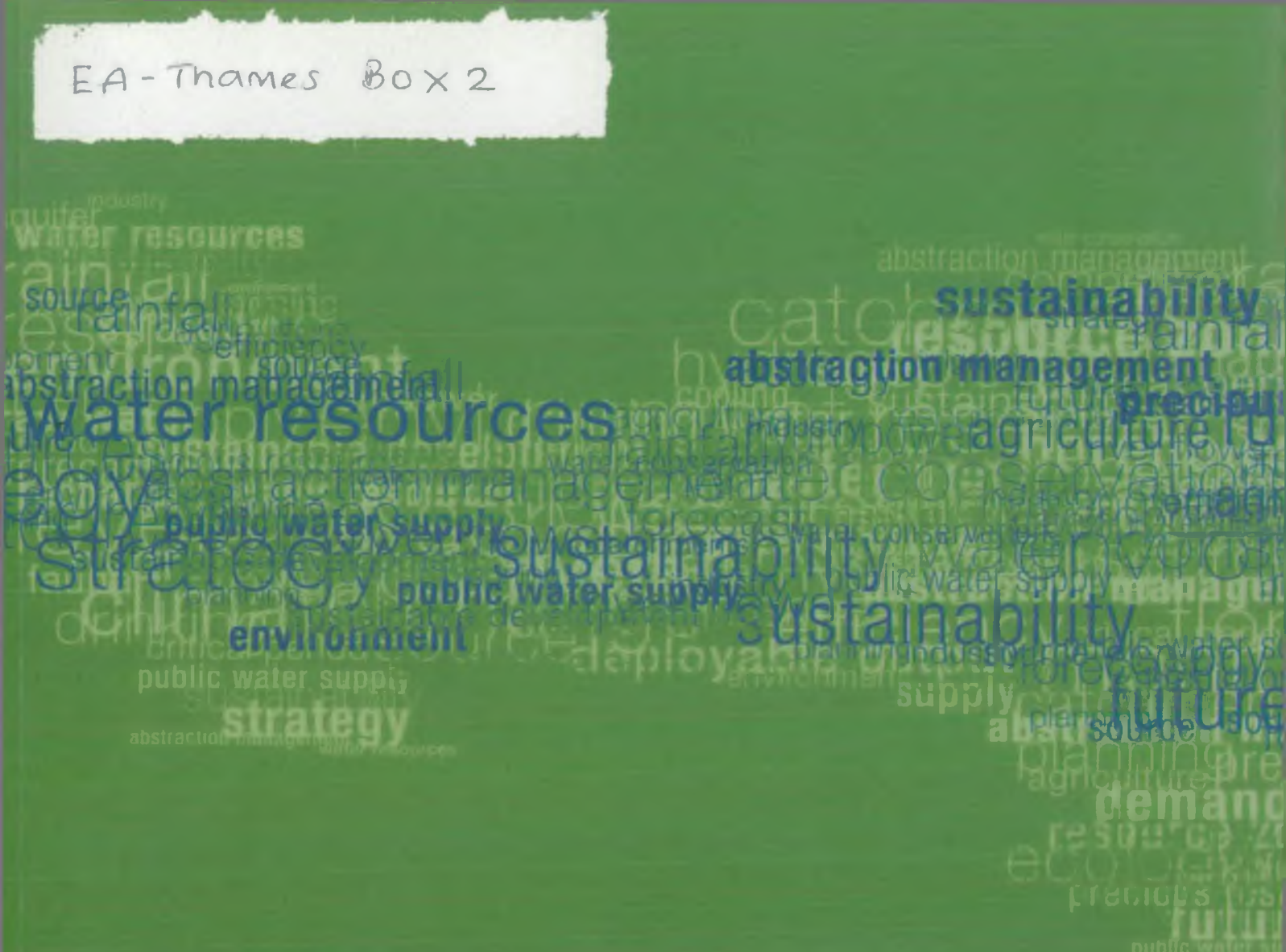
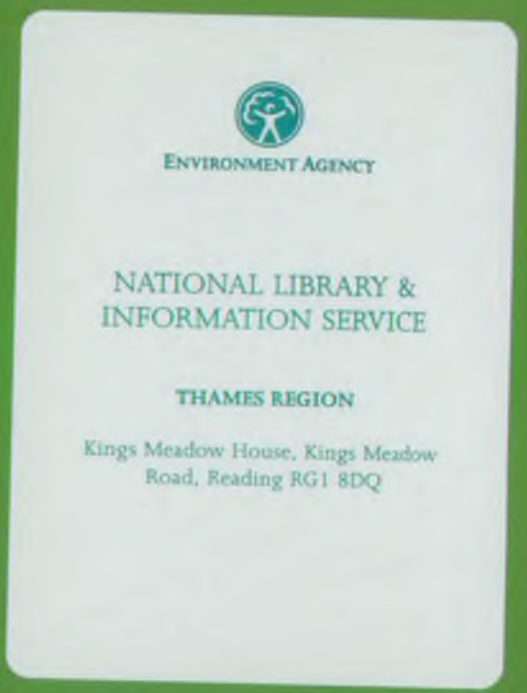


Water resources for the future

A STRATEGY FOR THAMES REGION

March 2001

ENVIRONMENT AGENCY



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Foreword

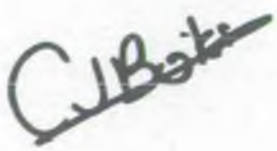
Water resources in the Thames Region are already intensively managed and face further pressures as we look ahead into the new millennium. Playing host to such a large, and growing, population imposes many and varied demands on our environment and natural resources. Continuing economic development and demand for a further 1.2 million homes in the south-east as well as our own propensity to use more and more water in and around the home are set to increase pressures on our water resources.

Water also plays a valuable role in sustaining many of the region's environmental assets. Our rivers, in particular, provide vital corridors for migration of wildlife. But our water environment is also under pressure in many ways, through the impacts of abstraction in some locations and from land use, affecting both the quality and quantity of resources. Add to this the potential impacts of climate change and it is obvious that there are significant challenges to achieving sustainable development in the region over the next twenty-five years and beyond.

This strategy is one of a suite of eight strategies that are consolidated in a national strategy for England and Wales, and is part of a broad framework of integrated planning for the sustainable management of water resources. It looks ahead to 2025, and considers the various pressures on water resources and how we might respond to them in a way that is robust to the many risks and uncertainties we face in planning and managing resources. In drawing this strategy together we have recognised the pivotal role that the Thames Region may play in sustaining further development of the south-east.

The scenario approach we have used, developed from the Government's Foresight "Environmental Futures", emphasises the difficult choices we may need to make in planning for sustainable development. We cannot provide complete answers at this stage; there are simply too many uncertainties in the face of significant decisions regarding new strategic resource requirements. We have, however, identified our priorities for urgent action in the short-term to resolve these uncertainties and have identified a range of potential options that may need to be considered for the longer-term.

Our strategy sets out a framework for action by many different organisations and individuals; water companies, planning authorities, farmers, environmental organisations and many others all have a part to play. The secret of success lies in partnership with all those organisations that have responsibility for different aspects of water management and with individuals, to gain a better understanding of our use of water and our expectations of the water environment. We are particularly keen to discuss the issues raised in this strategy and how we take the actions forward to achieve our vision.



Chris Birks
Regional Director

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Summary

Introduction

Water is essential for natural life and for human use. We use it in our homes and gardens, in commerce and industry, and in agriculture. The way that we use water has a direct impact on the natural environment. This means that it is essential that there is a secure framework for the management of water that protects the long-term future of the water environment while encouraging sustainable development.

The Environment Agency is the statutory body with a duty to secure the proper use of water resources in England and Wales. In accordance with this duty, we have prepared this strategy for managing water resources in the Agency's Thames Region. The region ranges from the hills of the Cotswolds, Chilterns, Berkshire Downs, North Downs and the Weald, to the intervening clay vales and the highly urbanised Thames Valley and Greater London. Supporting a population of 12 million people – 25% of the population of England and Wales in 8% of the area, almost three times the national average population density – imposes significant pressures on the region's limited resources.

This strategy forms part of a suite of eight strategies that are consolidated in the Agency's national strategy for England and Wales. It looks some 25 years ahead and considers the needs for water both for the environment and for society, examining the uncertainties about future demand for water and its availability. It is part of a framework of integrated water resources planning carried out by the Agency and key water users. Water companies play an important part in this framework, each having a published plan for the next 25 years that is kept under annual review. Our strategy sets a structure within which these plans can be refined, allowing them to meet the wider objectives of society. The Agency will continue to be active in encouraging initiatives that contribute to sustainable development.

Our strategy concludes that:

- In Thames Region, water is a precious and limited resource. We use, on average, 55% of the effective rainfall that falls annually; abstracting approximately 5000 Ml/d, approximately 86% of which is used for public water supplies.

- The supply – demand balance in London stands in deficit at present by some 180 Ml/d. Resolving problems of rising groundwater under central London could provide a resource of only 30-50 Ml/d but other schemes could bridge the gap.

- Reported leakage accounted for 26% of public water supply demand, approximately 1000 Ml/d, in 1998/9.

- Without any further action to manage demand and reduce leakage, new strategic water resources will be required, under some scenarios, by 2015 for the Upper Thames and by 2020 for London.

- In many places, further improvements to the water environment are necessary; we believe that this may amount to recovery of 100 – 350 Ml/d.

- Continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 600 Ml/d above present levels by the improvement of existing schemes and further investigation and development, where appropriate, of new resources. However, efficient water use is also vital. We recommend that water efficiency should be promoted actively, and that over the next 25 years we should expect household water metering to become widespread, albeit with continuing protection of vulnerable groups.

- Further attention to leakage control will also be essential. The scale and extent to which new water resource developments are required over the course of this strategy is ultimately dependent upon the extent to which leakage can be reduced further. The issue is particularly challenging in London.

- Commerce and industry should pay more attention to water efficiency. In many cases, water saving initiatives can pay for themselves in less than a year; active promotion of opportunities is essential.

- Agriculture must continue to use available water to best effect. In most agricultural areas, little further summer water is available. Farmers should consider the scope for further efficiencies in water use, crop suitability and irrigation requirements, and the possibility of increased winter storage.

- Working together will be the key to delivering the sustainable development of water resources. We will work to ensure that institutional structures and legislation assist effective water management.

Basis of the strategy

The Agency's vision for water resources for the next 25 years is:

Abstraction of water that is environmentally and economically sustainable, providing the right amount of water for people, agriculture, commerce and industry, and an improved water-related environment.

In preparing this strategy, we have considered the needs of public water supply, agriculture and industry, as well as the environment. We have taken into account population growth and housing projections.

We have looked at the present resource situation, identifying areas where abstraction needs to be reduced to correct damage and improve the environment. The overall position is increasingly challenging; summer surface water throughout the region is now fully committed and, generally, no further unconstrained consumptive use can be licensed. Further winter surface water resources are available (subject to local impacts and constraints) but would need to be developed in conjunction with storage to provide a reliable resource.

Groundwater resources across large parts of the region are now at or approaching full utilisation. The exception is in the middle Thames chalk and confined chalk aquifer under London where further limited resources remain available.

A number of rivers have been identified as having unacceptable flow regimes as a result of excessive licensed abstraction. Sites in the Wye catchment, the Gade and Bulbourne subcatchments of the Colne, and the Mimram and Beane subcatchments of the River Lee have been identified for investigation and action under the National Environment Programme. Where actions have already been taken to eliminate unacceptable flow regimes (on the Pang, Ver and Misbourne) no further strategic resource will be available. The Agency will also be initiating investigation of environmental conditions in relation to abstraction on two stretches of the River Thames, at Oxford and downstream of Windsor.

There are increasing demands for redressing the impacts of abstraction to meet the needs of the environment. Key drivers are the National Environment Programme and the Habitats and Birds Directives and concerns regarding the impacts of strategic abstraction from the Thames at Farmoor and London. In the longer term, these could have significant impacts on strategic resources and we have estimated further reductions in abstraction beyond those already planned may amount to between 100 and 350 megalitres per day (Ml/d) by 2025.

In developing this strategy, we have taken a new approach, basing our forecasts on socio-economic scenarios developed as part of the Department of Trade and Industry's Foresight programme. The Foresight scenarios define a broad framework of possible social, economic, political and technological change. They are presented as four different pictures that represent different ways in which our society could change. We have used these scenarios to consider how the demand for water could develop, taking into account the pressures of regional development planning in the south-east on water resources.

The scenarios show that demand for water is highly dependent on societal choice and governance. In two of the scenarios, total demand for water rises by as much as 53% (or 2100Ml/d) over the next 25 years, while in the other two it falls by as much as 42% (or 1800Ml/d). Changes are driven by economic pressures, people's desire to use water in different ways, and technological innovation. The scenarios highlight the potential risks, particularly in London, if further attention to leakage cannot be sustained and the significant benefits of further targeted reduction.

Climate change is an important issue facing water resources management over the next century. The latest climate change scenarios suggest that temperatures will rise across England and Wales. Although the wetter winters expected from climate change may increase overall water resources availability for the winter months, the warmer, drier summers in the south-east of England may result in unsupported river abstractions and many groundwater abstractions becoming less reliable and sustainable.

Climate change will affect not only water availability but also demand. Over the next 25 years, we believe the effects can be managed within the "twin-track" strategy that we propose. That is, seeking the efficient use of water while bringing forward timely proposals for resource development where appropriate. However, there is at present insufficient information about extreme events under climate change to allow detailed assessment of the probability of longer or more intense droughts. This is an area that we will keep under review. In facing climate change, adaptation strategies are the key, and our recommendations prefer options that are flexible to the range of possibilities encompassed in present climate change scenarios.

In choosing a way forward, we have considered costs and benefits, risks and uncertainties, and the contribution to sustainable development. The contribution to sustainable development has been tested using sustainability appraisal. This is a process that considers policies and plans against the four key strands of sustainable development: economic growth and employment, protection of the environment, making wise use of natural resources, and social progress that considers the needs of all.

Future needs and options

We recommend the enhancement of resources by up to 600 Ml/d by 2025. Around 200Ml/d of this total is for the replacement of sources considered to have an unacceptable impact on the environment. Much of this can be achieved by the enhancement of existing licensed resources, development of infrastructure, the further development of groundwater particularly in the London Basin and potential transfer and use of water via British Waterways' canal network. We also recommend continued investigations of new strategic resource schemes. The most significant of these is the potential development of a major new regulating reservoir. We have also proposed further investigation of transferring water from the Severn although recognising the significant potential for environmental risks from such schemes. We consider this to be viable only as a smaller scheme (less than 50Ml/d) operated directly by pipe to supply schemes, such as the Farmoor reservoir system, or potentially in conjunction with the restoration of the Thames-Severn canal.

The need for a major strategic reservoir remains uncertain and depends primarily on the extent to which further leakage reduction in London may be sustainable. Alternative schemes, including the potential for phased development or smaller development of storage at alternative sites, will require further investigation.

All resource development schemes will need careful investigation to ensure that their environmental impacts are acceptable. In view of the risk that some resource developments may be constrained by environmental impacts or indeed acceptability in planning terms, we recommend that water companies continue to explore viable alternatives that can be brought forward if needed.

The development of schemes to enhance water resource availability will be the responsibility of those who will own or benefit from the schemes. We expect them to take action to investigate such schemes and to promote their development at an appropriate time. Water companies' 1999 Water Resources Plans provide a good basis for public water supply planning for the next five to ten years. They include development of 200 Ml/d or more of new resources, mostly for London. The need for new resource development will be closely monitored against progress along the twin-track.

The Agency will complete the review of consents required under the Habitats Directive for 15 key sites in the region and ensure actions are taken to modify or revoke abstraction licences where necessary. Water companies should complete the investigations and actions required of them under the National Environment Programme for 13 sites in the region. The Agency will continue to work with English Nature and others on the investigations and actions summarised in our recent joint review of water abstraction and Sites of Special Scientific Interest (SSSIs) in England. We will prioritise and monitor progress on these and other abstraction related concerns through our Restoring Sustainable Abstraction Programme (RSAP) within the context of our future Catchment Abstraction Management Strategies (CAMS) process. We will also keep environmental demands under review in the context of the Water Framework Directive, Biodiversity Action Plan and other new initiatives.

Continued attention to leakage control will be essential in public water supply. We believe that application of best practice techniques can contribute significantly to the management of water resources. Continued regulation is essential to maintain the achievements of recent years driven by Government and regulatory attention.

Nevertheless, leakage remains a key issue for the region, particularly in London, where there is a clear need for better information on measurement and the economics of leakage. Thames Water has suggested there are unique circumstances preventing further economic reduction in leakage. These include disruption to urban transport and environment; statutory pressure requirements; aggressive clay soils prone to heave and fracture; and age of mains (many more than 150 years old in central London). Inadequate information on measurement, performance and costs means that this is an area with significant risks and uncertainties. In the absence of a clear plan of action including further investment in underground infrastructure, the long-term security of supplies may be at risk.

Metering of domestic customers can contribute greatly to sustainable water resources management. The Agency advocates more use of household metering within the context of the Government's broader social and environmental policies including the protection of vulnerable households. It is essential that further metering is accompanied by the development of appropriate tariffs that provide social safeguards.

Water efficiency will be essential if we are to achieve our vision of sustainable water resource development. The Government's proposed legislation (DETR, 2000e) will contribute to this. However, we believe that water efficiency also needs active promotion and the co-operation of many different groups. We think that the best way to achieve this is through an independent organisation specifically funded for this purpose. The organisation would undertake promotional work and the active identification and implementation of water efficiency measures. The Agency will seek views on this proposal and, if we find support, will encourage its further development. We will continue to support new initiatives to promote the benefits of integrated water

conservation and water use minimisation whilst sustaining economic development in the region. We believe commerce and industry could save water and money by taking simple actions. However, progress has been disappointing and it is clear that work is needed to facilitate the uptake of these actions.

The Agency will work to maintain good links between its water resources strategy and regional planning guidance, economic strategies and sustainability frameworks to help deliver integrated and sustainable regional planning. The large amount of new housing and commercial development predicted in the region will require increasingly innovative and integrated solutions, including, for example, exploring opportunities for reuse, where appropriate, and promoting sustainable urban drainage to maximise the available water resource. With appropriate attention to the twin-track approach, the region's water resources can still offer a good level of support to new inward investment and economic growth in the region. New development of commerce and housing will, never-the-less, place additional pressures on water resources and supply infrastructure. Investment will need to be appropriately located, or supported by infrastructure development to transfer water to centres of demand; the time-scale of provision may be an issue in some locations. There remain significant longer-term uncertainties in planning water resources that may impact on rates of development. The successful promotion of new water resources schemes cannot be guaranteed and without further innovation the carrying capacity of water resources systems could then become a constraint to development.

Agriculture should also work to make effective use of existing supplies, while considering opportunities to work with others to develop new sources of water. The development of storage will be essential to providing reliable supplies. Trading of licences may prove fruitful, but irrigation users especially should look towards the development of winter storage to ensure sustainable water resources provision. The Agency will seek discussion with supermarkets and food processors whose requirements may influence the use of water.

We have identified a number of areas in need of further research. The Agency will work with others to define the needs and enhance knowledge of these areas.

Future review

We have considered the risks that may arise from following this strategy. Our approach accommodates the range of demands that may arise in the future. It also allows for current scenarios of the effects of climate change. As new scenarios of climate change are developed, we will review the timing of the actions that we propose.

It is possible that further investigation could disqualify some of our preferred options. For this reason, we believe that the appropriate studies should be started in good time. Similarly, the demand management options carry some risks. Some may require support or facilitation by Government and regulators, as well as activity from water users; we will review progress.

We will publish an annual bulletin reporting on progress against this strategy and plan to review the strategy completely in a few years' time. However, we believe that this strategy provides an appropriate framework for long-term water resources planning in Thames Region and contributes directly to the Agency's water resources strategy for England and Wales.

Actions

Without any further action to manage demand and reduce leakage, new strategic water resources will be required in the region by 2015 under some scenarios. The driving purpose for proceeding with major new resource schemes must be to maintain public water supplies, but this case is not yet proven. There remain significant uncertainties; high levels of leakage present a fundamental risk to security of supplies in the longer term as well as forcing potentially unnecessary investment in the development of new schemes. Water conservation has yet to be seriously tried and tested. Furthermore, redressing the level of environmental need identified within our strategy will have a significant impact on the resources available to some water companies. Depending on the scale of this environmental requirement, proposals for change may need to be contingent on the provision of a new strategic resource.

Assuming agreement can be reached in principle between the Agency and Thames Water on the need for a reservoir, it would then take some 12–15 years for full implementation. Further investigations, aiming towards an agreed position before the next major review of water companies' Water Resources Plans, Agency strategies and Ofwat's periodic review of price limits in 2005, are essential to minimise risks to supplies and the environment and to ensure sustainable and timely development of water resources.

Table 8.1 (reproduced below) summarises the actions we propose to implement nationally in managing water resources. To meet the challenges of our regional strategy we have identified the following actions as a matter of priority:

(i) Review the need for major new strategic water resources by 2003 on the basis of progress in leakage reduction by Thames Water, and taking into account other zonal, regional and inter-regional considerations.

(ii) Agree with Thames Water an appropriate plan of action to ensure that sufficient information is gathered by 2003 for the decision on the need for major new strategic water resources to be well informed in relation to what can be achieved economically and sustainably through leakage reduction and demand management. To implement the plan as a matter of priority in 2001/2.

(iii) Progress initiatives for restoring sustainable abstraction and review the impacts and timing of these environmental demands on the strategy:
- complete investigations and implement schemes identified under the National Environment Programme by 2004/5.
- review existing consents to determine where there may be significant ecological impact on the interest features of sites identified under the Habitats and Birds Directives by 2004. Affirm, revise or revoke consents by 2010.
- complete the River Thames abstraction management strategy and further investigations to assess environmental flow requirements and the potential impacts on abstraction at Teddington and Oxford by 2003/4.
- Progress Catchment Abstraction Management Strategies and keep environmental demands under review in the context of the Water Framework Directive, Biodiversity Action Plan and other new initiatives.

(iv) Assess whether a new strategic reservoir could provide benefits for flood alleviation as well as water supply by 2002/3.

(v) Review whether and how the needs of other users and water companies within the region, and demands in neighbouring regions, may affect any of the above decisions by 2003/4. Form a view as to how to react to applications to proceed with a major new resource development to satisfy increased demand from a competition-driven enlarged consumer base by the end of 2001/2.

(vi) Agree with Thames Water by the end of 2001/2 those areas where studies to date can be accepted, and where further work is needed, concerning the appraisal of the proposed reservoir scheme and alternative options.

(vii) If a major new resource is required, assist Thames Water in developing appropriate operating rules that will meet the Agency's aspirations as well as those of the company.

(viii) Review with all water companies whether their supply systems are sufficiently robust against drought events, taking into account our developing knowledge of climate change effects. Where systems are not robust, agree how this may affect demand management and resource development decisions by 2003/4.

(ix) Monitor and review the implementation of schemes identified within water companies' Water Resources Plans and funded through the periodic review, to secure the twin track management of water resources within the region to 2004/5.

(x) Continue to work with strategic and local planning authorities in the region to ensure proposals for new development are based on integrated and sustainable water resources management practices. Identify any constraints especially in the timing of development.

Table 8.1 Actions

Action Ref	Action	Agency	Water companies	Agriculture	Industry	UK Government and NAW	Ofwat	Planning bodies	NGO's and others
A1	Where new or existing developments are not fully utilised water companies should consider sharing this water with others.		✓						
A2	Government should keep the Water Fittings Regulations under active review to ensure that they make the best possible contribution to efficient use of water and that water companies enforce them actively.		✓			✓			
A3	Water companies should actively promote waste minimisation schemes among their industrial and commercial customers in compliance with their statutory duty to promote the efficient use of water.		✓		✓				
A4	Ofwat, Government, water companies, trade associations and the Agency should vigorously promote water efficiency to all sectors and monitor the results of this work.	✓	✓			✓	✓		✓
A5	The Agency will work nationally and locally with water users and water companies to ensure that water efficiency is delivered.	✓							
A6	Government should ensure that any steps towards competition and restructuring maintain and encourage the efficient use of water resources.					✓			
A7	The Agency will seek better access to information on leakage and leakage-control.	✓							
A8	The water industry should continue to develop and implement new and better methods of leakage control.		✓						
A9	The system for setting annual leakage targets should be maintained and developed.	✓				✓	✓		
A10	The Agency will explore with Government, Ofwat and others how the current regulatory framework and the new legislation proposed in the draft Water Bill can assist in achieving good leakage control.	✓				✓	✓		

Table 8.1 **Actions** *continued*

Action Ref	Action	Agency	Water companies	Agriculture	Industry	UK Government and NAW	Ofwat	Planning bodies	NGO's and others
A11	The Agency will work with Ofwat, Government and the water industry in the provision of accessible information to householders about metering and in the development of tariffs that encourage water efficiency while having regard to the Government's broader social and environmental policies.	✓	✓			✓	✓		
A12	Water companies should take a positive attitude towards targeted household water metering where this is appropriate and where opportunities arise.		✓						
A13	The Agency will seek to identify opportunities to make water available for agricultural purposes from existing and new developments.	✓		✓					
A14	The Agency will encourage farmers to adopt good practice in water use around the farm.	✓		✓					
A15	The Agency will work with agriculture to continue to develop indicators of good practice in water use.	✓		✓					
A16	Farmers should actively seek ways of minimising their water use.			✓					
A17	Farmers should consider working together to develop schemes that can be shared by several farms.			✓					
A18	The Agency will assist trading of abstraction licences between abstractors, provided the trade is not doing any harm to the environment.	✓							
A19	Farmers should consider the possibility of trading abstraction licences to meet their needs.			✓					
A20	The Agency will seek dialogue with supermarkets and food processors to encourage greater understanding and consideration of the impact of their crop requirements on farmers' use and management of water and of the consequences for the water environment.	✓							
A21	The Agency will approach proposals for hydropower schemes positively and work constructively with the developers to achieve viable schemes.	✓							
A22	The Agency will seek the co-operation of others including environmental organisations and abstractors, in identifying the actions that are needed to improve the water-related environment in relevant areas.	✓	✓	✓	✓				✓
A23	The Agency will promote greater understanding of the value of the water environment, by providing clear information to the public on how water use affects the natural environment.	✓							
A24	Navigation authorities should consider whether boating demand will increase their need for reliable water resources. If it will they should prepare to identify and justify schemes to provide more water within the expected new legislative framework.								✓
A25	The Agency will encourage the development of more local transfers of raw or treated water to meet particular circumstances, provided that they take account of the needs of the environment and other users.	✓							
A26	The Agency will work with Ofwat towards further rationalisation of the ways that we each seek water resources information from water companies.	✓					✓		
A27	The Agency will work with planners to identify opportunities for water efficiency in new developments.	✓						✓	
A28	The Agency will work with Government to identify opportunities for streamlining the process of approval for essential water resources development while maintaining full public accountability.	✓				✓			
A29	The Agency will explore with others the idea of an independent water efficiency body; if we find support, we will encourage its further development.	✓							
A30	The Agency will work with others to prioritise and take forward appropriate Research and Development.	✓							

1 Introduction

1.1 The need for a strategy

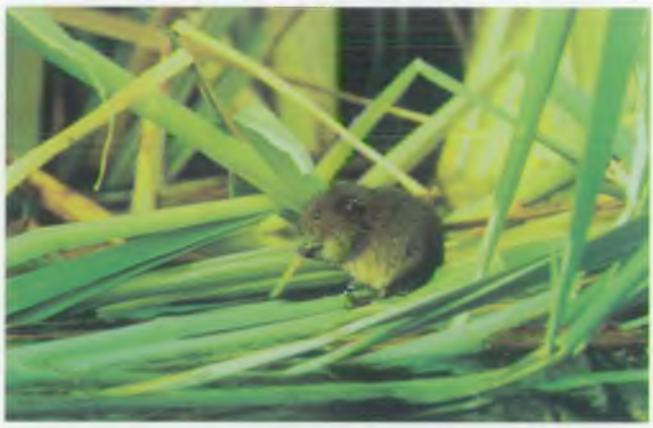
Water is essential for natural life and for human use. We use it in our homes and gardens, in manufacturing industry and agriculture, in navigation and recreation, and we expect to enjoy it in the environment. Of our natural resources, water is unique in that it is renewable but its use has a direct impact on the natural environment. Water in rivers and wetlands supports plant and animal life, and plays a great part in defining the essential character of the landscape and countryside of the Thames Region.

As the statutory body responsible for strategic water resources planning, the Environment Agency aims to protect the long-term future of the water environment through the sustainable management and development of water resources. Reconciling the needs of the environment with the demands of society is becoming an increasingly difficult challenge. Now more than ever, we must plan our long-term use of water so that there is a secure and integrated framework for its management.

The pressures on water resources are particularly acute in the south-east of England. The combination of demands arising from high population density and low average available rainfall in the south-east place increasing pressures on the natural environment and mean that the careful management of water resources is essential.

The Thames Region (Figure 1.1) ranges from the hills of the Cotswolds, Chilterns and the Berkshire Downs to the Thames and Avon vales and the highly urbanised Thames Valley and London Basin. Supporting a population of 12 million people – 25% of the population of England and Wales in 8% of the area, almost three times the national average population density – imposes significant pressures on the region's limited resources.

We use, on average, 55% of the effective rainfall that falls annually, substantially more than any other region in the country. Approximately 5000Ml/d are abstracted



The water vole is one of a number of nationally protected water-dependent species found in the Region

annually within the region, 86% of which is used for public water supply. Despite progress towards regulatory targets, leakage from the public water supply system still accounts for at least 26% of the public water supply demand. Balancing the continuing pressures of growth in demand on the region's resources from new development as well as improved lifestyles and expectations of water use against the need to sustain our water-related environment is increasingly challenging.

In London, which accounts for over half the regional demand, the supply-demand balance remains in deficit by some 180Ml/d. Resolving problems of rising groundwater under London could provide a resource of some 30-50Ml/d. Further resource availability throughout much of the region is extremely limited and in many places restoring sustainable abstractions is now a priority. The sustainable management of our future water resources will require a combination of more efficient use of water together with the development of strategic infrastructure and resource solutions to optimise available water resources.

The region is unique in its dependence mainly on one river system, that of the Thames. As a result, our water resources system is sustained by a significant amount of reuse, taking advantage of the use and subsequent

Figure 1.1 Thames Region: Key boundaries

Thames Region
County Boundary
Unitary Authority Boundary

Regional Development Agencies

East Midlands
Eastern
London
South East
South West
West Midlands

Thames Region

Water Companies

North Surrey Water
South East Water
Sutton & East Surrey Water
Thames Water Utilities
Three Valleys Water Services

return of high quality treated wastewater and the natural purification capacity of our rivers. Water resources and water quality are intricately related in terms of the availability and usability of resources. Urbanisation and land use have significant impacts on water resources; groundwater quality, in particular, is an increasing concern in the region.

As a result, the Thames catchment is one of the most intensively used water resources systems in the world and the integration of catchment management objectives is fundamental in sustaining the many and often competing pressures placed upon it.

This strategy, the first to be developed by the Agency since its inception, looks 25 years ahead and has the following features:

- considers water resources needs for the next generation;
- builds on a long tradition of water resources planning;
- adopts a flexible approach which reflects the many uncertainties that face water resources;
- provides a secure way forward that protects the water environment and contributes to sustainable development;
- provides a broad framework for the management of water resources;
- provides a backdrop for other strategies and plans which follow, from both within and outside the Agency.

As well as managing water resources, the Environment Agency has responsibility for water quality, flood defence, fisheries, navigation, and other ecological and recreational uses of water. This water resources strategy is part of an integrated approach to the management of the water cycle that is brought together by the Agency's Environmental Vision (Environment Agency, 2000d) which we describe below.

This strategy forms part of a suite of documents representing the water resources strategy for England and Wales. The national strategy deals with overarching policy, approaches and techniques. It considers national issues and an overview of the seven English regional and the Wales water resources strategies. This strategy for the Thames Region applies these approaches to focus on the current state of water resources locally and explores options for their long-term sustainable development. Together, these documents form part of a nationally co-ordinated and consistent process of strategic water resources planning.

Sailing is one of the many recreational activities that take place on and around the Region's waterways

1.2

Vision and objectives

The Environment Agency is the statutory body with a duty for strategic water resources planning. Our role is to protect the long-term future of the water environment while encouraging sustainable development. Our vision for water resources in the next 25 years is:

Abstraction of water that is environmentally and economically sustainable, providing the right amount of water for people, agriculture, commerce and industry, and an improved water-related environment.

This strategy will help us achieve the following objectives:

- to illustrate the impact of different social and economic choices on future water use;
- to manage water resources in a way that causes no long-term degradation of the environment;
- to improve the state of existing degraded catchments;

- to ensure that water is available to those who need it, and that it is used wisely by all;
- to indicate the present state of water resources;
- to cater robustly for risks and uncertainties;
- to promote the value of water to society and the environment;
- to review feasible water management options including innovative solutions where appropriate;
- to provide a framework for logical decisions to be taken at the right time;
- to identify actions and opportunities for the Agency and others to work together to achieve our vision.

Our strategy contributes to various themes of the Agency's new *Environmental Vision* (Environment Agency, 2000d) including:

- a better quality of life;
- an enhanced environment for wildlife;
- a greener business world;
- wiser, sustainable use of natural resources;
- improved and protected inland and coastal waters;
- limiting and adapting to climate change.

The long-term approach that we have taken complements the *Vision*, showing how the thematic approach to improving our environment translates into tangible actions affecting a specific sector. In water resources, actions in one place have implications elsewhere, making the direct consideration of links especially appropriate.

1.3 Consultation

While the Agency has statutory responsibilities for long-term water resources planning in England and Wales, there are many others with an interest in water resources. We believe that our strategy will be more successful if it meets the needs and concerns of others who are involved in the process. For this reason, in October 1999 we published a national consultation document (Environment Agency, 1999a) seeking the views of groups and individuals on a variety of issues.

In September 2000, we produced a consultation response document, summarising the 270 replies that we received (Environment Agency, 2000c). These included a good spread of responses across the main sectors with interests in water in the Thames Region and we have taken these views into account in the preparation of this strategy.

Responses from consultees broadly reflected many of the national trends, but also highlighted some strong local concerns amongst stakeholders. These included the view that water is undervalued and many water users are unaware of the impact they have on the water environment. This is further exacerbated by continuing pressures for new development and the challenges thus imposed for water resources and supply.

Turning to the opportunities for solutions, there were some areas of broad consensus amongst stakeholders, as well as other aspects where views differed. Key areas of agreement were:

- the importance of water efficiency and reducing wastage across all sectors, and the need to pursue water conservation with greater vigour to make the best use of existing water resources. The industry, generally, should investigate alternative incentives for water conservation in the absence of price signals through metering;
- although views on prospective targets differed, there was widespread agreement on the need for continued improvements in reducing leakage. The need to take a longer-term view within the regulatory process of infrastructure renewals, costs and probability of failure and the overall contribution to sustainable development was emphasised.
- acknowledgement of the need for a twin-track approach to managing future water resources, emphasising the importance of a water conservation led approach but recognising that water resources development still has an important role within a strategy for sustainable management;
- broad support for metering and development of appropriate tariffs but concern that this should not lead to social exclusion. Metering was seen as a part of a broader package of measures including promotion of water efficiency and awareness of water use and its impacts on the environment;
- additional winter storage, primarily for agriculture and for public water supply was seen as a sensible response, particularly where it could provide scope for environmental improvement (for example, in moving away from reliance on abstraction which may degrade the environment) and resilience to climate change. Caveats were given regarding costs and benefits, environmental impacts and broader planning considerations;

- the availability of water resources and supply should be a significant factor in planning decisions regarding proposed new developments in the south-east but should not necessarily be an overall constraint. Water efficiency and new technology all have a role to play and the Agency should use its powers to guide and influence the location and timing of new development;
- all users should be encouraged to prepare their own long-term water resources plans and contingency arrangements and to adapt their use of water in view of the risks and uncertainties of climate change.

Divergent views were particularly evident on:

- the extent to which we should seek environmental improvement and how the "precautionary principle" should be applied in managing continuing uncertainties in water resources. Many favoured continued improvements and greater precaution for the environment, planning for wider tolerance margins for future protection of the water environment. Abstractors, particularly from the water industry, saw time-limited licences and continued monitoring and investigation as the way forward for continuing environmental improvements and cited the need to consider the value of water in the context of Government's expectations of price reductions;
- competition was seen as providing contradictory drivers in efficiency. Whilst competition could provide benefits by encouraging water companies to look at their own (largely financial) efficiencies, making the marginal costs of leakage reduction more attractive, passing on cost efficiencies to the customer could provide negative signals for water efficiency and the value of water in the environment.

We have taken these views and many other details into account in formulating this strategy. The issues we consulted on are fundamental ones, where differing views are not unexpected. It is inevitable that some people will be disappointed. There are also areas of genuine uncertainty that have to be resolved with the opportunity for further input. However, we are keen to build on the areas of consensus, and to continue to work with all our stakeholders in the Thames Region to look for ways of reconciling the differences to achieve mutual gain.

Consultation does not end with the publication of our strategies. The published documents are part of an ongoing process. We welcome views on the contents of this document or on any other aspects of water resources management that are of interest. If you wish to comment, please write to the Water Resources Manager at our Reading address.

1.4

Links with other water resources planning initiatives

The Agency's water resources strategies are part of a framework of integrated water resources planning carried out both by ourselves and by water companies. These cover different timescales and different areas.

This strategy looks 10 to 25 years ahead, and covers the Thames Region. It covers all aspects of water resources management, including public water supply. This is always prominent in national and regional water resources strategies, because it is such an important part of water use. Each water company has its own water resources plan, setting out its view of how it will manage water resources over the next 25 years. These plans complement the supply-demand balance submissions that water companies make to Ofwat every five years. Annual updates to water company plans are submitted to the Environment Agency for review. The plans detail the actions that water companies intend to take, and are an important part of the water resources planning process. This strategy has used water company plans as the basis for the consideration of future public water supply. Further updates of water company plans will in turn be informed by this strategy.

The Agency's role in this strategy is to set the bounds within which decisions will be reasonable. This means that we must develop a good understanding of the values of society and Government, and combine these with a rigorous assessment of future demands and pressures to provide a framework for decision-making. In some cases, these values will mean that there is an obvious course of action. In others, limited time will mean that a single course of action will have to be chosen and acted upon. Our approach must be sufficiently robust to deal with all sorts of uncertainty and still meet the objectives that we have identified for our strategies. In providing strategies, it is not our intention to constrain the commercial decisions of water companies and other abstractors, but to provide a way forward that ensures that decisions meet the wider objectives of society as a whole, and any statutory obligations in the process. This strategy sets a broad framework within which detailed plans for action by water companies and other abstractors can be drawn up.

1.5

Structure of the report

In this document we describe the national framework for water resources management and how that will be used in the sustainable management of the region's water resources. The structure of the report is as follows:

- Chapter 2: sets out the principles that underpin the strategy.
- Chapter 3: summarises the current state of water resources in the region.
- Chapter 4: sets out the pressures that we expect to develop on water resources in the future.
- Chapter 5: quantifies these pressures.
- Chapter 6: describes the options that could be used to meet these pressures, discusses the tools that have been used to assess these options and describes how we have used the outcome of this assessment to build the strategy.
- Chapter 7: presents our results and conclusions.
- Chapter 8: sets out the actions and recommendations that are needed to deliver the strategy.
- Appendices 1 to 5: set out further details of our approach.

2 Frameworks and principles

This chapter sets out the institutional and regulatory framework within which our water resources are managed. It looks at the changes that may result from the introduction of competition and economic instruments, and sets out the principles that underlie the Agency's approach to water resources planning.

2.1 Institutional and regulatory framework

The management of water resources in England and Wales is carried out by several institutions.

2.1.1 The Environment Agency

The Environment Agency has the duty to conserve, augment, redistribute and secure the proper use of water resources in England and Wales. It is the central body with responsibility for long-term water resources planning in England and Wales. Other relevant responsibilities of the Agency include:

- flood defence on main rivers;
- water quality;
- waste minimisation in certain regulated industries (including the minimisation of the waste of water);
- fisheries; and
- navigation on some rivers.

We fulfil our duty of the management of abstraction through the licensing system. This was originally introduced by the Water Resources Act 1963 and subsequently amended by several pieces of legislation that have been consolidated by the Water Resources Act 1991. In November 2000 the Government published a draft Water Bill outlining legislation that it intends to introduce when there is time in the parliamentary timetable (DETR, 2000e). This will strengthen the Agency's role and powers in respect of water resources management.

Our water resources duties extend to all abstractors, including water suppliers, agriculture, industry, commerce and those who abstract for amenity, sports or leisure uses. With a few exceptions, any organisation that, or individual who, wants to abstract water in England or Wales needs an abstraction licence from the Environment Agency. This authorises the abstraction of a given volume of water. In exercising this regulatory role the Agency has additional duties under the Environment Act 1995 to contribute to sustainable development and to promote the conservation and enhancement of the natural environment. We also have a duty to take account of costs and benefits in the exercise of our functions, and to have regard to the economic and social well-being of rural communities.

The Thames Barrier is the largest of the Region's flood defences

Our primary duties are set down in legislation; policies describe the way that we fulfil these duties. The Environment Agency has developed a number of policies that inform the way that we manage and plan water resources. These water resources policies are endorsed by the Agency's Board and therefore represent a public statement of how the Agency will act. A copy of these policies is available from the Head of Water Resources at our Bristol address.

The Environment Agency is responsible for:

- Catchment Abstraction Management Strategies (CAMS), setting out the Agency's plan for managing the abstraction regime of each catchment. This is a new initiative, starting in 2001. CAMS will be reviewed every six years in a rolling programme;
- Local Environment Agency Plans and state of the environment reports, setting out the local and region-wide framework for sustainable management of the environment;
- drought plans, setting out the Agency's role in managing droughts;
- regular review of water company water resources plans and drought plans;
- this water resources strategy, setting out the Agency's vision for the long-term management of water resources in Thames Region;
- a national water resources strategy, setting out the Agency's vision for the long-term management of water resources throughout England and Wales.

2.1.2 UK Government and National Assembly for Wales

In England, the Secretary of State for the Environment, Transport and the Regions determines drought orders and deals with appeals against the Agency's abstraction licensing decisions. The Minister for the Environment is responsible for water regulations to control the waste of water. The National Assembly for Wales has statutory and policy responsibility for matters related to the water industry in Wales.

2.1.3 Water companies

Public water supply in England and Wales is provided by private water companies. Their water abstractions and effluent discharges are regulated by the Environment Agency. The Agency is bound to have regard to their water supply and sewerage services duties when it exercises its powers. Each water company has the statutory duty to develop and maintain an efficient and economical system for water supply in its area, and the Agency's duties in respect of water resources management do not relieve the companies of that obligation. The main water companies operating within the region are North Surrey Water, South East Water, Sutton and East Surrey Water, Thames Water and Three Valleys Water (see Figure 1.1).

Water companies are responsible for:

- providing a clean and reliable supply of water;
- water resources plans, submitted to the Environment Agency, setting out each company's view of how it will manage water resources over the next 25 years. These are reviewed annually;
- drought plans, setting out responses to different types of drought;
- proposing and justifying water resources schemes for incorporation into Ofwat's periodic reviews of water charges;
- promoting the efficient use of water on behalf of customers; and,
- maintaining an economical and efficient supply system.

Water companies make decisions about the way they want to manage their supply-demand balance according to the values of the company and their understanding of the needs of their customers. In many areas of water resources planning, several different courses of action are equally effective. Water companies legitimately make commercial decisions about how they wish to manage these areas.

2.1.4 Ofwat

Economic regulation of the water companies of England and Wales is carried out by the Director General of Water Services through the Office of Water Services (Ofwat). The Director General reviews water company prices to customers in a five-yearly price review (see Ofwat, 1999a). Water companies produce plans showing how they intend to manage and develop their supply systems. The Director General determines prices to customers so that companies have sufficient income to carry out the parts of these plans that he considers to be justified.

2.1.5 The Drinking Water Inspectorate

The quality of the water delivered by water companies to their customers is regulated by the Drinking Water Inspectorate.

2.1.6 Planning and local authorities

Strategic planning authorities and local authorities are responsible for the land use planning framework and planning decisions. Water resources has been the subject of much interest and concern in the recent round of revisions to Regional Planning Guidance in this

region which includes, principally, the South East of England but also the South West and East of England Development Areas (see Figure 1.1). Similar concerns have also been raised and discussed at county structure plan level within the region.

We anticipate a need to work increasingly closely with planning authorities to ensure that the water resources implications of new developments in the region are understood and to promote sustainable development. This not only covers the impact on water resources of new housing, but also includes other uses, such as mineral winning activities that dewater and affect local rivers and streams. Current draft regional planning guidance is discussed in more detail in Chapter 4.5.

Local authorities also regulate the quality of private drinking water supplies through their environmental health duties. Private wells and boreholes are still important sources of domestic drinking water in parts of the region.

2.2 Competition and economic instruments

In April 2000, the Government published a consultation document on **competition in the water industry** in England and Wales (DETR, 2000b). The Government believes that the extension of competition is desirable, as it should lead to greater efficiencies, lower prices, innovation and better services, to the benefit of customers. The Government is clear that this should be achieved without compromising public health, safety, the environment or wider social policy.

Different modes of competition are being considered. In this strategy we are concerned with the long-term future of water supply. We base much of our analysis on data related to present water companies. However, this does not mean that we assume that present water company structures will continue for the next 25 years. Our interest is in the people who use water in their homes and industry, and not in the commercial structure of the supplying company. However, the structure of the water industry could have serious effects on the ability to deliver our strategy.

We take the view that introduction of competition, and possible restructuring of water companies, must be controlled so that it encompasses good practice and innovation, without putting at risk environmental protection or delivery of water efficiency. We consider that accountabilities for promoting water efficiency, currently a duty of water undertakers, will become dissipated and therefore even harder to deliver. Water efficiency is of great importance, and we trust that Government will ensure that its delivery is not compromised by structural changes to the public water supply industry.

The Government also consulted on **economic instruments** in April 2000 (DETR, 2000c). The paper considered:

- the case for raising abstraction charges above the cost recovery level, either to make abstractors bear the environmental cost of the effects of their abstraction, or to reduce the amount of water abstracted for economically low-value uses;
- the potential for the trading of abstraction licences as an effective means of achieving the optimal distribution of water resources within and between different sectors of water use, hence contributing to sustainable development.

The paper invited comments on the Government's view that increasing charges beyond cost recovery would be unlikely to be the best way to reduce abstractions. Comments were also invited on the Government's view that licence trading should be promoted within a strong regulatory regime that provides a framework to protect the environment and other water users. The Government will produce a further document on economic instruments in relation to water abstraction early in 2001.

We consider the role of abstraction licence trading further in section 7.3.

2.3 Principles underpinning the Agency's approach to water resources planning

The Agency's approach to water resources planning is based on four main principles which we describe below.

2.3.1 Sustainable development

The Environment Agency has a legal duty to contribute to sustainable development. In May 1999, the Government published *A better quality of life: a strategy for sustainable development for the United Kingdom* (DETR, 1999a). It says that at the heart of sustainable development is the simple idea of ensuring a better quality of life for everyone, now and for generations to come. It means meeting four objectives simultaneously:

- social progress which recognises the needs of everyone;
- effective protection of the environment;

- prudent use of natural resources;
- maintenance of high and stable levels of economic growth and employment.

The concept of sustainable development provides a framework against which strategies can be tested. We have used a technique known as "sustainability appraisal" to measure the contribution of our strategies to sustainable development. This is discussed further in Chapter 6.

2.3.2 The "twin-track" approach

The "twin-track" approach takes a balanced view, seeking the efficient use of water while bringing forward timely proposals for resource development where appropriate. The twin-track approach recognises the value of water in the environment, and therefore seeks the efficient use of existing water resources. However, it recognises also that development of new water resources may be necessary, and that such development must be planned in advance so that it is ready when the water is needed. The approach implies that, as more resource development is required, increasing effort must be applied to the efficient use of water.

2.3.3 Robustness to uncertainty and change

In looking ahead, we must acknowledge explicitly the uncertainties that are associated with many of the factors that affect water resources management. This means that we must identify a way forward that is flexible and robust to a range of possible futures. To do this, we need to understand the implications of the different changes that could happen. For this reason, we have taken a scenario approach, looking at the different ways that society may use and value water in the future. Uncertainties include social values, systems of governance and climate change. We explain in Chapter 5 how we have allowed for them.

Adoption of a scenario-based approach also makes it easier to discard the old "predict and provide" doctrine that involved developing resources to meet all possible future demands. By considering different possible futures, we can develop an approach that involves managing water use and expectations to produce a strategy that is robust and flexible.

2.3.4 The precautionary principle

The precautionary principle says that, where there is uncertainty about the consequences, decisions should be cautious and should seek to clarify the source of the uncertainty. In water resources management, this principle means that, if there is a serious risk of environmental damage because of a proposed abstraction, the decision about the abstraction should ensure that the environment is protected. It also applies to a serious risk of failure of public water supply, which would be unacceptable in terms of its social and economic impacts.

3 State of water resources

This part of the report looks briefly at how water is taken from the environment, distributed and then used. It also discusses the environmental demand for water and its importance in terms of recreation.

Thames Region's water environment has developed from the combined influences of the natural hydrological cycle and human intervention (Figure 3.1). Major features of the region are:

- **The London Basin** – an expanse of low ground drained by the Thames, mainly comprising London Clay. Abstractions in the area are from surface water, from the confined chalk aquifer beneath the clay and from the perched water table in the river gravels overlaying the clay.
- **Chalk uplands** – the Berkshire Downs, Chilterns, Hampshire Downs, Hog's Back and North Downs. The chalk rivers, such as the Kennet and Lambourn, Mimram and Gade, are UK BAP (Biodiversity Action Plan) habitats, the first two being SSSIs (Sites of Special Scientific Interest) for much of their length and, in part, candidate SACs (Special Areas of Conservation). The chalk aquifer is a major source of water for both supply and environmental needs.
- **The Cotswolds** – hills bounding the region in the west, with steep limestone scarp slopes on one side and long gentle dip slopes to clay vales on the other. The limestone aquifers are major sources of water. The Cotswold Water Park, an SSSI formed by gravel extraction, is the most extensive marl lake system in Britain.
- **The Weald** – heavy clays and sands to the south of London and the North Downs. The lower greensand aquifer is a major source of water. Thursley, an internationally important wetland, is also nationally important for its bird, reptile and invertebrate populations.
- **Man-made and semi-natural areas of open water** – a number of embanked water supply reservoirs, sewage treatment lagoons and former gravel pits across the region, many of them SSSIs, which support various bird and invertebrate species. Apart from the Cotswold Water Park, most of these areas are in south-west London and the Lee Valley.

3.1 The water resource

Our water environment is ultimately dependent on rainfall and its movement over and through the ground. Water is a renewable resource; every year, large quantities fall in the form of rain and snow. Although it is renewable, it is a finite resource; the amount that is available depends on the quantity that falls each year.

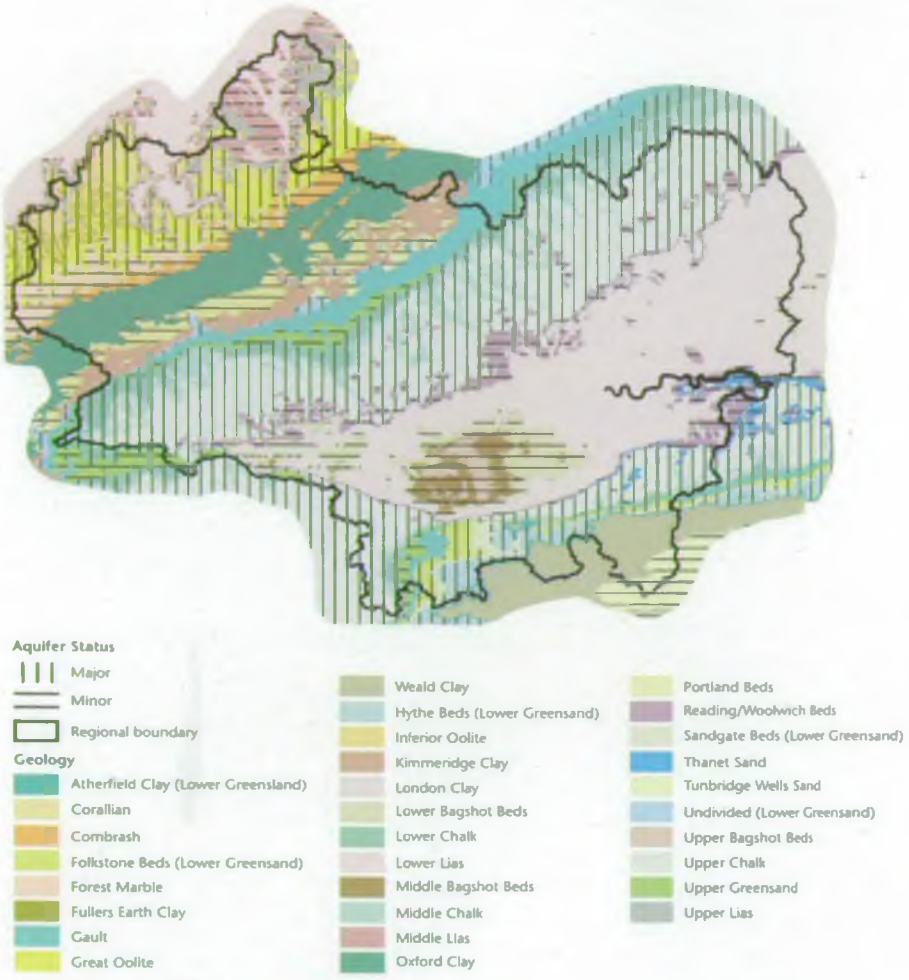
Average annual rainfall for the region as a whole is 690 mm. Rainfall patterns vary, reflecting both topography and the prevailing south-westerly weather patterns, with the wettest areas being in the west and south of the region and in the Chilterns (Figure 3.2). The quantity of rainfall is spread fairly evenly throughout the year. However, almost two thirds of that rainfall is evaporated or used by plants, so that the usable or effective rainfall is far less (as we shall explain below), especially in summer (Figure 3.3). Average effective rainfall for the region is 235 mm. Year-to-year variability in rainfall can be significant as shown in Figure 3.4. Prolonged dry periods, spanning two or more dry winters, are particularly significant for the region.

3.1.1 Rivers, groundwater and wetlands

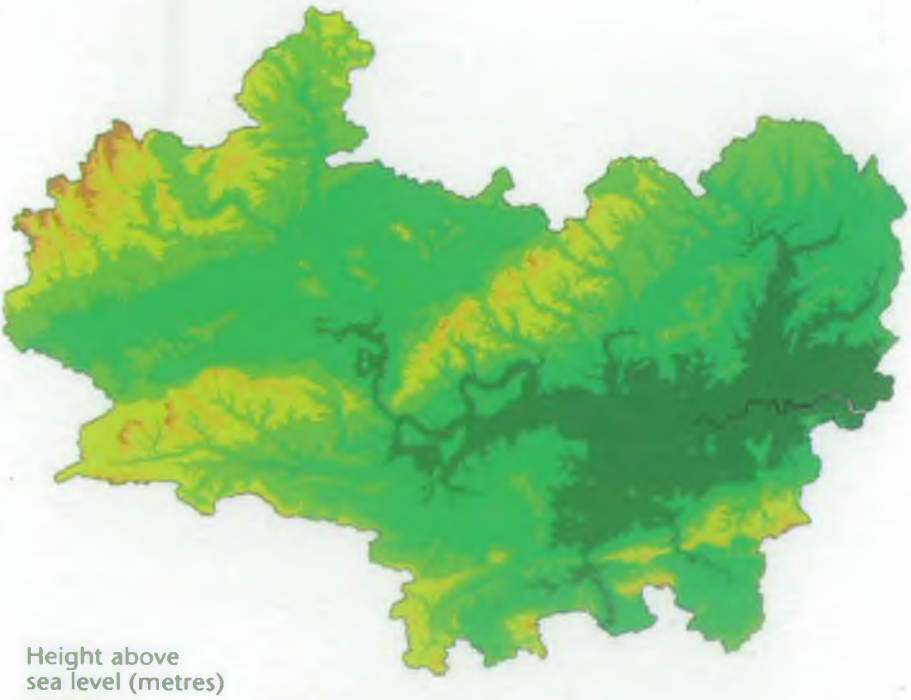
On reaching the ground, some rainfall evaporates or is used by plants (evapotranspiration). Evapotranspiration is greatest in the spring and summer, when plants are growing and temperatures are high. The rest of the

Continues on page 29.

Figure 3.1 **The physical characteristics and environmental assets of the region**



Source of data: British Geological Society and Environment Agency



Source of data: Ordnance Survey

Major and minor aquifer locations and geology

The expanse of low ground draining the Thames – the London Basin – comprises mainly London Clay. This is bounded by Chalk uplands – the Berkshire Downs, Chilterns, Hampshire Downs, Hog's Back and North Downs. The Region is bounded in the west by the Cotswolds, with the steep limestone scarp slope on one side and the long gentle dip slope to clay vales on the other. The Region is bounded to the north by the heavy clays and sands of the Weald.

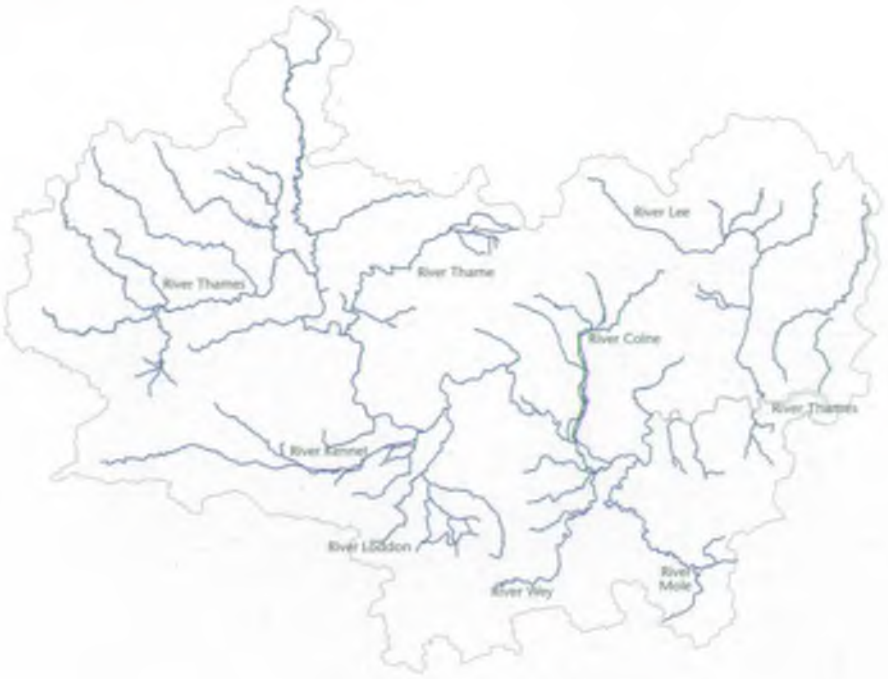
The chalk is the major groundwater resource for the Region, along with important contributions from the Cotswold Limestones, the Lower Greensands of the Weald and the perched water table on the river gravels which overlay part of the Region.

Topography

The topography of the Region is strongly influenced by the structure of the underlying geology and the effects of glaciation and the Region's drainage pattern. The Region varies in height from the Thames Estuary at sea level to parts of the Cotswolds, Chilterns, Berkshire Downs and North Downs which rise to approximately 300m above sea level.

Rivers

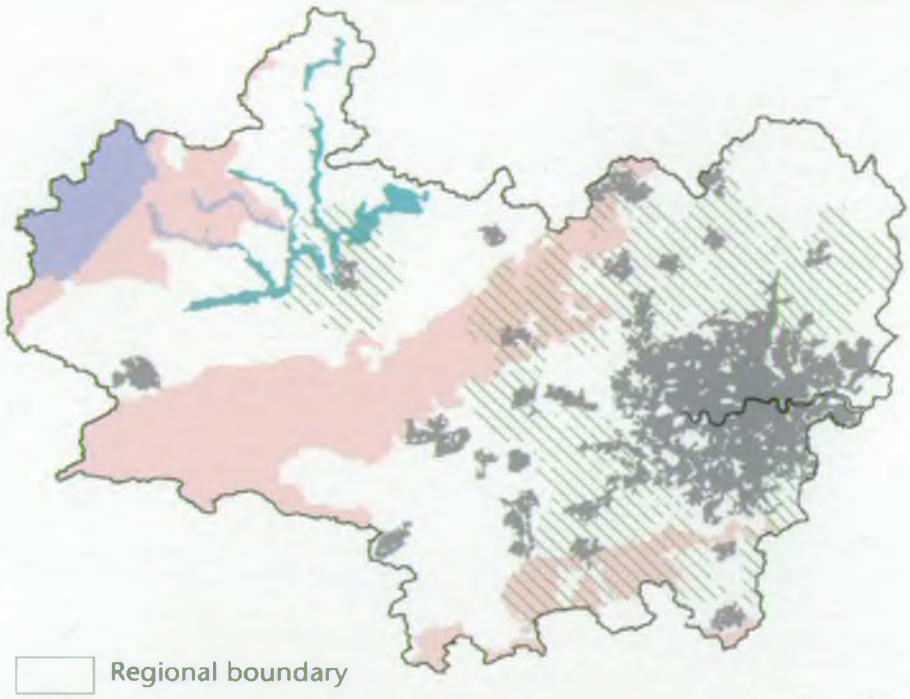
The Region includes the River Thames and its tributaries, including the Kennet, Thame, Loddon, Wey, Colne, Mole and Lee. There are 5330km of Main River in the Region as designated under the Water Resources Act 1991 – formal consent from the Agency is required for any activities that may obstruct flow or alter the bed or banks. The area of the fluvial floodplain in the region is 70,000ha.



Sites of Special Scientific Interest

There are 462 Sites of Special Scientific Interest (SSSIs) within the Thames Region covering 403 km² (3.1% of the Region). There are also 2 potential Special Protection Areas (pSPAs) and 23 candidate Special Areas of Conservation (cSACs) that may be designated in the Region. Two SPAs have been designated so far: the Lee Valley and the South West London Waterbodies. These are both major sources of water for public supply.

Source of data: English Nature

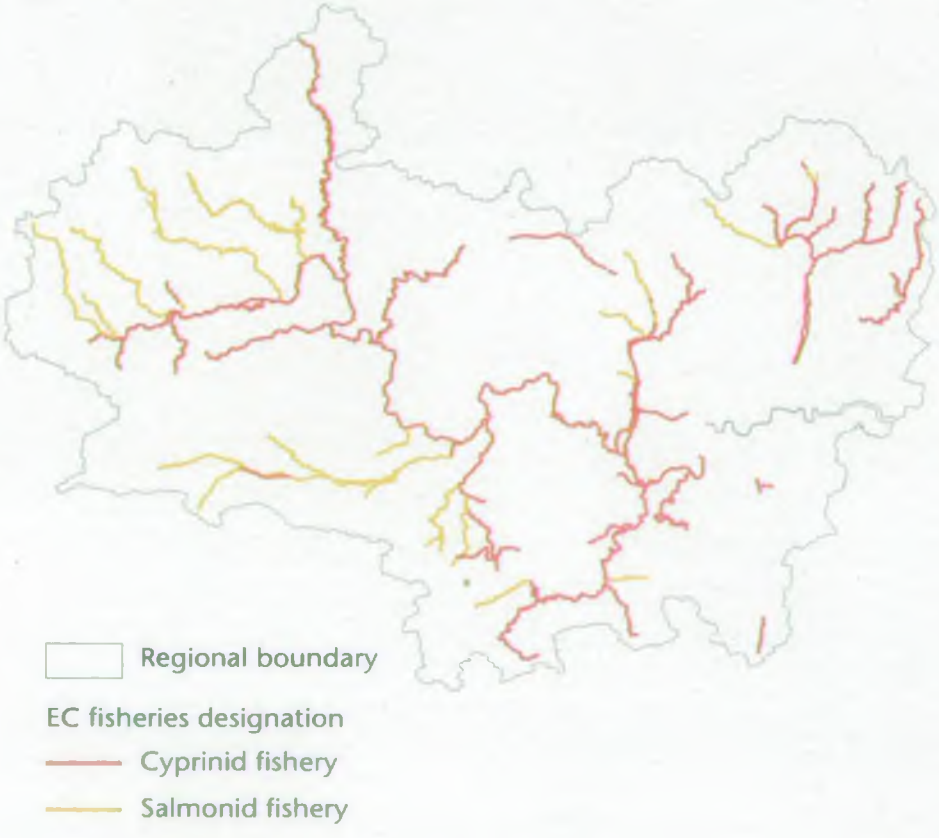


Source of data: Countryside Agency, Ministry of Agriculture, Fisheries and Food and local authorities

Areas of Outstanding Natural Beauty, Environmentally Sensitive Areas and Green Belt

The Region includes parts of five Areas of Outstanding Natural Beauty (AONBs) – Cotswolds, Chilterns, North Wessex Down, Surrey Hills and Kent Downs (a total of 3,454 km^2) – and parts of two Environmentally Sensitive Areas (ESAs) covering some of the upper Thames tributaries and the Cotswolds (656 km^2).

The London conurbation and Oxford are surrounded by Green Belt, established to prevent inappropriate development and protect open areas between towns and the character of settlements.

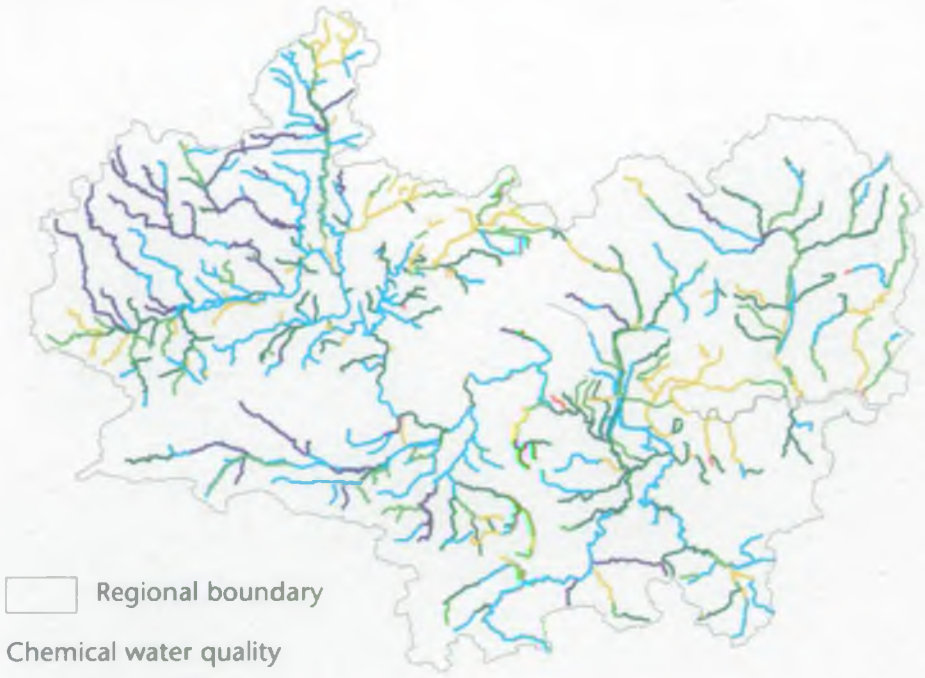


EC Designated Fisheries

The European Community (EC) Freshwater Fisheries Directive (78/659/EEC) 'on the quality of waters needing protection or improvement in order to support fish life' provides a statutory basis for the protection of water quality in certain rivers. The length of river in the Region designated as Salmonid fishery is 443.4km and Cyprinid fishery is 976.6km.

Chemical River Water Quality

The General Quality Assessment (GQA) scheme is used to assess the quality of rivers, to monitor trends over time and to compare rivers in different areas. The general chemistry component of the GQA is made up of six grades (A to F) defined by standards of dissolved oxygen, biochemical oxygen demand and total ammonia. Alterations in chemical river water quality may reflect changes in the quality of discharges and changes in flow conditions.



Biological River Water Quality

The biological assessment of river water quality provides a broad measure of pollution and is based on monitoring invertebrates which live on the river bed. While the majority of rivers are classed a 'very good' or 'good', poorer water quality is seen around urban areas and below significant discharges. Improvements in biological river quality may reflect improvements in the quality of discharges. Reductions in biological river quality may result from low flows which reduce the dilution of discharge.

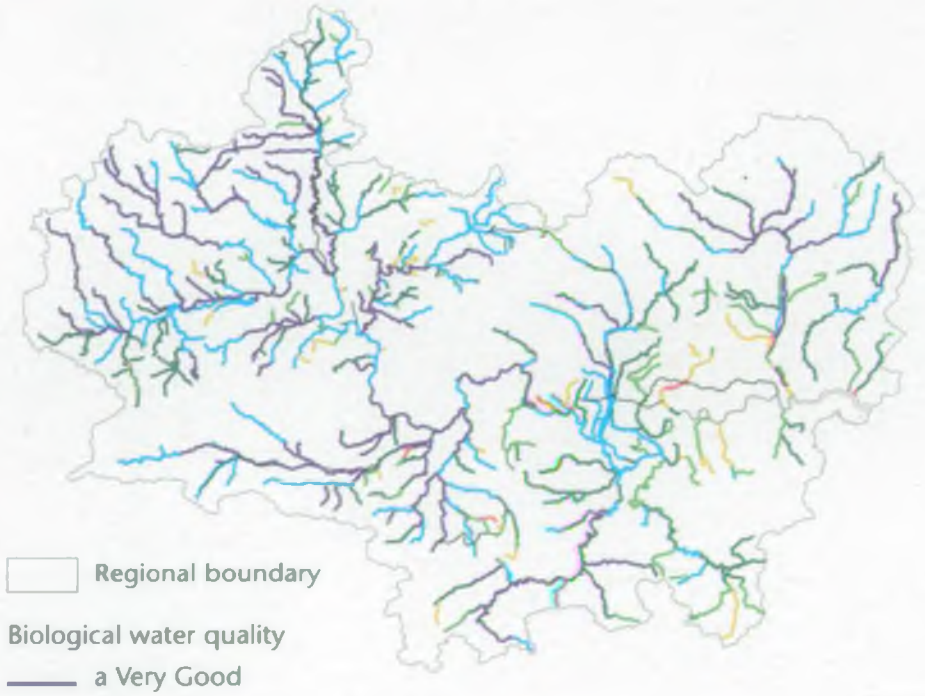


Figure 3.2 Average rainfall distribution, 1961-1990

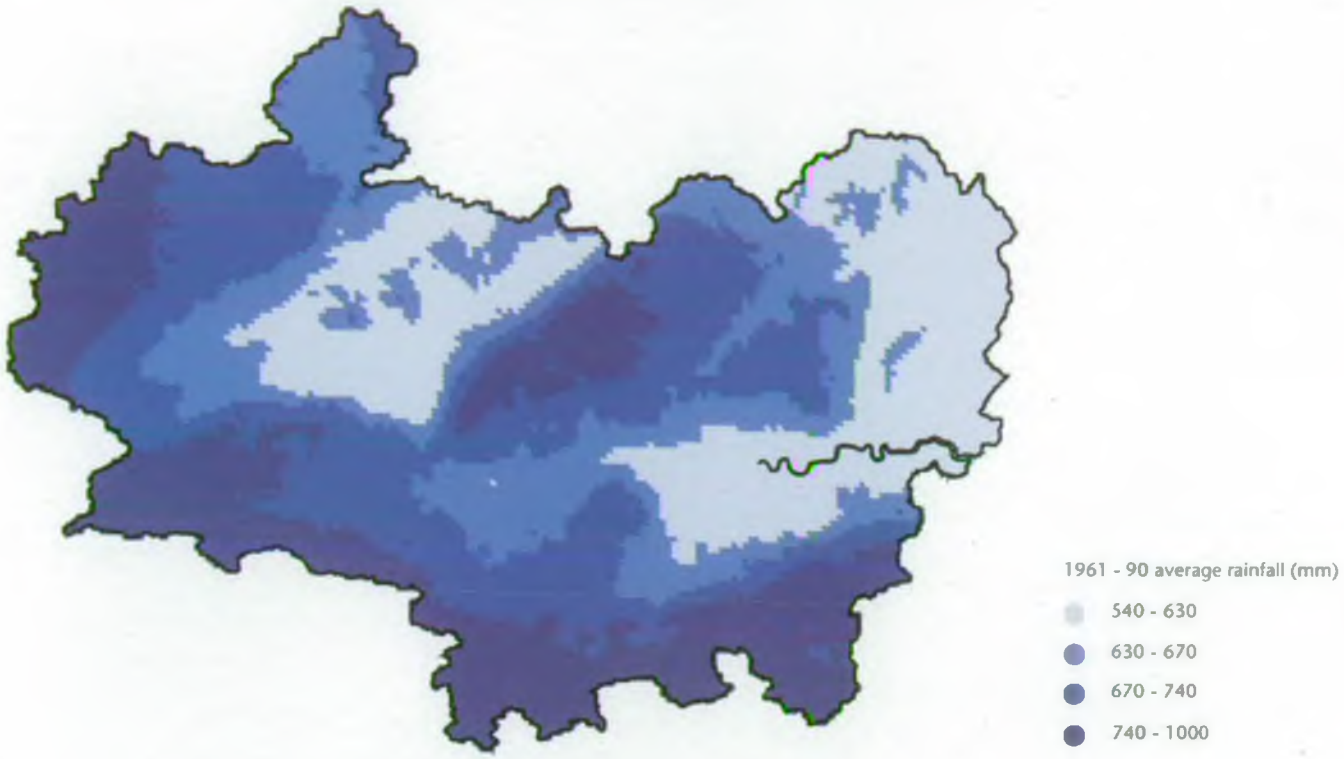


Figure 3.3 Long term average and effective monthly rainfall, 1961-1990

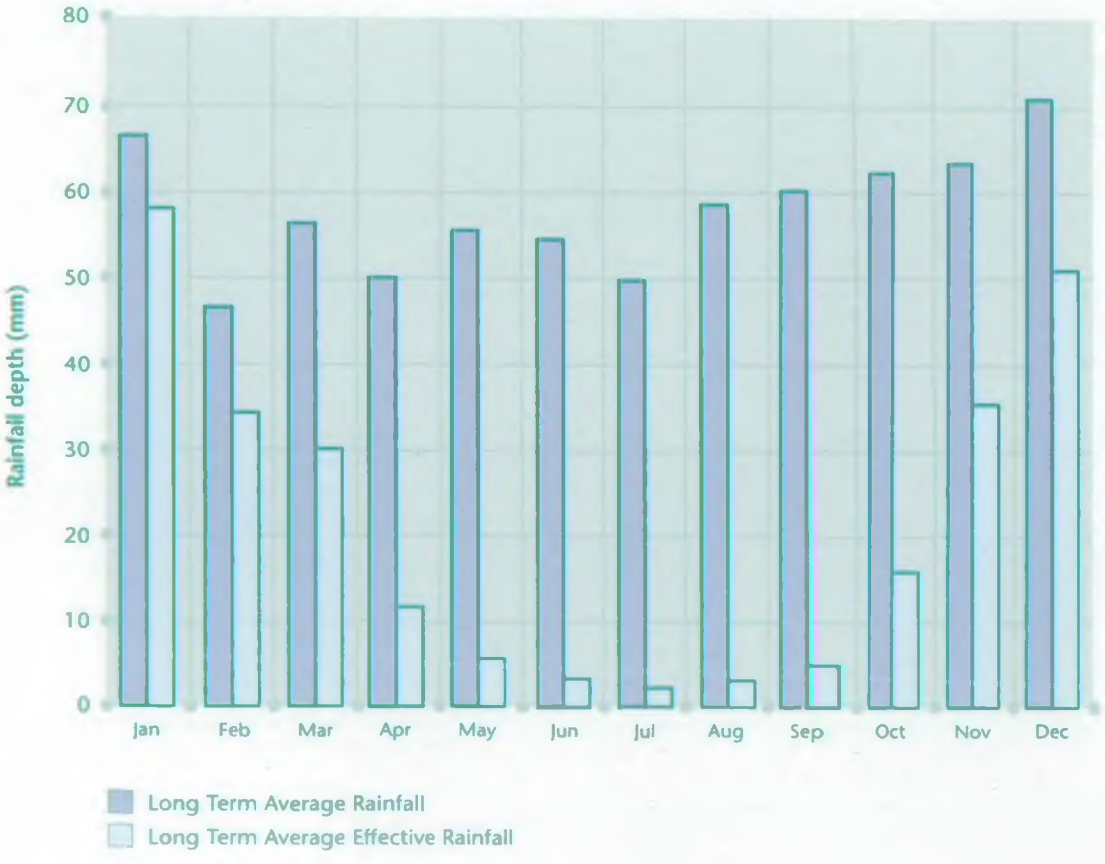
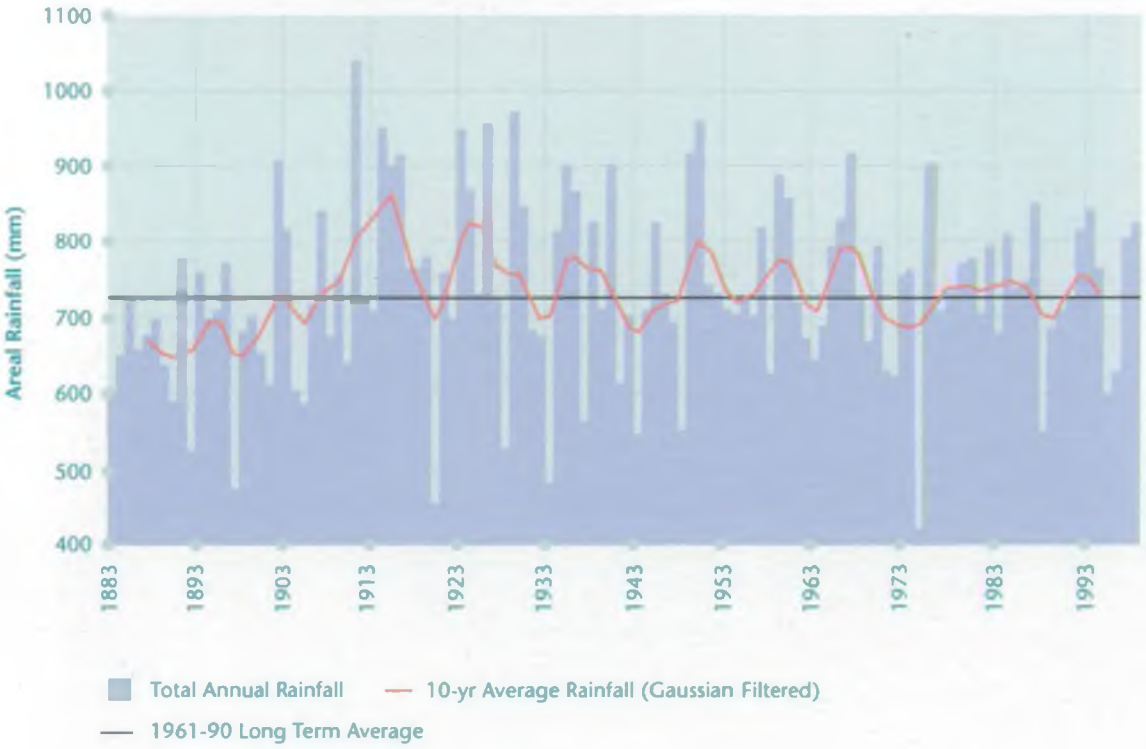


Figure 3.4 Rainfall in the Thames Region, 1883 to date



rainfall makes its way to streams, rivers or wetlands, and ultimately to the sea. Some water reaches rivers quickly, flowing over or through the soil. Where the underlying rocks are permeable, rainwater can infiltrate through the soil to become groundwater. The aquifers that carry groundwater act like a sponge, absorbing water and releasing it slowly to streams, rivers and wetlands. This stored groundwater maintains river flows during dry periods, particularly in summer, and is very important to our rivers, wetlands, water-dependent environment and our use of water.

The major aquifers in the region are the Chalk; the Great and Inferior Oolite Limestones of the Cotswolds; the Lower Greensand of Hampshire and Surrey; and parts of the lower Thames Gravel aquifers. Minor aquifers include the Bagshot Beds; the Upper Greensand; the Corallian Group; the Middle Lias and many of the various drift deposits such as Glacial Gravel. Different aquifers behave in different ways depending upon their storage and transmissivity characteristics. The Oolite aquifers tend to respond quickly to rainfall and equally quickly discharge that water to the streams and rivers of the Cotswolds. By contrast, the chalk aquifers tend to recharge and release water more slowly and play an essential part in sustaining the region's resources. The Lower Greensand aquifer reacts even more slowly than the Chalk.

Where there are no aquifers, water reaches streams and rivers quickly. This is more typical of the rivers draining clay or urban catchments in the region such as the Cherwell, the River Mole or the many smaller watercourses draining south-west London. In these catchments, the flow pattern is typically more "flashy", characterised by quick winter floods and very low summer flows.

Given a normal seasonal rainfall pattern, groundwater is replenished during winter and levels fall during summer. However periods of drought, especially with low winter rainfall, can change this pattern.

3.1.2 Drought

Droughts are natural phenomena caused by long periods of low rainfall. During such periods the annual effective rainfall across the region can be as low as 100 mm. Figure 3.4 shows the pattern of rainfall across the region recorded since 1883 and emphasises the key drought periods experienced in the region: from the late 1880s to early 1900s, 1921/22, 1933/34, 1943/44, 1975/76, 1989-92 and 1995-97.

These extended dry periods affect many rivers. Groundwater and wetlands maintain river flows long after the last rain has fallen. When these supplies are not replenished river flows drop to very low levels. The return of rainfall following a dry period is not the end of a drought as dry soils soak up the rain so that it may

Table 3.1 **International comparison of water resources**

	Annual internal renewable water resources		Annual abstraction 1997			Sectoral abstraction (%)		
	Total (cubic km)	Per capita (cubic meters)	Total (cubic km)	Percentage of water resources	Per capita (cubic meters)	Domestic	Industrial	Agricultural
England & Wales	68.17	1334.13	15.26	22.38	298.56	41	45	14
Regions								
Anglian	4.14	691.22	0.95	22.85	157.95	78	13	9
Midlands	6.12	726.62	2.36	38.50	279.78	34	64	2
North East	9.33	1299.30	1.32	14.11	183.39	63	23	15
North West	10.97	1643.03	1.02	9.33	153.35	54	38	8
Southern	3.73	921.38	1.03	27.48	253.18	50	7	44
South West	11.17	2739.69	2.06	18.47	505.94	19	31	50
Thames	3.09	265.59	1.82	59.02	156.76	87	6	8
Environment Agency Wales	19.61	6419.47	4.70	23.95	1537.78	16	81	3
Europe								
France	180.00	3065.00	37.73	21.00	665.00	16	69	15
Germany	96.00	1165.00	46.27	48.00	580.00	11	70	20
Italy	159.40	2785.00	56.20	35.00	986.00	14	27	59
Netherlands	10.00	635.00	7.81	78.00	518.00	5	61	34
Portugal	38.00	3878.00	7.29	19.00	738.00	15	37	48
Spain	110.30	2775.00	30.75	28.00	781.00	12	26	62
North America								
Canada	2849.50	94373.00	45.10	2.00	1602.00	18	70	12
United States	2459.10	8983.00	467.34	19.00	1839.00	13	45	42

Source: England & Wales - Environment Agency; rest of the World - data table by World Resources Institute 1998-99, Freshwater Resources and Withdrawals 1970-98.

take many weeks before a sustained rise in groundwater and river levels is seen.

Given the intensive use of water resources within the region, the pressure on the balance between the needs of abstractors and the environment is particularly acute during droughts. Both the Agency and the various water companies have prepared drought plans to identify the management and monitoring arrangements that would be implemented during drought periods in order to ensure a balance between essential water use, the imposition of restrictions on some uses and the requirements of the environment.

England and Wales are commonly perceived as wet; indeed, recent heavy flooding has reminded us how very wet it can be. Table 3.1 puts this perception into context. The relatively high population density means that England and Wales receive less rainfall per person than many other countries that are commonly perceived as dry. This is particularly true for the Thames Region where population density is especially high and where rainfall is relatively low. The table reveals that a high proportion of the rainfall that falls on the region is actually abstracted for use each year. This intensive use of water resources within the region is achieved by the downstream reuse of water that has been abstracted and discharged upstream.

3.2 Distributing water

3.2.1 Abstraction

In order to ensure that sufficient water is available for us to use, we need to ensure that water is available at the right place at the right time, whilst minimising the impact on the water environment.

Water is abstracted from surface and groundwater sources either for use directly by the end user, or for treatment and distribution by water companies. Five water companies supply the region: Thames Water, Three Valleys Water, North Surrey Water, Sutton and East Surrey Water, and South East Water. Unless otherwise stated, references to South East Water relate to their Hampshire and Surrey area, which lies within

Thames Region. In parts of the region local sources are insufficient, or provide inadequate security of supply in dry spells. This has led to the development of systems that make conjunctive use of groundwater, surface water resources and reservoirs to maximise the available resource particularly at times of drought. Larger schemes often involve the bulk transfer of water across the region. Two of the largest such systems are those operated by Thames Water, in the Upper Thames (incorporating both Swindon and Oxford) and in London. In addition, water resources in London are maximised through schemes that artificially recharge the confined aquifer in North London.

The region's main water resources are shown in Figure 3.5. This illustrates how the natural resources of the rivers and groundwater are supplemented by artificial storage in major reservoirs and transfers of various kinds, including transfers from outside the region. This network of abstraction, storage and transfers has evolved in line with rising water demand over the last century. It has proved largely robust during the severe droughts of the 1990s, although some limitations were imposed on water use. Some of the water companies had hosepipe bans and some restrictions on abstraction for irrigation were imposed by the Agency.

3.2.2 Leakage

A significant proportion of water abstracted for public water supply is lost through leakage from the distribution and mains systems, and supply pipes on customers' premises. Losses vary across the region (Figure 3.6). This is due to a number of different factors, including the age of the mains (more than 150 years old in London), statutory pressure requirements and clay ground conditions prone to heave and desiccation. Less obvious factors such as shrinkage of clay soils in summer and ground movement due to winter frosts result in mains and pipe bursts that further increase leakage levels.

Farmoor Reservoir, near Oxford, part of Thames Water's Upper Thames system

Over the last ten years there has been a significant shift in the perception of leakage by Government and the general public which has prompted a change in leakage control policy. After the 1997 Water Summit, mandatory leakage control targets were introduced and this has resulted in a marked reduction in total levels of leakage (Table 3.2). Current targets are set by Ofwat

Figure 3.5 **Principal features of the region's water resources**

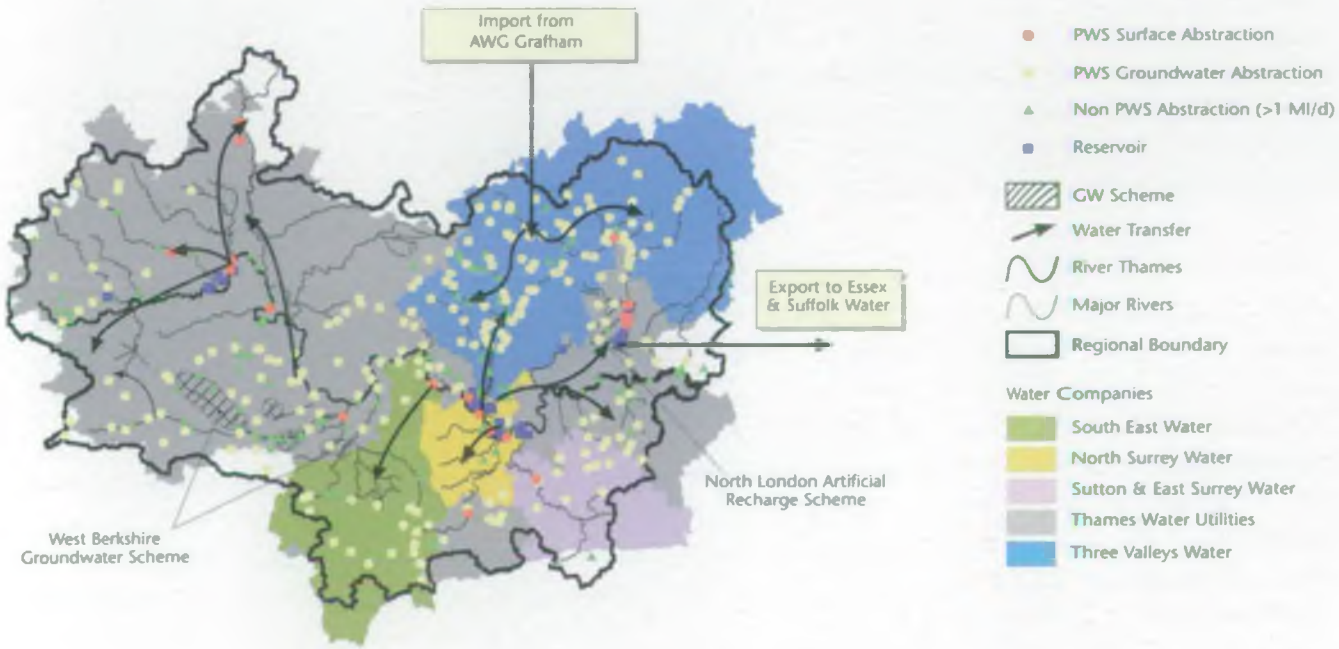
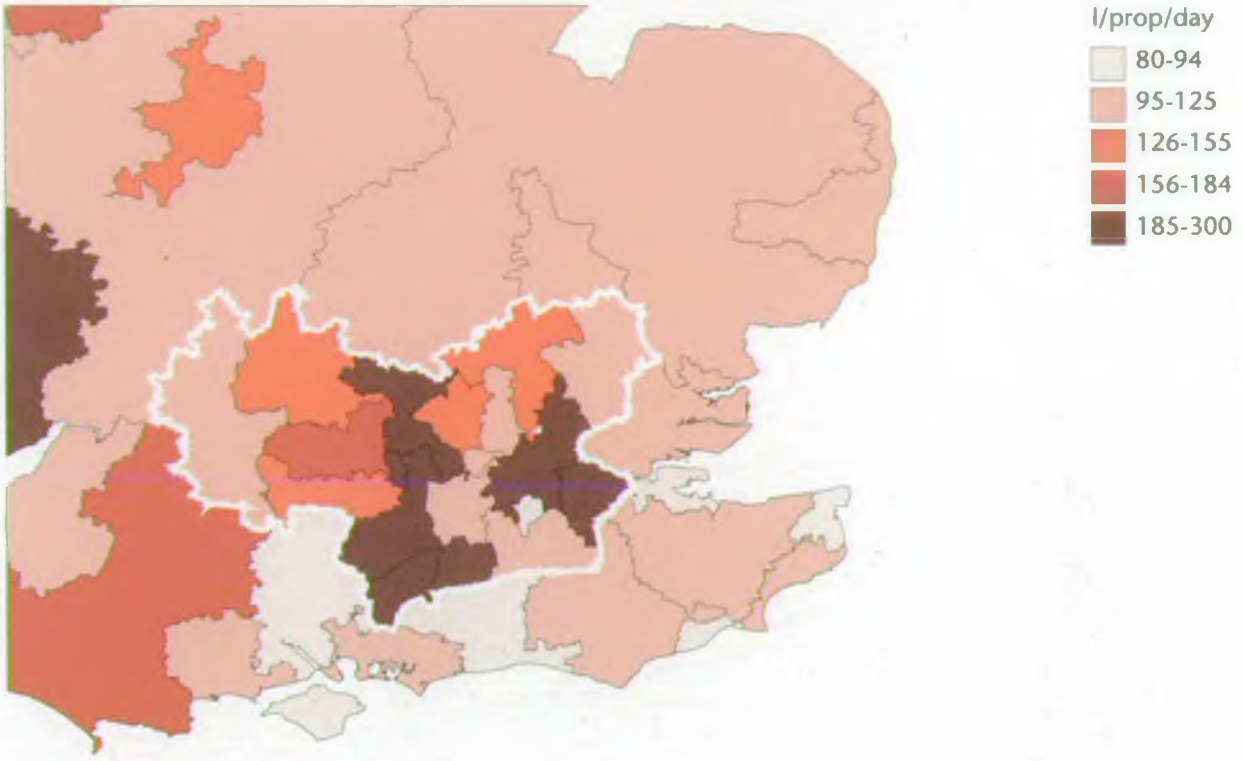


Figure 3.6 Estimated total leakage (1999-2000)

a. Leakage (litres/property/day)



b. Leakage (m^3/km of mains/day)

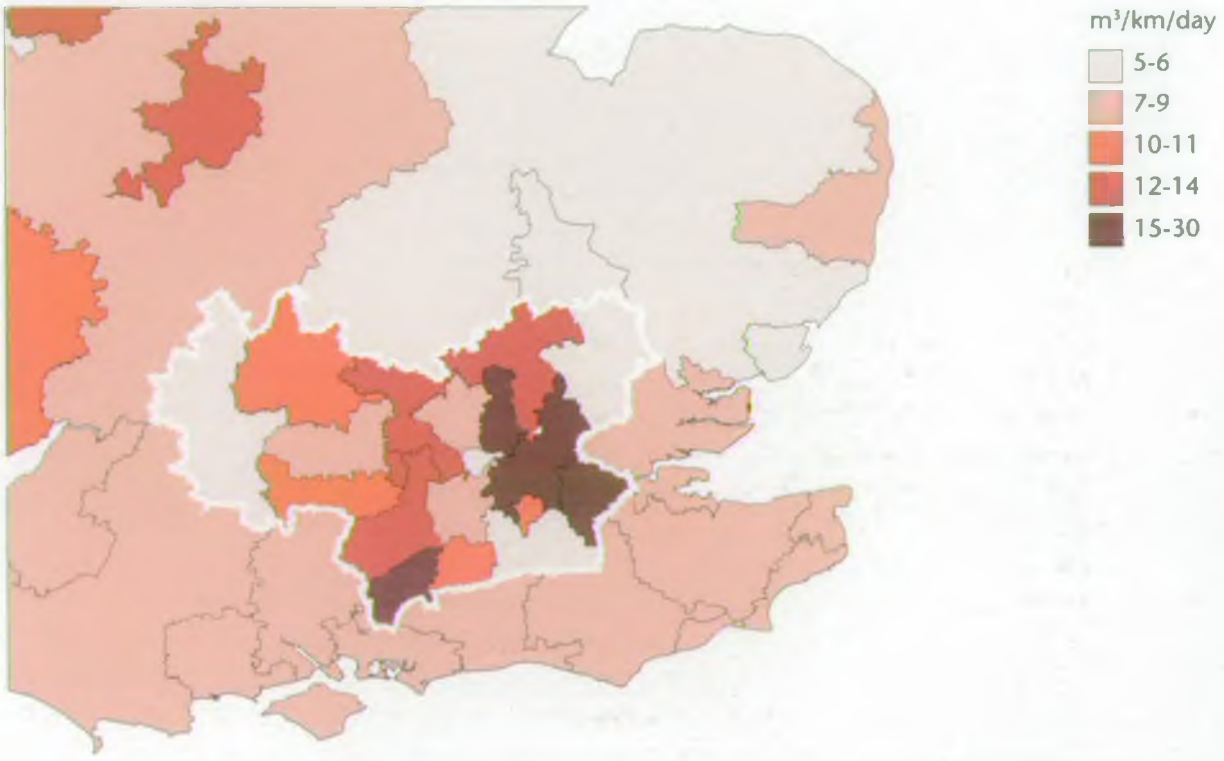


Table 3.2 **Water company leakage**

	Total leakage (Ml/d)			Leakage targets
	1992-93	1995-96	1998-99	1999-00
Anglian	212	236	201	195
Essex & Suffolk	95.9	90.3	76.4	74.3
Cambridge	16.1	16	13.1	14.4
Tendring Hundred	5.6	6.4	5.5	5.4
Severn Trent	570	632	344	342
South Staffs	83.1	92.9	77.1	76.1
Northumbrian	180	190	171	168
Hartlepool	5	6.1	4.7	4.7
Yorkshire	494	485	333	329
York	11.1	9.9	9	9.1
North West	945	789	510	489
Folkestone & Dover	14.3	12.7	8.7	8.6
Mid Kent	39.5	39.7	30.1	29.2
Portsmouth	33.4	30.3	30.5	30.3
South East	89.7	94.2	98.9[1]	79.1
Southern	161	120	95	93
South West	158	142	92	84
Wessex	137	133	100	89
Bristol	63.9	65.5	56.4	54.8
Bournemouth & W Hants	27.3	27.5	25.7	23.6
Thames	803	1109	770	665
Three Valleys	175.3	168.1	135	122.7
North Surrey	29.7	31.4	22.3	22.8
Sutton & East Surrey	34.7	26.1	24.9	24.5
Dŵr Cymru (Welsh Water)	383	413	306	292
Dee Valley	13.9	14.6	11.9	11.8
Industry total	4782	4981	3552	3337.4

[1] 1996/1997 figure
As Cholderton & District is a very small company, not all of the information is readily available or appropriate.

Source: Ofwat 1998-1999 Report on Leakage and Water Efficiency

based either on the company's assessment of the economics of leakage control or where this is not considered to be robust on the company's relative resource position and existing levels of leakage. Those companies with greater water stress are expected to have lower levels of leakage. A joint DETR, Environment Agency and Ofwat project has been instigated to explore opportunities to determine a future approach to leakage target setting.

In 1997/98 reported total leakage accounted for just over 26% of the total water put into supply in the region.

3.2.3 Transfers

A transfer of water from one place to another requires:

- a reliable source of water;
- a means for the transfer (pipeline, river, or canal);
- a demand for the water in another location.

Transferring water from one place to another is relatively expensive. Water is heavy and bulky, which means its movement can consume much energy.

There are a number of bulk transfers of water in operation across the region. These are shown on Figure 3.5 and described in Table 3.3 and include transfers into

Table 3.3 Principal strategic transfers

Bulk transfer agreements From	To	Type	Agreed Quantity (Ml/d)
Grafham Reservoir (Anglian)	Three Valleys	Raw water	91
Lee Valley Reservoirs (Thames)	Essex & Suffolk	Raw water	91
Egham (North Surrey)	South east	Treated water	36
Fortis Green (Thames)	Three Valleys	Treated water	27*
Kempton Park (Thames)	North Surrey	Treated water	23
London (Thames)	Sutton & East Surrey	Treated water	14
Thames Valley Reservoirs (Thames)	Iver (Three Valleys)	Raw water	10
Within company transfers From	**To**	**Type**	**Current Quantity (Ml/d)**
Iver (Three Valleys)	Three Valleys (Zone 4)	Treated water	227
Bray (South East)	Northern zone (South East)	Treated water	45
Gatehampton (Thames)	Oxford (Thames)	Treated water	40
Farmoor Reservoir (Thames)	Swindon (Thames)	Treated water	21
Farmoor reservoir (Thames)	Banbury (Thames)	Treated water	15

* (currently restricted to 10 Ml/d)

the region (from Anglian Water Group's Grafham reservoir to Three Valleys Water) and out of the region (from Thames Water to Essex and Suffolk Water).

3.3

Uses of abstracted water

We abstract water for many different purposes. An understanding of current water use is essential in helping to develop our view on the scale and scope of future changes. Figure 3.7 breaks down licensed and actual abstraction from non-tidal sources into its constituent uses. Public water supply represents by far the largest use of water in the region.

Below we consider both public water supply and direct abstraction under the following broad headings:

- household water use;
- industry (considering both mains water and direct abstraction);
- agriculture;
- power generation.

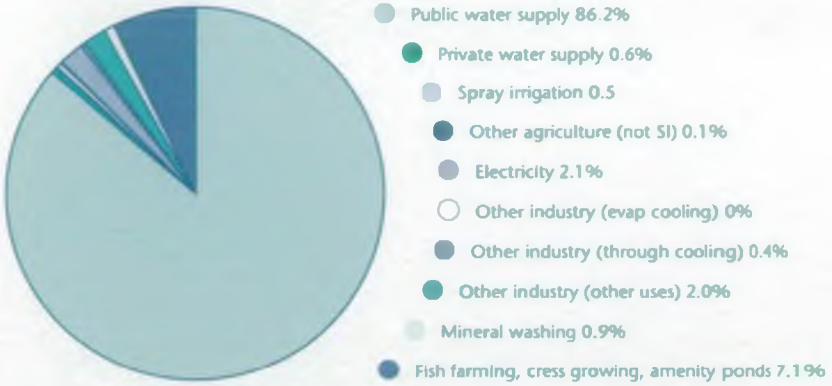
These categories cover the most important uses of water. Public water supply accounts for 86% of actual abstraction in the region (based on 1998 abstraction returns). The key components of public water supply demand are shown in Figure 3.8. and are described further below.

3.3.1 Household water use

Household water use is the largest single component of public water supply, accounting for just over half of the total demand, or two-thirds of consumption when leakage is subtracted. Personal or per capita use of water varies between measured and unmeasured households, and is influenced by many factors including: household size and type, appliances owned and their water efficiency and other water-using fixtures and fittings. Average per capita use across the region, and in neighbouring zones, is shown in Figure 3.9. Per capita consumption ranges from 164 litres/head/day (l/h/d) to 185 l/h/d. The number of metered households continues to increase (Figure 3.10) and currently accounts for 16% of total households across the region.

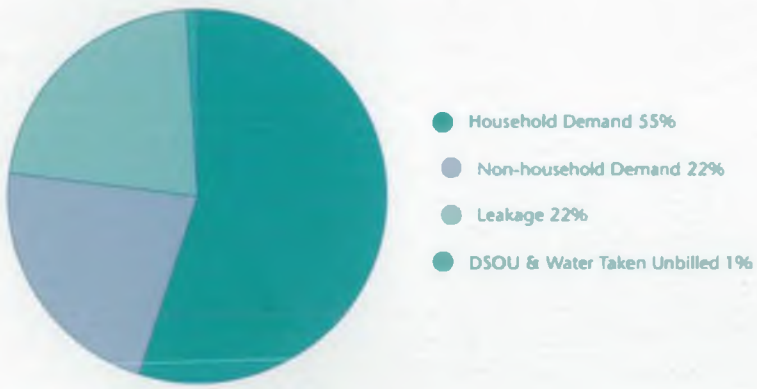
Most water used in households is returned to rivers or the sea through the sewerage network. The reuse of this water is an important element in the region's resources. Approximately half of the water abstracted for use is subsequently treated and returned to inland waters where it supports summer river flows and further abstractions. The exception is London, where water abstracted for supply is mostly returned after treatment to the Thames Tideway.

Figure 3.7 Non-tidal licensed & actual abstraction in 1998



	% of Total Licensed Quantity	% of Licensed Quantity Actually Abstracted	Actual Abstractions (Ml/d)
Private & Public Water Supply	82.3	82.7	4335
Agriculture & Spray Irrigation	0.9	56.2	33
Electricity	3.7	45.0	105
Industry & Services	5.4	49.8	170
Fish farming, cress growing & amenity ponds	7.8	71.8	355

Figure 3.8 Components of public water supply



	Population 000's	Properties 000's	Household Demand Ml/d	Non-household Demand Ml/d	Leakage Ml/d	DSOU & Water Taken Unbilled Ml/d	Total Demand Ml/d
Thames	7801	3426	1397	628	662	36	2723
Three Valleys	2441	1008	457	142	122	6	727
South East	752	291	129	47	62	2	239
North Surrey	480	198	82	35	23	0	140
Sutton & East Surrey	634	267	111	28	24	1	164
Region	12109	5190	2176	880	893	45	3994

Data for South East Water as a company total
DSOU = Distribution System Operational Use
Source: 1999-2000 Ofwat report on Leakage and the Efficient Use of Water

Figure 3.9 **Per capita consumption**

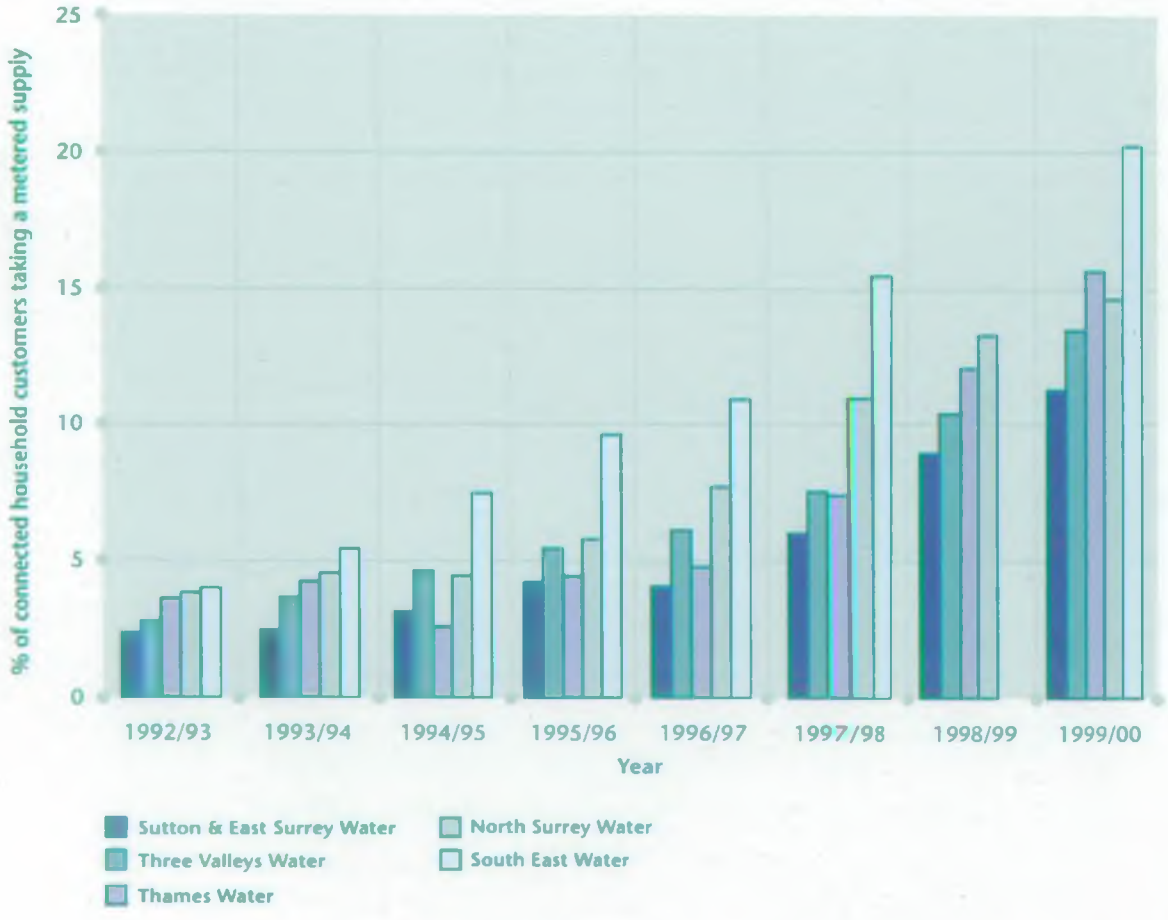
a. unmeasured PCC

b. measured PCC

l/head/day

130 - 147
148 - 157
158 - 167
168 - 179
180 - 196

Figure 3.10 **Trends in household metering**



Data for South East Water as a company total

Ofwat does not consider South East Water's water balance for 1998-99 to be robust. Therefore the data is omitted

Source: 1992-93/1995-96 Ofwat report on the Cost of Water Delivered and Sewage Collected
1996-97/1998-99 Ofwat report on Leakage and Water Efficiency
1999-2000 Ofwat report on Leakage and the Efficient Use of Water

3.3.2 Industry

Over 80% of demand by industry within the region is met through the public water supply system. This accounts for 21% of total public water supply and includes a wide range of industrial and commercial enterprise. Demand is closely linked to economic trends generally and across specific sectors. Whilst the region is well represented in traditional service and manufacturing sectors, new and rapidly growing sectors include: business services, information and communication technology and biotechnology. Current trends in demand reflect the reduction in intensity of water use in manufacturing, an increase in use in the services sectors (largely for domestic and air conditioning uses) and more positive drives over recent years in waste minimisation. These trends show a slight decline regionally.

The remaining 20% of industrial demand is met through direct licensed abstraction from rivers and groundwater. The main uses in the region are for primary industry and manufacturing and mineral extraction, mainly sand and gravel working.

Direct abstraction represents a relatively cheap source of supply for primary industry and manufacturing sectors, and is used for evaporative and non-evaporative cooling as well as for process water. Non-evaporative cooling is mainly non-consumptive, with a large proportion of the water returned to river systems below the point of abstraction.

Public water supply represents for industry a more costly supply of high quality water. In many parts of the region industry may require dual supply from direct abstractions and public water supply to ensure reliability and optimise costs.

3.3.3 Agriculture

The most significant use of water by the agricultural sector is spray irrigation. This is a highly consumptive use of water with virtually no return discharges to the river system. Because it is concentrated in summer months, and periods of exceptionally low rainfall, the demand for water for irrigation places severe stress on ground and surface water sources at a time of the year when flows are at their lowest. Over the last 15 years, the number of winter abstraction licences has increased, with many farmers investing in reservoir storage.

In the Thames Region, spray irrigation is a very small but locally very important use of water. It represents less than 0.5% of the total demand within the region.

Spray irrigation is a highly consupmtive use of water within the agricultural sector

Over the last five to ten years supermarkets and food processing firms have extended their influence over all areas of on-farm decision-making, through the development of farm assurance schemes and integrated crop management protocols. Within the context of these schemes and protocols, farmers have limited flexibility to incorporate water efficiency measures into their farm management practices. Only when these specifications change will it prove economically viable for farmers to implement medium-term water efficiency measures.

Apart from spray irrigation there are a number of other uses of water on the farm including milk cooling, animal watering, dilution of chemical sprays, vehicle washing, cleaning of yards and specialist dairy equipment, and food preparation. Farmers draw on both public water supplies and direct abstraction from rivers and groundwater.

Agricultural use includes fish farming and cress growing. In both cases, whilst they represent significant abstractive demands, water is used and returned to local watercourses. The local impact of these uses is normally managed through operating arrangements specified within licences.

3.3.4 Power generation

Power generation is a significant use of water in the region, with the water primarily used for cooling. Tidal waters provide nearly 95% of this demand. The Didcot Power Station in Oxfordshire is the only significant abstractor of non-tidal water for power generation purposes.

As part of its response to climate change, the Government has made a commitment to reduce the UK emissions of greenhouse gases. This includes a requirement that, by 2010, 10% of UK electricity will be produced from renewable sources. Whilst new power

Didcot power station is the largest abstractor of non-tidal water for power generation

stations generally use less water, with some being air-cooled, the specific implications for water resource management relate to the development of hydropower and new crops for bio-fuel.

Flat terrain and low reliably available river flows limit the potential for hydropower generation in the region. Nonetheless, there has been some interest in small-scale hydropower generation as an alternative means of producing energy, focussing particularly on the potential for "low head" energy schemes. These typically comprise turbines built into weirs, in bypass channels or tidal barrages and require large volumes of water to generate commercial quantities of power. As a consequence, the potential for schemes is limited largely to the lower reaches of rivers, and principally to the middle and lower Thames. We do not envisage a water resources issue with any future proposals specific to the River Thames control structures. However, further detailed consideration would be required of the impacts on water resources, flood defence and land drainage operations, fish passage (including protection from ingress into turbines) and navigation of any proposals for other watercourses where abstraction or diversion may be needed.

3.4

Recreation and other uses of water

3.4.1 Navigation

The rivers and canals of the region have a long history of navigation, which remains an important use of water. Use is now mainly recreational, but many people value the opportunity to travel on the waterways. While it is non-consumptive, navigational needs affect water resources in many ways. On rivers, it may be necessary to maintain levels to allow boats to pass. This is an important control on abstraction in some locations including the lower reaches of the River Thames, where Thames Water's abstractions need to be managed in such a way as to control and maintain river levels. Canals often take water from one catchment and move it to another, through the use of locks. If canal traffic rises, more water may be needed. The Government has signalled in the draft Water Bill (DETR, 2000e) its intention to bring abstractions to supply canals into the abstraction licensing system. The exact duties of the Agency and navigation authorities such as British Waterways will need clarification, but the new legislation will increase the need in the future for good forecasts and planning of navigational water demand in co-operation with the Agency.

In the Thames Region, the principal navigation authorities are the Environment Agency, for the navigation of the Thames, and British Waterways, for navigation of canals and waterways including the Kennet and Avon, Oxford and Grand Union canals and Lee navigation.

Abstractions on the Lower Thames are controlled to maintain levels for navigation

The restoration of disused canals or the creation of new navigations can present a significant challenge for the provision of water. The Agency has a Navigation Restoration Policy and works closely with those considering restorations to ensure that water will be available without detrimental impact on the environment or other abstractors. Important opportunities and issues for the region's water resources include the potential restoration of the former Thames-Severn and Wilts-Berks canals.

3.4.2 Angling

Fish are an integral part of the aquatic environment and often provide a good indicator of a well-balanced ecosystem due to their position towards the top of the

The otter is one of many BAP species found in the region

3.4.4 Other recreation and amenity

The region is rich in inland waters, rivers, canals, lakes and flooded gravel pits which act as magnets to people in their leisure time. These waters are used for all kinds of activities: angling, bird-watching, boating, canoeing, diving, rowing, walking or simply river watching. The requirements of these various activities often conflict, calling for careful management, especially in areas dependent on tourism, where growth may be desirable to sustain local communities but where there is a risk of damaging the essential nature of the environment on which tourism is built.

The Region's waterways are popular sites for recreation

3.5 Water resources and the environment

The present environment of the region is the result of many factors, including climate, geology and topography. Water is an essential part of our natural environment, because of the way that it supports plant and animal life and shapes the landscape.

To understand the present status of water resources, we need to identify how much water is required to protect these environmental assets. To summarise the current position we have produced three maps. They cover summer surface water availability (Figure 3.11), winter surface water availability (Figure 3.12) and groundwater availability (Figure 3.13). It is not appropriate to separate an assessment of groundwater availability between summer and winter, because the characteristics of most aquifers mean that rainfall stored in the winter is released to rivers and wetlands gradually throughout the year.

Each map shows three categories. These are:

- unsustainable or unacceptable abstraction: current actual abstraction is causing definite or probable environmental problems, or problems are anticipated if abstraction reaches full licensed volumes;
- no additional water available: licensed abstraction does not pose a threat to the environment, but it is considered that there is little scope for further abstraction;
- additional water available: additional water may be available, although at any specific site volumes available may be small and reliability may be low and usually restricted to the winter months.

These maps represent the strategic position across the region. They are not intended to prejudge licensing decisions for any proposed abstraction. Various considerations would be needed, including an appropriate evaluation of the environmental impacts of the proposal. Within each mapped area there will be local variations, so the map cannot be used to reach a conclusion for a specific site. The maps are based on the average conditions across large areas whereas individual locations may have further environmental needs for water.

3.5.1 Summer surface water

Figure 3.11 shows that summer surface water throughout the region is already fully committed to existing abstractions and the environment, and that no significant further resource is available. In most catchments existing abstractions do not cause widespread environmental problems. However, there are several areas, coloured red on the map, where the combination of licensed surface and groundwater abstractions does exceed the assessed limit and action to resolve the problems arising may involve changes to both surface and groundwater licences in the longer term. These are the Churn, Ampney Brook, Wye and upper Wey catchments, the Gade and Bulbourne subcatchments of the River Colne, and the Mimram and Beane subcatchments of the River Lee.

The Region's rivers, lakes and canals are hugely popular for angling

food chain. The length of river in the region designated as salmonid fishery is 443 km, with a further 977 km designated as coarse, cyprinid fishery.

Fish rely on an adequate supply of water throughout their life cycle. Of particular importance is the effect of water flow on the migrations of salmon and sea trout, both downstream as smolts and upstream as spawning adults from the sea. Generally increases in river flow, known as spates, stimulate these movements and are important in enabling adult fish to negotiate obstructions. The Agency, with the co-operation of Thames Water, has been managing abstractions from the lower reaches of the River Thames at times when flows are low, in order to provide artificial spates to assist the returning adult salmon.

Angling for both coarse and game fish is an important and hugely popular use of rivers, lakes and canals. The fish populations, as well as having a significant conservation value, support important rod fisheries in the region.

3.4.3 Wildlife conservation

As the main organisation with responsibility for pollution control and water management in England and Wales, the Agency is an important contributor to wildlife conservation, especially in wetland and river habitats. Wildlife conservation generally aims to maintain or enhance natural biodiversity. Its success depends on understanding the environmental requirements of habitats and species and how plants and animals interact.

The Environment Act 1995 gives the Agency a duty to promote the conservation and enhancement of the natural beauty and flora and fauna of inland and coastal waters and associated land. England and Wales have a relatively rich biodiversity, although between 10% and 20% of our native species are considered to be threatened in some way. The Agency has lead responsibility for 39 species and five habitats of wetland character under the UK Biodiversity Action Plan (UKBAP)(UK Government, 1994). The UKBAP identifies the need to take opportunities for enhancing wetland habitats. In its lead role, the Agency will need to explore with others how such opportunities can be supported.

The way that we manage water resources plays an important part in maintaining or enhancing biodiversity. In setting conditions on abstraction licences, we carefully consider the needs of wildlife, and where there is doubt, we make decisions based on the precautionary principle. The Agency is also a competent authority under the Conservation (Natural Habitats etc.) Regulations 1994 which implement the Habitats Directive, which is designed to protect sites of international importance to specified flora and fauna. This means that we must ensure that designated sites and associated wildlife are not harmed by current or proposed abstractions.

Flows on the Thames are managed to encourage salmon returning upstream

Figure 3.11 Current indicative resource availability: summer surface water

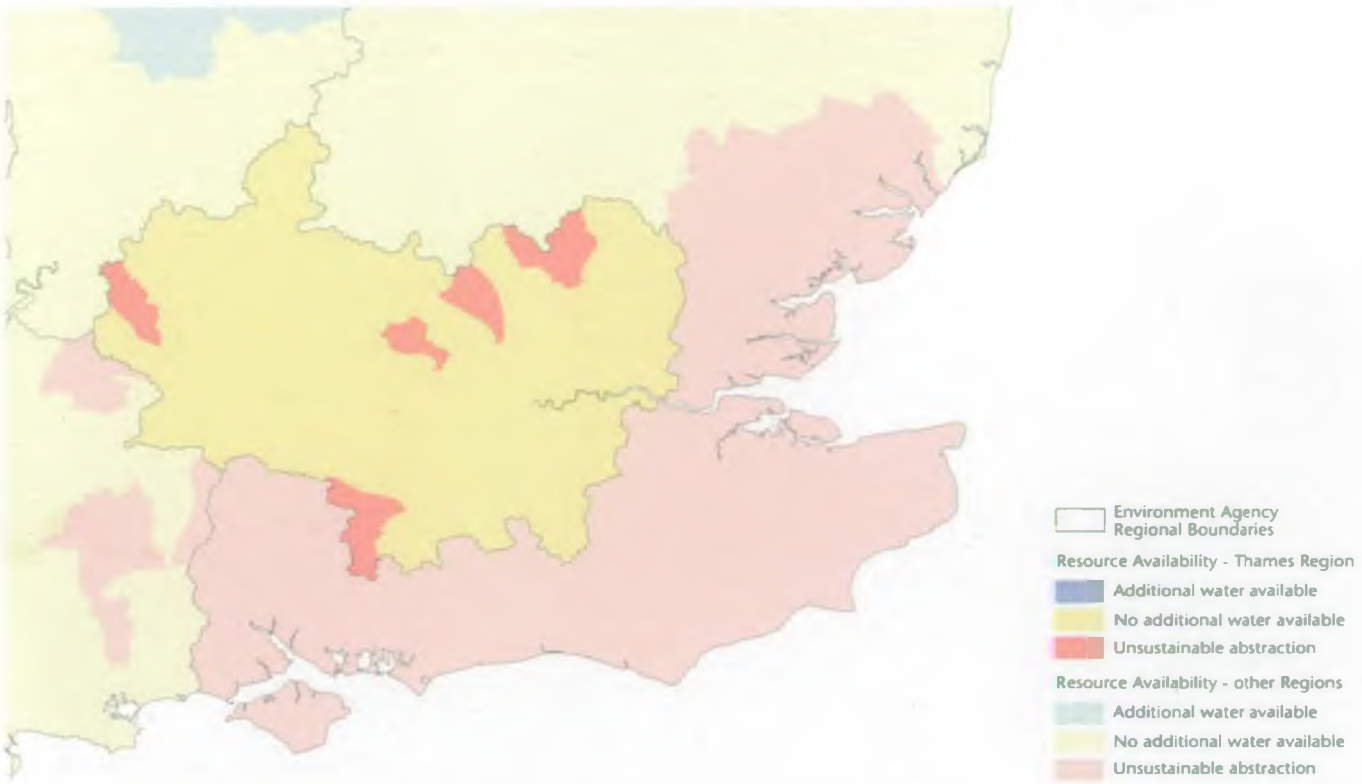


Figure 3.12 Current indicative resource availability: winter surface water

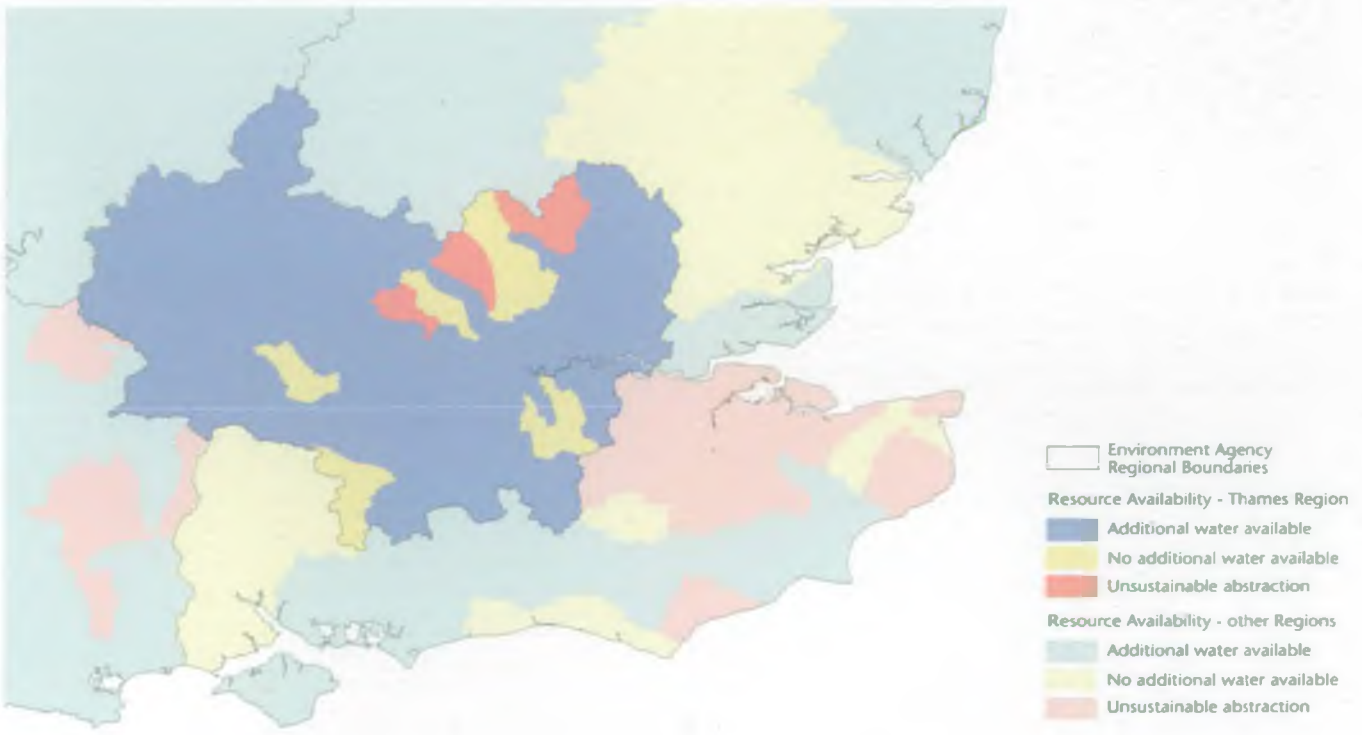
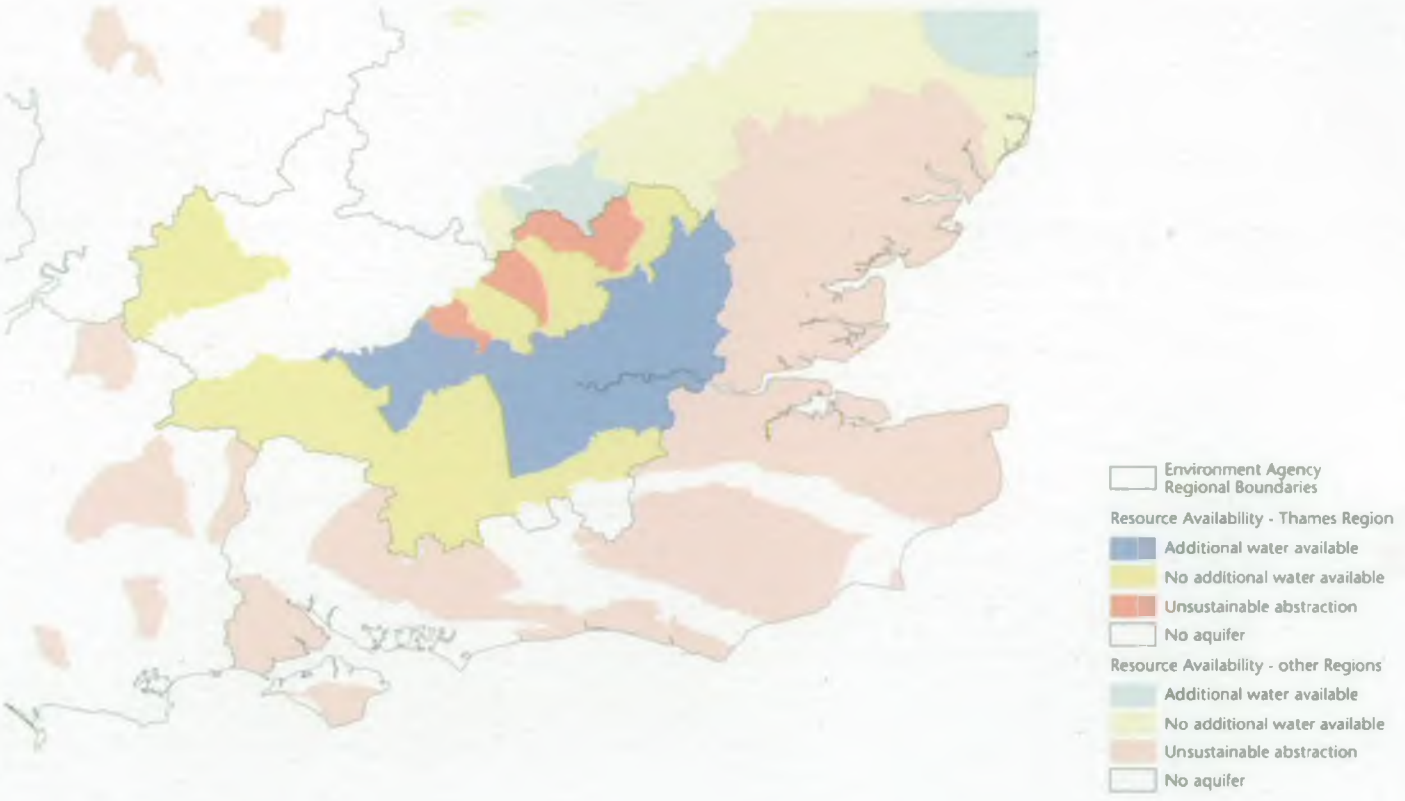


Figure 3.13 **Current indicative resource availability: groundwater**



3.5.2 Winter surface water

For much of the region further winter water is still available in principle. Any new or additional abstraction will be subject to local appraisal of need and impacts, and any licence granted would contain conditions to protect low flows and the environment.

There are some parts of the region where winter surface water is not reliably available (see Figure 3.12). These mostly occur in catchments that have existing or resolved abstraction problems and where the overall resource is either compromised or in balance. These include most of the catchments mentioned above (apart from the Churn and Ampney Brook). Other areas affected are the Pang, Wandle, Hogsmill, Misbourne, Ver and upper Colne catchments.

3.5.3 Groundwater

Large parts of the region's groundwater resources are broadly in balance. No significant further resource is available, but existing abstractions do not cause widespread environmental problems.

Figure 3.13 shows that additional groundwater resources are available in the middle Thames and in the confined aquifer under London.

There are, however, a few areas with significant environmental problems. They are those parts of the chalk and limestone aquifers which provide the base flow in those catchments where the current flow regime is unacceptable throughout the year. These are the Wye catchment, the Gade and Bulbourne subcatchments of the River Colne, and the Mimram and Beane subcatchments of the River Lee.

We have based the maps presented here on our local knowledge of catchment issues, our established licensing practices, and an understanding of the hydrology and hydrogeology of the area in question. We present these maps at the broad scale appropriate for the strategies, and they reflect our current understanding of the relevant issues. Catchment Abstraction Management Strategies (CAMS) will make detailed assessments for each catchment in a six-year programme starting later in 2001. Earlier this year we published the results of our consultation on the CAMS process and in the next few months we will present our proposed process.

3.5.4 Resource availability and water resource strategies

These maps provide important input to the development of our regional strategy in a number of ways:

- They highlight essential features of our regional licensing policies. For example, no licences are granted allowing abstraction of water in the summer months (April to October) for consumptive use except where a condition can be applied prohibiting abstraction at times when river flows fall below a prescribed flow.
- They highlight the important interdependence of groundwater and river flow and the need for appropriate constraints on abstraction to protect the environment and existing uses.
- They identify many of the additional environmental needs that we must begin to plan for.
- They highlight the constraints and challenges to the development of further water resources and start to point towards the type of solution that may be appropriate in different locations. Flow or level constraints will increasingly become the norm in licensing. The further development of water resources will need to be based on systems which optimise winter availability of resources through surface reservoir storage or artificial recharge of groundwater and which encourage the use and return of water upstream of the point of abstraction providing a net gain to the environment. This last point is particularly important to bear in mind when interpreting these maps. Seeking additional water resources in areas that suffer from over-abstraction would normally be inappropriate.

4 Pressures on water resources

Challenges to the sustainable management of water resources in the region come from a number of areas:

- Increasing demand for water, particularly from:
  - changing lifestyles and expectations pointing to more use of water around the home;
  - pressures in the south-east for new development (both housing and commercial);
  - high residual levels of leakage from public supply systems, particularly in London;
  - increasing competition in the industry.
- Environmental demands and environmental change:
  - reducing abstraction where there are existing, unacceptable impacts on the environment;
  - quantifying and planning for the environmental needs for water in future licensing;
  - trends in environmental quality affecting the treatment and use of water resources;
  - the impacts of land use change on hydrology, the environment and water resources availability.
- Drought and climate change:
  - managing the impacts of drought on supplies and the environment;
  - planning for the potential risks and uncertainties of climate change; not least in the development of "low 0regrets" policies and actions.

Whilst many of the potential pressures on our future water resources and the environment can be identified, in forecasting 25 years ahead many aspects of the future remain extremely uncertain. These include, for example, the effects of climate change and societal change. How society values the environment and chooses to use water in the future will determine the type and size of demands placed on water resources. Meeting these challenges will require a range of innovative and integrated solutions and responses.

4.1 Environmental needs

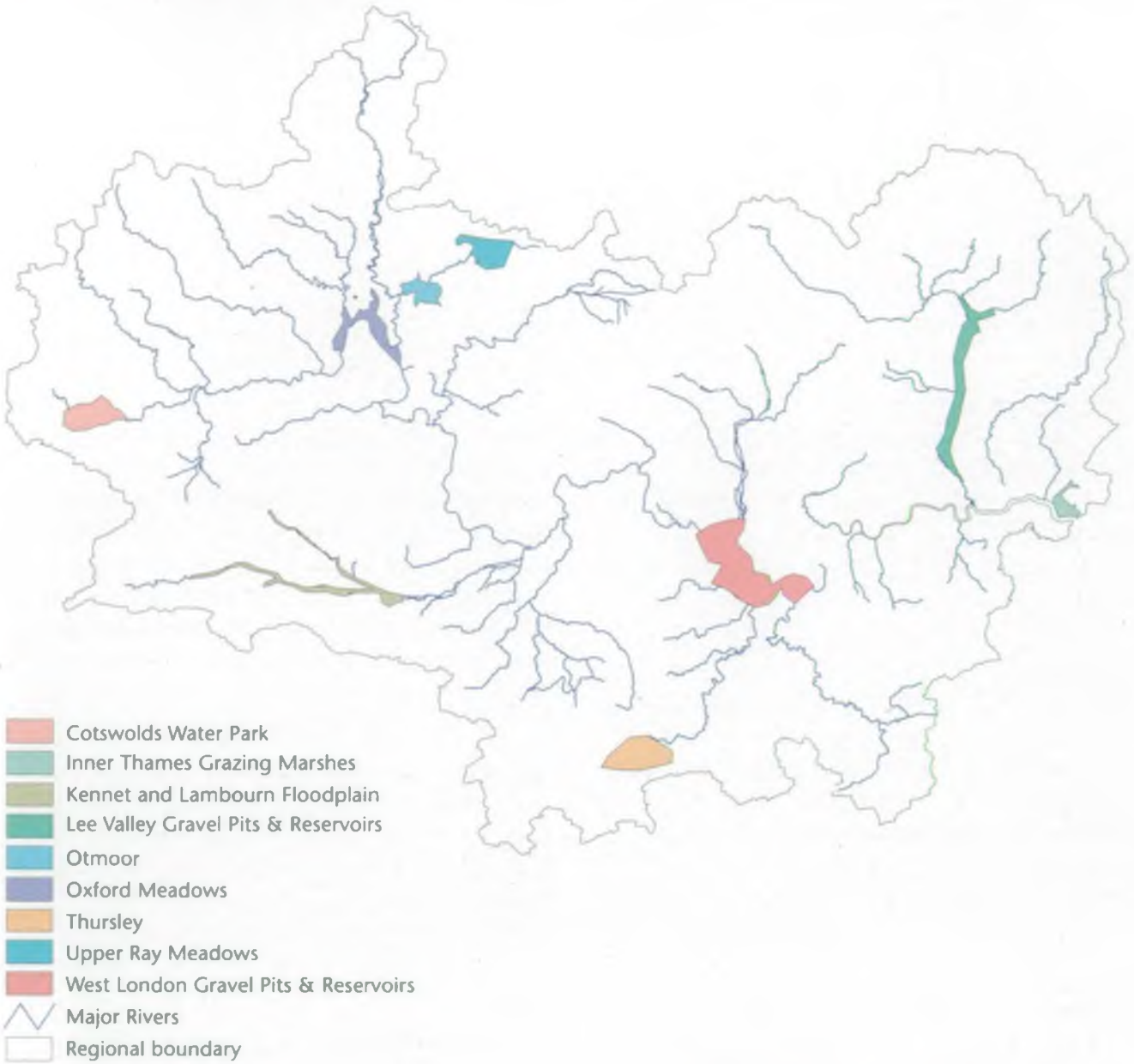
Water plays a key role in sustaining many of the region's environmental assets. These have developed from the combined influences of landscape, biodiversity and heritage on the natural hydrological cycle and our more recent use of water resources. Some of the notable water environments of the Thames Region are set out in Figure 4.1. Many of the sites are important Biodiversity Action Plan (BAP) sites, others are nationally and internationally recognised.

The highly developed nature of the Thames catchment means that there is very little natural watercourse left and wetlands are relatively small and highly fragmented. Less than 5% of the catchment area is designated under the European Habitats and Birds Directives as being of international importance and of this only 10% is wetland habitat. Nevertheless the region contains over 450 SSSIs of which more than 100 contain nationally important areas of river and wetland.

The fragmentation of these sites by development and agricultural intensification is so extreme that in many subcatchments, the only possible path for migration of the wildlife population is via the main river corridors. Even then, the way is often blocked or constrained by urban development. The Agency's approach towards wetland biodiversity is based on the principle that we should "enhance the best and link to the rest". Both enhancement and linkage schemes for rivers and wetlands are dependent on the availability and use of water.

In mapping resource availability in Chapter 3, we have shown that in some places current licensed abstraction is causing environmental problems, or that it would do so if actual abstraction reached full licensed volumes. For some abstractions, there is already evidence of a harmful effect, and others are under investigation.

Figure 4.1 Notable water environments



- **Chalk rivers** - UK BAP (Biodiversity Action Plan) habitats, including the Kennet, Mimram, Bulbourne and Gade, which are groundwater-fed producing clear waters and a generally stable flow and temperature regime. Low banks support a range of water-loving plants
- **Eutrophic standing waters** - UK BAP Habitat. Many are SSSIs. Highly productive waters with plentiful plant nutrients (either naturally or from artificial enrichment. Includes Cotswold Water Park, South West London Water Bodies and the Lee Valley Reservoirs.
- **Coastal salt marsh** - UK BAP Habitat. Only intertidal salt marshes in the Thames Tideway.
- **Cotswolds Water Park** - SSSI. Formed by gravel extraction. Most extensive marl lake system in Britain. Important for wintering birds and contains several nationally scarce plant species.
- **Oxford Meadows** - SAC. Seasonally flooded, flood meadow. Is noted as one of the best areas in the UK for lowland hay meadows. Contains nationally rare species.
- **Otmoor** - SSSI. Seasonally flooded, traditionally managed rough grazing marsh and extensive new RSBP reserve. Many species of nationally uncommon plants and animals and of high regional value for birds.
- **Upper Ray Meadows** - ESA. Seasonally flooded meadows which attract considerable numbers of wading birds.
- **Kennet and Lambourn Floodplain** - SAC. Supports an outstanding assemblage of wetland invertebrates and a particularly rare species-rich grassland type
- **Thursley** - SAC / SPA. RAMSAR status as an internationally important wetland. Of national importance for its bird and invertebrate populations and is one of the few sites in Britain to support all six native reptile species.
- **Lee Valley Gravel Pits and Reservoirs** - SPA. Ramsar site. Series of embanked water supply reservoirs, sewage treatment lagoons and former gravel pits that provide breeding and winter habitats to a wide range of wetland birds. During severe weather on the Continent wildfowl are attracted to the relatively mild climate.
- **South West London Waterbodies** - SPA. Ramsar site. Series of embanked water supply reservoirs and former gravel pits that support a range of man-made and semi-natural open-water habitats. Internationally significant as supports important bird populations and two rare invertebrate species.
- **Inner Thames Grazing Marshes** - SSSI. Includes Rainham Marshes. Series of bunded lagoons, low-lying grazing meadows, dry and flooded mudflats and fresh to brackish drains that support a wide range of wetland plants and invertebrates and is of great ornithological significance as a breeding area, as a stopover point for passing species and as a winter feeding and roosting ground.

Pinkhill Meadow is one of several Habitats and Birds Directives sites currently under investigation

Our programme of investigations into sites thought to be at risk due to adverse effects of abstraction continues to be developed within the region. Significant progress has been made since our 1994 water resources strategy on the investigation and implementation of schemes, including schemes implemented on the Ver, Misbourne, Pang and Letcombe Brook. However, further abstraction-related problem sites continue to be identified. These sites are shown in Figure 4.2 and listed in Table 4.1. The Environment Agency's National Environment Programme (NEP) sets out a five-year plan to resolve problems at sites where water company abstractions are known or thought to be causing an unacceptable impact on their immediate environment (Environment Agency, 1998b).

In the majority of these catchments, the total volume of water legally abstracted is more than the catchment can sustain. The result is low river flows and a degraded environment. Other abstractions cause environmental problems because of their location near to a site that is especially vulnerable. Sites we have identified for further investigation include, for example, the Sulham and Tidmarsh Woods SSSI and the Kennet and Lambourn Floodplain candidate SAC. In some cases, the total amount of water abstracted from the catchment overall may be acceptable, but the location or type of abstraction may need modification.

Elsewhere across the region, other catchments are approaching the total limit of abstraction, or are licensed to a level that could be detrimental, but not all abstraction licences are used. In these cases, more use of water could lead to general environmental degradation and could derogate other abstractors' rights.

New environmental drivers and new sites continue to be identified. The Agency is currently undertaking a major review of consents issued by all its functions, including abstraction licences, as part of our obligations under the European Habitats Directive. The review is due to be completed by March 2004. It will lead us to confirm, modify or revoke abstraction licences as necessary to protect European conservation sites (Special Protection Areas (SPAs) and SACs), following an appropriate assessment of their impact on these sites. Sites identified for the region are listed in Table 4.1; some of these have already been included in the NEP for investigation and implementation in due course.

We are also aware of potential issues associated with other abstractions, some of which have already been identified by the Agency and water companies for further investigation (see Table 4.1, non-NEP schemes). A number of sites were identified as a result of concerns regarding the impact of abstraction during the droughts of the 1990s; in some cases it has been difficult to disentangle the underlying causes of environmental problems, while in others the impact of abstraction is clear. The understanding and successful resolution of these problems will be an important part of our work over the coming years through the CAMS process and the development of the Restoring Sustainable Abstraction Programme (RSAP), which

River Ver, spring 1993, suffering from the effects of overabstraction

River Ver, summer 1999, after implementation of flow restoration scheme

Figure 4.2 Restoring sustainable abstraction: NEP schemes, Habitats and Birds Directives, and other sites.

Sites under investigation

✓ NEP - Implementation

? NEP - Investigation

? AMP3 Investigation (non-NEP)

Habitats and Birds Directives sites under investigation

Rivers that are affected by overabstraction, are Habitats and Birds Directives sites, or that are being investigated for other reasons

Major rivers

River Thames

Regional boundary

Table 4.1a Restoring Sustainable Abstraction: NEP schemes, Habitats and Birds Directives and other sites

Sites for investigation and action under the National Environment Programme

Site name	Amp3 funding allocated	County	Water Company	Type of site
Ampney Brook	Implementation	Gloucestershire	Thames	
Beane	Implementation	Hertfordshire	Three Valleys Water	
Bulbourne	Implementation	Hertfordshire	Thames	
Cherwell	Implementation	Oxfordshire	Thames	
Churn	Implementation	Gloucestershire	Thames	
Gade	Investigation	Bedfordshire	Three Valleys Water	
Hughenden Stream	Investigation	Buckinghamshire	Three Valleys Water	
Kennet and Lambourn Floodplain cSAC	Investigation	West Berkshire	Thames	cSAC, Habitats Directive, AMP3
Mimram	Investigation	Hertfordshire	Three Valleys Water	
River Kennet SSSI	Investigation	Wiltshire	Thames	SSSI
Sulham Brook inc. Sulham& Tidmarsh Woods & Meadows SSSI	Investigation and Implementation	West Berkshire	Thames	SSSI
Wey at Alton	Implementation	Hampshire	South East Water	
Wye	Implementation	Buckinghamshire	Thames	

Table 4.1b

Non-NEP sites (water company investigations)

Site name	County	Water Company
Blewbury Pond	Oxfordshire	Thames
Dickler	Gloucestershire	Thames
Law Brook	Surrey	Thames
River Lee at New Gauge	Hertfordshire	Thames
Windrush at Worsham	Oxfordshire	Thames

Table 4.1c

Non-NEP sites (Habitats and Birds Directives review – with interest features potentially susceptible to abstraction)

Site name	County	Water Company	Type of site
Cothill Fen	Oxfordshire	Thames	cSAC
Epping Forest	Greater London Authority	Thames	cSAC
Kennet and Lambourn Floodplain	West Berkshire	Thames	cSAC
Kennet Valley Alderwoods	West Berkshire	Thames	pSAC
Lee Valley Waterbodies	Hertfordshire	Thames	pSPA
Little Wittenham	Oxfordshire	Thames	pSAC
Mole Gap to Reigate Escarpment	Surrey	Sutton & East Surrey	cSAC
North Meadow and Clattinger Farm	Wiltshire	Thames	cSAC
Oxford Meadows	Oxfordshire	Thames	cSAC
River Lambourn	West Berkshire	Thames	pSAC
Wimbledon Common	Greater London Authority	Thames	pSAC
Shortheath Common	Hampshire	South East	pSAC
South West London Waterbodies	Surrey	Thames	pSPA
Thursley, Ash, Pirbright and Chobham	Surrey	South East	cSAC
Woolmer Forest	Hampshire	South East	pSAC

specifically addresses issues associated with other abstractions thought to be adversely affecting the environment.

Two particular sites in the Thames Region have strategic implications for water resources and supplies:

- abstraction from the River Thames at Farmoor, Oxfordshire. Concern arises from two main drivers: the Habitats Directive implications (North Meadow and Oxford Meadows) and the impacts of unconstrained abstraction on flows and levels of water courses and structures downstream of the abstraction;
- abstraction from the Lower Thames to supply London. Concerns continue to be raised regarding the impacts of abstraction on flows and levels, particularly in the Lower River Thames and Upper Tideway and associated impacts on water quality, fisheries, ecology and navigation.

In both these cases, any significant modification to abstraction will have equally significant impact on resource availability, which is likely to require new strategic water resource initiatives.

The Agency is committed to enhancing biodiversity, and in all of our work we consider opportunities to contribute to the success of the UK Biodiversity Action Plan (UK Government, 1994).

Our assessments of the changes to abstractions that may be needed will be refined in coming years, not only by our CAMS process but also through River Basin Management Plans developed under the Water Framework Directive. These plans must identify the changes needed to water quantity and quality to achieve suitable ecology everywhere.

Our strategy allows for the resolution of established problems. We have identified in broad terms the volume of water required to achieve this for each

catchment and resource zone, and considered this additional environmental demand as we develop the strategies (see section 5.5). Identifying and funding the most cost-effective implementation in each location will be a matter for the abstractor(s) concerned and the Agency, with input from Ofwat and/or Government as necessary. Where the timescales are not already established, such as through the NEP and Habitats Directives, we propose that the abstractions should be restored to a sustainable level within the time frame of this strategy although we have not stipulated exactly when.

4.2

Societal change

To take account of the uncertainties that surround the ways in which society will evolve, it is appropriate to examine different scenarios of societal change. To help us in formulating a robust set of scenarios for water use and resource management we have been guided by the Foresight "Environmental Futures" scenarios (Figure 4.3) (DTI, 1999). These were developed for the Government's Department of Trade and Industry (DTI). These scenarios are intended to inform and stimulate debate among businesses, regulators and Government departments about the environment and to encourage them to develop strategies and policies that will prove robust to a range of environmental futures. They look at the future by considering two aspects of development: social values and systems of governance. Details of the approach can be found in Table 4.2. The result is a set of four scenarios, each of which characterises one way in which England and Wales may develop over the next 25 to 50 years. They can be summarised as follows:

- **Provincial Enterprise Scenario**: a future in which the nation state disengages from international political and economic systems of governance. This is a low-growth, low-wage, and low-investment scenario with little concern for social equity. The environment is perceived as a low-priority issue, despite the increased pressures placed on natural resources;
- **World Markets Scenario**: a future in which a highly developed and integrated world trading system generates high levels of economic growth. Although average personal affluence rises, there is little concern for social equity. Awareness and concern for the environment is low, particularly among the less well-off;
- **Global Sustainability Scenario**: a future where global institutions play a central role resolving social and environmental problems. High levels of investment in research and development result in the development of innovative clean technologies, which benefit the environment;
- **Local Stewardship Scenario**: a future dominated by regional and local systems of government. Working at the local level, environmental problems are resolved through collective action.

All are possible pictures of the future. They are intended to define a broad contextual framework of social, economic, political and technological change. Experts are expected to add to the framework to develop coherent, sector-specific scenarios. The changes that

Figure 4.3 Foresight scenarios

Table 4.2 **Foresight "Environmental Futures"**

The Foresight programme, sponsored by the DTI, sets out to identify innovative market opportunities and new technologies, which will enhance the competitive advantage of businesses in the UK. In 1999, the Energy and Natural Environment Panel published a set of scenarios focused on the environment.

The scenarios are devised using two core dimensions of social change: social values and systems of governance. These dimensions are used as axes, which define four scenarios that describe the UK during the period 2010 - 2040.

Social values are reflected in policy-making priorities, political preferences, and patterns of economic development. At one end of the spectrum social values are dominated by consumerist attitudes, which emphasise individualism, materialism and private consumption. Concern for the environment focuses on specific problems, which impact on the individual or their immediate local area. In contrast, community-orientated values are concerned with securing long-term social goals such as equality and sustainable economic development. There is a strong emphasis on the enhancement of collective goods and services, reflected in the high priority placed on resource and environmental problems.

The second axis relates to the system of governance and represents the structure of political authority and decision-making. Globalisation is characterised by the redistribution of political power and influence away from the nation state towards Pan European and global institutions such as the United Nations (UN) and World Trade Organisation (WTO). Economic activity is locked into international trading systems, dominated by trans-national corporations. This is distinct from regionalisation, where national sovereignty is strengthened, and there is a movement towards regional devolution and local government.

Using the pressure-state-response model of environmental change, a story line is developed of the key drivers of social, economic and technological change under each scenario. On a broad scale, this involves assessment of the level of economic growth and structure of the economy. The degree to which environmental issues are prioritised by policy-makers, businesses and individuals is considered along with a review of the state of the environment. In some cases indicators are included to illustrate the direction and rate of change.

would lead to each scenario would not occur instantly. All of the scenarios considered represent a gradual change from our present conditions. By 2025, there are quite large differences between them but by 2010 the impacts are relatively small.

In the case of water resources the Foresight programme provides a high-level, qualitative assessment of the implications for water under each scenario, characterised simply in terms of demand for water increasing, stabilising or decreasing.

The water resources demand scenarios that result from this work are discussed in Appendix 2 and summarised in Chapter 5. It is important to note that these scenarios are the Agency's interpretation of the impact of the "Environmental Futures" framework on the demand for water; while they are derived from Foresight, they are not part of the Foresight programme itself. For this reason, we have named our scenarios Alpha, Beta, Gamma and Delta as follows:

- Provincial Enterprise – Scenario Alpha
- World Markets – Scenario Beta
- Global Sustainability – Scenario Gamma
- Local Stewardship – Scenario Delta.

4.3 Using scenarios

The water demand scenarios should be used appropriately. The Agency's use of the Foresight framework is formulated so that the resulting water demand scenarios cover the most likely pattern of water use. When adopting this approach there are several features which must be recognised:

- some of the scenarios lead to patterns of future behaviour that are not congruent with the current values of the Agency and other organisations. For example, there may be fewer commercial opportunities in one scenario, while in another environmental protection would be given a lower priority than it is today;
- all scenarios should be considered even though some outcomes may be uncomfortable. The challenge is to identify mechanisms and management measures for achieving society's present aims within the constraints that the scenarios present;
- a strategy should not be based on the scenario that the Agency or others consider most acceptable. This would leave the strategy vulnerable to other changes and influences;
- each scenario should be given equal weight;
- the Agency cannot offer a different strategy for each scenario but should provide a single framework to deal with a range of outcomes that may occur;
- the framework development should be flexible and monitored in order to know when it should be changed.

One of the main objectives of this regional strategy is to illustrate choices and options and their implications so

that the actions the Agency and others need to take to reduce uncertainty in water resources management over the next 25 years, can be identified.

The possibilities associated with each scenario have been investigated. We have taken an approach that involves building a set of solutions and testing their effectiveness under the different scenarios. In doing this, three basic principles were followed:

- there must be plans in place that deal with all reasonable futures;
- these plans should be centred around solutions that are reliable through all scenarios;
- decisions about actions should be finalised at the right time; making decisions too soon could involve unnecessary or inadequate solutions.

4.4

Global warming and climate change

There is mounting evidence that our climate is changing as a result of man-made atmospheric emissions. The DETR's UK Climate Impacts Programme has reported that UK temperatures have increased by about 0.7°C over the last 300 years, with about 0.5°C of warming during the twentieth century. This is part of a world picture of warming. Globally, 1998 was the hottest year since records began in the middle of the nineteenth century. It is thought that the 1990s may have been the warmest decade of the last millennium.

There is more confidence in some aspects of climate change than in others. For example, there is some confidence in the sea level rise and global temperature increase induced by a given change in carbon dioxide concentrations. However, predicting future climate change is difficult. Climate change could affect both demand for water and its availability, as well as having an impact on water-dependent ecology. Our understanding of the relationship between weather and water use is not perfect, so it is not possible to be absolutely certain about how climate change will affect demand or water resources. For this reason, UKCIP have published four scenarios for climate change. In addition to increasing year-round temperature, the scenarios indicate generally wetter winters and warmer, drier summers in the south-east of England.

The principal impacts on climate and available water resources for the south-east are summarised in Table 4.3

Climate change will have significant implications for the way that we manage supplies and demand. Household water use is likely to be increased given the greater frequency of hotter, drier summers. With the diverse range of industrial uses of water, it is not possible to generalise about their vulnerability to climate change.

Table 4.3 **Impacts of climate change on water resources in the South East**

Rainfall
• Mean annual rainfall increasing by up to 4% by 2020.
• Increasing probability of hot, dry summers by 2020.
• Dry summers (less than 50% average rainfall) occurring more frequently 1:14 years by 2020's compared with 1:100 currently.
• Wetter autumn and winters.
• Increased precipitation variability and more common drought periods.
Temperature & Potential Evapotranspiration (PE)
• Mean annual temperature increasing by 0.5 – 1.4°C by 2020.
• '1995 summer' temperatures occurring 1 year in 3 by 2020 compared to 1 year in 50 currently.
• PE increasing by up to 8% on average, up to 19% during late summer.
River Flow
• Increase in winter flows, decrease in late summer - early autumn flows (up to 21% in the south and east).
• Baseflows in groundwater dominated rivers benefit from additional winter recharge.
Groundwater
• Increases in average annual groundwater recharge across the country.
• There is no indication of (more important) impacts on groundwater level and yield of individual sources.

Source: Rising to the Challenge. Wade et al (Eds) 1999

Climate change will certainly have an effect on agriculture. It will affect not only planting and harvesting dates, but also the varieties of crop that are grown, leading to investigation of alternative opportunity crops such as grain maize and soya. Higher temperatures will also affect livestock production systems. We have outlined how we have taken the effects of climate change on demand into account in Chapter 5.

Changes in climate will also change groundwater and river regimes and therefore the availability of water for abstraction. Current estimates of climate change suggest that by the 2020s throughout southern and midland England there will be on average more winter rainfall and less summer rainfall. Trends in observed rainfall data for the region already tend to support this; Figure 4.4 shows winter and summer trends for Oxford Radcliffe Lawns since records commenced in 1767. Higher temperatures mean that potential evaporation rates will probably increase.

There is also evidence that climate change will increase the year-to-year variability of rainfall. Effectively, this means that the climate will be less predictable, with both more dry years and more wet years. This in turn means that low flows will occur more often. Evidence about the possibility of longer droughts is unclear; the best available view appears to be that increased variability makes droughts that last over several years slightly less likely. However, it is important to note that the understanding of changes in extreme events is more limited than that of changes in average climate.

We have assessed the impacts on water resources based on the results from Arnell (Arnell, 1999), using factors developed from the UKCIP scenarios for the 2020s, and our own regional water resources models. A pattern of significantly increased flows in the winter and spring combined with marginally reduced flows in the late summer and autumn is consistent across three very different catchment types. The Thames to Kingston is a very large, strategically important, mixed catchment. The Coln to Bibury is a much smaller, limestone catchment. The Mole to Kinnersley Manor is a clay catchment, with no significant groundwater. Even in those months when mean monthly flows are marginally reduced, the overall effects of climate change appear to be much smaller in dry years because of the increased baseflows as a result of the wetter winters. The overall impact of these scenarios on water resources is, therefore, minimal with estimated yields changing by less than 1%.

This outcome emphasises the dependency of our water resources system on the storage of winter water in aquifers, which subsequently support baseflows to rivers, and in reservoirs. We have not been able to model the potential impacts of climate variability in terms of more frequent drought periods or its impact on groundwater levels and flows in spring-fed tributaries. Direct, unsupported abstractions may become less reliable in summer if groundwater levels are reduced, which means that abstractors, particularly farmers and industries that rely on these sources, will have to consider adapting in some way if they wish to maintain current levels of reliability.

Changes in temperature, river flows and wetland levels as a result of climate change may have an impact on the plants and animals that rely on the water environment. Some species will be better suited to the new conditions, while others may find it harder to thrive. For this strategy, we will assume that we can protect the future environment by maintaining current levels of protection through the maintenance of existing controls on abstraction, except where we know that these are in need of improvement for other reasons. The environment that we protect will be dynamic, with species changing over time as climate and other environmental factors change.

Appendix 1 contains a summary of ongoing work on climate change and sets out in more detail how this may affect water resources.

4.5

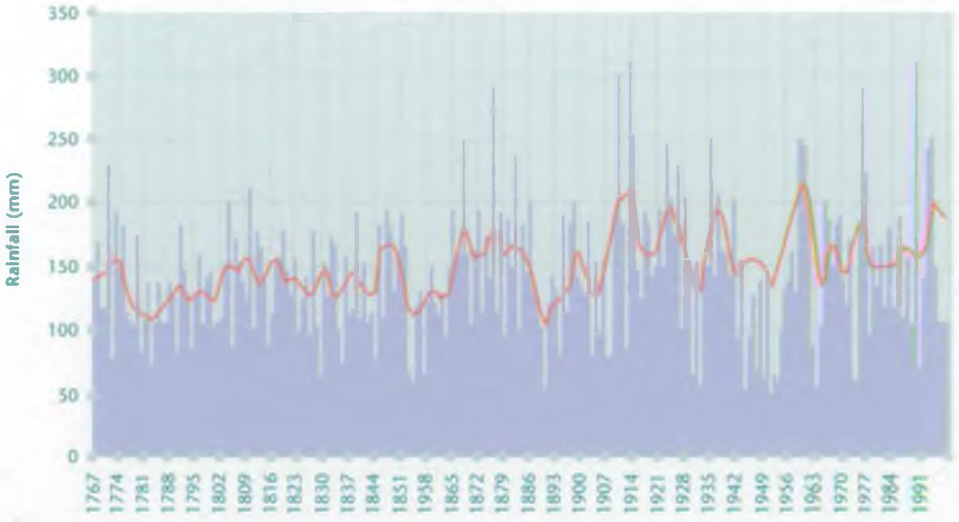
Population and household size

The latest Government projections show an increase of 3.3 million households in England and Wales between 1996 and 2016, including a total of 1.2 million households across the south-east. There are significant uncertainties in these projections; concern has been expressed at public examinations regarding the overall capacity of the region to absorb this level of development.

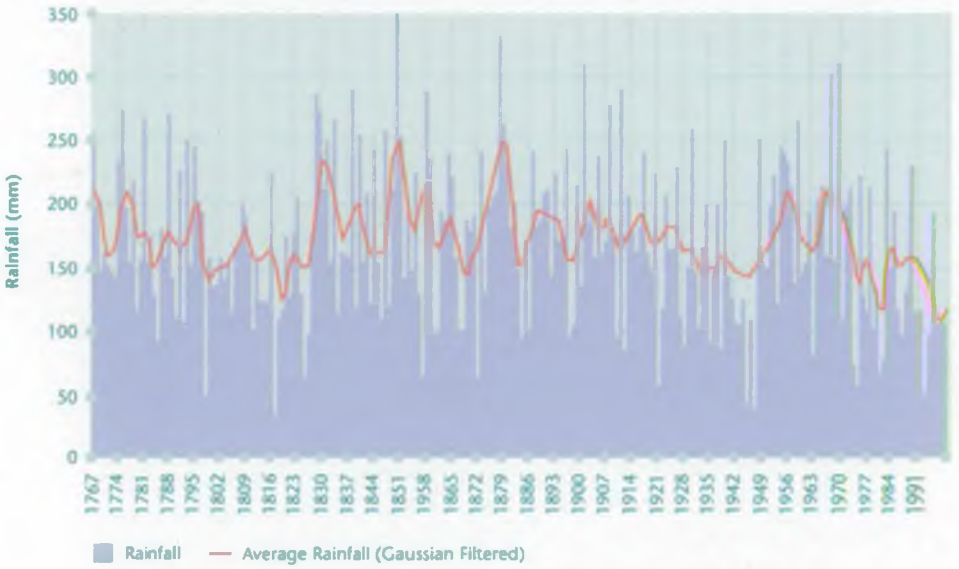
Draft regional planning guidance to 2006 (as of December 2000) has indicated that councils in the south-east should plan for an annual rate of housing increase of 39,000; the equivalent rate for London is 23,000 households per annum. This is largely due to the trend towards lower occupancy households, smaller household size and higher density planning. Within the region, this equates to approximately 0.7 million households whilst over the same period population is projected to increase by approximately 0.8 million. About half of the increase in population is due to net inward migration. These levels of provision apply only

Figure 4.4 **Long term trends in summer & winter rainfall: Radcliffe Lawns, Oxford, 1767 to date**

a. Oxford - Winter Rainfall totals (December to February)



b. Oxford - Summer Rainfall totals (June to August)



c. Variation in trend significance over time for rainfall at Oxford

When values are >1.96 this signifies a significant upward trend at 95% probability
When values are <-1.96 this signifies a significant downward trend at 95% probability
Source: Davis, R c2000

Proposed increased housebuilding puts pressure on the region's water resources

for the period up to 2006 and are subject to review within five years at the latest, in the light of monitoring and findings of urban capacity studies and studies of potential growth areas.

Evidence from household consumption monitors in the south-east shows that per capita consumption of water increases with decreasing household size. As a result, the impact of new development on demand for water is twofold: increases due to growth and due to per capita consumption, against a background trend of increasing consumption. This will increase existing pressures on the supply-demand balance across much of the region. Water companies' Water Resources Plans have considered this and proposed a range of schemes to secure supplies.

There are significant implications of, and for, development planning within the region in that the provision of new water resources schemes typically has long lead times. Development in advance of the provision of new schemes may jeopardise the security of water supplies and place unacceptable strain on the water environment. There are also significant uncertainties regarding the acceptability and successful promotion of new strategic water resource schemes. As many of the potential water resources schemes we will discuss later in this strategy are still subject to further investigation and promotion, the need for development planning to proceed on a precautionary basis and to emphasise water conservation and efficiency measures is paramount. The Agency has endorsed the South East Regional Planning Conference's (SERPLAN) proposed "plan, manage and monitor" approach. Where necessary, this may require plans for further development to be delayed or postponed. Key pressure areas include West Berkshire, Oxfordshire, Swindon and London.

The Agency has worked closely with SERPLAN in the development of SERP500, culminating in the latest draft revised regional planning guidance for the south-east, RPG9 (Government Office for the South East, 2000). This contains specific policies on water resources and supply issues (Policy INF2) for planning requiring:

- new development to take water-related issues into account from an early stage;
- new development to be located and implemented in such a way as to allow for sustainable provision and timely investment in infrastructure and water services;
- co-ordination of the timing of new development with the provision of sustainable supplies, sewage treatment and discharge systems (in accordance with PPG12);
- the promotion of water conservation measures, including sustainable urban drainage, in new development and the promotion of awareness of the need to reduce water consumption.

Although regional planning guidance sets out the broad requirements, in terms of housing stock, there remain significant uncertainties regarding the location and timing of new development. For that reason, in developing its strategies, the Agency has used a nationally consistent population and household data set obtained from CACI Limited for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025.

4.6 Land use

The way in which we use land has a significant impact on the water in our environment. For example, urbanisation, land drainage and mineral extraction all contribute to changes in the runoff characteristics of the region's rivers. Future changes in land use and drainage can exert further, or new, pressures both on the environment and on water resources availability.

Pressures for increasing urbanisation in the region have resulted in large expanses of impermeable surfaces forcing rainwater to simply run off the land without percolating through into the groundwater. Watercourses that flow through such areas respond quickly to rainfall and, in addition to presenting a flood risk, can have impacts on the availability and quality of the water resource. The Agency is co-operating with other bodies in investigating Sustainable Urban Drainage Systems (SUDS), which aim to reduce the runoff problems in the urban environment by increasing the presence of permeable surfaces, filter strips, swales and ponds allowing infiltration and attenuation of runoff.

Farming practices can also affect river flows. Field drainage increases the speed with which rainfall reaches rivers and streams compared to seepage through the soil. Bare soils can encourage soil erosion leading to siltation problems in river channels and alterations in channel shape as well as covering up gravel beds that would otherwise be important spawning grounds for fish.

The extraction of sand and gravel can affect groundwater in the shallow gravel aquifers and river flows locally. Whilst the use of water in these processes is non-consumptive, the operations and reinstatement can have significant local impacts on the water environment through changes to levels and flow patterns. The Agency is working increasingly closely with minerals companies to mitigate any local impacts.

Land use gives rise to a variety of pollution risks. Pesticides and fertilisers used in agriculture can reach rivers, streams and groundwater, affecting water quality. Urban developments give rise to particular pollution risks to surface and groundwater; for example, from industrial processes and spillage or leakage of fuels and oils. The growing demand for landfill for waste in the region also poses risks, particularly of organic waste that has the potential to release pollutants. The Agency works closely with all stakeholders to promote best practices for the control of diffuse pollution and the minimisation of point source risks. However, historic and previously unregulated practices within the region have left a legacy of largely hidden potential risks. Typically, these include older waste disposal sites and former industrial sites.

We have not taken account of land use change in this strategy but it is clear that a fuller understanding is needed of this cross-sectoral issue. Overall, land use and its impact on water resources is a complex issue and many parties share the responsibility for ensuring that it is considered in the context of sustainable development. The Agency will work to ensure that impacts on water resources are considered.

4.7

Water quality and water resources

Water quality and water resources are intricately related in terms of the availability and usability of resources. The management of water resources is carried out within the broader context of integrated river basin management, particularly recognising the links and interdependencies with the management of water and environment quality and the pressures that can result where unplanned change occurs. There are two key areas where integration is vital:

- **Protection of water quality for water supply.** In consenting discharges to the water environment, water quality standards are set to protect the environment and other uses of water, particularly public water supply. Through the application of the Surface Water Abstraction Directive, discharges to surface water are regulated to ensure that abstractions downstream are of a safe quality for water supply. The management and protection of groundwater is of paramount importance to water supplies across the region.

  The Agency uses its powers and influence to prevent pollution wherever possible, particularly through planning and development processes to ensure that new development includes best practice for preventing pollution. Where necessary, notice can be served to prohibit high-risk activities altogether.

  Where the use of nitrate in agriculture is a significant contribution to contamination of groundwater, a "nitrate vulnerable zone" can be designated restricting its use in those areas. This action is intended to prevent pollution from occurring and prejudicing the use of groundwater for potable use. However, in some parts concentrations are already very high and it may take many years before reductions in nitrate use bring about a fall in concentrations in groundwater.

- **Management of dilution effects.** Setting consent standards relies on there being sufficient water available in the environment to dilute discharges and for the natural purification processes of rivers to operate effectively. This is routinely done on a statistical basis, accounting for the large natural variations in flow that can be expected. However, if abstraction and natural variations reduce flow to unusually low levels, water quality can deteriorate quickly causing both environmental stress and problems for downstream users. This is fundamental in licensing abstraction and in planning for future water resources management in the context of changing environmental trends, such as climate change.

Infrastructure development (e.g. motorways, airports, urban and industrial developments), industrial activities, agriculture, waste generation and disposal can all pose risks of pollution to surface and ground waters, through accidental loss of contaminants (e.g. solvents and hydrocarbons) or through deliberate and controlled discharges (e.g. sewage effluent from septic tanks).

Generally the quality of surface and ground water is good, although in many areas it has been affected to some extent by these activities. Nitrate from agricultural use is found in groundwater and surface water across much of the region. Contamination of groundwater is an increasing pressure on water resources. In some cases it is necessary to treat for contamination by solvents, pesticides, nitrate or other contaminants although, in some instances it may be more cost-effective to obtain water supplies from other sources than to abstract and treat contaminated groundwater. The pressures are particularly acute in urban fringe areas, for example those supplied by Three Valleys Water. Where a borehole may be taken out of supply because of contamination, its future use will need to be reviewed with the Agency to ensure that the resource can be made available to others who could make good use of it rather than sterilise available resources in particular areas.

Some risk sites will remain unknown and inevitably incidents will occur. As a consequence the good quality of groundwater cannot be guaranteed.

Abstraction may exacerbate groundwater contamination in certain circumstances by drawing in contaminants from a wider area and the Agency may wish to constrain use of groundwater in these circumstances. For example, abstraction of groundwater in south Essex has caused saline waters from the Thames estuary to enter the Chalk aquifer and further licensed abstraction has to be restricted in this area in order to prevent further saline intrusion.

The nature and management of surface water resources for London results in the Tideway being especially vulnerable to changes in water quality. This is particularly so when intense summer rainstorms over urban areas are coincident with naturally low flows in the river, releasing large quantities of storm water into the Tideway. In order to manage this situation, operating arrangements have been agreed between Thames Water and the Agency which include the management of abstraction to safeguard environmental quality during times of environmental stress.

4.7.1 The Water Framework Directive

The EU Water Framework Directive, which came into force in December 2000, is due to be incorporated into UK legislation by 2003. It is intended to integrate existing European water legislation, implementing a system of "River Basin Management Planning". Achievement of 'good' ecological status for surface water and groundwater sources, as demanded by the Directive, will require integrated considerations of water quantity, water quality and ecology. The Water Framework Directive may influence future environmental standards and our management of water resources. This strategy embodies the broad principles and environmental expectations behind the Directive. We believe that the integrated framework of planning we are developing through LEAPs, CAMS, this water resources strategy and water companies' water resources plans will provide a sound basis for development in meeting the requirements of the Directive.

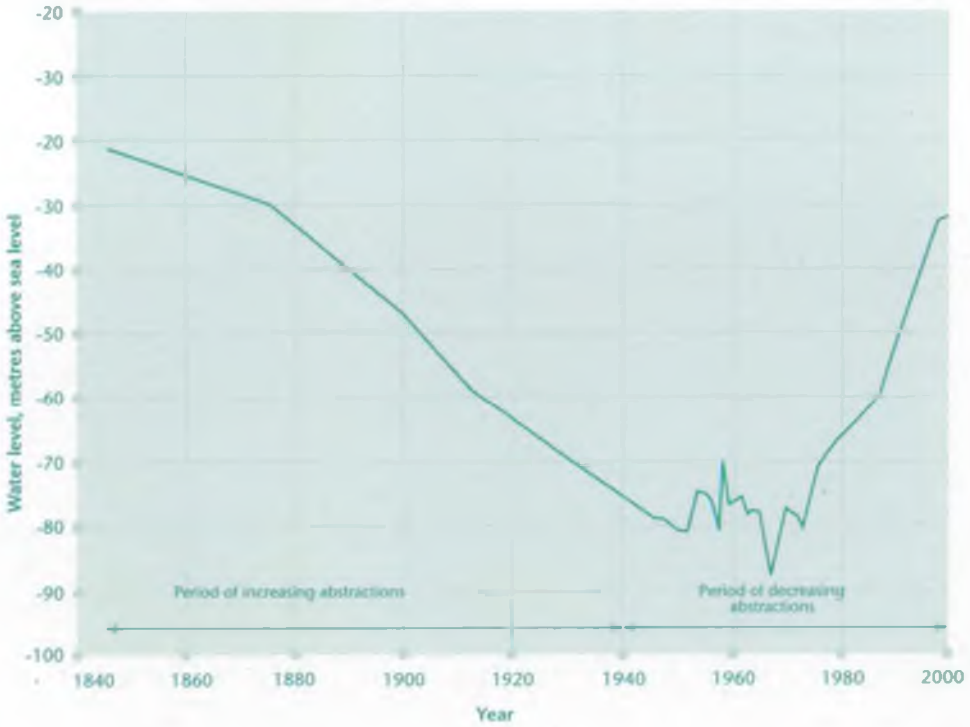
4.8 Rising groundwater in London

Since abstraction from the confined chalk aquifer under London started, nearly two centuries ago, there have been major changes in groundwater levels and hence the state of groundwater storage. Increasing abstraction, mainly for commercial and industrial purposes in the nineteenth and early twentieth centuries, led to a progressive decline of levels, reaching a maximum fall of 90 m in central London. However, since the Second World War, abstractions have declined, leading to a reversal of that trend and a rise in groundwater levels which continues to this day at up to 2.5 m per year with a total recovery of approximately 50 m in central London by 2000 (Figure 4.5).

The rising groundwater presents a threat to tunnels and building foundations, particularly in central London. Controlling the rise by pumping offers a potential resource, which the Agency, Thames Water and other interests are currently investigating. Some of the water is of poor quality and may be more suited for non-potable use, e.g. cooling and toilet flushing rather than for public water supply requiring expensive treatment.

By contrast, the decline in groundwater levels in other parts of London, dewatering a major volume of aquifer storage, also provides opportunities for artificially recharging the aquifer rather than building surface reservoirs. Thames Water's North London Artificial Recharge Scheme uses treated mains water (which is available in the existing distribution system at times of seasonally low demand) to meet drought deficiencies in the surface water resources supplying London. The aquifer is recharged between major abstraction operations by a combination of natural recovery and artificial recharge. Further schemes are being considered and are discussed later in this document.

Figure 4.5 **Rising Groundwater under London: Trafalgar Square groundwater levels, 1840 to date**



5 Quantifying the pressures on water resources

In preceding chapters we have set out the framework in which water resources are managed and set out the principles that underpin this strategy. We have summarised the current state of water resources and the pressures that we expect in the future. We need to quantify these pressures so that we can define appropriate options.

5.1 Incremental demand

The Agency has developed four demand scenarios incorporating the social and governance evolution reflected in the Foresight "Environmental Futures" scenarios. Our approach is to look at incremental demand for each of these scenarios at 2010 and 2025. Incremental demand is defined as the extra water needed compared to that which is used now. We consider the additional demand under the following headings:

- household demand;
- leakage;
- industry and commerce;
- spray irrigation.

The flexibility of this approach allows the consideration of additional demands as further elements become important. By using the concept of incremental demand we can compare future conditions with those of today. This also means that we can consider loss of resource as an element of demand. In this way, we do not need to estimate the available resource. This task is particularly difficult, because it depends on value judgements about different uses and users of water. Put simply, if the need is judged to be great enough, water can be made available, either by costly technological solutions or at the expense of existing water uses.

5.2 Developing the scenarios

We have considered in detail the drivers of water demand and how these vary for each scenario. Table 5.1 summarises the relative changes to each driver of water demand, which in turn affects how each component of demand may change over time. Importantly it shows that components change independently of each other, which emphasises the need to assess future water use at a component level.

5.2.1 Household demand

For household demand, we broke down household consumption into its micro-components (such as toilet flushing and washing machine use), and forecast changes under each scenario for that component, based on assumptions about future levels of ownership, frequency of use and volume of use. We have generated unmeasured per capita consumption for each resource zone on this basis.

Metering and its likely extent and impact have been considered for each scenario. Using the results of the National Metering Trials to guide our assumptions, metering of households provides reductions in consumption ranging from 3% to 21% (National Metering Trials Working Group, 1993). The proportion of metering varies across the scenarios.

5.2.2 Leakage

For leakage, the scenarios reflect different approaches to prioritisation and target setting. This in turn affects water companies' leakage control philosophy and

Table 5.1 **Key drivers of demand**

Component	Driver of Demand	Influence by scenario			
		Alpha	Beta	Gamma	Delta
All components	Cost of water	Very high	High	Medium	Medium
Household demand	Changes to personal washing use	Large increase	Large increase	Small decline	Small decline
	Garden watering	Increases	Increases	Slow decline	Moderate decline
	Miscellaneous	Moderate decline	High growth	High growth	Moderate decline
	Efficient technology (white goods)	Small decrease	Moderate increase	Increase	Increase
	Regulations particularly effects on WC cistern volumes, power showers and garden watering	Slow decline	Decline	Rapid decline to low volume flush WC	Slow decline to low volume flush WC
	Metering	Very variable locally	Moderate	High	Moderate
Leakage	Regulatory framework	Weak	Light	Strong orientated	Conservation
	Resource situation	Not considered	Secondary consideration	Important	Important
Non-household demand & direct abstraction primary industry	Economic growth (GDP)	1.5%	3%	2%	1%
	Output of manufacturing industries	Increase	Decline	Decline	Decline
	Employment in business services	Decline	Increase	Increase	Increase
	Water minimisation activity	Low	Mixed	High	High
	Greening of business initiatives	Low	Low	High	High
Spray irrigation	Reform of national and international agricultural policies (CAP & WTO)	Increase UK Government support	Removal	Full reform	Increase national & regional support
	Role of supermarkets & food processing firms	Continued role	Expansion	Realign position	Marginal role
	Crop quality premia (potatoes)	High	Very high	Medium	Low
	Drought tolerant crop varieties	Low uptake	Low uptake	Very high uptake	High uptake
	Organic production	Low	Low	High	Very high
	Irrigation efficiency	Medium	High	Very high	High

subsequent find-and-fix activity, pressure management levels, and service and mains replacement rates.

5.2.3 Industry and commerce

For industry and commerce, we have identified 19 different sectors to allow application of sector-specific assumptions. By differentiating between large companies and small and medium-sized enterprises (SMEs), the forecasts reflect variability in the level of uptake of water use minimisation options.

5.2.4 Spray irrigation

Agriculture is subject to a wide range of social, economic and political drivers of change which directly and indirectly affect the use and management of spray irrigation. Our new forecasts have developed the concept of economic demand, reflecting the costs and benefits of irrigating different crops.

The details of our approach and the outcome for each component of demand under each scenario are set out in Appendix 2.

Figure 5.1 Demand by scenario in 2010 and 2025: total and by component

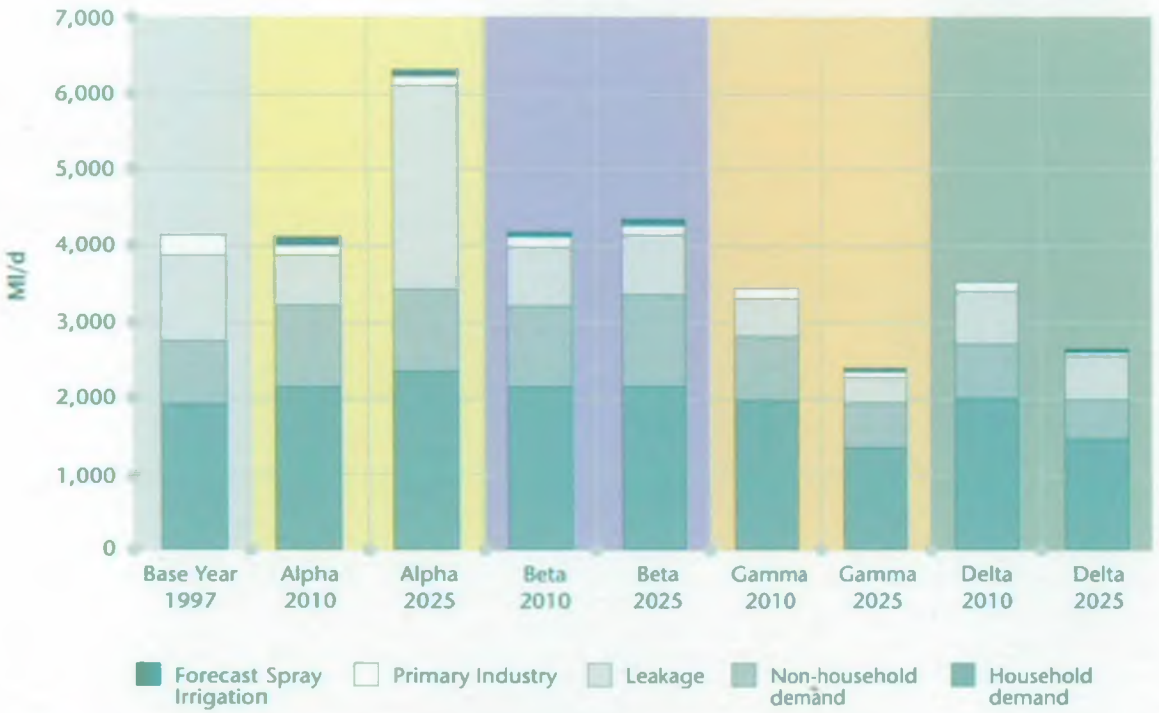
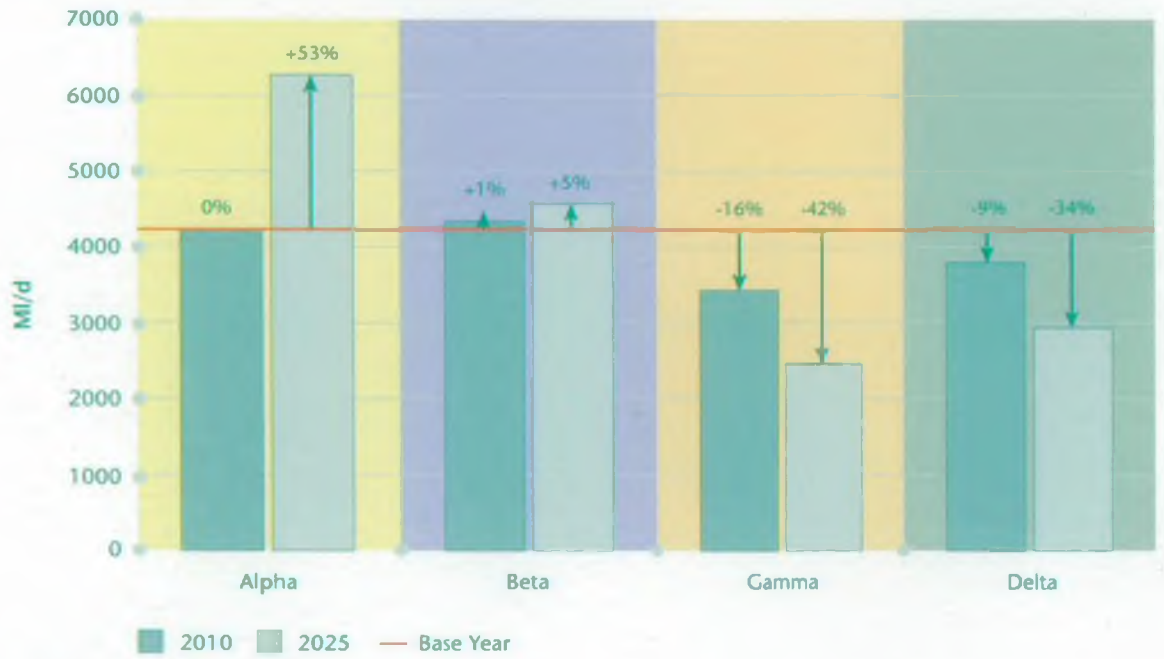


Figure 5.2 Total demand by scenario in 2010 and 2025



5.3

Scenario demand in 2010 and 2025

5.3.1 Differences in demand

Figures 5.1 and 5.2 show the results of this forecasting work for 2010 and 2025. By 2010, the differences between scenarios Alpha and Beta are small, reflecting a slow rate of divergence from today's values. However, a clear divergence is beginning to emerge between these two scenarios and scenarios Gamma and Delta, particularly through changes in non-household use and more significant reductions in leakage. By 2025, demand varies significantly between scenarios, with increases in total demand for water particularly under scenario Alpha by up to 53% (or 2150Ml/d), but decreases in scenarios Gamma and Delta by up to 42% (or 1750Ml/d). Within this, the different components behave in different ways and their effects are illustrated in Figure 5.1.

Household water use is projected to increase under scenario Alpha by up to 26% (approximately 500Ml/d); a slightly lower rate of growth is projected for Scenario Beta emphasising the impact of metering. The reductions in household water use under scenarios Gamma and Delta (by up to 29%) illustrate the range in potential savings that could be achieved through water conservation measures.

Potential changes in leakage have a dramatic impact on demand by 2025. The large rise in leakage under scenario Alpha after 2010 (by as much as 1600Ml/d or 140%) illustrates the possible outcome of a more passive approach to leakage management within the region and the potential threat to security of supplies that would arise without substantial new water resources development. By contrast, scenarios Gamma and Delta provide an indication of the scope of further savings that could be achieved beyond current leakage targets with total leakage in the region being reduced towards 300Ml/d.

Industrial and commercial demand increases most significantly under scenario Beta, with a 38% (or 300Ml/d) increase largely due to assumptions of higher rate of domestic growth. Scenarios Gamma and Delta both show significant reductions in demand, by up to 43% (or 350Ml/d) providing an indication of the potential savings in water use through wider implementation of waste minimisation initiatives.

The potential changes in agricultural demand, largely for spray irrigation, in the region are small reflecting the generally low level of existing use. Increases under scenario Alpha and Beta reflect growing trends for higher quality produce whilst reductions in demand, particularly under scenario Gamma, reflect a greater emphasis on growing drought tolerant crops and more efficient irrigation methods.

There are distinct differences between companies and resource zones across the region and this is demonstrated in Figure 5.3. All companies show a characteristic and substantial increase in demand by 2025 under the Alpha scenario reflecting assumptions about increasing leakage. Four of the five companies (the exception being Thames Water) show modest growth by 2010 under the Alpha and Beta scenarios with relatively little change under the Gamma scenario. Growth continues under the Beta scenario to 2025 whilst there are substantial reductions in demand under the Gamma and Delta scenarios reflecting the impact of leakage and water efficiency savings.

By contrast, the data for Thames Water only show an increase in demand under the Alpha scenario by 2025. In all other cases, total demand remains close to current levels or declines significantly, emphasising the effect of planned leakage targets (to 2000/01) and the impact of further leakage reductions under the Gamma and Delta scenarios. In all but the Alpha 2025 scenario, the effect on total demand of potential growth in household and non-household sectors is outweighed by reductions in leakage.

5.3.2 Climate change and demand for water

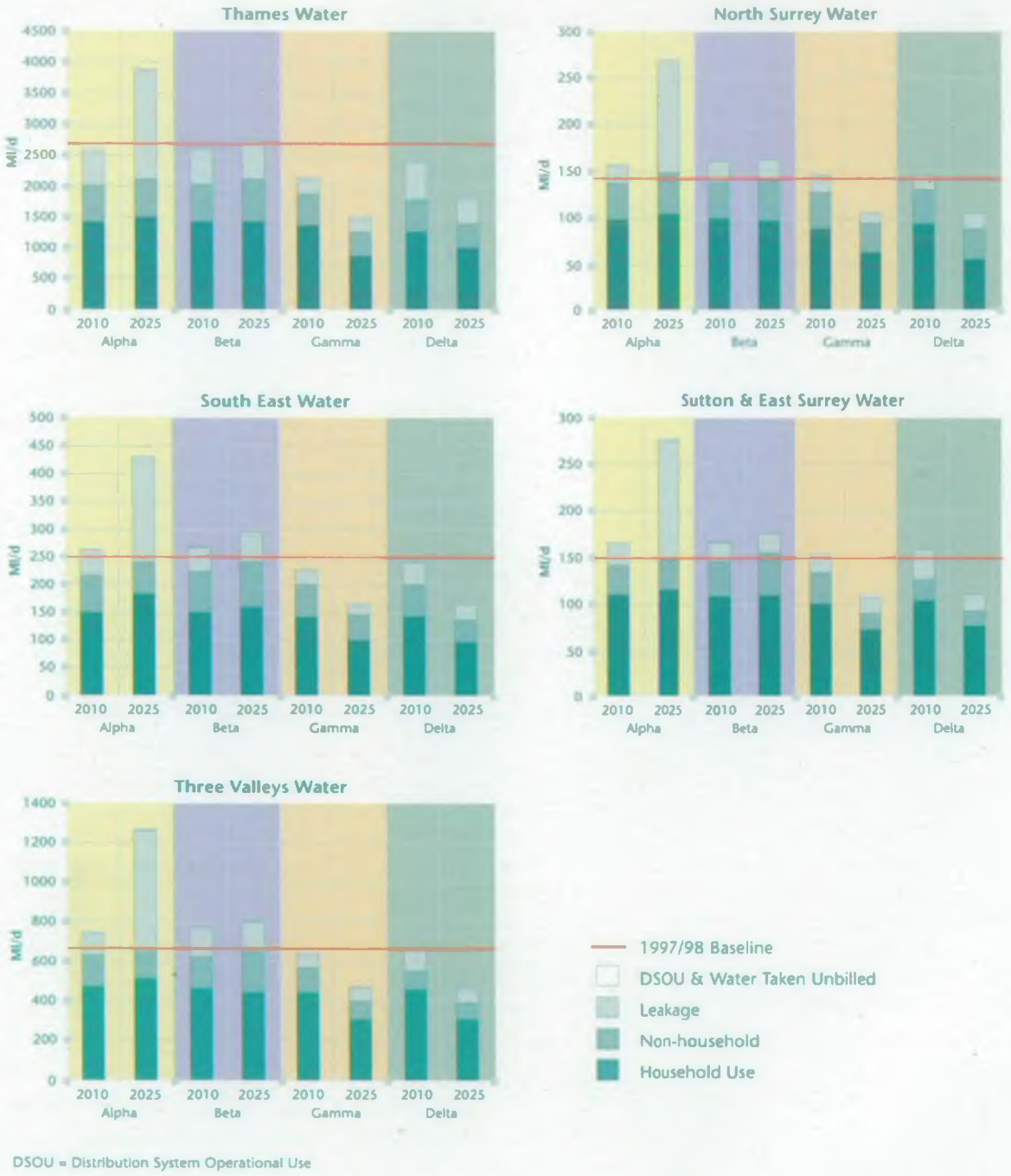
Changes in climate may have significant implications for the way that we manage supplies and demand within the region. Climate change will influence demand across the various sectors in a number of ways.

Household water use is likely to increase given the greater frequency of hotter, drier summers. Increases in demand are likely to come from increased garden watering and additional personal washing; driven predominantly by higher temperatures. We have estimated the potential impact on household demand caused by climate change, on the basis of the scenario Beta, a high-growth scenario. Regionally, this equates to a potential increase of approximately 50 Ml/d on average. The potential impacts on public supply systems at times of peak demand could be significant without proper attention to the management of both demand and available resources.

Industrial and commercial water use may be affected in two different ways: there may be increased demand for some products, while other processes may become less water-efficient at increased temperatures. We can also expect increased demand for water for both ordinary domestic purposes at work, but more significantly, for air conditioning and climate control. The precise nature of these changes is unclear, particularly in view of continuing innovations within industry in processes and waste and water minimisation. For the purposes of this strategy, we have assumed that our forecasts of industrial demand do not at this stage need to be modified to allow for climate change over the next 25 years.

Agriculture may be affected in several ways. Planting and harvesting dates will change, as will the types of crop grown and their distribution. Potentially longer growing seasons will affect irrigation needs both in terms of the level and timing. The increased risk of drought, particularly on arable soils, may lead to investigations of alternative opportunity crops such as grain maize or soya. Livestock production will also be affected, with increases in animal drinking, water

Figure 5.3 **Total demand by scenario for each water company in 2010 and 2025**



DSOU = Distribution System Operational Use

wallows for outdoor pigs, and increased cooling of indoor units. Constraints on available resources are likely to become an increasing concern locally.

We commissioned Cranfield University at Silsoe to develop and apply a new methodology to assess the impact of climate change on current optimum irrigation needs. The analysis indicates that for the eight crops studied, optimum irrigation need would increase at the six study sites considered. Over the next 25 years, climate change will be one of many challenges facing agriculture. Given that our results are preliminary we have not included climate change in the assessment of incremental demand. We will revise our forecasts in light of the results of the DETR climate change and demand study.

5.4

Environmental need

In Chapters 3 and 4 we identified a number of sites or catchments which are being harmed as a result of current levels of (licensed) abstraction; sites where schemes were scheduled for implementation and sites where further investigations were required. A strategy

aimed at sustainable use of water would not be complete if it left such a situation untouched.

We have therefore estimated, on the basis of a mixture of knowledge and judgement, the extent of licence curtailment that will be necessary within the region. Reductions in deployable output from sites where schemes have been identified for implementation through the NEP have already been accounted for within water companies' estimates of available resources. We have focussed on those sites where investigations have yet to be carried out and where there are new statutory drivers. These encompass a potential range of environmental demand of 100-350 Ml/d, impacting principally on Thames Water (145 Ml/d) and Three Valleys Water (40 Ml/d) companies.

Our strategy assumes that schemes will be in place to enable the resolution by 2010 of problems currently flagged up for investigation under the NEP and that the larger strategic demand potentially created by this environmental need will be addressed within the longer-term strategy to 2025. This recognises:

- the need for better understanding of environment needs and benefits before any major changes in public supply systems are enforced. The development of CAMS will play an important role;
- the extent to which water conservation measures and leakage reduction may bring about direct benefits to the environment and the need for further development of these measures within the region;
- the lead-time for development of major new strategic schemes which may be required to support reductions in abstractions and which, therefore, constrains early action in certain cases.

Our strategy assumes that this level of curtailment of existing abstractions will be necessary in the period of the strategy, although we will need to demonstrate the justification for any curtailment. This need represents a further "demand" to be set against available resources.

5.5 Determining incremental demand

In this chapter we have indicated how a set of scenario-based incremental demands has been assembled. These have been compared with currently available spare resources to identify a range of net incremental demands, for 2010 and 2025. We have assumed that existing demands for water are met through existing resources unless there are identified environmental needs (section 5.4) or in the case of public water supply a deficit has been identified in a water company's water resources plan.

Existing resources have been compiled from water companies' calculation of yield, and the current licensed abstractions for industry and agriculture. The latter may not be reliably available during severe droughts, but are appropriate for comparison with existing demands.

5.5.1 Public water supply

The balance between supply and demand for public water supplies under each scenario is shown in Figures 5.4 and 5.5. These show the balance at resource zone level between currently available supplies as assessed by the companies and demand under each scenario for 2010 and 2025.

The results show that without any further resource development or effort to manage demand, deficits emerge consistently in three of the four scenarios by 2010 in those zones supplying the Upper Thames and London. By 2025, deficits under scenarios Gamma and Delta are addressed through the assumptions regarding the management of demand for water under these scenarios. However, under scenarios Alpha and Beta, there are significant deficits in the London zones and persistent deficits in the Upper Thames zones.

The outcome of scenario Alpha demonstrates dramatically the potential impact of a significant increase in demand; in this case through the lack of management of leakage. Substantial potential deficits occur right across the region.

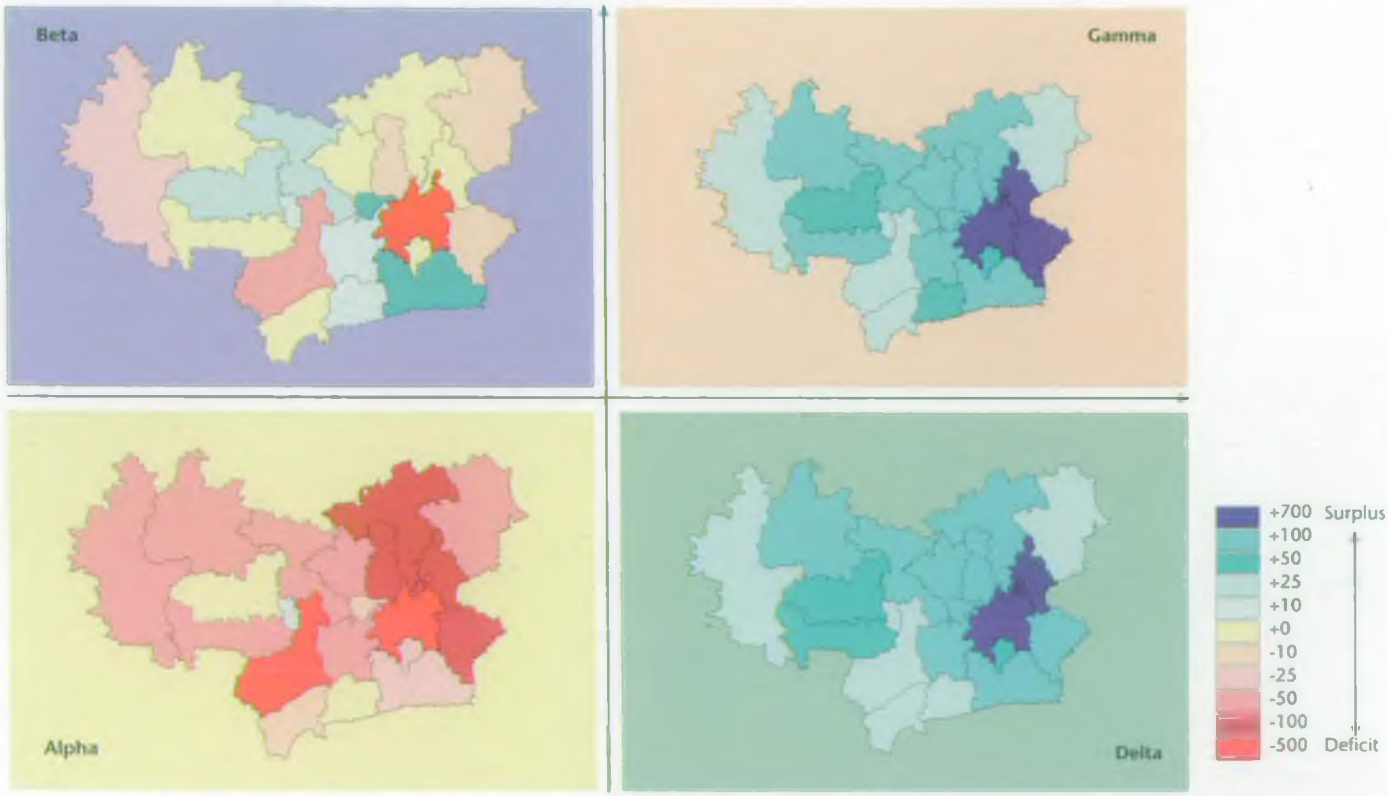
In Figure 5.6 we examine the 2025 supply-demand balance across the region assuming that companies maximise existing strategic links and their use of existing and planned licensed resources between resource zones. This allows us to aggregate zones and take a more strategic view of the potential deficits and need for new resources. In building this strategic view, we have assumed that companies will achieve their 2000/01 leakage targets and that the potential outcome of scenario Alpha will not occur. This allows us to focus at this point on dealing with the potential outcome of deficits under scenario Beta. In Figure 5.6 we show the potential deficits by 2025 under scenario Beta based on:

- currently available resources;
- allowing for those resource developments companies have proposed within their Water Resources plans to 2010; and,

Figure 5.4 **Supply/demand balance by scenario in 2010**

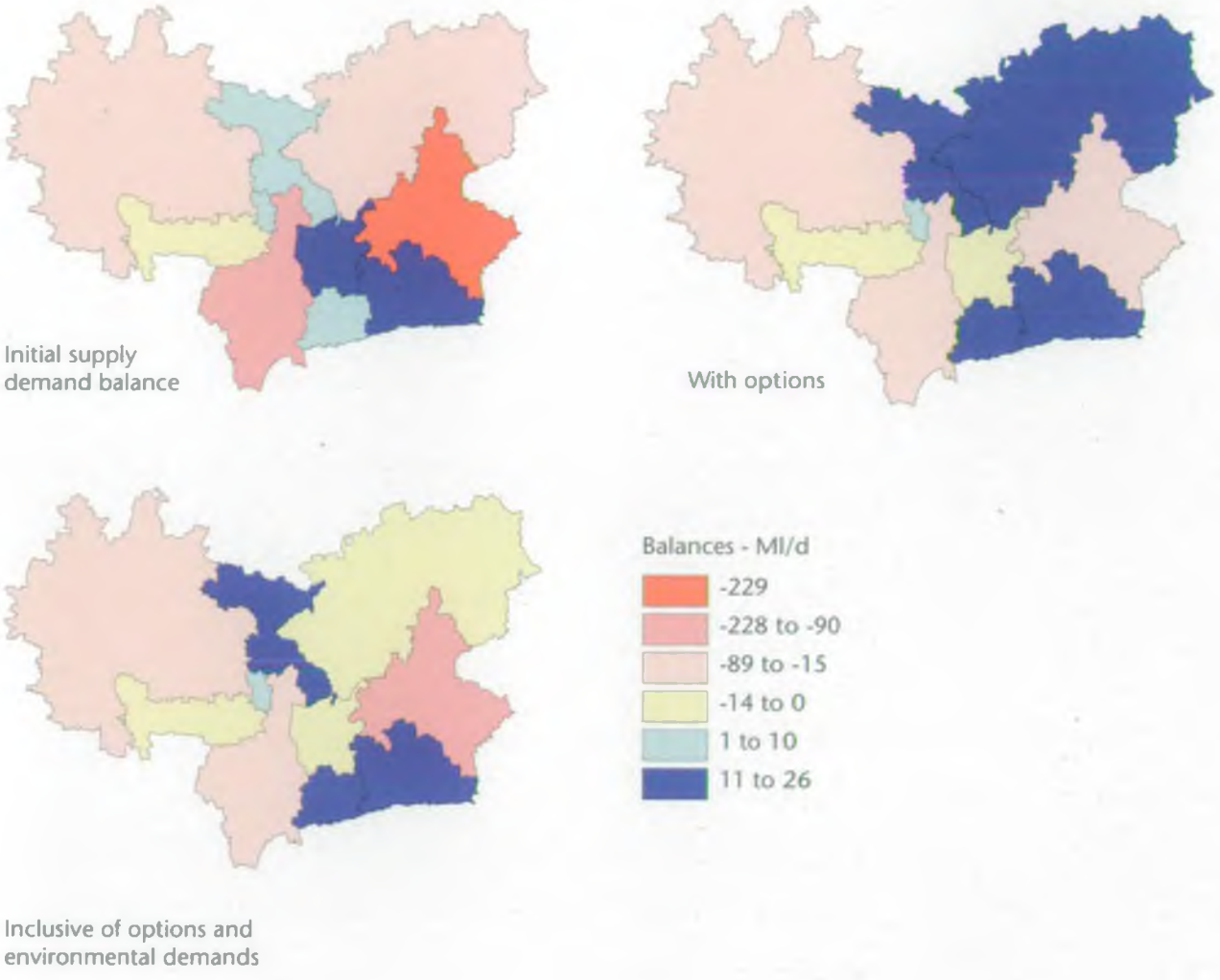
(Ml/d - based on comparison of scenario demand with water available for use (WAFU))

Figure 5.5 **Supply/demand balance by scenario in 2025**



(Ml/d - based on comparison of scenario demand with water available for use (WAFU))

Figure 5.6 Supply/demand balance by aggregate resource zones in 2025 (Scenario Beta)



- including the impacts of potential environmental demands for water.

The emerging picture is one of consistent deficits in the Thames Water London and Upper Thames resources zones, in South East Water, and potential deficits towards the end of our planning horizon occurring in Three Valleys areas. We return to these in more detail in Chapter 7 and examine the options to manage the supply-demand balance and the need for strategic water resource schemes.

5.5.2 direct abstraction uses

As we have discussed above, the overall demand for direct abstraction uses over the period to 2025 is forecast to remain largely unchanged or to decline significantly under the Gamma and Delta scenarios. Individual uses will continue to be an aspect of local licensing and the issues discussed earlier in this strategy regarding resource availability and reliability of supplies will need to be addressed at that local scale.

There would not appear to be any compelling requirements for additional demand for new strategic resource schemes solely for direct abstraction uses, although were any schemes to be developed, the opportunities for other uses would be an important consideration. Within industry, different trends forecast across sectors suggest there may be opportunities for review of licensed resources and potentially reallocation or trading. This will be an important aspect of our forthcoming Catchment Abstraction Management Strategies (CAMS).

In the next chapter we will look at the methods used to identify options and recommend solutions.

6 Options and option appraisal

In this chapter we describe how we have identified solutions to meet the incremental demand described in Chapter 5. The process has been iterative, considering a full range of possible resource development and demand management options. We have used a series of tools to help us to consider – for any set of options – costs, benefits, risks, uncertainties and contribution to sustainable development.

6.1 Identification of options

We have reviewed a wide range of potential options to manage the variety of future demands shown under each of the scenarios. The options examined in the 1994 strategy have been reassessed, and new options considered where appropriate. We have also drawn on proposals made by the water companies in their 1999 Water Resources Plans; particularly for those options proposed for the period to 2010 where their funding has already been considered through the Periodic Review of Prices.

The options considered fall into the following categories:

- **Supply management:**
  - infrastructure, treatment and supply schemes that make more effective and efficient use of existing licensed resources;
  - new groundwater sources;
  - new surface water sources;
  - winter storage (non-public supply);
  - artificial recharge of groundwater;
  - aquifer storage and recovery;
  - enlargement of existing reservoirs;
  - reuse of treated wastewater;
  - new reservoirs;
  - transfers of water (canal, river, pipe);
  - desalination.
- **Demand management:**
  - leakage reduction beyond current targets;
  - domestic metering, tariffs and water efficiencies;
  - waste minimisation by non-domestic uses;
  - greywater and rainwater recycling;
  - white goods subsidies to promote replacement and use of more water and energy efficient appliances;
  - retro-fitting water efficient domestic fittings.

The region's 1994 strategy discarded a number of options due to their potential impacts and costs. These included: a Thames estuary barrage, inter-regional transfers (from the Wye, from Kielder), a national water grid, and imports via the sea. The potential redevelopment of reservoirs remains a high risk and high impact option that could not be promoted without substantial reserve storage for the period of redevelopment. The potential for desalination schemes is currently being explored by companies in the south-east with a view to managing resources at times of seasonal peak demand or utilising cheaper sources of energy, such as that realised by the incineration of sewage sludge. Lower energy costs, together with continued improvements in technology and reductions in cost, means that desalination may become a more viable resource option for certain locations over the term of the strategy.

For resource development, we have had to make assumptions about schemes that may be feasible. Some of the schemes considered are well known and have been the subject of detailed investigation. This applies particularly to water supply options. Others are novel in some way, either because they are an adaptation of a scheme previously considered or because they are entirely new. All of the resource options considered would need specific investigation if they were to be progressed further.

For demand management options, too, there are uncertainties about future costs and effectiveness. We have aimed to err on the cautious side, in estimating what will be possible, basing our figures largely on existing or established technology.

The Agency is a competent authority under the Habitats and Birds Directives. We have considered the requirements of the Directives in our risk, uncertainty and sustainability appraisal. We will also ensure that individual actions are subject to appropriate assessment under the Directives.

6.2

Tools for considering options and strategies

In most cases there is a range of feasible water resources management options, each with strengths and weaknesses, and costs and benefits. To explore these we have used three approaches:

- a risk and uncertainty framework, looking at the risks, uncertainties and opportunities of options and strategies;
- a sustainability appraisal, looking at sustainability in its widest sense, including social progress that recognises the needs of everyone, the contribution to the effective protection of the environment, prudent use of natural resources and maintenance of high and stable levels of economic growth and employment;
- a costing exercise, looking at the broad financial costs of each option.

Each of these tools can be used either for individual options or for groups of options. We have applied them to both, to help us to think about the components that should make up the strategy, and then to consider the strengths and weaknesses of the strategy as a whole. Together, they help us to meet two of the Agency's duties: to have regard for costs and benefits, and to contribute to sustainable development.

6.3

Risk and uncertainty framework

Different options have different risks, uncertainties, opportunities and constraints. It is important to consider these when choosing the options that will contribute to the strategy. A balanced strategy will consist of a series of options that together produce an overall level of risk and uncertainty that is acceptable. Within this, there may be some individual options that are high-risk but may produce highly beneficial results. There is no simple way of calculating risks and uncertainties in the context of this strategy. To help us to think about the different characteristics of different options, we developed a tabular approach that provides a framework for the inevitably subjective analysis of this area. The approach considers:

- *uncertainty* in the technology, investigation, time, cost and resource value of an option;
- *opportunities* to meet wider objectives, including the ability to be flexible in implementation, opportunities for environmental enhancement, resilience to climate change, and to provide amenity and recreational benefits;
- *constraints* that may limit the success of the option, including attitudes and aspirations, and legal or institutional barriers.

Table A4.2 in Appendix 4 applies this framework generically to different resource management options. We used this framework in conjunction with sustainability appraisal to help us to understand the different characteristics of different options. The summary appraisal of regional options is shown in Table 6.1.

6.4

Sustainability appraisal

Our approach to sustainability appraisal draws on the DETR's *Proposals for a good practice guide on sustainability appraisal of regional planning guidance* (DETR 1999b), and the Agency's internal guidance documents. The appraisal was applied at each stage of the strategy formulation process, including the strategy objectives, strategic options and policies. These were appraised against the four themes of sustainability:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources;
- maintenance of high and stable levels of economic growth and employment.

In the assessment of strategic options, each of the sustainability themes was subdivided into criteria against which each option was assessed. These are outlined in Table A4.1 in Appendix 4; Table 6.2 summarises the appraisal of the regional options. The appraisal was carried out by an independent assessor.

Table 6.1 Uncertainty, constraints and opportunities framework: regional water resources management options

Option						Uncertainties					Opportunities					Constraints			
Type		Resource Value [Ml/d]	Time to implement [yr]	Estimated Cost [£m/Ml/d]	Renewal period [yr]	Technology and investigation	Promotion time	Construction/implementation time	Resource value	Cost	Flexibility in implementation	Environmental enhancements	Resilience to climate change	Meeting other needs	Amenity and recreation	Policy & legislation	Public & stakeholders	Environment	Energy Use
Resource Development	Tactical & strategic groundwater developments	200	2	○	30	○	○	○	◐	◐	●	○	◐	○	○	○	○	○	◐
	London rising groundwater	30-50	2 to 5	○	30	○	○	○	◐	◐	●	◐	●	●	○	○	○	○	◐
	Aquifer artificial recharge & storage & recovery	20	5 to 10	◐	15-30	◐	◐	◐	◐	◐	●	○	●	◐	○	○	○	◐	●
	BW Canal transfer (Grand Union/Oxford)	15	3 to 5	○	30	○	○	○	◐	◐	◐	◐	◐	◐	◐	○	○	◐	◐
	Indirect re-use of wastewater - river support (Pilot trials, R. L)	25	3 to 5	○	30	○	◐	○	◐	○	◐	○	◐	◐	◐	◐	◐	◐	◐
	Regional strategic reservoir (200-500 Ml/d)	490	15	●	100	○	○	○	○	○	○	●	●	●	●	◐	●	◐	●
	New reservoir (<200 Ml/d)	200	15	■	100	○	○	○	○	○	○	○	●	◐	●	◐	●	◐	●
	Bulk transfer Severn to Thames	50	5 to 10	◐	30	◐	◐	◐	◐	◐	○	◐	○	◐	◐	◐	●	●	●
	Desalination (using power from sewage sludge incineration)	20-50	5	●	10	○	◐	○	○	○	◐	○	●	◐	○	◐	◐	●	●
	Winter storage (direct abstraction)	-	1 to 5	○	15-30	○	○	○	○	○	○	○	●	○	○	○	○	○	○
Demand Mangement	Further leakage reduction	470	10	○ to ●	-	○	○	■	◐	■	●	◐	●	◐	○	■	◐	◐	○
	Increased household metering	45	10	●	10	◐	◐	◐	●	◐	●	○	◐	○	○	◐	◐	○	○
	Domestic water efficiencies	100	1 to 10	●	10	◐	◐	○	◐	○	●	○	●	○	○	◐	◐	○	○
	Waste minimisation (water) in PWS industry/commerce	150	1 to 5	○ to ◐	-	○	○	○	◐	○	●	○	●	○	○	○	◐	○	○
	Waste minimisation (water) in direct abstraction industry	30	1 to 5	○ to ◐	-	○	○	○	◐	○	●	○	●	○	○	○	◐	○	○

● High ◐ Medium ○ Low

Given that the climate is changing, all sectors of society and the economy will have to respond to new climate conditions. Adaptation strategies will be driven by changes both to long-term climate and to extreme events. However, as indicated above, the exact nature of climate change is uncertain. Assuming the worst can be very expensive, especially where decisions have to be taken many years in advance. One of the keys to a successful adaptation strategy is to ensure that it is sufficiently flexible to deal not only with current scenarios but at least to some extent with events that are less likely. In the context of the water resources strategy, this means that schemes that improve the management of water use, or developments that can be phased, will be more appropriate than schemes that are inflexible.

6.5

Costs

For this strategy, we have used the best available financial cost information to compare different options. We have drawn this from a variety of sources and commissioned a study to evaluate and place it on a reasonably consistent basis. However, the wide variety of types of option, and differing levels of detail available mean that precise cost comparison could be misleading. In addition some financial information has been provided in confidence. We have therefore classified the costs on a three-point scale of low, medium and high. In the longer term, we will seek to ensure that more cost information is placed in the public domain.

We have not tried to pursue a detailed application of environmental economics. We have considered this detailed investigation to be inappropriate at this stage of strategy development, although it would be an essential part in the development of schemes to implement our recommendations. Sustainability appraisal considers the components of environmental cost alongside other aspects in a way that is appropriate at this stage.

6.6

Building a strategy

The process we have followed to combine these approaches recognises the significance of cost but also takes account of the other elements in a logical and

Table 6.2 Sustainability appraisal of regional water resources management options

Options		Sustainability Themes							
		Effective Protection of the Environment		Prudent Use of Natural Resources		Social Progress which recognises the needs of everyone		Maintenance of high and stable levels of economic growth and employment	
Resource development:	Resource Value Ml/d	Positive impact	Negative Impact	Positive impact	Negative Impact	Positive impact	Negative Impact	Positive impact	Negative Impact
Improvements in infrastructure, treatment, outage and deployable output	100	0	0	+	0	+	0	+	0
Tactical and strategic groundwater development	200	+	(-)	+	0	+	0	+	0
London Basin: Artificial aquifer recharge, storage and recovery & rising groundwater	30-50 (Included above)	+	0	++	(-)	0	0	+	-
Transfer from Grand Union via Oxford Canal	15	++	--	++	--	+	-	+	-
Indirect re-use of wastewater - river support (R. Lee)	25	(+)	-	(+)	-	(+)	0	0	-
EITHER-Regional strategic reservoir	Up to 490	++	--	++	-	++	-	+	-
OR-Bulk transfer Severn-Thames	30-50	+	--	++	--	+	-	+	-
Increased bulk transfer from Anglian Water (Grafham)	22	+	(-)	+	(-)	0	0	+	(-)
Desalination (using power from sewage sludge incineration)	20-50	+	(-)	+	(-)	0	0	0	-
Winter storage (direct abstraction)	n/a	(+)	0	++	0	+	0	+	0
Demand management:									
Further leakage reduction	Up to 470	+	(-)	++	0	+	0	+	-
Increased household metering	45	+	0	+	0	+	-	+	-
Domestic water efficiencies	100	+	0	++	0	+	0	+	0
Water use minimisation: public supplies to commerce and industry	150	+	0	++	0	0	0	+	0
Waste minimisation (water) in direct abstraction industry	30	+	0	++	0	0	0	+	0

KEY:
++ = very positive impact
\+ = positive impact
(+) = slight or indirect positive impact
0 = the option is neutral
(-) = slight or indirect negative impact
\- = negative impact
-- = very negative impact

consistent manner. It is an iterative approach involving the following steps:

1. identify the options available for meeting any gap between supply and demand. These include both demand management and resource development;
2. for 25 years ahead, consider the biggest incremental demand;
3. identify a first solution (made up of a set of options) for this incremental demand;
4. look at the strengths and weaknesses of this solution, as indicated by the sustainability appraisal, application of risks and uncertainties framework robustness to climate change: how does the set of options perform?

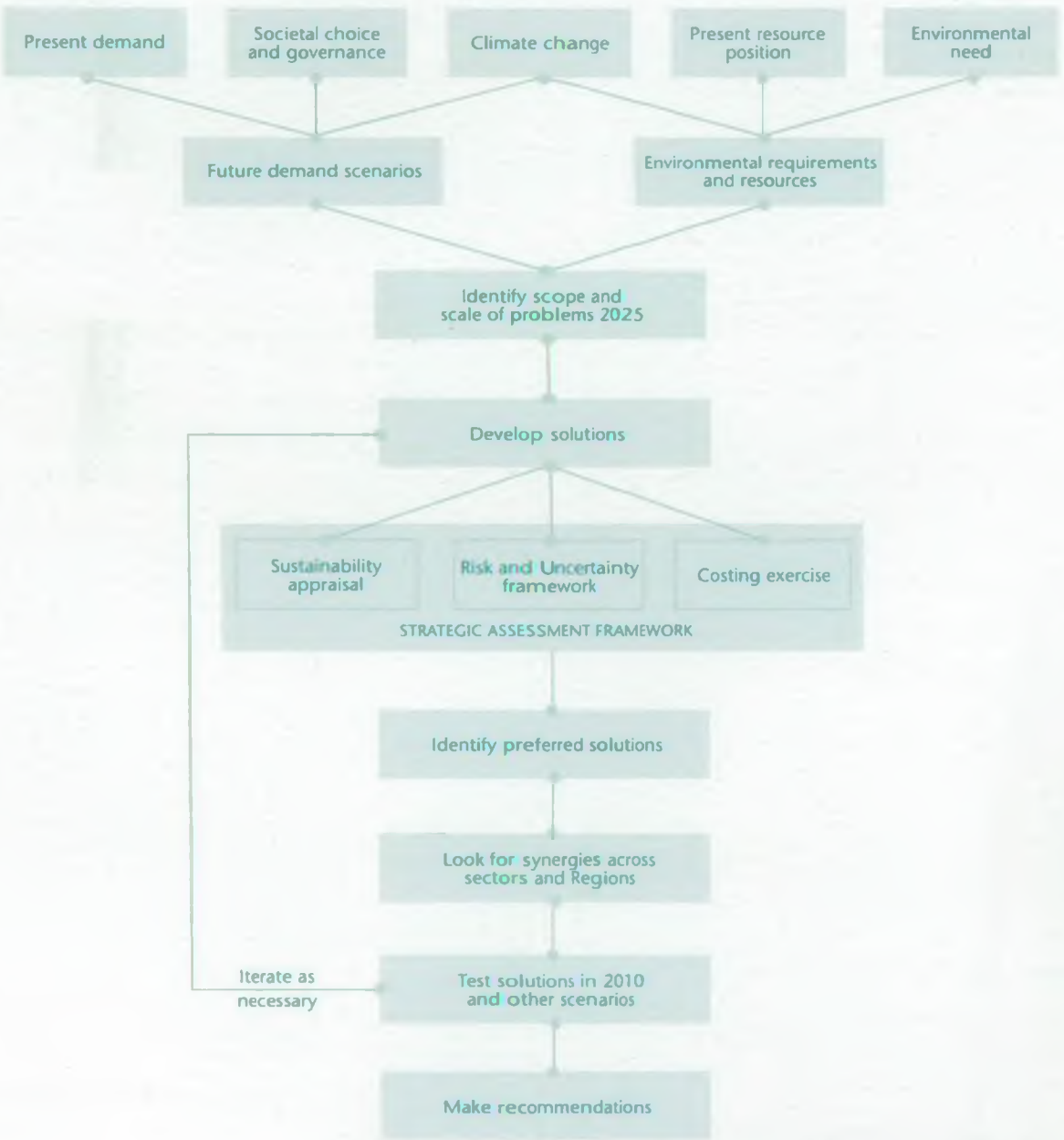
5. consider the weaknesses and constraints of the individual options identified: could other options improve the contribution to sustainable development, increase resilience to climate change or reduce uncertainties?
6. look at the effectiveness of this solution 10 years ahead;
7. consider the effectiveness and appropriateness of this solution in the other three scenarios;
8. refine and review the set of options, identifying a robust solution and the necessary timing of actions.

The strategy development process is illustrated in Figure 6.1.

We recognise that costs will influence the delivery of any strategy and we have taken likely costs into account in considering different strategy options. But we have not calculated in detail the financial cost of this strategy. It will be for the organisations who promote schemes in line with this strategy to assess their costs and value for money, and to justify them on that basis. Where the Agency itself needs to take action to help realise the strategy it is, of course, duty bound to consider the costs and the benefits of what it proposes to do.

The assessment of risks and uncertainty and sustainability appraisal of our basket of options is shown in Tables 6.1 and 6.2. In a region where the natural and developed resources are already heavily utilised, any

Figure 6.1 **The strategy development process**



new scheme is likely to have significant economic costs and environmental concerns. This is a key feature of both tables.

The tables highlight a number of issues, emphasising the difficult choices we have to make:

- developed sensitively and with appropriate environmental safeguards, groundwater resource schemes provide a low-risk, low-impact solution;
- "High" sustainability solutions tend towards higher cost, the exception being waste minimisation;
- resource-based solutions tend towards lower uncertainties but significant constraints in stakeholder concerns, environmental impact and energy use;
- demand based solutions have high uncertainties and significant stakeholder and policy constraints;
- with the exception of the large strategic engineering schemes (a reservoir or strategic transfer), all the options provide a flexible strategic response to changes in resources and demand;
- reservoir development is a largely inflexible solution; size has to be judged well in advance and the impacts are permanent. Reservoirs can, however, provide a wide range of opportunities.

Many of the potential impacts associated with resource-based solutions can be mitigated through the effective design and implementation of controls during the construction and operation of these schemes. Furthermore, the Agency has made clear to promoters its expectation that schemes should provide a net environmental gain. That is, whilst there may be some environmental change, this should be offset by the provision of greater environmental benefits. Any new scheme should also provide a wide opportunity for other uses.

7 Conclusions and proposals

In preceding chapters, we have looked at the state of water resources, the present and future pressures, and how we can use a scenario approach to develop a strategy. We have also outlined our approach to identifying and selecting options. In this chapter we describe the resulting strategy for managing water resources for the next 25 years.

7.1 Water resources strategy for Thames Region

Our recommendations consist of a combination of resource developments and demand management. This is a genuine "twin-track" approach. We propose:

Restoring sustainable abstraction:

- curtailing abstraction, where abstraction is shown to cause environmental problems, and seeking sustainable alternatives that provide a net benefit to the environment (providing a net reduction of resources of 100-350 Ml/d).

Supply management:

- improvements in infrastructure, treatment and supply systems to make more efficient use of existing licensed resources (providing approximately 100 Ml/d);
- tactical and strategic groundwater development, including utilising rising groundwater, further development of opportunities for artificial recharge in the London Basin and opportunities in the Middle Thames (providing up to 200 Ml/d);
- further investigation and potential development of options for canal transfer (providing approximately 15 Ml/d);
- further development of strategic bulk transfers of water, including additional transfers from Grafham to Three Valleys (providing approximately 22 Ml/d);
- indirect reuse of wastewater for enhancement of resources through river augmentation and for meeting demands for some non-potable uses (providing in excess of 25 Ml/d);
- further development of winter storage and on-farm efficiencies in water use, particularly for irrigation purposes;
- further investigation of the need for, and impacts of, the development of new strategic resources, principally for the Upper Thames but potentially including strategic river regulation for London. Options include new reservoir storage, such as the proposed Abingdon scheme (to provide up to 400 Ml/d), or a transfer from the River Severn to Farmoor reservoirs (to provide up to 50 Ml/d);
- further investigation and potential development of desalination utilising cheap power sources at sludge incineration sites on the Thames Tideway and continuing improvements in process technology and costs.

Demand management:

- significant further reductions in leakage beyond present targets (potentially providing up to 470 Ml/d);
- extension of household metering to 50-75% of domestic customers (providing approximately 45 Ml/d);
- development and promotion of water efficiency and water conservation measures for domestic users (providing approximately 100 Ml/d);
- waste minimisation in industrial and commercial sectors (public supply and direct abstraction-supplied) (providing approximately 150 Ml/d).

Regulation will continue to play an important role in the development of this strategy. In licensing, two particular aspects are worthy of mention:

- granting new or varied licences to facilitate trading of licences and competition in providing supplies but ensuring that no environmental degradation arises;
- imposing time limits on all licensed abstractions and, through CAMS, securing sustainable management of water resources at the catchment-scale.

Key elements of our strategy are summarised in Table 7.1. Of course, some actions need to be started considerably in advance to achieve a successful result by the dates shown. We have also identified some alternative actions that could be considered if our preferred options prove inappropriate in some way.

Figures 7.1 and 7.2 show our proposed solutions for 2010 and 2025. In these figures we show first the water taken for public water supply, industry (excluding power generation) and spray irrigation in 1997/98. The second column shows the same information for either 2010 or 2025, with the top section of the column representing the resource development or enhancement that we are proposing. The next four columns show the demands for the four different scenarios for the same year. The top section of the bars for scenarios Alpha and Beta represent the saving that we expect from demand management. These are the same demand management measures, but they deliver different savings in different scenarios.

We are proposing a single set of actions that is robust enough to manage water resources through all of the scenarios that we have considered. This does not mean that water can be made available for all uses at all times of year; for example, in some areas, the provision of water for spray irrigation is becoming increasingly problematical. The strategy also provides additional water to deal with the possible impact of climate change on domestic demand, and to restore sustainable abstraction regimes in those areas currently considered to be adversely affected. This combination of prudent demand management and development of additional resources is a twin-track approach.

Our proposed strategy identifies a basket of options to ensure that supply and demand are balanced through all four scenarios in the region and across the resource zones for both 2010 and 2025. Not all of the options will necessarily be required, as the strategy overprovides in recognition of the uncertainties in planning water resources and the need for further investigation of a number of options. Achievement in full, or better, of the demand management options means that the need for further strategic schemes is reduced. The need for larger strategic water resources schemes (a new strategic regulating reservoir or inter-basin transfer) may be avoided altogether under these circumstances. This is examined below in relation to London and the Upper Thames and the need for strategic schemes.

Winter storage options will provide resilience to climate change. However, long promotion and implementation times for reservoir development or enlargements will mean that they will need to be promoted soon if they are required before 2025. The considerable lead-time for major development can be challenging, given the significant uncertainties. We discuss this in more detail in section 7.8.

Local development options and wastewater reuse schemes are also proposed. The Agency considers properly and appropriately treated wastewater to be an important and sometimes undervalued element of our water resource. It can not only support a healthy river environment and provide an associated amenity, but can also provide for a range of reuses to support our quality of life and sustainable economic activity.

In some scenarios, our proposed strategy gives a significant surplus of supply over demand. In these scenarios, society would use less water, partly by individual choice but also because of changes in the economy and regulation. Our strategy does not propose that we must achieve these levels of reduction in demand. Such savings could not be realised on the basis of today's values and regulations. They would be a response to major shifts in societal attitudes to water use and the environment, which would be the result of many factors beyond the control of those who manage water resources. It would be unwise to base a water resources strategy on the possibility of such changes. However, these scenarios do illustrate that there is real potential for further efficiencies in water use.

In the light of such uncertainties, we have proposed a strategy that is flexible and can be phased. The final decisions on many of the later actions need to be made some way into the future, when there is more certainty about the result of earlier actions. This means that the monitoring of progress is essential.

In the following sections we consider in more detail our recommendations by sector.

7.2 Public water supply

Nowhere is the twin-track approach more appropriate than for public water supply. Whilst the efficient use of water is essential to protect the environment and to help to maintain adequate security of supply, it is also vital that supplies should not fail. Given the time that it

Table 7.1 **Summary of regional options**

For public water supply, by 2010

We expect to see water savings of up to 470 Ml/d and have allowed for resource developments of up to 340 Ml/d.

- Demand management options including metering and water efficiency measures.
- Surface water yield improvements (within licence, including River Lee and the Thames at Bray).
- Groundwater developments including London Rising Groundwater, and artificial recharge and recovery of London Basin groundwater.
- Indirect effluent re-use for river support (River Lee).
- Infrastructure/outage improvements.
- Full take-up of bulk transfers (within existing arrangements at Grafham).

For public water supply, by 2025

We expect to see water savings[1] of up to 750 Ml/d and have allowed for resource developments of up to 590 Ml/d.

- Demand management options including leakage control, metering and water efficiency measures.

Thames:

- British Waterways Grand Union and Oxford Canals - abstraction supported by transfers from the Midlands canal network. Further investigation will be required to confirm exactly how these transfers would be supported, although there are a number of local options available.
- New reservoir storage – a scheme, potentially of a significantly lesser size than currently being considered by the company, may be required. The size of scheme will depend upon need, reflecting the impact of leakage control and demand management activities on the degree of strategic requirement.
- Severn to Thames transfer – may provide an alternative option to new reservoir development, solely for the west of the region. However, potential schemes will require further investigation and feasibility studies prior to inclusion within the strategy. Potential options include a direct transfer to storage (Farmoor) and PWS links with a restored Thames-Severn canal.

Three Valleys:

- Small local groundwater development of the confined aquifer.
- Schemes to improve outage and deployable output.
- An increase in bulk transfer from Anglian Grafham reservoir. This is potentially required towards the end of the planning horizon to manage peak demands but could potentially be brought forward to manage losses in deployable output arising from pollution impacts and outage.

Sutton and East Surrey:

- Largely peak issues. Potential (joint) development projects in the South London confined aquifer based on aquifer artificial recharge and recovery.

[1]excludes water savings through maintaining current active leakage control targets

For agriculture, by 2025

- Demands predicted under the four scenarios are small. Winter storage and on-farm efficiencies will continue to be promoted.

For industry and commerce, by 2025

- Water use minimisation saving. Forecast trends across sectors indicate potential opportunities for licence review and re-allocation over the longer term of the strategy.

For the environment, by 2025

- Abstraction recovery of between 185 to 350 Ml/d; principally impacting on Thames (145 Ml/d) and Three Valleys (40 Ml/d).

Other options under consideration

- Major new strategic reservoir scheme.
- Desalination.

Other significant uncertainties

- Further investigations to confirm the operational viability of a Grand Union/ Oxford canals transfer scheme.
- Scale of strategic resource requirement, reflecting the impact of leakage control and demand management measures and operating constraints across the region.
- Alternative reservoir scenarios: size and strategic purpose will require further investigations of site feasibility, environmental impacts etc.
- Further investigations to confirm the resource availability and operational viability of transfer schemes from the River Severn, including full consideration of potential environmental impacts. There is also a risk that some proposed future resource developments may not go ahead because of Habitats Directive concerns.
- Increasing pollution risk to groundwater within the urban and fringe areas potentially bringing forward the need for water resources developments.

Figure 7.1 **Proposed regional solutions for 2010**

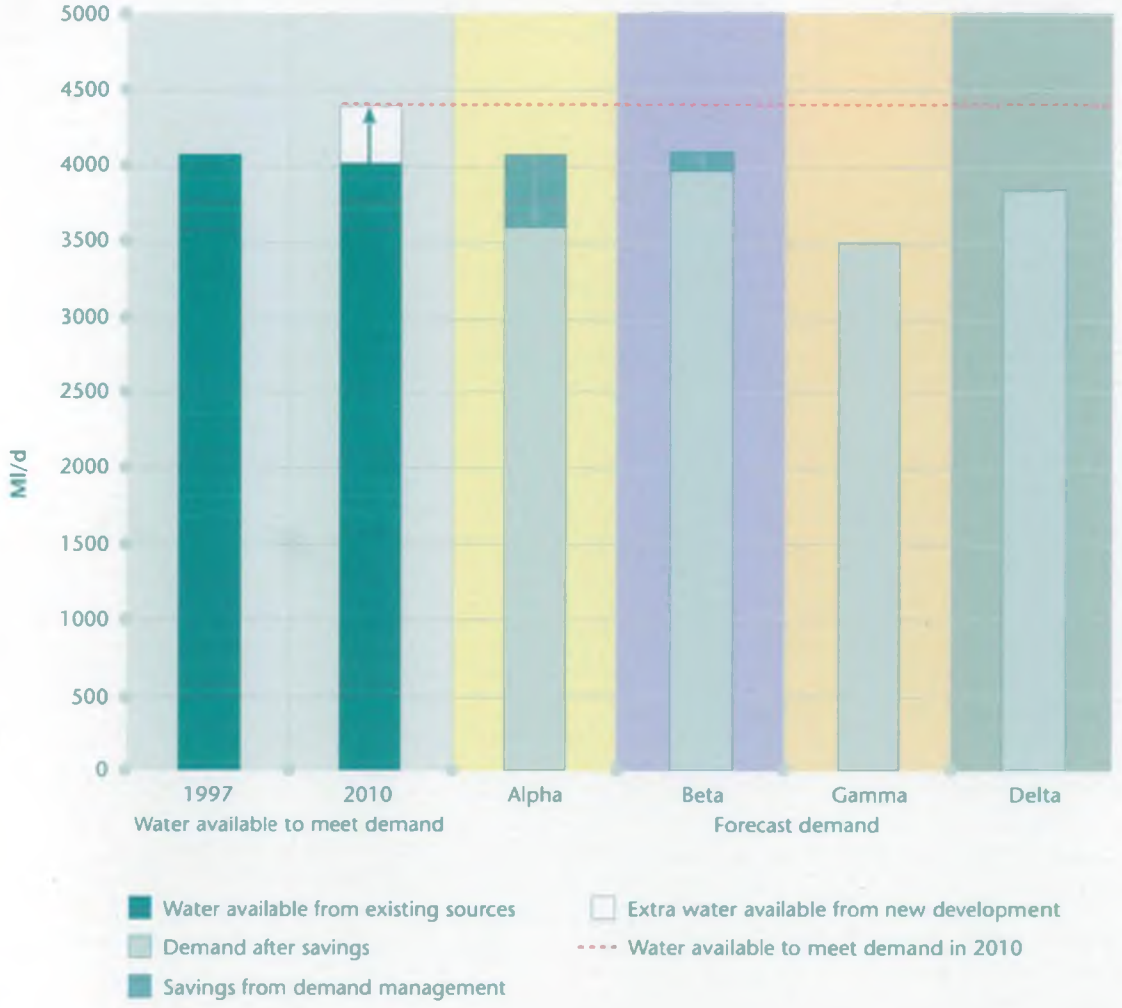
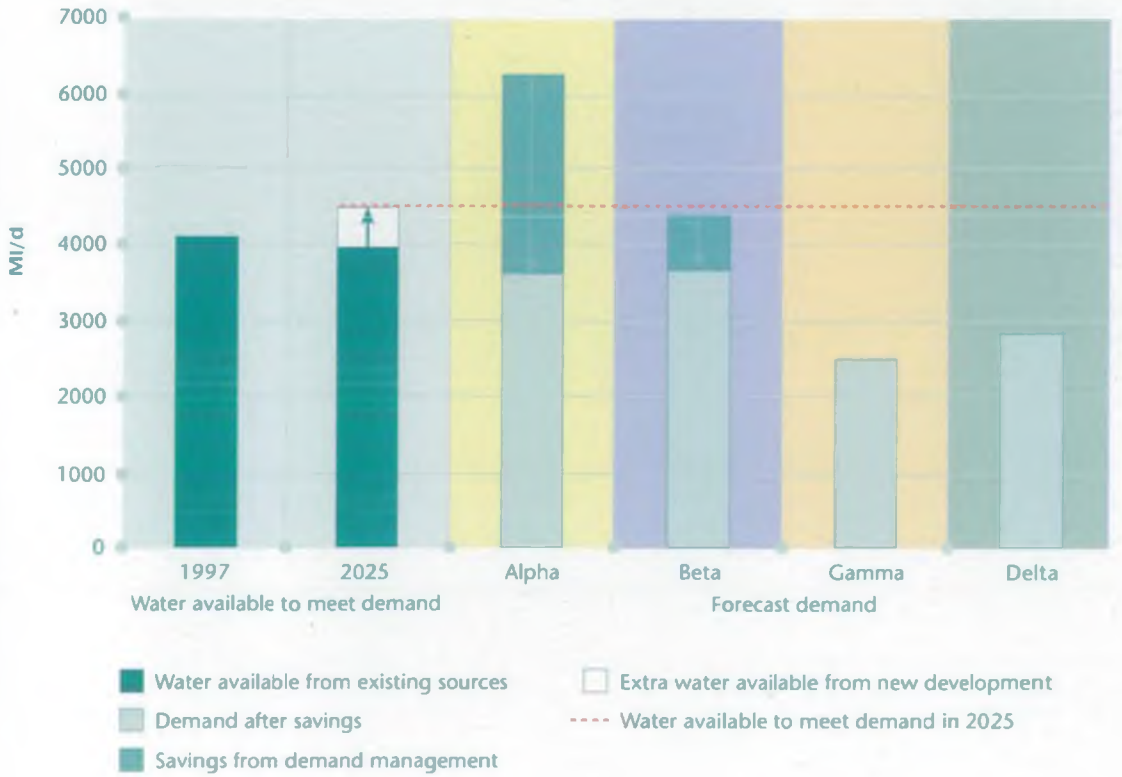


Figure 7.2 **Proposed regional solutions for 2025**



takes to develop some types of water resource, actions must be determined well in advance.

Table 7.1 shows our recommendations for the region for 2010 and 2025. In all cases, these consist of a combination of resource developments and demand management. In total by 2025, we propose resource development of approximately 600 Ml/d, providing over 400 Ml/d more water after environmental improvements are taken into account.

Our strategy assumes that the schemes that companies have proposed within their Water Resources Plans to 2010 will be fully investigated and can be successfully promoted within that period if they are required. This provides a potential increase to resources in the period to 2010 of some 340 Ml/d, approximately 210 Ml/d of which has been proposed for the Thames Water London resource zones. For most of the region, the twin-track development of further demand management measures together with those resource development options proposed by companies to 2010 is sufficient to balance supplies and demand throughout this strategy. There are two particular cases where this approach does not fully satisfy the supply-demand balance and where further water resources development may be required in the longer term: the Thames Water Upper Thames water resource zones and Three Valleys Water supply area. There are also significant uncertainties regarding the extent to which further strategic resources may be required to supply London.

We firmly believe there is greater scope for water efficiency and significant further reductions in leakage, especially in the Thames Water supplied areas, London in particular. These have a major bearing on the extent to which further strategic water resources development may be required. There remain fundamental issues and uncertainties to resolve; current levels of leakage have yet to be fully quantified and the costs, benefits and wider contribution to sustainability of further leakage reductions have yet to be realised. Our twin-track strategy recognises the inherent risks and uncertainties of this position and we have provided a basket of actions that can be called on to manage water resources both in the short to medium term and for the longer term. There are some fundamental actions required of the water companies within the first few years of this strategy and we will explore these below.

Our strategy recognises that some actions need to be started considerably in advance to achieve a successful result by 2010 and 2025; some resource developments will need to be commissioned whilst further work progresses on leakage and water efficiency. Other actions will need to be carefully considered for the longer term to ensure that appropriate schemes can be implemented as soon as their need has been confirmed. We have also identified some alternative actions that could be considered if our preferred options prove inappropriate in some way.

7.2.1 Enhancing resources

We consider that water companies will need to make developments to enhance resources over the period of this strategy. Many of our resource-side recommendations involve making the most of existing schemes. These include further integration of supply systems, improvement of machinery and equipment to reduce temporary interruptions to supply (outage), and bulk transfers of water between water companies. As a general principle, **we recommend that where new or existing developments are not fully utilised water companies should consider sharing this water with others (Action A1).** There are few opportunities for this principle to be applied within the region using enhancements to existing resources because of the fine balance between supplies and demand. There are, however, some further opportunities within companies' own supply arrangements to ensure that the use of resources is maximised through further integration of infrastructure; for example, further integration of resources in the Upper Thames resource zones. We expect companies to maximise their use of existing bulk supply arrangements and where they do not intend to do so, to relinquish or renegotiate those arrangements. We also expect companies to work closely together where they have interests in development within the same resource units (catchments, aquifers), and we expect this will be a key feature in considering the need for future strategic water resources development, such as the proposed Abingdon reservoir scheme. Further reduction in leakage also has a role to play in this context, by potentially releasing a valuable resource for others to use. As indicated earlier, competition may provide a useful driver for this to occur.

In identifying resource enhancements, we have drawn heavily on previous work, and particularly on the water companies' Water Resources Plans. We have worked closely with the water companies on the development of these plans, particularly in identifying where there is scope for improving output from existing licensed sources, but also in considering where new resource development may be feasible. Some schemes will require further investigation to assess the engineering requirements, cost, potential yield and environmental impacts and constraints. In some cases, investigations have already commenced or are at an advanced stage.

Given the complexities of water resources management in the region, it is useful to consider the need for potential water resources development in the context of those areas where the need occurs, and under what circumstances the need for new schemes may change.

The London Resource Zones – Thames Water

A number of resource developments have been proposed to address both the current deficit between supplies and demand and to cater for growth in demand. They include:

- Process improvements at the Coppermills water treatment works;
- Improvements within existing licences of groundwater in the Northern New River Well-field and the New River conduit;
- Utilising rising groundwater:
  - improvements at existing licensed sources;
  - investigation and development of new sources in central London (currently including Battersea, New River Head and Brixton);
  - investigation and development of new sources outside central London (including developments by other commercial interests which would result in decreasing commercial demands for water on the public supply system).
- Development of groundwater in south-east London: investigation of sources in the Ravensbourne Valley (Bell Green and Catford).
- Development of artificial recharge:
  - extension to the North London Artificial Recharge scheme;
  - investigations and potential development in south London: motivated by increasing abstraction demand from groundwater in the south London / Sutton and Merton areas.
- Aquifer storage and recovery: investigation of the potential use of currently unused aquifers for recharge of River Thames-derived surface water.
- Indirect reuse of wastewater for river augmentation and abstraction support: further investigations and potential development of a pilot project utilising wastewater from Deephams treatment works. Tertiary treated wastewater could be used for river support for the River Lee and Lee Navigation, allowing reactivation of the abstraction inlet (upstream of the discharge) at Keides Weir to increase output at Coppermills. Further investigation and development of pilot projects, where feasible, to examine potential opportunities for non-potable reuse of water.
- Desalination: the development of cheap power sources at the Beckton and Crossness incineration sites together with improvements in process technology and efficiency has prompted a review of the economics of desalination. A pilot investigation has already been licensed by the Agency at Western Pumping station (Chelsea).
- Major new strategic resource development: regulation of the River Thames based on new reservoir storage in the Upper Thames.

The extent to which all of these options will be required will depend on the company's progress towards the lower levels of leakage proposed within this strategy (see below) and being imposed by Ofwat. Figure 7.3 shows that over the longer term, the full achievement of the levels of leakage proposed here would create a substantial surplus in resources compared to demand and one that could be used to the benefit of both the environment and other uses in the south-east.

Our strategy considers the extent of risks and uncertainties that the company has indicated are peculiar to London. If leakage and underlying trends in growth in demand cannot be managed, the strategy recognises the potential requirement for a major river regulation scheme. Key indicators in demand and leakage will need to be agreed and monitored against to ensure appropriate actions are taken.

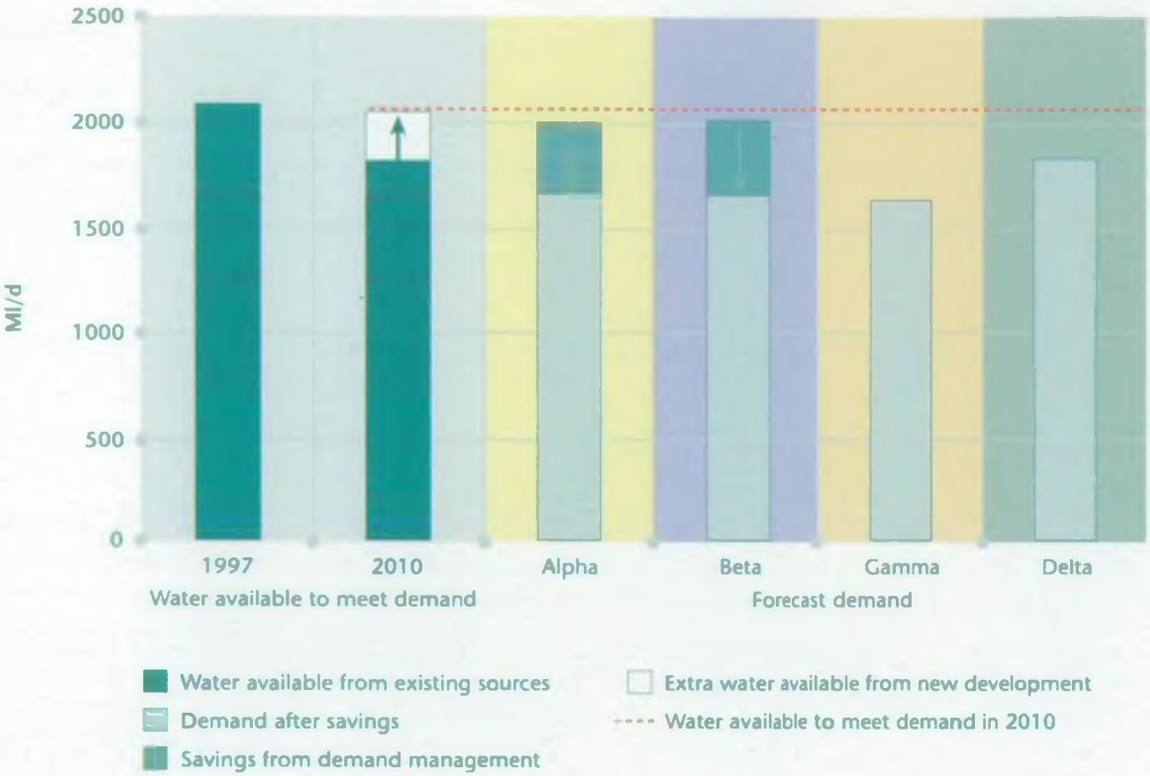
Upper Thames Resource Zones – Thames Water

The reduction in resources through the NEP and potential further environmental demand identified within this strategy, are key impacts on the Upper Thames. Figure 7.4 shows the impact of environmental demands in the Upper Thames and the overall balance of proposed solutions with demand. Addressing additional environmental demands that may arise, for example, through the Habitats and Birds Directives in the period to 2010, would result in a fine balance between supplies and demand, with little planning margin or headroom leaving the company exposed to risk without the development of further resources.

Continues on page 80.

Figure 7.3 **Proposed solutions for London for 2010 & 2025**

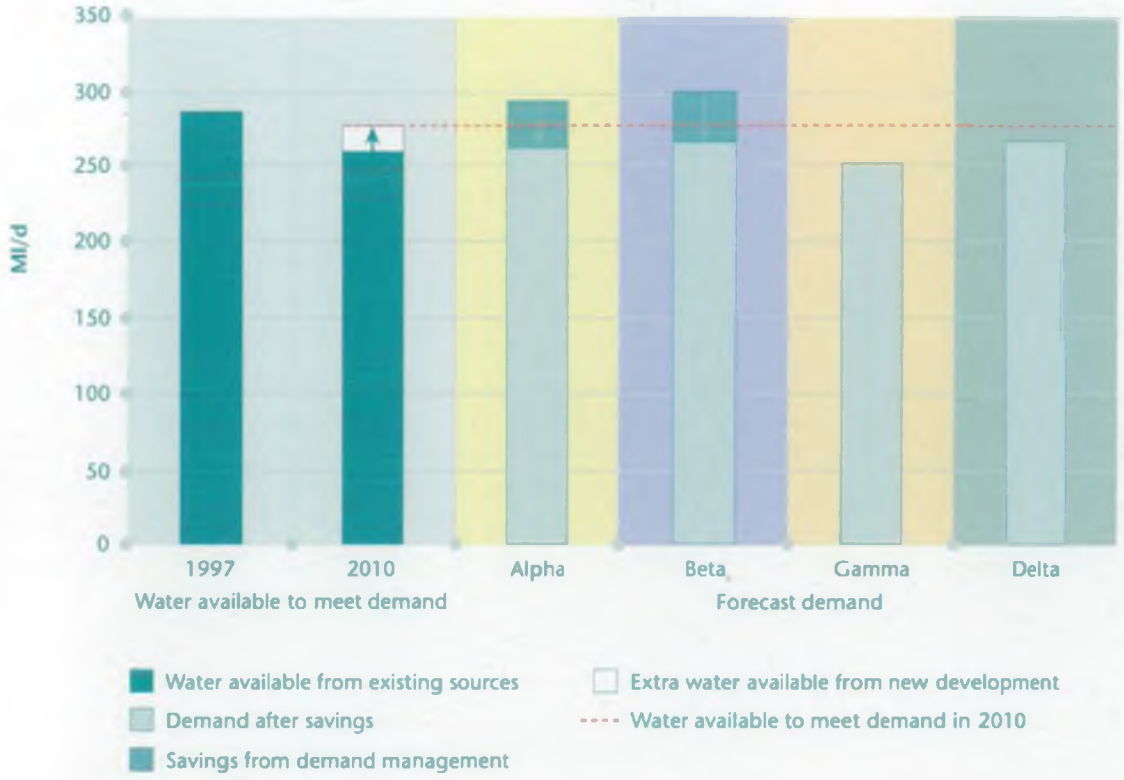
a. 2010



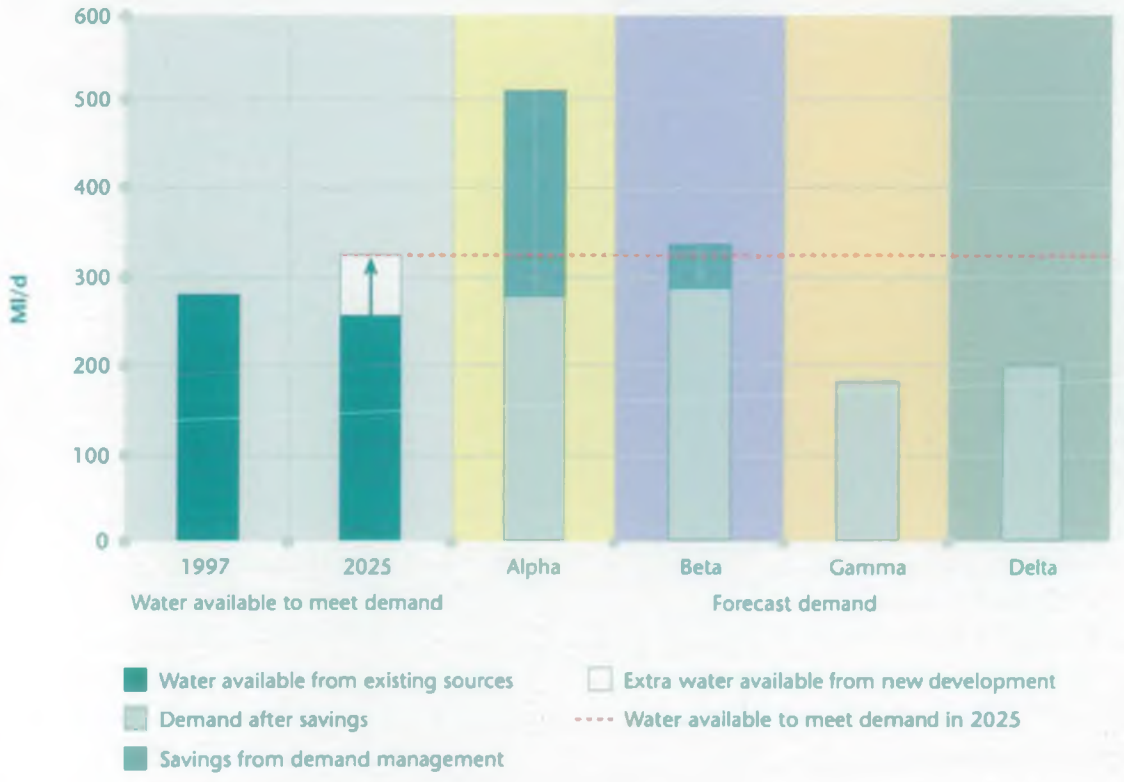
b. 2025

Figure 7.4 **Proposed solutions for the Upper Thames for 2010 & 2025**

a. 2010



b. 2025



In order to manage supplies and demand for the Upper Thames, a number of resource enhancements will be required:

- enhancement to existing treatment and transfer capacity: focussing particularly on the output from Farmoor water treatment works and enhancement of the strategic network links between the South Oxfordshire (Gatehampton), North Oxfordshire (Oxford, Banbury, Worsham etc.) and Swindon zones;
- further investigations of the potential for transfers via canal, potentially utilising the British Waterways Grand Union and Oxford Canal systems. This scheme has already been subject to investigation by British Waterways and Thames Water. Abstraction at Banbury, supported by transfers from the Midlands canal network, could provide additional benefits to the Cherwell NEP scheme. Further investigation will be required to confirm how such transfers could be supported via the Midlands canal network. Subject to environmental constraints, a number of potential options may be available.

For the medium to longer term, we have proposed further investigations of two alternative types of scheme, either:

- new reservoir storage in the Upper Thames; or,
- the potential for transfers from the River Severn into the supply system of the Upper Thames.

The choice of scheme depends very much on forecast demands and deficits across the region and the extent to which a strategic regulation scheme may be required for London or to which demand can be reduced particularly through further leakage reduction.

We have previously rejected the potential for large, direct transfers to the region's river system due to significant ecological risks and the need for substantial storage to ensure reliability of such a scheme. However, alternative schemes to meet a much smaller demand (less than 50 Ml/d) may prove feasible. Our strategy suggests that two alternative schemes based on potential transfers from the River Severn to the Upper Thames resource zones require further investigation:

- the potential for transfer by pipeline to, and conjunctive resource use with, the Farmoor reservoir system in Oxfordshire. Whilst storage at Farmoor is limited, the potential transfer of water from the River Severn at times of low flow in the River Thames and reduced reservoir storage could increase the deployable output of the system;
- the transfer of water in conjunction with development of resources for a restored Thames-Severn canal into the Upper Thames area. British Waterways are currently examining the feasibility of restoring the canal to an operational waterway. The potential restoration provides an opportunity to examine further the feasibility of transferring resources for use locally or strategically in the Upper Thames. Further studies of the engineering and hydrological feasibility of this option and the potential for ecological risks will be required.

Similarly, alternative reservoir schemes will require consideration. Investigations by Thames Water at their proposed site near Abingdon indicate a scheme of some 450 Ml/d yield could potentially be developed. Assuming that there is no regional strategic storage requirement, a scheme of significantly lesser size than currently being considered by the company may still be required. A number of alternatives will need to be examined:

- alternative reservoir sites to that proposed near Abingdon;
- potential development of the Abingdon site but at a significantly smaller scale than is considered technically feasible;
- the potential for phased development of the Abingdon site.

Three Valleys

The reduction in resources through the NEP and potential further environmental demand identified within this strategy, are significant impacts on the company. Additional drivers for new development included the need to manage peak demands and increasing risk of outage due to groundwater pollution. A number of schemes have been proposed, including:

- significant enhancements to existing licensed sources (e.g. Clay Lane groundwater) and improvements to the supply network to remove operational constraints;
- small-scale new groundwater development in the confined chalk aquifer in Essex;
- Increased bulk transfers from Anglian Water's Grafham reservoir. Although originally envisaged by the company as a requirement towards the end of the planning horizon, such a scheme may be brought forward in response to potential reduction in the company's deployable resources through climate change, environmental demands, groundwater quality, outage and treatment costs.

Other Companies / Resource Zones

A mix of resource enhancement has been proposed across the rest of the region, made up of:

- enhancements within existing licences: including full development of the River Thames (Bray, South East Water) source, and enhancements at the Chertsey (North Surrey) groundwater sources;
- local groundwater development: for South East Water, Sutton and East Surrey Water, and parts of the Thames Water Provinces zones.

7.2.2 Water efficiency and water use minimisation

We believe that water efficiency and water use minimisation should make a significant contribution to effective water resources management over the next 25 years. In this strategy we make a number of general recommendations relating to the efficient use of water in households, industry and commerce.

We believe that there is considerable scope for additional household water efficiency over the next 25 years. Opportunities include:

- per capita toilet use can be reduced by almost 10 l/h/d by introduction of dual-flush or low-flush systems;
- average washing machine volumes can be reduced to 50 litres per cycle;
- average dishwasher volumes can be reduced to 20 litres per cycle;
- use of efficient shower heads/flow restrictors as part of water audit would limit the impact of the growth of power showers/high-volume showers.

Currently, average per capita use in the region as a whole is 166 litres of water each day, ranging from 158 to 170 l/h/d depending on the water company. This compares to an average for England and Wales of 149 l/h/d.

Increasing water efficiency in the home, along with a general improvement in awareness of the value of water, could have significant impacts in terms of stabilising growth and potentially reducing demand.

There is already evidence of increasing efficiencies being brought about, many in conjunction with energy efficiency, such as water efficient washing machines and dishwashers. Our forecasts reflect these trends and the impacts of new water regulations on water appliances. Increased metering of houses will also provide an incentive to householders to value water.

Careful choice of planting can result in a garden that requires little or no watering

However, substantially more could be done through proactive approaches including water audits and raising awareness of more efficient techniques and equipment (such as low-use shower heads, and drought tolerant gardens and landscaping) and seeking opportunities through the planning and development processes of the benefits of saving water. We have estimated that water efficiency and water conservation in our homes could save in excess of 100 Ml/d over the next 25 years.

Influencing behaviour takes time and effort, and we believe that energetic facilitation is essential. Water companies have a duty to take an active role in this, and the draft Water Bill asks companies to consider water conservation in their own operations (DETR, 2000e). The Water Supply (Water Fittings) Regulations will continue to be important, as they provide a legal limit on the water consumption of devices and appliances. These are set by Government but enforced by water companies. While the Regulations have to be set within the context of the European single market, it is important that Government should keep them under active review to ensure that they make the

best possible contribution to the efficient use of water and that water companies enforce them actively (Action A2).

Just over 20% of the water supplied by water companies goes to commerce, industry and agriculture. Almost all of this is metered, but many independent studies have shown that there is considerable scope for reducing water use. Many industrial and commercial users could make changes to their use of water that would reduce their consumption and effluent discharges, and therefore their water bills. We propose simple water efficiency measures that generally would pay for themselves in less than one year. However, the uptake of schemes for water conservation has been slow. We estimate that water conservation in commerce and industry using public water supply could save up to 150 Ml/d over the next 25 years in scenario Alpha. It is essential that this saving is delivered and maintained to protect the environment and to secure appropriate water use for everyone. We recommend the further implementation of water conservation schemes across industry and commerce as a low-cost and effective way of managing water over the next 25 years. **Water companies should actively promote this among their industrial and commercial customers in compliance with their statutory duty to promote the efficient use of water (Action A3).**

Water efficiency is important in all sectors that use public water supply. To deliver the savings that we propose in this strategy will require widespread adoption of water-saving techniques. This can be achieved by building on water companies' water efficiency plans, and publicity campaigns such as DETR's "Are you doing your bit?". **Ofwat, Government, water companies, trade associations and the Agency should vigorously promote water efficiency and monitor the results of this work (Action A4).**

The Agency's National Water Demand Management Centre will continue to support and encourage water efficiency initiatives. **The Agency will work with water users and water companies to ensure that water efficiency is delivered (Action A5).**

Both increased competition in the water industry and future restructuring of water companies could play a part in determining how the efficient use of water develops. We consider it essential that the **Government should ensure that any steps towards competition and restructuring maintain and encourage the efficient use of water resources (Action A6).**

7.2.3 Leakage

Over the last five years, progress in leakage control has been rapid, with all water companies committed to maintaining or reducing current levels. Much of the reduction in leakage has been as a result of Government initiatives and the establishment by Ofwat of mandatory leakage targets.

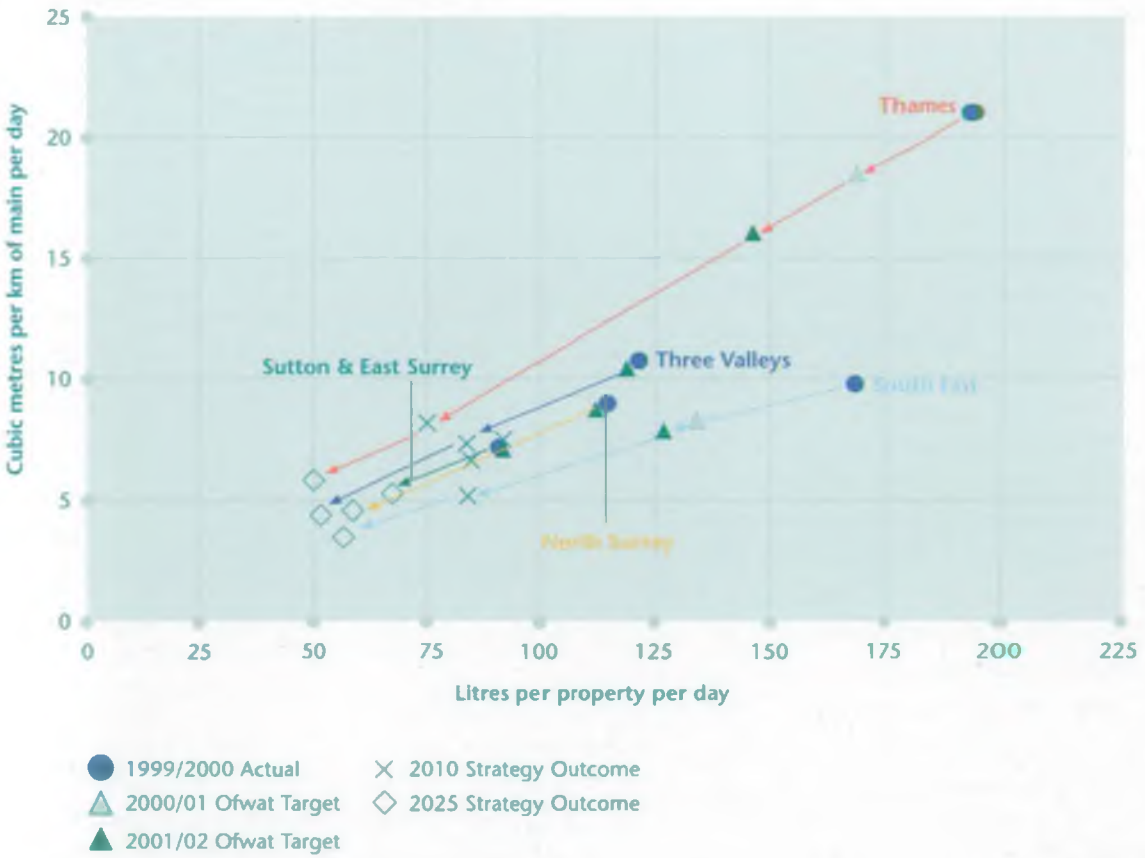
The calculation of appropriate leakage targets is complicated, because it depends on an understanding of the cost of leakage control effort as well as the cost of alternative options. Water companies' performance on leakage control is a matter of public interest, but some of the relevant information is not in the public domain. **The Agency will seek better access to information on leakage and leakage control (Action A7).** Government, Ofwat and the Agency are working together on a tripartite project to examine ways of progressing with leakage management. Such co-operative action should be instrumental in further enhancing opportunities for leakage control.

In compiling this strategy, we have had to take an informed view on how leakage can be managed over the next 25 years. Further progress on leakage control is vital to ensure the efficient and proper use of water resources in the region. Whilst the water companies have made substantial efforts in recent years, two (Thames Water and South East Water) continue to be set further challenging leakage targets by Ofwat. In both cases, developments are still being made in measurement, monitoring and targeting activity.

Further progress in leakage control will provide environmental protection by preventing the waste of valuable water resources and reducing the need for new resource development. For planning purposes, we have identified a level of leakage that would be achievable with the application of today's best practice and most advanced technology (Appendix 3). We have assumed that this represents a reasonable goal for leakage in 25 years' time. Following this route could save some 470 Ml/d of demand in the region beyond the Ofwat 2000/01 targets; 375 Ml/d within Thames Water, of which 310 Ml/d would occur within London. Figure 7.5 shows the impact of the levels of leakage proposed in this strategy on the five companies within the region. The potential savings are substantial and cannot be ignored.

Achieving progress towards this level will require concerted and co-ordinated effort by the water industry, Ofwat, the Agency and Government. If this progress is not achieved, further alternative demand management or resource development will be necessary.

Figure 7.5 Leakage targets and scenario outcomes



We recognise that achieving these savings will be challenging to companies; to Thames Water in particular in dealing with the scale of leakage in London. The company has raised a number of issues that they believe are peculiar to influencing and control of levels of leakage in London. Issues include: the age of mains (which the company indicates are more than 150 years old in parts of central London); statutory pressure requirements; and ground conditions which are both chemically aggressive (corroding mains) and prone to heave, causing fracturing of mains during climate extremes (freeze-thaw and summer desiccation).

Much will depend upon establishing appropriate levels of measurement of leakage and focussed effort in active leakage control; striking the balance between the sizing of district meter areas, so they are sufficiently sensitive to identify leaks from background use, and the costs of leakage control. There are also potential constraints on the company that will need to be addressed. These include, in the short term, public and political perception of the necessary street works to deal with leakage and the disruption that this can cause to traffic and the local environment. Over the medium to long term, companies will need to consider strategies based on increased rates of mains replacement. Over the term of this 25-year strategy, we believe many of these challenges can be met but they will require an integrated regulatory, planning and operating approach based on the provision of sound information.

We expect water companies to provide clear and robust information on leakage activity, and costs and constraints in support of their water resources plans and proposals for new licence application.

Leakage control can contribute significantly to balancing supply with properly managed demand. It is effective across the range of societal and climate scenarios. It lies firmly within the control of the water industry and its regulators. **To deliver the leakage savings proposed in the strategies, the water industry should continue to develop and implement new and better methods of leakage control (Action A8).** In this region, further work has been identified by Ofwat for Thames Water and South East Water in addressing discrepancies in their approaches and in ensuring that industry best practices in leakage management are put in place and continue to be developed. These actions will be fundamental to this strategy.

The Agency will be looking to Thames Water to set out a clear action plan for leakage management in its supply area. This will need to address related activities

and responsibilities (such as pressure management, mains renewals etc.), the need for innovative solutions, regulatory issues and communication with key stakeholders so that the vital importance of further leakage management is accepted.

In one of our scenarios, we see increasing leakage. This is a warning that effort in leakage management must be maintained; without measurement, control and targeted activity, leakage could start to rise. We consider that the present process of setting leakage targets has been both necessary and successful. **The system for setting annual leakage targets should be maintained and developed (Action A9).** The draft Water Bill proposes that the Secretary of State or the National Assembly for Wales should be able to set standards of performance that could apply, for example, to setting leakage targets (DETR, 2000e). **The Agency will continue to explore with Government, Ofwat and others how the current regulatory framework and the new legislation proposed in the draft Water Bill can assist in achieving good leakage control (Action A10).**

There are a few parts of the region where leakage reduction beyond present targets is unlikely to be essential. We propose that water companies in these areas must not let leakage rise and so will need to maintain leakage control, taking advantage of any new technical developments that may present opportunities for further reductions.

7.2.4 Metering

We believe that metering can make a significant contribution to the effective management of water resources. Most non-household customers of water companies are already metered and charged for water by the volume that they use. The Agency advocates more use of household metering within a regulatory framework that has regard to the Government's broader social and environmental policies including the protection of vulnerable households.

Metering of households encourages people to consider their use of water, partly by allowing them to understand how much they are using. It raises awareness directly, when the bill arrives. Provided that appropriate tariffs are charged, metering of households encourages high users of water to reduce their water use. In the longer term, it should lead to changes in attitude, so that, for example, when new appliances or bathrooms are needed, people will choose devices that are water efficient.

Household meter penetration in the region remains fairly low at only 16% of customers. All water companies in the region have planned for further increases in metering to varying degrees. We believe this is appropriate in view of the pressures on the region's limited water resources and water environment. Forecasts submitted in support of their water resources plans indicate that, across the region, companies are planning on the basis of approximately 55% of domestic properties being metered by 2025. This figure varies widely between companies, from as low as 43% (Thames) to greater than 75%.

There is, of course, a cost associated with the introduction of meters to household water customers. This includes the cost of the meter itself, the work required to adapt the existing pipework to allow the meter to be installed, and an ongoing revenue cost in collecting meter readings and producing bills. This must be set against the tangible and intangible benefits of a well-organised and understood system of water resource management. Metering may also enable household customers to benefit more readily from any increase in competition in the provision of household supplies. Charging for metered supplies by tariffs that give incentives to the efficient use of water will also benefit customers who are in a position to save on their water bills by sensible discretionary uses of water. Such tariffs can be designed to aid environmental protection and will also help to manage water resources in the face of climate change. The Agency believes that householders should understand all of the potential benefits in metering for themselves, for society and for the environment. **The Agency will work with Ofwat, Government and the water industry in the provision of accessible information to householders about metering and in the development of tariffs that encourage water efficiency while having regard to the Government's broader social and environmental policies (Action A11).**

Existing legislation means that the extension of household metering will occur gradually. One of the significant barriers to the growth of metering was removed when the Water Industry Act 1999 introduced the right to free meter installation for households. Almost all new homes are fitted with meters, because for these homes it is not possible to charge for water on the basis of rateable value. This means, for example, that the 1.2 million new homes that are envisaged for the south-east by 2016 will all have meters.

We believe that in most of England and Wales, metering should reach between half and three-quarters of households by 2025. By making it normal for water use

to be measured, a culture of awareness will be developed. This will place England and Wales in a strong position to face the challenges of the future, including societal and climate change and it can contribute to, or be driven by, competition in the water industry. **Water companies should take a positive attitude towards targeted household water metering where this is appropriate and where opportunities arise (Action A12)**. These opportunities include new homes, unattended sprinkler users and targeted metering of potentially large water users when properties change hands.

In certain locations where water is particularly scarce we advocate higher levels of metering. The water companies involved would need to seek the formal designation of supply zones as water-scarce areas.

7.2.5 Summary

Our strategy for public water supply is based on the best information available to us about different options. As more details emerge, other options may appear to be favourable. Water companies will need to make their own commercial decisions about how they will manage their water supplies. This will involve detailed studies of timing of need, feasibility, cost and environmental impact.

Metering can reduce household demand for water

7.3 Agriculture

We indicated in Chapter 5 some of the broad uncertainties facing farming over the next 25 years. In particular, changing economic frameworks and global warming may make for substantial change.

Whilst agriculture is not a major use of water in the region, it remains a locally important use. Agricultural demand for irrigation is likely to increase in the future but it is uncertain by how much. The cost of irrigation will be critical. Large joint schemes requiring substantial pipework and pumping are unlikely to be economic; therefore agricultural demand for water will remain essentially a matter needing local solution.

In most areas traditionally associated with spray irrigation across the region, little water is available for abstraction during the summer months. There are no remaining reliable summer surface water resources available for new abstraction and only limited locations where groundwater may be available. This will come as no surprise to users in these areas as the Agency has been refusing to grant summer abstraction licences in these parts for some time. In the majority of catchments, there remains scope for further abstraction of winter water, but this would need to be stored for use during summer.

Our twin-track approach applies equally to agricultural use. There is undoubtedly scope for water saving, even in general agricultural use. Spray irrigation is a significant local consumptive use of water, both because of the volume involved and because its use is concentrated in the summer months when flows are lower and the environment is under most stress. Water efficiency has an important role to play here, and the farming community has made significant progress in improving irrigation practices in recent years.

One option to consider is the potential for agriculture, commerce and industry to benefit from schemes developed principally for public water supply. Given appropriate agreements, it may be possible for agriculture to benefit, at least in the short term, from public water supply schemes before they are fully utilised. Further opportunities may also arise where licences granted for public water supplies are no longer fully utilised but where the resource is already fully allocated. For example, in some parts of the region water companies have taken the view that it is currently not economic to utilise certain sources because of the

treatment requirements for water quality. Whilst the economics of treatment may change over the period of this strategy, it may still be feasible to utilise the resource in other parts of the catchment for non-potable purposes. Where possible, **the Agency will seek to identify opportunities to make water available for agricultural, commercial and industrial purposes from existing and new developments (Action A13).**

The Agency will encourage farmers to adopt good practice in water use around the farm (Action A14). We will work in partnership with the National Farmers Union, central Government and the National Assembly of Wales. This needs to allow for radical changes as well as adjustments between traditional food crops. **The Agency will work with agriculture to develop indicators of good practice in water use (Action A15).**

The Government has said that it considers that the Agency should use its own existing powers to apply abstraction licence conditions in order to deal with profligate water use. The Agency will develop licence conditions accordingly, one possibility being a condition requiring abstractors to seek regular certification that their processes have undergone a water waste minimisation audit. Conditions could be included in new licences and we will want to see existing licence holders co-operating voluntarily with good practices similar to those expected of new licence holders.

However, our conclusion more generally is that the farming industry must review its own water resources. Water needs to be recognised in many farming areas as a scarce, maybe limiting resource. The Agency's recent R&D project entitled Optimum Use of Water for Industry and Agriculture Dependent on Direct Abstraction (Environment Agency, 1998a) should assist farmers. **We consider that farmers should actively seek ways of minimising their water use (Action A16).** To help with this, farmers could consider the installation of meters to help them to understand better their use of water around the farm.

Traditional methods, in particular individual or joint development of winter storage can provide reliable supplies in many places. Many farms already have winter storage reservoirs that allow water to be stored in times of surplus and used for irrigation during the summer. These provide more security of supply than direct surface water abstractions, but are relatively expensive. **Farmers should consider working together to develop schemes that can be shared by several farms (Action A17).** In some parts of the country, grants may be available from MAFF under the Rural Enterprise Scheme for the construction of water storage facilities and the provision of associated equipment.

The trading of abstraction licences can be of particular benefit to agriculture. Farmers may be able to acquire access to additional water without affecting the natural environment. An individual farmer holding an abstraction licence may find that a neighbour values use of some of his licensed abstraction more highly than he himself; in such a circumstance, a trade would make sense to both. **The Agency will assist trading of abstraction licences between abstractors, provided the trade is not doing any harm to the environment (Action A18).** We believe that this means trades that are for essentially the same body of water. **We recommend that farmers should consider the possibility of trading of abstraction licences to meet their needs (Action A19).** Trading can take place now, but provisions in the draft Water Bill would facilitate it (DETR, 2000e). The Government proposed other facilitation measures in its April 2000 consultation paper on economic instruments in relation to water abstraction and its decisions on those are expected early in 2001 (DETR, 2000c).

The Agency also recognises that the big retail chains and food processors are making product quality demands on farmers that involve more irrigation. **The Agency will seek dialogue with supermarkets and food processors to encourage greater understanding and consideration of the impact of their crop requirements on farmers' use and management of water and of the consequences for the water environment (Action A20).**

7.4 Industry and commerce

7.4.1 Direct abstraction

Increases in industrial demand are hard to identify long in advance and, by and large, will be local in nature. We do not envisage significant independent development of new sources by the industrial or commercial sectors. As new demands do arise, options will include supply from public water supply sources, direct abstraction if available, opportunistic use of spare water from a nearby declining demand through trading, use of rising groundwater in London and seeking opportunities for reuse. Use of a canal is another conceivable option, if one is nearby and where British Waterways can provide a reliable resource. Some commercial and industrial sites may also be able to benefit from rainwater harvesting.

Where abstraction comes directly from rivers or groundwater we make the same recommendation as in section 7.2.2: **water efficiency should be positively encouraged (Action A4).**

For direct abstractors, the economics of this are less direct. The abstractors face only abstraction charges rather than the full cost of public water supply; but they also face effluent treatment charges. The monetary savings will depend partly on the degree to which the water has to be treated. Studies have shown that most direct abstractors can make savings through schemes that pay for themselves within a year even if the abstraction is directly from the environment. Saving water in this way can have the added benefit of reducing other raw material costs and associated energy savings as well as the volume of water that has to be discharged. We estimate that savings of at least 30Ml/d are achievable within this sector in the region.

As for agricultural abstractors, the Agency will develop licence conditions to deal with profligate water use and hopes that existing licence-holders will co-operate voluntarily with similar good practices.

7.4.2 Power generation

We envisage limited new demand for abstraction for power generation. A further time-limited variation has been granted to the National Power Didcot licence for abstraction for cooling water from the Thames. The Didcot power station is now used as a baseload power source for the national grid and water cooling is vital to its operation. The variation to the licence has been time-limited in view of the interest expressed by Thames Water for the longer-term potential development of a new strategic regulating reservoir near Abingdon. Under Section 15 of the Water Resources Act 1995, the Agency is obliged to give due regard to public water supply. Should development of a new strategic public water supply scheme prove necessary, the varied licence conditions for the Didcot abstraction would need to be reviewed. In discussion with National Power, it has been recognised that there are opportunities for future changes to operation (moving to gas-fired) and efficiencies in water needs.

Interest has also been expressed in utilising the River Thames weirs for low-head hydropower generation. We do not envisage water resources issues with such proposals as the structures are in the river and no abstraction takes place. However, further detailed consideration would be required of proposals for any other watercourse or where abstraction or diversion of water would be necessary. **The Agency will approach proposals for hydropower schemes positively and work constructively with the developers to achieve viable schemes (Action A21).**

7.5 Environment

In Chapters 3 and 4, we showed the importance of water for the environment, fisheries, navigation and recreation. The Agency will work to clarify environmental needs, paying particular attention to those areas identified as in need of remediation in Chapter 4. **We will seek the co-operation of others, including environmental organisations and abstractors, in identifying the actions that are needed to improve the water-related environment in these areas (Action A22).** We will expect co-operation from relevant abstractors in implementing appropriate solutions.

The Agency will promote greater understanding of the value of the water environment, by providing clear information to the public on how water use affects the natural environment (Action A23).

We have identified in Chapters 3 and 4 unsustainable pressures on the environment imposed through some licensed abstractions and our plans through the National Environment Programme to resolve them. The Habitats and Birds Directives provide additional drivers for reviewing abstractions that may impact upon valuable habitat sites. Actions have been put in place to complete schemes identified for implementation by 2005 and to have completed investigations and reviews of other sites by 2004/05, leading to implementing schemes after 2005 where appropriate. We have also identified the potential for further environmental demand within the region over the course of this strategy, the implications of which for strategic water resources are significant. Further investigations will be required and the Agency will be working closely with all interested partners to identify appropriate actions.

We will continue to develop our understanding and information of both these sites and others perceived to be at risk from abstraction through the Restoring Sustainable Abstraction Programme. CAMS will play a key role in this, in helping to identify local issues and improving understanding and consensus of the extent of environmental need. This will include conservation needs as well as needs for other purposes such as amenity, recreation and navigation. Within this we will also include more detailed consideration of how the Biodiversity Action Plan targets for key water-dependent

habitats in the region may be met, following the development of joint research undertaken with English Nature and RSPB.

7.6

Navigation

Ensuring that water levels are maintained for navigation requires sufficient water resources to be reliably available. For the Thames navigation, this requires the management of abstraction, particularly at times of low flow. The balance has not always proved easy to achieve and concerns have been expressed regarding the impact of abstraction in both the tidal and non-tidal reaches of the Lower Thames at times of drought. This is one of a number of issues requiring further investigation in relation to the impact of abstraction from the Lower Thames.

The restoration of disused canals is likely to present a significant challenge for the provision of water. **Navigation authorities should consider whether boating demand will increase their need for reliable water resources. If it will, they should prepare to identify and justify schemes to provide more water within the expected new legislative framework (Action A24).** Two schemes, the Thames-Severn and Wilts-Berks canals, are the subject of further feasibility studies; both may benefit from the strategic water resources schemes being considered in this strategy.

7.7

Transfers

One important question concerns the need for large-scale transfer of water around the country. Transfers of water already feature in parts of our strategy. We have shown earlier the range of bulk water transfers (raw and treated) that are already in operation within the region. Our strategy proposes further work in relation to the feasibility of two particular schemes:

- the transfer of water via British Waterways Grand Union and Oxford canals; and,
- the transfer of water from the River Severn either via a pipeline direct to storage at Farmoor, or via a restored Thames-Severn canal.

Both schemes will require further investigation of their resource potential and reliability and potential environmental risks and benefits.

In the medium to longer term, if the levels of leakage proposed in this strategy can be achieved, sufficient resources may be released to provide benefits both to the environment and to support intra- and inter-regional supplies. The additional water released could potentially provide further viable supplies to Anglian Region (enhancing the current bulk supply from Thames Water to Essex and Suffolk Water) or to Southern Region (providing additional supplies to Kent). The potential for such transfers will need to be carefully monitored, evaluating the need for additional resources in these areas as well as the continued viability of further leakage reductions.

There may be further proposals for new transfers which we will consider where they can make a positive contribution to prudent water resources management. In particular, we will consider carefully any specific proposals that British Waterways put forward. **We will encourage the development of more local transfers of raw or treated water to meet particular circumstances, provided that they take account of the needs of the environment and other users (Action A25).** However, a transfer of any type may be limited by its effect on the receiving water, in terms of both its flow regime and quality. There are particular concerns associated with transferring water of different qualities, and with the movement of alien species and of plant, animal and fish diseases between different river habitats.

7.8

Overarching issues

Previous sections have shown the specific actions that we believe necessary for Thames Region. To facilitate the successful implementation of these actions, we propose the following additional actions:

The Agency will work with Ofwat towards further rationalisation of the ways that we each seek water resources information from water companies (Action A26).

New developments need water, as the Government's recently revised PPG11 and PPG12 make clear. **The Agency will work with planners to identify opportunities for water efficiency in new developments (Action A27).** We have worked closely with SERPLAN, the Government Office for the South East (GOSE), the South East England Regional Development Agency (SEERA), the Greater London Authority (GLA) and others on the development of integrated policies concerning water resources, water quality and the environment in the development of

regional planning guidance (see section 4.5). We also work closely with local planning authorities and developers. We will continue to use our powers to influence plans for new development to promote best practices in sustainable urban development and water conservation, and to ensure unsustainable pressures are not imposed on the region's water resources and the environment. Continued improvements in co-ordination and liaison will be required between planners, the Agency and water companies to ensure that water-related issues are taken into account at an early stage in the planning process. These may impact on the scale, timing and location of new development in some locations where there are no, or limited, resources available locally and more challenging demand management measures are pursued or new strategic schemes need to be promoted.

The development of new strategic resource schemes, such as large surface reservoirs, can take many years from inception to commissioning. There are many, often contentious, issues to consider in assessing feasibility, environmental impacts and alternatives; property blight is one obvious concern. The Planning Inspectorate has published guidelines on streamlining public inquiries into such schemes. These place a responsibility squarely with the promoters to establish dialogue with interest groups at an early stage to identify issues and to provide appropriate information so that as many issues and concerns can be addressed through early consensus. This would allow the planning inquiries to focus on those issues that remain unresolved. This would also help in the early identification of issues that may impact on regional development planning assumptions. **The Agency will work with Government to identify opportunities for streamlining the process of approval for resource development (Action A28).**

Saving water needs real encouragement, especially in industry and commerce, but also in farming and in the home. We think that the best way to achieve this is through an independent organisation specifically funded for this purpose. The Agency will seek views from Ofwat and Government departments, the water industry, farming and industrial organisations, and environmental and consumer groups. **If we find support for this idea, we will encourage its further development (Action A29).**

7.8.1 Further research and development

The thinking that has gone into developing our strategies has identified areas where further research is required. A full list of research topic areas can be found in Appendix 4.

The Agency will work with others to take forward an effective research and development programme (Action A30).

7.9 Conclusions

There are many benefits associated with this strategy. It provides a robust series of actions that help to ensure that adequate supplies of water are available across all sectors. Many of the actions that we recommend produce useful benefits in almost any circumstances. Our strategy also shows that we can manage water resources over the next 25 years or so in a way that will allow an improvement to present levels of environmental protection.

Development options and demand management options all require actions if they are to deliver the full benefit of the scheme. Some actions need to be started considerably in advance. For resource schemes, there are many stages that must be completed before construction begins, and these must be planned in good time. Demand management savings may also take some years to achieve. Business plans for water companies, commerce and industry, and agriculture should all take account of these time constraints.

For each option, we have considered environmental implications carefully. Any additional abstraction of water from the environment has the potential to pose a threat to habitats and therefore to plant and animal species. We have considered only those schemes where the effects are likely to be acceptable or, in the minority of cases, where their effects can be mitigated successfully. All these schemes would need further investigation, and any alternative schemes should be evaluated using similar criteria.

Our strategy provides significant environmental benefits in those areas identified as over-abstracted in section 3.5. We have used sustainability appraisal through the development of this strategy to help to ensure that it contributes to the four aspects of sustainable development. Consultants have been engaged by the Agency specifically to undertake an independent appraisal of the strategy. Their unedited summary is shown in Table 7.2. It shows that the contribution to sustainable development is generally positive, but that the strategy is weak in its contribution to social equity. As a result, we have addressed this aspect in some of our supporting recommendations.

Table 7.2 **Sustainability appraisal of the water resources strategy**

The proposed strategy for the Thames region makes a positive contribution to sustainable development. There are net positive impacts in terms of environmental protection and the prudent use of natural resources, particularly when leading with commercial water minimisation and domestic water efficiency options before 2015. Longer-term options within the strategy may also contribute positively to environmental protection and the prudent use of natural resources - a new reservoir or winter storage strategies, for example, could be a prudent use of available resources during high flows and provide water for strategic augmentation during low flow periods. Other longer term benefits from the strategies may accrue through their ability to help mitigate the negative hydrological impacts of climate change. However, these options also have potential negative environmental impacts. For example, the loss of landscape associated with the development of a new reservoir or the potential ecological impacts of transferring water from the Severn, or groundwater via the Grand Union and Oxford Canals, to the Thames.

The options generate generally positive impacts in terms of economic growth & employment, as well as social progress. Inevitably, however, in a region where the natural and developed resources are already heavily utilised, the social and economic costs associated with any new scheme (new reservoir or leakage savings) will be complex and potentially significant.

ERM, 2000

We recognise that costs will influence the delivery of any strategy and we have taken likely costs into account in considering different strategy options. However we have not calculated in detail the financial cost of this strategy. It will be for the organisations that promote schemes in line with this strategy to assess their costs and value for money, and to justify them on that basis. Where the Agency itself needs to take action to help realise the strategy, it is duty bound to consider the costs and the benefits of its proposals.

8 Actions and the way forward

8.1 Overview

This strategy is designed to offer a framework for decisions and actions that are needed to manage water resources over the next 25 years or so. The strategy sets out our expectations of others, and should guide all stakeholders as to what they can expect from the Agency. In the strategy, we have considered the sometimes conflicting elements of sustainable development and the substantial uncertainties about the future. We have allowed for uncertainty by using a scenario approach. As our understanding of climate change and societal trends develops we will be able to refine our conclusions. However, until significant change from our assumptions or analysis is apparent, we believe that this strategy provides a sound basis for water management in the region.

The conclusions we drew in Chapter 7 will require action and commitment from various parties if the vision we have set down is to be achieved. Inaction would increase risks unacceptably; and action that conflicts with our strategies would need particularly good justification to convince the Agency and, we believe, others. In particular, we will not expect to grant new abstraction licences unless they accord with the strategy or show convincing arguments why they do not.

In this chapter, we summarise our recommendations. Some of the outcomes will not be achieved easily; they will require energy and commitment from various players. In the area of water use minimisation, we consider that some institutional facilitation may be required to deliver the undoubted benefits. Enactment of legislation proposed in the draft Water Bill will also help materially (DETR, 2000e).

Working together will be the key to delivering the sustainable development of water resources. We will work to ensure that institutional structures and legislation assist effective water management. Chapter 7 indicated a number of opportunities for research and investigation to contribute to better informed decisions during the life of this strategy.

8.2 Regional Actions

Without any further action to manage demand and reduce leakage, new strategic water resources will be required, under some scenarios, by 2015 for the Upper Thames and by 2020 for London. There are, however, significant uncertainties regarding key elements of our regional strategy. High levels of leakage, particularly in London, remain a primary concern and, without further investment and action, must present a fundamental risk to security of supplies in the longer term as well as forcing potentially unnecessary investment in the development of new schemes. Water conservation has yet to be seriously tried and tested. Furthermore, redressing the level of environmental need identified within our strategy will have a significant impact on the resources available to some water companies. Depending on the scale of this environmental requirement, proposals for change may need to be contingent on the provision of a new strategic resource.

Assuming agreement can be reached in principle between the Agency and Thames Water on the need for a reservoir, it would then take some 12-15 years for full implementation, including approximately 2 years' further pre-application study, 3 years to obtain consents and up to 9 years to build and fill. The driving purpose for proceeding with a reservoir must be to maintain public water supplies, and this case is not yet proven in the Thames Region. Other regions would appear to have viable alternatives. Further investigations, aiming towards an agreed position before the next major review of water companies' Water Resources Plans, Agency strategies and Ofwat's periodic review of price limits in 2005 is essential to minimise risks to supplies and the environment and to ensure sustainable and timely development of water resources.

Table 8.1 sets out the actions we propose to implement nationally in managing water resources. To meet the challenges of our regional strategy we have identified the following actions as a matter of priority:

(i) Review the need for major new strategic water resources by 2003 on the basis of progress in leakage reduction by Thames Water, and taking into account other zonal, regional and inter-regional considerations.

(ii) Agree with Thames Water an appropriate plan of action to ensure that sufficient information is gathered by 2003 for the decision on the need for major new strategic water resources to be well informed in relation to what can be achieved economically and sustainably through leakage reduction and demand management. To implement the plan as a matter of priority in 2001/2.

(iii) Progress initiatives for restoring sustainable abstraction and review the impacts and timing of these environmental demands on the strategy:

- complete investigations and implement schemes identified under the National Environmental Programme by 2004/5;
- review existing consents to determine where there may be significant ecological impact on the interest features of sites identified under the Habitats and Birds Directives by 2004. Affirm, revise or revoke consents by 2010;
- complete the River Thames abstraction management strategy and further investigations to assess environmental flow requirements and the potential impacts on abstraction at Teddington and Oxford by 2003/4;
- Progress Catchment Abstraction Management Strategies and keep environmental demands under review in the context of the Water Framework Directive, Biodiversity Action Plan and other new initiatives.

(iv) Assess whether a new strategic reservoir could provide benefits for flood alleviation as well as water supply by 2002/3.

(v) Review whether and how the needs of other users and water companies within the region, and demands in neighbouring regions, may affect any of the above decisions by 2003/4. Form a view as to how to react to applications to proceed with major new resource development to satisfy increased demand from a competition-driven enlarged consumer base by the end of 2001/2.

(vi) Agree with Thames Water by 2002/3 those areas where studies to date can be accepted, and where further work is needed, concerning the appraisal of the proposed reservoir scheme and alternative options.

(vii) If a major new resource is required, assist Thames Water in developing appropriate operating rules which meet the Agency's aspirations as well as those of the company.

(viii) Review with water companies whether their supply systems are sufficiently robust against drought events, taking into account our developing knowledge of climate change effects. Where systems are not robust, agree how this may affect demand management and resource development decisions by 2003/4.

(ix) Monitor and review the implementation of schemes identified within water companies' Water Resources Plans and funded through the periodic review, to secure the twin track management of water resources within the region to 2004/5.

(x) Continue to work with strategic and local planning authorities in the region to ensure proposals for new development are based on integrated and sustainable water resources management practices. Identify any constraints especially in the timing of development.

8.3

Future of this strategy

This strategy is the Agency's present considered view of the actions that are required over the next 25 years to ensure the sustainable development of water resources. Some areas need monitoring and further evaluation. We will keep social and climate change scenarios under review, taking into account new information and ideas as they become available.

We will publish an annual bulletin reporting on progress against this strategy. We plan to review the strategy completely in a few years. However, we believe that this strategy provides an appropriate framework for long-term water resources planning.

Table 8.1 Actions

Action Ref	Action	Agency	Water companies	Agriculture	Industry	UK Government and NAW	Ofwat	Planning bodies	NGOs and others
A1	Where new or existing developments are not fully utilised water companies should consider sharing this water with others.		✓						
A2	Government should keep the Water Supply (Water Fittings) Regulations under active review to ensure that they make the best possible contribution to efficient use of water and that water companies enforce them actively.		✓			✓			
A3	Water companies should actively promote waste minimisation schemes among their industrial and commercial customers in compliance with their statutory duty to promote the efficient use of water.		✓		✓				
A4	Ofwat, Government, water companies, trade associations and the Agency should vigorously promote water efficiency to all sectors and monitor the results of this work.	✓	✓			✓	✓		✓
A5	The Agency will work nationally and locally with water users and water companies to ensure that water efficiency is delivered.	✓							
A6	Government should ensure that any steps towards competition and restructuring maintain and encourage the efficient use of water resources.					✓			
A7	The Agency will seek better access to information on leakage and leakage-control.	✓							
A8	The water industry should continue to develop and implement new and better methods of leakage control.		✓						
A9	The system for setting annual leakage targets should be maintained and developed.	✓				✓	✓		
A10	The Agency will explore with Government, Ofwat and others how the current regulatory framework and the new legislation proposed in the draft Water Bill can assist in achieving good leakage control.	✓				✓	✓		
A11	The Agency will work with Ofwat, Government and the water industry in the provision of accessible information to householders about metering and in the development of tariffs that encourage water efficiency while having regard to the Government's broader social and environmental policies.	✓	✓			✓	✓		
A12	Water companies should take a positive attitude towards targeted household water metering where this is appropriate and where opportunities arise.		✓						
A13	The Agency will seek to identify opportunities to make water available for agricultural purposes from existing and new developments.	✓		✓					
A14	The Agency will encourage farmers to adopt good practice in water use around the farm.	✓		✓					
A15	The Agency will work with agriculture to continue to develop indicators of good practice in water use.	✓		✓					
A16	Farmers should actively seek ways of minimising their water use.			✓					
A17	Farmers should consider working together to develop schemes that can be shared by several farms.			✓					
A18	The Agency will assist trading of abstraction licences between abstractors, provided the trade is not doing any harm to the environment.	✓							
A19	Farmers should consider the possibility of trading abstraction licences to meet their needs.			✓					
A20	The Agency will seek dialogue with supermarkets and food processors to encourage greater understanding and consideration of the impact of their crop requirements on farmers' use and management of water and of the consequences for the water environment.	✓							✓

Table 8.1 **Actions** *continued*

Action Ref	Action	Agency	Water companies	Agriculture	Industry	UK Government and NAW	Ofwat	Planning bodies	NGOs and others
A21	The Agency will approach proposals for hydropower schemes positively and work constructively with the developers to achieve viable schemes.	✓							
A22	The Agency will seek the co-operation of others, including environmental organisations and abstractors, in identifying the actions that are needed to improve the water-related environment in relevant areas.	✓	✓	✓	✓		✓		✓
A23	The Agency will promote greater understanding of the value of the water environment, by providing clear information to the public on how water use affects the natural environment.	✓							
A24	Navigation authorities should consider whether boating demand will increase their need for reliable water resources. If it will they should prepare to identify and justify schemes to provide more water within the expected new legislative framework.								✓
A25	The Agency will encourage the development of more local transfers of raw or treated water to meet particular circumstances, provided that they take account of the needs of the environment and other users.	✓							
A26	The Agency will work with Ofwat towards further rationalisation of the ways that we each seek water resources information from water companies.	✓					✓		
A27	The Agency will work with planners to identify opportunities for water efficiency in new developments.	✓						✓	
A28	The Agency will work with Government to identify opportunities for streamlining the process of approval for essential water resources development while maintaining full public accountability.	✓				✓			
A29	The Agency will explore with others the idea of an independent water efficiency body; if we find support, we will encourage its further development.	✓							
A30	The Agency will work with others to prioritise and take forward appropriate research and development.	✓							

Appendix 1
Climate change

A1.1

Overview

There is mounting evidence that our climate is changing as a result of man-made atmospheric emissions. The DETR's UK Climate Impacts Programme (UKCIP) has reported that UK temperatures have increased by about 0.7°C over the last 300 years, with about 0.5°C of warming during the twentieth century. This is part of a world picture of warming. Globally, 1998 was the hottest year since records began in the middle of the nineteenth century. It is thought that the 1990s may have been the warmest decade of the last millennium.

There is evidence that at least some of this change is the result of human action. Since the industrial revolution, the concentration of greenhouse gases in the atmosphere has increased, and by changing the atmosphere, we have changed the climate. Experts predict that the changes in climate will continue through this century. There is more confidence in some aspects of climate change than others. For example, the effect of a given change in carbon dioxide concentrations on sea level rise and global temperature increase is reasonably well understood.

This appendix looks in detail at the possible effects of climate change on water resources, and considers the role of adaptation in the planning of water resources.

A1.2

Climate change predictions

Predicting future climate change is difficult. In 1998, UKCIP published four scenarios for climate change. These are based on modelling carried out at the Meteorological Office's Hadley Centre and the Climate Change Unit at the University of East Anglia (Hulme and Jenkins, 1998), and make different assumptions about the proportions and effects of different greenhouse gases. The scenario approach was taken in recognition of the uncertainties associated with climate change prediction. In summary, all of these scenarios suggest that by the 2020s throughout southern and midland England and all of Wales, there will be more winter rainfall and less summer rainfall. The decrease in summer rainfall is more marked in the south and east of the country. Under all of the scenarios, northern England would receive more rain in winter and about the same volume in summer.

The interpretation of such results is difficult. The climate is naturally variable; water availability in the 2020s may differ from the present situation simply because of climatic variability. Climate change is superimposed on this natural variability. The result may either magnify or reduce the effect of climate change. Work carried out for the Agency by Arnell (1999) shows that changes due to climate change are systematic, with greater effects in the south than in the north. There is also evidence that climate change may increase the year-to-year variability of rainfall. Effectively this means that the climate will be less predictable, with both more dry years and more wet years. This in turn means that low flows will occur more often. However, it is unlikely that summers will be any drier than the extremes observed in previous decades. Evidence about the possibility of longer droughts is unclear; the best available view appears to be that the increased variability makes droughts that last over several years slightly less likely. While climate change prediction is inevitably uncertain, our understanding of changes in extreme events is even more limited than that of changes in average climate.

Over the next few years, we expect that the understanding of climate change will improve. It is most likely that this will involve refining existing results, adding detail and reducing uncertainty in the present scenarios. However, it is quite possible that new predictions could be quite different from those that we have now. It must also be acknowledged that we do not understand fully all of the possible effects of global warming. For example, it has been suggested that there could be a change in the behaviour of the Gulf Stream, resulting in the cooling of north-western Europe. While the best available information suggests that this is not likely, we must be aware that present assessments may change. We cannot rely on their accuracy, which means that we need ways to deal with climate change that are flexible. However, we must balance our concern about the possible effects of climate change against other

potential changes, and produce a measured response that allows society to adapt to accommodate the new climate as it evolves.

A1.3

The impact of climate change on water resources

Climate change has an effect on three elements of water resources planning:

- demand for water;
- availability of water;
- impact on the natural environment.

A1.3.1 Demand for water

Climate change will affect the demand for water in many different ways. Our understanding of the relationship between weather and water use is not perfect, so it is not possible to be absolutely certain about how climate change will affect demand. DETR has commissioned a study from the Environmental Change Institute at the University of Oxford to investigate the impact of climate change on domestic, industrial and agricultural water use. This will report in 2002. For this strategy, we have used the best information available at present.

Household water use is likely to be increased by hotter summers. This water will be used for increased garden watering and additional personal washing. Herrington (1996) carried out the definitive study looking at this. This additional water use is predominantly driven by temperature. While Herrington's work did not use the UKCIP climate change scenarios, it provides a reasonable first estimate of the effect on domestic demand. We have applied the appropriate factors to household consumption for scenario Beta to calculate an incremental demand as a result of climate change. Our calculation is based on the probable increase in garden watering, as this scenario already includes increased personal washing. Of course, under different Foresight scenarios society would respond to climate change in different ways. It would be possible to make an assessment of the different impact on garden watering in different scenarios. However, the quality of the data on changes in water use is poor, and does not warrant such sophistication. We have applied the value calculated for scenario Beta to the other scenarios as well. This is a precautionary assumption, as this scenario represents a worst case and it is anticipated that outdoor water use under the other scenarios would be lower. We have added this climate change demand to the incremental demands for each scenario. The total effect on public water supply demand nationally is about 180 Ml/d for 2025. This impact is distributed so that it is greater in the south and east than in the north. In the Thames Region, this equates to a potential increase on average of public water supply demand of approximately 50 Ml/d by 2025.

The impact of climate change on industrial water use is more problematical. Given the diverse range of industrial uses of water, vulnerability to climate change is likely to vary considerably between sectors. We can identify two possible areas where climate change may have an effect: in the demand for specific products, and in the efficiency of some industrial processes. Consumer demand for some products is sensitive to temperature fluctuations; this has a particular impact on the food and drink industry. Some industrial processes such as cooling may become less efficient with higher temperatures, leading to a greater demand for water. The precise nature of these changes is unclear. For the purpose of this strategy, we have assumed that our forecasts of industrial demand do not need to be modified to allow for climate change over the next 25 years. We will review this when the results of the DETR study are available.

Climate change will certainly have an effect on agriculture. It will affect not only planting and harvesting dates, but also the varieties of crop that are grown and their distribution across England and Wales. Climate change may allow an extension of the area given to crops that are presently marginal, such as lupins, sunflowers and navy beans. In combination, these changes will influence crop water requirements and irrigation need.

Livestock production systems will also be affected by higher temperatures, with increases in animal drinking and water wallowing sites for outdoor pigs. For indoor livestock units there may be a requirement for cooling, adding an additional demand for water.

Over the next 25 years, climate change will be one of many challenges facing agriculture. Other factors could include reform of the Common Agricultural Policy (CAP) and increased globalisation of the market for agricultural produce, as well as changes in consumer preferences. It is within this context that the impact of climate change on spray irrigation demand should be assessed.

Other factors that influence demand may be affected by climate change. For example, higher winter

temperatures may mean less frost-heave and therefore lower winter mains burst rates. However, the impact of such effects is probably small and at present almost impossible to quantify. Ignoring such secondary factors is reasonable in the context of this strategy.

A1.3.2 Availability of water

Changes in climate will change flow regimes and therefore the availability of water for abstraction. All of the current UKCIP scenarios suggest on average more annual rainfall throughout England and Wales, with less summer rainfall in the south. Higher temperatures mean that potential evaporation rates will probably increase.

Work carried out by Arnell (1999) has looked at the effect of the four UKCIP climate change scenarios on river flows. The impact varies according to location and the underlying rock type. For rivers dominated by groundwater, average flows decrease in late summer and increase through the rest of the year. The decrease in late summer flows is greatest in the south and east. Average recharge to aquifers is expected to increase in all scenarios for all aquifer types.

Rivers not dominated by groundwater show a similar pattern, with lower flows in July, August and September throughout England and Wales. However, the decreases are small in the north. Flows increase in the rest of the year in all scenarios, with the increases being lowest in the south.

The implication of this for water users is mixed. As recharge increases everywhere in all scenarios, groundwater abstractions should be at least as reliable as they are now. Abstractions that need summer water will become less reliable through much of England and Wales as licence conditions that protect low flows become effective more often. This will be a particular problem in the south, and will apply also to rivers dominated by groundwater in this area. However, higher winter flows mean that other abstractions should continue at current levels of reliability. The storage of winter water should be more reliable, with more potential for reservoir filling later into the spring.

The above refers to the average effect of climate change. It implies that climate change can be considered against the long-term average climatic conditions. However, we know that the climate varies naturally from year to year and that the long-term average changes over time. It is also possible that the frequency of extreme events will change: the present UKCIP scenarios suggest more dry summers by 2025 but about the same frequency of dry periods that last more than one year.

This discussion is deliberately very general. Individual catchments respond to rainfall and evaporation in different ways; understanding of the effect of a particular change in climate in a specific location requires detailed catchment modelling.

Different water supply systems will respond in different ways, according both to their physical characteristics and to the way in which they are operated. The yield and reliability of public water supply systems depend on the magnitude and duration of dry periods, as well as the frequency of occurrence of such events. The increased variability associated with present scenarios suggests that long dry events will be no more frequent than at present, which implies no change from present yields for large reservoirs and groundwater-fed systems. However, this result is by no means certain.

In this strategy, we have assumed that over the next 25 years most public water supply systems will retain their existing yields. This is a reasonably conservative assumption, as most systems depend to a great extent on the storage of winter water in either aquifers or reservoirs. Little analysis exists, but where modelling has been carried out it suggests that most reservoir systems will actually gain a little yield because of the wetter winters. However, some systems do appear to suffer from a reduced yield, emphasising the need to carry out careful investigations of individual systems.

Direct abstractions will become less reliable in summer, which means that farmers and industries that rely on these will have to consider adapting in some way if they wish to maintain current levels of reliability.

A1.3.3 Impact on the natural environment

Species and habitat dynamics in the face of climate change is an area that is poorly understood. Wildlife and habitats (including pests and diseases) are expected to move north and to higher altitudes as mean temperatures rise. One study for the DETR suggests that 10% of the UK's internationally designated areas could be at risk of permanent inundation or gradual loss of conservation value as a result of sea level rise, temperature rise and changes in water availability; water quality changes might exacerbate the situation (DETR, 2000d). We expect that further information and strategies to enable the protection of sensitive species will be developed in the coming years.

Changes in river flows and wetland levels as a result of climate change will have an impact on the plants and animals that rely on the water environment. Some species will be better suited to the new conditions,

while others may find it harder to thrive. The water requirements of different species are hard to establish, partly because factors other than water availability determine current species distribution. Many species can tolerate a certain level of stress due to occasional drought.

For this strategy, we will assume that we can protect the future environment by maintaining current levels of protection through the maintenance of existing controls on abstraction, except where we know that these are in need of improvement for other reasons. The environment that we protect will be dynamic, with species changing over time with climate change. This is an area in need of further research and public debate.

A1.4

Adaptation strategies

Given that the climate is changing, all sectors of society and the economy will have to respond to new climatic conditions. Adaptation strategies will be driven both by changes to long-term climate and by changes in extreme events. However, the exact nature of climate change is uncertain. This makes it difficult to plan, especially where decisions have to be taken many years in advance. Some decisions may involve significant investment; it is hard to justify expenditure that may turn out to be unnecessary. One of the keys to a successful adaptation strategy is to ensure that it is sufficiently flexible to deal not only with current predictions but at least to some extent with events that are less likely or not foreseen. In the context of water resources strategies, this means that schemes that improve the management of water use or developments that can be phased will be more appropriate than schemes that are inflexible.

The Agency has a significant role in helping to mitigate climate change by regulating major industries that emit greenhouse gases. While water resources has little impact on this, it is important to take into account the energy use of different schemes. Pumping large volumes of water around uses significant amounts of energy, and therefore contributes to total emissions. For this reason, our risk and uncertainty framework and sustainability appraisal both consider energy use.

Climate change is an important element of uncertainty in water resources planning. Over the next 25 years or so, it is not, however, the greatest source of uncertainty in aspects such as water use. Societal values and economic growth will also play an important role. Given the increase in average annual rainfall predicted by the current climate change scenarios, it would be difficult to justify new water resources development solely because of climate change. However, it is important to ensure that any water resources management initiatives consider climate change and the way that they may be affected by different weather conditions. Vulnerability to extreme events is especially important, given that the scenarios include predictions of more droughts with a duration of one year or less. Different sectors of water use are affected by extreme events in different ways. For example, arable agriculture is affected badly by severe summer droughts, but many water supply systems can cope with short periods of very dry weather but are vulnerable to long dry periods.

While all sectors suffer from dry weather, the impact on the availability of public water supply is especially important. Experience during the 1995 drought shows that failures in public water supply would be unacceptable, and that it is essential that we plan to maintain basic supplies through all types of drought. As a result, all water companies have developed drought plans, setting down the steps they will take to maintain supplies as a drought progresses. We reported to Government on these in June 2000 (Environment Agency, 2000b). In this strategy we prefer options that provide maximum security of supply during different types of drought. Different water company systems have different characteristics, depending for example on the proportion of water stored in reservoirs or taken from groundwater.

A1.5

Climate change in context

Climate change must be considered carefully in water resources planning. However, many other factors affect our use of water and the natural environment. Demand for water may change according to different social and economic factors. The range of possible demands is much greater than the effect of climate change on water availability. Of course, it is quite possible that the greatest demand could be combined with the worst climate change scenario, and our planning must take this into account. As long-term average water availability appears to change little over even the next 80 years, we must pay special attention to the vulnerability of water resource systems and the environment to more frequent drought events. Unfortunately, information about these is sparse and we must at present plan for these by enhancing flexibility where this is possible and practicable.

There is a substantial UK programme to develop further the understanding of climate change. This is being developed through initiatives such as UKCIP and the new Tyndall Centre in Norwich, as well as many individual projects, including some carried out by the Agency. Future work includes assigning probabilities of occurrence to different climate change scenarios, and developing better information on the frequency and magnitude of extreme events such as droughts. The DETR is presently running a project to look at the impact of climate change on all types of demand for water, as well as considering strategies for nature conservation in the face of climate change. Other studies focus on reducing the uncertainty in climate change models and developing climate scenarios with higher spatial and temporal resolution for western Europe. The Agency will keep these under review and examine their impact on strategies as appropriate.

Appendix 2

A scenario approach to water demand

A2.1

Overview

This appendix describes how we have used scenarios to consider a range of factors that could affect society's demand for water over the next 25 years. Drawing widely on expertise from within and outside the Agency, including our own National Water Demand Management Centre, we have developed a set of consistent water demand scenarios for the components of public water supply and direct abstraction. This builds on the Foresight "Environmental Futures" framework (DTI, 1999).

A2.2

The Foresight "Environmental Futures" scenarios and water demand

The Foresight scenarios are intended to define a broad contextual framework of social, economic, political and technological change. Assessment of the impact of these processes on specific sectors of the economy, or particular aspects of the environment, is deliberately general with the intention that experts will add to the framework to develop coherent, sector-specific scenarios. In the case of water resources, Foresight provides a high-level, qualitative assessment of the implications for water under each scenario, characterised simply in terms of water demand increasing, stabilising or decreasing.

Taking this framework as our starting point, we have considered the variable impact that changes in regulation, policy and social values will have on society's use of water. It is conceivable that within the same scenario some components of demand will increase while others decrease. To track such changes and fully illustrate their impact, we have built on latest information and methodologies to develop forecasts of water demand for the following components:

- household;
- leakage;
- non-household;
- primary industry and manufacturing;
- spray irrigation.

The UKWIR/NRA demand forecasting methodology and subsequent best practice manual identified the key drivers of household, leakage and non-household or industrial water demand (UKWIR and Environment Agency, 1997). The drivers of spray irrigation demand have been assessed in the Agency's *'Optimum use of water'* R&D project (Environment Agency, 1998a).

In developing our forecasts, we have assumed that the key drivers of demand will remain consistent in identity across all scenarios. This means that we can use a single forecasting model for each component of demand, making different assumptions about rates of change for each scenario.

Within each scenario, the assumptions regarding social, economic, technological and political change across the different components are consistent with the Foresight framework. For example, under Scenario Alpha (Provincial Enterprise), disengagement from international economic trading systems will affect both

agricultural and industrial demand for water, by increasing the level of production of certain goods within the UK. The timing of application of such assumptions has been carefully assessed to ensure that each water demand scenario is internally consistent and robust.

The drivers of demand are detailed in Table 5.1 in the main report. They have been broken down by component to reflect the Agency's assessment of how each will vary under the four scenarios. The starting point for each scenario is the same, and the assumptions that have been applied reflect a conservative assessment of likely changes at the micro-component level. The technologies and policies included within the four scenarios are all available within the UK or overseas today. Hence the assumptions are within present bounds of possibility and represent a realistic assessment of likely change.

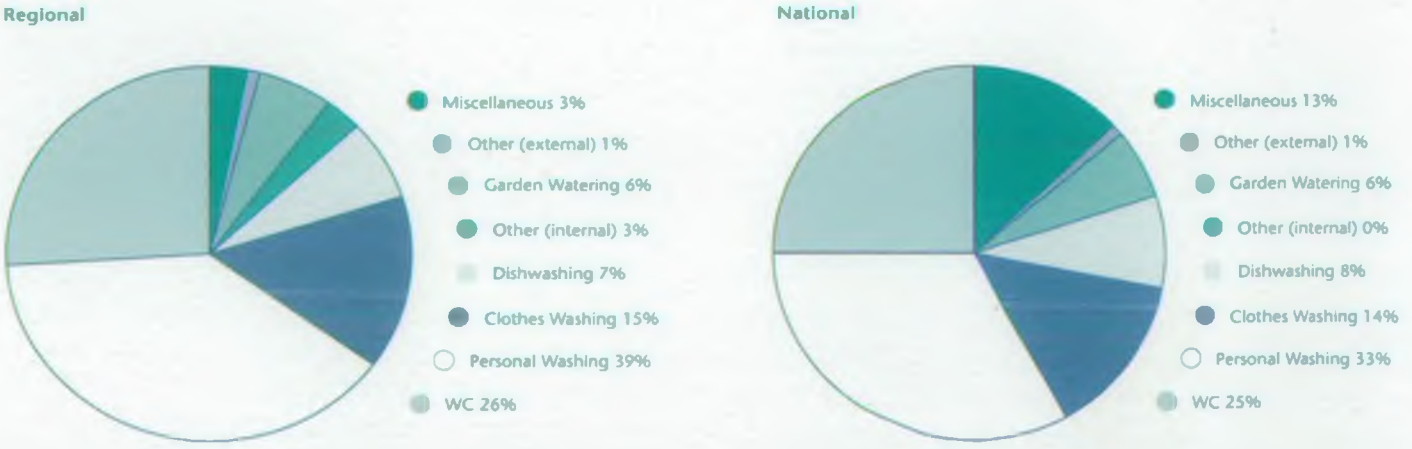
The methodologies and information sources informing this process are outlined in the rest of this appendix. Each section includes an indication of the scenario outcomes for each component at the national level, and the appendix concludes with an assessment of total demand for each scenario in 2010 and 2025.

We have adopted a micro-component approach in our household demand scenarios, breaking down consumption into 14 discrete micro-components (Table A2.1) falling under the eight broad categories identified in Figure A2.1. Such a disaggregated approach enables us to link the scenarios to the key drivers of demand to consider how behavioural factors will influence future water use.

Table A2.1 Household forecast micro-components

Component	Micro-component
Toilet use	Toilet use
Personal washing	Bath
	Standard shower
	Power shower
	Hand basin
Clothes washing	Clothes washing by machine
	Clothes washing by hand
Dish washing	Dish washing by machine
	Dish washing by hand
Car washing	Car washing
Garden use	Sprinkler use
	Other garden use
Direct heating system	Combination boilers
Miscellaneous	Miscellaneous

Figure A2.1 Micro-components of household demand



A2.3

Household demand

To establish base year values for Ownership, Frequency and Volume (OFV) for the relevant micro-components we drew on information supplied by eight of the water companies in their water resource plan submissions. The data supplied by these companies was reclassified into our 14 micro-component categories. Where OFV data were not available, we developed an analysis based on a socio-economic profile of each water company resource zone.

Projections of future changes in OFV values have been informed by a number of sources of information. The OFV values reported in Herrington (1996) have been updated for example in light of changes introduced in the Water Supply (Water Fittings) Regulations 1999. Technological innovation in the volume of water used by white goods and other appliances was assessed by reviewing manufacturers' information, while changes in the rate of uptake of sanitary ware were discussed with representatives from the British Bathroom Council.

Information on garden watering is sparse and often inconsistent. We developed a nationally consistent set of assumptions drawing on information from a number of organisations and equipment manufacturers.

Drawing on all of this information, scenario-specific assumptions have been developed for each of the 14 micro-components to generate an unmeasured per capita consumption for each resource zone.

A2.3.1 Metering scenario assumptions

Metering gives customers the opportunity to pay for the volume of water used, offering an element of choice to the consumer and also providing an incentive to manage demand. It is likely that different tariff structures would be developed under different scenarios; we have not considered these in detail because our general assumptions about water use within each scenario have a similar effect. Generalised savings based upon the results of the National Metering Trials have been used to guide our assumptions (National Metering Trials Working Group, 1993). The greatest reduction in demand is delivered in Scenario Gamma (Global Sustainability). The proportion of metering also varies across the scenarios to reflect differences in the degree of social acceptability and regulatory influence. This differentiated approach is presented in Table A2.2.

It is essential to note that this table reflects the changes that would happen under certain social and governmental scenarios. For example, the compulsory metering in some scenarios would require a change in the law. The Agency is not seeking or endorsing such a change, but merely illustrating what might develop in some future scenarios.

To complete the forecasts, a nationally consistent population and household data set was obtained from CACI for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025. These data were based on the 1996 population projections (building on the 1991 census information), adjusted to incorporate 1997 mid-year estimates.

A2.3.2 Household demand: scenario outcomes

See Figure A2.2

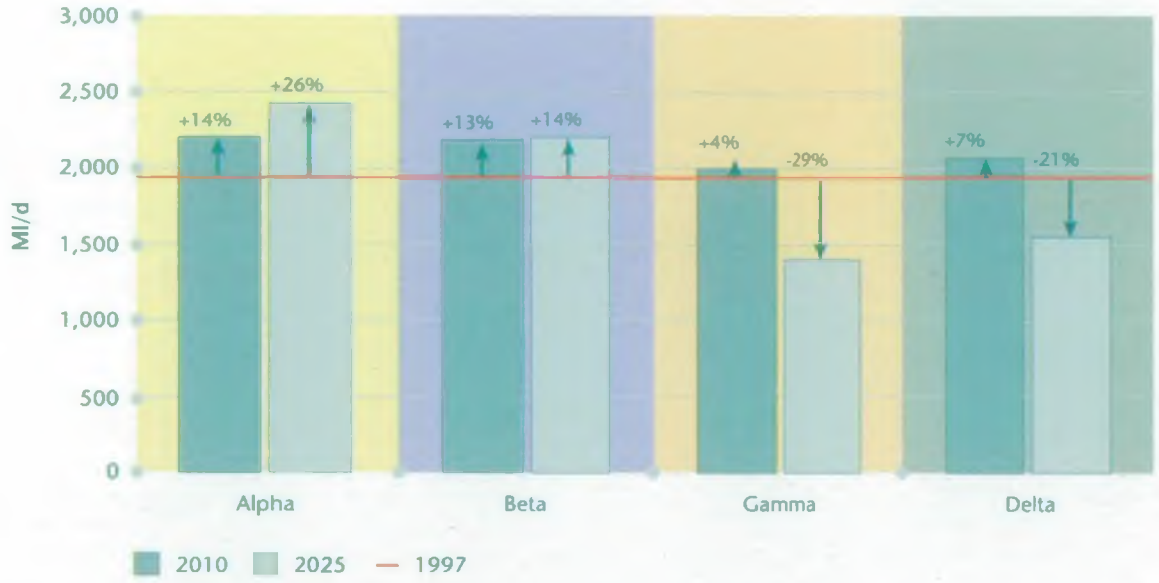
- **Scenario Alpha (Provincial Enterprise):** Growth in personal affluence is stifled, with the result that availability and take-up of more efficient technologies is limited. Replacement of white goods and investment in new water-using devices declines, with households preferring to repair existing appliances as necessary. Existing sanitary ware is retained.
- **Scenario Beta (World Markets):** With high economic growth, technological innovation leads to improvements in the water efficiency of white goods

Table A2.2 Metering assumptions for each scenario

	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Alpha	Likely water company rates following Ofwat final price determination	Continue with rate of metering allowed by Ofwat in 2005 for those companies in the south and east, elsewhere no additional metering			
Beta		Water company rates	Metering to a maximum of 95% of all properties		
Gamma		Water company rates	Metering to a maximum of 95% of all properties		
Delta		Water company rates			

Figure A2.2 Public water supply household demand by scenario in 2010 and 2025

a. Regional total



and average washing machine use reduces to 50 litres by 2025. Discretionary uses of water increase with more power jetters, power showers and swimming pools.

- **Scenario Gamma (Global Sustainability):** By 2010 measures to manage demand within existing regulations are fully implemented. From 2010 revisions to flow and volume limits in regulations provide stricter controls, particularly associated with power showers. New high-water-efficiency technology is promoted leading to a 15 litre reduction in the volume of water used by washing machines. Given the relatively high rate of growth and affluence, the rate at which consumers replace appliances does not decline markedly. Purchases reflect their positive attitude to the environment with the uptake of more water-efficient appliances.
- **Scenario Delta (Local Stewardship):** Consumer attitudes shift markedly with a major impact on water-using behaviour. Overall, there is a decline in the use of water for discretionary purposes such as garden watering, which declines from 9 l/h/d to less than 3 l/h/d by 2025. There is a widespread uptake of demand management measures, and a shift to low-water-using appliances. Community initiatives become more widespread. Rainwater collection for garden watering is the norm where some form of watering is required.

A2.4

Leakage demand

For our strategy, the formulation of the four leakage scenarios has focused in particular on the political and regulatory framework likely to influence the setting of leakage targets, and the consequent impacts for total leakage at water company level (see Table 3.2 in the main report). High-level changes in political and social attitudes will affect the priority given to leakage by Government, and therefore will influence the formulation of targets. This in turn will affect water companies' leakage control philosophy and subsequent find-and-fix activity, pressure management levels, and service and mains replacement rates.

A2.4.1 The leakage scenario approach

Our four leakage scenarios reflect differential approaches to setting leakage targets. Three scenarios reflect recent UK and overseas experiences, and draw on information from the recent past to inform the development of company leakage targets. Only one scenario has necessitated detailed modelling, to reflect the impact of new technologies.

The calculation methods and associated timings for each scenario are detailed in Table A2.3.

b. By water company

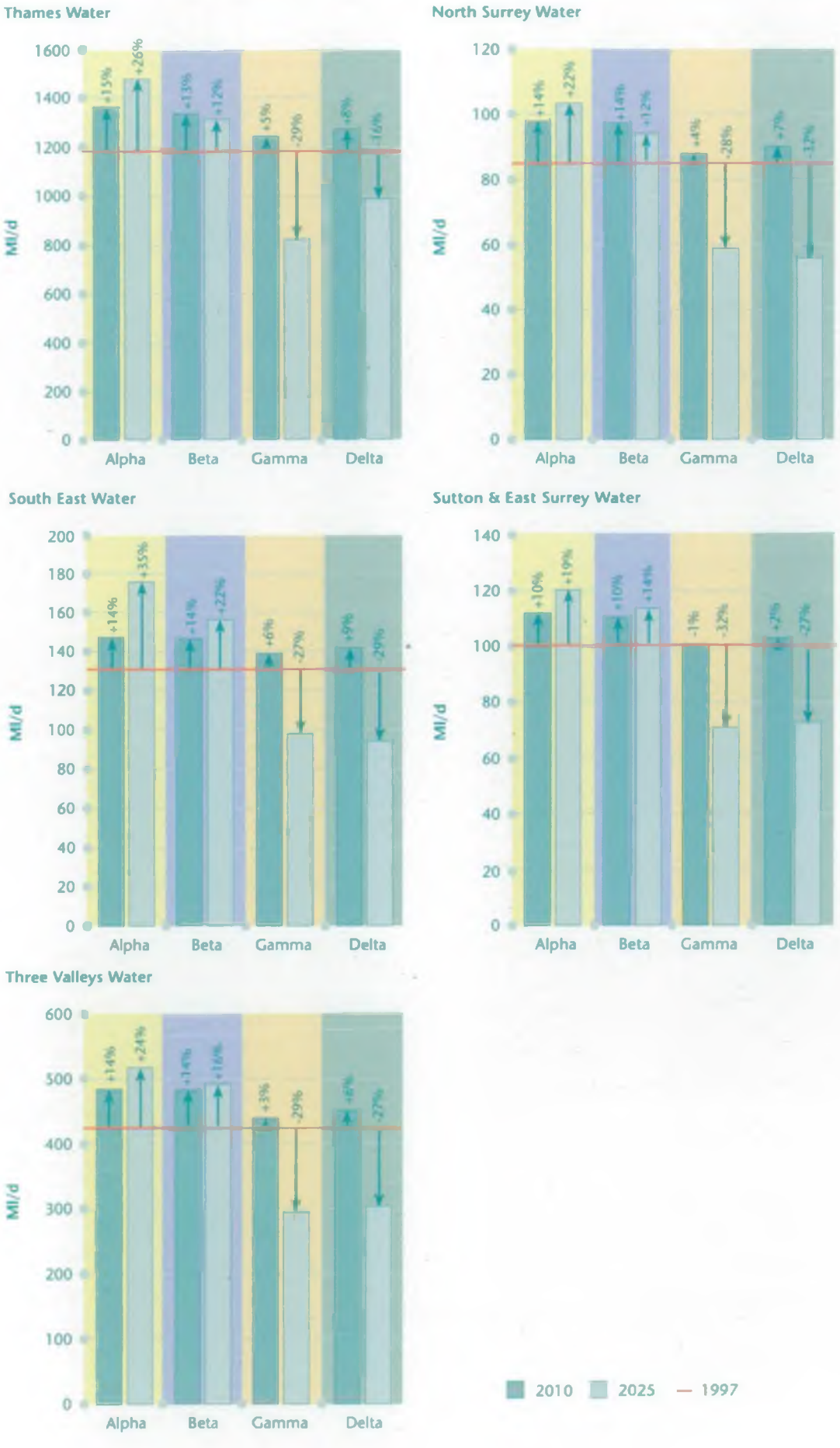


Table A2.3 **Leakage assumptions by scenario**

	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Alpha	Ofwat 2000/01 target level	Ofwat 2000/01 target level	Passive leakage control policy		
Beta		Ofwat 2000/01 target level			
Gamma		Apply leakage targets that would be achievable with the application of today's best practice and most advanced technology			
Delta		Ofwat 2000/01 target level	Reduce total leakage by 1% per annum until 10% reached. Then hold at 10%		

Scenario Alpha (Provincial Enterprise) *leakage assumptions*

Given the lack of investment and short-termism that characterises this scenario, leakage levels are forecast to increase in line with the natural rate of rise (NRR). The natural rate of rise relates to the average rate at which leakage rises when a water company practises passive leakage control, when the only bursts that are repaired are the ones reported by members of the public. Lambert *et al* (1998) recognise that the average rate of rise can vary widely from 0 to over 20 litres/property/hr each year.

It is important to note that this leakage scenario would result from a completely different set of values to those that are held at present. We are not suggesting that present water companies would allow leakage to rise in this way, but that there is a real possibility that this could result from a relaxation of the rules governing leakage in a less regulated scenario. The rate of rise may look extreme. It is possible to postulate a mechanism of relaxed control that allows leakage to rise more slowly but has the same result by 2025, the time horizon of this strategy.

Scenario Gamma (Global Sustainability) *leakage assumptions*

The implementation of improved leakage control methods forms the cornerstone of leakage targets in this scenario, based on the assumption that techniques currently available are developed slightly. We have identified a level of leakage that would be achievable with the application of today's best practice and the most advanced technology. This is described in detail in Appendix 3.

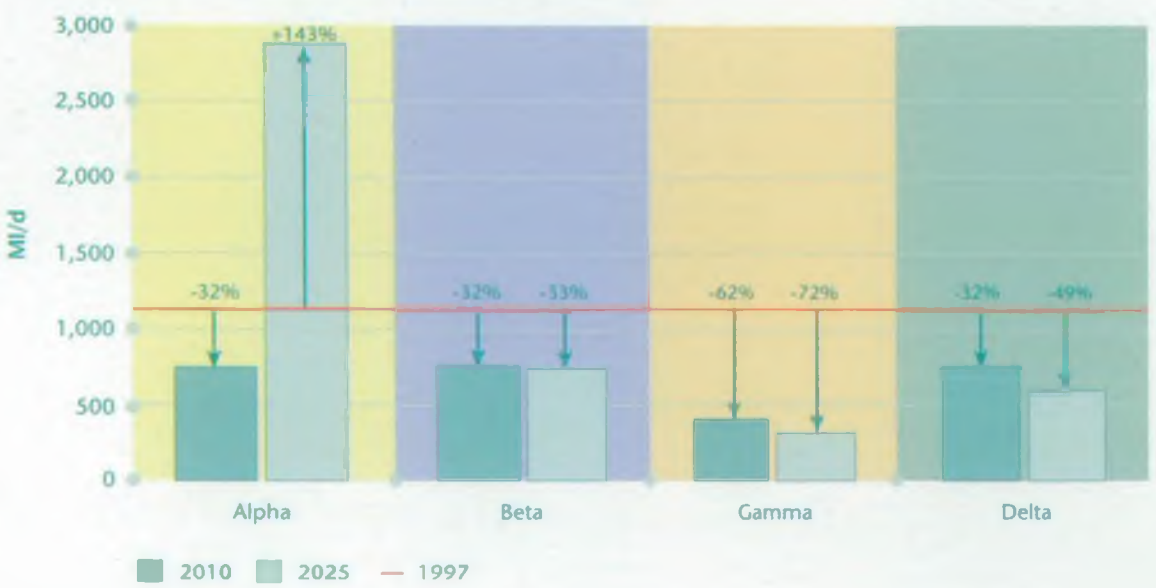
A2.4.2 Leakage demand: scenario outcomes

See Figure A2.3

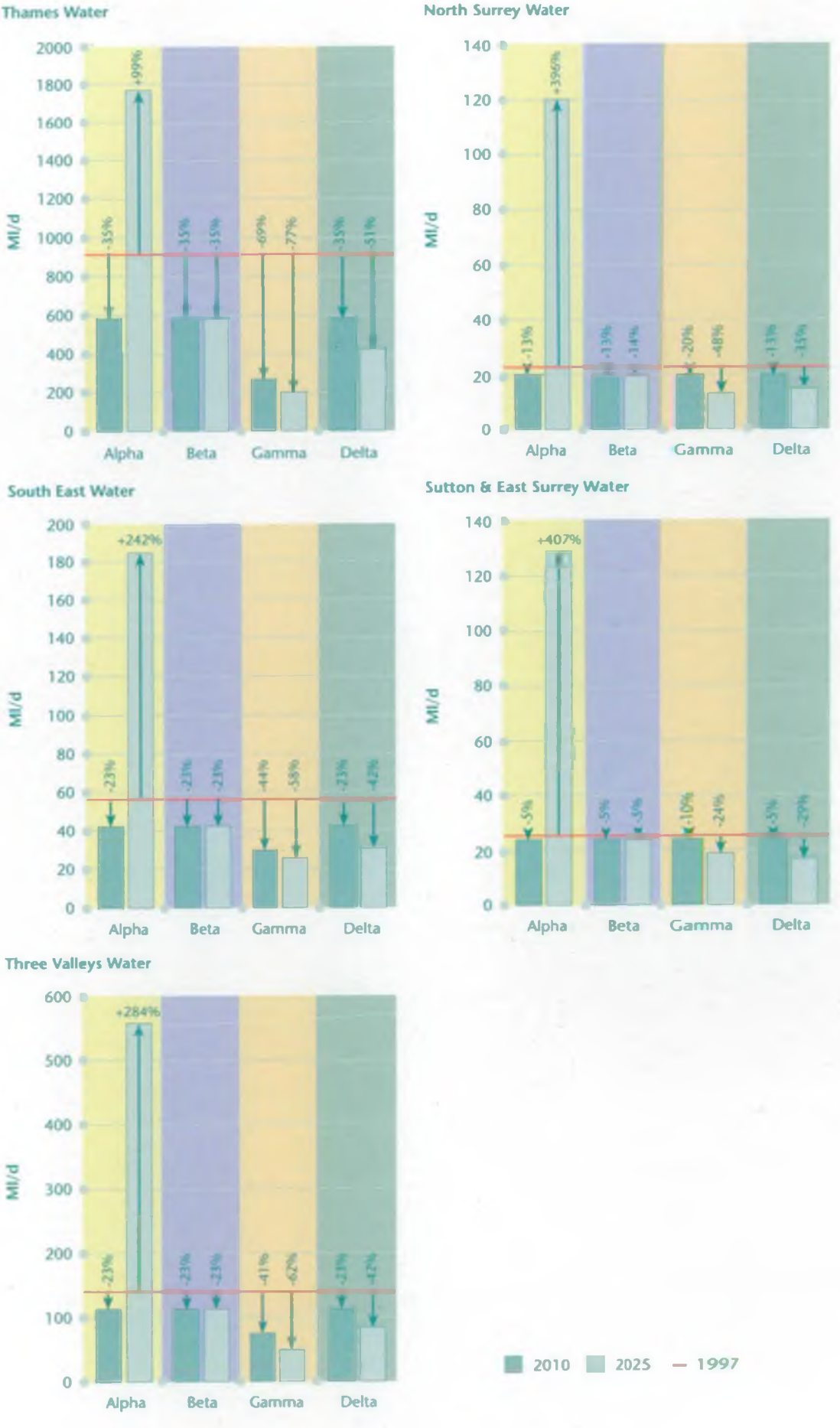
- **Scenario Alpha (Provincial Enterprise):** This is a low-growth, low-investment scenario in which short-

Figure A2.3 **Leakage by scenario in 2010 and 2025**

a. Regional total



b. By water company



termism predominates. Government regulation of the water industry is very weak, with no political commitment to sustainable development. Investment in leakage control is curtailed.

- **Scenario Beta (World Markets):** The water industry is subject to light levels of regulation. Given the primacy of market forces, leakage targets are not considered necessary, as the need to be competitive is assumed to promote sufficient incentive. Leakage control is not perceived as a critical issue in maintaining public water supplies. Although there is a slight deterioration in system leakage, this is balanced by improvements in supply pipe leakage achieved through universal metering.
- **Scenario Gamma (Global Sustainability):** Sustainable development is accorded high political priority, with the water industry subject to strong regulation to protect and enhance the environment. There is rapid technological innovation, with Government placing a high priority on research and development. The leakage target setting process reflects innovative technical solutions.
- **Scenario Delta (Local Stewardship):** Leakage control is given high priority, although this is inhibited by the decentralised system of regulation. Capital constraints curtail investment in research and development, slowing development of innovative leakage control technologies. Leakage targets are based on a political judgement that 10% of water put into supply is an appropriate level.

A2.5

Non-household and primary industry demand

Each of the drivers of non-household demand identified in Table 5.1 (in the main report) play a critical role in shaping the use and management of water within industry.

To address these issues and avoid applying blanket assumptions, two key distinctions are drawn in our forecast model. Firstly, to allow application of sector-specific assumptions, the forecast has broken down water consumption by industrial sector. Linked to the Standard Industrial Classification, we have broken down public water supply non-household demand into 19 sectors, while direct abstraction includes 11 sectors (SIC, 1992). Secondly, we have drawn a distinction between Small and Medium-sized Enterprises (SMEs) and large companies to reflect variability in the level of uptake of water use minimisation options.

A2.5.1 Forecast methodology

Availability of base year water consumption data, disaggregated by industrial sector, played an important role in determining our forecast methodology. Owing to the paucity of non-household water use data, we identified weighted output growth as the most appropriate forecast method for both public water supply (PWS) non-household and direct abstraction primary industry demand. This method allows us sufficient flexibility to apply a range of assumptions at the industrial sector level regarding economic growth, employment and output, as well as the direct application of water efficiency assumptions.

Drawing on information from the Environmental Technology Best Practice Programme (ETBPP) (now Envirowise) and other published sources, we have devised sector-specific water savings that reflect differences in cost and payback period. Hence for production and manufacturing industries five water efficiency measures have been defined:

- good housekeeping;
- management;
- re-use;
- recycle;
- redesign.

Good housekeeping represents the cheapest options with immediate payback, while plant redesign or refurbishment requires significant capital investment and incurs payback periods of three years or more.

Reflecting the different nature of water use, we defined three separate categories for the business and service sectors, and education and health, once again ranging from the cheapest to the most expensive options. These are:

- good housekeeping;
- management;
- water saving technology.

The water efficiency reductions employed in this analysis are all technically feasible today, and these values have been held constant across all four scenarios. Variability between scenarios is introduced through the level of uptake by businesses of relevant water efficiency measures.

A2.5.2 Industrial demand: scenario outcomes

See Figure A2.4

- **Scenario Alpha (Provincial Enterprise):** The political climate results in a decline in the levels of both imports and exports. Sectors such as chemicals, business services and electronics face slower rates of growth from 2005, reflecting the reorientation of production to meet domestic demand. This is counter-balanced by growth in primary industry and manufacturing industries, such as metals, textiles and engineering, where long-term changes to the structure of the economy are reversed. There are very low levels of water use minimisation activity, compounded by the lack of investment in manufacturing infrastructure.
- **Scenario Beta (World Markets):** The removal of all international trade barriers results in a reduction in the level of gross output and employment within UK-based primary manufacturing industries such as textiles, machinery and metals. This decline is balanced by an increase in the level of output and employment within business services, chemicals and biotechnology. Given the drive towards technological innovation we assume that, by 2025, 20% of firms across all sectors will implement low-cost water efficiency measures such as good housekeeping, management and re-use options. This only partially suppresses the demand generated by high levels of growth within the business sectors.
- **Scenario Gamma (Global Sustainability):** Resource-intensive systems of production such as paper, minerals, rubber, textiles, metals and fuels are subject to stricter environmental regulations from 2010. These emphasise water efficiency and 90% of businesses within these sectors are affected. Other industrial and business sectors adopt voluntary measures to minimise their impact on the environment, with 50% of businesses within retail, business services, and construction implementing water efficiency measures by 2025.
- **Scenario Delta (Local Stewardship):** From 2010 retail and business services, and leisure industry decline, reflecting the shift in consumer attitude. Industries such as chemicals, a high-water-using sector, also decline, in part reflecting the shift towards organic systems of agricultural production. The environment is placed at the centre of industry and business decision-making, with eco-efficiency driving the decline in raw material use. By 2025, 65% of firms across all sectors have implemented low-cost water efficiency measures, but more expensive measures such as plant redesign are inhibited by the lack of available capital for investment.

Figure A2.4 Public water supply non-household and direct industrial abstraction demand by scenario in 2010 and 2025

a. Regional total

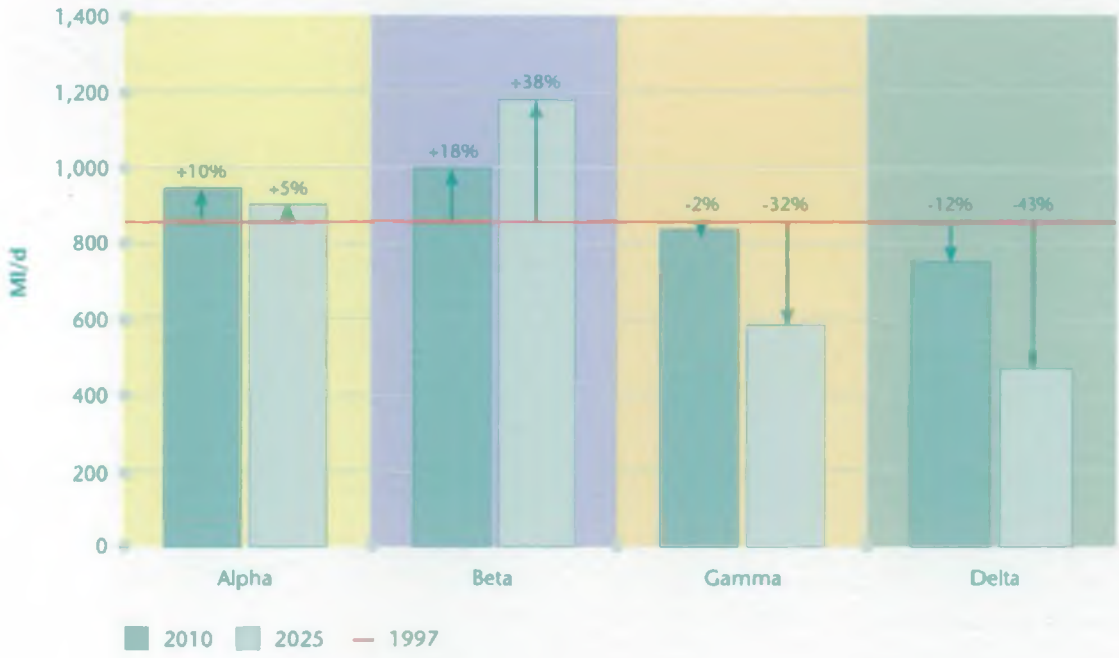
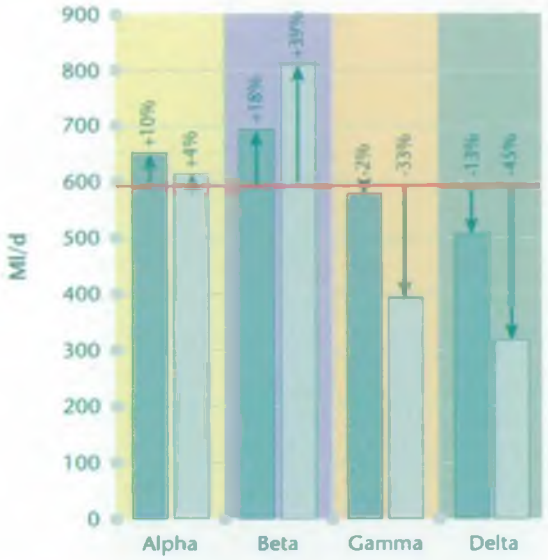


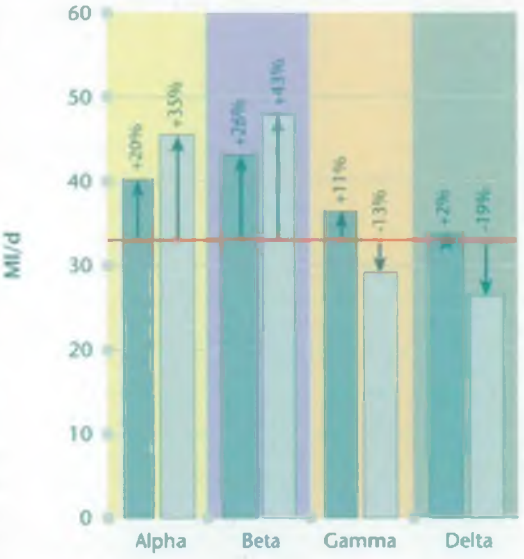
Figure A2.4 Public water supply non-household and direct industrial abstraction demand by scenario in 2010 and 2025 *continued*

b. By water company

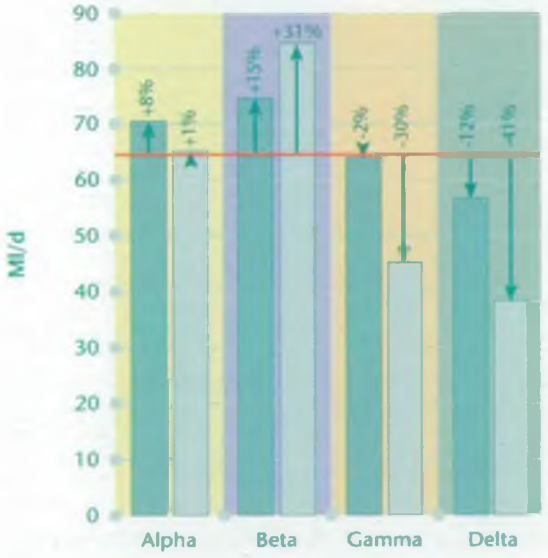
Thames Water



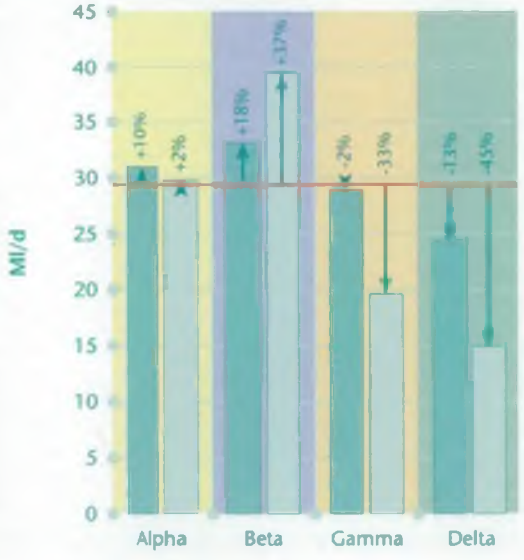
North Surrey Water



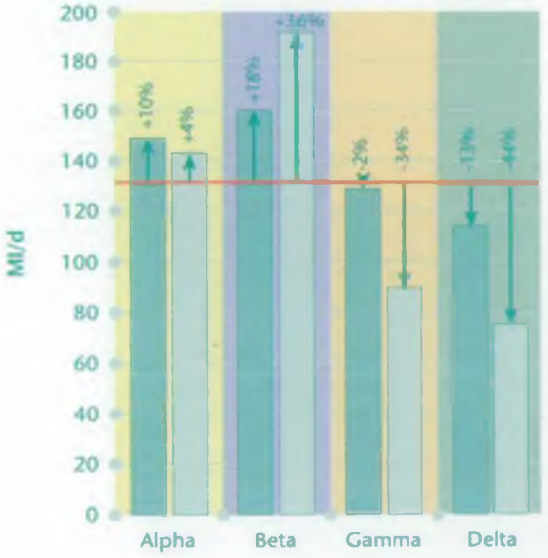
South East Water



Sutton & East Surrey Water



Three Valleys Water



2010 2025 1997

A2.6

Spray irrigation demand

Agriculture is subject to a wide range of social, economic and political drivers of change, which directly or indirectly affect the use and management of spray irrigation.

A2.6.1 Forecast methodology

Previous forecasts of spray irrigation demand have been based on the concept of theoretical crop water requirements to maximise crop yield and quality. Such approaches fail to take into account the costs and benefits of irrigation, which play a critical role in determining the actual level of irrigation. For example, in some situations the benefits of irrigating a crop, although positive, may not be sufficient to justify the investment and risk. In other cases, decreasing returns to irrigation may only justify investment in a lower level of irrigation capacity.

The new Environment Agency forecasts, undertaken by Cranfield University at Silsoe, have developed the concept of economic demand, reflecting the costs and benefits of irrigating different crops. The methodology draws on the optimum irrigation water requirements developed under the Agency's *The optimum use of water for industry and agriculture dependent on direct abstraction: best practice manual* R&D project (Environment Agency, 1998a). The forecasts estimate the ratio between the economic demand and the optimum demand for selected crops, under different economic and water resource constraints. This approach assumes that water resource constraints or low economic returns will limit on-farm investment in irrigation capacity (total licensed quantity or reservoir capacity) and in peak application rates (pump and pipeline capacities, number of hosereels, etc.). These constraints then limit irrigation depending on each year's weather pattern, with the greatest effect occurring in years with highest demand.

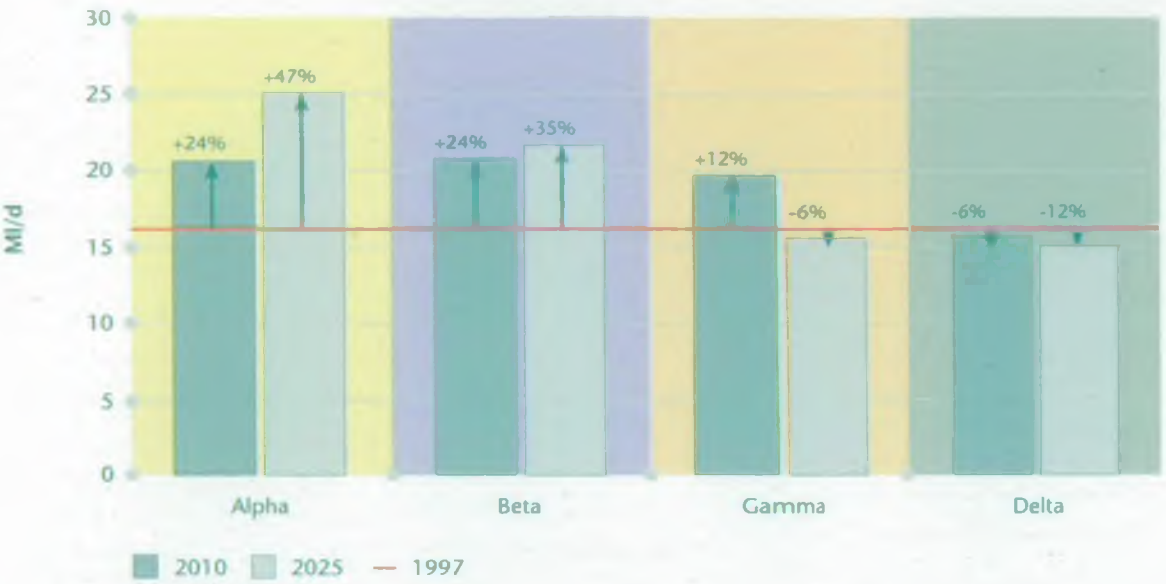
This approach marks an important development. Comparison with "baseline" crop irrigation forecasts based on theoretical and economic demand highlights a number of important issues. The methodology confirms that for high-value crops, such as potatoes, vegetable and fruit crops, economic and theoretical demand are closely matched. However, the economic benefit of irrigating lower-value crops, such as sugar beet, cereals or grass, is not sufficient to justify applying the full theoretical crop water requirement. Irrigation forecasts for these crops, based on the economic optimum, are significantly reduced.

A2.6.2 Spray irrigation demand: scenario outcomes

See Figure A2.5

- **Scenario Alpha (Provincial Enterprise)**: There is strong emphasis on home produce and self-sufficiency, with a reduction in the level of food imports. This serves to increase the total area of crops such as potatoes, sugar beet, field-scale vegetables and horticulture, although as yields gradually increase the total area under production declines slightly by 2025. Supermarkets and food processing firms continue to focus on produce quality with high price premiums. The price premiums encourage greater efficiency in the use of irrigation, although there is limited technological innovation in irrigation equipment and scheduling systems.
- **Scenario Beta (World Markets)**: Agriculture is subject to strong international competition with the level of food imports increasing. This impacts in particular on potato, sugar beet and orchard fruit crops, where total area declines. Despite this, the emphasis on produce quality, and the associated high price premiums, favours increased irrigation of high-value potato and horticultural crops.
- **Scenario Gamma (Global Sustainability)**: The level of imports increases, with a consequent reduction in the total areas of potatoes, sugar beet and orchard fruit. Supermarkets realign their approach to agriculture, using their influence to promote and support environmentally sensitive systems of production. Price premiums for irrigated produce fall, with less emphasis placed by consumers on the appearance of produce. This, combined with the widespread adoption of drought-tolerant varieties, encourages farmers to reduce the volume of water applied. Irrigation efficiencies increase rapidly, reflecting national investment in irrigation technology development.
- **Scenario Delta (Local Stewardship)**: Significant emphasis is placed on food self-sufficiency, with a movement away from reliance on supermarkets to local shops and farmers' markets. Less emphasis is placed on appearance, reducing the incentive to irrigate. The area under organic or low external-input systems increases, with a consequent increase in total crop areas. Average yields reduce, average farm commodity prices rise and input costs fall. Water is used wisely because of its associated public good, rather than its commercial value, leading to high irrigation efficiencies.

Figure A2.5 **Spray irrigation by scenario in 2010 and 2015**



Appendix 3

Calculating possible leakage levels in 2025

A3.1

Introduction

Our strategy recommends that further leakage reductions should play a part in managing public water supply over the next 25 years. We have drawn attention in the main body of the report to the tripartite leakage study being sponsored by Ofwat, DETR and the Agency. This will help to clarify the potential for progress. In the meantime we have developed our own approach to calculate possible future leakage levels. The assumptions should be useful material for the tripartite study; this appendix provides details of the approach.

A3.2

General approach

Our approach makes an estimate of the progress that can be made in leakage control over the next 25 years. We take into account the application of existing technology and methods, as well as changes that are already widely anticipated in the water industry.
We have assumed that methods that some companies find cost-effective today will probably be cost-effective for all water companies in the future. We have not tried to calculate economic levels of leakage over the 25-year period, principally because these require comparison of the cost of leakage control against the cost of other options. Instead, we have looked at the way that leakage control methods can be applied, and calculated the resulting level of leakage for each water supply zone.

A3.3

Method

We have considered three components of leakage:

- reported bursts: leaks that are noticed and reported by the public;
- unreported bursts: leaks that are not noticed by the public, but are found by a water company's active leakage control work;
- background leakage: the sum of small leaks from joints, fittings and small holes that cannot at present be found by active leakage control methods.

The duration of a burst depends on:

- awareness time: how long it takes before a company is aware that there is a burst;
- location time: how long it takes to find the burst's location;
- repair time: how long it takes to repair the burst.

By definition, active leakage control cannot find bursts that are presently undetectable. This does not mean that background levels of leakage will never change: it is to be expected that advances in leakage technology will improve the sensitivity of leakage detection. Additionally, background leakage depends on the pressure in the system and it is also reduced as pipes are refurbished or replaced.

To calculate the effect of leakage practice for a given water company requires information about:

- number of properties or connections;
- length of mains;
- average zone night pressure;
- annual burst rate.

We have obtained this information from companies' reports to Ofwat and information provided to the Agency. We have used industry standard data on average flow rate from bursts, the number of service pipe bursts, the ratio of reported to unreported bursts, background levels of leakage, and the relationship between pressure and leakage.

A3.4

Assumptions

To calculate the leakage control that could be achieved over the next 25 years, we have made the following assumptions:

A3.4.1 Find-and-fix activities

"Find-and-fix" is the general term for the activities involved in locating and repairing leaks. Some companies have introduced permanent acoustic loggers that sit in the leakage network listening for leaks. They emit signals to a receiver that is mounted in a van that is driven round the network. Over the next decade it should be possible to combine the technologies of acoustic loggers and mobile leak noise correlators that will locate the leak and report it to a control room by telemetry. This could reduce the time taken to find and locate leaks to as little as half a day compared to the present average of around 11 days. As the technology is proven and acoustic loggers are already in place in some companies, it is reasonable to assume that these methods could be widespread over the next 25 years. We have not made any assumptions about increased sensitivity of leakage detection or faster repair methods, although it is likely that these will both improve over time.

A3.4.2 Pressure management

Pressure reduction reduces the rate of leakage. Where pressures are higher than necessary, reducing them is known to be cost-effective. Pressures can be lower in areas that have low relief or where there are few very tall buildings. We have assumed that over time companies can reduce pressures so that their average zone night pressures approach an optimum based on the topography of the company's area. This means, for example, that companies in the north or the west would be expected to have higher pressures than companies in East Anglia. We have assumed that the following average zone night pressures could be achieved by 2025:

- areas of low relief – 30 m;
- areas of mixed relief – 37.5 m;
- areas of high relief – 45 m.

Reducing pressure is also thought to reduce burst frequency, but there is too little information to predict this effect with any certainty.

A3.4.3 Service pipe and mains replacement

We have assumed that replacing pipes and mains reduces background levels of leakage to values that are currently achieved in areas of low leakage. We have assumed that water companies can achieve a rate of replacement of between 1% and 3% in a year. The maximum rate that we have assumed for each company depends on its existing resource position. The present average replacement rate is 1.5% each year.

Our calculated possible leakage rate for each public water supply resource zone is based on modelling the effects of these three changes on present leakage rates. For this we have used the computer model BABE (Bursts And Background Estimation). We have modelled the present leakage rate of each resource zone using current data, and then used our three new assumptions to identify the potential reduction in leakage over the next 25 years.

A3.5

Conclusions

This appendix describes how we have calculated a possible leakage level for each water company and resource zone. By assuming a modest extension of existing good practice, we may assume that achieving this calculated level should not be excessively expensive.

Whether this level of leakage activity is necessary depends on the relative merits of other options. The area of leakage control attracts much attention, and it is to be expected that our results will be refined as the result of further studies over the next few years. The current tripartite leakage study being carried out by Ofwat, DETR and the Agency will help to clarify the potential for progress.

Appendix 4

Appraisal of generic water resources management options

Table A4.1 Sustainability criteria applied to the water resources strategy

A Effective protection of the environment	
Air/soil/noise pollution	The changes in emissions of pollutants to air or land or in noise generation
Waste generation	The amount of waste generated and the amount of waste disposed of in landfills
Biodiversity	The effects of the option on biodiversity
Water quality/pollution	The effects on water quality or the changes in diffuse pollution of surface and ground waters and discharge of pollutants to surface waters.
Cultural and amenity value	The effects on urban and industrial heritage, sites of historic, cultural value and amenity value
Landscape & tree cover	The effects on natural and environmental assets, landscape and tree cover
B Prudent use of natural resources	
Energy consumption	The level of energy consumption, especially from non-renewable sources
Water resources	The effects on water resources/water table
Fisheries/fish stock	The effect on the quality of fisheries and on fish stock
Aggregates & minerals	The level of use of aggregates and minerals especially from primary sources The level and use of any other resources/materials, such as water treatment chemicals
Infrastructure use	How the option maximises the infrastructure use
Greenfield/brownfield site	The effects on the development of brownfield sites/greenfield sites and open spaces in urban areas
C Social progress which recognises the needs of everyone	
Good quality and affordable water & treatment	Any changes in the affordability of good quality water, waste water collection and treatment (will tend to favour lower cost options)
Availability, protection & quality of amenity value	The changes in the availability (access) of leisure facilities, recreation areas, parks, fisheries and other (diverse) uses
	The changes in the quality (range) of leisure facilities, recreation areas, parks, fisheries and other (diverse) uses
Human health and safety	The effects on human health, including perceptions of possible health impacts
	The effects on safety, including perceptions of possible safety issues for households and operational safety issues
Equal opportunities available to individuals	Opportunities available for education about water management (to learn, understand and gain knowledge about water management)
Public perception of quality of life	Opportunities for community involvement and sharing responsibility for water management
	Possible effects on lifestyle, through technological change, impacts on socio-economic status and disruption
D Maintenance of high and stable levels of economic growth and employment	
Construction costs	Impacts on investment (capital) costs
Operation costs	Impacts on operation costs
Income, employment and attractiveness of area	The direct economic benefits (maintenance or net creation of jobs, income generation), indirect economic benefits (wider effects on economy, for example the effect of environmental quality on investment in the area) and infrastructure improvements which attract investors to the area (transport communications, energy supply and environmental infrastructure)
Agency and public sector	Additional costs to the Agency or public sector.

Source - adapted from *Integrated Appraisal of Environment Agency Policies: Version 1.0* Environment Agency, National Centre for Risk Analysis and Options Appraisal.

Table A4.2 **Uncertainty, constraints and opportunity framework: generic options**

Option				Uncertainties					Constraints				Opportunities				
Type		Time to implement [yr]	Renewal period [yr]	Technology and investigation	Promotion time	Construction/implementation time	Resource value	Cost	Policy & legislation	Public & stakeholders	Environment	Energy Use	Flexibility in implementation	Environmental enhancements	Resilience to climate change	Meeting other needs	Amenity and recreation
Resource Development	New reservoir	15-20	100	◐	○	○	◐	◐	◐	●	●	●[1]	○	◐	●	●	●
	Reservoir raising	5-10	100	○	○	○	◐	◐	◐	◐	◐	●[1]	○	◐	●	●	◐
	Winter storage reservoirs (single farm)	1-2	15-30	○	○	○	○	○	○	○	○	○	○	○	●	○	○
	Winter storage reservoirs (farm consortium: 10-15)	3-5	15-30	○	◐	○	○	◐	○	○	○	◐	○	◐	●	○	◐
	Surface water abstraction (unsupported for pws)	1-3	30	○	○	○	◐	○	○	○	◐	◐	◐	○	○	○	○
	Groundwater abstraction or enhancement	1-3	30	○	○	○	◐	◐	○	◐	◐	◐	●	○	◐	○	○
	Desalination	2-5	-	○	◐	○	○	○	◐	◐	●	■	◐	○	●	◐	○
	Wastewater re-use (direct pws)	3-5	30	●	●	○	○	●	●	●	○	◐	●	○	●	○	○
	Wastewater re-use (direct non-pws)	3-5	30	○	○	○	○	○	○	○	○	◐[2]	●	○	●	○	○
	Wastewater re-use (indirect pws)	3-5	30	◐[2]	◐	○	◐	◐	◐	◐	◐	◐[2]	●	◐	◐	◐	○
	Wastewater re-use (indirect non-pws)	3-5	30	○	○	○	○	○	◐	◐	◐	◐[2]	●	◐	◐	◐	○
	Aquifer artificial recharge and recovery	5-10	15-30	●	◐	◐	◐	◐	◐	◐	◐	●	●	○	●	◐	○
	Canal transfer	3-5	30	○	○	○	◐	◐	○	○	◐	◐	◐	○	○	◐	◐
	River transfer	3-5	30	◐	◐	○	◐	○	○	●	●	◐	◐	◐	○	◐	◐
	Pipeline transfer	6-10	30	●	◐	◐	○	◐	◐	●	●	●	○	○	◐	◐	○
	Operational improvements	1-3	30	○	○	○	○	○	○	◐	○	◐	○	○	●	○	○
Demand Management	Improved leakage control	1-5	-	○	○	○	◐	◐	○	○	○	○	●	○	●	○	○
	Rainwater use (new development, non-potable)	1-3	15	◐	◐	○	◐	○	◐	●	○	○	○	○	○	○	◐
	Greywater use (new development, non-potable)	1-3	15	●	■	○	○	○	●	●	○	○	○	○	●	○	○
	Waste minimisation of industrial/commercial	1	-	○	○	○	◐	○	○	◐	○	○	●	○	●	○	○
	White goods subsidies	1-3	10	○	●	○	●	○	◐	◐	○	○	●	○	●	○	○
	Retrofit of toilets to dual flush/ interruptible flush	-	15	◐	◐	○	◐	○	◐	●	◐	○	●	○	●	○	○
	Metering (domestic)	10	10	◐	●	○	●	○	●	●	○	○	●	○	●	○	○
	Tariffs for measured charges	10+	-	●	●	○	●	○	●	●	○	○	●	○	●	○	○

[1] Pumped storage = high, gravity = low [2] Low to Medium ● High ◐ Medium ○ Low

Precipitation	Deposition of moisture including dew, hail, rain, sleet and snow.
Pumped storage reservoir	Surface water storage area where the natural inflow is supplemented by water pumped from a separate source, typically a nearby river.
PWS	Public water supply. Term used to describe the supply of water provided by a water undertaker.
Recharge	Water that percolates downward from the surface into groundwater.
Regulated river	A river where the flow is augmented through the addition of water from another source.
Resource zone	The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall.
RSAP	Restoration of Sustainable Abstraction Programme.
SAC	A Special Area of Conservation is one classified under the EC Habitats Directive and agreed with the EC to contribute to biodiversity by maintaining and restoring habitats and species.
SME	Small and medium – sized enterprises.
Source	A named input to a resource zone. A multiple well/spring source is a named place where water is abstracted from more than one operational well/spring.
SPA	A Special Protection Area is one classified under the EC Wild Birds Directive and agreed with the EC to contribute to biodiversity by maintaining and restoring habitats and species.
SSSI	Site of Special Scientific Interest.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
UKCIP	UK Climate Impacts Programme.
UKWIR	UK Water Industry Research Limited.
Waste minimisation	The reduction of waste by the adoption of more efficient and cleaner technologies.
Water available for use	The value in Ml/d calculated by the deduction from deployable output of allowable outages and planning allowances in a resource zone.
Winter storage reservoir	Reservoirs to store water during the winter months when it is plentiful for re-use during the summer.
Yield	The reliable rate at which water can be drawn from a water resource.

DETR	Department of the Environment, Transport and the Regions.
Drought order	A means whereby water companies and/or the Environment Agency can apply to the Secretary of State or the NAW for the imposition of restrictions in the uses of water and/or which allows for the abstraction of water outside of existing licence conditions.
Effluent	Liquid waste from industrial, agricultural or sewage plants.
EIA	Environmental impact assessment.
Flow regime	The pattern of a river's varying (daily) flow rates.
GATT	General agreement on tariffs and trade.
GDP	Gross domestic product.
Groundwater	Water within the saturated zone of an aquifer.
Habitat	The customary and characteristic dwelling place of a species or community.
Households	Properties (normally occupied) receiving water for domestic purposes which are not factories, offices or commercial premises.
Hydrogeology	The study of the quality, quantity, storage and movement of water in rock and the interaction with geology.
Hydrology	The study of water on and below the Earth's surface.
l/h/d	Litres per head per day.
l/prop/hr/year	Litres per property per hour per year (change in the rate of use).
LEAF	Linking Environment And Farming.
Leakage	The sum of distribution losses and underground supply pipe losses.
LRMC	Long run marginal cost.
MAFF	Ministry of Agriculture, Fisheries and Food.
Main river	The watercourse shown on the statutory "main river maps" held by the Agency and MAFF. The Agency has permissive powers to carry out works of maintenance and improvements on these rivers.
Ml/d	Megalitres per day (one megalitre is equal to one million litres).
NAW	National Assembly for Wales.
NEP	National Environment Programme.
NFU	National Farmers Union.
Non-consumptive use	Use of water where a significant proportion of the water is returned directly and immediately to the source of supply.
NRR	Natural rate of rise.
OFV	Ownership, Frequency and Volume.
Ofwat	Office of Water Services.
PCC	Per capita consumption – (consumption per head of population).
Potable water	Water of a suitable quality for drinking.

Glossary of terms

Term	Definition
Abstraction	The removal of water from any source, either permanently or temporarily.
Abstraction charges	The charges payable to the Environment Agency under the terms of an abstraction licence.
Abstraction licence	The authorisation granted by the Environment Agency to allow the removal of water from a source.
Active leakage control	Water company operating practices of detecting leakage from knowledge of night flows, pressure etc.
AISC	Average incremental social cost.
Aquifer	A geological formation, group of formations or part of a formation that can store and transmit water in significant quantities. An aquifer is *unconfined* where the water table is not covered by a confining layer.
AARR	Aquifer artificial recharge and recovery.
Borehole	Well sunk into a water-bearing rock from which water will be pumped.
Catchment	The area from which precipitation and groundwater will collect and contribute to the flow of a specific river.
CAMS	Catchment Abstraction Management Strategies.
CAP	Common Agricultural Policy.
Conjunctive use	Combined use of different sources of water.
Consumption	Water delivered billed less underground supply pipe losses. Consumption can be split into customer use plus total plumbing losses.
Consumptive use	Use of water where a significant proportion of the water is not returned either directly or indirectly to the source of supply after use.
Demand management	The implementation of policies or measures that serve to control or influence the consumption or waste of water. (This definition can be applied at any point along the chain of supply.)
Deployable output	The output of a commissioned source or group of sources or of bulk supply as constrained by: – environment; – licence, if applicable; – pumping plant and/or well/aquifer properties; – raw water mains and/or aqueducts; – transfer and/or output main; – treatment; – water quality; for specified conditions and demands.

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Appendix 5
Further research and development

The thinking that has gone into developing our strategies has inevitably thrown up a range of issues where we do not currently have enough information or understanding.

Issues include:

- Environmental requirements of plant and animal species – there is scope for further work on the requirements of different species and species assemblages.
- Implementation of recent work on reconciling surface and groundwater resource yields – this would improve future plans.
- Impact of land use changes, including forestry, on water availability and on atmospheric flows.
- The use and economics of introducing drought-tolerant varieties and cropping systems into agriculture.
- Cultivation and land-management techniques that improve the retention of water in soil, modifying catchment response to floods and droughts.
- Impacts of climate change on demand for water – the DETR study (Climate Change and Demand for Water) will develop new methods of assessment, but these will need to be applied across England and Wales.
- Impact of climate change on water availability – improved climate change scenarios and related information should enable more detailed assessments at regional and local level.
- The impact of extreme events on resource availability – further work is essential to consider the security of supply systems.
- The acceptability and effectiveness of customer restrictions – more understanding of the effect of, for example, hosepipe bans on demand is necessary.
- Components of per capita consumption – more work is necessary to understand the drivers of individual components of water use.
- Garden watering – to help predict how and when gardeners will use water.
- Population projections – a source of uncertainty, with different organisations working with different information; a working group on population projections would help the water resources planning process.
- Impact of price and tariffs on domestic and industrial demand – more development work would help our understanding.
- The evaluation of costs and water savings of demand management options.

The Agency will work with others to prioritise and take forward an appropriate programme of research and development.

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