td><td rowspan="2">Impacts only likely where:
• There are freshwater commercial fisheries within the watercourse or these could develop if water quality improves (particularly dissolved oxygen levels)
• Water quality likely to improve such that dissolved oxygen levels will be maintained at all times above lowest acceptable levels (warm water fish 5 mg/l, cold water fish 6 mg/l, spawning season 7 mg/l)</td><td>Estimated change in likely/actual production</td><td>Use value for commercial rainbow trout in UK rivers and streams from EVL Tool, £2,000 per tonne (2014 value)</td></tr>
<tr><td>Advanced</td><td>Consultation with commercial fisheries impacted to determine increased potential carrying capacity/production and reduction in fish mortalities</td><td>Consultation with commercial fisheries impacted to determine reduction in cost of using aeration equipment and increased value of production</td></tr>
<tr><td>Output</td><td>• Qualitative description of commercial fishery potential, dissolved oxygen levels, carrying capacity, etc</td><td>• Tonnes per year (low, central, high)</td><td>• £ per year (low, central, high)</td></tr>
</table>

Food production	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • The watercourse supports food production (e.g. through nutrient	Estimated change in likely/actual production	Use value for UK crops (food) in enclosed farmland from EVL Tool, £300-£700 per tonne (2014 value),

	enrichment) that could improve significantly as a result of the option, or • Reduced overflows lead to improved sludge production and availability as a soil conditioner (this will depend on the wet weather capabilities of the plant)		£30-£200 (low), £1,000-£7,000 (high)
Advanced		Consultation with food producers impacted to determine increased potential production	Consultation with food producers impacted to determine reduction in cost of food processing and/or increased value of production
Output	• Qualitative description of commercial fishery potential, dissolved oxygen levels, carrying capacity, etc	• Tonnes per year (low, central, high)	• £ per year (low, central, high)

Air Quality

All types of storm overflow improvements that incorporate new green infrastructure components (e.g. trees, green roofs, green walls, swales, basins) can have a positive effect on local air quality, particularly in areas where air pollution is an existing problem (i.e. air quality management areas). They can absorb or remove certain pollutants, including nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulates (PM_{10}) and ozone (O_3), providing a number of benefits to people that live, visit or pass through the area. As such, improvements have the potential to impact on air quality in two main ways:

- Avoided/reduced health care costs from air quality improvements (see table below for guidance on assessment)
- Physical/mental health benefits from air quality improvements (however assessment of this benefit is not recommended due to potential for double counting with benefits associated with avoided/reduced health care costs above and also those in 'health' category)

Health care costs	**Description of impact**	**Quantification**	**Valuation**
Basic	Impacts only likely where: • Option is in an Air Quality Management Area • Option involves green infrastructure (e.g. tree planting, green roofs)? • Option is in a populated area or a transport corridor	Use BeST to identify change in level of pollutant	Use BeST, based on UK government's air quality economic assessment
Advanced		Annual pollutant removal estimates from bespoke air quality study, or using tools such as i-tree Eco (http://www.itreetools.org/eco).	As above

		In London, use GLA air quality guidance[7]	
Output	• Qualitative description of impacts on pollutants and air quality	• Tonnes of pollutant load removed per year (low, central, high)	• £ per year (low, central, high)

Climate Regulation

All types of storm overflow improvements have the potential to impact on climate regulation in four main ways

- Cost savings from reduced summer or increased winter building temperatures (see first table below)
- Physical/mental health benefits from improved local climate (assessment not recommended due to potential for double counting with benefits in 'health' category)
- Reduction/ sequestration of GHG emissions (see second table below)
- Embedded and operational carbon associated with the measures put forward as part of the option (see third table below)

Building temp	**Description of impact**	**Quantification**	**Valuation**
Basic	Impacts only likely where: • Option involves green infrastructure (e.g. tree planting, green roofs) or water bodies providing evaporative cooling • Option is in a built-up area • Option includes planting that provide shading and wind protection to properties	Use BeST to identify change in buildings' energy use. For example, where green roofs are included in the option, BeST requires information on the green roof size for buildings using air conditioning (m^2), the annual number of heating and cooling (using air conditioning) degree days and the type of energy used (gas or electricity).	Use BeST, based on UK government's long-run variable costs (LRVC) of energy supply
Advanced		Annual energy use savings from bespoke study	As above
Output	• Qualitative description of impacts on building temperature and energy use	• kWh per year (low, central, high)	• £ per year (low, central, high)

7 https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/health-and-exposure-pollution

GHG emissions	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option involves planting (including trees) over and above that which would occur without the option • Option involves new planting (including trees) rather than replacement	Use BeST to identify change in greenhouse gas emissions. This uses for example the SMUD Tree Benefits Estimator to estimate the amount of carbon sequestered by trees.	Use BeST, based on UK government's guidance on carbon valuation in policy appraisal
Advanced		Impact on annual greenhouse gas emissions from bespoke study	As above
Output	• Qualitative description of impacts on greenhouse gas emissions	• tonnes per year (low, central, high)	• £ per year (low, central, high)

Carbon of options	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option includes measures that involve embedded carbon in construction or operational carbon in ongoing use • Option involves significant pumping (e.g. of oxygen into river) that is linked to energy use	Use BeST to identify change in greenhouse gas emissions	Use BeST, based on UK government's guidance on carbon valuation in policy appraisal
Advanced		Impact on annual greenhouse gas emissions from whole-life carbon costing tool or bespoke study	As above
Output	• Qualitative description of impacts on greenhouse gas emissions	• tonnes per year (low, central, high)	• £ per year (low, central, high)

Water Regulation

All types of storm overflow improvements have the potential to impact on water regulation in three main ways

- Change in water available for use (see first table below)
- Change in river flows (see second table below)
- Additional/reduced pumping of water (see third table below)

Water for use	Description of impact	Quantification	Valuation
Basic	Impacts only likely where:	Estimate of additional volume of water	Marginal cost of new water supplies (£ per

	• Change in river flows or groundwater infiltration are likely to lead to change in abstraction license conditions; or • Option includes demand management measures (e.g. rainwater harvesting) that will significantly reduce water demand		Ml) from water company water resource management plan
Advanced		Estimate of additional volume of water and detailed description of uses to which the additional water is likely to be put	Marginal cost of new water supplies (£ per Ml) for each use (e.g. public water supply, agricultural use, industrial use) to which the additional water is likely to be put
Output	• Qualitative description of degree of flow change, impact on current or future abstractions, etc	• Ml per year (low, central, high)	• £ per year (low, central, high)

River flows	Description of impact	Quantification	Valuation
Basic	Impacts only likely where • Option is expected to deliver a significant change (increase or decrease) in flows in the watercourse	Estimate of watercourse at reduced risk of low flows	Use 1/6 of the appropriate NWEBS value (relating to 'the condition of the river channel and flow of water')
Advanced		As above	As above, or water company WTP value for km river with improved flow
Output	• Qualitative description of degree of flow change, impact on WFD-related flow requirements, etc	• Km of watercourse (low, central, high)	• £ per year (low, central, high)

Pumping	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option will lead to a change in the amount of wastewater pumped to treatment (NB this could increase, e.g. where option includes additional storage) • Option requires pumping stations to be added that increase energy use	Use BeST to identify energy and carbon impact on pumping stations	Use BeST, based on UK government estimates for energy costs and carbon emissions
Advanced		Impact on reduced depreciation and maintenance, energy consumption and greenhouse gas emissions from bespoke study	As above

Output	• Qualitative description of impacts on pumping stations and energy use	• kWh per year (low, central, high)	• £ per year (low, central, high)

Water Quality

All types of storm overflow improvements have the potential to impact on water quality in a number of ways:

- Change in WFD status
- Reduced fish kills
- Reduced micropollutants – cannot be assessed at the current time due to lack of evidence and high risk of double counting with impacts on WFD status or reduced fish kills
- Reduced water treatment costs

WFD status	Description of impact	Quantification	Valuation
Basic	Impacts only like where: • Stage 2 SOAF assessment indicates overflow is non-compliant with percentile and Fundamental Intermittent Standards (FIS)	Use Water Quality modelling to determine the change in likely impact and length of river[8].	Use 3/6 of the appropriate NWEBS value (relating to 'plant communities' and 'the safety of the water for recreational contact'). Where the receiving water body has a high amenity, increase by 1/6.
Advanced		Consider model detailed level of water quality modelling as defined in UPM3 Manual	As above, or water company WTP value for km river improved by change in WFD status
Output	• Qualitative description of change in water quality and impact on WFD-related outcomes	• Km watercourse improved • Change in WFD status or (if no change in status) WQ impact classification[9]	• £ per year (low, central, high)

[8] UPM3 Manual (2012) contains information to translate the predicted water quality impacts to WFD status for FIS and percentile status. Note that for FIS analysis, this should only be viewed as pass (at Good or High status) or fail whereas percentile enables the differences between all WFD status' to be considered. The UK Technical Advisory Group on the WFD provide guidance on linking the types of waterbody defined in UPM3 (http://www.wfduk.org/sites/default/files/Media/Environmental%20standards/Environmental%20standards%20phase%201_Finalv2_010408.pdf).

[9] Note where the water quality modelling indicates there is no failure, or that the predicted water body status is greater than that currently defined, then no benefit should be valued.

<table>
<tr><th>Water treatment</th><th>Description of impact</th><th>Quantification</th><th>Valuation</th></tr>
<tr><td>Basic</td><td rowspan="2">Impacts only likely where:
• Improvements in water quality mean abstractors will be able to reduce treatment applied or amount of water treated
• Size of works is large and complex enough to make a meaningful impact on treatment costs
• Option includes works that impact on pumping stations</td><td>Use BeST to identify impact on works</td><td>Use BeST, based on cost of treatment (related to nutrient removal or UWWTD compliance) and UK government estimates for energy costs and carbon emissions</td></tr>
<tr><td>Advanced</td><td>Impact on flows, energy consumption and greenhouse gas emissions from bespoke study</td><td>As above</td></tr>
<tr><td>Output</td><td>• Qualitative description of impacts on the quality of the flows and works</td><td>• Ml per year (low, central, high)</td><td>• £ per year (low, central, high)</td></tr>
</table>

Natural Hazards

All types of storm overflow improvements have the potential to impact on natural hazards in two main ways:

- Avoided flood damage to property/land, infrastructure, and other assets; and
- Disruption, inconvenience, anxiety caused by flooding

Flood damage	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • There are properties, buildings, areas or infrastructure (including transport) at risk of flooding currently (not necessarily connected to the overflow, which may indeed be helping to reduce flood risk) • Growth or climate change is expected to change the risk of flooding from storm overflows in the area • The option is expected to increase (although an unlikely acceptable	Use Multi-Coloured Manual or BeST to estimate • Number of properties of different types at reduced risk • Change in risk (flood frequency) • Any quantitative information relating to non-property impacts (see below); and • The reduction in time lost by people through flooding (an estimate of the number of people and time).	Use Multi-Coloured Manual or BeST to estimate change in damage cost caused by flooding

Advanced	outcome) or reduce local flood risk	Output from modelled flood risk assessment	Water company WTP value for reduction in internal/external flood risk (£ per property)
Output	• Qualitative description of impacts on flooding and properties	• Change in number of properties/other buildings at risk of flooding per year (low, central, high)	• £ per year (low, central, high)

Disruption	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • There are properties, buildings, areas or infrastructure (including transport) at risk of flooding currently (not necessarily connected to the overflow, which may indeed be helping to reduce flood risk) • Growth or climate change is expected to change the risk of flooding from storm overflows in the area • The option is expected to increase or reduce local flood risk	Use Multi-Coloured Manual or BeST to estimate • Reduction in time lost by people through flooding (an estimate of the number of people and time)	Use Multi-Coloured Manual or BeST to estimate change in non-property impacts caused by flooding
Advanced		Output from modelled flood risk assessment	May be captured in 'flood damage' above, if water company WTP value for reduction in internal/external flood risk (£ per property) has been used. Therefore, do not value impacts here if WTP values for flooding have been used already.
Output	• Qualitative description of non-property impacts of change in flood risk	• Change in non-property impacts (e.g. travel time) per year (low, central, high)	• £ per year (low, central, high)

Aesthetic Values

All types of storm overflow improvements have the potential to impact on aesthetic values in four main ways:

- Increased property/land values
- Litter, odour & noise
- Community cohesion (it is currently not possible to value impacts in this category due to insufficient robust evidence)
- Landscape (impacts should not be assessed in this category due to high risk of double counting with 'increased property/land values')

Property value	Description of impact	Quantification	Valuation
Basic	Impacts only likely where improvements in attractiveness or desirability of area are expected as a result of: • New/improved water bodies, landscaping or greening, in a visible and populated area, or an area used for recreation, work, commuting, tourism, etc	Use BeST to estimate • Number of households or residents	Use BeST to estimate change in property prices or willingness-to-pay for improvements
Advanced		Modelled impact on aesthetics or amenity	As above
Output	• Qualitative description of impacts on properties	• Change in number of people or households affected (low, central, high)	• £ (low, central, high). Note that property price changes are a one-off (not annual) impact

Litter, odour, noise	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: Stage 2 SOAF assessment indicates 'moderate', 'high' or 'severe' aesthetics impact	Aesthetics assessment score (output from Stage 2 SOAF)	Use 1/6 of the appropriate NWEBS value (relating to 'the clarity of the water')
Advanced		NIRS incidents due to storm sewage attributed to overflow (output from Table 2 SOAF) Number of households directly impacted by overflow (maximum = those within 30 miles, EA 2016b)	Water company WTP value for reduction in pollution incidents (£ per incident per household) or odour (£ per property affected) Specific impacts on noise should be valued using Defra (2014)[10]
Output	• Qualitative description of change in water quality and impact on aesthetics	• Change in number of pollution incidents • Number of households	• £ per year (low, central, high)

[10] www.gov.uk/noise-pollution-economic-analysis

Recreation

All types of storm overflow improvements have the potential to impact on recreation in two main ways:

- Increased revenues from formal recreational activities; and
- Enhanced enjoyment of and/or participation in informal recreation

Revenue	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Area is currently used for formal recreation (e.g. fishing, water sports) • Option is expected to improve facilities or opportunities for formal recreation	Use MENE (Monitor of Engagement with the Natural Environment) or BeST to estimate • Number of additional informal recreational visits	Estimate cost per visit (e.g. from day ticket prices, activity charges) or, for in-stream recreation, use 1/6 of the appropriate NWEBS value (relating to 'the safety of the water for recreational contact')
Advanced		Bespoke study on number of visits	As above
Output	• Qualitative description of change in formal recreational opportunities	• Change in number of visits	• £ per year (low, central, high)

Enjoyment	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Area is currently used for informal recreation (e.g. walking) • Option is expected to improve facilities or opportunities for informal recreation	Use MENE (Monitor of Engagement with the Natural Environment) or BeST to estimate • Number of additional informal recreational visits	Based on Sen et al (2014), use £2 (low), £4 (central) and £6 (high) per visit or (for general recreation), and £30 per visit for anglers
Advanced		Bespoke study on number of visits	Use Outdoor Recreation Valuation Tool (ORVal)[11]
Output	• Qualitative description of change in informal recreational opportunities	• Change in number of visits	• £ per year (low, central, high)

Education

All types of storm overflow improvements have the potential to impact on education by providing:

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[11] http://leep.exeter.ac.uk/orval/

- Enhanced learning opportunities

Learning	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option could engage children about water and environment, whilst supporting the science curriculum • Option could lead to improved awareness and more educational visits/talks • Option could lead to an increase in the number of community events or open days	Use BeST to estimate • Number of additional school trips	Use BeST to estimate value of trips based on 'cost of investment' approach
Advanced		Consultation with schools in the area or a bespoke evaluation study to estimate number of additional trips	As above
Output	• Qualitative description of change in educational opportunities	• Change in number of trips	• £ per year (low, central, high)

Health

All types of storm overflow improvements have the potential to impact on health in three main ways:

- Avoided/reduced health care costs from enhanced physical & mental wellbeing
- Avoided costs of sickness/illness to employers, schools and others
- Enhanced physical & mental well-being

Health costs	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option will encourage residents or others to spend more time outdoors or participating in physical activity/exercise, e.g. as a result of increased green infrastructure; or • Option could improve health by reducing the potential for high	Use BeST to estimate • Change in physical activity	Use BeST to estimate value of avoided health costs
Advanced		Use results from health impact assessment	Use Health Economic Assessment Tool[12]

[12] http://www.heatwalkingcycling.org/

	temperatures in summer and cold temperatures in winter		
Output	• Qualitative description of change in physical activity and resultant health outcomes	• Change in level of physical activity	• £ per year (low, central, high)

Sickness	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option will lead to reduction in sickness/illness for employers, schools and others	Estimate • Change in days lost to sickness or illness	Average net salary and/or cost of providing educational place for the region
Advanced		Use results from health impact assessment	As above
Output	• Qualitative description of change in sickness and illness	• Change in level of sickness and illness	• £ per year (low, central, high)

Well-being	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option involves green infrastructure (e.g. tree planting, green roofs) that will lead to an increase in number of people having a view over green space from house or regular place of work	Use BeST to estimate • Change in number of people having a view over green space	Use BeST to estimate value of increased well-being, based on 'view of green space'
Advanced		Use results from health impact assessment	As above
Output	• Qualitative description of change in well-being and resultant health outcomes	• Change in level of well-being	• £ per year (low, central, high)

Biodiversity

All types of storm overflow improvements have the potential to impact on biodiversity by providing:

- Enhanced habitats and ecology

Habitats	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option will impact on a designated site (e.g. SSSI,	Use BeST to estimate • Area of habitat created or improved	Use BeST to estimate value of biodiversity improvements

Advanced	SAC, SPA), Habitat of Principal Importance (BAP priority habitats), a site of local importance for nature, or a non-designated site of local or regional value • Option includes components that may improve these sites, or create new sites	Use results from habitat survey or assessment	As above
Output	• Qualitative description of change in habitat and biodiversity outcomes	• Change in area impacted and degree of impact	• £ per year (low, central, high)

Headroom

All types of storm overflow improvements have the potential to impact on headroom by providing:

- Additional drainage network capacity (headroom)

Headroom	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option is likely to create additional drainage capacity, deferring or delaying investment in piped systems or treatment works	Population equivalent of deferred systems or works (noting that deferred investment may erode over time)	Water company estimate of per person infra charge
Advanced		Amount and timing of deferred capital investment (noting that deferred investment may erode over time), based on local development plan, water cycle study or sewerage management plan	Water company estimate of value of deferred investment
Output	• Qualitative description of change in headroom and type/scale of investment likely to deferred or delayed	• p.e. or amount of investment	• £ per year (low, central, high)

Planning

All types of storm overflow improvements have the potential to impact on planning by providing:

- Reduced/avoided planning delays for construction of new homes or other buildings otherwise impacted by lack of drainage capacity

Planning	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Population growth is currently occurring or expected in the future • Storm overflows are a barrier to this growth or development	Amount of additional land available	Value of potential developable land (e.g. from Government's 'Land value estimates for policy appraisal')
Advanced		Amount and timing of additional land available (noting that this may erode over time), based on local development plan, water cycle study or sewerage management plan	As above
Output	• Qualitative description of process by which additional land may become available	• Area of land (ha)	• £ per year (low, central, high)

Economic Growth

All types of storm overflow improvements have the potential to impact on growth by providing:

- Local economic growth, development & regeneration, increased tourism

Growth	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option could play a part in regeneration programmes, tourism or other types of economic development	High level estimate of number of: • Number of buildings benefiting from impact of option on regeneration of area • Additional tourists expected	High level estimate of: • Increase in rateable value of buildings • Spend per tourist
Advanced		Quantified impact on value added to local economy, based on economic impact assessment or similar	Monetised impact on value added to local economy, based on economic impact assessment or similar

Output	• Qualitative description of impact of option on economic growth	• Number of additional buildings or tourists	• £ per year (low, central, high)

Jobs

All types of storm overflow improvements have the potential to impact on jobs by improving prospects for:

- Employment & productivity

Jobs	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option could lead to <u>new</u> jobs or training opportunities (e.g. green economy)	High level estimate of number of: • Jobs created	High level estimate of: • Value of each job created
Advanced		Quantified impact on value added to local economy, based on economic impact assessment or similar	Monetised impact on value added to local economy, based on economic impact assessment or similar
Output	• Qualitative description of impact of option on employment and productivity	• Number of additional jobs	• £ per year (low, central, high)

Skills

All types of storm overflow improvements have the potential to impact on skills by providing:

- Value added skills (impacts should not be assessed in this category due to high risk of double counting with 'jobs' above)

Leveraging

All types of storm overflow improvements have the potential to impact on leveraging by providing:

- Engagement of new partners for collaboration and/or co-funding

Leveraging	Description of impact	Quantification	Valuation
Basic	Impacts only likely where: • Option is likely to lead to new partners actively engaged or contributing to	High level estimate of number of new partners engaged or actively contributing	High level estimate of additional funding provided by each new partner

	delivery of desired outcome		
Advanced		Detailed estimate of ratio of partner contribution to contribution by lead organization	Monetized estimate of value of partner contribution, based on value of investment by lead organisation
Output	• Qualitative description of impact of option on new partnerships	• Scale of leveraging (number of partners or ratio)	• £ per year (low, central, high)

Construction

All types of storm overflow improvements that include construction activity have the potential to create dis-benefits through impacts on construction as a result of:

- Congestion and traffic disruption to motorists and pedestrians caused by excavation of roads or pavements to lay new pipes or perform repairs of burst pipes, or by above ground asset building or repairs.

Construction	**Description of impact**	**Quantification**	**Valuation**
Basic	Impacts only likely where: • Option involves construction in a populated area that could lead to traffic (e.g. road closure) or other disruption	Estimate of time lost using NERA (1998) methodology as described in UKWIR (2011), Section 4.5	Value of time using NERA (1998) methodology as described in UKWIR (2011), Section 4.5
Advanced		As above	As above
Output	• Qualitative description of impact of option on disruption	• Time lost (hours per year)	• £ per year (low, central, high)