Water resources for the future

A SUMMARY OF THE STRATEGY FOR ANGLIAN REGION

March 2001

ENVIRONMENT AGENCY

Water resources for the future

Water is vital for life

All living things need water to survive. People rely on water not only for drinking and for personal hygiene but also for many other purposes:

- around our homes, for cooking, washing and cleaning;
- in our gardens, to water plants;
- on farms, to water crops and clean equipment, and for animals to drink;
- in offices, schools, universities and hospitals, for cooking and cleaning;
- in commerce and industry, to help with manufacturing.

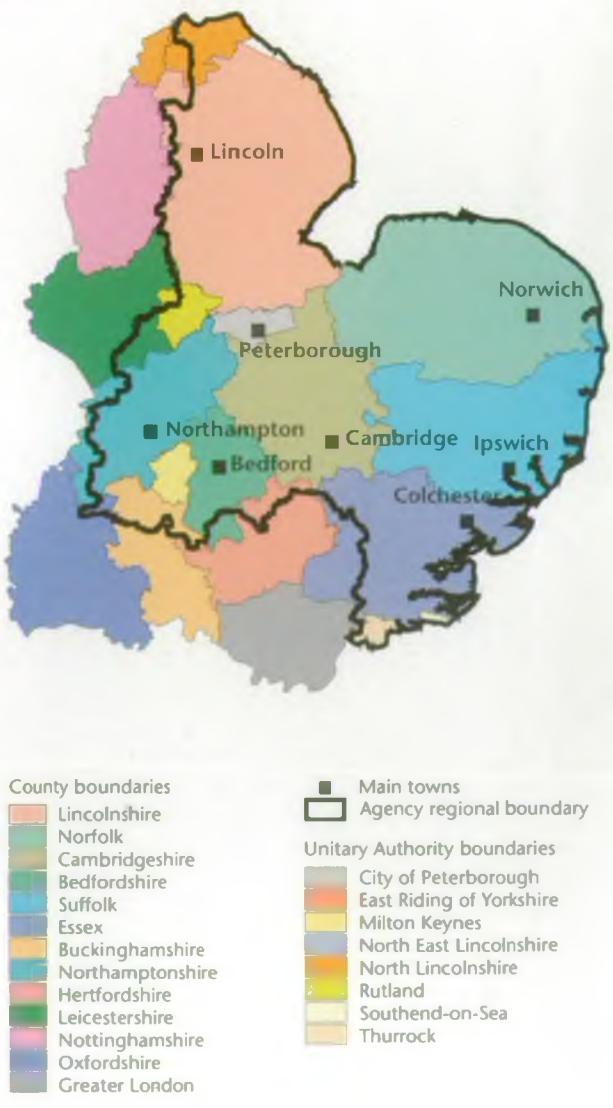
All the water we use is taken from streams, rivers or water-bearing rocks below the ground (aquifers). Water in the environment – in streams, rivers and wetlands – serves many other purposes that we must take into account. It allows plants to grow and keeps fish, insects and mammals healthy. It also gives people pleasure in many ways. We like the appearance of rivers and streams in the landscape, and many of us enjoy fishing, boating, canoeing or just walking by rivers. Our use of water needs to safeguard these benefits.

A water resources strategy for Anglian Region

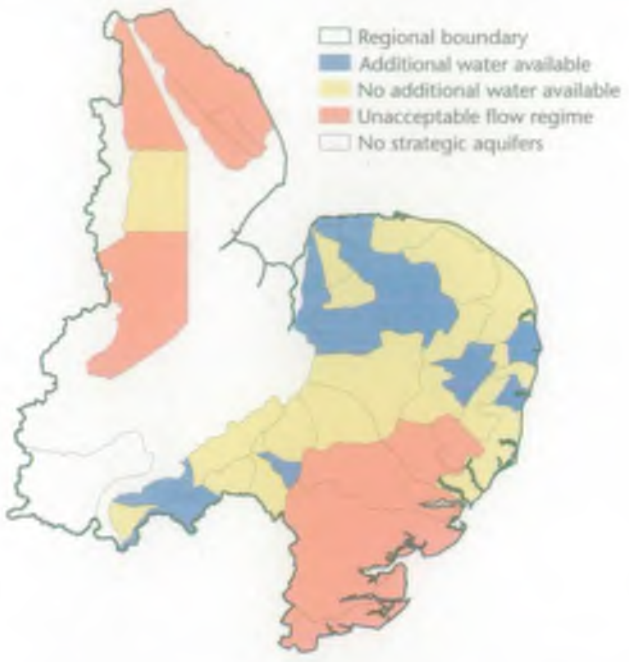
The Government has given the Environment Agency the task of planning our use of water. As part of this process, we have developed a new water resources strategy for our Anglian Region. At the same time we are publishing seven other strategies for the rest of England and Wales, as well as a national strategy providing an overview. This leaflet summarises the strategy for Anglian Region.

The region extends from the Humber estuary to the Thames, as shown in Figure 1. It comprises all catchments draining from the main chalk outcrop of East Anglia and eastwards from the Lincolnshire limestone. Major catchments include the Rivers Ancholme, Witham, Welland, Nene, Great Ouse, Wensum, Waveney, Stour, Blackwater and Chelmer. The region is low-lying and intensively farmed, with a landscape ranging from gentle chalk and limestone ridges to the extensive lowlands of the Fens and the East Anglian coastal estuaries and marshes. The total land area of the region is 27 000 km^2. Our valuable natural environment and high population growth rate mean that the careful management of water resources is essential.

Figure 1 **Anglian Region**



Groundwater resource



This map shows strategic resource availability based on simple water balance calculations for groundwater units. Even if a unit has resources available, each abstraction proposal would be subject to an assessment of local impacts and there are some units where current policy is that no new significant licence application are accepted.

danger of being damaged here, and we must stop taking so much water if we want to restore the environment in such places. There are also areas where we think that there is no damage now, but that no more water should be taken. In the rest of Anglian Region, water may be available. Almost anyone who wants to abstract water needs a licence from the Environment Agency. Before we give a licence, we must be sure that it will not cause damage, and detailed studies are often necessary.

The maps in Figure 2 illustrate the availability of water across Anglian Region. They show that surface water throughout our region is already fully committed to existing abstractions and the environment during the summer, and that no significant additional quantities of water are available then. There may however be a few localised stretches of river where limited amounts of summer surface water are available. Winter surface water is still available over most of our region, apart from some small chalk catchments and coastal streams. Large parts of the region's groundwater resources are broadly in balance, although there are limited areas where some additional groundwater is available. Any new abstractions will be subject to rigorous local assessment.

In most of the fully committed catchments, existing abstractions do not cause widespread environmental problems. However, in the areas coloured red, the combination of licensed surface and groundwater abstractions exceeds the assessed limit. Action to resolve any associated problems may involve changes to both surface and groundwater licences in the longer term.

Future demand for water

The amount of water we need is known as demand. The demand for water will change over the next 25 years, under the differing influences of a variety of factors.

In the home, we each choose how much water we use. We need water for washing, bathing and cooking, to water our gardens, and to wash our cars. Today, on average we each use about 150 litres every day – enough to fill about 15 buckets. Future household water use depends on the choices that we make as individuals and collectively as a society. For example, showering usually uses less water than a bath, but using a power shower for five minutes can use more water than taking a bath. Depending on attitudes, individual household water use could increase or decrease over the next 25 years. In some places, more homes are planned. While individually any new homes built could be more water-efficient, they will add to the total demand for water.

Similar arguments about the effect on demand of differing water use practices apply to industry, commerce and agriculture. Their needs for water are also affected by market considerations such as the price commanded by different product or crop types.

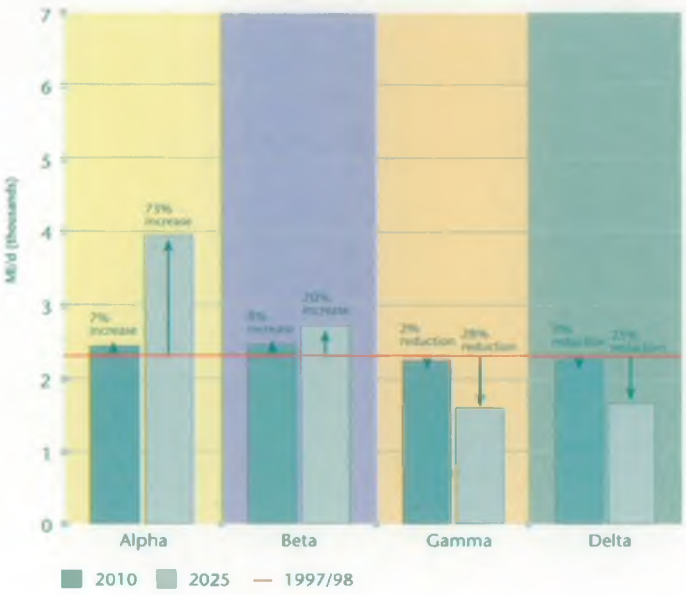
To consider many of these different effects, we have taken a scenario approach to predict future demands. The Government's Foresight framework looks at the different ways that our political and social values could change over time; we have used it to consider a range of possible social and economic changes, and calculated the resulting future demands.

Current and likely future demands in Anglian Region are dominated by public water supply. The rate of growth predicted by government planners for our region is among the fastest in England and Wales, and could lead to 600,000 additional households and an 800,000 increase in population by 2025.

Figure 3 illustrates our demand forecasts for Anglian Region to 2025. The forecasts show that total demand for water could fall or rise over the next 25 years, depending to a great extent on the choices we make.

It is unlikely that the future will follow any one of the scenarios we have used. By showing what could occur under each, we have identified boundary limits to guide our resource planning. Clearly, in the relatively dry climate of Anglian Region, it would be particularly challenging to meet the higher forecasts whilst continuing to safeguard environmental interest adequately.

Figure 3 Total demand by scenario in 2010 and 2025



Climate change

Climate change is of great significance to water resources. Changes to rainfall patterns and amounts could affect how much water is available for people and for the environment. Climate change could also influence people's demand for water. For example, if it becomes hotter, we may wish to water our gardens more.

Present analysis suggests that over the next 25 years, summers could become drier and winters wetter, with more rain in total. Temperatures are likely to increase. Since many questions remain about the effects of climate change, it makes sense to use our existing water resources carefully, and to look for flexible solutions to future demands that can cope with different climatic conditions. This is an area that we will keep under review.

Our strategy for Anglian Region

Our strategy is designed to improve the environment, while allowing enough water for human uses. We have considered its contribution to sustainable development, including social progress that addresses the needs of all, protection of the environment, making wise use of natural resources, and maintenance of high and stable levels of economic growth and employment. Our strategy is flexible and phased, so that we can avoid unnecessary investment while retaining the security of our water supply and improving the water environment.

Our strategy shows that:

- water is a scarce resource in Anglian Region. In many places, further improvements to the water environment are necessary. We believe that this may amount to recovery of current licensed abstractions amounting to some 210 Ml/d. We estimate that some 40 Ml/d of this will be required by 2010 and the remainder as a precautionary estimate by 2025.
- continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 300 Ml/d above present levels. To achieve this we will improve existing schemes and develop new resources;
- efficient use of water is also vital, and 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, whilst continuing to protect vulnerable groups. Further attention to leakage control will also be necessary. Together these measures will meet demands and allow for environmental improvements;
- recommended resource developments include: the raising of Abberton reservoir supported by Ely Ouse transfers, greater use of Rutland Water, enhancements to the Agency's Trent-Witham-Ancholme transfer scheme, some further local use of groundwater and effluent reuse. Detailed assessment of the impacts will be needed, to ensure the environment is protected. Alternative schemes could become necessary.
- agriculture and industry must use available water to best effect. In most agricultural areas, little further summer water is available. Farmers should consider water needs in their choice of crops and we recommend increased winter storage.

We will publish an annual bulletin reporting on progress against this strategy, and review it fully in a few years' time.

How to find out more

You can find more information in the full water resources strategy for Anglian Region, available from our Anglian Region address. Details of our strategies for other regions of England and for Wales can be obtained from regional Environment Agency offices. You can obtain our water resources strategy for the whole of England and Wales from Water Resources, Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD. Further information on all our water resources activities can be found on the Agency's website at **www.environment-agency.gov.uk.**

Contents

Foreword

Water is vital to life – we all use it in our homes and gardens, farming and industry needs it, the wildlife of rivers and wetlands depends on it. Water is a magnet for recreational activity and quiet relaxation, adding value to the quality of life in urban and rural areas. Yet much of the time we take water for granted. It is a renewable resource, dependent on rainfall. Only when water becomes scarce, as it did during the droughts of the 1990s, does everyone realise its importance.

Water is a magnet for recreation and relaxation, adding to the quality of life

The Environment Agency's vision in Anglian Region is for our rivers and wetlands to support a healthy and diverse wildlife that everyone can enjoy, while we have reliable water supplies for use in our homes, industry and agriculture. This strategy sets out how we believe these aims can be achieved. We advocate a dual approach, within which demand management plays an important role alongside the development of some future resources.

We recognise the magnitude of the challenge facing us to achieve this. Our region is the driest part of the country. There are pressures from continued economic growth and new housing developments, irrigation of crops as well as the potential future impacts of climate change. We have a valuable diverse water environment with many national and international conservation sites which need protection and, in some cases, restoration or enhancement. Work is underway already to address these issues, such as the recent relocation of Essex and Suffolk Water's borehole away from Redgrave and Lopham Fen.

This strategy sets out a framework which requires action by many different organisations and individuals to achieve it. Water companies, planning authorities, farmers, environmental organisations and many others all have a part to play. The publication of this strategy is an important step in a continual process, and we look forward to working with others to deliver together the actions required to make our vision a reality.

Andrew Dare
Board Member with responsibility for Anglian Region

ANGLIAN REGION ADDRESSES

REGIONAL OFFICE
Environment Agency
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR
Tel: 01733 371 811
Fax: 01733 231 840

NORTHERN AREA OFFICE
Environment Agency
Waterside House
Waterside North
Lincoln LN2 5HA
Tel: 01522 513 100
Fax: 01522 512 927

CENTRAL AREA OFFICE
Environment Agency
Bromholme Lane
Brampton
Huntingdon
Cambs PE18 4NE
Tel: 01480 414 581
Fax: 01480 413 381

EASTERN AREA OFFICE
Environment Agency
Cobham Road
Ipswich
Suffolk IP3 9JE
Tel: 01473 727 712
Fax: 01473 724 205

www.environment-agency.gov.uk

ENVIRONMENT AGENCY GENERAL ENQUIRY LINE
0845 933 3111

ENVIRONMENT AGENCY FLOODLINE
0845 988 1188

ENVIRONMENT AGENCY EMERGENCY HOTLINE
0800 80 70 60

ENVIRONMENT AGENCY

Planning our use of water

Anglian is the driest region of England and Wales. In an average year, the region receives enough rain to cover its whole area to a depth of nearly 595mm. Some of this rainfall is taken up by trees, crops and other growing plants, and some evaporates. The remainder, known as effective rainfall, amounts to about 1,900 litres each day (about 190 buckets), for every person who lives in the region. Effective rainfall is unevenly spread through the year, with much of it occurring during the winter months. We can't use all this water, because we want to leave enough in our rivers and streams to protect nature and allow us to enjoy our landscape. In a dry year, our use of water can lead to problems. Since every drop of water that humans take comes from our natural environment, we need to plan our use of water to make sure that we have enough for our needs while protecting plants and animals from damage.

Our strategy reflects these issues. It looks 25 years ahead, and considers the many changes that may occur over this time. Our vision is:

Enough water for all human uses with an improved water environment.

The availability of water

Most of the water abstracted in the region is used for public water supply, which accounts for 77 per cent of the annual licensed amount. Agriculture, and in particular spray irrigation, is the second major use. Although it accounts for 10 per cent of total annual licensed abstraction, its impact is heightened because the water is used by plants, and so little or none of it is returned to rivers. In addition, demand is concentrated in the summer months when river flows are at their lowest. Peak day irrigation demands in our region can exceed public supply demand. The total licensed for direct abstraction by industry, the region's other main water user, is similar to that for agriculture.

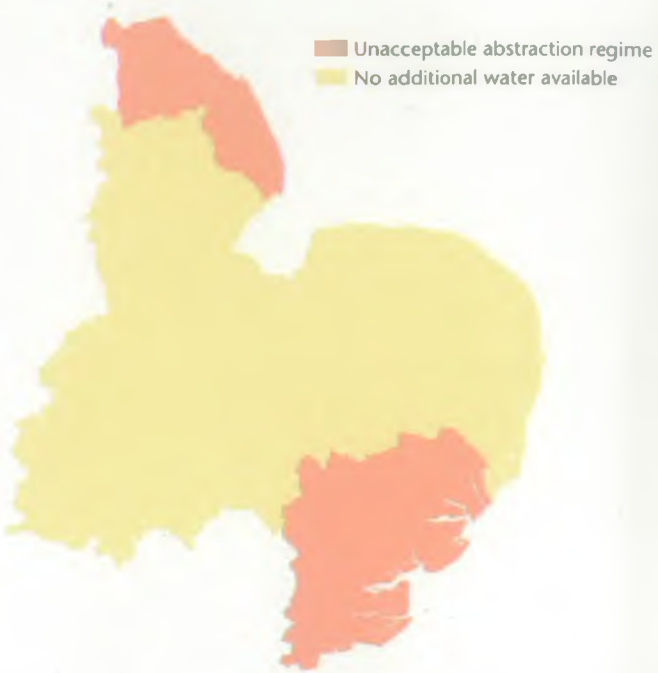
The proportions and total amounts licensed for abstraction have remained fairly constant in the last five years. Actual abstraction quantities for public supply and general industry have also remained fairly stable. Agricultural abstraction amounts are more variable, as they are weather-dependent, with higher abstraction occurring in drought years.

Just over half the region has useable underlying aquifers. Groundwater is an important resource for direct abstraction for local use by farmers and industry, as well as for public water supply. As well as the large public water supply reservoirs such as Rutland Water, there are many smaller farm reservoirs throughout the region, which store water from high-flowing winter rivers for irrigation use in the summer.

In some places we think that too much water is taken already. The environment may already be damaged or is in

Figure 2 Resource availability

Summer surface water



This map shows, at a coarse resolution, where there are resource sustainability issues. It is derived from the underlying groundwater situation which has particular influence on summer river flows.

Winter surface water

This map shows, at a coarse resolution, where there may be reliability problems in particularly dry years. Licence applications may still be considered in these areas, but will be subject to assessment of local impacts and licences if granted may be less reliable. There tends to be more resource available at the lower ends of the catchments.

4

5

6

7

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 it is essential that there is a secure framework for the management of water to protect 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 water resources strategy for the Agency's Anglian Region. The region stretches from the Humber to the Thames, and is the driest part of the country. This strategy forms part of a suite of eight strategies that are consolidated in the Agency's national strategy for England and Wales. This strategy looks some 25 years ahead. It considers the needs for water both of the environment and of society, examining the uncertainties about future water demand and availability.

This strategy is part of a framework of integrated water resources planning carried out by the Agency and 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 Anglian Region, water is a scarce resource. In many places, further improvements to the water environment are necessary. We believe that this may amount to recovery of current licensed abstractions amounting to some 210 Ml/d (Megalitres per day). We estimate that some 40 Ml/d of this quantity will be required by 2010 and the remainder as a precautionary estimate by 2025.

- Continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 300 Ml/d above present levels by the improvement of existing schemes and the development of some 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, in the context of the Government's broader social and environmental policies including the protection of vulnerable households. Further attention to leakage-control will also be necessary. Together these measures will meet demands and allow for environmental improvements.

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

- 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.

- 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 present resources, identifying areas where abstraction needs to be reduced to correct damage and improve the environment. In the Anglian Region, there are large areas where no further water is available during summer and some areas where damage is already occurring. We estimate that, in total, further reductions in abstraction beyond those already planned will amount to up to 210 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 show different ways in which our society could change. We have used these scenarios to consider how the demand for water could develop.

The scenarios show that demand for water is highly dependent on choices made by society and systems of government. In two of the scenarios, total demand for water rises over the next 25 years, while in the other two it falls. Changes are driven by economic pressures, people's desire to use water in different ways, and technological innovation.

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. In Wales and the southern half of England, including Anglian Region, summers will be drier, while winters will be wetter throughout England and Wales.

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 we propose. However, there is at present insufficient information about extreme events to allow detailed assessment of the probability of longer or more intense droughts. This is an area we will keep under review. Adaptation strategies are the key to facing climate change. Our preferred options are flexible, allowing for the wide range of possibilities suggested by present climate change scenarios. Anglian Region is also particularly vulnerable to the effects of sea level rise on coastal environments. We have, therefore, considered the water resources actions needed to maintain wetland biodiversity.

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.

Conclusions

We recommend the development of new resources that total some 300 Ml/d by 2025. Around 210 Ml/d of this total is for the replacement of water sources considered to have an unacceptable impact on the environment. Much of this can be achieved by the enhancement of existing resource systems, such as extension of Wing Water treatment works at Rutland Water and improvements to the capability of the Agency's Trent-Witham-Ancholme transfer scheme. However, we recommend some new large schemes. The most significant of these is the raising of Abberton reservoir in Essex, supported by increased transfer of water from the Ely Ouse. We also recommend minor local development of groundwater and further re-use of effluent.

Careful investigation is needed to ensure that the environmental impacts of all resource development schemes are acceptable. Some resource developments may be constrained by environmental impacts. We, therefore, 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.

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 (English Nature and the Environment Agency, 1999). These and other abstraction related concerns will be prioritised and monitored through our Restoring Sustainable Abstraction Programme within the context of our future Catchment Abstraction Management Strategies process. The Agency will complete the review of consents required under the Habitats Directive and ensure actions are taken to modify or revoke abstraction licences where necessary according to nationally agreed timescales. Water companies should complete the investigations and actions required of them under the National Environment Programme for 34 sites in the region.

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. The achievements of recent years have been driven by Government and regulatory attention. Continued regulation in this area is essential.

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 needs active promotion and the co-operation of many different groups. We feel this is best achieved by an independent organisation specifically funded for this purpose. Such an 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. Stakeholders in Anglian Region have already indicated widespread support for this concept. There are many initiatives in the region to promote water efficiency. We will continue to work with partners, seeking the benefits of integrated waste minimisation for industry and agriculture in particular. We will strive to achieve best practice standards in our own offices and facilities. We will also work with planners, developers and the water companies to ensure that the large amount of new housing development predicted in the region makes efficient use of our scarce resources.

Commerce and industry could save water and money by taking simple actions. However, uptake has been disappointing. It is clear that further work is needed to facilitate the uptake of these actions.

Agriculture should also work to make effective use of existing supplies, while considering opportunities to work with others to develop new sources of water. Trading of licences may prove fruitful, particularly in Fenland where we have already facilitated some trading activity. 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 problem and subsequently 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 takes into account 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 report annually on progress against this strategy. We plan to review the strategy completely in a few years.

This strategy provides an appropriate framework for long-term water resources planning in Anglian Region and contributes directly to the Agency's water resources strategy for England and Wales.

Actions

Our recommended actions are summarised in Chapter 8 and in Table 8.1 and reproduced below. In many cases, we seek co-operation across sectors and between different organisations. We will work to facilitate such activities. More details for Anglian Region can be found in Chapter 7 of this strategy.

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.	✓							

1 Introduction

1.1 Need for a strategy

Water is essential for all natural life and human use. We use it in our homes and gardens, in manufacturing industry and in agriculture. 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 Anglian Region.

The Anglian Region extends from the Humber estuary to the Thames as shown on Figure 1.1. It comprises all catchments draining from the main chalk outcrop of East Anglia and eastwards from the Lincolnshire Limestone. Major catchments include the rivers Ancholme, Witham, Welland, Nene, Great Ouse, Wensum, Waveney, Stour, Blackwater and Chelmer. The region is low lying and intensively farmed with a landscape ranging from the gentle chalk and limestone ridges to the extensive lowlands of the Fens and East Anglian coastal estuaries and marshes. The total land area of the region is 27,000 km^2.

Anglian is the driest region of England and Wales. Our valuable natural environment and high population growth rate make the careful management of water resources essential.

The Environment Agency is the statutory body with a duty for strategic water resources planning in England and Wales.

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 framework for its management.

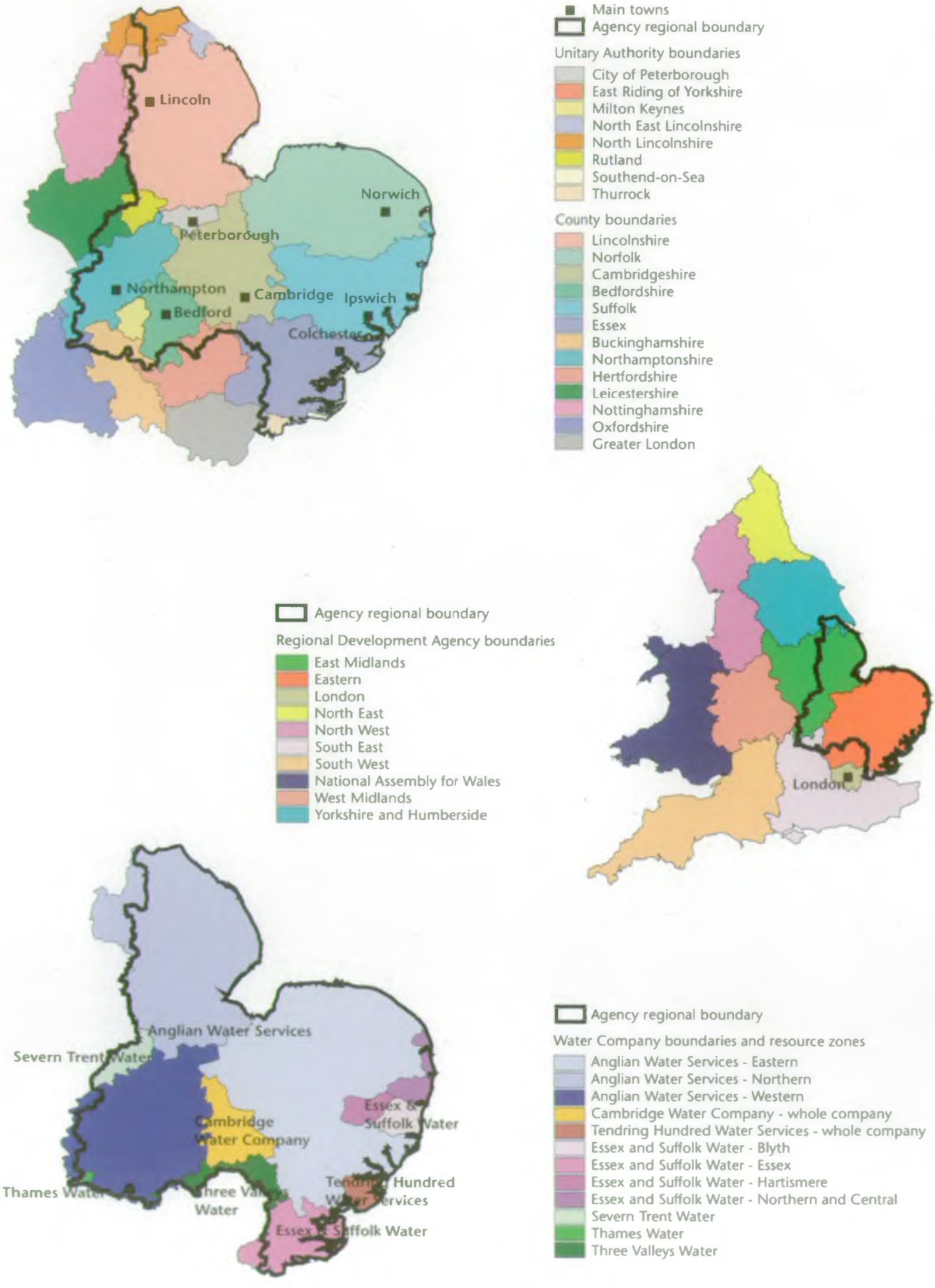
This is the first regional water resources strategy to be developed for the Anglian Region by the Agency since its inception. It looks 25 years ahead and:

- considers water resources needs for the next generation;
- builds on a long tradition of water resources planning, including the previous regional water resources strategy published by the National Rivers Authority in 1994;
- adopts a flexible approach which reflects the many uncertainties facing 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).

This strategy forms part of a suite of documents representing the water resources strategy for England and Wales. The national water resources 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 water resources strategy for the Anglian 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.

Figure 1.1 Anglian region



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.

This 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 above 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 or specific role in water resources. We believe that our strategy will be more successful if it meets the needs and concerns of all those involved in the process. For this reason, in October 1999 we published a national consultation document ("Water resources for the future – values and challenges", Environment Agency 1999a) seeking the views of groups and individuals on a variety of issues.

In view of the high level of interest and concern for water resources issues in this region, we also put a significant effort into regional consultation processes. To accompany the national document we produced a supplement for the Anglian Region (Consultation Document for the Environment Agency Water Resources Strategies, the Anglian Region Perspective) in November 1999. Widely distributed within the region, this gave regional background information to help people think further about the local implications of the issues. We met with many groups of stakeholders and individuals, as well as consulting widely with Agency regional committees and Area Environment Groups

A highly successful stakeholder conference was held within the East of England Region to discuss ways to move towards a common understanding on water resources in the region. It was sponsored by the Sustainable Development Round Table (SDRT) for the East of England and organised by a water resources sub-group which included the Agency. About 70 people attended, representing a wide range of stakeholders. For many it was the first time they had met such a diverse range of sectoral interests in water resources. The Agency gathered useful feedback in terms of perceptions, information needs and ideas for resolution of some of the issues in the region. This has helped inform our thinking for the regional strategy, as well as providing a basis for a wider on-going dialogue amongst stakeholders in the region. A more long-term goal, which came out of the process, was the need to improve sharing of information to gain understanding

of each other's different and often complex areas of expertise.

A national consultation response document was produced in September 2000, summarising the replies received (Environment Agency, 2000c). Of the 270 responses, 61 were from the Anglian Region. A further 13 regional responses were received after the main national consultation deadline closed. We have been able to take these into account regionally. We had a good spread of responses across the main sectors with interests in water in the Anglian Region.

Responses from consultees broadly reflected many of the national trends, but also highlighted some strong local concerns amongst stakeholders. These included the threats of climate change, the relative priority of agricultural demands compared to environmental protection and other demands, the implications of housing and population growth and the limitations of a "first come first served" licensing system when resources are stretched.

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

- The importance of water efficiency and demand management across all sectors to make best use of our existing resources, with some expressing a view that this region should take a leading role nationally. There was also widespread support for metering with appropriate customer safeguards.
- An expectation that demand management alone will not be sufficient to manage all future needs plus support for some form of twin-track approach to demand management and resource development, although details differed.
- Additional winter storage, especially for agriculture, is seen as a sensible response to the predicted impacts of climate change. However, concerns were expressed about costs, the need to consider environmental impacts and local authority planning considerations.
- A widespread desire for better understanding of environmental water needs; although there were differing perspectives on how to manage the continued uncertainties in this area. Environmental organisations favoured greater precaution for the environment whilst abstractors saw time-limited licences and monitoring as a solution. The value of consensus-based approaches and consultation was often flagged as a positive way forward for all.

Divergent views were particularly evident on:

- Whether water resources should be a constraint within the development planning system, and if so to what extent. There was, however, general support for closer liaison between planners, Environment Agency and water companies to anticipate future problems and to seek their resolution.
- The extent of perceived need for additional transfers of water within and from outside the region, and the merits of a national grid.

We have tried to take these views and many other details into account as we have formulated 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 Anglian Region to look for ways of reconciling the differences to achieve mutual gain.

We were delighted by the quality of responses and the effort made by regional consultees to give us their views. Consultation does not end with the publication of our strategies. The published documents are part of an on-going 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 Regional Water Resources Manager at our Peterborough address, or E-Mail: anglian.water.resources@environment-agency.gov.uk.

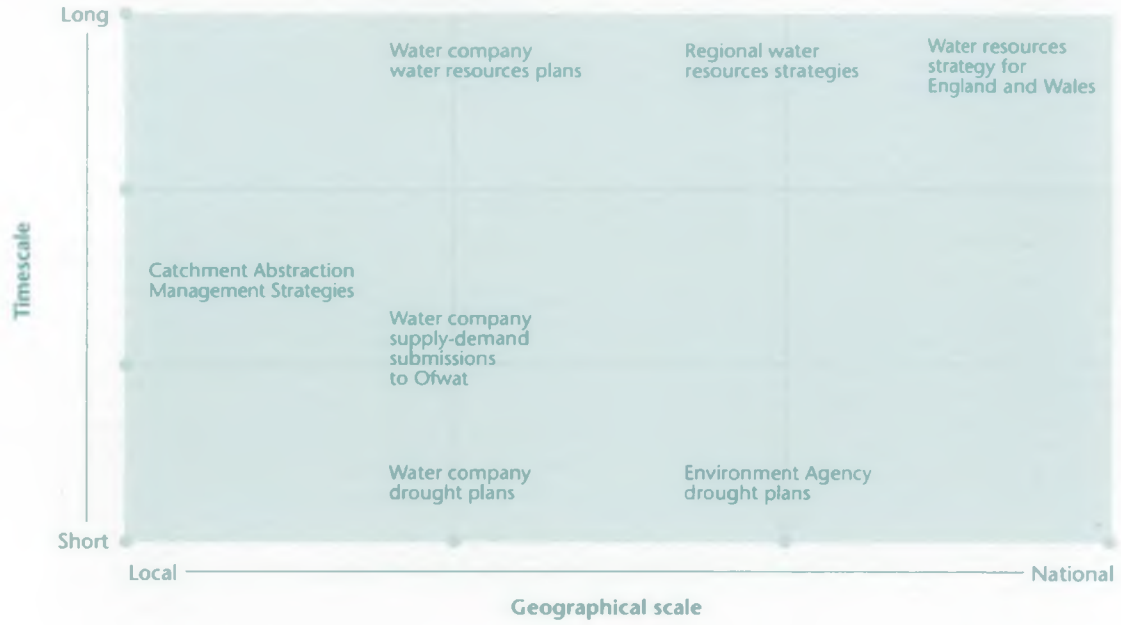
1.4

Links with other water resource planning initiatives

The Agency's water resources strategies are part of a framework of integrated water resources planning carried out by both the Agency and water companies. These cover different timescales and different areas (Figure 1.2).

This strategy looks 10 to 25 years ahead, and covers Anglian Region. It deals with all aspects of water resources management, including public water supply. This is always prominent in 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

Figure 1.2 Scales of water resources planning activities



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. Rather we seek to provide a way forward that ensures that decisions meet the wider objectives of society as a whole and any statutory obligations. 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 framework for water resources management and we set out the principles that underpin the strategy (Chapter 2). We summarise the current state of water resources (Chapter 3) and the pressures that we expect to develop on water resources in the future (Chapter 4). We move on to quantify these pressures (Chapter 5). We describe the options that could be used to meet these pressures, discuss the tools that have been used to assess these options and describe how we have used the outcome of this assessment to build the strategy (Chapter 6). Our results and conclusions are presented in Chapter 7, while Chapter 8 sets out the actions and recommendations that are needed to deliver the strategy. A glossary of terms, references and appendices of supporting information are included at the end.

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 this strategy.

2.1 Institutional and regulatory framework

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

2.1.1 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;
- navigation on some rivers.

The management of abstraction to fulfil our duties is achieved 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 and industry, commerce and those who abstract for amenity, sports or leisure uses. With a few exceptions, any organisation or individual wanting 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 its functions, and to have regard to the economic and social well-being of rural communities.

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 (LEAPs) which set out an integrated framework for sustainable management of the environment at a catchment level;

- 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 Anglian Region;
- a national water resources strategy, setting out the Agency's vision for the long-term management of water resources throughout England and Wales.

We also have an important role in the application of European legislation, such as the Habitats Directive and Water Framework Directive.

2.1.2 UK Government

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.

2.1.3 Water companies

Public water supply in England and Wales is provided by private water companies. The Environment Agency regulates their water abstractions and effluent discharges. The Agency is under a duty 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 Anglian Region are Anglian Water, Cambridge Water, Essex and Suffolk Water, Tendring Hundred Water and Three Valleys Water.

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;
- 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 his Office of Water Services (Ofwat). The Director General reviews water company prices to customers in his 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 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

Local authorities 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 rural parts of East Anglia, especially in Norfolk.

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 for East Anglia and for the South East of England. Similar issues have also been raised and discussed at county structure plan level within the region.

The increased emphasis on regionalism has meant that the Agency's Anglian Region has major links with the East of England Region, East Midlands Region (via our Midlands Region) and the South East Region (via our Thames Region). This includes interests in economic

strategy and the forthcoming sustainability frameworks. We also have an on-going role in the water resources sub-group linked to the East of England Sustainable Development Round Table (SDRT). This group includes representatives from all the key sectors with an interest in water resources. It has a remit on behalf of the SDRT to support its work in promoting the sustainable use of water resources in the East of England.

We anticipate a need to work increasingly closely with planning authorities and water companies to ensure that the water resources implications of new developments in the region are understood and managed sustainably. This not only covers the impact on water resources of new housing, but also mineral winning activities that de-water and affect local rivers and streams.

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 the benefit of customers through greater efficiencies, lower prices, innovation and better services. The Government clearly states 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 accountability for promoting water efficiency, currently a duty of water undertakers, could 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.

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 affecting 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, specifically, social values and 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.

This chapter has set out the framework within which our strategy has been developed. In the next chapter we look at the present state of water resources.

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.

Much of the region is low lying with slow flowing rivers and many wetlands

Anglian Region's water environment has developed from the combined influences of the natural hydrological cycle, and human intervention. Major features are:

- twenty percent of the region lies below sea level, including the extensive low-lying area of the Fens with slow flowing or ponded rivers and extensive washlands. The area is artificially drained and managed as highly productive irrigated farmland. It also contains large sites that have international conservation value for their wildlife and habitats, such as the Ouse and Nene Washes;
- chalk springs and streams stretching from Humberside to Hertfordshire, including the SSSI rivers of the Wensum and the Nar. These support great biodiversity as well as providing a major source of water for public supplies in the region;
- a large proportion of the country's groundwater-fed wetlands are found in Cambridgeshire, Norfolk and Suffolk (including the Broads, which form Britain's only lowland national park);
- coastal marshes and estuaries, many of which are international bird sites;
- many of the major reservoirs, such as Rutland Water and Abberton Reservoir, support internationally important bird populations.

The general features of the region are shown in Figure 3.1, and the important water dependent conservation sites are shown in Figure 3.2.

3.1 The water resource

Water is a renewable but finite resource; the amount that is available depends on the rainfall each year. The region's rainfall is fairly evenly spread throughout the year. A significant proportion of rainfall is evaporated or used by plants, particularly in spring and summer when temperatures are highest. This means that useful or effective rainfall is far less. In Anglian Region annual average rainfall is 595 mm, compared with a national average for England and Wales of 897 mm. Effective rainfall in Anglian Region is only a quarter of average rainfall at 147 mm. Long dry summers during which evaporation exceeds rainfall are a normal part of the climate in the region. Figures 3.3, 3.4 and 3.5 illustrate these features.

Rivers, groundwater and wetlands

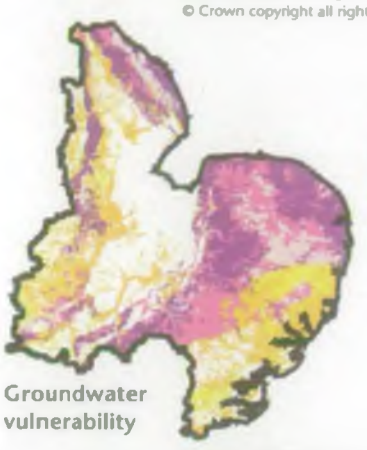
On reaching the ground, rainfall that is not evaporated or used by plants finds its way to the rivers and ultimately the sea. Some water reaches rivers quickly whilst the rest is slowed down by infiltrating into soils and rocks, or by being stored in lakes and reservoirs. The soil water store tends to dry out in summer: it evaporates and is used by growing plants. In winter it refills. Where there are suitable rocks (known as aquifers) underneath, they can store large amounts of water in pores and cracks. These usually start to refill

Aquifers

Based on British Geological Survey data
© Crown copyright all rights reserved

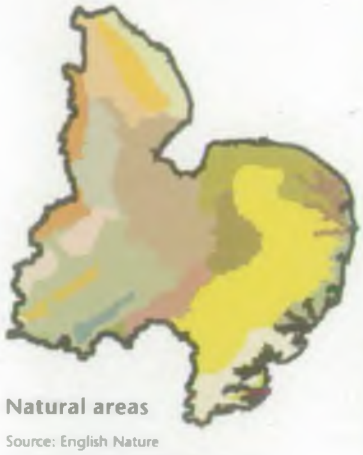
Topography

Note: Height is in metres above ordnance datum Newlyn
Source: Ordnance Survey
© Crown copyright all rights reserved



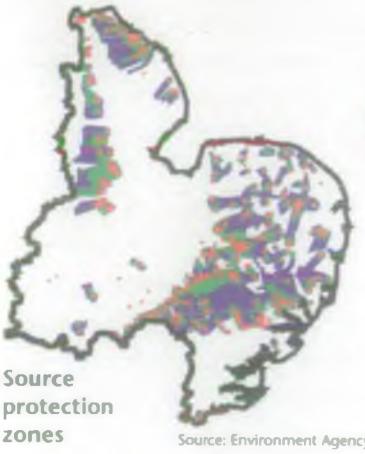
Groundwater vulnerability

Source: various Environment Agency and National Rivers Authority publications



Natural areas

Source: English Nature
© Crown copyright all rights reserved



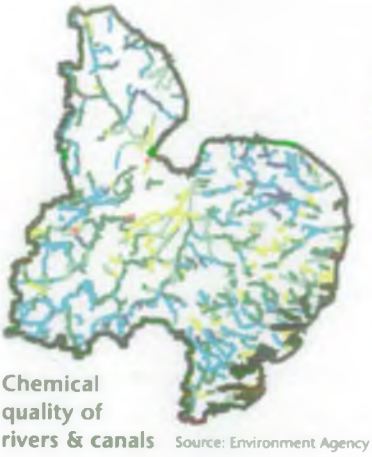
Source protection zones

Source: Environment Agency database 2000

Note:
Fluvial Flooding is based on a 1 in 100yr return period
Tidal flooding is based on a 1 in 200yr return period

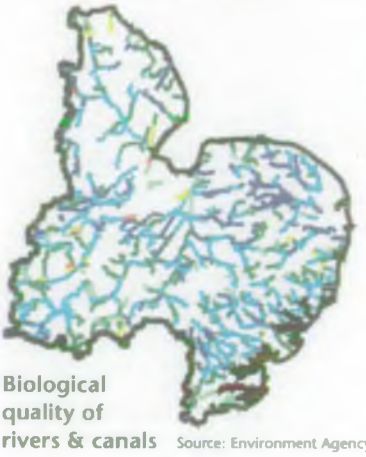
Floodplain

Source: Environment Agency database 2000



Chemical quality of rivers & canals

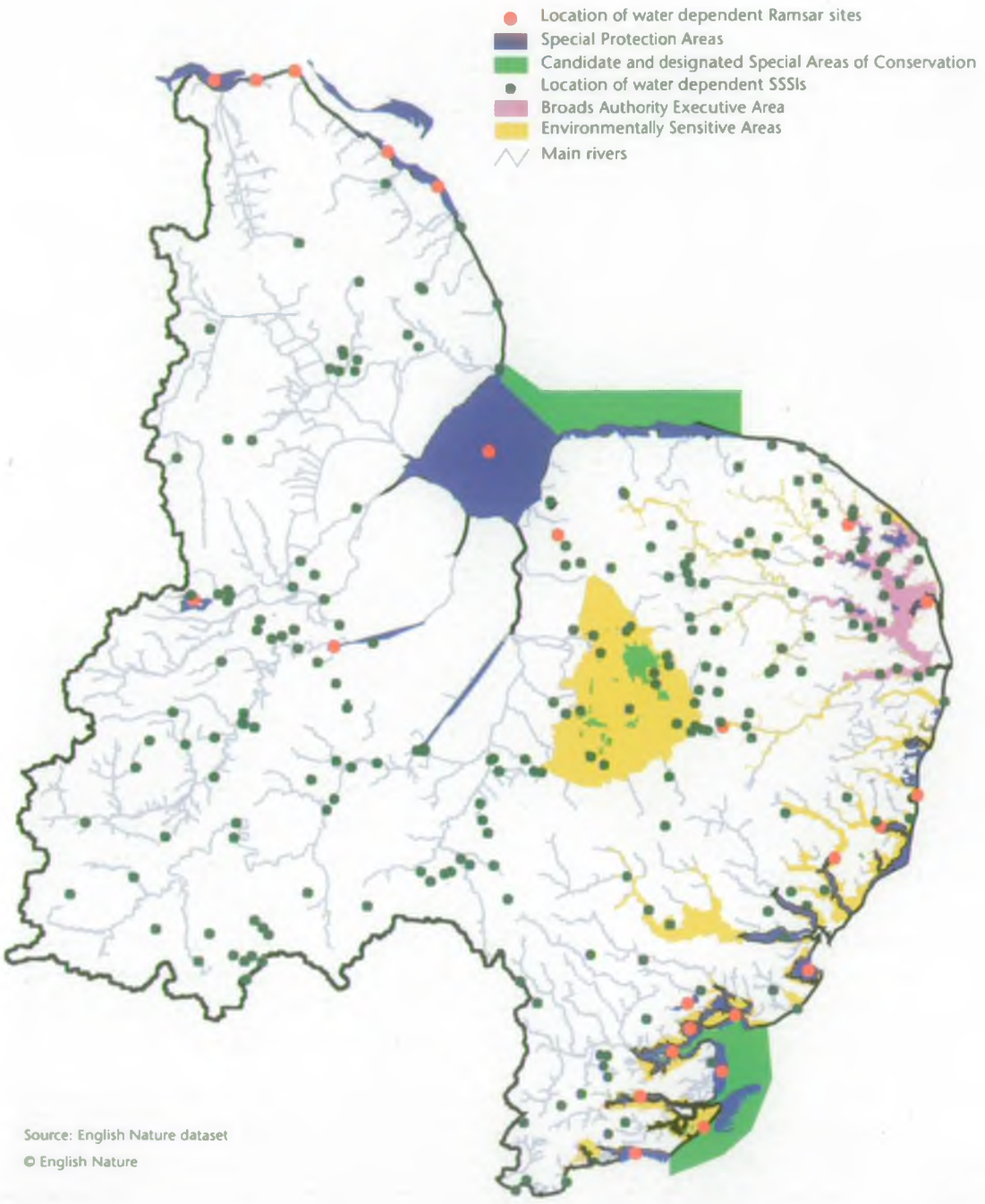
Source: Environment Agency database 1998



Biological quality of rivers & canals

Source: Environment Agency database 1998

Figure 3.2 Water dependent conservation sites



Source: English Nature dataset
© English Nature

only when the soil water store is full. Where this groundwater reaches the surface it may emerge as springs or form wetlands. Often, these springs and wetlands are the starting points of rivers. Their contribution keeps rivers and streams flowing during dry periods. They also form important water supplies, particularly for private domestic sources, and many are of historical and religious importance.

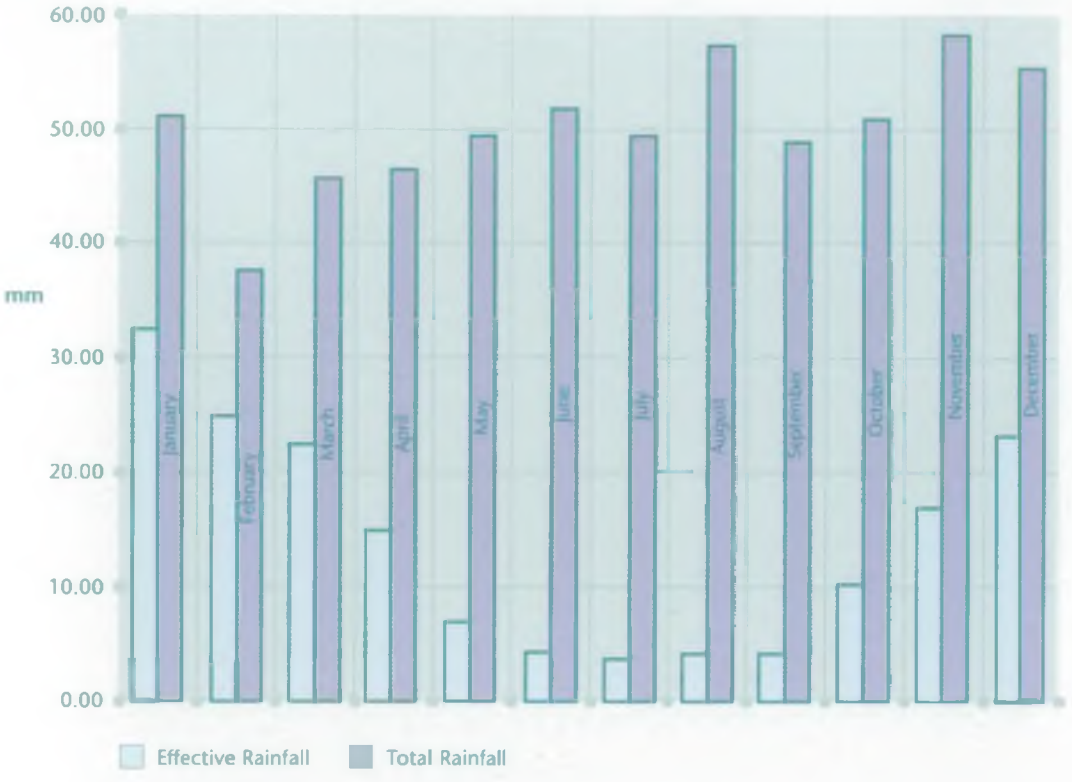
The main aquifers in Anglian Region are: the Chalk underlying large parts of the east, limestones in the west and sandstones in parts of the centre and east as shown on Figure 3.1. There are other minor aquifers, which can be significant locally.

The Environment Agency devotes considerable effort to measuring the various components of the hydrological cycle, with an extensive network in Anglian Region of:

- 1,229 rain-gauges
- 869 river flow/level gauges
- 1,872 boreholes monitoring groundwater levels.

Surface and groundwater quality is also monitored through an extensive network.

Figure 3.3 Average monthly rainfall



Source: 1961-1990 MORECS data supplied by the Meteorological Office

Drought

Rainfall varies from year to year with dry spells and wetter intervals. Hot dry summers are often memorable as serious droughts - such as 1976 and 1995. However, longer periods of low rainfall and dry winters can place equal or greater strain on Anglian Region's water resources, as happened in 1989-1992. Figure 3.6 shows how droughts are a regular feature of our climate.

Droughts are natural phenomena caused by long periods of low rainfall. During such periods the effective rainfall in a year may be halved due to lack of rainfall, higher plant use and evaporation. Dry periods may continue over several years, creating a cumulative deficit in water resources, particularly in groundwater. Major droughts have occurred in Anglian Region in 1899-1902, 1920, 1933-34, 1961-64, 1971-73, 1975-76, 1989-92 and 1995-97.

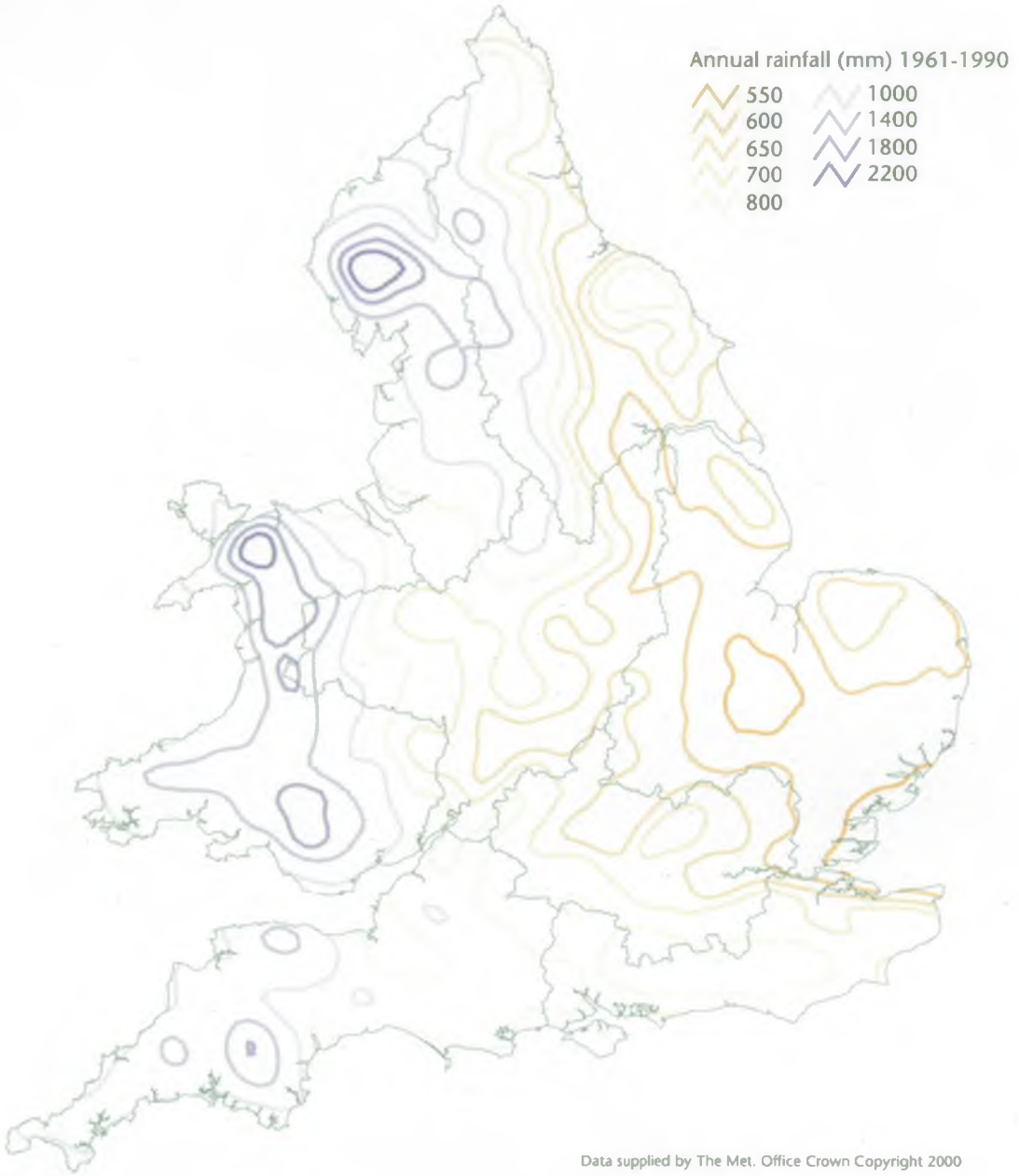
These extended dry periods affect many rivers. Groundwater and wetlands maintain river flows long after the last rain has fallen. When these supplies are not replenished, wetlands dry up and river flows drop to very low levels. Low river flows affect water quality through higher temperatures, less dilution of effluent and lower oxygen levels. They expose areas of the river channel, such as fish spawning grounds, that lead to their damage or disruption. Droughts often lead to water supply difficulties, both in terms of water available for abstraction and peak demands on distribution and treatment systems. They also greatly increase the need for crop irrigation.

The return of rainfall following a dry period is not the end of a drought. Dry soils soak up the rain so that it may take many weeks before a sustained rise in groundwater and river levels is seen.

The sequence of droughts in the 1990s focused attention on the management of water resources during extreme conditions. The Agency has developed its own regional drought plans, and water companies have also produced drought plans that show how they will monitor conditions and respond to differing types of drought.

Although England and Wales are perceived as wet, we also have a high population density. The result is that for each person, on average, there is relatively little water. The regional and international context is given in Table 3.1 and shows that within England and Wales Anglian Region is second lowest to Thames Region in terms of annual average water availability per person.

Figure 3.4 **Annual average precipitation**



Data supplied by The Met. Office Crown Copyright 2000

3.2

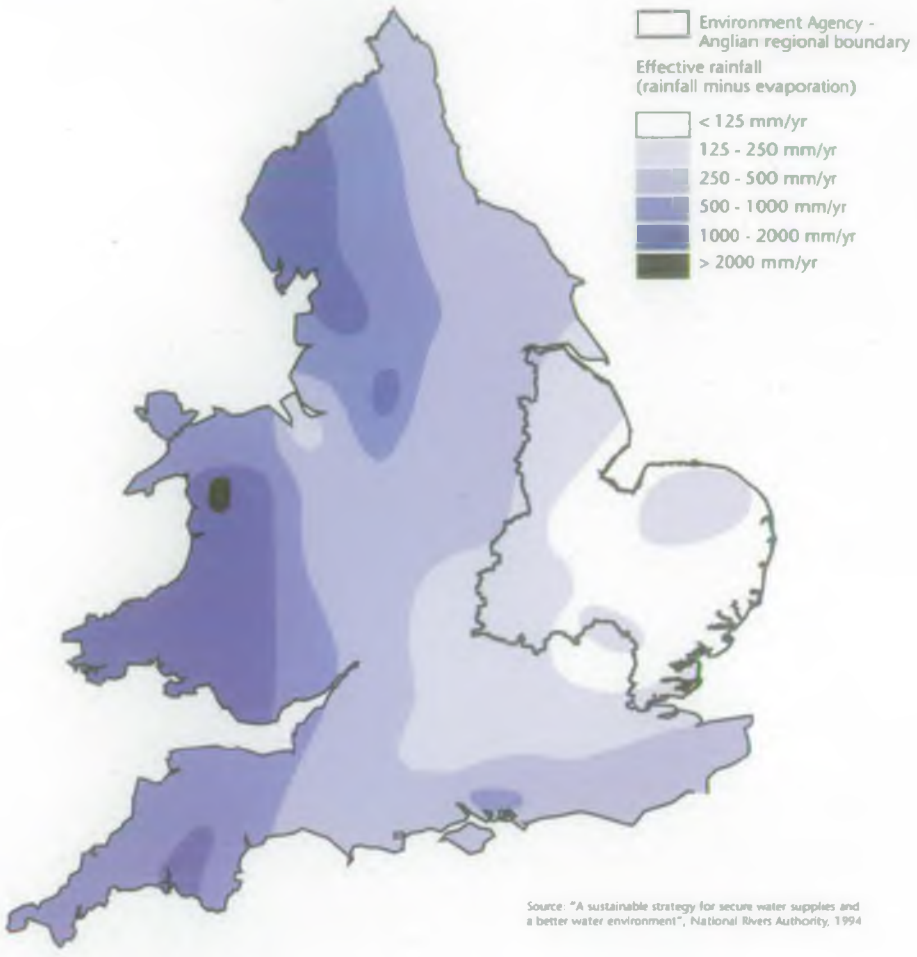
Distributing water

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 by water companies and distribution to industrial and domestic customers. In many parts of England and Wales local sources are insufficient, or provide inadequate security of supply in dry spells. This has led to the development of a wide variety of public water supply systems. Most are based on conjunctive use of abstractions from different types of resources. Water from reservoirs, direct abstractions from rivers and groundwater can be used at different times to give greater reliability. Larger systems often involve transfer of water, either by pipeline or aqueduct or within rivers and canals. The Agency itself also operates major surface water transfer schemes and groundwater river support schemes in Anglian Region as part of its duties to redistribute and augment supplies of water.

Figure 3.5 **Average annual effective rainfall**



Source: "A sustainable strategy for secure water supplies and a better water environment", National Rivers Authority, 1994

Figure 3.6 **Droughts and wet periods**

Source: Environment Agency rain gauge database

Note: This graph was produced by calculating the cumulative difference between rainfall and potential evapotranspiration for that year and all preceding years until a change between surplus and deficit is reached. For clarity all non-cumulative totals in the range -100 to +100mm have been removed.

Table 3.1 **International comparisons of water resources**

	Annual internal renewable water resources		Annual abstraction 1997			Sectoral abstraction (%)		
	Total (cubic km)	Per capita (cubic metres)	Total (cubic km)	Percentage of water resources	Per capita (cubic metres)	Domestic	Industrial	Agricultural*
England & Wales	68.17	1334.13	15.26	22.00	299.00	41	45	14
Regions								
Anglian	4.14	691.22	0.95	23.00	158.00	78	13	9
Midlands	6.12	726.62	2.36	39.00	280.00	34	64	2
North East	9.33	1299.30	1.32	14.00	183.00	63	23	15
North West	10.97	1643.03	1.02	9.00	153.00	54	38	8
Southern	3.73	921.38	1.03	27.00	253.00	50	7	44
South West	11.17	2739.69	2.06	18.00	506.00	19	31	50
Thames	3.09	265.59	1.82	59.00	157.00	87	6	8
Environment Agency Wales	19.61	6419.47	4.70	24.00	1538.00	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.

*Agriculture includes fish farming

The role of Internal Drainage Boards (IDBs) in managing extensive low lying areas of farmland is a particular feature of Anglian Region. The IDBs' primary function is to provide land drainage. However, IDBs now have a water level management role in legislation. Transfer of water from the main rivers during most summers to support water levels in the low lying drains for irrigation and other needs has also become a major role in recent years.

The region's main water resources are shown on Figure 3.7. This shows 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.

Just over half of the region is underlain by useable aquifers and groundwater is an important resource for direct abstraction for local use by farmers and industry, as well as public supply. In addition to the large public supply reservoirs, there are many smaller farm storage reservoirs throughout the region which store water from high winter river flows for summer irrigation use.

This network of storage and transfers has evolved in line with rising water demand over the last century. It proved largely robust during the severe droughts of the 1990s, although some limitations were imposed on water use. Some of the water companies imposed hosepipe bans and the Agency set extensive spray irrigation restrictions.

The water companies' supply boundaries and resource zones are shown on Figure 1.1 and public water supply sources in the region are summarised in Table 3.2.

The relative importance of groundwater and surface water sources varies between companies and zones. The range extends from Cambridge Water Company, which obtains all its supplies from groundwater, to Anglian Water's Western zone that is almost entirely supplied by the large integrated reservoir network known as Ruthamford (composed of Rutland, Grafham and Pitsford reservoirs). Overall, 40 per cent of the region's public water supplies are provided from groundwater, mainly from the chalk and limestone aquifers, and 60 per cent from surface water.

The reservoirs mostly rely on refill by pumping from the main rivers during winter when flows are higher. Abstractions at the direct river intakes are supported by natural baseflows from the groundwater and, in some locations, are supplemented by transfers or returning effluents. In most cases the water companies operate their direct river intakes in combination with groundwater boreholes or other sources that provide an alternative reliable source when river flows are low.

Re-use of water is also an important element in the region's resources. Approximately half of the water abstracted for use is subsequently returned to inland waters as treated effluent, where it supports summer river flows and their abstractions. Some rivers and streams that previously would have dried out during summer now have reliable flows as a result. An example is the Willow Brook near Corby. Treatment standards are set to ensure suitable quality of discharges, and a major programme of investment in treatment works is scheduled to continue to raise standards. Permissions have recently been granted to allow Essex & Suffolk Water to redirect Chelmsford effluents into the river Chelmer upstream of the company's abstraction points. This has been subject to a thorough appraisal of both environmental and public health aspects and will increase the resources available for public supply in one of the driest parts of the region.

3.2.2 Leakage

Over the last 10 years there has been a significant change 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 3.3). Current targets are set by Ofwat 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

Figure 3.7 **Major elements of regional water resources**

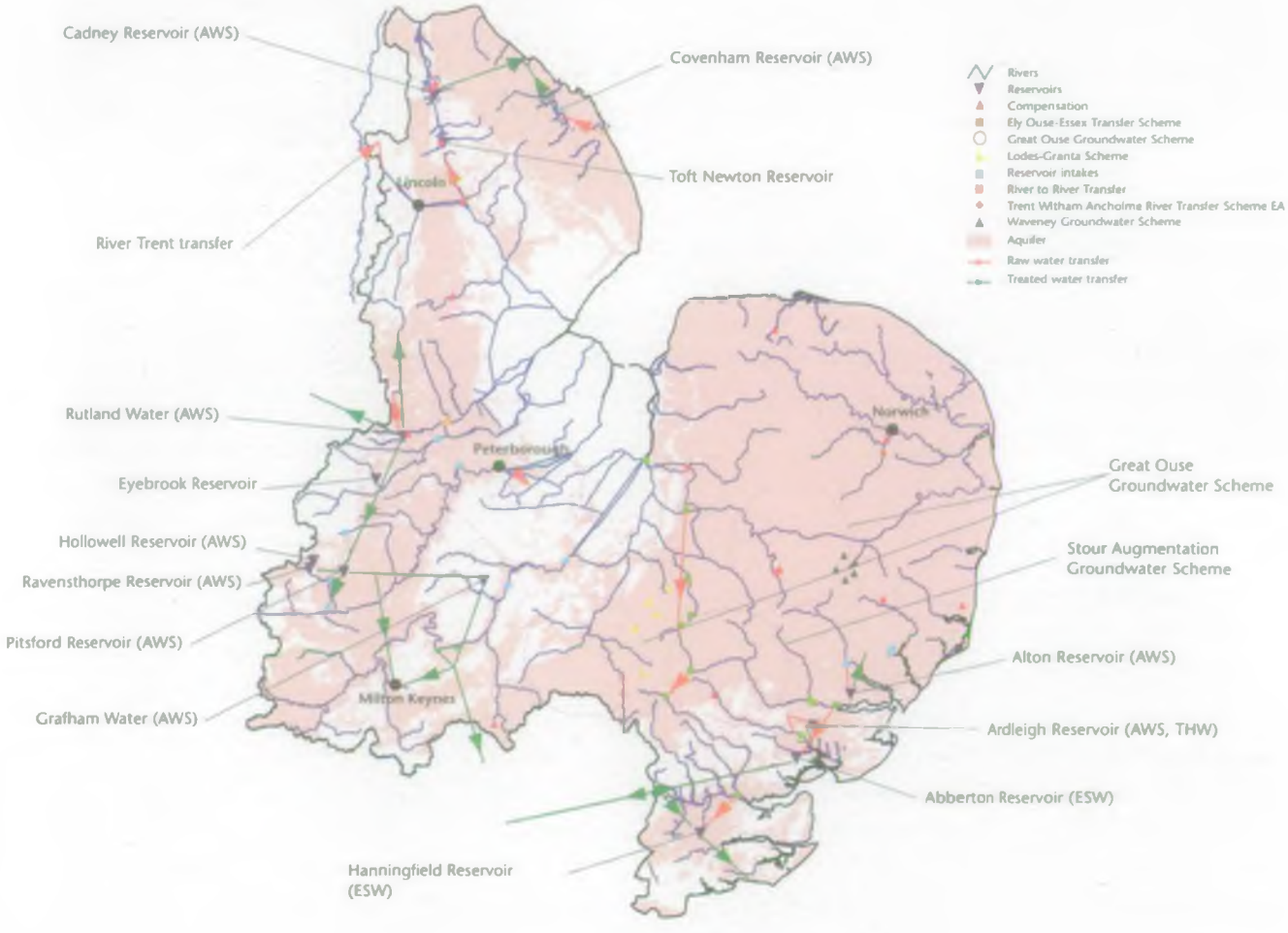


Table 3.2 **Summary of public water supply sources**

Company/Zone	Source	Reservoir Storage Vol. (Mm³)	Deployable Output (Ml/d)	Outage (Ml/d)	WAFU (Ml/d)	Comments
Anglian Water Services						
Northern	Covenham Reservoir	10.7	59	Total resource zone outage 10Ml/d	Total resource zone WAFU *459.5 Ml/d	
	Saltersford		22.3			
	Elsham (potable)		30			
	Elsham (non-potable)		50.6			
	Groundwater sources		301.1			
Western	Ravensthorpe & Hollowell	3.6	7.0	Total resource zone outage 30Ml/d	Total resource zone WAFU - *413 Ml/d	Includes 18 Ml/d allocation for export to Severn Trent Water and 91 Ml/d export to Three Valleys Water.
	Rutland	117	220			
	Grafham	56	252			
	Pitsford	16	38.5			
	Foxcote	0.6	0			
	Clapham		16			
	Groundwater sources		34.1			
Eastern	Alton	9.5	31	Total resource zone outage 30Ml/d	Total resource zone WAFU - *471.5 Ml/d	AWS share of Ardleigh Reservoir. Includes 3 Ml/d allocation for import from Essex and Suffolk Water.
	Ardleigh	2.2	11			
	Costessey/Heigham		44.2			
	Marham		20.9			
	Stoke Ferry		16			
	Groundwater sources		366.6			
AWS TOTAL		**215.6**	**1520**	**70**	***1344**	***WAFU for 00/01**

Company/Zone	Source	Reservoir Storage Vol. (Mm³)	Deployable Output (Ml/d)	Outage (Ml/d)	WAFU (Ml/d)	Comments
Essex & Suffolk Water						
Essex	Abberton	25.0	342.6	Total resource zone outage 18.5 Ml/d	Total resource zone WAFU 430.1 Ml/d*[2]	*[1]Includes +91 Ml/d transfer from TWUL at Chigwell and -1.5 Ml/d sustainability reduction.
	Hanningfield	26.1				
	River Blackwater & Chelmer					
	River Stour					
	Denver variation					
	Roman River					
	Groundwater sources		16.5			
Suffolk	Belaugh intake		17.8	Total outage of all Suffolk resource zones 4.0 Ml/d	Total WAFU of all Suffolk resource zones 97.6 Ml/d	
	Horning intake		-			
	Ormesby Broad		8.59			
	Waveney Intake		20.55			
	Lound		8.09			
	Groundwater sources		46.59			
ESW TOTAL		**51.1**	**550.22*[1]**	**22.5**	**527.7**	

Company/Zone	Source	Reservoir Storage Vol. (Mm³)	Deployable Output (Ml/d)	Outage (Ml/d)	WAFU (Ml/d)	Comments
Cambridge Water Company						
Company wide	Groundwater sources		106.2	15.6	92.1	DO for 2000/01
CWC Total		**0**	**106.2**	**15.6**	**92.1**	
Tendring Hundred Water Services						
Company wide	Ardleigh Reservoir	2.4	9.55	Total resource zone outage 1.55 Ml/d	Total resource zone WAFU -38 Ml/d	DO for 2000/01. THWS share of Ardleigh Reservoir
	Groundwater sources		30			
THWS Total		**2.4**	**39.55**	**1.55**	**38**	
Three Valleys Water Services			N/A	N/A	N/A	TVWS have some groundwater abstractions in Anglian Region but their main operations lie in Thames Region

Table 3.2 **Summary of public water supply sources** *continued*

Company/Zone	Source	Reservoir Storage Vol. (Mm^3)	Deployable Output (Ml/d)	Outage (Ml/d)	WAFU (Ml/d)	Comments
Region Wide Summary						
Surface water sources	Reservoirs, river intakes		60% (1315 Ml/d total)	109.7	2001.8	
Groundwater sources	Boreholes (mainly in the Chalk and Limestone)		40% (901.1 Ml/d total)			

Note: WAFU = Water Available For Use

Agency and Ofwat project has been instigated to explore possible future approaches to leakage target setting.

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 do not vary greatly across the region, although there are some localised differences. Leakage is affected by differences in the length of pipe in rural areas, high water pressures in hilly areas and the age of the system. 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. Some features of the region, notably its flat topography, make leakage management easier. The leakage performance of Anglian Region's water companies continues to compare favourably with companies in neighbouring regions and the national average.

In 1998/1999, leakage accounted for approximately 17.5 per cent 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 that moving it can consume much energy. The flat terrain of Anglian Region means that few transfers or reservoir refills can be achieved by the use of gravity alone.

Anglian Region has an extensive network of transfers of varying size and type. Significant examples include:

Surface water transfers:

- A major transfer of water into the region from the River Trent via the Agency's Trent-Witham-Ancholme scheme in Lincolnshire;
- Significant transfers within the region, the largest being the Agency's Ely Ouse to Essex scheme

Pumped storage schemes and strategic distribution networks:

- Anglian Water's Ruthamford system based on Rutland, Grafham and Pitsford Reservoirs;
- Essex and Suffolk Water's Essex system based on Hanningfield and Abberton Reservoirs

Agency groundwater to river support schemes, which are operated to maintain river flows during dry periods:

- Great Ouse groundwater scheme;
- Waveney groundwater scheme;
- Stour augmentation groundwater scheme

Bulk transfers between water companies:

- Water is imported into the region as a treated bulk supply of water from Thames Utilities to Essex & Suffolk Water at Chigwell in Essex;
- Bulk supplies to Three Valleys Water and to Severn-Trent Water from Anglian Water's Ruthamford system.

Table 3.3 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

3.3

Uses of abstracted water

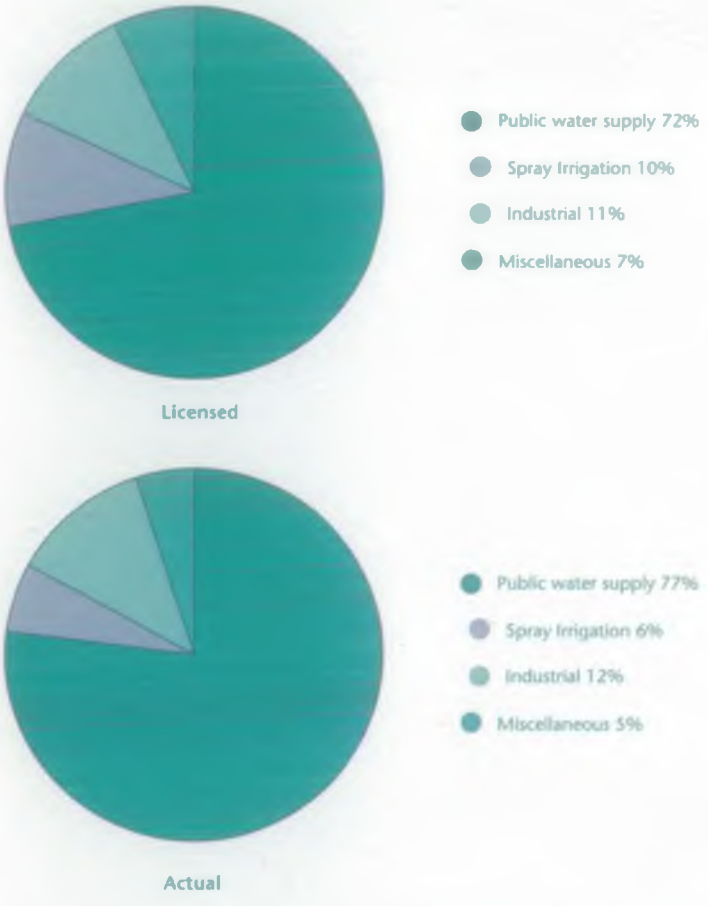
Humans take water for many different uses. An understanding of existing water use is essential in helping to develop our view of the scale and scope of future changes.

Figure 3.8 breaks down the quantities licensed for abstraction and actual amounts taken from fresh water sources into the main categories of use in the region. Figure 3.9 shows the breakdown of public water supply.

The largest use of water in the region is for public supply, accounting for 72 per cent of total annual licensed abstraction. Agriculture, and in particular spray irrigation, is the second major use, accounting for 10 per cent of total annual licensed abstraction. The impact of agricultural use is heightened because the water is used by plants for growth and evaporation, and so, unlike public water supply, little or none of the water is returned to river flow. In addition, demand is concentrated in the summer months when river flows are typically at their lowest. Peak day irrigation demands in the region can exceed public supply demand. Industry is the other main user, with licensed abstraction at a similar level to agriculture.

The proportions and total amounts of abstraction licensed have remained fairly constant in the last five years. Actual abstraction quantities for public supply

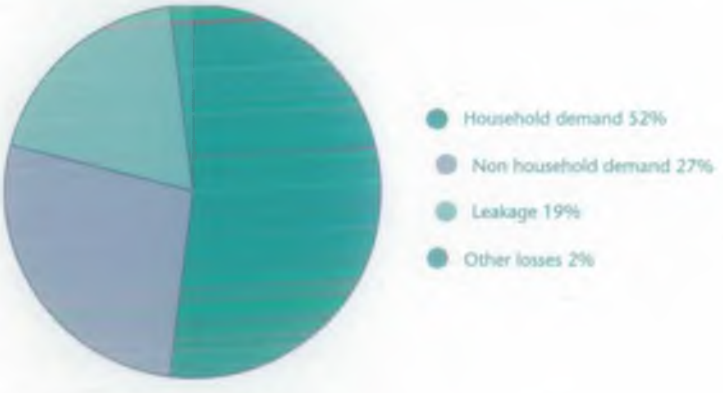
Figure 3.8 **Licensed and actual abstraction of water by main categories of use in Anglian Region**



Source: 1998 data from Environment Agency licence database (excludes surface water tidal abstractions)

Note: Actual abstraction in 1998 was 60% of licensed total.

Figure 3.9 **Public water supply components of demand in Anglian Region**



Source: Environment Agency Demand Management Centre data for 1997/98

and general industry have also remained fairly stable, whilst the amount used by agriculture is more variable, depending on the weather which results in higher abstraction during drought years.

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.

Figure 3.10 1997/98 per capita consumption of water

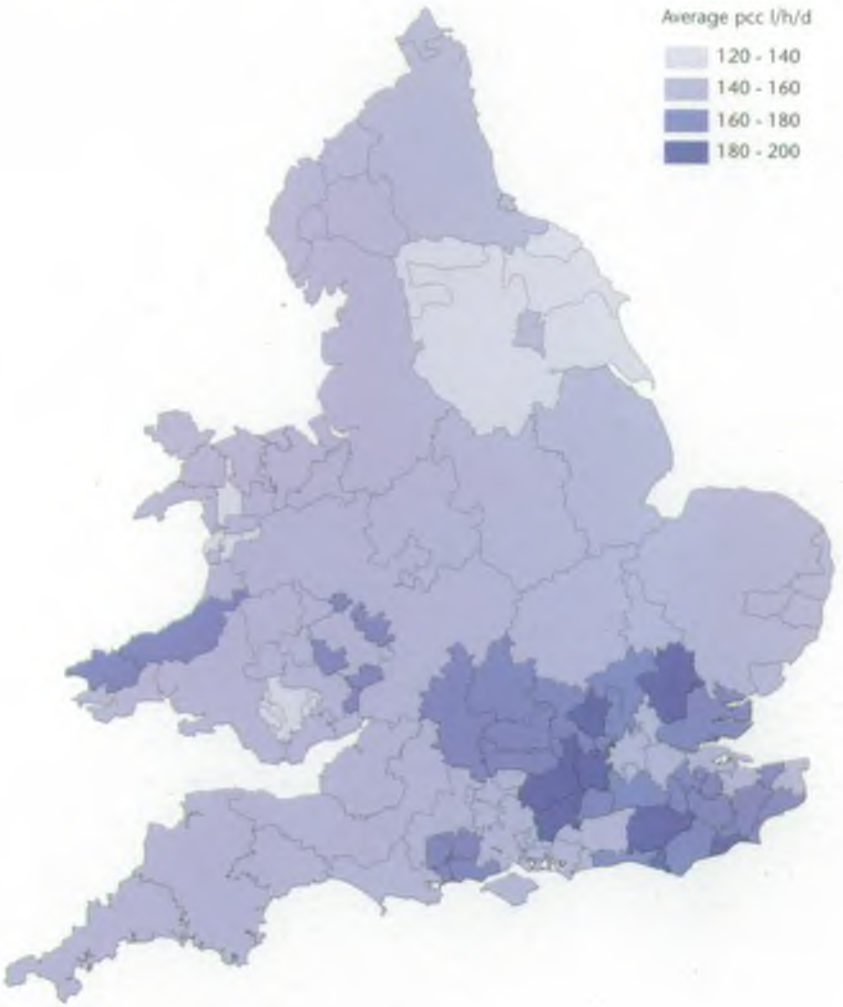
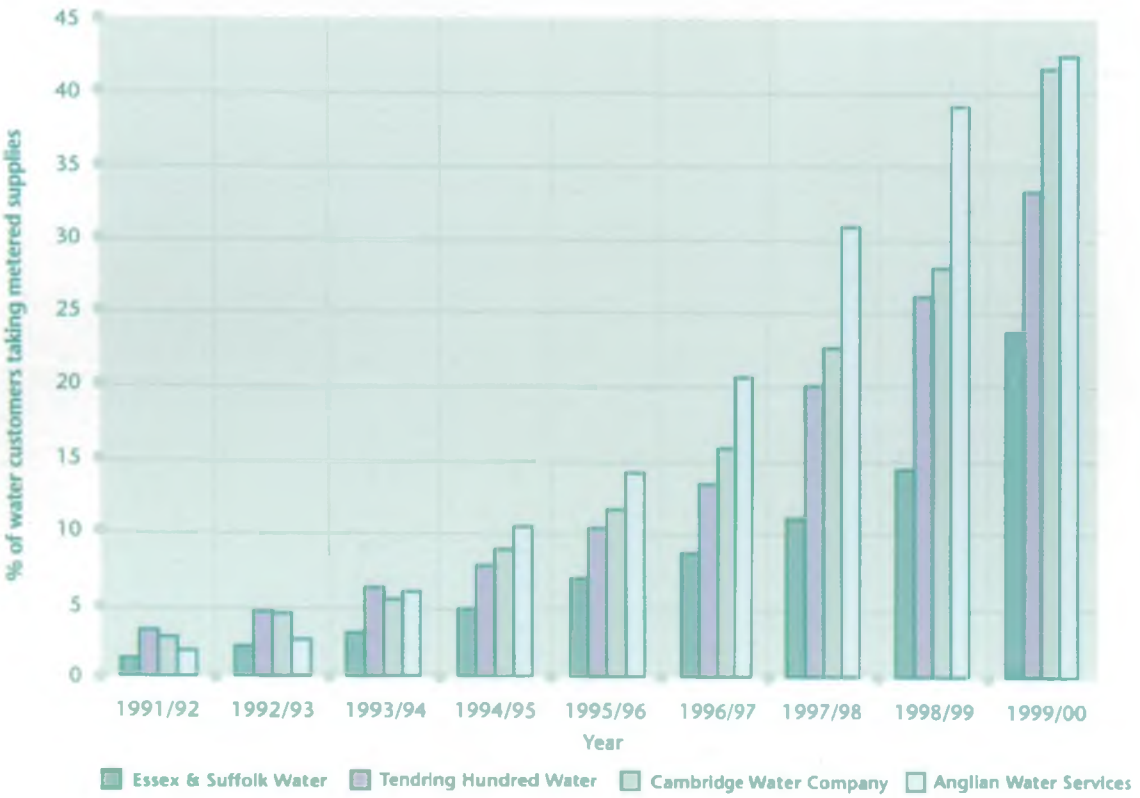


Figure 3.11 Recent trends in household metering



Source: Various OFWAT reports and Environment Agency database.

3.3.1 Household water use

Household use is the largest single component of public supply demand in the region, accounting for roughly two thirds after leakage and other minor losses are subtracted. Average per capita use of water by customers in Anglian Region ranges from about 120 to 160 litres per person per day, compared to a national average of 150 litres per person per day. Comparisons with the rest of England and Wales are shown in Figure 3.10.

On average we each use 120-160 litres of water a day in our homes and gardens

Personal or per capita use of water varies between measured and unmeasured household customers, and is influenced by many factors, such as household size and type, appliances owned, efficiency of the appliances and choice of bath or shower. Recent trends in per capita use have been complicated by the influence of drought years on outdoor use for garden watering, and the rapid installation of water meters within the region as shown in Figure 3.11. A higher proportion of domestic customers are metered than in any other part of the country. Over 40 per cent of Anglian Water and Cambridge Water customers are metered.

Customer attitudes have also evolved, following privatisation of the water industry in 1989. There is generally less acceptance of the imposition of hosepipe bans than previously. On the other hand, there is recognition both by customers and other stakeholders that East Anglia is a dry region and that demand management should have an important role here.

The study of domestic consumption is complex. Much useful work has been done in recent years by the water companies in the region to improve understanding of domestic water use, such as Anglian Water's Survey of Domestic Consumption. However, the Agency believes there is more still to be learned, which could then be used to better predict and influence future demand trends.

Private domestic supplies are important in rural parts of East Anglia, particularly Norfolk, where they form the only viable source of water. Most of the water is returned close to the point of abstraction after use, often through soakaways, with the rest consumed.

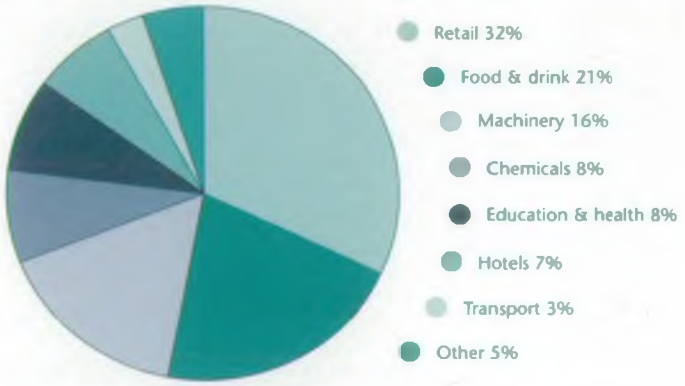
3.3.2 Industry

About two thirds of industrial demand in the region is met by provision of water through the public supply system. The remaining one third is met by industries taking water directly from rivers or groundwater under abstraction licences granted by the Agency. Where industry requires water of high quality, chalk groundwater is favoured. Alternatively, for industry, public water supply represents a more costly source of high quality water. River water is more usually abstracted for cooling or lower quality washing requirements.

Industrial use in the region includes a wide range of industrial and commercial enterprise. Demand is very closely linked to the economic trends in the region and reflects the main economic sectors and their state of buoyancy. Heavy industry is concentrated to the extreme north and south of the region on Humberside and Thameside. Elsewhere, important sectors are food and drink processing, chemicals, light engineering and commerce. Demands have generally declined in recent years, reflecting structural changes in the national and regional economy away from manufacturing, with particular dips during economic recession. There have also been positive drives for water efficiency in business, linked to a range of waste minimisation programmes that have helped reduce demands. Figure 3.12 shows the main categories of industrial water use in the region.

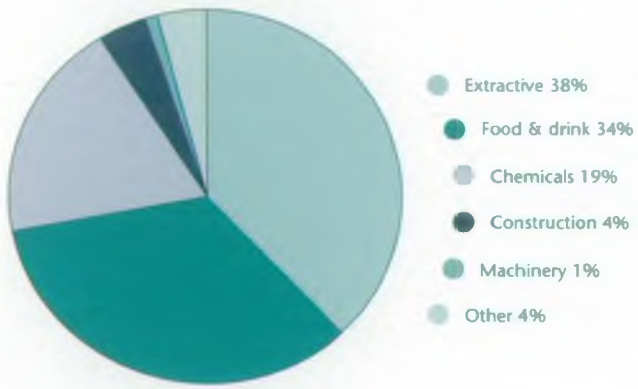
Industry on the Humber is a large user of water

Figure 3.12 Estimated use of public water supply by industry in Anglian Region



Source: Environment Agency research. "Other" includes Utilities, Paper, Metals, Minerals.

Licensed direct abstraction of water by industry in Anglian Region



Source: 1998 data from Environment Agency database. "Other" includes Paper, Metals, Textiles.

NOTE:- Licensed industrial use by direct abstraction was similar to public water supply industrial use in 1998.

The largest direct industrial water use in Anglian Region is the mineral extraction industry. The main activities are de-watering operations (mostly exempt from abstraction licensing) and washing of sands and gravels. These are largely non-consumptive uses, with much of the water pumped being returned to rivers or soakaways. Other major direct industrial sectors in the region are food and drink processing and chemicals.

3.3.3 Agriculture

Agriculture is a key water user in Anglian Region, accounting for half of the national demand for spray irrigation. General agriculture uses minor quantities of water by comparison, but nonetheless is important to many individual farms, particularly for pig rearing. Trickle irrigation is not currently regulated by the Agency and does not account for large quantities of water. It is however of local importance to fruit farmers, particularly in parts of Norfolk and Essex.

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. In some places, peak day spray irrigation demand in the region can exceed that for public water supplies. The demand for water for irrigation is concentrated in summer months and periods of exceptionally low rainfall, thus placing severe stress on ground and surface water sources at a time of the year when flows are at their lowest.

Figure 3.13 shows the current breakdown of irrigated areas and irrigation demand between crops in the region. The bulk of irrigation water is used for maincrop potatoes that, together with early potatoes, account for over half the total irrigation demand. The other large volume uses are for field vegetables and sugar beet. These are crops with significant yield and crop quality benefits from irrigation. Irrigation is a vital element of total crop management, ensuring that farmers meet the

Spray irrigation is a highly consumptive use of water concentrated in the summer months

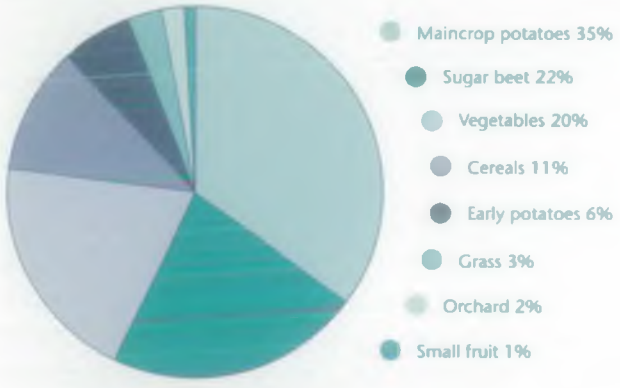
crop quality criteria set down by their supermarket and food processing customers. An unreliable abstraction supply can have a significant impact on the quality and yield of the crop, with farmers potentially incurring a significant reduction in crop value. Although this has a direct impact on the economic viability of the individual farm, the implications are more far reaching, with indirect impacts on rural employment and the national balance of trade.

About 40 per cent of spray irrigation demand in the region is met from groundwater sources which are particularly important in Norfolk and Suffolk. Direct surface water accounts for another 40 per cent, and winter storage reservoirs provide the remaining 20 per cent. The proportion of water provided by winter storage reservoirs grew rapidly during the last decade. This trend has developed in response to:

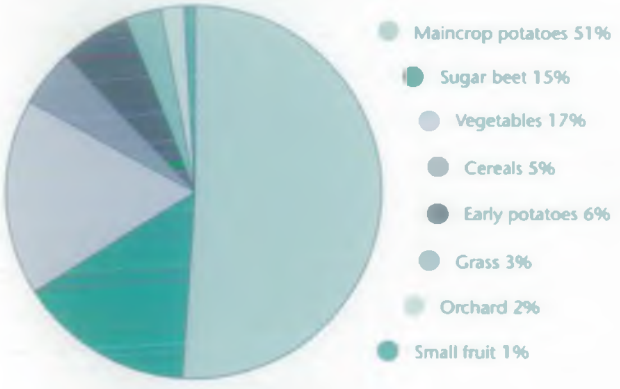
- the increasing limits placed by the Agency on direct summer water availability for new licences;
- the unreliability of such licences during droughts, with restrictions imposed in a number of years during the 1990s;
- the increasing requirements for quality and reliability placed on farmers by the supermarkets and other buyers tied into contracts that often specify reliable irrigation water.

Within the region there is a particular concentration of irrigation use in the large fertile area of the Fens stretching from Lincolnshire through Cambridgeshire to Norfolk and Suffolk.

Figure 3.13 **Irrigated areas and main uses of irrigation water by crop type in Anglian Region**



Irrigated areas (Hectares)



Annual irrigation demand (Megalitres)

Other major areas of irrigation occur on the light sandy soils of Breckland and the coastal sandlands of Norfolk and Suffolk. Fruit growing is also important in parts of the region, and irrigated glass-house horticulture is a particular feature in parts of Essex and Bedfordshire.

Over the last five to 10 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 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. To date, limited attention has been paid to quantifying these uses of water.

3.3.4 Power Generation

Power generation is a significant use of water in England and Wales, with the water primarily used for cooling. New power stations generally use less water, with some being air-cooled.

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 per cent of UK electricity will be produced from renewable sources. The specific implications for water resources management relate to the development of hydropower and new crops for biofuel. Currently, hydropower is concentrated in Wales and the south west and north of England.

Hydropower is a clean source of energy. However, care is needed to ensure that its impact on the local river environment is acceptable. The most important issue is the volume of water abstracted, and the effect of that loss on the deprived reach. With sensitive design and operation, the local environmental impact can often be minimised.

Anglian Region has not historically been a major power-generating region. It lacks the coal deposits which have influenced the siting of power stations in the past. Several major nuclear power stations are located on the coast and use seawater for cooling. During the 1990s, the region was affected by the structural changes in the power generating industry and a number of gas-fired stations were constructed. Some of these power stations use river water for cooling, but in many locations reliable surplus river flows are not available and air cooling has been installed, with the residual water demands on the site met from public supplies.

The potential for hydropower generation in Anglian Region is limited by the generally flat terrain and limited reliable river flow volumes. Nonetheless, there has been some interest in recent years, encouraged by the non-fossil fuel obligation and by advances in low-head hydropower technology. The only recent scheme in the region has been installed by the National Trust at Houghton Mill on the River Ouse.

Sizewell (Source: Nuclear Electric)

3.4 Recreational and other uses of water

Integrated river basin management is a key part of the Agency's role in water resources management.

3.4.1 Navigation

The rivers and canals of Anglian Region have a long history of navigation. Use is now mainly recreational, but many people value the opportunity to travel on the

Boating on the River Ouse

waterways. Navigation is an important use of water. While they are non-consumptive, navigational needs affect water resources in many ways. On rivers, it is necessary to maintain levels to allow boats to pass; this is an important control on abstraction in some locations. Canals, which are artificial waterways, 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 canals into the abstraction licensing system. The exact duties of the Agency and navigation authorities such as British Waterways will need clarification. This points to the need in the future for good forecasts of canal traffic.

In Anglian Region the Environment Agency is the navigation authority for the major rivers. Other important waterways in the region include the Norfolk Broads, the Middle Level in the Fens and British Waterways canals such as the Grand Union and the Fossdyke.

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 supports in principle proposals for navigation restoration that will enhance the recreational use of waterways. We will work with those considering restorations to ensure that the environment and other users are not adversely affected by such proposed developments as the Grand Union Canal - River Ouse link and the Fens Waterway link.

3.4.2 Angling

Fish are an integral part of the aquatic environment. They often provide the best indicators of a well-balanced ecosystem, due to their position towards the top of the food chain. More than 13,000 km of river in England and Wales are EC designated as salmonid fisheries and another 6,500 km are designated as coarse fishery.

Water is the most important aspect of the fisheries habitat. It is the environment in which fish live; the source of oxygen and carrier of nutrients; and it mediates light and temperature. Fish rely on an adequate supply of water throughout their life cycle. Rivers of good quality with an adequate flow of water are essential for successful and sustainable fisheries. Too little, or too much, water can have significant impact on resting, feeding and spawning habitats, and migration to and from these areas. The Agency manages abstraction and control structures such as sluices to regulate water availability.

Fishing

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

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 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 of flora and fauna of inland and coastal waters and associated land. England and Wales have a relatively rich biodiversity, although between 10 and 20 per cent 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 Plan (UKBAP) (UK Government, 1994). The UKBAP identifies the need to take opportunities to enhance 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. When setting conditions on abstraction licences, we carefully consider the needs of wildlife. 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, 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.

Sailing boat - Rutland Water

3.4.4 Other recreation and amenity

Water is an important resource for a variety of sports and recreation, including angling, canoeing, sailing and rowing. It has an important value as a landscape and amenity feature enjoyed by the millions who visit rivers, canals and lakes for relaxation. The requirements often conflict, calling for careful management. This is especially true 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. In Anglian Region this challenge is particularly evident in the Norfolk Broads, where the Agency works in partnership with the Broads Authority and English Nature on many issues.

3.5 Water resources and the environment

The present environment of Anglian 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 needed to protect these environmental assets. To summarise the current position we have produced three maps. They cover summer surface water availability (Figure 3.14), winter surface water availability (Figure 3.15) and groundwater availability (Figure 3.16). It is not appropriate to divide 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.

These maps represent the strategic position in Anglian Region. They are not intended to prejudge licensing decisions. For any proposed abstraction, various considerations would be needed, including an 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. Individual locations may have further environmental needs for water.

Summer surface water

The map 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. There may be limited stretches of river where surface water is available, depending upon rigorous local assessment. In most of these fully committed catchments existing abstractions do not cause widespread environmental problems. However, in those areas coloured red the combination of licensed surface and groundwater abstractions does exceed the assessed limit. Action to resolve the problems arising may involve changes to both surface and groundwater licences in the longer term.

Winter surface water

For most 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. Any licence granted would contain conditions to protect low flows and the environment.

There are some limited parts of the region where winter surface water is not reliably available. These mostly occur in small chalk headwater catchments that have limited total resource, and in coastal catchments where small stream flows are important to over-wintering bird populations.

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.

There are some limited areas, principally in parts of Norfolk and North East Suffolk, where some additional groundwater is available. However, any new or additional abstraction will again be subject to local appraisal of need and impacts, and any licence granted would, if needed, contain conditions to protect the environment. The density of wetland sites and the status of the River Wensum as a SSSI and candidate SAC site under the Habitats Directive, do constrain local opportunities to develop this resource. Similarly, much of the apparent surplus resource shown for the chalk aquifer of the Upper Ouse is dependent on a high volume of effluent return to support river flows that cannot be fully relied on.

In those areas coloured red, the combination of licensed surface and groundwater abstractions does exceed the assessed limit. Action to resolve the problems arising may involve changes to both surface and groundwater licences in the longer term.

More detail on the method and regional breakdown of groundwater availability is given in Appendix 1.

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.

Figure 3.14 **Summer surface water resource availability**

There is generally no further summer surface water available. This map (an excerpt from the national map) shows areas where there are sustainability issues at a coarse resolution (based on LEAP areas). It is derived from the underlying groundwater situation which has particular influence on river flow during the summer.

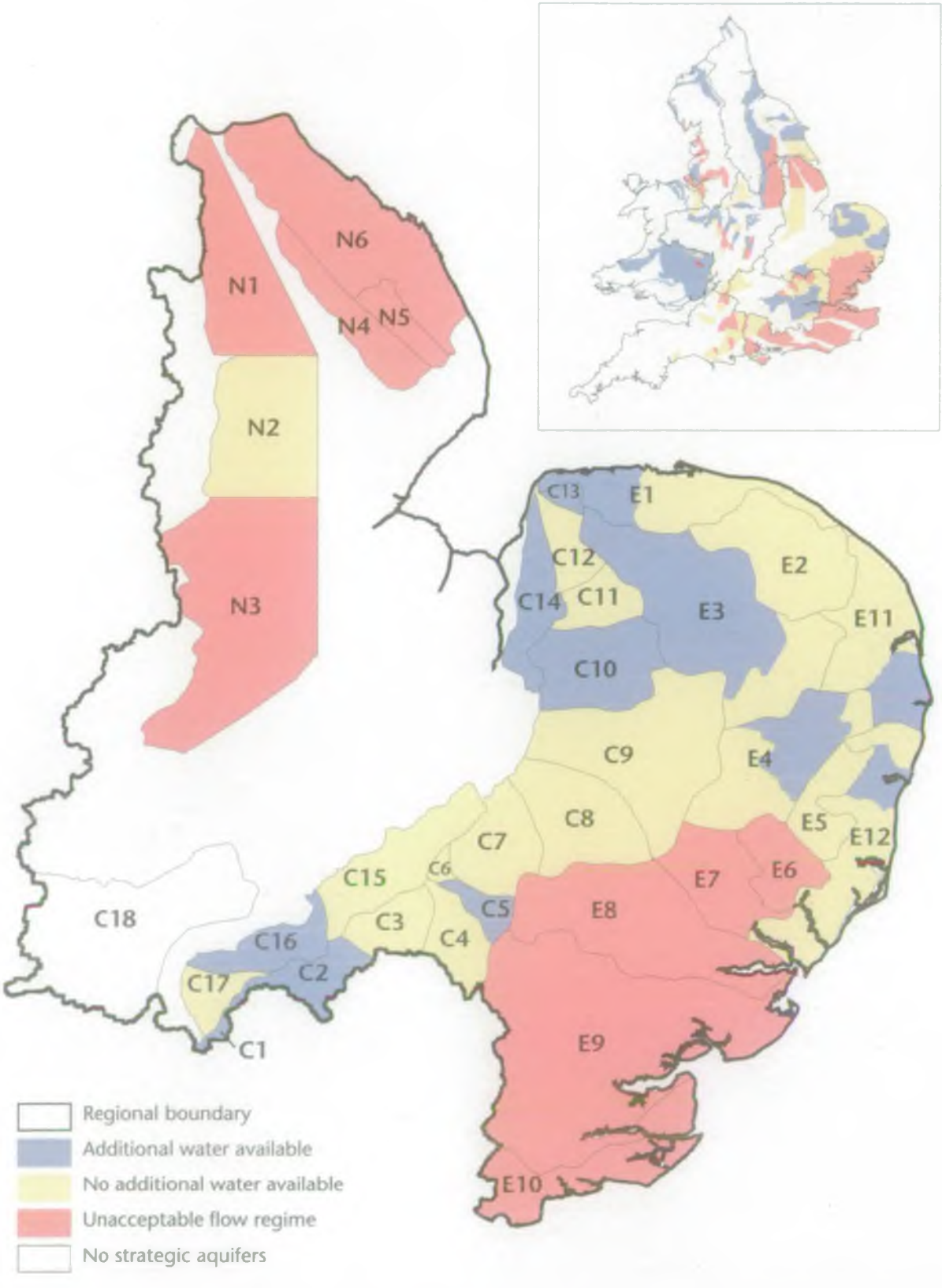
Unacceptable abstraction regime
No additional water available

Figure 3.15 **Winter surface water resource availability**

There is generally winter surface water available across the region. This map (an excerpt from the national map) shows areas where there may be reliability problems in particularly dry years at a coarse resolution (based on LEAP areas). Although these areas of potential low reliability are shaded as having "No additional water available" we are still prepared to accept licence applications here - the issue of whether a licence with low reliability is worthwhile is within reason a matter for the licence holder to decide. There tends to be more resource available at the lower ends of individual catchments, but each licence application is subject to an assessment of the potential impacts on the water environment and existing abstractors.

No additional water available
Water available

Figure 3.16 **Groundwater resource availability**



This map shows strategic resource availability based on simple water balance calculations. Superimposed are the boundaries of the regional resource units referred to in the table in Appendix I, although at the local level some of the units displayed here are sub-divided and there are also numerous small sand and gravel deposits. Even if a unit has resources available, each abstraction proposal would be subject to an assessment of local impacts and there are some units where, for reasons outlined in the table, no new significant licence applications are accepted.

4 Pressures on water resources

Whilst we know most of the current pressures on water resources and the environment, there are many aspects of the future which are uncertain. These include, for example, the effects of climate change and changes in society. How society values the environment and chooses to use water in future will determine the type and size of demands placed on water resources. Population pressures and land use change will also have an effect on the way that water is used. While it is an important part of everyday life, the consequences for water and the environment are rarely considered when making choices.

4.1 Environmental needs

Some existing licensed abstractions are already causing low river flows and environmental problems, or would do so if they were fully utilised, as shown in Section 3.5 and associated maps. This happens where the volume of water legally abstracted exceeds the sustainable limit, or where abstractions are located near to a site that is especially vulnerable. These environmental problems reflect historic licensing practices that were based either on a weak understanding of catchment processes, or on values that gave a lower precedence to the environment.

Successfully resolving these problems will be an important part of our work over the next few years. This will involve changing or revoking abstraction licences, through the Catchment Abstraction Management Strategies process. Reductions to licensed quantities, addition of conditions, and, where practical, redistribution of abstraction to more sustainable sources will be implemented over a period of time depending upon the risk of impact. Any decision on the best way to do this will have to weigh the benefits to the water environment against the costs to abstractors and society as a whole, including the economic and social well-being of rural areas.

There are already programmes of investigations under way to improve our understanding of environmental water needs, and of sites that are thought to be at risk of adverse impacts from abstraction. Significant progress has been made since our 1994 strategy, with a monitoring programme established to gather water level and flow information at 50 wetland conservation sites throughout the region. There are also 34 sites in the region which have been included in the National Environment Programme (NEP) for investigation and action where necessary. These are sites where water company abstractions are known or thought to be causing an unacceptable impact on the environment. Funding of the necessary investigations and some actions has been agreed by Ofwat. These sites are listed in Table 4.1 and shown on Figure 4.1. We have also jointly produced a report with English Nature that summarises the status of problems and progress of investigations at SSSI sites nationally *(English Nature and the Environment Agency, Sept 1999)*.

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 of consents is due to be completed by 2004. It will lead us to confirm, modify or revoke abstraction licences as necessary to protect European conservation sites (Special Protection Areas and Special Areas of Conservation) following an appropriate assessment of their impact on these sites. Some of the sites thought to be adversely affected by abstraction have already been included in the NEP investigations. We do not have the information yet to make an estimate of the scale of any abstraction licence

Figure 4.1 National Environment Programme sites

changes that may arise from this review. We will, however, incorporate such information as it becomes available. We have also considered the potential need for changes to abstraction licences, arising from the Habitats Directive review of consents, as a risk in our appraisal of options for the strategy.

We are aware of further potential issues associated with other abstractions and the Agency has a programme of work to investigate these via its Restoring Sustainable Abstraction Programme (RSAP). Considerable concerns arose regarding the impacts of abstraction during the droughts of the 1990s and it has often been difficult to disentangle the underlying causes of environmental problems. The understanding of these problems, identification of solutions and a programme of actions through the CAMS process will be an important part of our work over the next few years. River Basin Management Plans produced as part of the Water Framework Directive will also be an important part of this process. In addition, we propose further research in Section 7.8.1 and Appendix 5. We expect to need to work closely with others, to ensure that where abstraction is only one of various contributory factors an integrated solution is found that will be sustainable in the long term.

In parts of Anglian Region, existing licences are either already causing catchment-wide environmental damage or would do so if they were fully utilised. For the purposes of this strategy we have used our groundwater balance assessments described in Appendix 1 to identify where wider areas of potential environmental deficit occur within the region. These are the areas coloured red in Fig 3.16. We have identified in broad terms the volume of water required to achieve this for the region.

Table 4.1 Sites for investigation and action under the National Environment Programme

Site Name	County	Water Company	Type of site	Funding Allocated
Sheringham & Beeston Regis Common	Norfolk	Anglian Water Services	Habitats Directive	Investigation and implementation of a solution
Yare Broads & Marshes (Strumpshaw Fen)	Norfolk	Anglian Water Services	Habitats Directive	Investigation and implementation of a solution
Ant Broads & Marshes (Catfield Fen)	Norfolk	Anglian Water Services	Habitats Directive	Investigation
Booton Common	Norfolk	Anglian Water Services	Habitats Directive	Investigation
Coston Fen	Norfolk	Anglian Water Services	Habitats Directive	Investigation
Foulden Common	Norfolk	Anglian Water Services	Habitats Directive	Investigation
Great Cressingham Fen	Norfolk	Anglian Water Services	Habitats Directive	Investigation
Nene Washes	Cambridgeshire	Anglian Water Services	Habitats Directive	Investigation
Burgh Common & Muckfleet Marshes	Norfolk	Essex & Suffolk Water	Habitats Directive	Investigation
Wash & North Norfolk	Norfolk & Lincolnshire & Cambridgeshire	Anglian Water Services and Essex & Suffolk Water	Habitats Directive	Investigation
Ouse Washes	Cambridgeshire	Anglian Water Services and Essex & Suffolk Water	Habitats Directive	Investigation
East Ruston Common	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation and implementation of a solution
Didlington Park Lakes	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation and implementation of a solution
Kenninghall & Banham	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation and implementation of a solution
Fowlmere	Cambridgeshire	Cambridge Water Company	SSSI (Non-Habitats Directive)	Investigation and implementation of a solution
Cattawade Marshes	Essex	Essex & Suffolk Water	SSSI (Non-Habitats Directive)	Investigation and implementation of a solution
Beetley & Hoe Meadows	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation
Scoulton Mere	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation
Whitwell Common	Norfolk	Anglian Water Services	SSSI (Non-Habitats Directive)	Investigation
Dernford Fen	Cambridgeshire	Cambridge Water Company	SSSI (Non-Habitats Directive)	Investigation
Sawston Hall Meadows	Cambridgeshire	Cambridge Water Company	SSSI (Non-Habitats Directive)	Investigation
Waithe Beck	Lincolnshire	Anglian Water Services	Non-SSSI	Investigation and implementation of a solution
Laceby Beck, R Freshney	Lincolnshire	Anglian Water Services	Non-SSSI	Investigation
Northern Limestone	Lincolnshire	Anglian Water Services	Non-SSSI	Investigation
Southern Limestone	Lincolnshire	Anglian Water Services	Non-SSSI	Investigation
Stringside Beck	Norfolk	Anglian Water Services	Non-SSSI	Investigation
River Deben	Suffolk	Anglian Water Services	Non-SSSI	Investigation
River Gipping	Suffolk	Anglian Water Services	Non-SSSI	Investigation
River Lark	Suffolk	Anglian Water Services	Non-SSSI	Investigation
River Brett	Suffolk	Anglian Water Services and Essex & Suffolk Water and Tendring Hundred Water Services	Non-SSSI	Investigation
Lower River Nene	Cambridgeshire	Anglian Water Services	Non-SSSI	Investigation
River Granta	Cambridgeshire & Essex	Anglian Water Services and Cambridge Water Company	Non-SSSI	Investigation
Upper River Pant	Essex	Anglian Water Services and Three Valleys Water	Non-SSSI	Investigation
Upper River Colne	Essex	Anglian Water Services	Non-SSSI	Investigation

This additional environmental demand is considered as we develop the strategy (see 5.4).

The Agency is committed to resolving the problems of such catchments. However the actions needed to achieve environmentally sustainable abstraction regimes may be complex, time consuming and costly. The benefits will have to be weighed against the costs, taking into account the needs of abstractors and society as a whole, as well as the benefits to the water environment.

Wetland habitats are an important feature of Anglian Region. Much habitat has been lost in the past through intensification of agriculture and drainage practices, and many coastal habitats are vulnerable to future sea level rise. There is particular interest in ensuring sufficient future wetland habitats to achieve biodiversity targets in Anglian Region. We have carried out a specific study to assess the potential water needs to meet these targets. The results of this are given in Section 5.4.

4.2

Societal change

To take account of the uncertainties that surround the ways in which society may evolve it is appropriate to examine different scenarios for 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" (DTI, 1999) scenarios 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 which will prove robust to a range of "possible environmental futures". They look at the future by considering two aspects of development: social values and systems of governance. The result is a set of four scenarios, each of which characterises one way that the country 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.

Figure 4.2 Foresight scenarios

Table 4.2 **Foresight environmental futures**

The Foresight programme, sponsored by the Department of Trade and Industry (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 National Environment Panel published a set of scenarios focussed on the environment. These scenarios are intended to inform and stimulate debate among businesses, regulators, and Government departments about the environment and encourage them to develop strategies and policies that will prove robust to a range of 'possible environmental futures'.

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 describing 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 environment 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 transnational 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. At 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.

- 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 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 water demand increasing, stabilising or decreasing.

The water resources demand scenarios that result from this work are discussed in Appendix 3. 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. Whilst 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 that 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. The Agency has taken an approach that involves building a set of solutions and testing their effectiveness under the different scenarios. In doing this, three basic principles are 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;
- finalise decisions about actions at the right time. Making decisions too soon could cause 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 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 the impact of these changes on climate is more 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 certain about how climate change will affect demand. Household water use is likely to be increased by hotter summers. Given the diverse range of industrial uses of water, it is not possible to generalise about their vulnerability to climate change. 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. Higher temperatures will also affect livestock production systems. We have outlined how we have estimated the effect of climate change on household demand in Chapter 5.

Changes in climate will also change groundwater and river flow regimes and therefore the availability of water for abstraction. Current estimates of climate change suggest that by the 2020s throughout Anglian Region there will be, on average, more winter rainfall and less summer rainfall. 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 probably occur more often. Evidence of 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.

In this strategy we will assume, based on the results from Arnell (1999), 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 either in aquifers or reservoirs. Little analysis exists, but where modelling has been carried out it suggests that most reservoir systems and aquifers will actually gain a little yield because of the wetter winters. 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.

Changes in 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 with climate change.

The potential consequences of climate change for Anglian Region are a major concern for many stakeholders in the region. We already have a climate with a comparatively close balance between rainfall and evaporation, and frequent dry summers where evaporation exceeds rainfall. This means that we are especially vulnerable to changes in the fine balance between rainfall and evaporation that could affect the availability of water resources.

The region is also particularly vulnerable to sea level rise. The land is still sinking under isostatic adjustments following the last ice age. Much of the region is low-lying, with 20 per cent of the land area already below sea level. A rise in sea level and increased storminess as a result of climate change is an additional pressure. Apart from the consequences of these effects of climate change on flood defences, there are potential effects for water resources. The increasing risk that some valuable coastal conservation sites will be lost leads to a need to consider future strategies for their replacement in order to maintain biodiversity in the region. Saline incursion into freshwater habitats is already an issue and concern, for example in parts of Broadland. The combined effects of lower summer flows and sea level rise could worsen such problems. The risk of reduced reliability for river abstractions near the tidal limit could also increase.

Table 4.3 **Regional household and population increases over the period 1997 - 2025**

Region	Household Growth (millions)	Population Growth (millions)
Anglian	0.6	0.8
Midlands	0.5	0.5
North East	0.3	0.1
North West	0.3	0.2
South West	0.4	0.6
Southern	0.3	0.3
Thames	0.7	0.8
Environment Agency Wales	0.1	0.1

Saline intrusion into coastal aquifers is a further potential risk to groundwater resources, although currently assessed as a relatively minor impact.

Appendix 2 contains a summary of on-going 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. This is largely due to the trend towards smaller household size. Total population is also predicted to increase by 2.8 million over the same period.

In developing the strategies, the Agency has used a nationally consistent population and household data set for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025. These data were obtained from CACI Limited. The figures for each region are given in Table 4.3. These show that Anglian Region is predicted to be one of the fastest growing regions over this period, with an increase in households of 0.6 million and population growth of 0.8 million.

4.6

Land use

The way in which we use land has a significant impact on the water in our environments. Urbanisation, land drainage, forestry and mineral workings have all altered the run-off characteristics of our rivers.

Urban areas have a large proportion of impermeable surfaces and drainage systems designed to remove water quickly. Where they overlie aquifers, recharge can be reduced. Rivers and streams in such areas rise and fall rapidly when it rains, such as the River Ouse at Newport Pagnell. This can cause problems for flood control as well as reducing the useful water resource. The Agency has co-operated with other bodies in investigating more sustainable approaches to such issues. Slowing such runoff by the use of permeable paving surfaces to allow infiltration and other measures have gained greater attention in recent years. These and other measures are known as sustainable urban drainage systems.

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 also increase peak flows and

encourage soil erosion that may then be deposited in river channels. Such siltation can alter the channel shape as well as covering up gravel beds which would otherwise be important spawning grounds for fish. Pesticides and fertilisers used in agriculture can reach rivers, streams and groundwater, affecting water quality. We work increasingly closely with farmers and agricultural bodies to promote best practices for the control of such diffuse pollution.

Forestry may affect the hydrological cycle in various ways, dependent on soil type and species of tree. Conifer plantations can reduce infiltration and recharge to aquifers by their increased use of water. Previous research indicates that recharge to the Chalk aquifer is reduced by 60 per cent under Thetford Forest. DETR and the Agency are currently supporting research into the effects of afforestation on recharge of sandstone and chalk aquifers. Deciduous trees can help soil moisture retention in the long term by the build up of soils rich in organic matter, as well as providing other environmental benefits. The Agency welcomes the wider environmental gains that can be brought from projects such as the extension of woodland in Northamptonshire.

Mining and quarrying can have major impacts on both surface and groundwater flows. In Anglian Region, extensive gravel workings are a feature of the major river valleys. Pumping for dewatering can affect local wetlands as well as changing the river flow pattern.

Major construction works, such as road or railway cuttings and new settlement developments, can disrupt groundwater flow and change surface drainage routes.

Over the centuries our river channels have been altered to meet human needs. Some have been widened and deepened to allow navigation, and locks, weirs and secondary channels have been constructed. Others have been straightened or channelled to improve land drainage, particularly to maximise the use of land for arable farming, and to alleviate the impact of floods. This can also lead to increased erosion from the faster flows. In the extensive low lying area of Fenland, the main rivers form high level "carriers" above the main level of the surrounding land which has lowered over the centuries through peat shrinkage and losses. A network of low-level drains managed by Internal Drainage Boards serves the farmland. Water is pumped out of the drains in winter to maintain the fields in workable condition. In summer the process is reversed, using a system of slackers (penstocks, pipes or siphons) to divert water into the drains from the main rivers for distribution to the fields. Here it provides sub-irrigation by maintaining high water tables, as well as providing the source of water for irrigation abstraction licences.

Historically many of our rivers were used for water power. The old mills and their associated structures now form heritage features.

The Agency's flood defence function has a leading role in managing main river channels. In recent years we have increasingly sought to reduce the risk of flooding in a way that works with natural processes to slow down and reduce peak flows. This includes the use of balancing reservoirs to temporarily store peak flows and encouraging sustainable urban drainage. In some places river restoration projects have reversed previous channel deepening and straightening, for example the Rivers Little Ouse and Great and Long Eau. Such projects bring integrated benefits to water resources, conservation and local enjoyment of the river as well as protecting against floods.

It is important that the quality of water is protected. Discharges of treated effluent from sewage works or industrial or commercial users return water to the environment. About half of the region's effluent is discharged to rivers; the remainder is discharged to coastal waters. Pressures to abstract greater quantities of water will reduce the river flows available to dilute the effluent received, but this can be mitigated by improving the quality of the effluent.

We have defined groundwater protection zones around critical public water supply sources. These zones prohibit or restrict certain activities and processes that would pose a significant threat. The main issues facing groundwater quality in Anglian Region are rising nitrate levels from agricultural fertilising activities, pesticides from a variety of sources, hydrocarbon contamination from oil storage and usage, chlorinated solvent pollution from industry and disposal of liquid or solid wastes to land.

The Agency has embarked recently on a research contract with the Centre for Environment and Hydrology at Wallingford, aimed at improving the understanding of the links between changes in land use and all aspects of water management. We will need to examine the results of these studies in terms of their impact on water resources and will plan to give strategic advice if the impact could be significant.

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. 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.

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". The Directive demands a "good" ecological status for surface water and groundwater sources. This 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.

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. These forecasts were based on assumptions about future levels of ownership, frequency of use and volume of use. We have generated figures for unmeasured per capita consumption for each resource zone on this basis.

The likely extent and impact of metering 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 per cent to 21 per cent (National Metering Trials Working Group, 1993). The proportion of metering varies across the scenarios.

Table 5.1 **The key drivers of component demand by scenario**

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)	Increased 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

5.2.2 Leakage

The leakage scenarios reflect different approaches to prioritisation and target setting. This in turn affects water companies' leakage control philosophy and subsequent find-and-fix activity, pressure management levels, and service and mains replacement rates.

5.2.3 Industry and commerce

We have identified 19 different sectors of industry and commerce 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.

For clarity we have put the details of scenario development into Appendix 3.

5.3

Scenario demand in 2010 and 2025

5.3.1 Differences in Demand

Figures 5.1 and 5.2 and Table 5.2 show the results of this forecasting work for Anglian Region in 2010 and 2025. It can be seen that by 2010, the differences between scenarios are relatively small, reflecting the slow rate of divergence from today's values determined by regulatory mechanisms, such as the price limits set by Ofwat for the period 2000-2005. By 2025 demands vary significantly, with increases in total demand for water under two of the scenarios, but decreases in the other two. Within this, the different components behave in different ways. Incremental demands for each sector are as follows:

Table 5.2 **Regionwide summary of demand changes at 2010 and 2025**

2010	Alpha (Ml/d)	Beta (Ml/d)	Gamma (Ml/d)	Delta (Ml/d)
Additional environmental needs	42	42	42	42
Direct Industry	-46	-37	-76	-86
Spray irrigation	64	45	16	24
Public Water Supply	147	172	0	-9

2025	Alpha (Ml/d)	Beta (Ml/d)	Gamma (Ml/d)	Delta (Ml/d)
Additional environmental needs	210	210	210	210
Direct Industry	-58	-41	-148	-139
Spray irrigation	123	57	-35	-6
Public Water Supply	1553	402	-464	-451

Baseline demands	1997/98 (Ml/d)
Direct Industry	226
Spray irrigation	253
Public Water Supply	1807

Figure 5.1 **Anglian Region demand by scenario in 2010 and 2025**

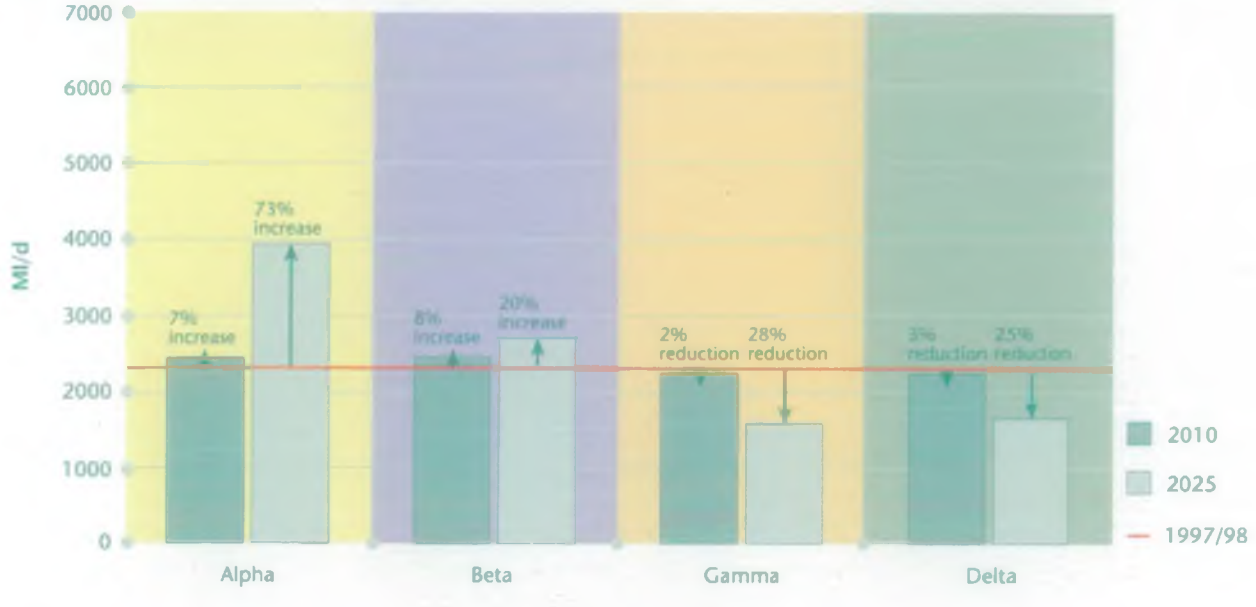
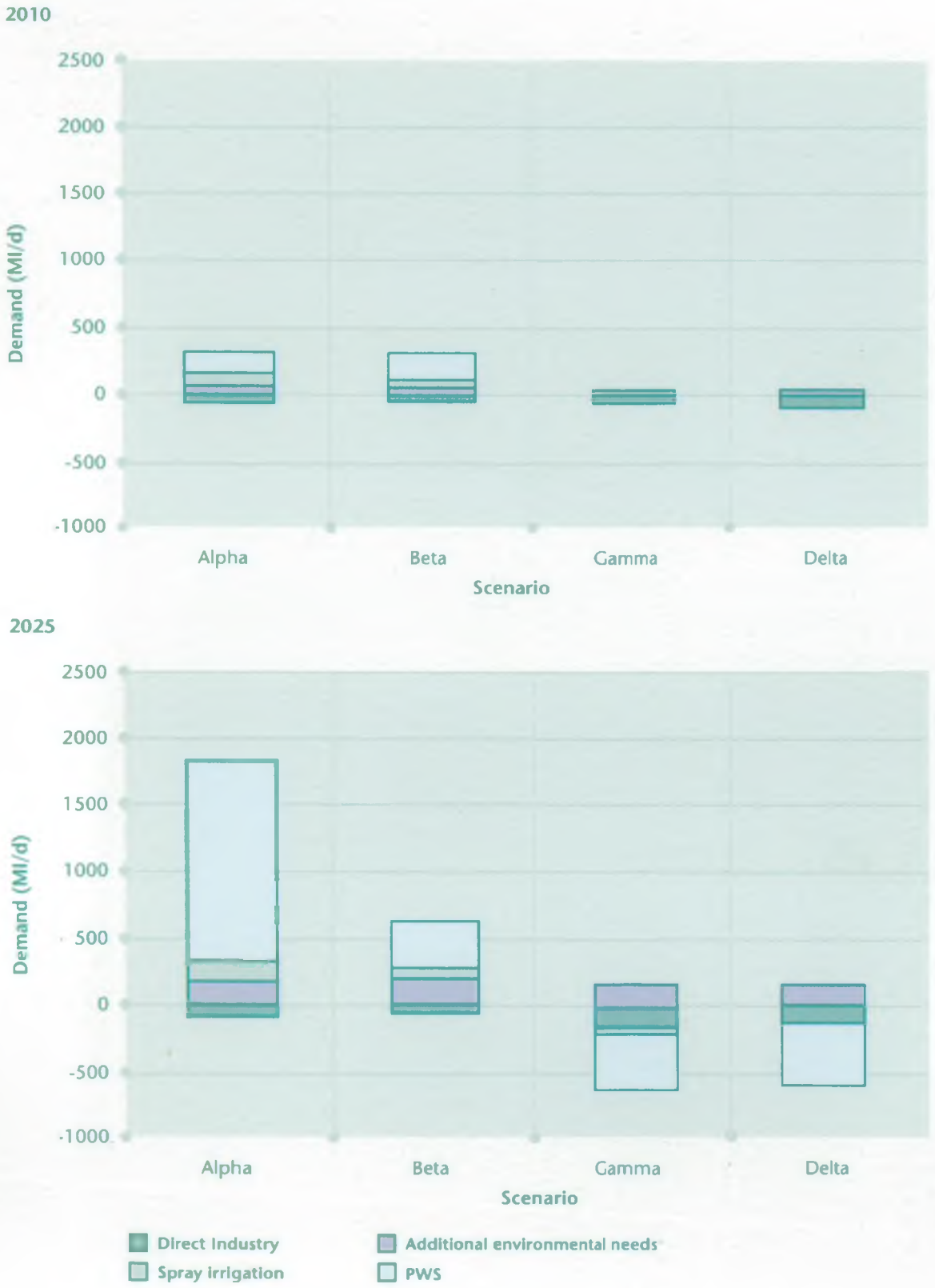


Figure 5.2 Region wide summary of demand changes at 2010 and 2025

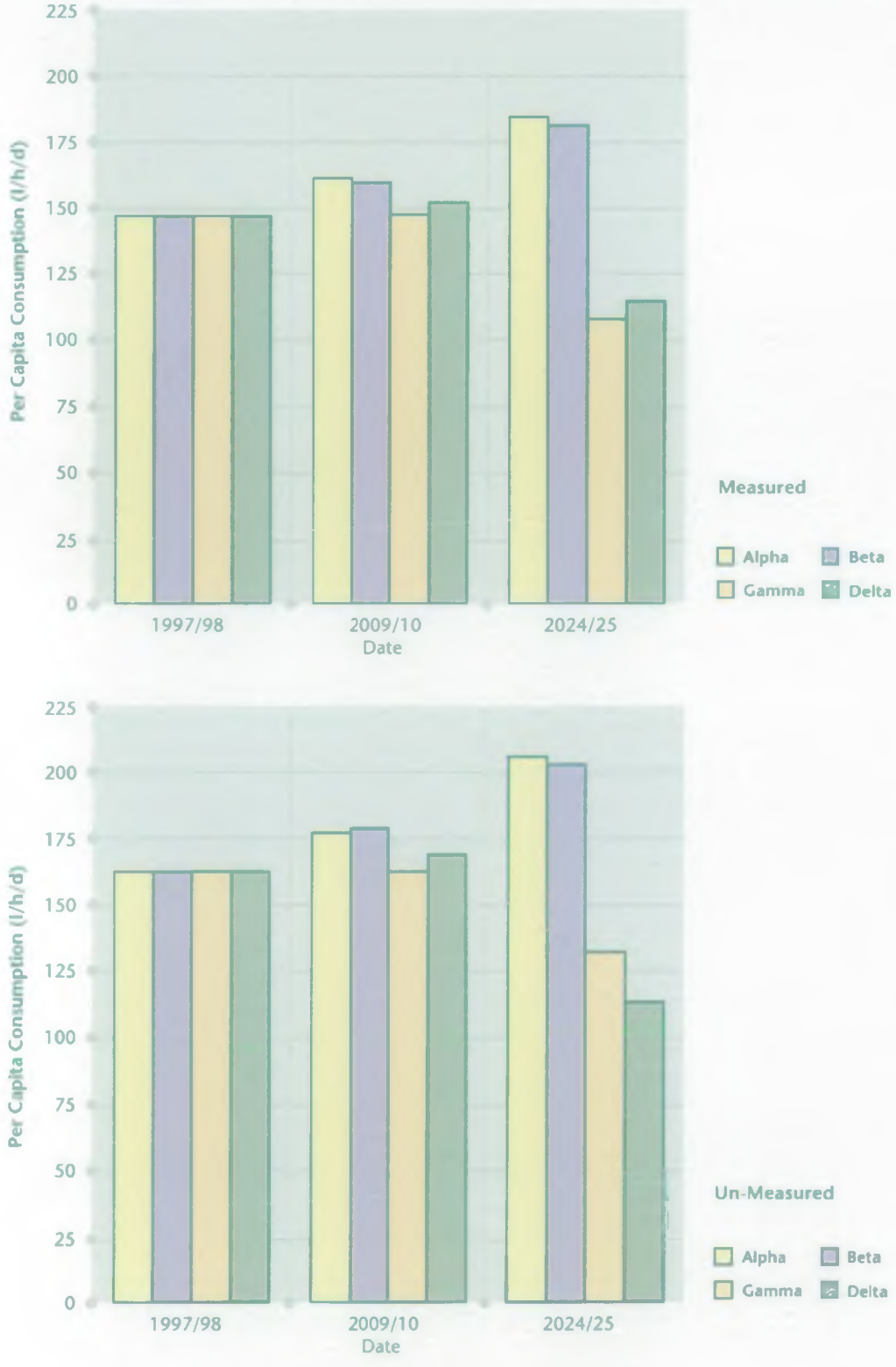


5.3.1.1 Household Demand

The scenarios show a wide divergence in potential regional household demands by 2025, with most of the changes developing after 2010, as the immediate future is more directly determined by current values and regulatory mechanisms, such as the price limits set by Ofwat for the period 2000-2005. The range of future personal use of water in the region under each scenario is shown in Figure 5.3.

Household demands rise most under scenario Alpha, influenced by a market driven, consumer led society combined with limited regulation and technological innovation. Household demands rise to a slightly lesser extent under scenario Beta, as technological innovation and investment moderate some of the trends towards increase which are otherwise present. Key areas of growth in demand under both these scenarios are personal washing (especially power showers), garden use and miscellaneous uses.

Figure 5.3 **Regional household per capita consumption**



Under the Gamma and Delta scenarios household demands decline significantly by 2025, with demand reductions across all components, apart from garden watering which remains relatively stable.

Some differences arise between companies and zones within the region. The highest current and future per capita use figures are seen in the Essex zone of Essex & Suffolk Water, whereas the lowest are found in the small companies of Cambridge Water and Tendring Hundred.

The use of differing tariffs to further influence customer behaviour has not been included explicitly in the scenarios, but represents one of the ways in which some of the demand savings may be encouraged. Some water companies already offer alternative tariffs to particular customer groups.

The higher range of demands shows the risks to the region of continued increases in personal water use under an affluent society. These pressures are then increased further by the underlying growth in population and housing common to all scenarios for Anglian Region. More powerfully still, the lower range outcomes demonstrate that the region could achieve the same growth, whilst reducing the total demand for household water use. In establishing our final strategy in Chapter 7 we aim to build positively on this challenge.

5.3.1.2 Leakage

Anglian Region companies already achieve good levels of leakage control, approaching current economic levels, although environmental costs and benefits are not fully included. The companies themselves have predicted further leakage savings over their 25 year plans. Scenario Beta is broadly consistent with this and shows a further reduction in leakage across the region of 60 Ml/d by 2010 with minor additional savings of 5 Ml/d by 2025.

Scenario Gamma achieves similar savings by 2010, but continued progress beyond then reduces leakage by an additional 85 Ml/d by 2025.

Scenario Delta also leads to leakage reductions, along similar lines, with savings of about 60 Ml/d by 2010 and a further reduction of 65 Ml/d achieved by 2025.

The Alpha scenario illustrates the risks of failure to actively control leakage. Up to 2010 the same trend is shown as for the other scenarios. Beyond 2010 leakage rises rapidly over a five year period. If this were to happen in practice, problems would quickly arise with the security of public supplies, as leakage would soon exceed the headroom available. We therefore take this particular element of the scenarios as a warning of the speed or scale of problems that could arise if leakage does not continue to be actively managed as at present.

5.3.1.3 Industry and Commerce

To assess non-household demands we have made a combined study of the industrial and commercial demands within the public supply sector and the demands that are met by direct abstraction under licences granted by the Agency. The results are described below in terms of their implications for public supply demand and direct abstraction.

Public water supply non-household

The results show a potentially large rise under the Beta scenario of 185 Ml/d across the region by 2025. There are particularly large concentrations of this growth in Essex and Anglian Water's Northern Zone in Lincolnshire and Northamptonshire, with further growth distributed over the rest of the region. Growth also occurs under scenario Alpha, but to a much lower extent of 75 Ml/d. Once again, the growth pressures are focused on Essex and the northern part of the region.

Under scenario Gamma, demands decline by 100 Ml/d between 2010 and 2025, as longer term economic changes and waste minimisation schemes take effect. Under the Delta scenario, demands decline faster and further, reducing by 140 Ml/d by 2025. The distribution of reductions is a mirror image of the increases under the other two scenarios, with the largest declines seen in Essex and in the north of the region.

Direct industrial abstraction

Future overall trends in direct industrial demands are dominated by an expected decline across all four scenarios in the largest current use, which is for extractive industries. Most of the decrease occurs by 2010, based on current trends. This is principally non-consumptive use for sand and gravel working, as described in Section 3.3.2 previously.

Underlying this influence, the next largest sectors of food and drink processing and chemicals show markedly different trends. Increases under both the Alpha and Beta scenarios are driven by economic growth in these sectors and limited waste minimisation initiatives. The food and drink industry shows highest growth under the Alpha scenario, closely linked to growth in local irrigated crop production, whereas the chemicals sector grows more strongly under Beta. By contrast, these sectors show decreased demands under the Gamma and Delta scenarios influenced by waste

minimisation and greening of business initiatives coupled with structural changes in the economy.

The remaining direct industrial demand sectors show relatively stable demands or slight increases under the Alpha and Beta scenarios and modest reductions under the other two scenarios.

No specific scenarios have been examined for power generation. The use of inland water for this purpose is a relatively minor demand in the region as described in Section 3.3 and is not expected to grow significantly.

5.3.1.4 Agriculture

Irrigation is a key water use sector in the region, and has shown substantial growth in demand over the last two decades. Previous forecasts from a variety of sources have predicted that this trend will continue - although the rates of increase vary. Our new forecasts of spray irrigation demand differ in the inclusion of economic demand.

Once economic demand and scenario influences are considered, the outcome is as follows:

Alpha Scenario This scenario shows the greatest increase in total irrigation demand. This arises from a combination of cropped area increases and some application rate increases. The key increases are for maincrop potatoes, vegetables and sugar beet (which remains economic under the more protective trade policies envisaged). Limited water efficiency gains are expected under this scenario. Technological improvements, either to irrigation equipment or crop varieties, are slow to develop.

Beta Scenario Moderate increases in demand are seen under this scenario, dominated by increased use for maincrop potatoes and vegetables. An increase in cropped area is the biggest factor underlying this, with a slight increase in application rates. Some efficiency gains are expected from improved irrigation scheduling and technology, plus new drought tolerant crop varieties towards 2025. Sugar beet irrigation declines in contrast to the other crops. This results from a combination of the development of drought tolerant varieties and the premise that it becomes less economic for East Anglian farmers to compete with sugar beet in the global market.

Gamma Scenario There is an overall moderate decline in irrigation demand driven by a combination of factors. Key drivers within this scenario are efficient use and "water friendly" produce. Some increase in cropped area occurs, but this is outweighed by reduced application rates derived from water efficiencies. A slight decrease in irrigation demand for maincrop potatoes is shown, larger declines for sugar beet and cereals, and a slight increase for vegetables.

Delta Scenario Under this scenario there is a modest decline in irrigation demand (less than for the Gamma scenario). The greatest decrease predicted is for maincrop potato irrigation, lesser decreases are predicted for sugar beet and cereals, and a moderate increase for vegetables. Underlying these changes are increases in cropped area but reduced productivity per hectare and reduced water application rates.

General agriculture General agricultural demand, primarily for livestock and miscellaneous use on the farm, has not changed significantly in recent years. There are no driving factors to suggest this picture will alter greatly in future. It is a relatively small component of total regional demand, built up from a large number of widely distributed small abstractions. No explicit forecasts have therefore been made and the sector is expected to remain stable overall at a regional and broad sub-regional level.

Similarly, fish farming and other miscellaneous uses are not regarded as significant at a regional level and have not been assessed. Where such demands are important at a local level, they will be considered more closely within the Catchment Abstraction Management Strategies process in future.

5.3.2 Climate change

We have calculated a likely increase in household demand caused by climate change, on the basis of scenario Beta, a high-growth scenario. The effects have been attributed to an increase in demand from watering, which has been added to the incremental demands for each scenario. The total effect on public water supply demand in Anglian Region is about 27 Ml/d by 2025. This represents a small but additional demand that has been included in our incremental demands for public supply. Under the two declining demand scenarios, even if increases of a similar size arose, they could easily be met from the demand savings elsewhere. Further details are given in Appendix 2.

Climate change will certainly have an affect on agriculture. It is likely to affect planting and harvesting dates, but also crop varieties grown and their distribution across England and Wales. Previous work for DETR in 1996 (Herrington, 1996) indicated that unconstrained irrigation demand in Anglian Region could increase by an additional 129 Ml/d between 1991 and 2021 as a result of climate change.

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. This preliminary work, undertaken for the Agency as part of the background studies to our strategies, suggests that irrigation demand for the key irrigated crops could increase by between 12 per cent and 27 per cent. More details are given in Appendix 2.

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 for irrigation. We will revise our forecasts in light of the results of the DETR Climate change and demand study.

5.4 Environmental need

We have said that a number of sites or catchments are being harmed as a result of current levels of abstraction or would be harmed if licences were fully utilised. 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 in the region. We estimate that a reduction of 210 Ml/d may be necessary, primarily from groundwater abstraction. The bulk of this need is located in two parts of the region, in north/central Lincolnshire and in south Suffolk and Essex. It includes 20 Ml/d related to Anglian Water abstractions from the Sherwood Sandstone in our neighbouring Midlands Region.

We estimate that some 40 Ml/d of this total quantity will be required by 2010, primarily to resolve problems currently flagged up for investigation under the NEP. The remainder is required as a precautionary estimate by 2025. It allows for completion of the current regional groundwater modelling programme, and at least one full cycle of CAMS. This will ensure fuller understanding of environmental needs before any major changes or developments in public supply systems, including replacement source works, are triggered solely to meet such needs. In this sense the environmental demand figure for 2025 is quite precautionary.

The summary results are in table 5.3.

Table 5.3 Additional environmental need by 2010 and 2025

	Environmental need in Ml/d	
	2010	2025
Anglian	42	210
Midlands	110	200
North East	25	25
North West	0	0
South West	14	14
Southern	20	80
Thames	46	187
Environment Agency Wales	0	0
Total	257	716

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 doing so. This need represents a further demand to be set against available resources.

Water for wetland creation

Wetland habitats are an important feature of Anglian Region. Much habitat has been lost in the past through intensification of agriculture and drainage practices, and many coastal habitats are vulnerable to future sea level rise. There is particular interest in ensuring sufficient future wetland habitats to achieve biodiversity targets in Anglian Region. The Environment Agency as a whole has a role in helping deliver the UK Biodiversity Action Plan. This is one of the actions the government signed up to at the 1992 Earth Summit. Our statutory guidance and codes of practice include the need to conserve and, where practicable, enhance biodiversity.

We therefore commissioned a joint study with English Nature and the RSPB as part of the background work to our water resources strategy. This assessed the feasibility of creating new wetlands and the quantities of water needed to maintain them. The study (Cranfield University, 2000) provided the potential water requirements for each key habitat type. This was then combined with provisional regional and county Biodiversity Action Plan targets to calculate annual average water requirements as shown in Table 5.4.

The total regional water requirement for potential wetland creation is in the order of 150-200 Ml/d by 2015. This is a substantial volume of water if it were to be provided as a reliable daily supply. We plan that this demand should be met by use of higher winter flows, winter storage and appropriate design of specific

Table 5.4 Biodiversity action plan targets for wetland creation and water demands

Habitat Type Component	Estimated hectares of habitat to be re-created or restored	Water requirement mm/Ha	Water requirement Ml/d
Reedbed	2500	659	45.0
Fen	1000	527	14.4
Coastal & Floodplain Grazing Marsh	6000	565	92.9
Wet Woodland	1000	672	18.4
Total			**170.7**

NOTE: Biodiversity Action Plan (BAP) targets were not available for the Anglian Region when the strategy was being prepared. Some draft targets were available from English Nature, RSPB and county BAPs which have been used to estimate the likely scale of demand. These data contain many inconsistencies.

Habitat re-creation and restoration targets have been combined. Targets to varying dates have been accumulated to give 2015 total. In some cases no targets were available (eg.fens), and reasonable assumptions have been necessary.

wetland schemes. The resources available will not be fully reliable through all dry winters and critical droughts, but should be sufficient to maintain habitats in the longer term, accepting some natural variability. This is the approach already taken by one major scheme under development by the RSPB to restore a major gravel workings to reed bed and other habitat at Needingworth in Cambridgeshire. It should be reasonably robust against predicted climate change. It would not be appropriate to take the alternative route of triggering major transfer schemes or other resource developments to meet such potential needs when there are alternative ways of achieving the requirement in a more sustainable way.

The study also looked at land suitability, and explored methods for appraising specific wetland creation opportunities at local catchment level. We hope to develop this approach further for future use within the CAMS process.

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' calculations 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.

The results show that irrigation and direct industrial demands across all four scenarios remain largely within current licensed totals at both 2010 and 2025. Under the higher growth scenarios, small deficits do arise for irrigation in the catchments of the rivers Welland and Nene. This broad sub-regional picture also masks the likelihood of further localised deficits. In addition, issues will arise from the fact that existing resources are often fully allocated, but individual licences are not fully used. As a consequence, some potential demands could not be met whilst other licences are not used. At the same time, climate change could further increase demands and reduce reliability of summer river abstractions. This will lead to a greater peak deficit for spray irrigation demand.

The public supply figures show that demands remain largely within existing reliable developed resources at 2010. Small deficits arise under the Alpha and Beta scenarios in the following areas:

- Anglian Water's Eastern and Western resource zones;
- Essex and the small Hartismere zone of Essex and Suffolk Water;
- Tendring Hundred;
- Cambridge Water.

The deficit in Anglian Water's Western zone arises from the assumption that neighbouring companies Severn-Trent Water and Three Valleys Water Services may use their existing bulk supply entitlements in full. These bulk transfers total 109 Ml/d and are not fully used at

present. However, we must plan for the possibility that the maximum bulk supplies may be called on in future.

The deficits in the Essex and Suffolk Water resource zones relate to known current shortfalls in security of supplies. The company is planning actions to redress these deficits, but their implementation is not yet guaranteed and is not assumed in our assessment of potential deficits.

By 2025, larger deficits for public supply are predicted across the whole of the region under the Alpha and Beta scenarios. Leakage is greatest under scenario Alpha. Assuming that this is reduced to economic levels, the remaining increases in demand are highest in scenario Beta, primarily as a result of higher non-household demand. These demand increases, coupled with the potential additional environmental demand of 210 Ml/d and some additional pressures from climate change, could give rise to a substantial regional shortfall in the order of 300 to 400 Ml/d.

Under the Gamma and Delta scenarios no major deficits arise within the region, although a small localised deficit arises for Tendring Hundred by 2025. This would only occur if the full additional environmental reduction in abstraction licences were to be required. Much more work is needed to assess this need in detail. However, these scenarios overall show a substantial surplus of water resources created by reduced demands. Within such a context it would not be difficult to deal with a localised small deficit by re-allocation.

In the next two chapters we will look at the methods used to identify options and recommend solutions to redress these deficits identified.

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 considered a range of options for managing water resources. These include both options that increase supplies and options that reduce demand. The types of option considered are listed in Table 6.1.

We have reviewed a wide range of potential options to manage the range of future demand shortfalls shown under the scenarios. The options examined in the 1994 strategy have been re-assessed, and new options added which were not considered at that time. Some of these come from water company plans or our own considerations, others have arisen from our consultation exercise.

Some of these options may appear extreme, whether on grounds of cost, environmental impacts or engineering - for example a Wash barrage or major transfers across the fens. Such options would be difficult to promote and are unlikely to progress ahead of simpler alternatives. Nonetheless, it is clear that we have some real choices between future options for the region.

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.

There are uncertainties about future costs and effectiveness of demand management options. 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 Directive. We have considered the requirements of the Habitats Directive in our risk, uncertainty and sustainability appraisal. We will also ensure that individual actions are subject to the Habitats Directive process.

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 costing exercise, looking at the broad financial costs of each option;
- 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.

Each of these tools can be used either for individual options or for groups of options. We have applied them

to both. This helps us think about the components that should make up the strategy, and then 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.

The Agency is a competent authority under the Habitats Directive. We have considered the requirements of the Habitats Directive in our selection of options. We will also ensure that individual actions are subject to the Habitats Directive process.

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 providing amenity and recreational benefits;
- *constraints* that may limit the success of the option, including attitudes and aspirations and legal or institutional barriers.

Table 6.1 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.

6.4

Sustainability appraisal

Our approach to sustainability appraisal draws on the DETR *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 sub-divided into criteria against which each option was assessed. These are outlined in Table 6.2. The appraisal is carried out by an independent assessor, using specified questions to produce a comprehensive coverage of possible impacts and risks.

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 comparisons 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.

Table 6.1 **Option risk and uncertainty - Anglian Region**

Option			Resource Value [Ml/d]	Time to implement [yr]	Estimated Cost [£m/Ml/d]	Renewal period [yr]	Uncertainties					Opportunities					Constraints			
Type							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	Reservoir	New reservoir																		
		Feltwell Reservoir	80-150	15-20	Medium	100	◐	◐	○	◐	◐	◐	◐	●	●	●	◐	●	●	●
		Great Bradley Reservoir	50	15-20	Medium	100	■	■	○	◐	○	○	◐	■	●	●	◐	●	●	●
		Lower Witham Storage	100-200	15	Medium	100	◐	◐	○	◐	◐	◐	◐	●	●	●	◐	◐	◐	◐
		Wash storage	180	15	Medium	50	●	●	◐	◐	●	○	○	○	●	○	■	◐	●	●
		Reservoir raising																		
		Abberton Reservoir	50	10	Medium	100	○	◐	○	◐	○	◐	○	●	○	◐	◐	◐	◐	◐
		Reservoir extension																		
		Ardleigh Reservoir	5-15	10-20	Low	100	○	◐	○	◐	○	◐	◐	●	○	◐	◐	○	◐	◐
		Winter storage reservoirs (single farm)	<1	1-2	Low	15-30	○	○	○	○	○	○	○	●	○	○	○	○	○	○
		Winter storage reservoirs (farm consortium: 10-15)	<5	3-5	Low	15-30														
		Fens development					◐	◐	○	○	◐	○	◐	●	◐	◐	◐	○	◐	◐
		Greater utilisation of existing reservoir																		
		Eye Brook Reservoir	11	1-2	Low	75	○	○	○	◐	◐	◐	○	●	◐	○	○	◐	◐	○
	Surface Abstraction	Surface water abstraction (unsupported for PWS)																		
		Reduction in Ely Ouse HOF (Denver)	15-30	1-2	Low	25	◐	◐	○	◐	○	●	○	○	○	○	◐	●	●	●
		Reduction in Ouse HOF (Offord)/Brownshill	50-100	2-4	Low	25	◐	◐	◐	◐	○	◐	○	○	◐	○	◐	●	●	◐
	Groundwater	Groundwater abstraction or enhancement																		
		Greater utilisation of groundwater locally	localised	2-3	High	30	○	○	○	○	○	●	○	◐	○	○	○	◐	◐	◐
		Major groundwater development for export	50-100	5-10	Medium	30	◐	■	◐	◐	◐	●	◐	◐	◐	◐	◐	●	●	●
		Dewatering water locally (inc Thurrock)	5-10	1-3	Medium	20-30	○	○	○	◐	◐	◐	○	◐	○	○	○	○	◐	○
	Other schemes	Desalination																		
		Brackish Suffolk/Thames estuaries	5-10	2-5	High	25	◐	◐	○	◐	○	◐	○	●	○	○	◐	◐	●	●
		Effluent re-use (direct - pure)																		
		Newton-le-Marsh - Covenham	15	3-5	High	30	◐	■	□	◐	◐	◐	○	●	○	○	◐	●	○	●
		Effluent re-use (indirect - pure)																		
		Ipswich - Alton Reservoir	30	3-5	High	30	◐	◐	○	◐	◐	◐	◐	●	○	◐	◐	◐	◐	●
		Peterborough - Rutland	30	3-5	High	30	◐	◐	□	◐	◐	◐	◐	●	○	◐	◐	◐	◐	●
		Witham - Essex reservoirs	10	3-5	High	30	◐	◐	○	◐	◐	◐	◐	●	○	◐	◐	◐	◐	●
		Norwich - River Wensum/Costessey intake	30-40	3-5	High	30	◐	◐	□	◐	◐	◐	○	□	○	○	◐	■	●	●
		ASR																		
		Essex Chalk	10-20	5-10	High	15-30	●	◐	○	◐	◐	●	○	●	○	□	●	○	◐	●
		Canal transfer																		
	Transfers	Grand Union transfers to Anglian (Nene)	50-100	1-3	Medium	50+	◐	○	○	◐	◐	◐	◐	○	◐	◐	○	○	◐	◐
		River transfer																		
		Increased TWA transfer (summer)	30	1-2	Low	30	○	○	○	○	○	●	◐	○	●	◐	●	○	◐	◐
		Increased TWA transfer (winter)	300	2-3	Low	30	◐	○	○	□	□	●	◐	◐	◐	◐	●	○	◐	◐
		Transfer across Fens from TWA (rivers)	150	5-10	Medium	30	◐	◐	■	●	◐	◐	◐	○	■	◐	◐	◐	■	●
		Pipeline Transfer																		
		Trent to Rutland raw water transfer (winter)	200	5-10	Medium	30	●	◐	◐	○	◐	◐	○	●	◐	◐	◐	◐	●	●
		Enhanced links Rutland/Grafham (inc Wing)	50	2-3	High	30	◐	●	○	◐	○	◐	○	◐	◐	□	●	◐	●	◐
		Bulk Transfer TWUL (Chigwell) - Anglian	20	2-3	Low	30	◐	○	○	○	○	◐	○	◐	○	○	□	○	○	◐
		Bulk Transfer TVW to Essex	25	2-3	Low	30	●	○	○	○	○	◐	○	◐	□	□	◐	□	□	◐
		Bulk Transfer TWUL (Abingdon) - Anglian	20-50	15-20	Low	30	○	◐	○	○	○	○	○	●	○	□	◐	○	◐	●
		Increased Bulk Transfer Severn Trent/AWS	20	2-3	Low	30	◐	○	○	○	○	◐	○	◐	○	○	○	○	◐	□
		Dewatering water Kent - Essex (rail tunnel)	15-20	10-15	Low	30	◐	□	◐	◐	○	○	○	◐	○	○	◐	◐	◐	◐
		Transfer across Fens from TWA (pipes)	150	5-10	High	30	◐	◐	◐	◐	◐	◐	○	◐	○	○	○	◐	◐	◐
		Transfer across Fens from TWA (tunnel)	150	10-15	High	50	●	◐	◐	◐	◐	□	□	◐	□	□	◐	◐	◐	◐
	Ops	Operational improvements	5	1-3	High	30	□	□	○	◐	◐	◐	□	◐	□	□	□	□	◐	◐
		Conjunctive use	25	1-5	Medium	15-30	◐	○	○	◐	○	●	◐	●	□	□	◐	□	□	□
Demand Management		Leakage reduction[1]		1-5	*3	-	□	□	○	◐	◐	●	□	●	□	□	○	○	○	□
		Rainwater use (new development, non-potable)[4]		1-3	High		◐	◐	○	◐	○	○	○	○	○	◐	◐	■	○	○
		Greywater use (new development, non-potable)		1-3	High		●	●	○	○	○	○	○	●	○	○	●	●	○	○
		Waste minimisation of industrial/commercial		1	*4		○	○	○	◐	○	●	○	●	○	□	○	◐	□	○
		White goods subsidies		1-3	High		□	●	○	●	□	●	□	●	□	□	◐	◐	□	□
		Retrofit of toilets to dual flush/conservation flush			Medium		◐	◐	○	◐	○	●	○	●	○	○	◐	●	◐	○
		Metering (domestic)		10	High	10	◐	●	○	●	○	●	○	●	○	○	●	●	□	○
		Tariffs for measured charges		10+			○	◐	○	◐	○	■	○	●	○	○	◐	●	○	○
		Household Water Audits		1-2	High		●	●	○	●	○	●	○	●	○	○	●	●	□	○

● High
◐ Medium
○ Low

NOTES

[1] Ongoing renewal needed for effective leakage control. [2] Including social safeguards. [3] Leakage reduction costs vary from low to high depending on activity level required.
[4] Industrial and commercial waste minimisation costs vary from low to high depending on site and level of activity.

Table 6.2 **Sustainability criteria applied in 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.

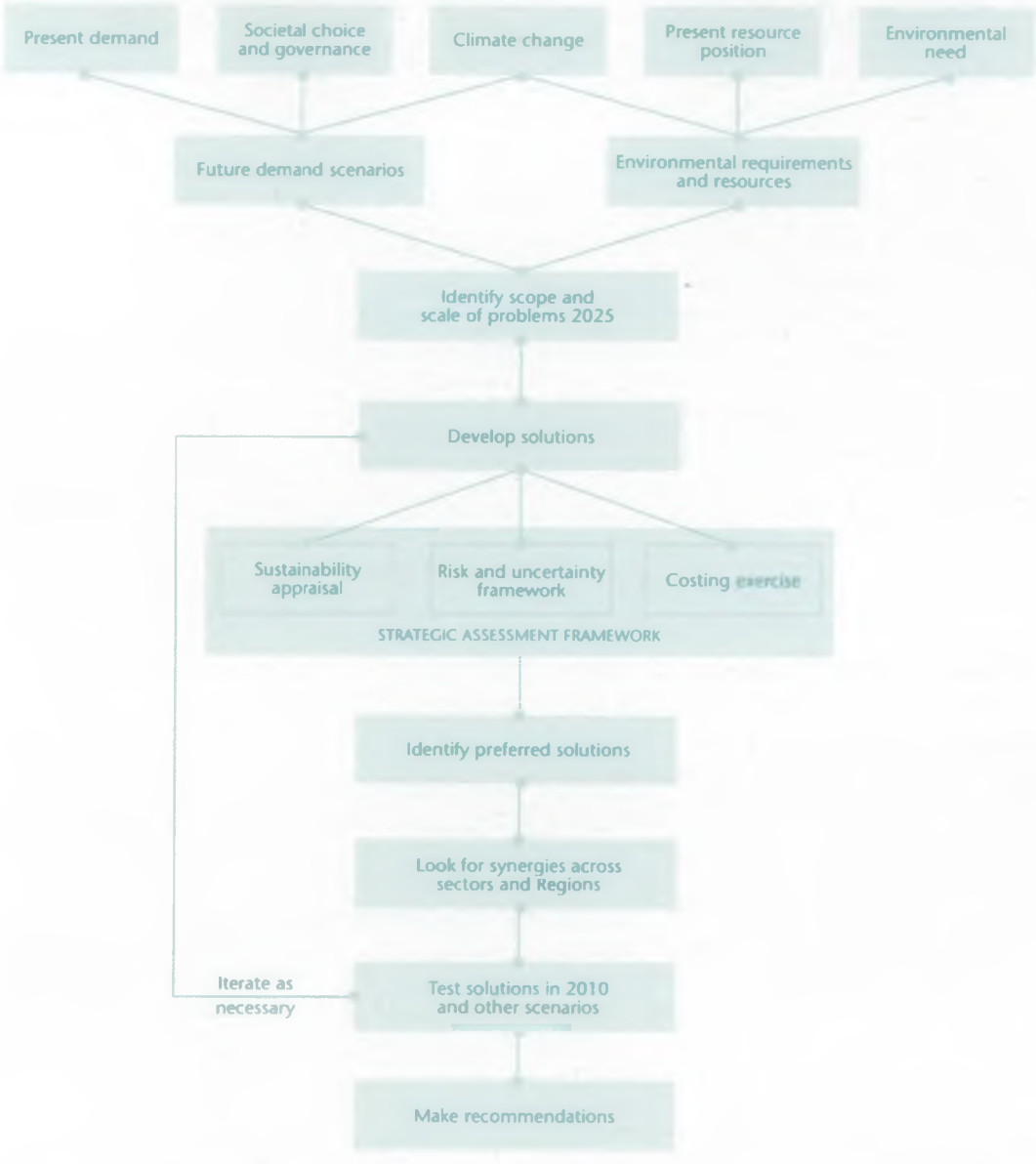
We have not tried to pursue a detailed application of environmental economics. We have considered such a detailed investigation to be inappropriate at this stage of strategy development, although it would be an essential part in the development of schemes to implement our recommendations. Sustainability 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 costs, but also takes account of the other elements in a logical and consistent manner. It is an iterative approach involving the following steps:

Figure 6.1 **The strategy development process**



- identify the options available for meeting any gap between supply and demand. These include both demand management and resource development;
- for 25 years ahead, consider the biggest incremental demand;
- identify a first solution (made up of a set of options) for this incremental demand;
- look at the strengths and weaknesses of this solution; as indicated by the sustainability appraisal and application of risks and uncertainties framework, which included robustness to climate change. How does the set of options perform?
- 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?
- look at the effectiveness of this solution 10 years ahead;
- consider the effectiveness and appropriateness of this solution in the other three scenarios;
- 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. 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, of course, duty bound to consider the costs and the benefits of its proposed actions.

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.

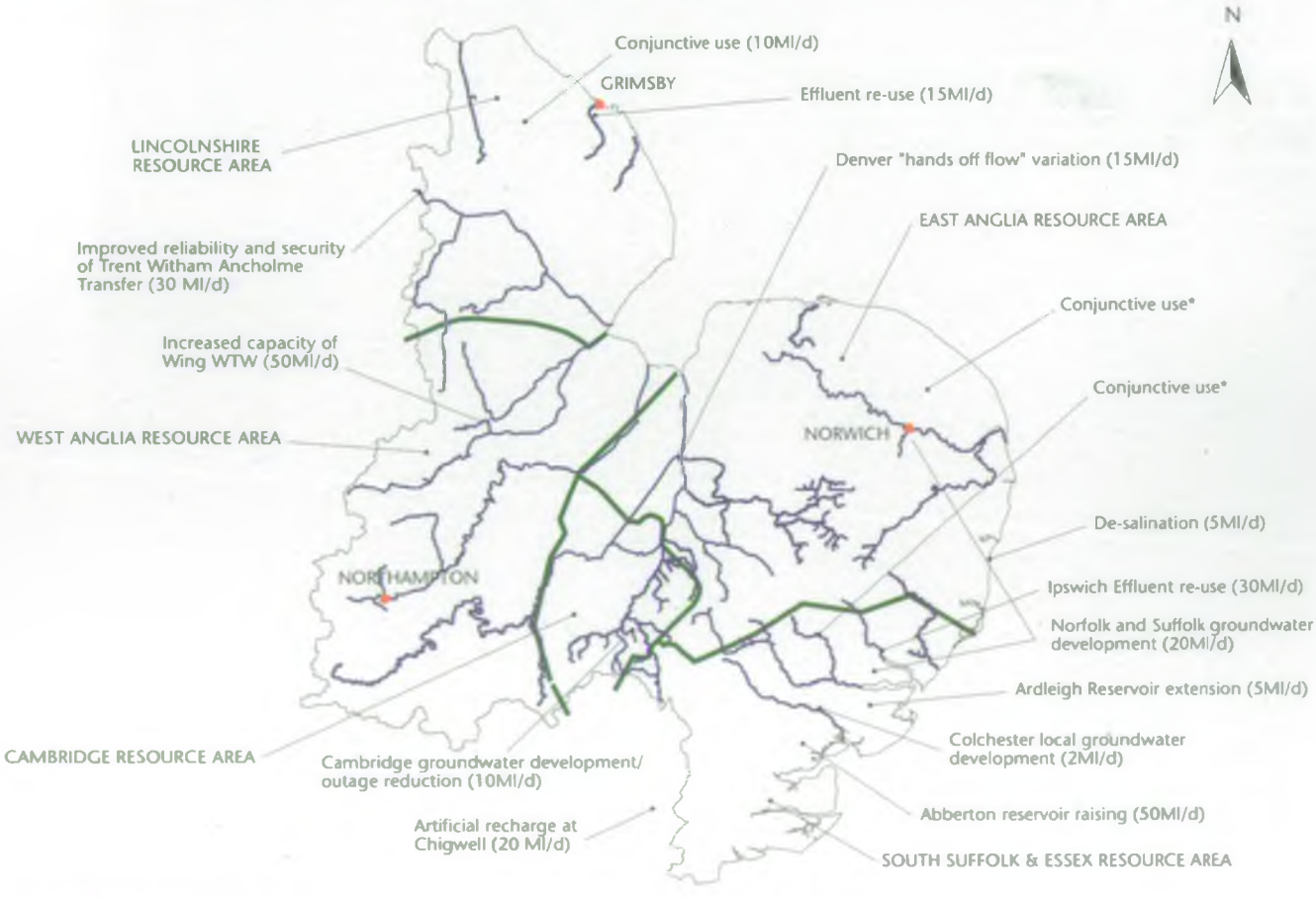
7.1 Water Resources Strategy for Anglian Region

This strategy has been developed as part of a suite of strategies for England and Wales. The process has identified and considered any inter-regional transfer opportunities or other scope for co-operation.

Our recommendations for Anglian Region consist of a combination of resource developments and demand management. Details are given in Table 7.1 and Figure 7.1. This is a genuine twin-track approach. We propose:

- Resource developments that total about 300 Ml/d. These include: the raising of Abberton reservoir, supported by Ely Ouse transfers, extension of Wing

Figure 7.1 Regional strategic solutions



* conjunctive use to provide a combined total of 25Ml/d

Table 7.1 **Regional strategic solutions**

(The areas described are shown on Figure 7.1, and represent natural water resources management areas related to counties as far as possible)

	Ml/d	Timing	Beneficiaries	Description	Sustainability, risk & uncertainty
Lincolnshire					
Public supply demand management	27	Progressive implement-ation from 2000	PWS	Increased household metering. Household and non-household water conservation. Leakage reduction.	Positive contribution to all four sustainability themes. Flexible, progressive implement-ation. Environmental and energy use benefits. High cost and some social un-certainty and risk for metering, to minimise by associated tariffs and advice
Industrial water efficiency		Ongoing	Direct Industry	Waste minimisation with major abstractors	Positive contribution to all four sustainability themes. Integrated waste minimisation benefits and cost savings to businesses. A flexible option that is resilient to climate change, with relatively small risks and uncertainties
Enhanced reliability of Trent-Witham-Ancholme transfer	30	2005	PWS, Agriculture	Increase in daily transfer combined with changes to operating rules to optimise protection of the Humber Estuary SPA whilst transferring additional water to Anglian Region	Positive contribution to all four sustainability themes. Infrastructure is already in place. Key uncertainty is addressing the environ-mental needs of the lower Trent/Humber Estuary
Effluent re-use Covenham	15	2025	PWS	Redirection of Grimsby Effluent (currently discharged to sea) to augment yield of Covenham reservoir. Alternatively may be possible to focus the use to non-potable customers	Less sustainable in terms of energy use. Resilient to climate change and relatively flexible to implement. Promotion and social concerns risks reduced if non-potable Customers targeted
Winter storage	As needed	Ongoing	Agriculture	Individual or joint farm storage reservoirs	Long term sustainable option, positive contribution to all four sustainable development themes. Resilient to climate change, relatively low risk and uncertainty. Joint schemes have greater uncertainty but potential cost advantage
Environmental need	20 100	2010 2025	Environment	Potential reduction in abstraction licences from Sherwood Sandstones, Lincolnshire Chalk and Lincolnshire Limestone	Positive contribution to environment and natural resources, potential negative effects on social and economic progress. Uncertainty regarding quantities minimised by staged approach.
Wetland creation	10	2010-15	Environment	Use of high winter flows to support wetland creation to meet Biodiversity Action Plan targets	Positive contribution to sustainability themes, particularly environment and natural resources. Risk that water and suitable land availability may not coincide

	Ml/d	Timing	Beneficiaries	Description	Sustainability, risk & uncertainty
East Anglia (Norfolk, most of Suffolk and north-east Cambs)					
Public supply demand management	31	Progressive implement-ation from 2000	PWS	Increased household metering. Household and non-household water conservation. Leakage reduction.	Positive contribution to all four sustainability themes. Flexible, progressive implement-ation. Environmental and energy use benefits. High cost and some social un-certainty and risk for metering, to minimise by associated tariffs and advice
Industrial water efficiency		Ongoing	Direct Industry	Waste minimisation with major abstractors	Positive contribution to all four sustainability themes. Integrated waste minimisation benefits and cost savings to businesses. A flexible option that is resilient to climate change, with relatively small risks and uncertainties
Groundwater	20+	Progressive as required	PWS, direct industry, agriculture	Local development only, to meet local needs across all sectors, where resources still available	Sustainable long term option, particularly for social progress and prudent use of natural resources. Risk of adverse environ-mental impacts which would need to be mitigated. Flexible option. Key uncert-ainties arise from stakeholder and public concerns regarding environmental impacts
Desalination	5	2025	PWS	Potential scheme to meet minor local deficit in Suffolk. Link to use of brackish water (and possibly Sizewell power station)	Generally positive contribution to sustain-ability, provided linked to brackish water and off-peak power from Sizewell to optimise energy use. Moderately flexible and resilient to climate change. Risks of environmental impacts and public concerns
Winter storage	As needed	Ongoing	Agriculture	Individual or joint farm storage reservoirs	Long term sustainable option, positive contribution to all four sustainable development themes. Need to allow for environmental needs of small coastal streams. Resilient to climate change, relatively low risk and uncertainty. Joint schemes have greater uncertainty but potential cost advantage
Wetland creation	70	2010-15	Environment	Use of high winter flows to support wetland creation to meet Biodiversity Action Plan targets. Includes areas near coast and fenland locations	Positive contribution to sustainability themes, particularly environment and natural resources. Risk that water and suitable land availability may not coincide

Table 7.1 **Regional strategic solutions** *continued*

	Ml/d	Timing	Beneficiaries	Description	Sustainability, risk & uncertainty
Essex (Essex and south Suffolk)					
Public supply demand management	102	Progressive implement-ation from 2000	PWS	Higher level of metering in water scarce areas. Household and non-household water conservation. Leakage reduction. Opportunities for greywater re-use in new development schemes. Largest suite of measures reflects tight resource situation.	Positive contribution to all four sustainability themes. Flexible, progressive implementation. Environmental and energy use benefits. High cost, social uncertainty and risk for higher level of metering, to minimise by associated tariffs and advice
Industrial water efficiency		Ongoing	Direct Industry	Waste minimisation with major abstractors	Positive contribution to all four sustainability themes. Integrated waste minimisation benefits and cost savings to businesses. A flexible option that is resilient to climate change, with relatively small risks and uncertainties
Increased Ely Ouse transfer	15 15-25	before 2010 after 2010	PWS - ESW PWS - ESW, AWS, THWS	Increased transfer through existing scheme; requires new infrastructure/enhance-ment of links for longer term	Mixed contribution to sustainability themes, less sustainable in terms of operating costs and prudent use of natural resources. Moderate use of existing infrastructure. Opportunities to mitigate some existing impacts, but also uncertainty and risk of new adverse environmental impacts as well as negative public perception. Flexible option with low capital cost.
Abberton reservoir raising	50	2025	PWS	Raise level of existing reservoir, refill partly from local flows, during critical periods will continue to rely on Ely Ouse transfers	A sustainable option provided that potential environmental impacts on reservoir and in Ely Ouse catchment can be mitigated especially during critical periods. Moderate use of existing infrastructure. Moderately flexible, resilient to climate change. Risk and uncertainty attached to promotion time, energy use and public perception
Ardleigh reservoir extension	15	2025	PWS	Extension of storage by gravel working, to make greater use of existing abstraction licence, plus share of additional Ely Ouse transfer	A sustainable option provided that potential environmental impacts associated with Ely Ouse transfer and additional abstraction from river Colne can be mitigated. Relatively low risk and uncertainty for an additional resource option, although some risk over promotion time and environmental impacts. Flexible and resilient to climate change.
Ipswich effluent reuse	30	2025	PWS	Use of effluent either to enhance yield of Alton reservoir, or opportunities to substitute for non-potable industrial supplies	Less sustainable in terms of energy use. Resilient to climate change and relatively flexible to implement. Promotion and social concerns risks reduced if non-potable customers targeted.
Groundwater - artificial recharge Thames region	20	2010	PWS	Scheme based at Chigwell treatment works site, opportunity to use surplus treated water for aquifer recharge	A long term sustainable option providing periods of excess resource are reliable and available. Some negative effects from pumping and energy use. Flexible and resilient to climate change but some uncertainty regarding technology and energy use.
Winter Storage	As needed	Ongoing	Agriculture	Individual or joint farm storage reservoirs	Long term sustainable option, positive contribution to all four sustainable development themes. Need to allow for environmental needs of small coastal streams. Resilient to climate change, relatively low risk and uncertainty. Joint schemes have greater uncertainty but potential cost advantage.
Environmental Need	22 110	2010 2025	Environment	Potential reduction in abstraction licences in Essex and South Suffolk Chalk area.	Positive contribution to environment and natural resources, potential negative effects on social and economic progress. Uncertainty regarding quantities minimised by staged approach.
Wetland creation	40	2010-15	Environment	Use of high winter flows to support wetland creation to meet Biodiversity Action Plan targets.	Positive contribution to sustainability themes, particularly environment and natural resources. Risk that water and suitable land availability may not coincide

water treatment works, enhancements to the yield of the Trent-Witham-Ancholme transfer, some further local use of groundwater and effluent re-use;

- Demand management measures to achieve about 200 Ml/d of savings, primarily through increased metering of households, water conservation and waste minimisation programmes and further reductions in leakage. Further initiatives in industry and agriculture could deliver additional savings.

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 7.2 and 7.3 show our proposed solutions for Anglian Region in 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 either for 2010 or 2025. The top section of the column represents the resource

Table 7.1 **Regional strategic solutions** *continued*

	Ml/d	Timing	Beneficiaries	Description	Sustainability, risk & uncertainty
Cambridge area					
Public supply demand management	10	Progressive implementation from 2000	PWS	Increased household metering. Household and non-household water conservation. Leakage reduction. Opportunities for greywater re-use in new development schemes.	Positive contribution to all four sustainability themes. Flexible, progressive implementation. Environmental and energy use benefits. High cost and some social uncertainty and risk for metering, to minimise by associated tariffs and advice
Industrial water efficiency		Ongoing	Direct industry	Waste minimisation with major abstractors	Positive contribution to all four sustainability themes. Integrated waste minimisation benefits and cost savings to businesses. A flexible option that is resilient to climate change, with relatively small risks and uncertainties.
Operational efficiency	5	2010	PWS	Reduction in outage through measures to secure sources	Positive contribution to sustainability themes. Costs may be high
Groundwater	5	2025	PWS	Re-opening of minor sources, particularly in Greensand	Generally positive contribution to sustainability themes but higher treatment costs than current sources.
Winter storage	As needed	Ongoing	Agriculture	Individual or joint farm storage reservoirs	Long term sustainable option, positive contribution to all four sustainable development themes. Resilient to climate change, relatively low risk and uncertainty. Joint schemes have greater uncertainty but potential cost advantage
Wetland creation	40	2010-15	Environment	Use of high winter flows to support wetland creation to meet Biodiversity Action Plan targets. National Trust Wicken Fen proposal is in this area	Positive contribution to sustainability themes, particularly environment and natural resources. Risk that water and suitable land availability may not coincide

	Ml/d	Timing	Beneficiaries	Description	Sustainability, risk & uncertainty
West Anglia (Primarily Northants, Beds and Bucks plus the Fens of South Lincs and North Cambs)					
Public supply demand management	42	Progressive implementation from 2000	PWS	Increased household metering. Household and non-household water conservation. Leakage reduction.	Positive contribution to all four sustainability themes. Flexible, progressive implementation. Environmental and energy use benefits. High cost and some social uncertainty and risk for metering, to minimise by associated tariffs and advice
Industrial water efficiency		Ongoing	Direct industry	Waste minimisation with major abstractors	Positive contribution to all four sustainability themes. Integrated waste minimisation benefits and cost savings to businesses. A flexible option that is resilient to climate change, with relatively small risks and uncertainties.
Wing water treatment works extension	50	2025	PWS including Three Valleys and Severn-Trent	Extension of water treatment works and transfer infrastructure	Positive contribution to sustainability themes provided Habitats Directive risk of adverse environmental impacts on Rutland Water and Nene Washes/The Wash can be mitigated. Risk over timing and permissions if needs of neighbouring companies lead to early promotion.
Winter storage	As needed	Ongoing	Agriculture	Individual or joint farm storage reservoirs	Long term sustainable option, positive contribution to all four sustainable development themes. Resilient to climate change, relatively low risk and uncertainty. Joint schemes have greater uncertainty but potential cost advantage
Wetland creation	10	2010-15	Environment	Use of high winter flows to support wetland creation to meet Biodiversity Action Plan targets.	Positive contribution to sustainability themes, particularly environment and natural resources. Risk that water and suitable land availability may not coincide

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 represents 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. It can be seen that our proposed strategy ensures that supply meets demand through all four scenarios in Anglian Region for both 2010 and 2025. 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

Figure 7.2 Proposed regional solutions for 2010: Anglian Region

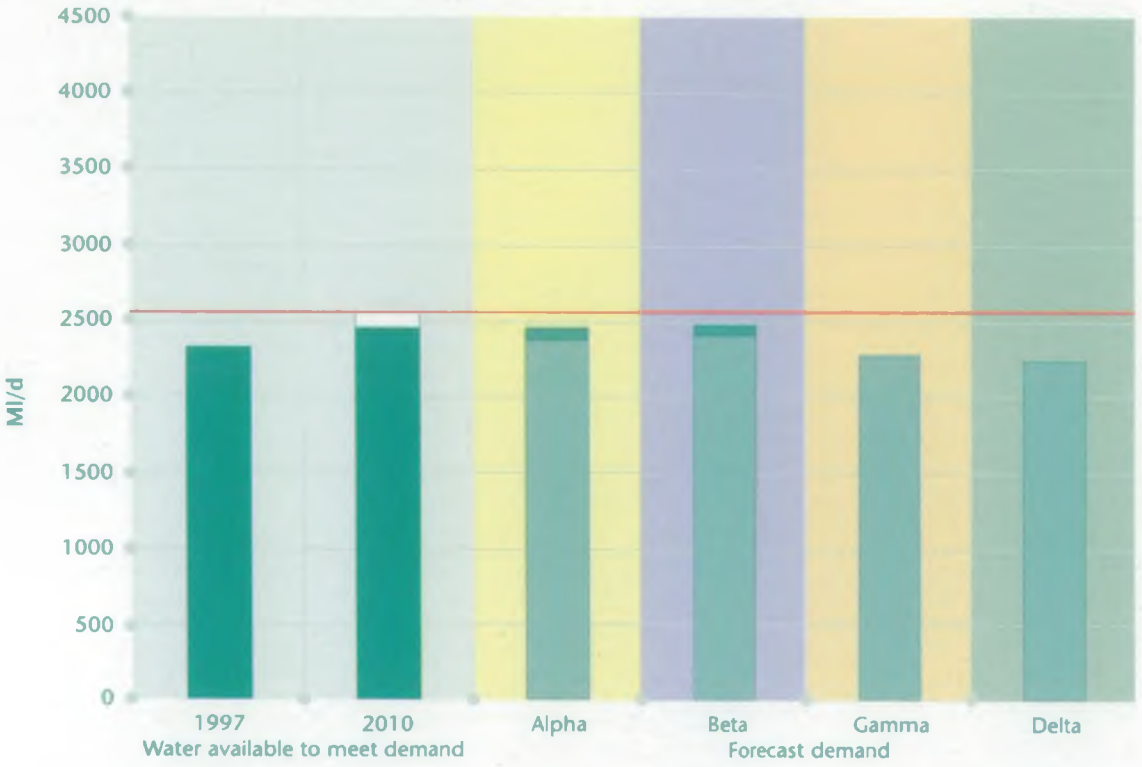
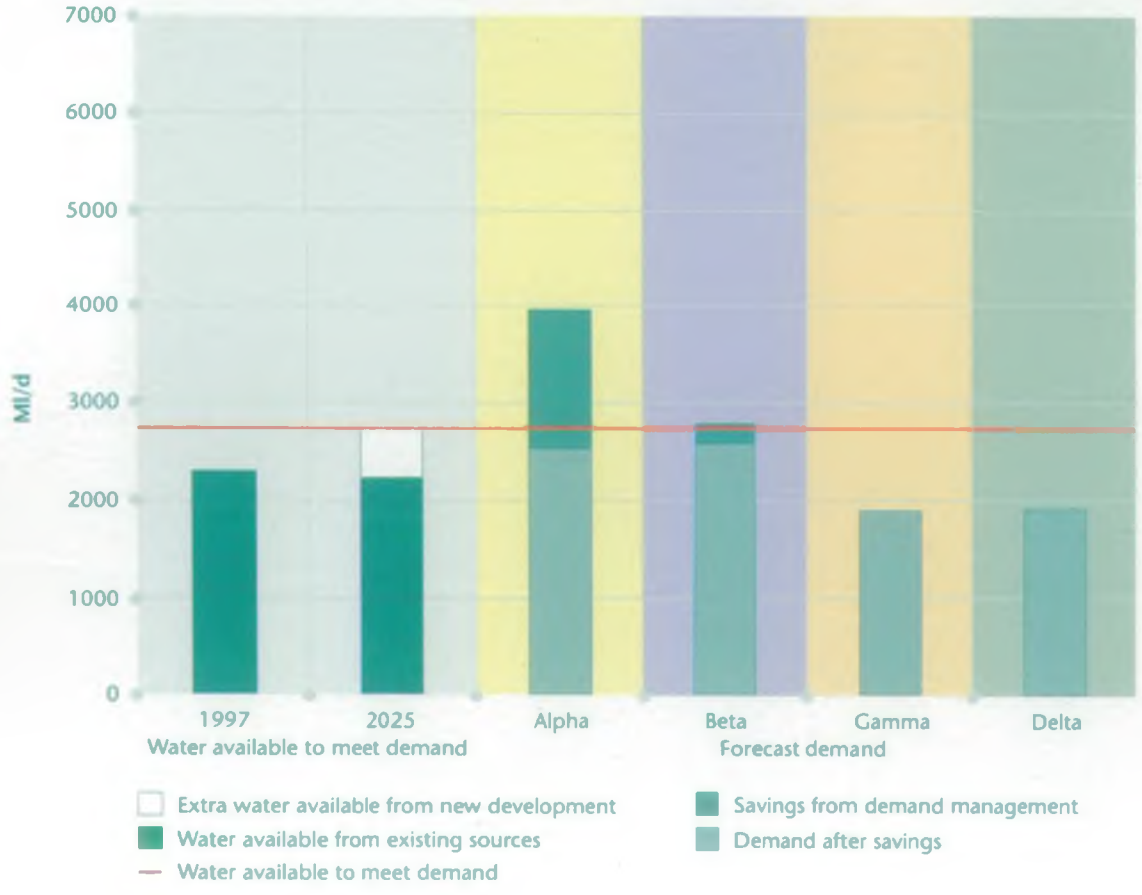


Figure 7.3 Proposed regional solutions for 2025: Anglian Region



affected. This combination of prudent demand management and development of additional resources is a twin-track approach.

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. Anglian Region is one of the driest regions in England and Wales, with limited water resources, high growth in housing and population and an important water environment to protect. We, therefore, believe that Anglian Region should continue to lead the way in managing demands.

In the light of such uncertainties, we have proposed a strategy that is flexible and 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 monitoring progress is essential.

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

7.2 Public water supply

7.2.1 Enhancing resources

We consider that water companies will need to make developments to enhance resources over the period of this strategy. The resource development options that we have selected as a preferred package provide, alongside demand management, locally based solutions where possible. They make best use of existing infrastructure and schemes. They also make use of current abstraction licence entitlements provided there are no unacceptable adverse impacts on the environment. The options 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. **We recommend that where new or existing develop-ments are not fully utilised, water companies should consider sharing this water with others (Action A1).** In Anglian Region, we will consider how any future enhancements to the major water transfer schemes should be allocated between future needs, both for public water supply and other users. For example, enhancement to the yield of our Trent-Witham-Ancholme scheme would benefit farmers as well as public supply and additional transfers through the Ely Ouse to Essex scheme could potentially benefit three water companies as well as agriculture. Enhancements to Anglian Water's Ruthamford system could provide additional security to two other water companies.

Details of our resource development proposals are given in Table 7.1.

Preliminary studies have been made of both yields and environmental impacts for most of the resource development schemes included in our strategy. For example, studies were undertaken prior to the temporary Denver abstraction licence variation in 1997. The water companies also did additional work on the comparison of options in preparing their water resource plans. However, further detailed assessments are still in progress, such as the on-going monitoring of the Denver licence variation or the studies for Anglian Water's Wing water treatment works extension. In other cases, where it is anticipated the need will occur later, detailed studies are not yet commissioned. We cannot be certain that these schemes will be successful until this more detailed work and other assessments, such as the Habitats Directive review of consents, are completed.

We have also considered the two major reservoir proposals provisionally advocated in the 1994 NRA regional strategy - at Feltwell and Great Bradley. Each of these could provide multi-user benefits, and the Agency commissioned some further work on potential agricultural demand from Feltwell during 1996 (Young Agricultural). The water companies also carried out further investigations and appraisal. However, both sites performed poorly on costs, sustainability appraisal and risk and uncertainty. This was especially so in the case of Great Bradley. In addition, the proposals lack a clear promoter at present to lead development. For these reasons we do not recommend either in the preferred strategy.

Minor local development of groundwater is proposed, where this can be done sustainably. It includes limited further conventional use of groundwater in Norfolk and Suffolk, as well as options for artificial recharge in Essex and reconsideration of minor local sources that have closed due to water quality problems elsewhere.

Treated wastewater re-use 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 support a healthy river environment and provide an associated amenity, but also can provide for a range of re-uses to support our quality of life and sustainable economic activity. The Chelmsford re-use scheme now being developed by Essex & Suffolk Water represents one regional example that has recently been granted permission. Further schemes, at Ipswich and in Lincolnshire, are included in our strategy. Re-use can take a variety of forms and we will encourage alternative approaches, such as the Anglian Water scheme to provide a direct alternative supply at Peterborough power station, effectively releasing an equivalent amount of public water supply.

We recommend that work continues on the investigations necessary for the main resource developments included in our strategy. The main developments proposed all require further work to demonstrate whether they are environmentally sustainable. We expect the major beneficiaries to fund and carry out investigations, and to consult widely with the full range of stakeholders in the process. The Agency will ultimately determine the abstraction licence applications where these are needed on the basis of appropriate supporting information. We will expect to see adequate progress on demand management measures ahead of major new resource developments.

In view of the risk of some of the resource development options being constrained by unacceptable environmental impacts, we recommend that the water companies continue to explore viable alternative options. This is especially the case in Essex, where resources are most constrained.

Additional options and residual uncertainties

We have put together an optimum package of options for our strategy, assessed against a wide range of demand scenarios and selected on cost, sustainability, risk and uncertainty criteria. However residual uncertainties remain. For example, the resource development options have yet to undergo final detailed appraisal and could meet genuine barriers to implementation or provide a lower yield.

There are some other resource development options, many of which involve inter-regional transfers, which we believe should be kept under review. These have scored relatively favourably on sustainability and appraisal of opportunities but have other constraints to their development at present. They could, however, be pursued actively if problems arise with some of the options within the preferred package. They would also provide additional options if the restoration of environmental problems requires even more water than currently estimated. These development options are:

A drilling rig engaged in borehole construction at Swanton Morley

- increased bulk supply from Thames Utilities to Essex & Suffolk Water near Chigwell;
- opportunities for transfers or substitution of supplies arising from any future Abingdon Reservoir or other major resource development to the west of the region. Areas supplied by all the water companies in Anglian Region could potentially benefit;
- additional transfers from the Trent;
- transfers via the Grand Union canal system into the upper reaches of the Nene and Great Ouse;
- Lower Witham reservoir in Lincolnshire, which could be supported by Trent transfers;
- further integration of water company supply networks and bulk supplies between companies within the region, to re-direct resources from the west towards the east of the region.

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 regional 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 constrictors as part of water audit would limit the impact of the growth of power showers/ high-volume showers.

In Anglian Region personal water use currently ranges from about 120 to 160 litres of water per person each day. This compares to an average for England and Wales of about 150 litres per person each day. An increase of water efficiency in the home along with a general improvement in awareness of the value of water will not only stabilise our demand but actually reduce it. The techniques and equipment, such as low use showerheads, water efficient washing machines, and drought tolerant gardens, are all well established. Increased metering of houses will also provide an incentive to householders to value water. There are many ways in which customers can be helped and encouraged to save water and at the same time save themselves money. This can be linked with energy savings. Positive action is needed to provide customers with information and advice. In some cases financial incentives are also appropriate, such as discounts for more water efficient washing machines or rain butt offers. Significant progress in household water efficiency has already been made in the last few years in Anglian Region and we recommend continued work.

People need to appreciate the benefits of saving water. 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).

We have calculated that such water efficiency in our homes could save in the order of 85 Ml/d over the next 25 years across the region in the Alpha scenario. It is essential that this saving is delivered and maintained to protect the security of public water supplies.

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 they have to be set within the context of the European single market, it is important that **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 (Action A2).**

In Anglian Region, about a third of the water supplied by water companies goes to commerce, industry and agriculture. Almost all of this use 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 have calculated that water conservation in commerce and industry using public water supply can save up to 50 Ml/d in the region over the next 25 years in the Alpha scenario. It is essential that this saving is delivered and maintained to protect the environment and to secure appropriate water use for everyone. Some successes have already been achieved in the region. For example, the recent waste minimisation campaign in the East Anglian food and drink industry – one of the large sectors with potential for growth – brought about savings of £1.1m and water savings of 69 Ml/year to just 13 participating companies. Benefits in energy savings have also been achieved through reduced pumping and treatment of water. Additional water savings of 79 Ml/year were also identified which we hope will be implemented in future. This project and Lincolnshire waste minimisation 2000 were two of a number shortlisted in the recent national water efficiency awards 2000.

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). In Anglian Region, all the water companies provide waste minimisation advice to such customers. They have also undertaken a variety of targeted projects with their major customers, as well as working in partnership with the Agency and others on integrated waste minimisation schemes. We recommend the continuation and extension of this work, particularly to target small and medium enterprises.

Water efficiency is important in all sectors that use public water supply. Delivering the savings that we propose in this strategy will require widespread adoption of water saving techniques by commerce (including amenity, sport and leisure uses), industry and agriculture. 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).** We will work to achieve best practice standards of water efficiency in Agency offices and facilities, leading by example.

The approach to water conservation should be collaborative, targeted and based on an understanding of costs and outcomes from information reported in the public domain. **The Agency will work nationally and locally with water users and water companies to ensure that water efficiency is delivered. (Action A5).** In Anglian Region we will work with the water companies, regional and local planning authorities, developers and others to promote a wider regional culture of waste minimisation that includes water efficiency as a major element.

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. In much of England and Wales we believe that in the longer term further progress on leakage control will be appropriate. This 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 4). We have assumed that this represents a reasonable goal for leakage in 25 years' time. Achieving progress towards this level will require concerted effort by the water industry, Ofwat, the Agency and Government. If this progress is not achieved, further demand management or resource development will be necessary.

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).** The water companies in Anglian Region have already made some progress in sharing of data and best practice, through a regional technical leakage group. We will continue to support the work of this group. We will also encourage the participation of Ofwat and DETR, and sharing of the findings with a wider audience as appropriate.

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 England and Wales where reducing leakage 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 which may present opportunities for further reductions. In Anglian Region we recommend that all water companies continue their progress on leakage control throughout the region, taking advantage of new technical developments. This could deliver significant further savings, in the order of 85 Ml/d across the region as a whole.

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 Anglian Region is already the highest in England and Wales, with over 40 per cent of customers metered in many parts of the region. The water companies in the region all plan further increases in metering. We believe this is appropriate in view of the region's limited water resources and important water environment. There is support for metering from a wide base of stakeholders and customers in the region, provided appropriate safeguards are made for vulnerable customers

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 on-going 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

Most industrial and commercial water customers are already metered

supplies. A system of tariffs that gives incentives to the efficient use of water will also benefit customers. This would give them the opportunity 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, society and 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).**

The water companies in Anglian Region have collected a considerable amount of data on household water use. In particular, Anglian Water's Survey of Domestic Consumption (SODCON) is well recognised. We will continue to work with the regional water companies through a regional technical group to make further use

of the data collected to improve understanding. This in turn will help target actions to help customers save water in ways that are socially and economically sustainable. Anglian Water has already developed specialist tariffs aimed at assisting single householders and large families who might otherwise be disadvantaged by the standard metering tariff.

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 3.8 million new homes that are envisaged nationally between 2000 and 2021 will all have meters.

We believe that in most of Anglian Region 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 Anglian Region in a strong position to face the challenges of the future, including societal and climate change. 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. Within Anglian Region we recommend this should apply to much of the county of Essex, and particularly the parts supplied by Essex and Suffolk Water.

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.

7.3 Agriculture

We indicated in Chapters 3 and 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. Agricultural demand for irrigation is likely to increase.

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 that needs local solution.

Unfortunately, much of the current and future demand for irrigation water is in parts of the country where local resources are very stretched. Some increased availability of water can be envisaged in certain places, such as the River Ancholme, using increased water from the Trent, and limited amounts of groundwater in parts of the region. However, in most places where farmers may need significant extra irrigation water, none is reliably available.

One option to consider is the potential for agriculture, commerce and industry to benefit from schemes that are developed principally for public water supply. Given appropriate agreements, it may be possible for agriculture to benefit in the short term from public water supply schemes before they are fully utilised. Many such opportunities are local. Where possible, **the Agency will seek to identify opportunities to make water available for agricultural use from existing and new developments (Action A13).** This would include considering the opportunities for agriculture from any future enhancements to the existing Agency transfer schemes in the region, such as the actions proposed to secure the yield of the Trent-Witham-Ancholme scheme.

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 for Wales. We need to allow for radical changes in cropping patterns as well as for adjustments between traditional food crops. **The Agency will work with agriculture to continue to develop indicators of good practice in water use (Action A15).**

The Government has said that it considers 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 may be a condition

Winter storage is a key component of future agricultural water use

requiring abstractors to seek regular certification that their processes have undergone a water waste minimisation audit. Conditions could be included in new licences. We will want to see existing licence-holders co-operating voluntarily with similar good practices.

However, our more general conclusion is that the farming industry must review its own 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 in industry and agriculture dependent on direct abstraction: best practice manual* (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 better understand their use of water around the farm.

Traditional methods, in particular individual or joint development of winter storage, can provide reliable supplies in some 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 are available from MAFF under the Rural Enterprise Scheme for the construction of water storage facilities and the provision of associated equipment. In Anglian Region we are actively working with MAFF and other farming organisations to facilitate the allocation of such grants to farmers.

We recommend winter storage as a key component of the regional strategy for agriculture. We will work with farming organisations, such as MAFF, NFU and CLA, as well as individual farmers, to facilitate development of individual and consortium storage schemes. We will also liaise with others, such as local planning authorities and conservation organisations, to seek wider benefits from such developments where appropriate. The Agency will ultimately determine the abstraction licence applications, where these are needed, on the basis of appropriate supporting information.

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. This applies in particular to areas in the Fens that are managed by Internal Drainage Boards, and where some trading does already occur. **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 (DETR, 2000c). Its decisions on those are expected early in 2001.

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).**

In Anglian Region we will continue to build on close liaison arrangements with the agricultural community, both at regional level and local catchment level, to improve mutual understanding of needs and constraints. We expect our future CAMS process to further facilitate such understanding. Anglian Region has the largest proportion of the existing national irrigation demand and potentially the greatest future growth in demand. We, therefore, also expect to continue to play an important role in national liaison and actions in consultation with the agricultural community and food suppliers.

General agricultural use is a relatively minor component of demand in Anglian Region compared to irrigation. Nonetheless, water saving through simple measures will still be encouraged, particularly in locations where water resources are stressed. We will work with individual abstractors through the abstraction licensing process as well as with farming organisations to achieve this. We will continue to allow for small additional abstractions (under 20 cubic metres/day, 5 Ml/year) wherever possible, subject to local assessment, to meet minor general agricultural needs, such as for small livestock units.

Agriculture and water quality

There are also important opportunities for integrated work within the Agency and with agricultural business to achieve protection of water quality which will be of benefit to water resources and the environment. For example, the establishment of uncropped buffer zones around headwaters and vulnerable stretches of river can reduce siltation and nutrient input from soil erosion.

We also recognise the need to cope with potential surprises. For example, potato brown rot problems occurred in 1999-2000 in parts of the region. This led to a MAFF ban on direct use of river water for irrigation of potatoes in those areas. Where unexpected issues arise, we will work with farmers and other regulators to seek appropriate solutions. We regard on-going close dialogue with the agricultural community as a vital part of managing water resources in this region.

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 water company resources, direct abstraction if available, or opportunistic use of spare water from a nearby declining demand through trading.

Where abstraction comes directly from rivers or groundwater we make the same recommendation as in 7.2.2 above: water efficiency should be positively encouraged (Action A4). The economics of this are less immediate because the cost of raw water is lower than that of public water supply. The monetary savings will depend partly on the degree to which the water has to be treated before use, as well as effluent treatment charges. However, studies have shown that most direct abstractors can make savings 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.

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. In the same way as for public supply customers, integrated waste minimisation can deliver savings across a whole range of inputs such as energy, raw materials, waste and water. For direct abstractors the Agency has the primary responsibility to promote water efficiency. We will use the information in our recent national optimum use R&D report to ensure best practice is promoted through abstraction licensing. We will work with colleagues in other functions of the Agency to promote integrated waste minimisation schemes. We will also help to make the links with water companies, local authorities, developers and other partners to promote water efficiency in this context, and to target key sectors for action.

Integrated waste minimisation can deliver savings in water, energy, raw material and waste : Rugby Cement

7.4.2 Hydropower

In recent years, interest in the development of hydropower schemes has increased, largely in response to UK Government initiatives encouraging the greater use of renewable sources of energy. For hydropower schemes, as with all other abstraction proposals, we will endeavour to work closely with planning authorities and conservation organisations in order to try to prevent

conflicts or duplication between regulators. Hydropower developers need to consider carefully the design of their schemes and the possible environmental impacts. **The Agency will approach proposals for hydropower schemes positively and work constructively with the developers to achieve viable schemes (Action A21).**

We do not currently envisage major growth in hydropower demand in Anglian Region, and will assess any individual proposals through our normal abstraction licensing process.

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).

There are several initiatives already under way to improve our understanding of the environment's water needs and to restore sites that are perceived to be suffering from the impacts of abstraction. These are included in the list of actions that follow.

(1) We will complete the review of the impact of pumping under existing abstraction licences on relevant European conservation sites, as required by the Habitats Directive. In order to maintain international sites in favourable conservation status, we will ensure actions are taken to modify or revoke those abstraction licences which have an adverse effect. A total of 51 sites are under review in this region.

(2) Water companies should complete the investigations and actions required of them under the National Environment Programme to ensure that sites are not adversely affected. A total of 35 sites are included in the Anglian Region. We will continue to facilitate common standards for this process through the Anglian regional steering group with water companies and English Nature.

(3) 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 SSSIs in England (Environment Agency and English Nature, September 1999)

(4) We will draw together information on these and other sites perceived to be at risk from abstraction through our national Restoring Sustainable Abstraction Programme to prioritise and monitor progress on resolving problems.

(5) We will take into account local stakeholders' views on the local water environment needs, both from the LEAPs process and through the future CAMS process. We will aim to improve understanding and build consensus. Conservation needs and other purposes, such as amenity, recreation and navigation will be included. We will give more detailed consideration to how Biodiversity Action Plan targets for key water-dependant habitats in the region may be met, following the joint research undertaken with English Nature and RSPB.

7.6

Navigation

Maintaining water levels for navigation requires sufficient water. In some catchments this is a significant demand. **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).** British Waterways are already in discussion with us regarding proposals for the Grand Union Canal - River Ouse link and Fen Waterways link in Anglian Region.

7.7

Transfers

One important question concerns the need for the large-scale transfer of water around England and Wales. Transfers of water already feature in parts of our strategy. There may be further proposals for new transfers; we will consider these 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.

We have found that most demands for water over the next 25 years can be met by maximising use of existing sources and infrastructure, and by local development of additional resources. However, as set out earlier in section 7.2.1, we do believe that there are a number of future resource options for the region which would be reliant on additional transfers, both within the region and from outside the region. These options would be based on the following transfers:

- increased Ely Ouse transfer from Denver for public water supply in Essex;
- increased bulk supply from Thames Region, either directly to Essex & Suffolk Water near Chigwell or transfer opportunities that will benefit all the region's water companies. Substitution of supplies could arise from any major resource development in the west of the Thames Region;
- increased transfer from the River Trent, either directly to Rutland Water for public water supply, or indirectly through the Trent-Witham-Ancholme scheme to meet agricultural, industrial and public water supply demands in Lincolnshire;
- transfer via the Grand Union Canal to the upper reaches of the River Nene and Great Ouse.

Transfer of water into the River Ancholme at Toft Newton

7.8

Overarching issues

Previous sections have shown the specific actions that we believe necessary for Anglian Region. To facilitate the successful implementation of these actions, we propose the following 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 (Planning Policy Guidance Notes) make clear. **The Agency will work with planners to identify opportunities for water efficiency in new developments (Action A27).** An important part of our strategy for public water supply in Anglian Region is to build on the increasing dialogue with planning authorities, water companies and developers to ensure that all new development in the region takes into account the water resources dimension. There has been much concern in the region in recent years about the sustainability of continued growth in housing and population in terms of a range of impacts, including that on water resources. We have input over the last few years to the revisions of Regional Planning Guidance and County Structure Plans, where water resources has been one of the major issues for debate.

Our strategy shows how it will be possible to meet the proposed new development in the region, whilst protecting and improving the water environment. However, this development will contribute a substantial portion of the region's housing stock over a longer period than our strategy considers. To ensure longer term sustainability there are several vital aspects to address, which require close and continued liaison, both at regional and local level, between the Agency, planners, developers and water companies. Firstly, development should not be committed ahead of secure water supplies. Secondly, the location of development should take into consideration the relative availability of existing developed water resources, where there is a choice on other grounds. In addition, every opportunity should be taken to build water efficiency into new developments, and innovative approaches should be encouraged. Other water resource management measures should be incorporated into new developments, including sustainable urban drainage and waste water re-use

It can take many years to develop a large water resources scheme such as a major reservoir. **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 (Action A28).** At the same time, we will encourage companies to make timely plans and applications for the permissions needed; as will be necessary in the case of Essex and Suffolk Water's proposals for raising the level of Abberton reservoir.

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).** There is much support for this proposal already from stakeholders in Anglian Region, as expressed at the regional event held in November 1999, as well as in responses to the Agency's consultation document.

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 national research topics can be found in Appendix 5.

The Agency will work with others to prioritise and take forward appropriate research and development (Action A30).

There are always opportunities to improve our knowledge and understanding of water use and water needs. The following are key areas where we believe efforts should be focused in the next few years within Anglian Region.

General

(1) The building up of local knowledge, understanding and consensus regarding water resources availability and allocation through the CAMS process.

(2) Improving regional common understanding of water resources by continuing work on stakeholder dialogue with the East of England Sustainable Development Round Table. Key actions include better information sharing and provision across sectors, including the Agency's own data and water company water resources plans.

(3) Climate change effects on resources, demands, the environment and response strategies. Specifically to include following up on the detail of irrigation demands and public supply demands following the current DETR study, and continuing participation in regional cross sector studies.

Environment and resources

(1) A regional programme of work on the water needs of the environment to provide supporting information for CAMS.

(2) Flow naturalisation studies to improve our understanding and assessment of surface water resources.

(3) Continuation of wetlands monitoring (installed after last strategy) and use of the results to improve our understanding and management of these sites.

(4) Refining our understanding of groundwater resources by progressing our technical programme to produce computer models to simulate flows from those catchments underlain by significant groundwater resources. This will inform longer term assessment of resources and availability and how these may be affected by changes in land-use and climate.

(5) Review and improvements to our monitoring networks for both surface and groundwater, to ensure that we gather the information needed to underpin these studies and longer-term resource management.

(6) Using the information gathered from the above programmes to refine our estimates of environmental water needs and deliver changes through the CAMS process in a way that protects the environment and meets the needs of abstractors.

(7) Investigations to improve our understanding of the effects of field drainage on groundwater recharge.

Public water supply

(1) Further work on understanding of household per capita water consumption and the role of metering and tariffs in delivering demand management. Work by individual companies should be shared, building on studies, such as Anglian Water's SODCON, through the regional group of companies in which the Agency participates.

(2) Joint work in the region on Agency demand scenarios, company forecast models and links with regional and local planning authorities on housing and population forecasts.

Agriculture

(1) Research to gain a better understanding of irrigation demands and their link to the rural economy.

Water quality

(1) Integrated approaches with development planners, industry and agriculture are important to protect and improve the quality of our water resources. Protecting the existing water users' interests and those of the water environment through Source Protection Zones, Nitrate Vulnerable Zones, agricultural best practice and other measures is essential. Such measures are also needed to avoid risks from new pollution of groundwater from a variety of causes which lead to costly water treatment and are difficult to remedy.

(2) The continued clean-up of our rivers by the water and sewerage companies under AMP3 investment is a further vital part of making best use of our scarce water resources. Many of our rivers are dependent on well-treated effluents to maintain flows during summer. Recent improvements in treatment standards have also opened up new or better opportunities for water resources management. The recently approved Chelmsford effluent recycling scheme has only been possible through modern treatment processes. The continuing improvements in River Trent water quality bring benefits to our rivers as well as enabling a wider range of uses to be made of the transferred water.

7.9

Conclusions

There are many benefits associated with this strategy. It provides a robust series of actions that help to ensure adequate supplies of water are available across all sectors. Many of the actions 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. The appraisal has been carried out by the independent consultants ERM, employed by the Agency for this purpose. 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.

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 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 its proposals.

We have put together an optimum package of options for the Anglian Region strategy, assessed against a wide range of demand scenarios and selected on cost, sustainability, risk and uncertainty criteria. Our strategy is a twin-track approach that should be robust against future uncertainties. We show that effective control of public water supply leakage, increased domestic metering and simple water efficiency measures across all sectors can make a major contribution to stabilising future demands. At the same time, some resource developments will still be needed, particularly to meet needs in Essex. Where possible, we recommend actions that make use of existing infrastructure.

However, residual uncertainties remain. For example, some of the resource development options contain unknowns and could meet genuine barriers to implementation. Due to the existence of such uncertainties, we have proposed a strategy that is

flexible and phased. The final decisions on some of the later actions need to be made some way into the future, when there should be more certainty about the result of earlier actions. This means that the monitoring of progress is essential and we will report on this annually.

Table 7.2 **Sustainability appraisal of Water Resources Strategy**

		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	
Proposed options	Water figures Ml/d	Positive impact	Negative Impact	Positive impact	Negative Impact	Positive impact	Negative Impact	Positive impact	Negative Impact
Increased household metering		+	0	+	0	+	-	+	-
Ardleigh Reservoir extension	5	(+)	(-)	+	-	+	(-)	+	-
Desalination (brackish water)	5	+	(-)	+	(-)	0	0	0	-
Outage reduction for groundwater sources	5+10	+	(-)	+	(-)	0	(-)	0	(-)
Transfer and Denver hands off flow variation (based on assessment of "cost and benefits" by Regional Staff)	15	0	-	0	-	0	(-)	0	-
EITHER: Artificial Recharge	20	+	0	+	-	0	0	+	0
OR: Aquifer Storage and Recovery	20	+	0	+	-	0	0	+	0
Additional use of groundwater (Option 10)	10+10	0	(-)	+	(-)	+	(-)	+	(-)
Conjunctive use in Anglian Water N/E Zones	10+25	(+)	0	+	0	+	0	+	0
Higher level of metering in water scarce areas	22	++	0	++	0	+	--	++	-
Trent-Witham-Ancholme river transfer (op 4)	30	(+)	(-)	+	(-)	0	0	0	(-)
White goods	[illegible]	+	0	+	0	+	0	+	-
Water audits - domestic	36+50	+	0	+	0	+	0	+	0
Water use minimisation	38+64	+	0	++	0	0	0	+	0
Effluent re-use schemes (Option 9)	45	0	-	++	-	0	-	+	-
Increased capacity at Rutland (Option 6)	50	0	-	0	-	+	0	(+)	-
Abberton Reservoir (Option 2)	50	+	-	+	-	+	(-)	+	-
Leakage reduction	85	+	(-)	++	0	+	0	+	-

KEY:

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

Table 7.2 **Sustainability appraisal of Water Resources Strategy** *continued*

Availability of water resources in the Anglian Region is increasingly recognised as one of the region's key sustainability issues. The sustainability appraisal of the proposed basket of options shows that the options are generally positive in terms of promoting the core themes of sustainable development and in balancing environmental, economic and social considerations.

Most of the options have positive effects on environmental protection and prudent use of natural resources. This is particularly true for the demand management options, such as water audits and water use minimisation, which Anglian Region has focused on in order to meet a significant portion of its water requirements (245 Ml/d from all demand management options).

There are some possible negative impacts in terms of environmental protection and prudent use of natural resources associated with Abberton reservoir and potential negative impacts on water levels associated with abstraction from the Rutland reservoir, which may require actions to mitigate these effects. The Abberton option may have impacts on the Habitats Directive sites linked to the Ouse estuary and the Wash, while mainly temporary negative impacts (on landscape and water quality) are expected in relation to the construction phase at Rutland.

In terms of 'social progress', the proposed options are generally positive, with the exception of the higher level of metering in water scarce areas option for 2025 (and to a lesser degree the increased household metering option). However the negative social impacts of these options will greatly depend on the pricing policy and are likely to impose lower costs than major new infrastructure investments.

8 Actions and the way forward

In this strategy we have described the framework for the management of water resources, the pressures that we expect, and the conclusions that we have drawn. Here we summarise our recommendations and look at 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 Anglian 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.

In Table 8.1 we summarise our recommendations and the groups that are involved in their implementation.

8.2 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 in Anglian Region.

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

Groundwater resources assessment detail

There are a number of methods for assessing resource availability. To obtain full understanding of resources requires complex catchment simulation models, dealing with both groundwater and surface water in an integrated way. We already have such models for some of the resources in Anglian Region. In addition, we have embarked on a programme over the next 10 years of investigations and modelling for all the major aquifer units in the region.

The groundwater investigations programme will deliver tools for more advanced understanding and management of resources at the catchment level. It will also provide a framework for local investigation of issues and options for resolving abstraction related problems. It will provide an important technical foundation to aid future CAMS work.

The information presented in this strategy is based on simpler methods to present a broad picture of the status of water resources. We have used an annual water balance method, as applied in our 1994 strategy.

Figure A1.1 shows schematically how the region's groundwater resources are assessed and "balanced out" between the needs for abstraction and the needs of the rivers. Note that this is a grossly simplified "water accountancy" procedure. The availability of water at any one spot or from any one groundwater unit will always be subject to local evaluation.

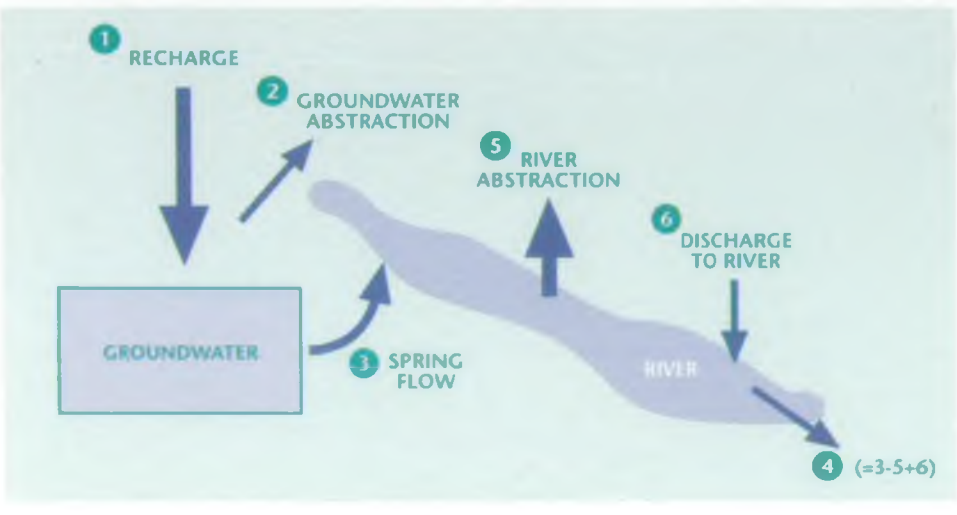
The procedure shown in Figures A1.1 (and A1.2) works as follows:-

1. Long average recharge (1) is assessed by reference to groundwater models (where available), records of river flows and abstractions. It is checked against analysis of effective rainfall, catchment areas and geology .The long average recharge is referred to as the "gross resource". As far as possible, recharge estimates have been based on 1961 -1990 standard period.

2. The gross resource is reduced to reflect the inadequacy of aquifer storage in order to fully even out the year to year variations in recharge. Typical reductions are 20 per cent for chalk catchments, 40 per cent for limestone. These are empirical factors, based on experience, and may be subject to review. The reduced quantity is referred to as "effective resource"; it is this which is reliably available for allocation either to abstraction (2) or to the environment (4).

3. The environmental requirement for groundwater (4) is assessed. This is primarily the minimum required river flow. Ideally, this might involve detailed ecological studies, but no satisfactory objective method is yet available. In its absence, current practice is to use the natural 95 percentile flow (ie the flow which, in the absence of any abstractions or

Figure A1.1 **Groundwater balance methodology**



discharges, would be equalled or exceeded 95 per cent of the time).

In some cases an additional environmental allocation is made to prevent saline intrusion. This is presently based on the surface area of the unit, and requires refinement.

4. In practice, river flows are sustained by treated sewage effluents (6), and reduced by abstractions (5). These are quantified and the allocation to the river from groundwater (3) is adjusted accordingly. Abstractions are taken as the annual average licensed quantity. Reliable effluents are taken as 75 per cent of their normal dry weather flow, to account for reduced water usage in drought conditions.

5. The quantity allowable for abstraction (2) is the effective resource minus this allocation of groundwater to the river (3).

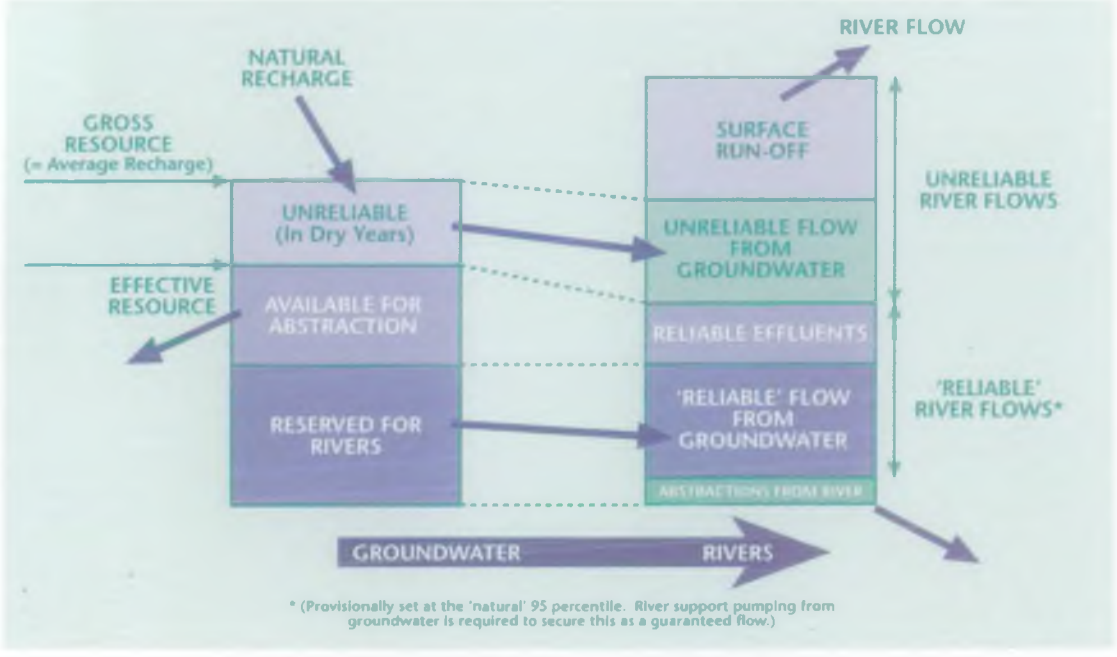
6. The quantities thus allocated to the river are the natural 95 percentile flow plus the remaining 20 per cent (or 40 per cent) of "unreliable" recharge, plus all surface runoff. (Note that this leaves a river with naturally varying flow characteristics. If a sustained minimum flow is required, river support pumping is necessary. The method of allocating the resource leaves sufficient for this purpose up to the natural 95 percentile flow).

Fig A1.2 shows how the method allocates the groundwater resource between abstractions and the river, and the resulting components of river flow.

The results of the assessments are shown on Table A1.1 leading to a tabulation of the balance of nominal over- or under-abstraction in each unit. However, these nominal figures must be interpreted in the light of the comments included within the table.

The underlying presumption in this method of assessment is that as resource development increases, river flow support will be needed to deliver environmental flows at the right time and place. This can come from large schemes such as the Agency's groundwater schemes in the Lodes-Granta and Rhee catchments, or by smaller developments required as a condition of individual licences. Whilst our under-standing of groundwater increases, local river support schemes would still be considered as an option. The Agency would need to be satisfied that this would be the most appropriate option to contribute to the four themes of sustainable development.

Figure A1.2 **The allocation of groundwater to rivers**



Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
	Lincs Limestone							
N1	Northern Limestone	92.0	55.2	36.4	30.9	-12.1	committed	
N2	Central Limestone	80.0	48.0	23.8	22.0	2.2	committed	Increases in abstraction from the Limestone are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
N3	Southern Limestone	143.4	86.0	41.4	88.3	-43.7	committed	The large deficit reflects a possibly unrealistically high environmental allocation due to the characteristics of the river flow. However, problems are anticipated if abstraction reaches full licensed volumes
	Lincs Chalk and Sandstone							
N4	Spilsby Sandstone	68.0	68.0	38.7	36.7	-7.4	committed	Concerns over sustainability are based on a continuing decline in groundwater levels. Problems are anticipated if abstraction reaches full licensed volumes
N5	Southern Chalk	105.0	28.0	38.8	1.0	-11.8	committed	
N6	Northern Chalk	245.0	196.0	23.0	180.8	-7.8	committed	This aquifer has historically been over-licensed and actual abstractions are managed by reference to a groundwater model in order to ensure that the situation remains sustainable with regard to groundwater quality
	Central Area Chalk							
C1	Ouzel Chalk	35.0	28.0	8.3	8.9	10.8	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a surplus. The surplus is viewed with caution because firstly, there is a large volume of effluent and it may not be wise to plan to rely on such high effluent flows in future and secondly, this unit overlaps with Thames Region which may rely on groundwater resources in this unit
C2	Ivel Chalk	118.8	95.0	6.0	37.3	51.7	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a surplus. The surplus is viewed with caution because firstly, there is a large volume of effluent and it may not be wise to plan to rely on such high effluent flows in future and secondly, this unit overlaps with Thames Region which may rely on groundwater resources in this unit
C3	Rhee Chalk	70.5	56.4	18.8	37.6	0.0	committed	
C4	Cam Chalk	65.5	52.4	0.0	63.7	-11.3	committed	
C5	Granta Chalk	33.4	26.7	3.9	16.3	6.5	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a surplus. This is in order to protect river flows which remain low during drought periods even though there is river support in this catchment

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
C6	Cambridge Chalk	2.9	2.3	0.0	0.4	1.9	committed	The environmental allocation is zero because total effluent flow is greater than the combined total of surface water spray irrigation abstraction and the river 95 percentile. Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment.
C7	Lodes Chalk	84.9	67.9	15.3	57.9	-5.3	committed	
C8	Lark Chalk	159.4	127.5	44.5	84.1	-1.1	committed	
C9	Little Ouse Chalk	263.4	210.7	132.0	85.4	-6.7	committed	
C10	Wissey Chalk	177.7	142.2	69.4	54.5	18.3	available	The resource balance indicates that there is a surplus of Chalk groundwater and increases in abstraction from the Chalk may be acceptable. However, there are large areas where increases in abstraction from the Chalk are not acceptable as local river flows could be adversely affected
C11	Nar Chalk	87.4	69.9	43.5	21.8	4.6	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment in particular the river which is a riverine SSSI
C12	Babingley Gaywood Chalk	72.5	58.0	30.1	27.4	0.5	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment.
C13	North West Norfolk Chalk	14.9	11.9	2.1	3.5	6.3	available	The resource balance indicates that there is a surplus of Chalk groundwater and increases in abstraction from the Chalk may be acceptable but only if abstraction does not cause adverse impact to the coastal marshes to the North
	Lower Greensand							
C14	Sandringham Sands including Carstone	74.4	74.4	27.8	35.7	10.9	available	The resource balance indicates that there is a surplus of Sandringham Sands and Carstone groundwater and increases in abstraction may be acceptable only if local wetlands are not adversely affected
C15	Cambs Woburn Sands	19.1	19.1	2.9	13.8	2.4	committed	Increases in abstraction from the Woburn Sands are not acceptable despite the water balance showing a small surplus. This is a precautionary decision. The groundwater table is rising as existing licences are not being fully utilised. This situation may change if licensed abstraction is resumed. if licences are revoked the groundwater balance can be reviewed
C16	Sandy Woburn Sands	43.3	43.3	0.0	24.2	19.1	committed	The resource balance indicates that there is groundwater available. However, increases in abstraction from the Woburn Sands are not acceptable in order to protect local wetland sites and existing users in this and the adjacent Leighton Buzzard Unit
C17	Leighton Buzzard Woburn Sands	11.0	11.0	0.0	18.7	-7.7	committed	

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
C18	Bedfordshire Oolite				18.0			This aquifer is local and discontinuous and therefore a surplus/deficit calculation is inappropriate. Small abstractions may be acceptable where the groundwater is shown to be locally available without adverse effect on the water environment or existing abstractors
E1	North Norfolk Chalk							**Protection of the groundwater flow to the coastal marshes is a major factor in local impact assessment**
34/1	River Hun & Coast	16.7	13.4	5.7	1.5	6.2	available	
34/2	River Burn	24.6	19.7	11.2	2.2	6.3	available	
34/3	River Stiffkey	34.8	27.8	14.5	10.3	3.0	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/4	River Glaven	37.8	30.2	23.0	8.0	-0.8	committed	The deficit does not reflect a larger amount of abstraction relative to other units so much as a high environmental allocation due to the groundwater fed characteristics of the river flow
34/5	River Mun	21.1	16.9	9.5	7.7	-0.3	committed	
E2	Bure and Ant Chalk							**Deficits do not reflect a larger amount of abstraction relative to other units so much as a high environmental allocation due to the groundwater fed characteristics of the river flow**
34/6	River Bure above Horstead	135.6	108.5	100.1	16.7	-8.3	committed	
34/7	Spixworth Beck	16.7	13.4	9.0	3.7	0.7	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/8	River Ant above Honing Lock	21.0	16.8	14.3	5.5	-3.0	committed	
34/9	River Bure, Horstead to Ant confluence & River Ant below Honing Lock	33.7	27.0	15.4	20.8	-9.2	committed	
E3	Wensum and Yare Chalk							**The high environmental value of these rivers together with the vulnerability of the lower end of the unit to saline incursion means that new abstractions are subject to rigorous assessment of local impacts - which can often be significant**
34/11	River Wensum	234.6	187.7	74.5	38.9	74.3	available	

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
34/12	River Tud	15.7	12.6	3.3	2.5	6.8	available	
34/13	River Yare above Norwich	63.4	50.7	12.8	21.5	16.4	available	
34/14	River Tas	37.7	30.2	11.5	14.3	4.4	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/15a	Tidal River Yare below Norwich (Chalk)	38.4	30.7	12.9	21.8	-4.0	committed	
E4	Waveney Chalk							
34/16	River Waveney above Billingford	21.9	17.5	2.3	12.0	3.2	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/17	River Dove	29.9	23.9	5.2	13.9	4.8	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/18	River Waveney Billingford to Ellingham	51.0	40.8	12.5	15.5	12.8	committed	Surplus resource provides underflow to the confined Chalk of the Tidal River Waveney.
34/19a	Tidal River Waveney above Aldeby	4.9	3.9	5.6	21.0	-22.7	committed	
E5	Blyth/Alde Chalk							
35/2a	River Blyth (Chalk)	9.1	7.3	3.0	6.2	-1.9	committed	
35/4a	River Alde/Ore (Chalk)	21.1	16.9	5.7	8.8	2.4	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
E6	Deben Chalk							**Despite the river support scheme unacceptably low flows are often experienced and the Agency is actively seeking to improve river flows**
35/6	River Deben	25.5	20.4	7.3	10.9	2.2	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
35/7	River Fynn/Lark	7.1	5.7	0.3	6.6	-1.2	committed	
E7	Gipping Chalk							**Groundwater abstractions are known to deplete river and spring flows and the Agency is actively seeking improvement**
35/8	River Gipping	57.7	46.2	6.7	42.3	-2.8	committed	

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
35/9	Belstead Brook	4.2	3.4	0.0	7.7	-4.3	committed	
35/10a	Felixstowe Peninsula (Chalk)	0.0	0.0	8.6	3.5	-12.1	committed	
E8	Stour Chalk							**Groundwater abstractions are known to deplete river and spring flows. The apparent surplus in the upstream sub-units is useful for meeting the large deficits in some of the downstream ones**
36/11	Upper River Stour	47.9	47.9	9.0	19.2	19.7	committed	Surplus resource provides underflow to the confined Chalk of the Lower Stour
36/12	River Glem	17.5	17.5	5.6	0.1	11.8	committed	Surplus resource provides underflow to the confined Chalk of the Lower Stour
36/13	Chad Brook	10.4	10.4	3.2	0.1	7.1	committed	Surplus resource provides underflow to the confined Chalk of the Lower Stour
36/14	Belchamp Brook	9.5	9.5	3.6	0.1	5.8	committed	Surplus resource provides underflow to the confined Chalk of the Lower Stour
36/15	Lower River Stour	3.4	3.4	0.0	57.2	-53.8	committed	
36/16	River Box	3.0	3.0	0.8	0.7	1.5	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
36/17	River Brett	30.8	30.8	7.0	18.8	5.0	committed	Increases in abstraction from the Chalk are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
36/18	Stratford/Flatford	0.0	0,0	0.0	8.3	-8.3	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit.
36/19	Stour Estuary	0.0	0.0	6.9	18.3	-25.2	committed	The gross resource is zero because the aquifer is confined throughout this unit, the environmental allocation consists solely of an amount to prevent saline intrusion
E9	Mid Essex Chalk							**Groundwater abstractions are known to deplete river flows. The apparent surplus in some of the upstream sub-units is useful for meeting the large deficits in some of the downstream ones**
37/21	River Colne 37/21	14.1	14.1	0.0	7.3	6.8	committed	The environmental allocation is zero because total effluent flow is greater than the combined total of surfacewater spray irrigation abstraction and the river 95 percentile. Surplus resource provides underflow to the confined Chalk
37/22	River Colne 37/22	1.2	1.2	0.0	0.2	1.0	committed	The environmental allocation is zero because total effluent flow is greater than the combined total of surfacewater spray irrigation abstraction and the river 95 percentile. Surplus resource provides underflow to the confined Chalk
37/23	River Colne 37/23	0.0	0.0	0.0	18.7	-18.7	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
37/24	River Colne 37/24	0.0	0.0	0.0	0.3	-0.3	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit
37/25	River Colne 37/25	0.0	0.0	0.0	0.1	-0.1	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit
37/26	River Colne 37/26	0.0	0.0	0.0	0.2	-0.2	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit
37/31	Rivers Blackwater /Chelmer 37/31	16.0	16.0	6.3	25.3	-15.6	committed	
37/32	Rivers Blackwater /Chelmer 37/32	0.0	0.0	0.0	2.9	-2.9	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit
37/35	Rivers Blackwater /Chelmer 37/35	5.8	5.8	0.0	5.9	-0.1	committed	The environmental allocation is zero because total effluent flow is greater than the combined total of surfacewater spray irrigation abstraction and the river 95 percentile
37/39	Rivers Blackwater /Chelmer 37/39	0.0	0.0	0.0	1.6	-1.6	committed	The gross resource and environmental allocation are zero because the aquifer is confined throughout this unit
E10	Thameside Chalk							**Confined conditions exist across the unit, recharge is limited and any further abstraction would be unsustainable**
37/43	Crouch/Thameside 37/43	0.0	0.0	0.0	1.5	-1.5	committed	
37/44	Crouch/Thameside 37/44	0.0	0.0	0.0	1.1	-1.1	committed	
37/56	Crouch/Thameside 37/56	9.3	9.3	0.0	23.7	-14.4	committed	
E11	Norfolk Crag							**In many Crag units there is insufficient data to generate a realistic environmental allocation; the data that does exist is Chalk influenced and therefore probably an underestimate. As a result the licensing policy has to be precautionary and decisions place greater emphasis on an assessment of local impacts**
34/10A	River Thurne	14.8	11.8	5.9	1.0	4.9	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. There is concern that the sub-catchment could be vulnerable to saline intrusion not yet accounted for in the balance and this merits further investigation. This is a precautionary decision in order to protect the environment.
34/10B	Ormesby and Filby Broads	13.7	11.0	7.0	6.6	-2.6	committed	

Map ref.	Name of groundwater management unit	Gross Resource	Effective Resource	Environmental Allocation	Licensed Abstraction	Surplus	Licensing Policy	Comments (all policies will be reviewed as part of the current Catchment Abstraction Management Strategies [CAMS] process)
34/10C	Lower River Bure, South Walsham to Acle	9.0	7.2	2.6	1.6	3.0	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
34/15B	Tidal River Yare below Norwich (Crag)	3.3	2.6	5.5	1.2	-4.1	committed	
34/19B	Tidal River Waveney below Aldeby	32.3	25.8	11.4	3.5	10.9	available	
E12	Suffolk Crag							In many Crag units there is insufficient data to generate a realistic environmental allocation; the data that does exist is Chalk influenced and therefore probably an underestimate. As a result the licensing policy has to be precautionary and decisions place greater emphasis on an assessment of local impacts
35/1	Lothingland Hundred	16.7	13.4	9.1	1.8	2.5	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
35/2b	River Blyth (Crag)	19.4	15.5	1.6	4.0	9.9	available	Although increases in abstraction may still be accepted subject to an assessment of local impacts, this unit contains some environmentally valuable sites and a review of the current policy may be needed
35/3	River Yox	13.6	10.9	3.3	6.9	0.7	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
35/4b	Rivers Alde/Ore (Crag)	8.5	6.8	1.4	1.3	4.1	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
35/5	Tidal Rivers Alde/Ore	31.0	24.8	10.6	7.9	6.3	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision pending a review of the environmental allocations of the rivers Butley,Tang and Hollesley Black Ditch
35/10b	Felixstowe Peninsula (Crag)	37.0	29.6	24.9	3.4	1.3	committed	Increases in abstraction from the Crag are not acceptable despite the water balance showing a small surplus. This is a precautionary decision in order to protect the environment
Not on map	Minor Aquifers							Across the region there are numerous localised and discontinuous sand and gravel deposits; a single surplus/deficit calculation is therefore inappropriate. Small abstractions may be acceptable where the groundwater is shown to be locally available without adverse effect on the water environment or existing abstractors.

Appendix 2
Climate change

A2.1

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 20th 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 throughout 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.

A2.2

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 there will be more winter rainfall and less summer rainfall throughout southern and midland England and all of Wales. 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 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.

A2.3

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.

A2.3.1 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. The definitive study looking at this was carried out by Herrington (Herrington, 1996). 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 the 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 the scenario Beta to the others 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 Anglian Region, this has a total effect on public water supply demand of 27 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. Indoor livestock units may require cooling, adding an additional demand for water.

To provide indicative estimates of the potential impact of climate change on current optimum irrigation needs, we commissioned Cranfield University at Silsoe to develop and apply a new methodology. This builds on the concept of agro-climatic zones, defined as areas with common climatic conditions that will lead to similar crop growth patterns. The analysis indicates that, for the eight crops studied, optimum irrigation need

would increase at the six study sites considered. The magnitude of the increase varies quite markedly in relation to the climate change scenario. For example, for main crop potatoes in Norfolk, the increase above current optimal levels is between five and 14 per cent. The range of potential increases based on data for climate stations at Wattisham and Silsoe within Anglian Region are shown in Table A2.1. The DETR study of the demand for water will build further on our preliminary results.

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.

Within Anglian Region, the two areas of demand that are of greatest concern in relation to climate change are irrigation demand and public water supply demand, particularly for garden watering. These are already significant demands in the region as a result of the dry climate.

A2.3.2 Availability of water

Changes in climate will change flow regimes and therefore the water available 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.

Table A2.1 Potential increases in optimum irrigation need

Crop	Average year % increase	Dry year % increase
Maincrop potatoes	18%	12%
Carrots	26%	19%
Sugarbeet	27%	22%

Note:- based on data for climate stations at Wattisham and Silsoe

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. Detailed catchment modelling is required to understand the effect of a particular change in climate in a specific location.

Anglian Region Resources

Predicting the effects of climate change on water resources at the Anglian Region level is still an uncertain and developing science. However, considerable progress has been made since the previous strategy was published in 1994, in work commissioned by the Agency and others. The predicted effects on resources in the region vary across the standard range of climate change scenarios, but common features are:

- An increase in annual rainfall;
- An increase in annual potential evaporation;
- Increased seasonality of rainfall, with wetter winters and drier summers;
- Increased winter flows and decreased summer and early autumn flows for both surface and groundwater-fed rivers;
- Overall limited change to average annual resources for both surface and groundwater, but with small increases under most scenarios;
- Increased frequency of dry summers (e.g. 1976), but little or no change to the frequency of longer multi-year droughts (e.g. 1989-1992).

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 depends on the magnitude and duration of dry periods, as well as the frequency 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.

Preliminary analysis by the water companies in Anglian Region has shown little or no impact of climate change on their sources when modelled using existing licence conditions and constraints.

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

A2.3.3 The 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 per cent 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 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.

A2.4 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 have 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, whilst 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.

Within the Anglian Region there are a number of relevant studies in progress and important centres of expertise at the University of East Anglia (UEA) in Norwich and Cranfield University near Bedford.

There are two significant studies in the region looking at cross-sectoral impacts of climate change and response strategies. The regional climate change impact and response studies in East Anglia (RegIS) has examined impacts and potential responses to climate change on agriculture, coasts, biodiversity and water resources in Norfolk, Suffolk and Cambridgeshire. It is due to report soon. A new scoping study is under way for the East Midlands Region, including Northamptonshire and Lincolnshire within Anglian Region. This will cover similar aspects. Both studies place a major emphasis on the involvement of stakeholders.

Work by the Centre for Social and Economic Research on the Global Environment (CSERGE) at UEA in the region has included a study linked to the Norfolk Agricultural Land Management Initiative (NALMI). This study looked at the potential impacts of climate change for agriculture in a particular area of Norfolk and the adaptive strategies that could be taken by farmers to cope with these impacts. Key impacts identified were reduced water availability, particularly during the summer crop growing season, and increased risk of soil erosion. A wide range of mitigation measures is recommended for both the short and long term. These include changes to crop selection and timing of sowing, soil conservation and water retention and increased irrigation efficiency.

A2.5

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 further develop 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. 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 for western Europe with higher spatial and temporal resolution. The Agency will keep these under review and examine their impact on strategies as appropriate.

The Agency has a significant role in mitigating climate change as well, through its regulation of industries that emit greenhouse gases. Our patterns of water resources use have an indirect influence on this, through the use of energy to pump, treat and deliver water. It is therefore important to take into account the energy use of different schemes. Transferring large volumes of water across river basins and into storage reservoirs uses significant amounts of energy and so will contribute to the total emissions. Our risk and uncertainty framework and sustainability appraisal have therefore included energy use in the factors assessed.

There is a major UK programme of climate change research. The Agency funds some projects, participates in others and will continue to play an active role.

Appendix 3

A scenario approach to water demand

A3.1

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).

A3.2

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 (see Table 4.1 in the main report).

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 *The optimum use of*

water for industry and agriculture dependent on direct abstraction: best practice manual 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.

We have adopted a micro-component approach in our household demand scenarios, breaking down consumption into 14 discrete micro-components (Table A3.1) falling under the eight broad categories identified in Figure A3.1. 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.

A3.3

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 were 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.

A3.3.1 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 A3.2.

Table A3.1 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 A3.1 Micro-components of household demand 1997/98

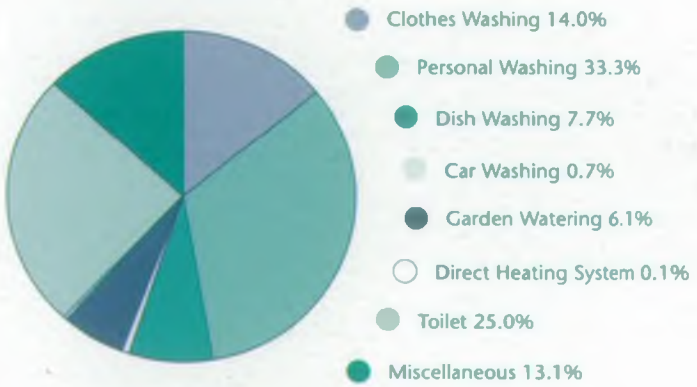
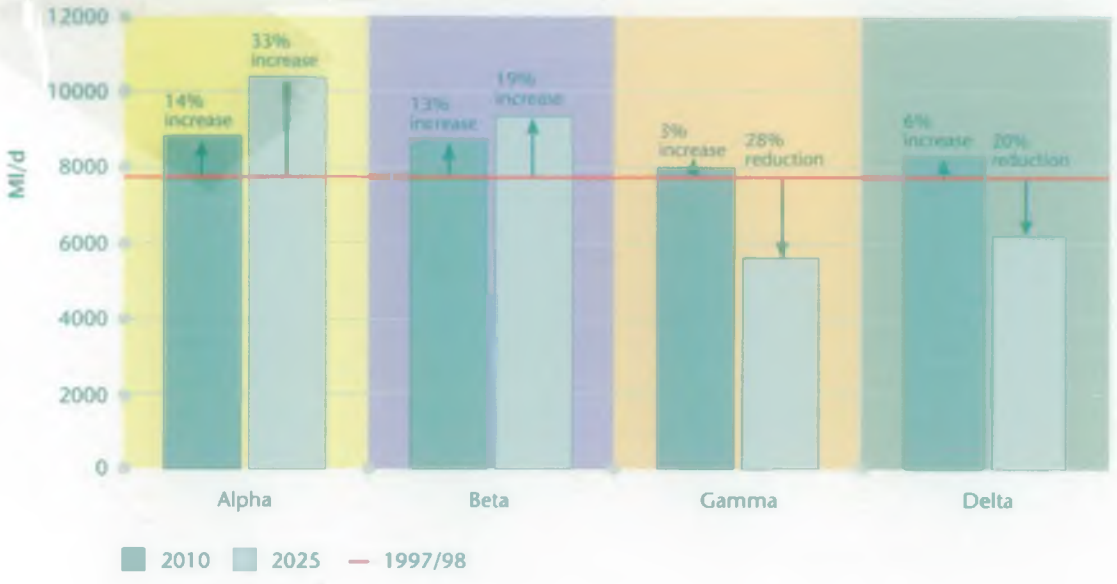


Table A3.2 Metering assumptions for each scenario

	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 A3.2 Public water supply household demand by scenario in 2010 and 2025



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.

A3.3.2 Household demand: scenario outcomes

- **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 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 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.

A3.4 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 3.3 in the main report). High-level changes in political and social attitudes will affect the priority given to leakage by

Table A3.3 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%		

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.

A3.4.1 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 A3.3.

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.

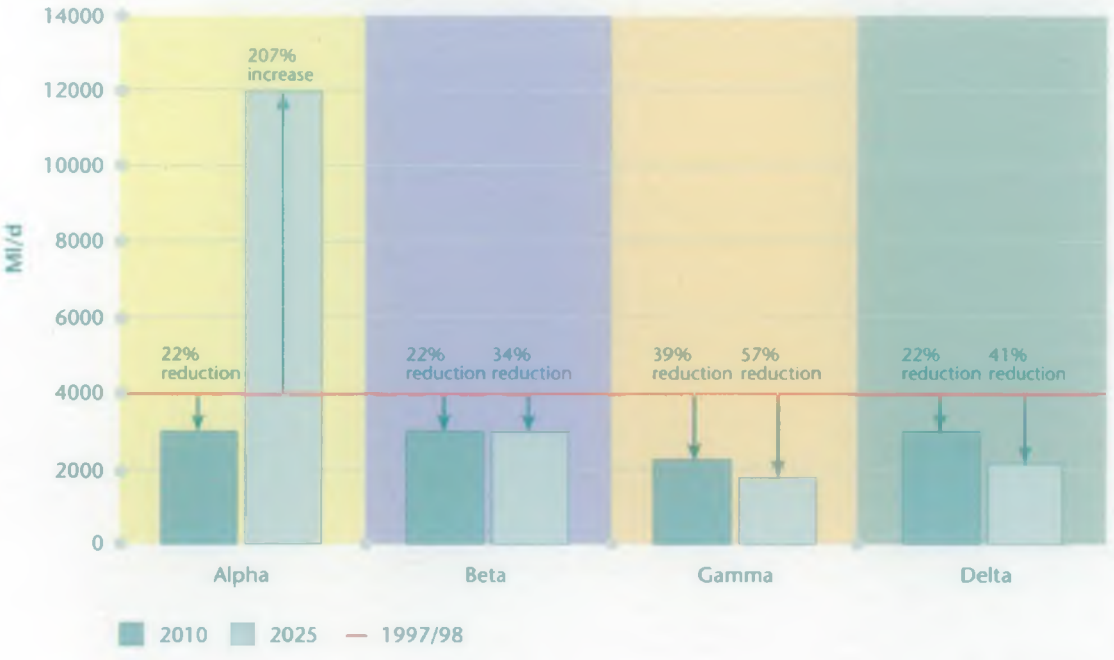
Scenario Gamma (Global Sustainability) *leakage assumptions*

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 4.

A3.4.1 Leakage demand: scenario outcomes

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

Figure A3.3 Leakage by scenario in 2010 and 2025



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.

A3.5

Non-household and primary industry demand

Each of the drivers of non-household demand identified in Table 5.1 (in the main report) plays 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.

A3.5.1 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 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

Figure A3.4 Public water supply non-household demand by scenario in 2010 and 2025

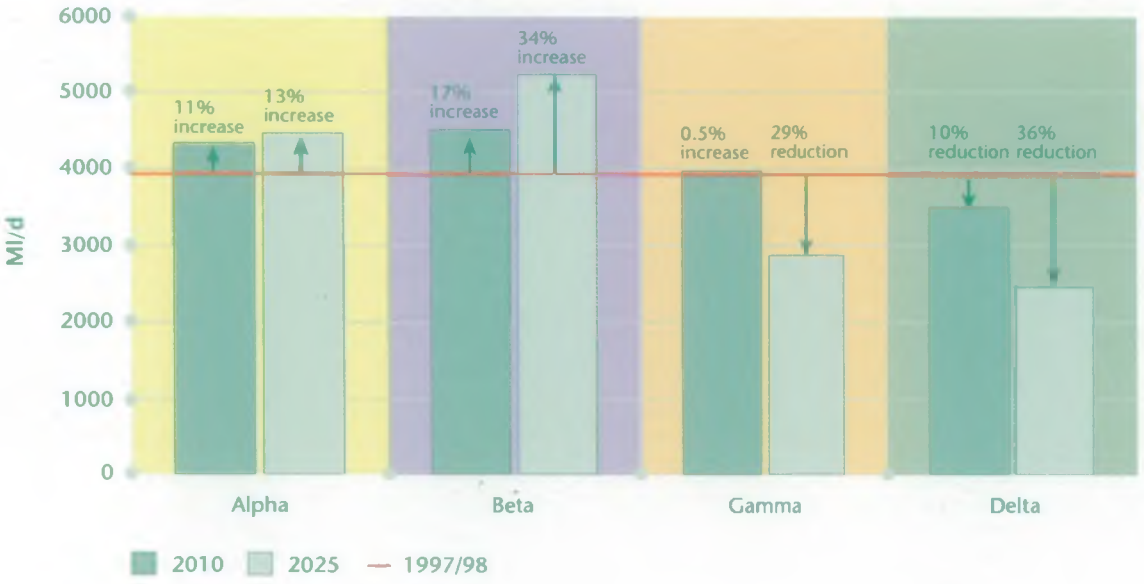
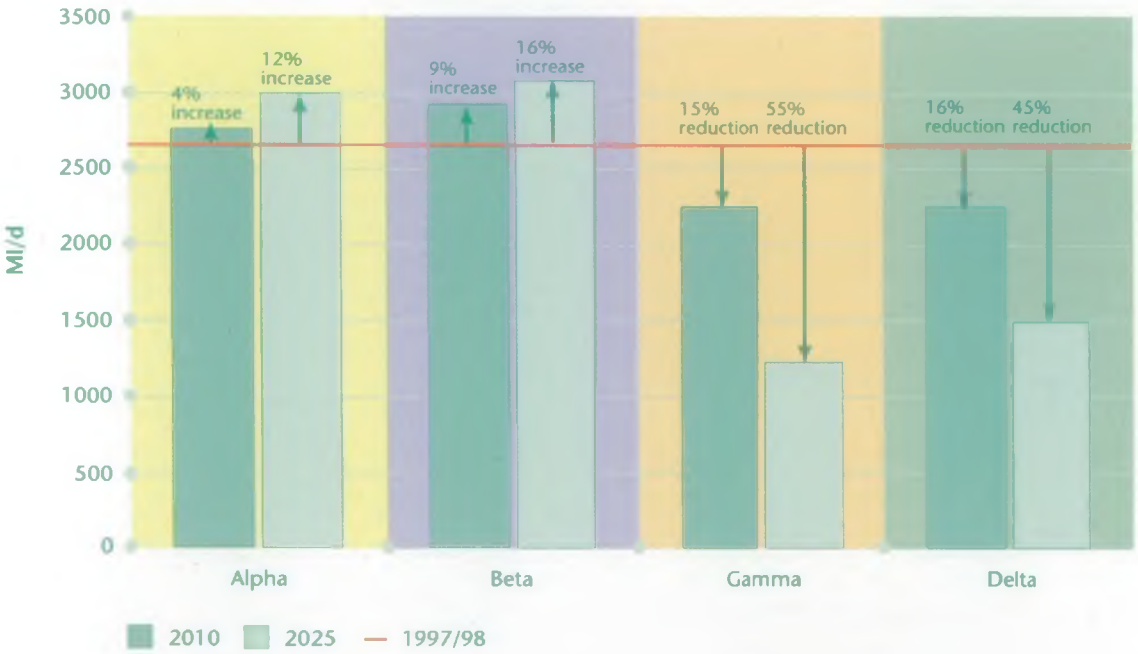


Figure A3.5 Direct abstraction industial demand by scenario in 2010 and 2025



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.

A3.5.2 Industrial demand: scenario outcomes

- **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.

A3.6

Spray irrigation demand

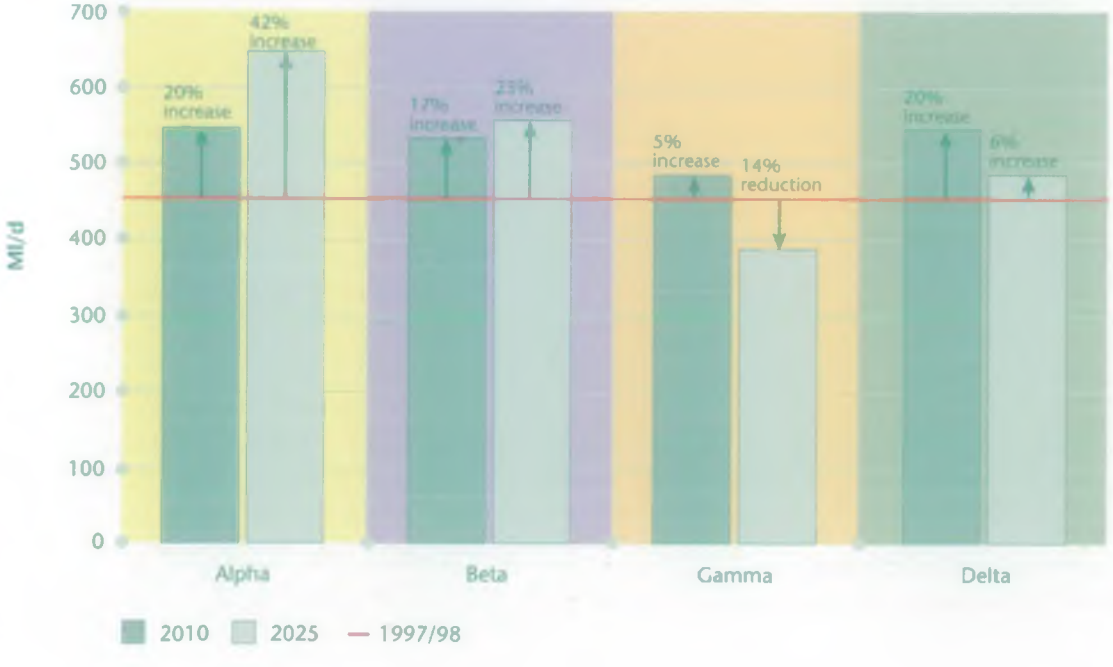
Agriculture is subject to a wide range of social, economic and political drivers of change, which directly or indirectly affect the use and management of spray irrigation.

The key drivers of irrigation demand affect the following forecast micro-components:

- total crop area;
- irrigated area;
- crop yield;
- crop prices and quality premiums;
- irrigation practice;
- irrigation need or depth of water applied;
- cost of irrigation;
- irrigation efficiency.

Drawing on information within the MAFF irrigation survey (MAFF, 1995), the forecast is built up from total

Figure A3.6 Spray irrigation by scenario in 2010 and 2025



crop and irrigated crop area. Eight crop categories are defined:

- potatoes;
- sugar beet;
- vegetables for human consumption;
- grass;
- cereals;
- soft fruit;
- orchard fruit;
- other.

For each crop category, information related to the eight micro-components feeds into the base year data, to which scenario-specific assumptions are applied. Assumptions have been based on many sources of data, including MAFF, British Potato Council, National Institution of Agricultural Botany, Soil Association and National Farmers Union. Two core assumptions underpin the development of scenario-specific assumptions at the crop level:

- Increases in supply of a crop, through high yields, will affect the price that it realises when sold. Thus, if high yields result in over-supply of the market, there is likely to be a reduction in the prices paid.
- There are natural limits on the availability of land and its suitability to certain types of production due to soil type and agro-climatic conditions; in addition rotational restrictions prevent crops being grown on the same piece of land continuously.

We note that under some Foresight scenarios, there is a prospect of a significant switch from agriculture to forestry, or specific planting for bio-energy through coppicing. The expectations are that this would occur not on class one land where irrigation demand will be most pressing, but that it will be concentrated mainly in the west side of England and Wales, on poorer quality land where the natural rainfall will provide the support. This switch is therefore not treated as a driver of future irrigation demand.

A3.6.1 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.

A3.6.2 Spray irrigation demand: scenario outcomes

- **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.

Appendix 4

Calculating possible leakage levels in 2025

A4.1

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.

A4.2

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.

A4.3

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.

A4.4

Assumptions

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

A4.4.1 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.

A4.4.2 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.

A4.4.3 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.

A4.5

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 5

National research and development proposals

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. These 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 local climate;
- 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 the 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.

Bibliography

Arnell, N. (1999) *Effects of Global Warming on Water Resources: Implications of Multi-decadal Variability and Changes in Year-to-year Variability – Report to the Environment Agency.* Department of Geography, University of Southampton: Southampton.

DETR (1999a) *A Better Quality of Life: A Strategy for Sustainable Development for the United Kingdom.* Department of the Environment, Transport and the Regions: London.

DETR (1999b) *Proposals for a Good Practice Guide on Sustainability Appraisal of Regional Planning Guidance.* Department of the Environment, Transport and the Regions: London.

DETR (1999c) *Quality of Life Counts – Indicators for a Strategy for Sustainable Development for the United Kingdom: A Baseline Assessment.* Department of the Environment, Transport and the Regions: London.

DETR (1999d) *Planning Policy Guidance Note 12: Development Plans.* Department of the Environment, Transport and the Regions: London.

DETR (2000a) *Climate Change – Draft UK Programme.* Department of the Environment, Transport and the Regions: London.

DETR (2000b) *Competition in the Water Industry in England and Wales – Consultation Paper.* Department of the Environment, Transport and the Regions: London.

DETR (2000c) *Economic Instruments in Relation to Water Abstraction – A Consultation Paper.* Department of the Environment, Transport and the Regions: London.

DETR (2000d) *Potential UK Adaptation Strategies for Climate Change.* Department of the Environment, Transport and the Regions: London.

DETR (2000e) *Water Bill – Consultation on Draft Legislation.* Department of the Environment, Transport and the Regions: London.

DETR (2000f) *Planning Policy Guidance Note 11: Regional Planning.* Department of the Environment, Transport and the Regions: London.

DETR and Welsh Office (1999) *Taking Water Responsibly – Government Decisions Following Consultation on Changes to the Water Abstraction Licensing System in England and Wales.* Department of the Environment, Transport and the Regions: London and Welsh Office: Cardiff.

DTI (1999) *Environmental Futures.* Foresight, Office of Science and Technology: London.

English Nature and the Environment Agency (1999) *Water abstraction and Sites of Special Scientific Interest in England - a review.* English Nature: Peterborough.

Environment Agency (1997) *A Guide to Sustainable Urban Drainage.* Environment Agency.

Environment Agency (1998a) *The Optimum Use of Water for Industry and Agriculture Dependent on Direct Abstraction. Best Practice Manual.* Environment Agency.

Environment Agency (1998b) *A Price Worth Paying: The Environment Agency's Proposals for the National Environment Programme for Water Companies 2000 – 2005, A Submission to Government.* Environment Agency: Bristol.

Environment Agency (1998c) *Water Resources Planning Guideline.* Environment Agency: Bristol.

Environment Agency (1999a) *Sustainable Water Resources for the Future: Values and Challenges.* Environment Agency: Bristol.

Environment Agency (1999b) *Planning Public Water Supplies: The Environment Agency's Report on Water Company Water Resources Plans to the Secretary of State for the Environment, Transport and the Regions and the Secretary of State for Wales.* Environment Agency: Bristol.

Environment Agency (1999c) *Sustainable Urban Drainage.* Environment Agency.

Environment Agency (2000a) *Managing Water Abstraction: Towards a Shared Strategy – A Consultation for Catchment Abstraction Management Strategies.* Environment Agency: Bristol.

Environment Agency (2000b) *The Environment Agency's Review of Water Company Drought Plans.* Environment Agency: Bristol.

Environment Agency (2000c) *Water Resources Strategies Consultation Response.* Environment Agency: Bristol.

Environment Agency (2000d) *An Environmental Vision: The Environment Agency's Contribution to Sustainable Development.* Environment Agency: Bristol.

Environment Agency National Centre for Risk Analysis and Options Appraisal (undated) *Integrated Appraisal of Environment Agency Policies: Version 1.0.* Environment Agency: London.

Herrington, P. (1996) *Climate Change and the Demand for Water.* HMSO: London.

Hulme, M and Jenkins, G. (1998) *Climate Change Scenarios for the United Kingdom: Scientific Report, UKCIP Technical Report No. 1.* Climate Research Unit: Norwich.

Lambert, A., Myers, S., Trow, S. (1998) *Managing Water Leakage: Economic and Technical Issues.* Financial Times Energy: London.

MAFF (1995) *Survey of Irrigation of Outdoor Crops in 1995, England and Wales.* Ministry of Agriculture, Fisheries and Food: York.

MAFF (1996) *Irrigation Demand and On-Farm Water Conservation in England and Wales.* Ministry of Agriculture, Fisheries and Food: London.

MAFF and National Assembly for Wales (2000) *Salmon and Freshwater Fisheries Review.* Ministry of Agriculture, Fisheries and Food: London and National Assembly for Wales: Cardiff.

National Metering Trials Working Group (1993) *National Water Metering Trials Final Summary Report.* Department of Environment: London.

NRA (1994) *Water – Nature's Precious Resource.* HMSO: London.

NRA and UKWIR (1995) *UKWIR/NRA Demand Forecasting Methodology.* NRA: Bristol and UKWIR: London.

Ofwat (1999a) *Final Determinations: Future Water and Sewerage Charges 2000-05.* The Office of Water Services: Birmingham.

Ofwat (1999b) *1998-1999 Report on Leakage and Water Efficiency.* The Office of Water Services: Birmingham. December.

Ofwat (2000) *Leakage and Efficient Use of Water: 1999-2000 Report.* The Office of Water Services: Birmingham. September.

SIC (1992) *Standard Industrial Classification.* The Stationery Office: London.

UK Government (1994) *Biodiversity: The UK Action Plan, CM 2428.* HMSO: London.

UKWIR and Environment Agency (1997) *Forecasting Water Demand Components: Best Practice Manual.* UKWIR: London.

World Resources Institute (1998-99) *Data table of Freshwater Resources and Withdrawals 1970-98.*

Anglian Region additional bibliography

Cranfield University (July 1997) *Spray Irrigation Cost Benefit Study*

Cranfield University (May 2000) *Anglian Region joint study on water resources for each key habitat type*

Environment Agency (May 1998) *Review of Water Company yields*

Environment Agency (November 1999) *Sustainable Water Resources for the Future Values and Challenges: The Anglian Region Perspective*

National Rivers Authority (September 1994) *Water Resources In Anglia: A sustainable Strategy for Secure Water Supplies and a Better Water Environment.*

Young Agricultural (1996) *The Demand for water from a new reservoir at Feltwell*

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.
CSERGE	Centre for Social and Economic Research on the Global Environment
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.

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) which are not factories, offices or commercial premises receiving water for domestic purposes.
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.
IDB	Internal Drainage Board.
Isostatic adjustment	Movement of the earth's crust to maintain equilibrium, affecting relative levels of land and sea.
LEAF	Linking Environment And Farming.
Leakage	The sum of distribution losses and underground supply pipe losses.
LEAPs	Local Environment Agency Plans.
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).
NALMI	Norfolk Agricultural Land Management Initiative
NAW	National Assembly for Wales.
NEP	National Environment Programme.
NFU	National Farmers Union.
NGO	Non Governmental Organisation
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.

PPG	Planning Policy Guidance (issued by DETR).
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.
RegIS	Regional climate change Impact and response Studies
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.
RSPB	Royal Society for the Protection of Birds.
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.
SDRT	Sustainable Development Round Table.
SODCON	Survey Of Domestic Consumption (Anglian Water Services detailed measurement and study of household water use)
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 reuse during the summer.
Yield	The reliable rate at which water can be drawn from a water resource.

NOTES

NOTES

ANGLIAN REGION ADDRESSES

REGIONAL OFFICE
Environment Agency
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR
Tel: 01733 371 811
Fax: 01733 231 840

NORTHERN AREA OFFICE
Environment Agency
Waterside House
Waterside North
Lincoln LN2 5HA
Tel: 01522 513 100
Fax: 01522 512 927

CENTRAL AREA OFFICE
Environment Agency
Bromholme Lane
Brampton
Huntingdon
Cambs PE28 4NE
Tel: 01480 414 581
Fax: 01480 413 381

EASTERN AREA OFFICE
Environment Agency
Cobham Road
Ipswich
Suffolk IP3 9JE
Tel: 01473 727 712
Fax: 01473 724 205

www.environment-agency.gov.uk

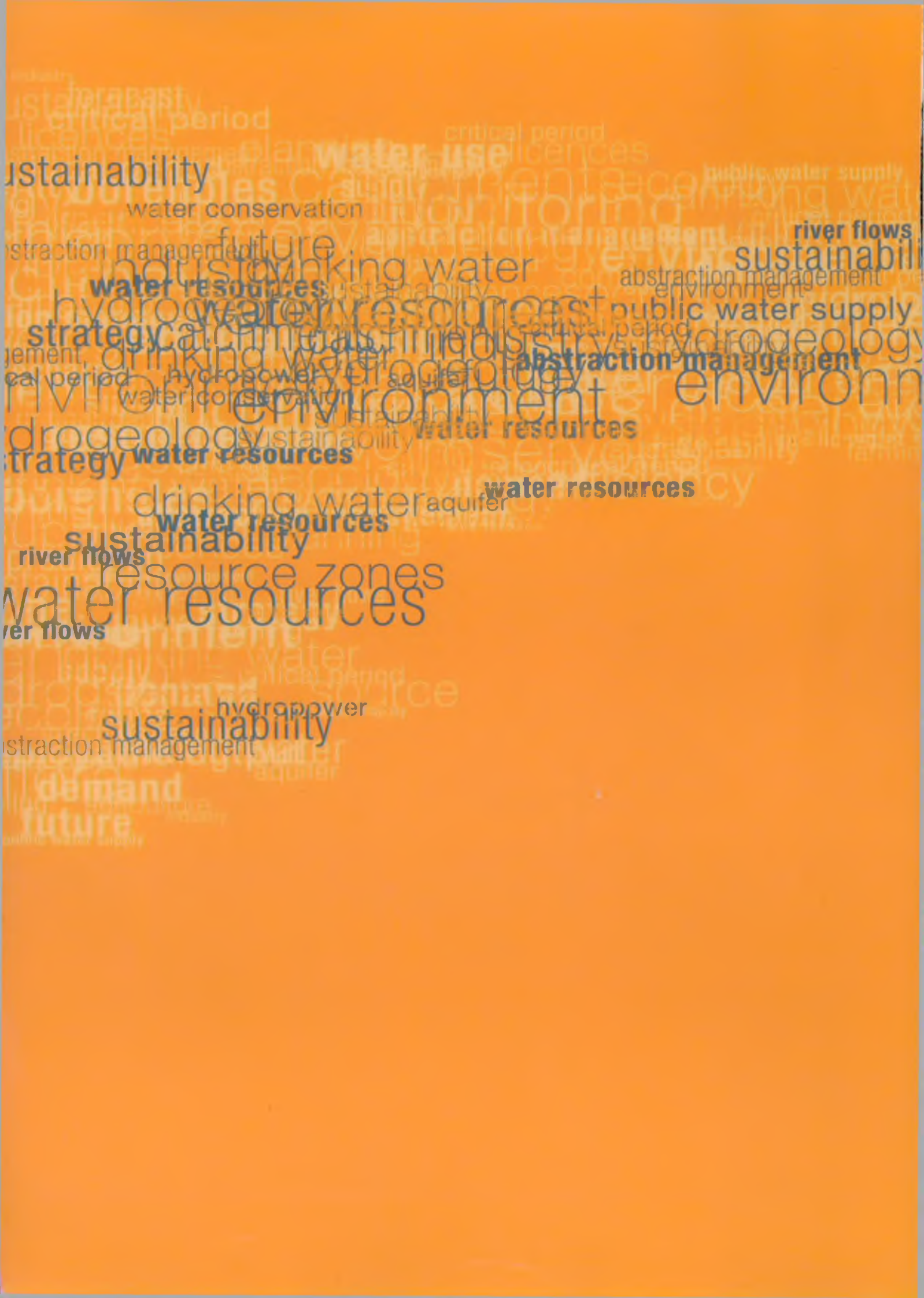
ENVIRONMENT AGENCY GENERAL ENQUIRY LINE
0845 933 3111

ENVIRONMENT AGENCY FLOODLINE
0845 988 1188

ENVIRONMENT AGENCY EMERGENCY HOTLINE
0800 80 70 60

ENVIRONMENT AGENCY

AN-3/01-2K-A Printed on Cyclus


sustainability
water conservation
future
drinking water
water resources
hydrogeology
strategy
environment
river flows
abstraction management
public water supply
aquifer
resource zones
hydropower
demand