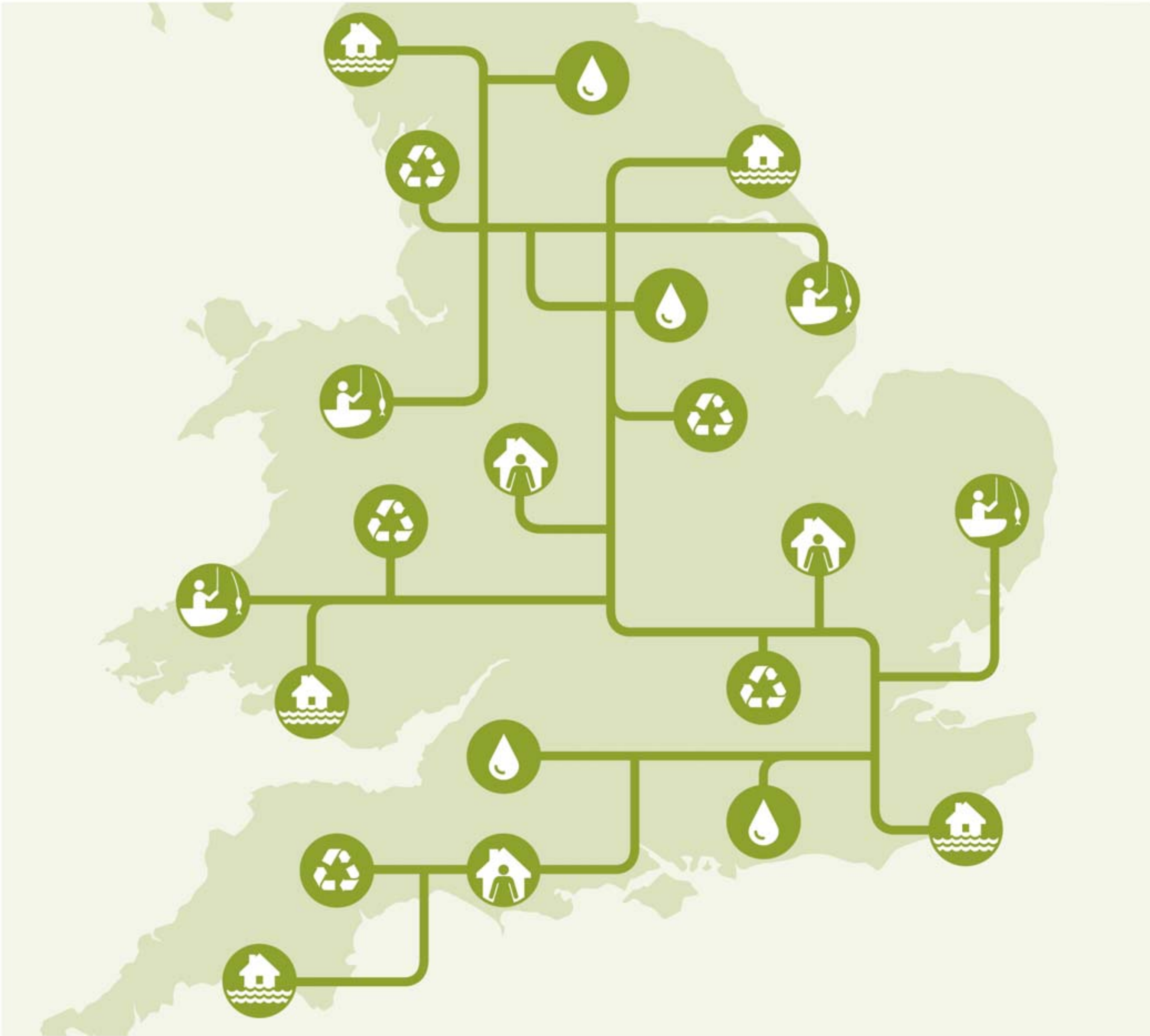

A Methodology for Evaluating Environmental Infrastructure Needs

Report SC090910/R1

The Environment Agency is the leading public body protecting and improving the environment in England and Wales.

It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned and funded by the Environment Agency.

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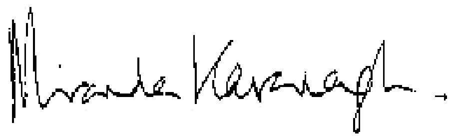
- **Delivering information, advice, tools and techniques**, by making appropriate products available to our policy and operations staff.



Miranda Kavanagh

Director of Evidence

Executive summary

Services provided by environmental infrastructure, such as waste disposal and sewage treatment, are essential to our quality of life and the environment that we inhabit. However, we need to ensure that new and existing housing developments have a lower environmental impact and supporting environmental infrastructure. As communities grow, it is vital we make plans to manage the increased demand from new households and related development.

The Environment Agency commissioned Halcrow to develop a method to assess the environmental infrastructure needs associated with housing growth. The method, outlined in this report, covers five areas of environmental infrastructure: water quality, water resources, waste, flood and coastal risk management, and green infrastructure.

The method set out in this report offers a standard approach for researchers, planners and policymakers to estimate the additional capacity and investment in environmental infrastructure needed to support housing growth in a given location and over a given timeframe. This should help us to develop national and local policies on the planning and building of infrastructure and on growth within environmental limits.

The method allows users to test a range of demand variables that affect the pressures on environmental infrastructure, including water use and the rate of waste generated. Studies carried out using the method can combine cost and capacity estimates from the modelling with place-specific analysis, interpretation and recommendations.

However, cost and capacity figures generated by the method should be treated as indicative rather than exact. Cost and capacity information is not yet precise or comprehensive enough to allow exact figures to be produced. The method aims to give an idea of the scale of infrastructure needed and how this might vary under different demand scenarios. Variations in demand scenarios include different levels of water consumption or waste generation, as well as variations in housing growth rates.

Equally, the method should prove useful in making comparisons between different strategic areas, though it does not provide information on small geographic areas, such as individual housing developments. The methodology is not a definitive planning tool, nor should its results be taken as a green or red light on any new development. It should be used in conjunction with other evidence to make informed decisions about housing growth and environmental infrastructure provision.

Our study found that the availability and quality of cost data lags behind data on demand and supply for most areas of environmental infrastructure. It is also clear that some areas of environmental infrastructure are much more advanced in their data than others. Data on green infrastructure, water quality and surface water are much less detailed than those on water resources, flooding and waste. Recommendations for future work include improving the overall data available.

In terms of extending the method, at present the method only considers housing development, though other types of development have an impact on environmental infrastructure. In particular, commercial and industrial activity and construction contribute significantly to pressures on environmental infrastructure. Extending the method to take account of non-household activities would boost its completeness.

Contents

1 Introduction

Our towns and cities would be uninhabitable without the network of services that protect us from flooding, deal with our rubbish and sewage and provide us with clean water and natural spaces. These services — provided by environmental infrastructure — are essential to our quality of life and the environment that we inhabit. Their failure can harm health, damage the environment and cost money.

The Environment Agency is at the forefront of work to ensure that new and existing developments have a reduced environmental impact and well-planned environmental infrastructure. As communities grow, it is vital that we have plans to manage the increased demand from new households and related development.

Our 2007 report *Hidden Infrastructure*[1] sets out the principles to ensure that environmental infrastructure can support growing communities and protect the environment. These principles are:

Getting the location of new housing right	**Planning for environmental infrastructure for the longer term**	**Reducing demand on environmental services**	**Securing funding at an early stage**

We carried out two studies examining environmental infrastructure needs associated with housing growth projections in the South East (2007)[2] and North West (2009)[3]. These studies and the potential for further work in this area highlighted the need to agree a common way to make future reports on environmental infrastructure.

To build on this work, the Environment Agency engaged Halcrow to develop a methodology for assessing environmental infrastructure needs associated with housing growth. This methodology covers five areas of environmental infrastructure, as shown in Figure 1.1.

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[1] *Hidden Infrastructure: The pressure on environmental infrastructure,* Environment Agency 2007. http://publications.environment-agency.gov.uk/pdf/GEHO0307BMCD-E-E.pdf

[2] *A strategy for provision of environmental infrastructure to meet the needs of the South East Plan*, Environment Agency 2007. http://www.environment-agency.gov.uk/static/documents/Research/smeise__1674280.pdf

[3] *Costs of Environmental Infrastructure Needs to Meet the North West Regional Spatial Strategy,* Environment Agency 2009. http://publications.environment-agency.gov.uk/pdf/SCHO0709BQRR-e-e.pdf

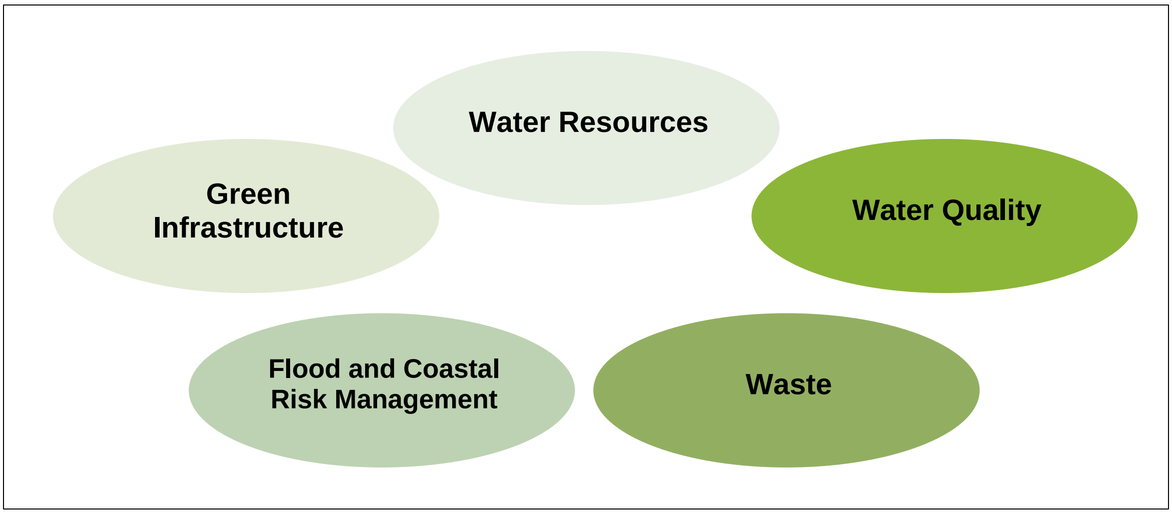

Figure 1.1 The five areas of environmental infrastructure

1.1 What is the methodology for?

The methodology set out in this report offers a standard approach for further environmental infrastructure studies. Such studies will allow us to estimate the additional capacity and investment in environmental infrastructure needed to support housing growth in a given location and over a given timeframe. The methodology should help us to develop a common and comparable understanding of the variables involved. It will ensure that our studies are consistent and developed using the best possible information and practices.

Studies based on the methodology will support the Environment Agency's work to inform policies on housing and infrastructure in spatial planning frameworks. They will also help us to develop national policy on the planning and delivery of infrastructure and on growth within environmental limits.

The ability to vary demand variables is a key benefit of using this methodology. The methodology allows us to test a range of demand variables that affect the pressures on environmental infrastructure, including water usage and the rate of waste generation. The findings will help us explore options to manage the additional infrastructure requirements associated with housing growth.

1.2 Scope

The methodology is not intended to be a technical tool for the detailed planning of environmental infrastructure. Instead, it aims to help us to provide a strategic forecast of environmental infrastructure needs, along with evidence to help us manage these needs effectively.

We do not want to duplicate existing work on environmental infrastructure, much of which is advanced and can be readily applied. Thus, we do not look in detail at different ways in which environmental infrastructure can be supplied. Our assumptions about supply are largely taken from existing strategies to provide environmental infrastructure. That said, where the need for additional capacity is identified, findings can be compared to and discussed alongside policies on sustainable approaches to providing infrastructure and managing demand.

The quality of information on environmental infrastructure has been a key determinant of the scope of this methodology. In some areas, lack of publicly available information about environmental infrastructure has limited the level of detail that can be included within the methodology. However, this methodology is intended to be flexible. As new information becomes available, the methodology can be adapted to make use of it.

1.3 How will the methodology be used?

The methodology sets out a standard approach to studying the relationship between housing growth and environmental infrastructure. Studies carried out using the methodology will combine cost and capacity estimates from modelling with place-specific analysis, interpretation and recommendations. The first three studies using the methodology were carried out for London and the City Regions of Leeds and Greater Manchester.

The methodology is capable of producing powerful conclusions at a strategic level, but the cost and capacity figures should be treated as indicative rather than exact. Cost and capacity information is not yet precise or comprehensive enough to allow exact figures to be produced. The methodology should provide evidence on the scale of the challenge and on how the challenge might vary under different demand scenarios. Variations in demand scenarios might include different levels of water consumption or reduced waste generation rates, as well as variations in housing growth rates.

Equally, the methodology should prove useful in making comparisons between different places, though it does not attempt to provide information on small geographic areas, such as individual housing developments. The methodology is not a definitive planning tool, nor should its results be taken as a green or red light on any new development. It should be used in conjunction with all other available evidence to make informed decisions about housing growth and environmental infrastructure provision.

The table below provides a brief overview of the geographic levels at which the methodology operates. These represent the lowest level at which results and information can be usefully presented.

Table 1.1 Geographical levels

Environmental infrastructure area	Geographic levels
Water resources	Water Resource Zone
Water quality	Sewage treatment catchment
Flooding	Local authority
Waste	Waste collection and disposal authority
Green infrastructure	Local authority

1.4 Who is the methodology for?

This methodology provides a framework for conducting studies at the strategic level – across groups of local authorities.

Studies using the methodology will provide evidence on environmental infrastructure needs associated with housing growth, including existing capacity and costs for additional provision.

This evidence can be used by the Environment Agency with planning bodies, at national level, and across groups of local authorities. Users include:

- strategic environmental planning teams;
- area-level planning and corporate services teams;
- sustainable communities team and wider policy teams.

The findings of these studies will also be directly relevant to work on housing and infrastructure provision by a number of external bodies. These include the Department for Environment, Food and Rural Affairs (Defra), the Department for Communities and Local Government (DCLG), the Homes and Communities Agency, Ofwat as well as utilities and contractors.

1.5 Our approach to this project

This study was guided by a steering group comprising experts in the five areas of environmental infrastructure from across the Environment Agency, the Homes and Communities Agency, the Department for Environment, Food and Rural Affairs, the Department for Communities and Local Government and the Welsh Assembly Government. The project was carried out in seven main stages:

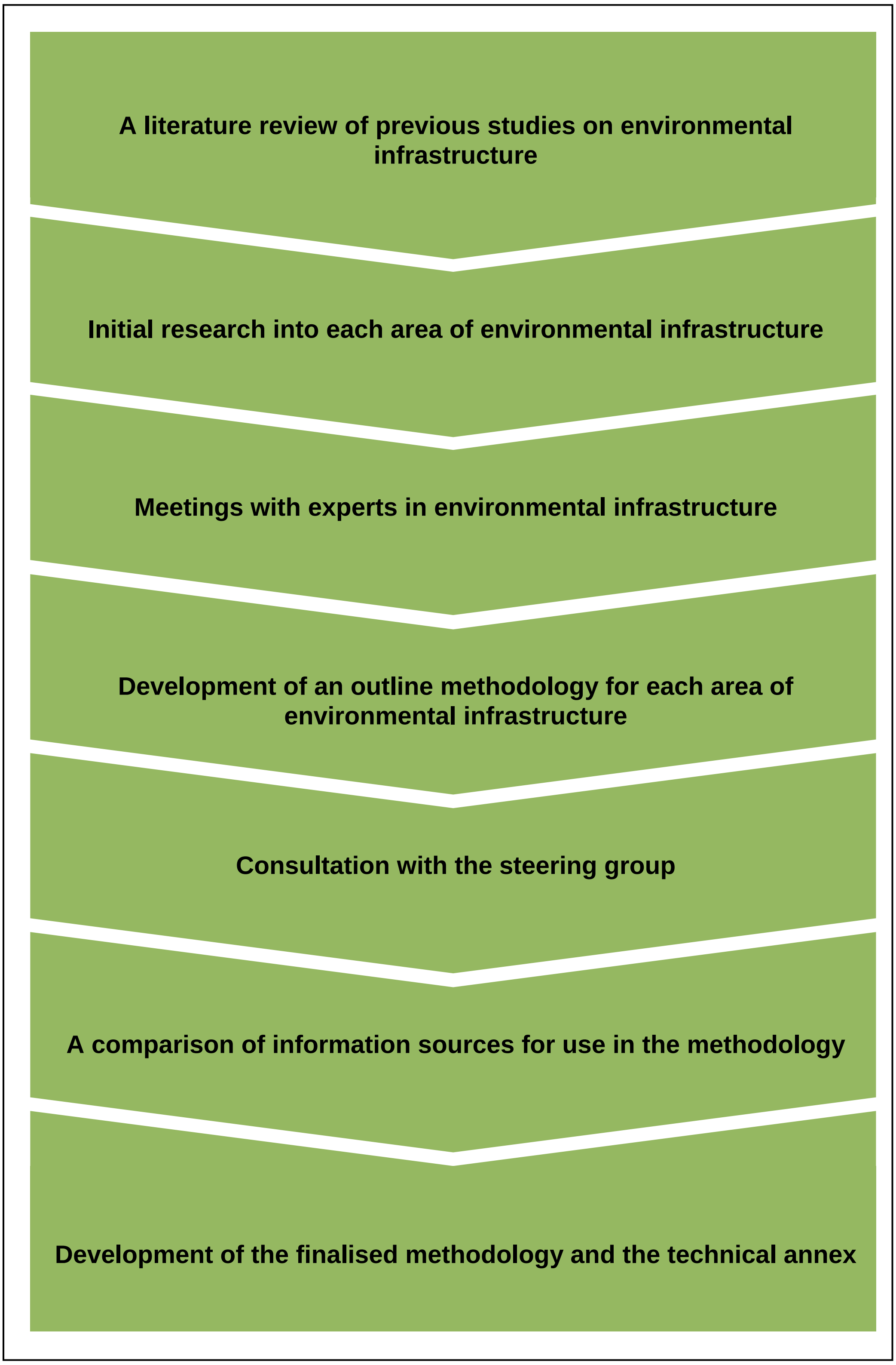

Figure 1.2 Approach

2 Policy context

2.1 Overview

"Sustainable communities are places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life. They are safe and inclusive, well planned, built and run, and offer equality of opportunity and good services for all."
ODPM (2005) Sustainable Communities: People, Places and Prosperity.

(http://www.communities.gov.uk/archived/publications/corporate/peopleplacesprosperity)

We want new and existing dwellings to have a lower environmental impact and to be supported by long-term plans for environmental infrastructure. This means that homes need to be built in the right place, with measures to manage demand as well as plans for additional infrastructure.

The UK has a growing and ageing population. By 2030 there could be up to 30 percent more households in England and 25 percent more in Wales. The recent economic downturn may have slowed housing growth, but high projections for long-term housing needs remain. This growth will increase demand for natural resources and stretch the capacity of existing environmental infrastructure.

Climate change will also have an impact on the provision and management of environmental infrastructure. New and existing buildings and infrastructure will need to be resilient to warmer, wetter winters and hotter, drier summers. They also need to use energy, water and materials more efficiently and produce less waste.

Tensions between development and flood risk are also likely to increase through climate change. We need to avoid development in places at major risk of flooding through the application of PPS25[4] in England and Planning Policy Wales and TAN15[5] in Wales. In some areas water quality standards, or water availability, could also challenge the extent to which further housing growth can be accommodated without harming the environment.

Investment in environmental infrastructure is also shaped by wider policy developments. The implementation of the Water Framework Directive[6] (WFD) is likely to mean additional investment in infrastructure to manage the water environment (including greater protection from diffuse pollution). Likewise, the Landfill Directive and Landfill Tax is driving investment in alternative waste treatment.

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4 Planning Policy Statement 25 sets out government policy on development and flood risk. For details, see http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps25/

5 For more on Technical Advice Note 15 (TAN15), see http://wales.gov.uk/topics/planning/policy/tans/tan15?lang=en

6 More information on the Water Framework Directive (2000/60/E) can be found at http://www.environment-agency.gov.uk/wfd

Our understanding of environmental infrastructure is also widening. The provision of green infrastructure via urban spaces and waterways, for example, will play an important role in managing the environmental impacts and requirements of developments. The potential benefits span a range of functions including water management, cooling, recreation and biodiversity.

2.2 How the methodology fits into the policy context

The Environment Agency is a regulator, operator and adviser on the environment in England and Wales. Our interest in planning and the built environment focuses on where these affect environmental services and people's quality of life.

The methodology will help to ensure that strategic planning deals with environmental constraints at an early stage. It will also help to make strategic analysis of housing growth scenarios across five areas of environmental infrastructure easier and more informative.

Findings are presented in terms of capacity shortages and costs. The effect of demand management options can also be modelled to allow us to discuss a variety of growth options. This will be key to our work with communities and partners to develop shared solutions to local environmental issues.

The methodology deals primarily with the impacts of housing growth on environmental infrastructure. The quality of information used in the methodology will determine the extent to which wider issues are taken into account in evaluating the future capacity and costs of infrastructure.

2.3 Climate change considerations

Future studies using this methodology will need to present their findings in the context of a changing climate. We need to mitigate and adapt to climate change.

As discussed above, the methodology is not intended as a detailed planning tool for infrastructure provision. As such, it does not make recommendations on the specific infrastructure that should be provided to manage additional demand in each of the environmental infrastructure areas. Instead it identifies capacity shortages and forecasts costs based on existing plans and expenditure. The capacity deficits and cost estimates provided need to be matched with recommendations on the need for investment in infrastructure that is low-carbon and resource efficient.

More central to the methodology are climate change adaptation considerations. As discussed above, our changing climate will place additional pressures on existing infrastructure. This will include warmer, wetter winters and hotter, drier summers, along with more extreme events such as flooding, droughts and sea level rise. New infrastructure will be needed to withstand the additional pressures of climate change.

Government recently published the latest UK Climate Change Projections (UKCP09). These provide climate projections for each decade through the century for three emissions scenarios (low, medium and high). Ideally, these probabilistic scenarios would be taken into account in this methodology, particularly for water resources, water quality and flood and coastal risk management. The extent to which we can do so depends on the information available. Information on water resources and water quality is informed by the previous set of climate projections, rather than UKCP09, as highlighted in the table below.

Table 2.1 Climate change compatibility

Environmental infrastructure area	UKCP compatibility
Water resources	Information from current water resource management plans takes into account UKCIP02 scenarios
Water quality	Information from current water company plans takes into account UKCIP02 scenarios
Flooding	NaFRA information does not take climate change into account at present
Waste	N/A
Green infrastructure	N/A

The Environment Agency is carrying out a project to translate UKCP09 for the purposes of our work. We hope that this will inform our understanding of how the new projections will impact on the capacity of infrastructure. Further discussion of how the methodology might be extended to reflect this work is included in Section 10.

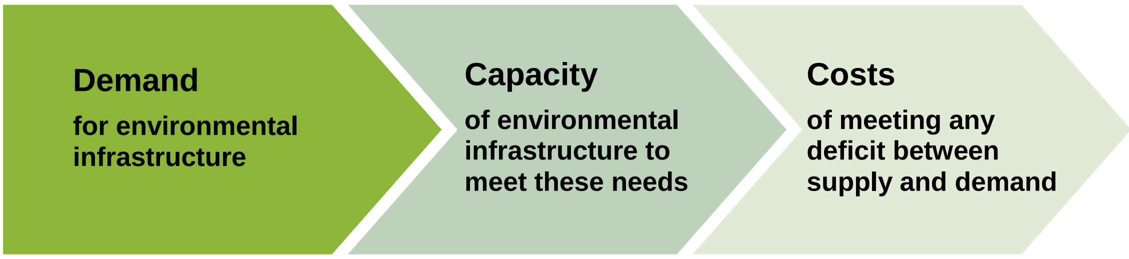
3 Logic behind the methodology

3.1 Overview

The current methodology builds on existing environmental infrastructure studies. It incorporates a number of strengths and benefits, such as the ability to test different demand scenarios and the effect of core variables on cost estimates. It is particularly helpful when applied across a broad scale and can produce comparable results.

3.2 General logic

In general, the methodology looks at environmental infrastructure through a three-stage process:



3.3 Drivers of demand

Using the methodology means we can test different levels of demand and obtain different results on the capacity and costs of environmental infrastructure. Demand is measured in such a way that it is directly comparable to supply. This is outlined in the table below for each of the five areas of environmental infrastructure.

Housing growth is the main driver of demand for environmental infrastructure. For flooding and green infrastructure, the amount of land developed has a direct impact on the demand for environmental infrastructure. Housing growth influences the other three areas of environmental infrastructure through its impact on population.

The intensity of resource use is also important in determining demand. For water resources, the amount of water consumed per person is a key figure. Similarly, the waste generation rate per person influences the total amount of waste generated, while recycling and landfill rates will have a significant bearing on the infrastructure needed to manage our waste. Flooding and green infrastructure demand are not affected by the intensity of resource use in the same way.

Table 3.1 Measures of demand

Environmental infrastructure area	How is demand expressed?
Water resources	Megalitres per day of water
Water quality	Megalitres per day of wastewater generated and biodegradable load of sewage
Flood and coastal risk management	The area of land which needs to have its flood risk reduced by a certain level
Waste	Tonnes of waste generated
Green infrastructure	Amount of green infrastructure in square metres

3.4 Setting target figures for environmental infrastructure

Targets for provision are required to establish the capacity of environmental infrastructure.

Table 3.2 Target levels of provision for environmental infrastructure

Environmental infrastructure area	Target level of provision
Water resources	Target headroom between demand and supply, as determined by Environment Agency, Ofwat and water companies
Water quality	Meeting consent levels (set by the Environment Agency) on flow and concentration at sewage treatment works, which are assumed to be sufficient to maintain water quality standards
Flood and coastal risk management	Protecting all new homes to an acceptable standard, at minimum against a one in 100 chance of flooding in a given location in any given year (one in 200 for tidal flooding). SuDS is assumed to be mandatory for new developments, and mitigates all additional surface water impacts
Waste	Managing all waste. As part of the methodology's ability to test scenarios, we can set hypothetical targets and examine the results
Green infrastructure	Increases in green infrastructure set for each local authority as a user-defined variable in the methodology

3.5 Strategic approach

This methodology has been designed to offer a strategic perspective of environmental infrastructure. Its primary purpose is to inform policy on housing development. The method looks at the current capacity but not the detailed planning of environmental infrastructure. It focuses on how changes in demand can change the capacity and costs of environmental infrastructure. The methodology focuses on the key variables which have implications on a local, strategic or national scale for the costs of environmental infrastructure.

What do we mean by strategic?

The capacity and cost figures produced by the methodology apply to large geographic and administrative areas – most commonly at local authority level. This *strategic approach* means that we can draw out conclusions significant to wider sub-national and national policy-making. The methodology is applicable across all parts of England and Wales.

There are advantages to using a strategic as opposed to locally specific approach to forecasting environmental infrastructure needs. These advantages include:

- avoiding unreliable information and anomalies which occur on a small scale;
- generating cost figures which are significant on a strategic or national scale;
- being much more cost-effective;
- allowing more flexibility, given the uncertainty of forecasting into the future.

Of course, a strategic approach means high-level results. The methodology generally uses average costs per unit of environmental infrastructure. These costs are set for areas no smaller than local authorities. Since the purpose is to provide evidence useable at national and strategic levels, this is not a major issue.

3.6 Using unit costs rather than costs per house

The two previous reports on environmental infrastructure modelled costs on a per household basis. The problem with this approach is that it does not take account of the different levels of demand which can be generated by a given house with fewer people living in it, or where residents use resources more efficiently. The main factor affecting cost is the volume of environmental infrastructure required, not the number of houses served by it. This methodology uses cost per unit of environmental infrastructure as its core measurement. This allows the user much more flexibility in testing different demand scenarios. It also provides a much more accurate picture of how the costs of environmental infrastructure arise. Total costs can still be broken down by each household, which may be useful for discussions with planners. See Section 4.3.2 for further details.

3.7 Who should pay for environmental infrastructure?

This methodology is not intended to assign the costs of environmental infrastructure to different groups. However, the methodology provides a starting point for considering the allocation of costs.

4 Applying the methodology

4.1 Overview

This section offers a brief explanation of how the methodology should be applied. Technical specialists may also find it useful to refer to the Technical Annex.

The methodology requires information from a range of sources to be collated and entered. There are three main types of information involved in the methodology:

i. **User-defined inputs** – these are flexible variables which can be altered by the user to test different scenarios.

ii. **Fixed inputs** – these are inputs which are entered into the methodology, but which cannot be altered.

iii. **Calculated outputs** – these are figures which are calculated from other variables in the model.

4.2 Putting information into the methodology

All information entered into the methodology needs to be held in a coordinated format, which allows different information to be compared and used together. Outlined below are some of the key features which apply to all information fields used.

Geographic level

All information must be assigned to a geographic area. There are a number of different geographic levels within the methodology. The most common of these is local authority level.

Different geographic levels also need to be related to one another, so that information for one geographic level can be obtained by aggregating all geographic levels which fall into that area. For instance, housing information is entered at local authority level. Each local authority should be assigned to larger geographic areas (such as Water Resource Zone), or a percentage assigned to different areas where boundaries do not coincide. The number of houses within a Water Resource Zone is calculated by aggregating all houses in local authorities which fall within that zone.

Timescale

The methodology can be used over a flexible timescale. However, the timescale for each study should be agreed at the outset, and held constant across all environmental infrastructure areas. All information must be entered for every year covered in the methodology. Where a variable does not change over time, it will have a constant value for all years. Applying a timescale to the information is important. Without it, the methodology cannot assess how costs change in the future.

Units

All information must be entered in consistent units across the methodology.
The unit for each component can be found in Sections 5.6 through to 9.6, and in the Technical Annex.

Using household-only information

This methodology only considers impacts on environmental infrastructure which arise from household activities. Where the information includes non-household figures, these should be removed to avoid distortions. In some cases, this may involve adjusting figures by a percentage, to reflect the contribution of household activities.

Estimating information

In some places, the methodology requires information to be estimated rather than taken directly from an information source. The methodology does not prescribe a fixed approach for estimating figures. Estimates should be made using the best available information and the user must apply his or her own discretion in determining the best way to make an estimate. In general, estimates are likely to take average costs per unit from a particular information source.

4.3 Getting results out of the methodology

4.3.1 User-defined variables

A number of variables within the methodology are flexible, and can be altered by the user to test different demand scenarios. The most significant of these are:

Housing growth figures	**Proportion of waste recycled, going to landfill and to other means of waste management**	**Increases in green infrastructure**
Water consumption per person	**Waste generation rates**	**Location of newly developed properties in relation to flood zones**

These variables should be presented in a single, user-friendly area, allowing the user to change them easily. The user-defined information needs to be set over the chosen timescale. The user should be offered the option of setting an initial level for each variable, and then specifying a percentage change in the variable for each year.

4.3.2 What outputs will the methodology produce?

Three key types of output are produced:

The capacity deficit or surplus of environmental infrastructure each year	**The costs of environmental infrastructure provision needed to meet demand**	**Comparisons between different ways of managing environmental infrastructure needs**

The methodology enables demand and supply to be mapped over time. This allows us to predict when future capacity constraints will occur, and when action may be required.

The cost outputs from the methodology can be presented in a number of ways. The total costs of providing environmental infrastructure for a given demand scenario can be presented as a total over the chosen timescale, and broken down on a per year basis for this timescale.

Total costs can also be broken down into operational, maintenance and capital costs. Again, these will be available as a total for the chosen timescale or as a year-by-year amount.

The cost per house can be obtained by dividing the total costs of environmental infrastructure by the total number of houses. This can be presented as a total for the chosen timescale and a year-by-year figure. The additional cost per new house can also be obtained by comparing a given scenario with a zero housing growth scenario. The figure is obtained by dividing the additional cost by the additional number of houses.

4.3.3 How can the costs be interpreted?

The cost outputs provided by the methodology are designed to be estimates and indicators of the relative scale of challenges involved in providing adequate levels of environmental infrastructure.

One of the methodology’s key strengths is that it allows the user to test different demand scenarios. The methodology is particularly useful where it produces significant variations in the capacity and costs of environmental infrastructure between different scenarios. For instance, a small change in water consumption, or recycling rates, might generate a large change in overall costs for the respective areas. Where there are significant variations in the methodology’s outputs, the evidence in favour of certain policy measures is at its strongest.

For more detailed information on applying the methodology, see the Technical Annex.

5 Water resources

5.1 Background

Water resources concerns the supply and distribution of clean water to homes. For the purposes of this methodology, the process is considered to start with abstraction and treatment of water and finish with distribution of this water to homes. Examples of water resources infrastructure include reservoirs, pumping stations, water treatment plants and a piped distribution system.

The water industry in England and Wales consists of 24 privately owned water companies, each of which provides water to customers within a given geographic area.

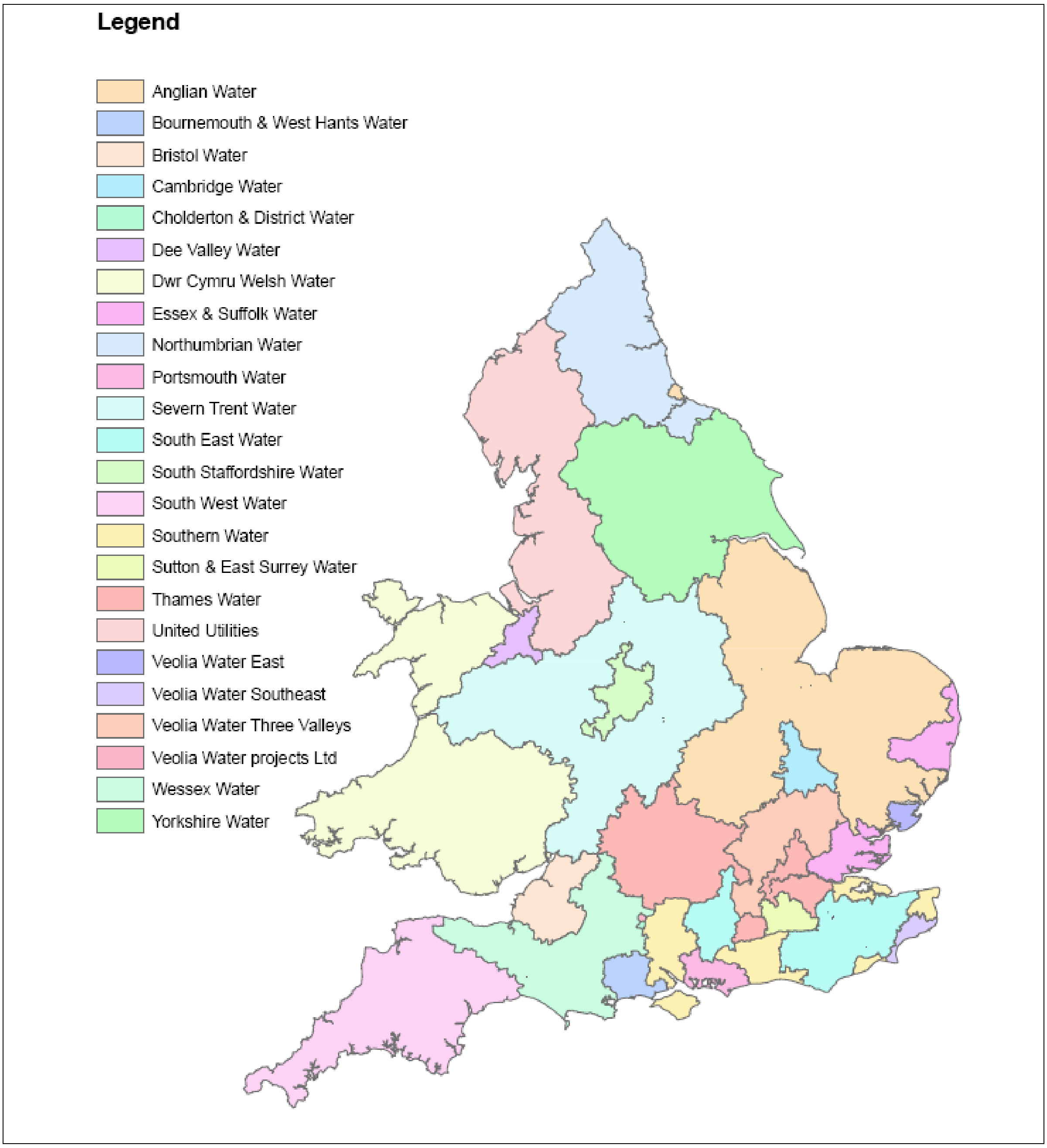


Figure 5.1 Water companies in the UK

Who regulates water resources

Supply and distribution of water is regulated in England and Wales. Ofwat regulates customer prices and company expenditure on infrastructure. The Environment Agency regulates the licensing of abstractions and the environmental impacts of water resources. The Drinking Water Inspectorate regulates the level of treatment of raw water. Defra and the Welsh Assembly Government oversee the statutory water resource management planning process in England and Wales respectively.

Every water company plans for water resources over a 25-year period and submits a Water Resource Management Plan (WRMP) according to guidance from the Environment Agency. These plans are reviewed every year. Water companies also submit a Business Plan to Ofwat every five years. These plans contain the companies' proposed investment schedule and are used to set water prices within their given area over this period. Water companies report against this business plan annually and submit information to Ofwat, in a process commonly known as the June Returns.

5.2 Existing work

The water resources methodology used in the North West study[7] examined the capacity of existing assets in the study area. No information was obtained from water companies and therefore the costs used were average costs per house, developed from information available from Ofwat.

This methodology uses a more sophisticated approach to estimating the future capacity and costs of water resources infrastructure. This methodology takes into account the strategic planning by water companies, to provide a more detailed picture of how much extra infrastructure will be needed in future, and how much this will cost.

Advances in this methodology mean our approach is nationally applicable. For this reason, supply, demand and costs are based on publicly available, consistent water company information. This has enabled us to evaluate the suppl- demand balance at the water companies' Water Resource Zone (WRZ) level. Water Resource Zones can vary greatly in size, with the largest covering most of a wide region, and the smallest covering individual towns and cities. This is the functional planning level for water resources and allows us to demonstrate differences across the water company area. Costs are also determined at the WRZ level, based on water company-specific interventions.

An additional benefit of the methodology is the introduction of input variables, such as per capita consumption, allowing us to examine different demand scenarios into the future. This means that the methodology can actively test the implications of different demand and policy scenarios.

7 Environment Agency 2009. See http://publications.environment-agency.gov.uk/pdf/SCHO0709BQRR-e-e.pdf

5.3 What is within the scope of water resources?

Water resources infrastructure is required to supply enough water to meet household demand[8]. This methodology is designed to consider the capital, operational and maintenance costs of providing enough infrastructure to meet different levels of demand for water in the future. Three aspects of water resources are considered within this methodology:

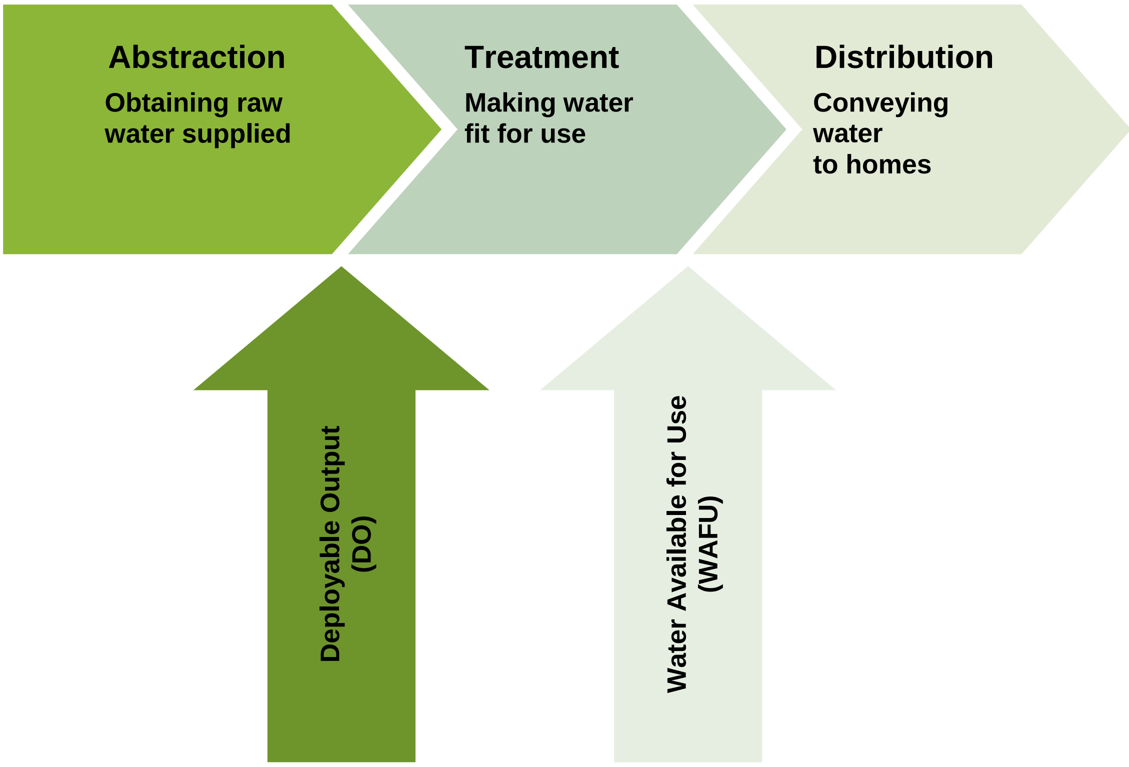


Figure 5.2 Water resource process

5.4 Outline methodology

The methodology for water resources is based on achieving a balance between demand and supply. Demand is calculated using population and per capita consumption (PCC) figures.

The amount of water in supply is determined from existing infrastructure and any new interventions introduced over time to increase the supply of water. These interventions might include building new reservoirs, abstracting from groundwater, and building new treatment plants. The costs of increasing supply are based on feasible interventions proposed in water company WRMPs.

[8] Note that water resources infrastructure also meets demands from non-household activities, but this is not included in the method.

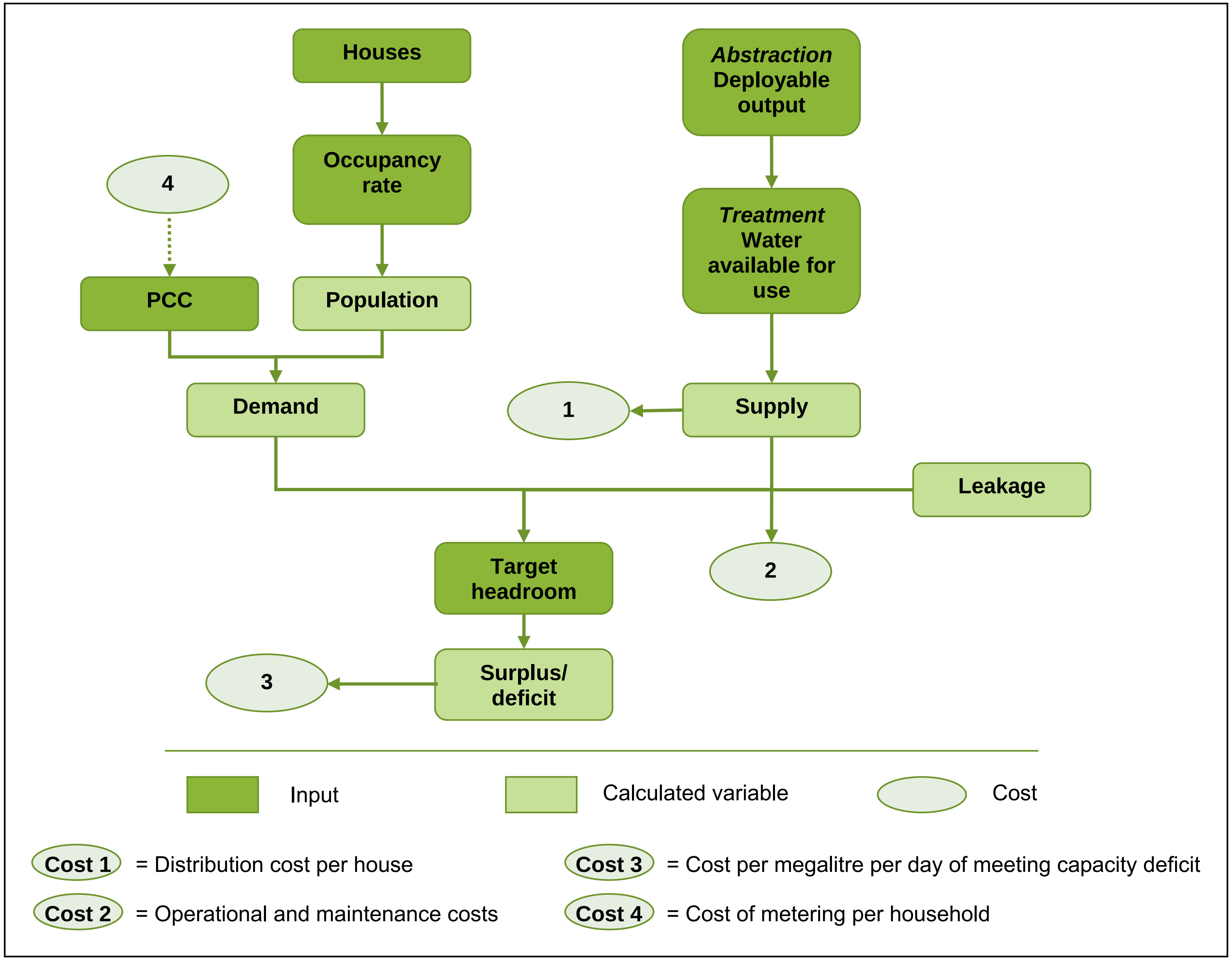


Figure 5.3 Water resources overview

5.4.1 Geographic level

The key geographic level used for water resources is the WRZ. Water Resource Zones are designated by water companies. They are defined as zones sharing the same ‘deployable output’ and within which water can normally be transferred anywhere. An example of the size of WRZ compared to the water company area is shown below. Each local authority can be assigned to a WRZ (or split across several zones), and supply, demand and costs are calculated at this level.

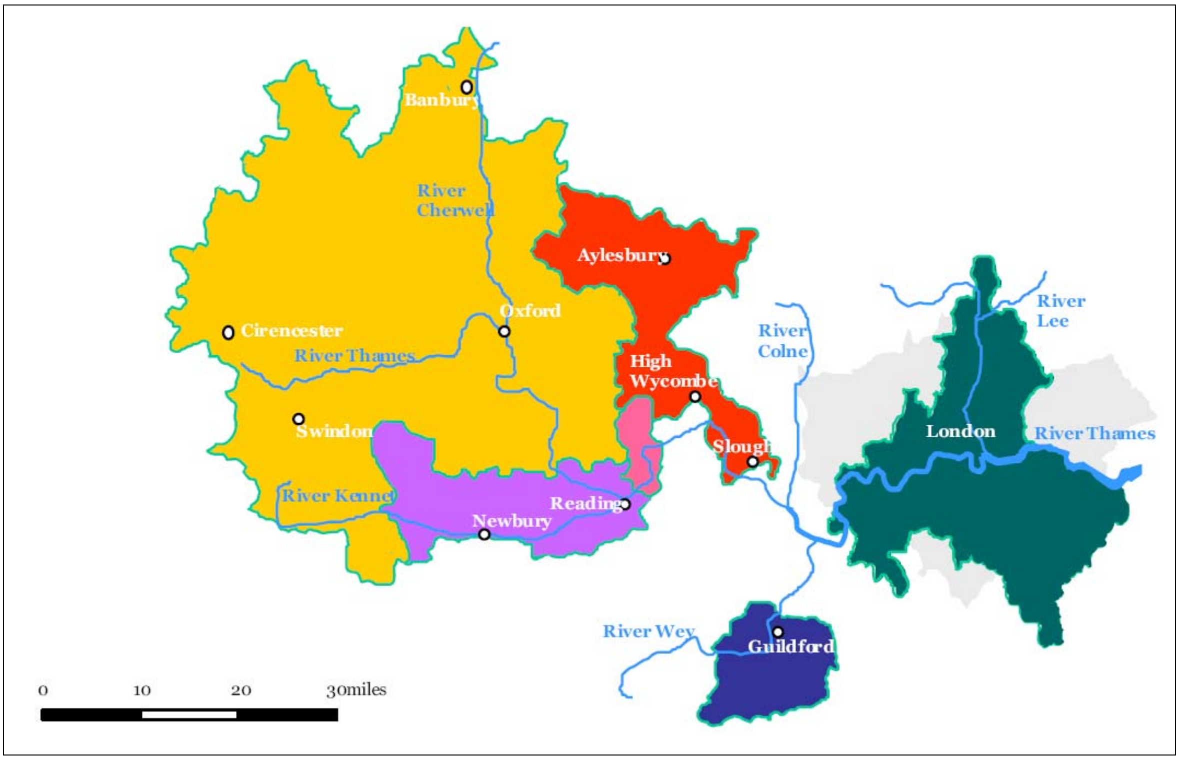


Figure 5.4 Water Resource Zones in the Thames Water Area (Source: Thames Water, 2009)

5.4.2 Demand and user defined inputs

The main drivers of demand are population and per capita consumption. Population is calculated from housing numbers using occupancy rates. Per capita consumption is a user-defined input, and can be expressed in a number of ways. An average per capita consumption figure can be used across all households, or separate per capita consumption figures can be used for new, metered and unmetered houses. This range of inputs allows us to look at the effects of different ways of managing water demand, such as building water-efficient new homes, retrofitting existing homes and rolling out metering schemes more widely.

5.4.3 Supply capacity

The supply side is based on water company plans for investing in the future. Water companies produce a WRMP for each of their WRZ, which set out plans for balancing supply and demand over a 25-year period. The methodology derives supply from the baseline scenario, which reflects how much water is available before any proposed interventions are carried out. The key measure of supply is ‘water available for use’, which takes into account abstraction and treatment of water.

Supply is also affected by levels of leakage. Leakage occurs at all stages of the water resource process, from abstraction through to distribution. Leakage reduces the effective supply, and needs to be factored into the methodology. Some of this leakage occurs before and during the treatment process, and therefore WAFU directly takes account of this. Leakage within the distribution system, however, must be subtracted from WAFU. Leakage figures are estimated by the water company and are provided in the WRMP. Leakage is expressed as a percentage of total supply in the method.

5.4.4 Balancing supply and demand

In the methodology, supply must be equal to demand plus a headroom target. Water companies need to maintain some headroom between supply and demand, to guard against potential inaccuracies and future unknowns. WRMPs set out a target level of headroom for each year. This increases into the future, to reflect greater uncertainty over levels of supply and demand.

5.4.5 Costs

The types of costs for water resources can be broken down into two areas:

Capital and operational costs for new interventions required to meet the supply-demand balance	**Base service costs for operating and maintaining supply network**

The costs of supplying extra water are derived from the list of feasible interventions set out in the WRMP. Rather than model which interventions water companies pursue, the methodology derives a unit cost for increasing supply from these interventions.

Base service costs for new homes are derived from June Return data, which sets out a base service cost per house.

5.5 Information sources

The two key sources of information for water resources are the WRMP (including supporting tables) and Final Business Plans. Both are submitted by water companies every five years.

Water Resource Management Plans (WRMP) contain a wide range of information, including the demand forecasts used by water companies, their proposed supply-side or demand-side interventions, and the average incremental cost for each intervention. This information covers a 25-year period, and is available at WRZ level.

June Return data is submitted by water companies each year, and provides detailed information on water company activities and spending for that year.

Final Business Plans outline a water company's overall investment plan for the next five years. This information is more limited than that in the WRMP, because it covers a shorter timeframe. Also, in the publicly available versions of these plans the cost is not broken down to lower levels.

The **Environment Agency** has developed sophisticated models for some areas which predict the costs of supplying water under different demand scenarios. These models reappraise the feasibility of interventions for each WRZ each time the demand forecast is altered. For areas covered by such models, the methodology is designed to allow the outputs from these models to override the figures used in the methodology.
In the absence of this information (the model is currently limited to the South East of England), a simpler approach must be adopted.

5.6 Data requirements

The information required for the water resources methodology is detailed in Table 5.1 below.

Table 5.1 Data required for Water Resources

Data	Units	Type	Geographic level	Source
Water available for use	Megalitre/day	Fixed input	WRZ	WRMP
Leakage (excluding during abstraction and treatment)	%	Fixed input	WRZ	WRMP
Target headroom	%	Fixed input	WRZ	WRMP
Capital cost per extra unit of water	£/megalitre/day	Fixed input	WRZ	Derived from WRMP
Annual operational cost per extra unit of water	£/megalitre/day	Fixed input	WRZ	Derived from WRMP
Base service cost per house	£/megalitre/day	Fixed input	WRZ	Derived from WRMP

Table 5.2 Input variables for water resources

Variable	Units	Geographic level
Average per capita consumption	Litres per person per day	WRZ
Percentage houses converted to meters each year	Percentage change	WRZ
Per capita consumption (unmetered homes)	Litres per person per day	WRZ
Per capita consumption (metered homes)	Litres per person per day	WRZ
Per capita consumption (new build homes)	Litres per person per day	WRZ

5.7 Considerations

Water companies invest much time in developing WRMP and the selection of interventions is based on the demand forecast used. The growth in demand is fixed within the WRMP. However, different interventions may become feasible when the level of demand changes.

The purpose of this methodology is to test variations in demand. It is beyond the scope of this methodology to reappraise the different interventions available to a water company every time the demand scenario is altered. Therefore, the recommended approach is to establish an expected *cost per megalitre per day* for increasing the supply of water. This figure is calculated from the current suite of interventions planned by water companies within a given WRZ, but it does not take into account the indivisibilities involved with large interventions. The methodology does not predict exact spending by water companies, but indicates the scale of costs expected in the future.

5.7.1 Taking climate change into account

Current water company draft WRMP use UKCIP02, the previous set of climate change projections. Although these projections have now been superseded by a further round of UK Climate Change Projections (UKCP09), they give similar results to the median scenario in UKCP09. However, all water companies are required to update their plans to take account of UKCP09 projections prior to 2012. Final WRMP may not be available when the method is applied. In that case, information from draft plans should be adjusted once the results of the ongoing project to translate existing work for UKCP09 are known.

Applying the methodology in Wales

This methodology should be easily applicable in Wales. Welsh Water and Dee Valley Water, the main water companies in Wales, are regulated by Ofwat and the Environment Agency in the same way as the water companies in England. Welsh Water and Dee Valley Water are required to produce a Final Business Plan and WRMP in the same way as other water companies although Welsh Assembly Government overseas the process rather than Defra.

5.8 Assumptions

- Local authorities are assigned to Water Resource Zones using information held by the Environment Agency. Local Authorities that fall across two or more WRZ are allocated between them by percentage of population.
- Water can be transferred anywhere within a WRZ, and costs the same amount anywhere within each zone.
- Supply-side plans are based on currently planned interventions by water companies. The costs of increasing the supply of water are based on a cost curve, which is derived from water companies' lists of feasible interventions.
- Operational and maintenance costs are fixed according to water company forecasts of cost per megalitre per day of water supplied.
- The cost of abstraction and treatment are included within the costs given for proposed interventions in the WRMP.
- Leakage is assumed to be a proportion of water delivered, and is expressed as a percentage. Other impacts on the supply-demand balance are expected to remain the same as in water company plans.

6 Water quality

6.1 Background

Water quality refers to levels of pollution in natural water courses, such as rivers, lakes and the sea. Water quality is measured according to two standards:

Chemical quality	Biological quality
Levels of harmful chemicals	The ability of a water course to support a range of living creatures

There are a number of ways in which water can be polluted, from discharges of untreated human effluent from households, to the presence of chemicals, such as nitrates and ammonia. Water quality can be affected by many different activities, including industrial activities and agriculture, as well as household waste.

This methodology cannot take account of the full spectrum of factors affecting water quality. Its purpose is to evaluate the costs and capacity of *infrastructure*, rather than the costs of damage to the environment. The method aims to establish a link between water quality and infrastructure, and evaluate how much infrastructure will be needed to maintain the desired water quality.

As part of our work in regulating water quality in rivers, lakes and the sea, the Environment Agency sets limits on the volume and concentration of sewage that can be released into natural water courses. These limits are designed to ensure that sewerage and sewage treatment infrastructure is sufficient to maintain acceptable water quality standards. This methodology assumes that these limits are set at the correct levels, such that complying with them is sufficient to meet the desired water quality standards, all other things being equal. Therefore, this methodology measures the amount of sewerage and sewage treatment infrastructure required to meet these limits.

Households create demand for sewerage and sewage treatment infrastructure by emitting effluent into the sewerage network. There are two key aspects of household effluent which determine the amount of sewerage and sewage treatment infrastructure required:

Volume	Load
The total volume of wastewater emitted from homes (this does not include surface water run-off)	The amount of biodegradable load emitted from homes[9]

[9] Load is commonly measured in population equivalent terms (amount of biodegradable effluent per person). One population equivalent is defined as the biodegradable organic load having a five-day oxygen demand of 60g of oxygen per day.

In the methodology, each sewage treatment works needs to have sufficient capacity to deal with the volume of wastewater and load of effluent entering it. For the purposes of this methodology, these are called *hydraulic* capacity and *treatment* capacity respectively. Both of these capacities are important in different ways. If a sewage treatment works does not have sufficient hydraulic capacity to deal with the volume of wastewater entering it, excess volume is sometimes discharged into watercourses without being treated. If the works does not have sufficient treatment capacity to deal with a given load, the treated sewage will not meet acceptable water quality standards.

Volumes of wastewater are complicated by the effect of surface water on the sewerage system. Many sewerage systems function as combined sewers, which carry both household wastewater and surface water run-off. During periods of heavy rain, surface water run-off can greatly increase the volume in the sewerage network, often exceeding the hydraulic capacity of sewage treatment works and resulting in discharges. This makes the hydraulic capacity required to maintain acceptable water quality standards hard to measure. For reasons outlined in the box below, the methodology does not attempt to model the effects of surface water directly (although allowances for surface water are made within the flow limits at sewage treatment works).

Why isn’t surface water included?

Due to a lack of information, we cannot measure the impact of surface water run-off on sewerage capacity, or on water quality. Because surface water run-off leads to such wide fluctuations in the volume of sewage within the sewerage system, complex calculations are required to establish how much capacity is required to handle these fluctuations. Such complex calculations are beyond the scope of this methodology. Information made available by water and sewerage companies is not sufficiently reliable for use here.

Some information on surface water, including the use of sustainable drainage systems for new homes, is considered under flood and coastal risk management.

6.2 Existing work

The North West study used Environment Agency flow information at sewage treatment works to determine the current capacity of infrastructure. As no information was obtained from water companies, the study used average costs per house, developed from information from Ofwat.

This methodology creates a nationally consistent approach using information from a range of sources. By considering the different constraints and costs at different sewage treatment works, this methodology can reflect varying pressures on wastewater infrastructure and water quality.

An additional benefit of the methodology is the introduction of input variables, such as per capita consumption, allowing us to examine different demand scenarios into the future.

6.3 What is within the scope of water quality?

This methodology is designed to calculate the costs of environmental infrastructure, rather than the benefits or costs of environmental assets or problems. Therefore, it focuses on the costs of the sewerage infrastructure required to maintain acceptable levels of water quality.

In doing so, it looks at the capacity of the sewerage system to cope with volumes of effluent (hydraulic capacity) as well as levels of load (treatment capacity).

Commercial and industrial sewage are not included, despite their effect on the nation's overall water quality. At this stage, only household activities are within the scope of the methodology.

6.4 Outline methodology

The publicly available information on sewerage infrastructure is only sufficient to generate approximate information. In order for this section of the methodology to be applied most usefully, access is required to information which is confidential to water and sewerage companies. Although some of this information can be estimated by the Environment Agency, the exact methodology to be followed for water quality depends on the data available for each study.

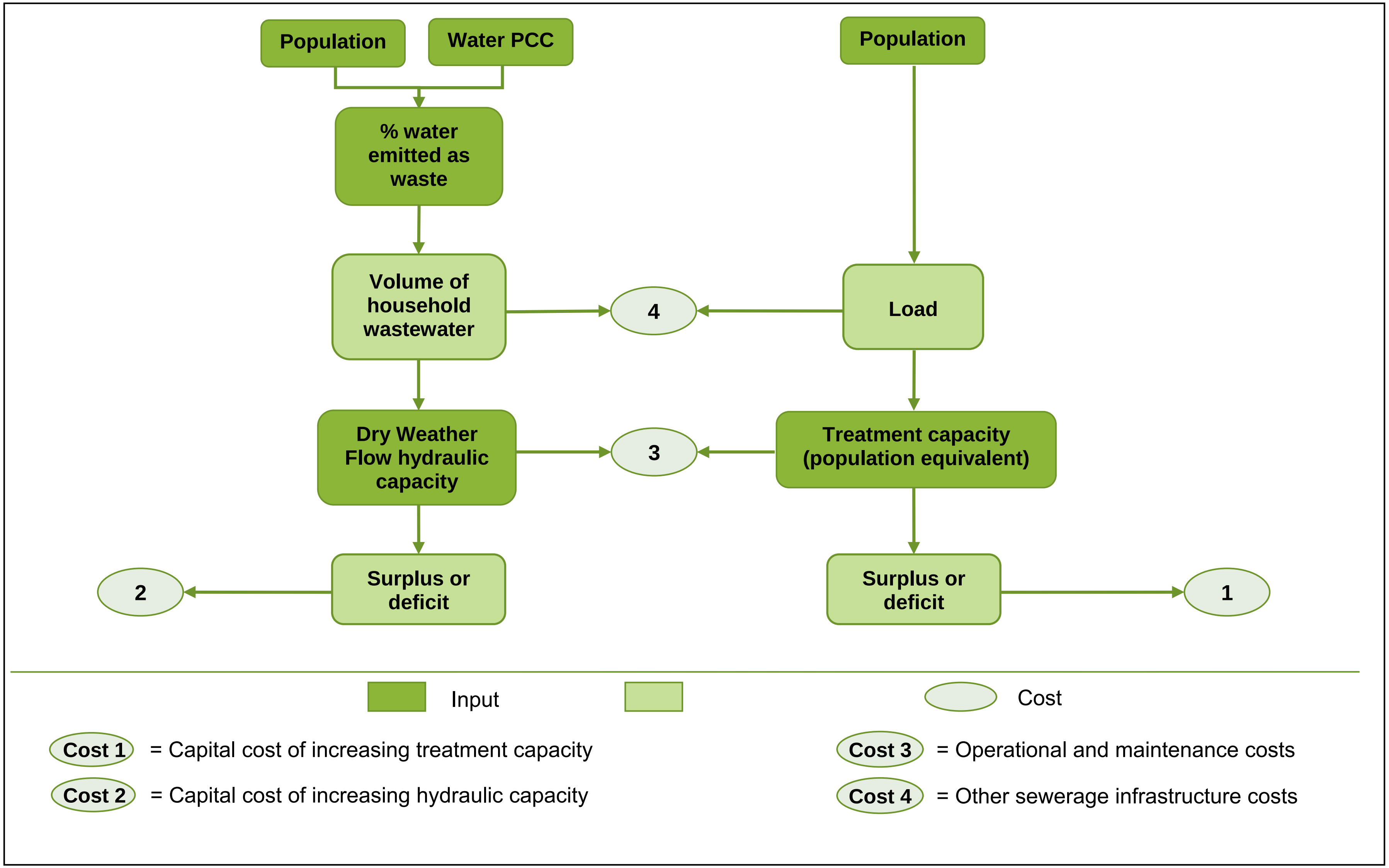


Figure 6.1 Water quality overview

6.4.1 Geographic level

Wherever possible, the methodology uses sewage treatment catchments as its core geographic level. This allows us to look at differences between areas for housing growth. Accurately defining sewage treatment catchment boundaries usually requires information from water companies, although the Environment Agency may be able to provide this information in some cases.

6.4.2 Demand and pressures

Within the scope of this methodology, household demand for sewerage infrastructure is driven by the volume of wastewater and the load of effluent produced by households.

The amount of wastewater released by households is linked to the amount of water consumed. Therefore, it is calculated in much the same way for water quality as for water resources. The key difference is that a proportion of the water delivered to households does not become wastewater (primarily due to leakage and evaporation). Therefore, household wastewater is calculated as a fixed proportion (normally less than 100 per cent) of water delivered.

Biodegradable load is assumed to be a constant multiple of population. The treatment capacity of sewage treatment works is often expressed in population equivalent terms, and so load can be expressed as the population of a sewage treatment catchment area.

6.4.3 Capacity

The hydraulic capacity of each sewage treatment works is based on the consented dry weather flow (DWF) level. Some sewage treatment works do not have dry weather flow permits, and in these cases a judgement must be made on the desirable flow from households. The Environment Agency holds information on the dry weather flow capacity of sewage treatment works. The current headroom between hydraulic capacity and dry weather flow volumes can be found from information on current flows and levels of discharge.

The treatment capacity of each sewage treatment works at current consent levels is held by the Environment Agency as part of its Urban Waste Water Treatment Directive information[10]. This capacity is most easily used in population equivalent form.

The methodology can also look at treatment capacity where sewage treatment works are required to treat wastewater to a higher standard in the future (when consent levels are tightened). In this case, forecasts for how the consent level will change for each sewage treatment works need to be put into the methodology. It is also possible to measure a “no deterioration” scenario, where the amount of load emitted by sewage treatment works does not increase in absolute terms.

[10] This only applies to sewage treatment works with capacity over 2,000 population equivalent.

Why use dry weather flows?

Using dry weather flows to measure the hydraulic capacity seems counterintuitive. Sewage treatment works rarely overflow during periods of dry weather. It is the increases in volume during periods of heavy rainfall which normally cause the capacity of sewage treatment works to be exceeded.

The advantage of using dry weather flows (or an estimate of the flow from households) is that it allows the methodology to focus solely on household wastewater, and ignore the effects of surface water, which are difficult to predict. The actual hydraulic capacity of a sewage treatment works (the full to flow treatment) is a multiple of dry weather flow, normally between three and six times higher. However, using dry weather flows gives an indication of whether the sewage treatment works has sufficient hydraulic capacity to deal with household wastewater. If it fails this criterion, it is assumed that it also lacks full to flow treatment capacity required to maintain acceptable water quality standards.

Some caveats relating to the use of dry weather flow limits should be taken into account:

- The current definition of dry weather flow (based on seven prior dry days) is difficult to accurately measure and enforce. It is due to replaced with a percentile-based definition.
- Dry weather flow limits include trade effluent, which needs to be discounted from the figures. Allowance for infiltration should also be made.
- When a sewage treatment works' hydraulic capacity is exceeded, excess sewage is discharged from storm tanks and combined sewer overflows. Our knowledge of these intermittent discharges is limited, but the volume of household wastewater does not always have a significant impact on their severity.

Many sewage treatment works do not have dry weather flow consent levels set. In London, only the largest sewage treatment works are consented for dry weather flow.

6.4.4 Balancing supply and demand

The difference between volume and hydraulic capacity, and load and treatment capacity at each sewage treatment works gives the deficit or surplus of capacity. If a sewage treatment works has a deficit in hydraulic or treatment capacity, capital costs will be triggered to meet this deficit. If a sewage treatment works has a deficit of both hydraulic and treatment capacity, both types of cost will be triggered in the methodology.

6.4.5 Costs

The availability of information will have a major impact on how cost information is gathered for sewerage infrastructure. Ofwat can provide cost curves, based on water company plans, for increasing treatment capacity. These cost curves provide unit costs for increases in population equivalent capacity, where consent levels do not change. There are also cost curves which provide unit costs for increasing the standard of treatment. These express unit costs for each extra litre of load removed by a sewage treatment works.

Unit costs for increasing treatment capacity depend on the size of the sewage treatment works, and the consent level it operates to. In general terms, larger works have lower units cost for increasing capacity, while works with tighter consents have higher unit costs.

Deriving costs for hydraulic capacity is more complicated, partly because the cost per unit of extra capacity is unpredictable. Broad unit costs can be estimated from Final Business Plans or June Return data, but these results must be treated with caution.

Where possible, data obtained from water companies can also be used to supplement and refine these sources of cost information.

Operational costs, and the costs of maintaining base levels of service, can be derived from June Return data from water companies.

6.5 Information sources

Access to the information held by water companies would allow us to operate the methodology in more detail. Therefore, engaging with Ofwat and the relevant water companies to obtain this information should be a priority for future studies.

The Environment Agency regulates flows and discharges from sewage treatment works and it places limits on the amount of discharges consented for each sewage treatment works. For some works, these consent levels include a dry weather flow level, which relates to acceptable discharges under dry weather conditions. Ofwat can also provide information on unit costs.

Publicly available information from water companies, including Final Business Plans and June Returns, can also be used to inform the methodology.

Water Framework Directive information

By 2015, investigations resulting from the first cycle of the Water Framework Directive should be completed, subject to work gaining approval and proceeding as currently planned. These investigations will greatly increase our understanding of the different measures that improve water quality. Once this information is available, it should be possible to conduct more detailed assessments of the link between environmental infrastructure and water quality.

6.6 Data requirements

The key sources of information for water quality are listed below. On the capacity and cost side, the information source may vary depending on availability.

Table 6.1 Data required for water quality

Data	Units	Type	Geographic level	Source
Total water demand	Megalitre/day	Calculated	Water Resource Zone (WRZ)	Water Resources Component
Percentage of water delivered to wastewater	%	Fixed input	Water company	Derived from Final Business Plans
Population	People	Calculated	Local authority	Calculated
Treatment capacity	Population equivalent	Fixed input	Sewage treatment works	Environment Agency
Hydraulic capacity (dry weather flow)	Megalitre/ day	Fixed input	Sewage treatment works	Environment Agency permit data
Operational and maintenance cost of sewers and other non-treatment infrastructure	£/home	Fixed input	Drainage area/sewage treatment catchment	Final Business Plans/June Returns
Cost of increasing hydraulic capacity	£/megalitre/ day	Fixed input	Water company level	Estimated from publicly available Final Business Plan and June Returns
Cost of increasing treatment capacity	£/population equivalent	Fixed input	Water company level	Ofwat cost curves
Average annual operational cost per unit	£/megalitre/ day	Fixed input	Water company level	June Returns
Annual base service cost per home	£/home	Fixed input	Water company level	June Returns

6.7 Considerations

In reality, surface water drainage imposes an environmental infrastructure cost, and has a significant impact on water quality. Given the complexity of surface water drainage, assumptions are required to include surface water in the methodology. As the methodology also assumes that new developments will create no additional surface water flows (due to SuDS mitigation), the implications of not including surface water are somewhat less severe.

This approach also relies on obtaining cost information from water and sewerage companies, or making estimates and extrapolations. This is a limitation of the methodology, but it cannot be avoided without better information sources.

6.7.1 Taking climate change into account

The latest water company Business Plans are in draft form, and take into account UKCIP02, the last set of climate change projections. These projections have now been superseded by a further round of UK Climate Change Projections (UKCP09). However, final versions of the Business Plans should take into account UKCP09. Where final versions are not available, the information from Business Plans should be adjusted using the results of the ongoing project to translate existing work for UKCP09.

Applying the methodology in Wales

This methodology should be easily applicable within Wales. The Environment Agency regulates sewerage infrastructure in the same way as in England, while water companies in Wales fall under the same regulatory requirements as those in England.

6.8 Assumptions

- The methodology looks at the capacity of sewage treatment infrastructure to support the additional load and volume from new housing. No direct link is made to water quality.
- Sewage treatment infrastructure is measured in terms of hydraulic, treatment and environmental capacity.
- Hydraulic capacity is determined by the dry weather flow capacity of a sewage treatment works. If this is exceeded by household wastewater it is assumed that the sewage treatment works does not have sufficient hydraulic capacity to keep discharges to an acceptable minimum during periods of rainfall.
- Treatment capacity is defined in terms of population equivalent estimates. The relationship between population and load is defined by a fixed, constant amount of load per person.
- Non-treatment sewerage infrastructure has a constant cost per home, reported in June Return table E.
- The method does not cover surface water. SuDS are assumed to mitigate all additional effects of surface water from new development.

7 Waste

7.1 Background

The waste section of the methodology deals with collecting and managing household waste. There are a number of options for managing waste, from landfill to recycling, composting and energy from waste technologies. Different combinations of options can lead to different costs per household.

Waste services are provided by local authorities, although often services are contracted out to private sector companies. Waste authorities are split into waste collection authorities (often district councils) and waste disposal authorities (often county councils), but there are also unitary authorities which perform both functions. In some cases, local authorities group together to form larger waste authorities. In London, for example, there are several waste disposal authorities which cover numerous local authorities, while local authorities in Greater Manchester are combined into a single waste disposal authority

7.2 Existing work

The methodology applied in the North West study[11] used a generic waste scenario to model a detailed picture of waste processes and infrastructure. Multiple inputs were used to derive costs. Although the North West study provided a useful framework for considering capacity and cost, it allowed little room for changes in waste processes over time.

This methodology improves on the North West study by allowing for significant changes in the method used to manage waste over time. The user can alter the proportion of waste managed through different means, making it possible to test the costs of different waste management scenarios. This allows the methodology to adapt to changes in waste management processes. It also allows a range of conclusions to be drawn by testing different waste scenarios.

7.3 Scope

All types of household waste are included in the scope of this methodology. This includes waste collected from households.

The methodology does not consider non-household waste. This includes commercial and industrial waste and construction and demolition waste (including waste from construction of new houses). Both of these contribute significantly to the volume of waste generated, but they lie outside the scope of this methodology, because it is based on households. That said, these waste streams are taken into account when considering current capacity of waste infrastructure.

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[11] Environment Agency 2009. See http://publications.environment-agency.gov.uk/pdf/SCHO0709BQRR-e-e.pdf

7.4 Outline methodology

Unlike other areas, waste operations are not limited by geography. For example, it is possible to transport waste from any one local authority area to any other. As a result, we developed two approaches to be used alongside one another.

The ***Internal Capacity Approach*** considers the available capacity of waste infrastructure within a given area, and assesses the costs of increasing this capacity to deal with increases in demand. This approach is designed to look at waste self-sufficiency scenarios.

The ***Market Approach*** makes no assumption on where waste is managed, and instead focuses on the costs to individual waste authorities for managing waste through different means. This branch is based on per tonne costs for managing waste through various means, and corresponds more closely to a model where most waste management is contracted out to the private sector.

Why do we need these two approaches?

It is useful to compare and contrast the results generated using two different assumptions:

- The market for waste disposal has no geographic limits. This means that waste produced in one area can be transported to another for disposal. We call our approach using this assumption the ***Market Approach***.
- Local authorities will need to manage more of their waste within their own boundaries. The ***Internal Capacity Approach*** allows us to consider the associated capacity and cost requirements.

Both approaches are useful in discussing how future infrastructure might be provided.

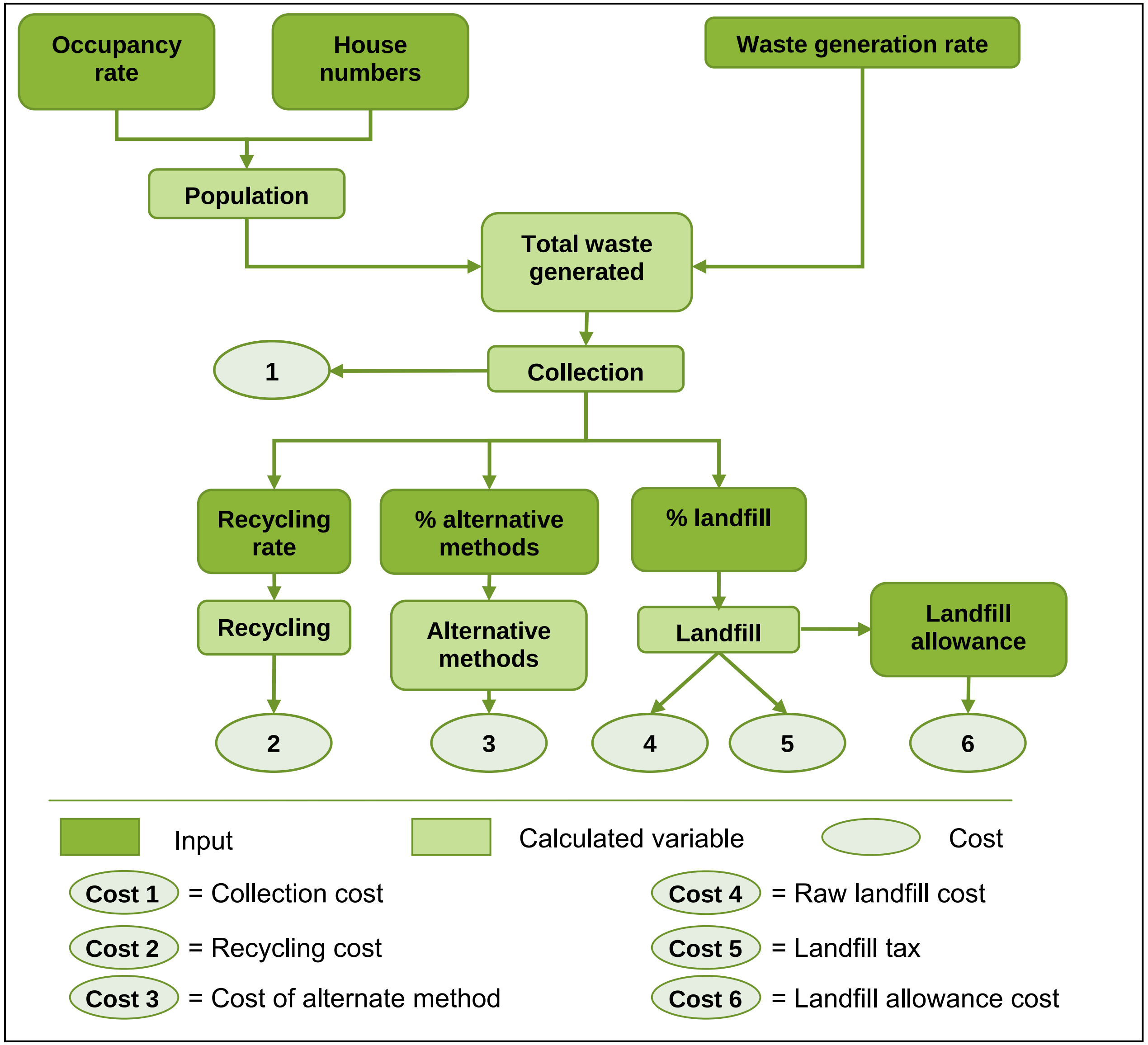

Figure 7.1 Waste overview: Market Approach

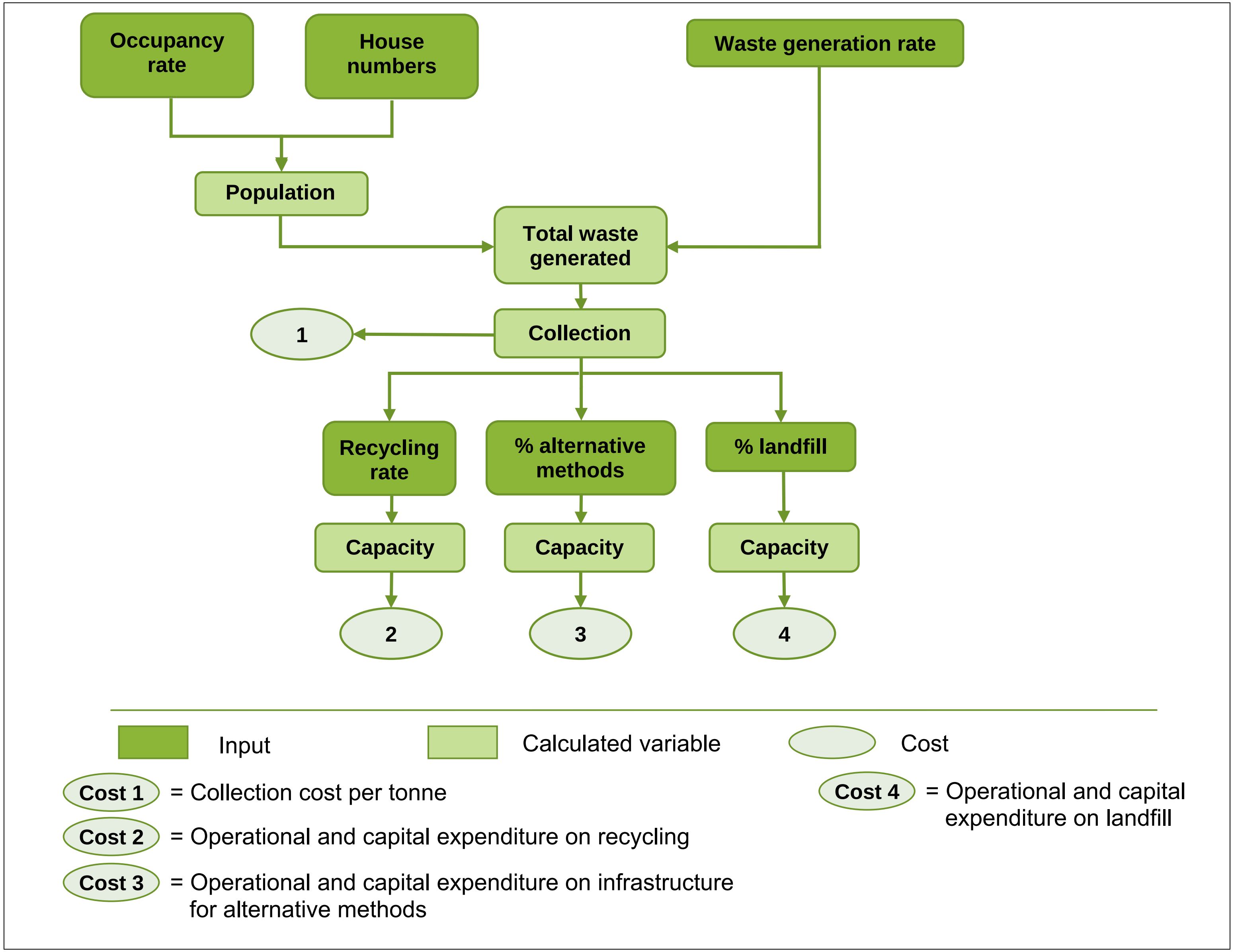

Figure 7.2 Waste overview: Internal Capacity Approach

7.4.1 Geographic level

Internal Capacity Approach

The Internal Capacity Approach looks at the capacity of waste infrastructure in a given spatial area. The size of these areas is determined by the user according to the waste scenario being tested. The user could model a requirement that all waste should be dealt with within certain geographic limits. For instance, Greater London and the Leeds and Manchester City Regions would be appropriate geographic levels for this approach, because it would be interesting to model an option where all waste generated in these areas was dealt with within them. These strategic areas are made up of a number of waste authorities grouped together. Therefore, information entered for waste authorities can easily be aggregated up to this geographic level.

Market Approach

Waste collection authorities and waste disposal authorities are the key geographic level for the Market Approach. In this approach, waste authorities deal with all aspects of waste management, and pay a cost per tonne to collect and manage waste. Waste authority boundaries follow local authority boundaries (although they sometimes comprise more than one local authority), and therefore local authorities can be easily assigned to the relevant waste authority.

7.4.2 Demand and user defined inputs

Both approaches use the same demand calculations and user-defined variables. This means that the total amount of waste generated, and proportions of waste managed through different means, are the same for both approaches.

The main variables which affect the demand for different means of waste management are:

Population (derived from housing growth)	**Rate of waste generation**	**Recycling rate**	**Proportion of waste going to landfill**	**Proportion of waste managed by composting and energy from waste**

The total amount of waste produced is derived from the household population and rate of waste generated. The number of new houses will affect population, which is calculated from housing numbers using occupancy rates. The rate of waste generation is entered into the methodology by the user. This allows the method to test how different rates of waste generation affect the overall cost of waste management. This means the methodology should be useful in evaluating the effectiveness of schemes to reduce rates of waste generation.

The user can then define the proportion of total waste generated that is managed through different means, including landfill, recycling and alternative means. Each type of alternative means is given a separate proportion within the methodology. From these user-defined inputs, the methodology gives a tonnage of waste that is managed through each means.

7.4.3 Capacity of waste infrastructure

Internal Capacity Approach

The Internal Capacity Approach considers the total capacity of waste infrastructure within a given area. Capacity is broken down into different means of waste management. A total capacity for landfill, for recycling, for composting and for energy from waste is established. These capacities are expressed in available tonnage.

The capacity of waste disposal infrastructure is established from Environment Agency information on permitted capacity. For landfill, the capacity is expressed in void space. For recycling and alternative methods, capacity is expressed in tonnes per year.

The capacity of each type of disposal infrastructure is then compared with the total amount of waste which is managed through each means. Where the amount of waste generated exceeds the capacity, the deficit is calculated, along with the years in which this deficit occurs. For landfill, a deficit occurs when the cumulative amount of waste generated exceeds the total capacity.

7.4.4 Costs

Collection costs – both approaches

For both approaches, the methodology calculates collection costs according to the tonnes of waste collected. The method makes no assumptions about how waste is collected within each waste collection authority. There are a number of possible variations in the process (such as kerbside recycling, transfer after collection), but no attempt is made to differentiate between these.

The costs of collection (calculated as a unit cost per tonne collected) are taken from waste authority information provided to Defra, which is collated within WasteDataFlow[12]. The costs of collection should, where possible, take account of collection directly from households and from civic amenity sites. However, where no information on the costs of operating civic amenity sites is available, total collection costs must be used.

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[12] WasteDataFlow is the web-based system for municipal waste information reporting by local authorities in England and Wales to government. http://www.wasteinformationflow.org/

Costs – Internal Capacity Approach

Where there is a deficit of capacity for any of the means of managing waste, there will be a cost for alleviating this deficit. This requires a cost per tonne of capacity to be estimated for each means. There are a range of sources for the costs of waste infrastructure, but no single definitive source. The Waste and Resources Action Programme (WRAP) holds cost information for different types of facility, and some information is held by the Environment Agency and Defra. The operational and maintenance costs per tonne of each means of waste management should also be estimated from these sources where possible.

Costs – Market Approach

Under the Market Approach, waste disposal authorities face a cost per tonne for managing waste through different means. The Gate Fee Survey[13] conducted by WRAP provides useful information on market costs, although market costs could change significantly in the future.

Under the Market Approach, there are no explicit constraints on the amount of waste any waste disposal authority can send to landfill. However, environmental limits on the amount of waste that can be sent to landfill are modelled through cost mechanisms. Over time, as the amount of land available for landfill declines, the cost per tonne of waste sent to landfill will increase, acting as a limiting factor on landfilling.

The cost of landfilling is also affected by landfill taxes and the landfill allowance trading scheme. Landfill tax is currently on an escalator[14], and will reach very high levels in the future. This should limit the amount of waste which waste disposal authorities can feasibly send to landfill. Equally, the landfill allowance trading scheme will cause waste disposal authorities which exceed their allowances to incur large costs (or large fines for non-compliance). Rates of landfill tax and landfill allowances will be set in accordance with currently planned schedules.

7.5 Information sources

WasteDataFlow is produced by Defra and provides a wealth of information on volumes of waste handled by waste authorities. However, WasteDataFlow provides only two total cost figures, for collection and for disposal. This methodology requires a breakdown of the relative costs of different waste management methods to draw out incisive conclusions, but such cost information is limited.

The Waste and Resources Action Programme (WRAP) conducts an annual survey of gate fees for different types of waste management, which can provide high-level average cost figures.

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[13] Gate fees are the charges applied to waste entering disposal facilities. A study outlining the relative cost of different waste treatment options and how they are expected to change in the future has been published by the Waste and Resources Action Programme (WRAP). For more information, see:http://www.wrap.org.uk/recycling_industry/publications/gate_fees_report_09.html

[14] A tax escalator is a mechanism which increases the rate of taxation on something by increments over a period of time. Tax escalators are usually applied to goods considered by the taxing body to have a negative impact on society or the environment.

The Environment Agency holds information on the permitted capacity of all waste management facilities. These permits effectively determine the capacity of each waste management facility, making them a good source of capacity information.

The Chartered Institute of Public Finance and Accountancy (CIPFA) collect information on local authority spending on waste which can help with costings for both the market and internal capacity approach. Their annual waste statistics are available by subscription.

7.6 Data requirements

The table below lists the information inputs needed for this section of the methodology.

Table 7.1 Data required for waste

Data	Units	Type	Geographic level	Source
Collection costs from households	£ per tonne	Fixed input	Waste collection authority	WasteDataFlow
Market cost of recycling	£ per tonne	Fixed input	Waste disposal authority	WRAP
Gate fee for landfill	£ per tonne	Fixed input	Waste disposal authority	WRAP
Landfill tax	£ per tonne	Fixed input	National	Defra
Market cost of composting	£ per tonne	Fixed input	Waste disposal authority	WRAP
Market cost of energy from waste	£ per tonne	Fixed input	Waste disposal authority	WRAP
Total capacity for each means of waste management (recycling, landfill, composting, energy from waste)	Tonnes	Fixed input	Fixed internal waste disposal area	Environment Agency permit information
Cost of providing extra capacity for each means of waste management	£ per extra tonne	Fixed input	Fixed internal waste disposal area	Estimated from waste authority contacts
Operational and maintenance costs for each means of managing waste	£ per tonne	Fixed input	Fixed internal waste disposal area	Estimated from waste authority contacts

Table 7.2 Input variables for waste

Variable	Units	Geographic level
Waste generation rate	Tonne/person	Waste collection authority
Recycling rate	%	Waste collection/unitary authority
Proportion of waste to landfill	%	Waste disposal authority
Proportion of waste composted	%	Waste collection/unitary authority
Proportion of waste to energy from waste	%	Waste disposal authority
Cost of management by alternative means (separate information for each means)	£ per tonne	Waste disposal authority
Total capacity for each means of waste management	Tonnes	Fixed internal waste disposal area

7.7 Considerations

The waste methodology does not consider in detail how costs may change over time (with the exception of landfill taxes). The costs of collection, and of the various means of managing waste, are fixed at current levels into the future, because there is no information on how costs are expected to vary in the future. It would be possible to extend the methodology to consider such changes in cost. However, at present there is not enough evidence to make this worthwhile.

The methodology for waste allows the user to generate different waste scenarios. The dual approach method also affords the user a choice in deciding how to frame the policy agenda around waste. This allows the user to test different scenarios relating to different methods of managing waste in the future. Given that there is no coordinated process for planning waste management into the future, these user-defined inputs allow the user the flexibility to explore different strategies.

7.7.1 Taking climate change into account

Climate change should not have a significant impact on the capacity of waste management infrastructure required. However, the need to manage waste more sustainably will have a bearing on the way that waste is managed in the future, both in terms of the types of waste generated and the facilities provided. This has implications for many waste management techniques, especially landfill and conventional incineration.

Applying the methodology in Wales

This methodology should be easily applicable within Wales. WasteDataFlow provides similar information for Wales as for England, while the Environment Agency regulates waste permits in the same way as for England. The public sector is much more involved in the waste process in Wales, meaning that the Internal Capacity Approach may be more appropriate.

7.8 Assumptions

General assumptions

- The methodology only deals with the additional household waste generated by new houses.
- Transport, transfer and separation costs are included within collection costs. No attempt is made to model these.
- Collection costs are proportional to the amount of waste collected, not the number of households.

Internal Capacity Approach assumptions

- All waste produced within a given strategic area must be dealt with within that area. A linear progression towards this goal can be modelled over the given timeframe.

Market Approach assumptions

- The costs of waste collection and management are the same anywhere within the same waste authority.
- Current government policies (such as landfill tax) will continue into the future.
- Current trend costs for collection and different means of waste management remain constant over time.

8 Flood and coastal risk management

8.1 Background

This section of the methodology aims to determine the investment in structural flood defences needed to protect new houses. The main factors shaping these costs are the location of new houses in relation to flood risk areas, and the costs of the required defences.

Flood and coastal risk management can be split into three separate areas:

Fluvial flooding	**Coastal flooding**	**Surface water flooding**

Although there are relationships between these three types of flooding, their causes are sufficiently different to treat surface water flooding separately within this methodology.

There are many ways of managing flood risks. These include:

- avoiding development in areas at risk of flooding;
- building structural flood defences to reduce the risk of flooding;
- adopting resistance and resilience measures to reduce the impact of flooding.

Since this methodology deals with the costs of infrastructure, it does not consider the costs of flood damage. For our purposes, demand for flood infrastructure is determined by the amount of investment required to protect new housing to a minimum given standard in any given year.

Minimum standards of protection are guided by flood risk vulnerability and flood zone compatibility classifications in PPS25, to ensure less than a one in 100 chance of flooding in a given location in any given year (one in 200 for coastal flooding). This is in line with moderate probability of flooding.

This methodology only considers the costs of structural flood defences required to protect all new houses. The reasons for only looking at structural defences are set out in the box below.

What types of defences are included in the methodology?

This methodology considers structural defences against flooding. This includes hard and soft flood defences, but excludes resistance and resilience measures designed to reduce the impact of flooding. Structural defences might include:

- banks, walls and purpose-built concrete defences;
- inland flood storage areas;
- wetlands.

The following examples of resistance/resilience measures are not included in the method:

- flood warning systems;
- sandbags, air brick covers and other measures to stop water entering homes;
- designs to minimise impacts of flood damage, such as raised plug sockets.

Surface water is considered separately from fluvial and coastal flooding within the methodology. The introduction of Sustainable Drainage Systems (SuDS)[15] is assumed to mitigate all additional effects of surface water on flooding for new developments.

8.2 Existing work

The flooding and coastal risk management method used in the North West study examined damages due to residual risk. These costs were therefore not comparable to other environmental infrastructure costs in the study.

This methodology incorporates existing defences to a larger degree than the previous study. It uses the National Flood Risk Assessment (NaFRA)[16], incorporating defences, rather than the flood zones. This allows the methodology to take account of existing flood defences. Also, to enable the methodology to be consistently applied across different areas, and to enable comparison within areas, cost estimates have been altered depending on the prevailing local flood defences.

8.3 What is within the scope of flood and coastal risk management?

For the purpose of this methodology, flood and coastal risk management covers protecting all new homes to a minimum standard of less than a one in 100 chance of flooding at that location in any given year of fluvial flooding. Once this one per cent minimum standard is met, the methodology does not take account of the costs which arise from flooding itself.

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[15] SuDS is an approach to drainage which seeks to decrease the amount of surface run-off, decrease the velocity of surface run-off, or divert it for other useful purposes, thereby reducing the contribution it makes to sewer discharge and flooding. For more information see http://www.environment-agency.gov.uk/business/sectors/36998.aspx

[16] The National Flood Risk Assessment (NaFRA) covering the whole of England and Wales is undertaken using a method called Risk Assessment for Strategic Planning (RASP). RASP is flood risk assessment method that uses a risk-based approach to factor in the location, type, condition and effects of flood defences. For more information see http://www.environment-agency.gov.uk/research/library/publications/108660.aspx

The standard for coastal flooding is set at a one in 200 chance of flooding at that location in any given year (0.5 per cent). The costs of coastal erosion are not taken into account in the method due to a lack of information, and the complexities involved in geographic modelling.

One important difference between the methodology for flood and coastal risk management and that for the other four areas is that it only considers the costs of protecting new homes. Minimum standards for flood risk protection are only applied to new homes, in line with PPS25 and TAN 15. Although the methodology will still highlight the costs of maintaining existing flood defences, these costs will be constant, and unaffected by changes in any of the variables in the methodology.

Assumptions on SuDS and the Code for Sustainable Homes

Limited information is available on the take-up of SuDS and associated costs. For SuDS to be included in this work, it is necessary to assume that all new homes are built to Code for Sustainable Homes standards which include SuDS as a mandatory requirement. SuDS are assumed to mitigate all additional surface water impacts of the new development, so that the land has the same impact on surface water drainage as it did prior to development. Costs for SuDS provision have also been taken from the associated impact assessment.

To date, however, the Code for Sustainable Homes is only mandatory for new social housing in England.
http://wwwmmuni.coties.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/

In Wales, the Code for Sustainable Homes is mandatory for developments of five houses or more (Level 3 and six points for energy). From September 2010, the code will be mandatory for all new housing developments.
http://wales.gov.uk/topics/planning/policy/mipps/mipps012009/?lang=en

8.4 Outline methodology

8.4.1 Geographic level

Local authorities are the core geographic level for flood and coastal risk management. Local authorities each have a Local Development Framework[17], which sets out where new housing development will take place within the area.

Depending on information availability, the asset systems defined in System Asset Management Plans[18] is also an important geographic level within the methodology. Local authorities can be assigned between asset systems using estimated percentages. It is essential that, where System Asset Management Plans contain housing figures, these figures are exactly the same as the figures assigned to each asset system in the methodology.

[17] A Local Development Framework is the spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004 and given detail in Planning Policy Statement 12. For more information see http://www.planningportal.gov.uk/uploads/ldf/ldfguide.html

[18] System Asset Management Plans are described at http://www.environment-agency.gov.uk/jobs/64171.aspx

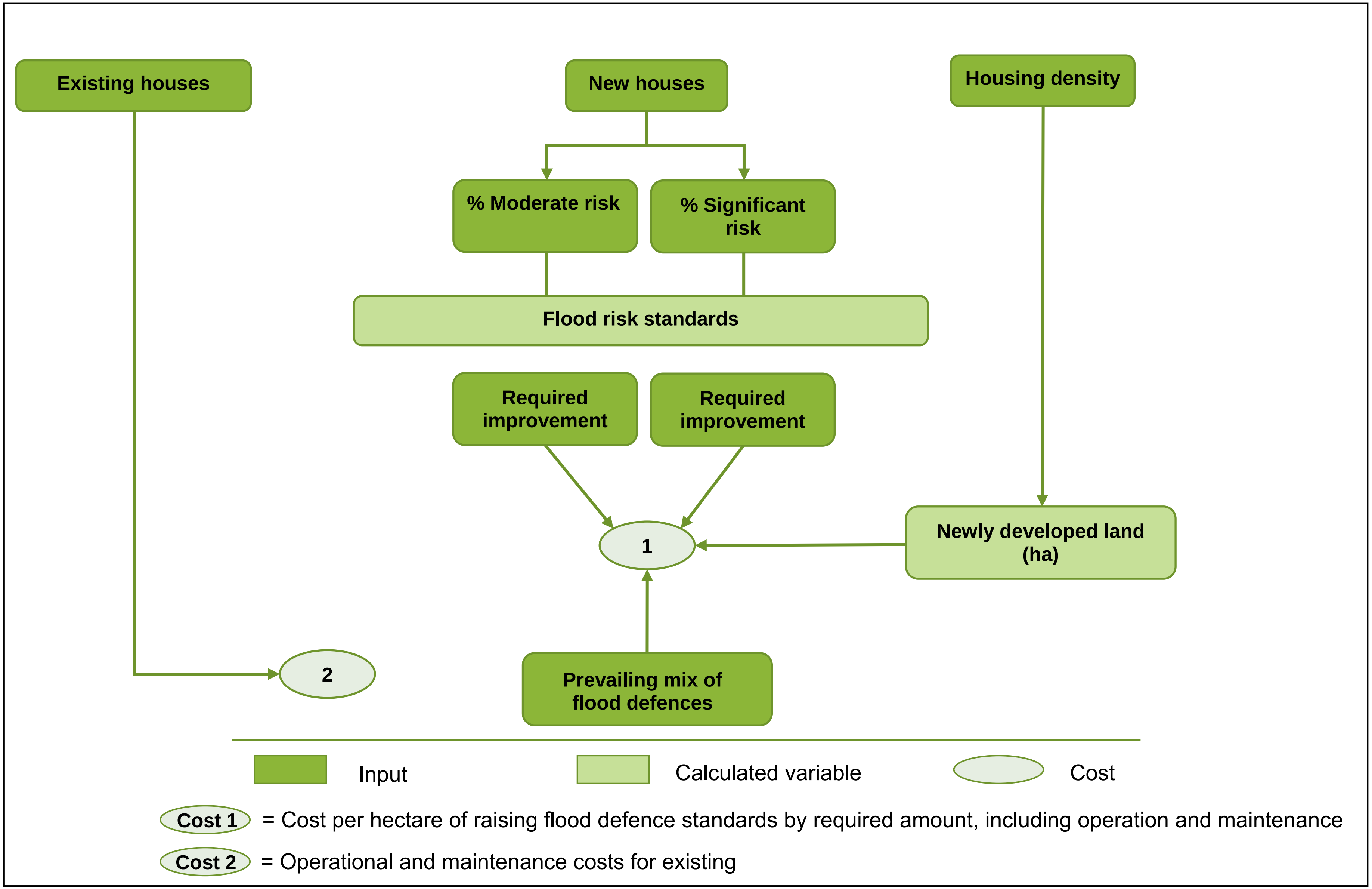

Figure 8.1 Flood and coastal risk management overview

8.4.2 Assessing flood risk

The methodology assesses flood risk using information from NaFRA. NaFRA provides an assessment of the level of flood risk from rivers and the sea. It divides areas into three flood risk categories: low, moderate and significant. NaFRA does not cover land which has been designated Flood Zone 1 by the Environment Agency. Crucially, NaFRA takes into account the effects of existing flood defences, and so can provide a gap analysis of existing flood defences.

The location of new housing can be determined relative to the location of existing houses, or by using Local Development Frameworks. By combining these estimates with the flood risk categories produced in NaFRA, we can establish the percentage of new homes that will be built in the significant and moderate risk categories. Multiplying this by the number of homes built within a local authority gives the total number of homes falling within each NaFRA category.

The total area of new development that needs to be protected against flooding in each local authority area is obtained by multiplying the number of houses within each NaFRA risk category by housing density. Housing density can be based on existing densities or drawn from Local Development Frameworks.

Why use NaFRA rather than other flood risk assessments?

There are a number of sources of information on flood risks besides NaFRA. Strategic Flood Risk Assessments (Strategic Flood Consequence Assessments in Wales) are produced by local authorities, and highlight areas which are most at risk of flooding. Catchment Flood Management Plans are produced by the Environment Agency to assess flood risks and to outline options for mitigating risks. Flood zone maps also provide information on levels of susceptibility to flooding.

For the purposes of this methodology, NaFRA has two main advantages over other sources of information. First, it takes into account existing flood defences, allowing us to look at the *additional* flood defences needed for new development. Second, it provides information on a specific level (based on 50 square metre cells), which allows us to be more specific about the distribution of houses within each local authority.

8.4.3 Assessing required improvements in flood defences

In order for the methodology to assign costs, it is important to know the extent of extra flood defences needed to exceed the minimum standard of a one in 100 chance of flooding in that location in any given year. This is not easy to do at a strategic level without assessing each individual area. Therefore, the methodology assumes that, within each of the flood risk categories, the level of flood defence required to meet the minimum standard is the same. The required level is worked out by taking an average level of flood risk for each risk category within NaFRA. The difference between this level and the one per cent annual probability of flooding standard is the level of improvement required for each risk category.

Flood risk levels are usually measured in terms of the annual probability of flooding. The more likely flooding is to occur, the greater the annual probability of occurrence. A proposed development with a *significant* flood risk, defined by NaFRA as having an annual probability of flooding of greater than one in 75, will require more costly flood defences than development with a *moderate* level of flood risk, defined by NaFRA as having an annual probability of one in 75 or less. As shown in the table below, each potential development area can be assigned to a category of flood risk improvement required to meet the national standard annual probability.

The increase in flood risk can be measured by comparing the current level of risk with the national standard for fluvial flooding. The required improvement in flood defences can be defined in terms of the difference in annual probability compared with a one per cent annual probability of flooding.

Table 8.1 NaFRA flood risk categories

NaFRA flood risk category	NaFRA flood risk category annual probability	Category of flood risk improvement to national standard annual probability
Low	0.5% (1 in 200) chance of flooding each year or less	A
Moderate	1.3% (1 in 75) chance or less but greater than 0.5% (1 in 200) chance in any year	B
Significant	Greater than 1.3% (1 in 75) chance in any year	C

8.4.4 Calculating the costs of flood defences

Information on the costs of structural flood defences is limited. Due to the bespoke nature of flood defences, it is not possible for this methodology to establish an exact cost for each flood defence required. Assumptions and estimates are therefore required to obtain cost figures.

The cost of flood defences in the methodology depends on three main factors:

The required improvement in defences in each flood zone (category A, B or C)	The amount of newly developed land within each flood zone	The prevailing mix of flood defences within each local authority or System Asset Management Plan

Using replacement cost information from System Asset Management Plans (if available) or the National Flood and Coastal Defence Database[19], it should be possible to estimate the cost per hectare of improving flood defences in each of the improvement categories. These costs should vary for each local authority or asset system, due to different mixes of prevailing flood defences in each. Where it is not possible to estimate costs for a particular local authority or asset system, average figures from a national or sub-national level should be used. Guidance on the prevailing mix of flood defences in each catchment can be obtained from the Catchment Flood Management Plans, although these will only provide limited detail.

It is also possible to derive cost estimates from existing Environment Agency models. The Long Term Investment Strategy features a costing tool, which can provide an interpretation of costs.

8.5 Information sources

8.5.1 National Flood Risk Assessment (NaFRA)

The most important source of information on flood risks is NaFRA[20]. NaFRA provides information on flood risks for all areas within Flood Zones 2 and 3 (as defined by the Environment Agency). The model uses a 50 m2 grid, and assigns each of these grid areas a flood risk of low (0.5 per cent chance of flooding each year or less), moderate (1.3 per cent chance or less but greater than 0.5 per cent chance in any year) or significant (greater than 1.3 per cent chance in any year). Crucially, NaFRA's calculations of flood risk take account of existing flood defences, making it more appropriate for this method than the Environment Agency's other flood risk mapping tools.

8.5.2 Catchment Flood Management Plans (CFMPs)

CFMPs[21] assess flood risk and set out mitigation measures within individual catchments. As they are main planning tools for identifying and agreeing policies and interventions at catchment level, it is important that this methodology is considered alongside existing CFMPs. CFMPs themselves could also be used as a source of information on flood risk, although they only assess flood risks at a high level. It would also be difficult to apply this information to local authority boundaries.

8.5.3 Long Term Investment Strategy

The Long Term Investment Strategy (LTIS)[22] contains models which estimate the costs of providing flood risk protection for existing homes. LTIS uses a cost model which can be applied to estimate the costs of providing flood defences for new homes.

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[19] The Environment Agency-owned National Flood and Coastal Defence Database is a centralised database that contains all data on flood and coastal defence assets in England and Wales. For more information on the NFCDD, see http://www.scisys.co.uk/casestudies/government/environment/nfcdd.aspx

[20] For more information on NaFRA, see: http://www.environment-agency.gov.uk/research/library/publications/108660.aspx

[21] For more information on CFMPs, see http://www.environment-agency.gov.uk/research/planning/33586.aspx

[22] For more Information on LTIS, seehttp://www.environment-agency.gov.uk/research/library/publications/108673.aspx

8.5.4 National Flood and Coastal Defence Database (NFCDD)

The NFCDD[23] provides comprehensive information on the locations of existing flood defences. It provides estimates of replacement costs for a limited number of flood defences, but these figures should be treated with caution. In spite of uncertainties in this information, these estimated replacement costs may be used extensively to estimate costs within the methodology.

8.5.5 System Asset Management Plans (SAMPs)

SAMPs[24] are currently under development by the Environment Agency. These plans will provide an assessment of flood defences as well as maintenance costs for individual asset systems. They may also include some estimated replacement costs.

8.5.6 Unit Cost Database

The Unit Cost Database provides detailed information on the costs of different components of flood defences (such as prices per tonne of concrete). These figures may be too detailed to be useable here, but where they provide estimates for the costs of entire flood defences, may be easier to use.

8.6 Data requirements

The table below lists the information inputs needed for this section of the methodology.

Table 8.2 Data required for flood and coastal risk management

Data	Units	Type	Geographic level	Source
Percentage of houses within an area with a moderate risk of flooding	%	Fixed input	Local authority	NaFRA
Percentage of houses within an area with a significant risk of flooding	%	Fixed input	Local authority	NaFRA
Flood risk for an area with a moderate risk of flooding	Less than one in 75 chance of flooding at that location in any given year	Fixed input	Local authority/ National	NaFRA
Flood risk for an	Greater than	Fixed input	Local	NaFRA

[23] The Environment Agency-owned National Flood and Coastal Defence Database is a centralised database that contains all data on flood and coastal defence assets in England and Wales. For more information on the NFCDD, see http://www.scisys.co.uk/casestudies/government/environment/nfcdd.aspx

Data	Units	Type	Geographic level	Source
area with a significant risk of flooding	one in 75 chance of flooding at that location in any given year		authority/ National	
Standards of flood protection	One in 100 chance of flooding at that location in any given year	Fixed input	National	PPS25 (CLG)
Housing density	Houses per hectare	Fixed input	Local authority	Local Development Frameworks/Plans
Cost of improving flood defence level	£ per hectare per level	Fixed input	Local authority/ System	Estimated from NFCDD, SAMP or Unit Cost Database
Costs of maintaining existing flood defences	Total £	Fixed input	Local authority	Strategic Flood Risk Assessments/Local Authority Accounts/ Environment Agency spending information
Cost of SuDS per new house	£ per house	Fixed input	Local authority	Estimate from available cost information. Sources include Cost Review for Code for Sustainable Homes (Feb 2007)
Percentage of houses within an area with a moderate risk of flooding	%	Fixed input	Local authority	NaFRA
Percentage of houses within an area with a significant risk of flooding	%	Fixed input	Local authority	NaFRA

Table 8.3 Input variables for flood and coastal risk management

Variable	Units	Geographic level
Housing density for new houses	Houses per hectare	Local authority
Location of new houses	Proportions of houses within each NaFRA risk category	Local authority

8.7 Considerations

Consideration must be given to the location-specific nature of flood defence costs, and the strategic level used within this methodology.

In general, decisions about how much to invest in flood defences in a given location are based on appraisals of the costs and benefits. The method estimates costs but these are approximate, because they are not specific to the type of flood defence, and because the cost information they are derived from may not be fully accurate.

The methodology also takes a strategic approach to estimating the level of flood risk within a given area. Although NaFRA can provide information on flood risks, this information is used to produce strategic results within this methodology.

Also, within each risk category it is assumed that the cost to improve the annual probability of flooding to national standard levels is uniform for a given type of defence. It is acknowledged that differences in flood levels within this risk category would mean differences in costs of flood defences. This is considered sufficient, however, given the availability of information and the application of the methodology over a large scale.

The outputs from studies using this methodology should be discussed alongside locally specific planning tools on flood risk, including Strategic Flood Risk Assessments and Catchment Flood Management Plans.

Surface water flooding

At the Environment Agency, we are pioneering the use of new science to better understand surface water flooding, including maps to highlight areas that are likely to be at risk. This information has been made available to planning authorities for strategic purposes, to be used in conjunction with historical records on flooding. Existing mapping information provides an indication of areas of susceptibility but does not take into account key local features that affect surface water flooding, such as local drainage systems or buildings. As such, the modelling information does not provide the level of detail necessary to incorporate the risk of surface water flooding within this methodology at this time.

These maps are a first step to boosting our knowledge of surface water flood risk. The Flood and Water Management Bill sets out measures that should go some way to improving research into surface water flooding. The Bill is likely to call for all local flood authorities to publish a flood risk management strategy for dealing with surface water run-off, and to issue guidance on implementing this strategy. This should result in a better understanding of how we and our partners can consider surface water flooding mitigation measures.

8.7.1 Taking climate change into account

Climate change will have a major impact on flood risks and the need for mitigation measures. Increased rainfall and rising sea levels will change the distribution of flood risks across England and Wales. NaFRA does not take into account climate change projections at present. Although this is a constraint in the short term, we expect NaFRA to be updated over the medium term to take into account the latest climate change projections. Catchment Flood Management Plans are thought to be broadly in line with the latest climate change projections, and can be used alongside this methodology to discuss likely additional capacity requirements associated with climate change.

Applying the methodology in Wales

This methodology should be easily applicable within Wales. The key information sources, including NaFRA, cover Wales in the same way as England.

8.8 Assumptions

- All new houses can be protected by structural flood defences to at least a standard of at least one in 100 (fluvial)/one in 200 (coastal) chance flooding in any given year.
- A generic prevailing mix of flood defences can be established for each local authority or asset system.
- The cost of improving flood defences by a given level for a fixed area of land can be estimated along with associated operational and maintenance costs.
- The cost to improve the annual probability of flooding to national standard levels is uniform within each risk category for a given type of defence.

9 Green infrastructure

9.1 Background

There has been much innovative thinking on green infrastructure in recent years. However, while the policy agenda has developed rapidly, there is a shortage of nationally consistent data and evidence on green infrastructure to support this. This methodology seeks to build on existing work on green infrastructure, but also to cover some new ground.

What do we mean by green infrastructure?

Green infrastructure (GI) is a concept that describes a network of interconnected, multifunctional green and blue spaces that are designed and managed to meet the environmental, social and economic needs of communities.

Examples of GI include:

- Parks and gardens
- Playing fields and allotments
- Towpaths and wildlife corridors
- Beaches
- Watercourses
- Wetlands and flood storage areas
- Woodlands
- Grasslands
- Green roofs and walls.

The methodology requires the user to set a target figure for every local authority to provide and maintain green infrastructure within its boundaries. The target figure will determine the quantity and quality of green infrastructure required. It should also reflect the existing stock of undeveloped land (rather than population, as with some other targets). The use of locally specific targets should avoid the generation of unrealistic capacity deficits and cost projections associated with using a single national standard.

The relationship between housing growth and green infrastructure is complicated. On the one hand, housing development can reduce the amount of open space available for green infrastructure. Conversely, it is increasingly common for new housing to provide green infrastructure as part of the development. This methodology takes account of both these effects.

How should green infrastructure target figures be set?

The green infrastructure target figure is the key user input within this section of the methodology. Targets should be set at local authority level with the local context in mind. The main considerations will be the existing stock of green infrastructure, the amount of undeveloped land and housing density.

The Eco-Towns Planning Policy Statement could provide a useful starting point, if translated to the local context. This specifies that forty per cent of a town's total area should be allocated to green space, of which at least half should be public. See: **http://www.communities.gov.uk/publications/housing/ecotownsprospectus**

Welsh Assembly Government Planning Policy can be found in Planning Policy Wales (PPW) and its supporting Technical Advice Notes, most notably TAN 5 (nature conservation) and TAN 12 (design), relate to GI.

9.2 Existing work

The North West study did not produce a methodology for green infrastructure. The study considered adopting a biodiversity module, but failed to find a suitable method for this. The main obstacle to developing a method was the proposed use of access standards, which was not workable due to existing capacity deficits.

One of the main purposes of this methodology is to examine green infrastructure alongside other types of environmental infrastructure. This will make an important contribution to evidence-based policy in this area, providing a framework for thinking about levels of provision, capacity and costs.

9.3 What is within the scope of green infrastructure?

Green infrastructure[25] is more than just open space. The Town and Country Planning Association provide a comprehensive definition which emphasises its multi-functionality:

"The sub-regional network of protected sites, nature reserves, green spaces and greenway linkages. The linkages include corridors and floodplains, migration routes and features of the landscape, which are of importance as wildlife corridors. Green infrastructure should provide for multi-functional uses i.e. wildlife, recreational and cultural experience, as well as delivering ecological services, such as flood protection and microclimate control. It should also operate at all spatial scales from urban centres through to open countryside."[26]

[25] Environment Agency Fact Sheet. Green Infrastructure: Internal Guidance (May 2009)
[26] This definition is quoted from the Town and Country Planning Association by the Environment Agency

Much green infrastructure, especially parkland, is owned by the public sector, but a significant proportion is owned by private parties such as school grounds and green infrastructure around canals. For the purposes of this methodology, the stock of undeveloped land within a local authority is divided into three types:

Publicly owned green infrastructure	**Privately owned green infrastructure**	**Other undeveloped land**

The methodology allows provision of green infrastructure to be measured in terms of quantity (hectares) and quality (where information is available). Other work on green infrastructure has considered access to green infrastructure, rather than the amount provided. This methodology does not consider access as a measure of green infrastructure provision.

Why use quantity and quality but not access?

There are some advantages to using access, rather than total quantity, as a measure of green infrastructure provision. However, using access would create practical problems difficult to resolve within this methodology. These problems include:

- many functions of green infrastructure do not require access;
- it is not clear how housing growth would affect access to green infrastructure;
- modelling access to green infrastructure over a large area would be complicated;
- existing information on access to green infrastructure is limited.

As with other areas, the methodology is concerned solely with the costs of investing in green infrastructure, rather than the value of green infrastructure, or the cost of destroying it. Green infrastructure is something which benefits people and communities, and there is a strong case for public and private sector investment in it.

9.4 Outline methodology

The methodology for green infrastructure is designed to allow as much flexibility as possible in testing different scenarios and to allow different approaches to be taken.

The methodology is based around local authorities achieving increases in green infrastructure relative to their current level of provision. The costs of green infrastructure arise from the gap between current and target levels of provision. The costs of maintaining green infrastructure are also included. Planned housing growth will also have an impact on the provision and costs of green infrastructure.

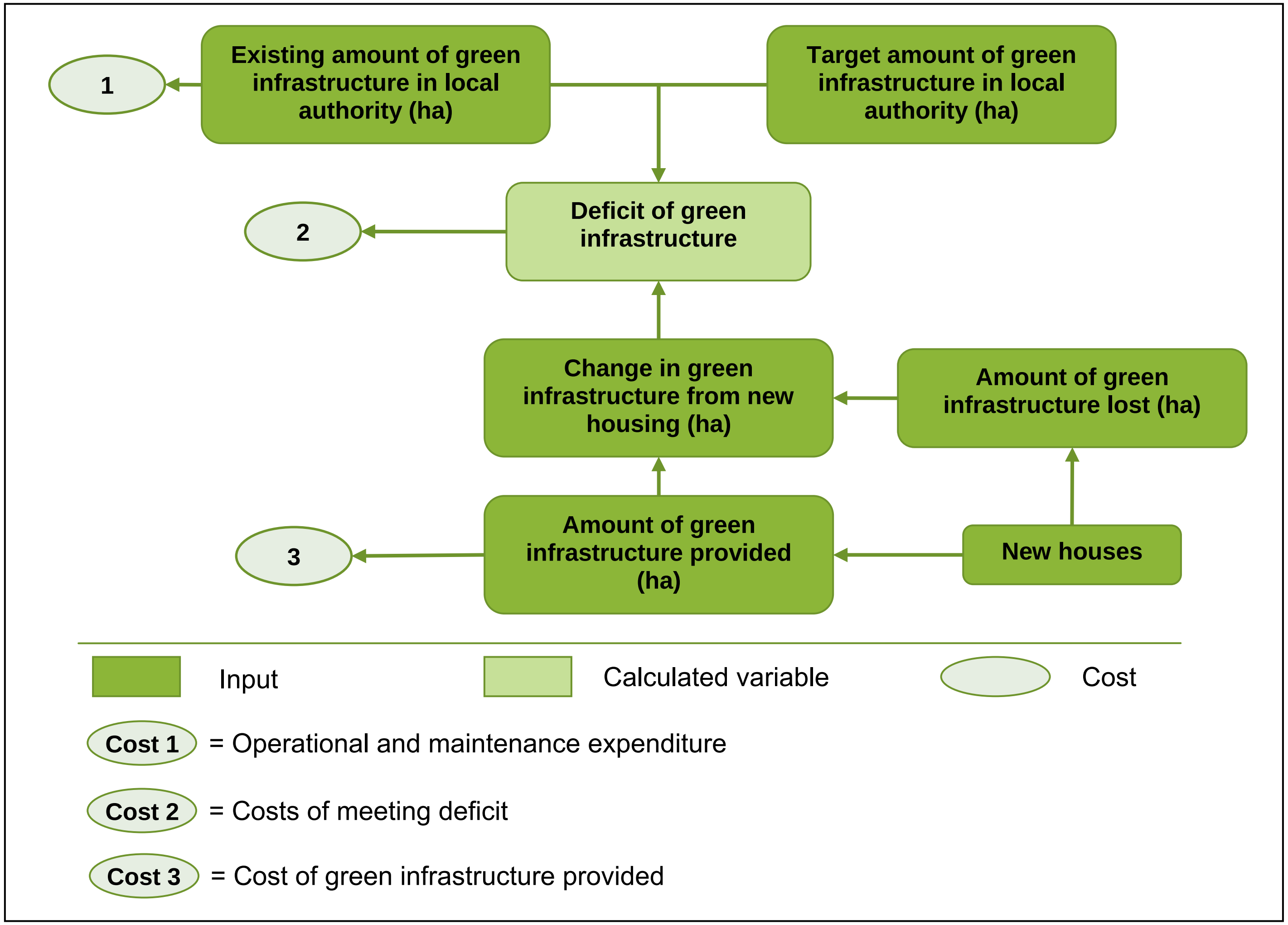

Figure 9.1 Green infrastructure overview

9.4.1 Geographic level

Green infrastructure is best considered at local authority level, because local authorities are most active in determining the stock of green infrastructure within their boundaries. Local authorities control local planning policy and are responsible for local development. In many ways, green infrastructure forms an extension of this process.

9.4.2 Existing levels of green infrastructure

The first step is to determine how much green infrastructure is currently provided within each local authority. Local Authority Open Space Strategies also has useful information on green infrastructure, but the nature of the information varies. The Generalised Land Use Database[27] has information about open space in all parts of the country. This can often be supplemented by more detailed local or strategic information. By overlaying the information on publicly owned green infrastructure from local authorities with the information in the Generalised Land Use Database, we can obtain a breakdown between publicly and privately owned green infrastructure.

Information from these sources needs to be reviewed to ensure that all land identified within it meets the definition of green infrastructure. From this information, a total amount of existing green infrastructure (expressed in hectares) should be calculated for each local authority. If there is undeveloped land which does not count as green infrastructure, this should also be included in the methodology, to assist in assessing the impact of housing development.

In some cases, information will be available on the quality of Green infrastructure provided within a local authority. This quality information may rely on different indicators. It should only be used within the methodology where similar indicators can be applied across several local authorities. The existing quality of green infrastructure could be expressed as a score, or as a percentage of land meeting a certain quality standard, or by any other appropriate means.

9.4.3 Green infrastructure target figures in the methodology

Under the methodology, each local authority should be assigned a target level of green infrastructure based on its existing stock of green infrastructure. This target figure should be defined by the user as an input for each local authority, allowing the users of the methodology the flexibility to fit it around their policy objectives. The target figure in the methodology is set this way (rather than based on population or another measure) so that the green infrastructure target figure is realistically achievable in each local authority, given its baseline situation.

Where information on quality exists, the methodology allows quality target figures to be set. The quality target figure is expressed in the same form as quality measures, either as a score or a percentage of green infrastructure meeting a certain standard.

[27] The Generalised Land Use Database can be found at http://www.communities.gov.uk/documents/planningandbuilding/xls/154329.xls

For example, the target figure for provision of new green infrastructure can be broken down into recreation space and biodiversity infrastructure. The user can input a target amount for each of these, allowing a balance to be struck between different types of green infrastructure. One advantage of this split is that it can be used to take account of the multi-functionality of green infrastructure. Land which has both recreational and biodiversity functions can be counted towards both target figures simultaneously.

9.4.4 The impact of housing growth on green infrastructure

Once green infrastructure target figures have been fixed, the impact of housing growth needs to be taken into account. As mentioned above, housing development can reduce the amount of green infrastructure by developing the land, but it can also create green infrastructure as part of the development.

The amount of land developed as a result of housing growth is calculated using housing density figures. The number of new houses multiplied by the density gives the area developed. The proportion of this newly developed land which was previously green infrastructure is assumed to be the same as the current ratio of green infrastructure to total undeveloped land. The amount of green infrastructure which is developed is subtracted from the existing amount of green infrastructure.

In terms of provision by new developments, the user can set a target amount of green infrastructure to be provided by new developments in each local authority. This target is expressed as a percentage. The amount of green infrastructure gained from housing development equals the amount of land developed multiplied by this target figure.

How will housing development affect green infrastructure provision?

The net impact of housing development on green infrastructure within a given local authority will depend on the proportion of privately owned land which is green infrastructure. It is assumed that publicly owned land cannot be built on. Some development will take place on non-green infrastructure land (such as some brownfield sites or contaminated land). However, some will take place on privately owned green infrastructure. If the proportion of privately owned land which is green infrastructure is higher than the target amount of green infrastructure to be created for new developments, housing development will have a negative net impact on green infrastructure. This is because more existing green infrastructure will be built on than will be provided by new developments.

9.4.5 The costs of green infrastructure

The methodology requires a cost per unit of area of new green infrastructure to be calculated. It also requires this cost to be broken down by primary function (such as habitat provision, recreation). While there is no definitive information on these costs, some estimates can be made from relevant sources and research. Costs per square metre can be estimated from some Local Authority Open Space Strategies and research from the Commission for Architecture and the Built Environment (CABE) also provides a good source of estimated replacement costs for large parks.

A further difficulty is estimating the costs of improving quality. If quality targets are used, the user must estimate costs with whatever sources of evidence are available.

The methodology also requires a cost per hectare for operating and maintaining green infrastructure. Some local authorities provide information on this in their Open Space Strategies. For authorities which do not supply this information, estimates can be made based on average figures from other local authorities.

9.5 Information sources

The Generalised Land Use Database gives an overview of all open space within every local authority within England and Wales. Local Authority Open Space Strategies provide some information on open space and green infrastructure, but these are not coordinated, and the type of information available varies between local authorities. In some areas, local tools can provide more detailed information on types and location of green infrastructure.

Other resources can offer helpful information on green infrastructure. These include:

- Research by CABE Space into Green Infrastructure, entitled *A CABE Space research programme scoping the state of England's urban green spaces and its impact on people's quality of life* (to be published in 2010).[28]
- Information collected by Natural England.
- Local resources, such as GIGL[29] (Greenspace Information for Greater London).

9.6 Data requirements

The table below lists the information inputs needed for this section of the methodology.

Table 9.1 Data required for green infrastructure

Data	Units	Type	Geographic level	Source
Existing amount of green infrastructure	Hectares	Fixed input	Local authority	Generalised Land Use Database (GLUD)
Existing quality of green infrastructure (optional)	Various	Fixed input	Local authority	Various
Cost of maintaining and operating green infrastructure	£ per hectare	Fixed input	Local authority	Estimate drawing on Local Authority Open Space Strategies
Cost of creating new green infrastructure	£ per hectare	Fixed input	Local authority	Estimate drawing on various sources
Cost of increasing quality of green infrastructure (optional)	£ per % improvement	Fixed input	Local authority	Estimates from various sources
Cost of providing new green infrastructure in housing developments (optional)	£ per hectare	Fixed input	Local authority	Estimates from various sources

[28] More information about CABE Space and its work can be found at http://www.cabe.org.uk/public-space
[29] GIGL is an open space and biodiversity records centre. For more information, see http://www.gigl.org.uk/

Table 9.2 Input variables for green infrastructure

Variable	Units	Geographic level
Housing density	Houses per hectare	Local authority
Target amount of green infrastructure	Hectares	Local authority
Target quality of green infrastructure (optional)	Various	Local authority
Proportion of new developments designated as green infrastructure	%	Local authority

9.7 Considerations

Cost estimates for green infrastructure derived from this method are only indicative. Given that this is a relatively undeveloped policy area, much estimation and extrapolation is required here, and will have implications for the accuracy of outputs.

9.7.1 Taking climate change into account

Green infrastructure will help communities to adapt to the effects of climate change. For example, it can provide water storage, open space for cooling, or networks for habitats and biodiversity. However, it is not possible to assess the impact of climate change itself on the capacity or cost of green infrastructure. UKCP09 projections inform our understanding of the need for green infrastructure but do not influence our assessment of overall levels of provision or cost.

Applying the methodology in Wales

There may be some differences in the way this methodology applies in Wales. One of the main sources of information, the Generalised Land Use Database, does not cover Wales. However, the Countryside Council for Wales has a "Greenspace" mapping toolkit, and provides funding for local authorities to carry out mapping. The policy context on green infrastructure is also different in Wales, where research has been conducted by the Welsh Assembly Government.

9.8 Assumptions

- Existing proportions of green infrastructure and undeveloped land can be identified and distinguished using Environment Agency tools and information from local plans.
- The proportion of privately owned green infrastructure lost to housing development can be determined by information on existing brown field land. Undeveloped land can be assumed to perform a green infrastructure function.
- Future levels of housing growth will occur at the same density as forecast in Local Development Framework, or alternatively at the same density as existing housing.
- The costs per hectare of creating and maintaining green infrastructure are constant for each local authority and based on high-level estimates.

10 Conclusions, further work and next steps

10.1 Next steps

This methodology offers a standard approach to assessing the capacity and costs of environmental infrastructure associated with housing development. The purpose of developing the method was to set out an approach which could be used across England and Wales. It can and will be used to produce consistent and comparable results for different areas. The methodology has been used as the basis for three initial studies, in London and the Leeds and Manchester City Regions.

As well as providing valuable evidence and insights into environmental infrastructure needs in these three cities, the studies should provide an opportunity to test and refine the methodology. The method will evolve over time as new data sources become available, and as lessons are learned. As the methodology is used to create studies, it is vital that it is applied consistently and accurately, and that all departures from the methodology are clearly highlighted in the studies.

10.2 How good is the data on environmental infrastructure?

The project team considered the relative quality of supply-demand information and cost data across the five areas of environmental infrastructure. The diagram below provides a summary of our views. We included surface water within the diagram given its importance to the FCRM and water quality infrastructure and because it has sources of data unlike the other areas of environmental infrastructure. This interpretation is based solely on the project team's view of data availability at present, since there are no generally recognised fixed standards to make an assessment.

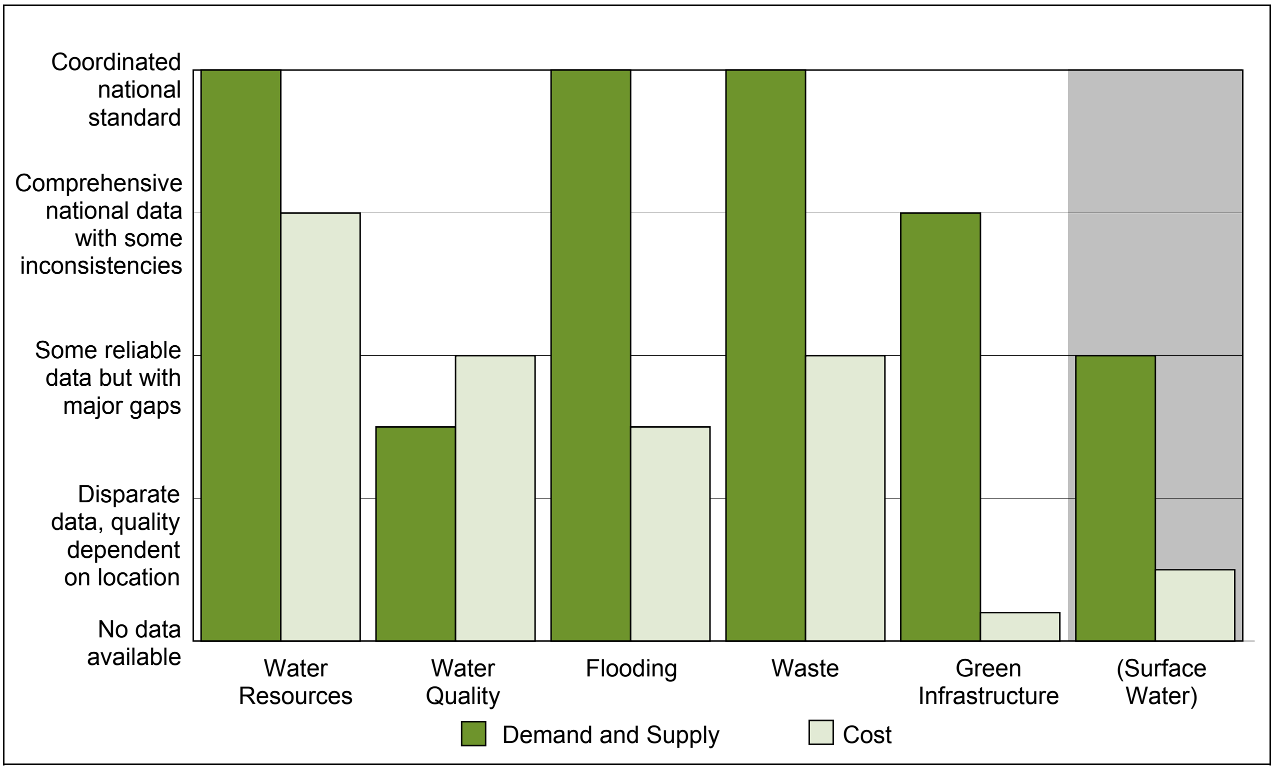

Figure 10.1 Relative data quality

Our research suggests that the quality of cost data lags behind data on demand and supply for most areas of environmental infrastructure. It is also clear that some areas of environmental infrastructure are much more advanced in their data than others. The data on green infrastructure, water quality and surface water are much less detailed than those on water resources, flooding and waste. Recommendations for future work include improving the overall data available (see Section 10.5).

10.3 How will the data landscape change?

Data on environmental infrastructure are constantly changing, and many of the future improvements in data sources will directly benefit this methodology. The Environment Agency and its partners are currently involved in projects that should improve knowledge and data on environmental infrastructure. Here we outline the likely changes to the data landscape for each area. Those updating the method will want to ensure that they have accounted for any major changes to the data landscape.

10.3.1 Water resources

Water companies produce a large amount of data as part of their water resource planning process, and there is little scope or need to improve on this data. The publicly available parts of Water Resource Management Plans and Final Business Plans provide a substantial amount of data. This information is typically at company level. Detailed information at Water Resource Zone and Supply Zone level is considered commercially sensitive and is therefore not usually publicly available. It is unlikely that this more detailed information will become publicly available in the foreseeable future. However, it may be possible to acquire more data through negotiation with Ofwat and the water companies if required. We recommend that this contact is made as a matter of priority in future studies. Note also that WRZ could change over time. This reflects a move towards an integrated grid and increased competition and innovation as highlighted by Ofwat in the Cave Report[30].

10.3.2 Water quality

Investigations in the first cycle of the Water Framework Directive could provide more detailed information on factors affecting water quality, and the relative effectiveness of different interventions to improve it. If such information is acquired, it may be possible to produce a more sophisticated method for assessing the impacts of housing growth on water quality. This data is expected to be available by 2015.

The water quality section may benefit from the development of the Environment Agency's Integrated Regulation database, which may provide more coordinated data on consent limits and discharges from sewage treatment works.

10.3.3 Waste

Although excellent data is available on the volume of waste, there is much less publicly available information on the costs of waste management. However, the data on waste have been evolving rapidly over recent years, and it is likely that more cost information will become available through coordinated national sources in coming years. Further, the Waste and Resources Action Programme (WRAP) is conducting much research, and it is likely that new streams of cost data could benefit the methodology.

Waste may also benefit from the development of the Environment Agency's Integrated Regulation database, which should provide more coordinated information on the permitted capacity of waste management facilities.

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[30] For further information on the Cave Report, visit http://www.defra.gov.uk/environment/quality/water/industry/cavereview/index.htm

10.3.4 Flood and coastal risk management

The extensive data provided by NaFRA continues to improve year by year, raising the quality of flood risk assessments. A number of promising sources of cost data continue to develop. These include the National Flood and Coastal Defences Database[31] and System Asset Management Plans[32].

The National Flood and Coastal Defences Database provides extremely detailed information on the location of flood defences, but at present contains limited cost data. However, as the database evolves, more cost data may become available.

System Asset Management Plans should provide detailed information on the costs of maintaining and replacing flood defences within given areas. Plans for high consequence asset systems (areas where flooding could have high impact) are scheduled to be in place by April 2010, with all plans to be ready by April 2011.

10.3.5 Green infrastructure

At present, sources of data on green infrastructure are limited. However, considerable work is underway to improve the data on green infrastructure and open spaces. It has recently become commonplace for local authorities to develop Open Space Strategies, and it is likely that, as this process becomes more widely used, further data will become available. Natural England is involved in mapping exercises for green infrastructure, and this work is supported by similar local studies. CABE Space has also undertaken extensive research on the availability of data on green infrastructure, which has generated some data on supply and costs.

The Department for Communities and Local Government, in conjunction with the Environment Agency, also manages the Generalised Land Use Database, which provides a large amount of the data on green infrastructure used in this methodology. This dataset is currently designated as experimental by the Office for National Statistics, but it is possible that this database might improve in years to come.

10.3.6 Surface water

The Flood and Water Management Act 2010[33] should greatly improve the quality of data on surface water. The legislation sets out measures for the development of local flood risk management strategies, encompassing flood risk from groundwater, surface water runoff and watercourses.

This should result in a coherent framework for considering surface water flooding mitigation measures. Data will also improve, although it may be several years before evidence and data on this area are suitable for use at a national level.

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31 For further information on the National Flood and Coastal Defences Database, visit http://www.environment-agency.gov.uk/cy/ymchwil/polisi/40125.aspx

32 For more information on System Asset Management Plans, visit http://www.environment-agency.gov.uk/cy/ymchwil/polisi/40125.aspx

33 For further information on the Flood and Water Management Act, see: http://www.opsi.gov.uk/acts/acts2010/pdf/ukpga_20100029_en.pdf

Defra issued guidelines in March 2009 for Surface Water Management Plans to be drawn up by local authorities. These plans should identify areas at risk of surface water flooding, and set out mitigation measures. Although we expect the information within these to be fairly high-level, they should contribute to a better understanding of surface water, which may support the development of this methodology. It is likely to be several years before Surface Water Management Plans are completed for all local authorities.

10.4 Extensions to the methodology

10.4.1 Intensity of resource use

At present, some of the variables relating to the amount of environmental infrastructure required per person are entered by the user into the method. These variables include the amount of waste produced per person, and per capita consumption of water.

This is a new and valuable feature of the methodology which gives it considerable flexibility, and should be retained in future. However, it may also be possible to provide more detailed modules for deriving consumption rates from several variables.

A number of factors affect the intensity of resource use by households. These include:

- Occupancy rates – households with fewer people tend to use more resources per *person* than those with more residents (although households with more residents will still tend to consume more per *household*).
- Size of home – Larger homes will tend to generate more pressure on environmental infrastructure than smaller homes. The number of bedrooms could act as a proxy for home size.
- Area of home – the total area of a home usually affects the intensity of resource use, in large part due to the impact of gardens.

The relationship between these factors and the intensity of resource use is complex and potentially difficult to replicate. However, developing a new module which does this could be a useful extension to the methodology.

10.4.2 Effects of non-household activities on environmental infrastructure

This methodology only considers housing development, but other types of development have an impact on environmental infrastructure. In particular, commercial and industrial activity and construction both contribute significantly to pressures on environmental infrastructure. Extending the methodology to take account of non-household activities would boost its coverage and completeness.

10.4.3 Surface water

Surface water has a major impact on flood and coastal risk management and water quality. However, it sits between the two areas (and overlaps to some extent with green infrastructure), and has different characteristics to the core strands of these areas. Data and knowledge on surface water are also limited at present, making it difficult to include in this methodology.

However, thinking on surface water is likely to improve in the coming years, as a result of the Flooding and Water Management Bill. The increasing prevalence of SuDS is also likely to have a major impact on surface water.

Developing a new module for surface water, which would sit between water quality and flood and coastal risk management, is a possible extension to this methodology. It should become clearer how to achieve this as more data become available over the coming months. Updaters of the methodology should consider the outcomes of the Flood and Water Management Bill.

10.4.4 Estimating further cost data

In the short term, application of this methodology to London will enable us to explore methods for estimating the costs of SuDS and resistance and resilience measures. Including a case study, which considers the average cost per home of SuDS and of resistance and resilience measures, would be a useful addition to the method.

10.5 Recommended areas for further work

Numerous areas for further research could be considered. The following are recommendations of the project team. They are not necessarily the agreed or approved plans of the Environment Agency.

10.5.1 A national database for green infrastructure

There have been calls for a national database on green infrastructure, which would provide coordinated and comparable information on green infrastructure and open space across different parts of the country. A national database, with a standard format for collating data from local authorities, would be of much benefit to this methodology. Data sources on green infrastructure are limited, making it difficult to develop a coordinated approach to the provision of green infrastructure at a strategicl or national level. Establishing a national database would greatly enhance our ability to work with partners in promoting green infrastructure.

10.5.2 Research into demand management measures

To manage the additional pressures on environmental infrastructure from growing communities, measures to reduce demand will be as important as providing new infrastructure. This is reflected in moves by Government at all levels to curb the amount of waste generated by households, and to reduce water consumption. This method provides a useful means of thinking about and evaluating the impact of some demand management measures. However, many options are available for controlling demand, but little certainty in how effective some of these options are. Further research on the drivers of demand for environmental infrastructure, and the effectiveness of measures to reduce demand, would help this methodology to contribute to the policy debate.

Many types of demand management measures are available to policymakers. Some rely on new technology, such as appliances which use little water, or alternative means of managing waste. Others use price incentives to reduce demand. Such measures might include installing water meters in homes with rising tariffs, landfill taxes and potential carbon taxing or pricing. Other options involve introducing mandatory standards, such as making SuDS compulsory, placing caps on the amount of waste a local authority can send to landfill, or setting compulsory standards on flood risks for new developments. For instance, research could focus on the price elasticity of demand[34] for environmental infrastructure, or on the extent to which compulsory standards are met by developers.

10.5.3 The impact of climate change

Climate change will have a major impact on the capacity of environmental infrastructure. In the future, sea level rises and climatic changes could affect patterns of flood risk, availability of water, and many other aspects of environmental infrastructure. This methodology should be extended to fully capture these impacts. However, more research is need for climate change to be better integrated into the methodology without making broad assumption-based calculations.

In summer 2009, the United Kingdom Climate Projections (UKCP09) were released. Work is ongoing to incorporate UKCP09 into existing Environment Agency projections and modelling tools. In the medium term this should mean that data sources such as NaFRA include climate change projections. In the meantime, findings from studies should be discussed alongside existing information on the impacts of climate change.

[34] The price elasticity of demand is a measure of how sensitive demand for something is to changes in price. So, if a small change in price has a large effect on demand, the item is price elastic, and can be easily manipulated by price incentives. If a large change in price has a small impact on the demand for an item, it is relatively price inelastic, and is not easily influenced by price changes.

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