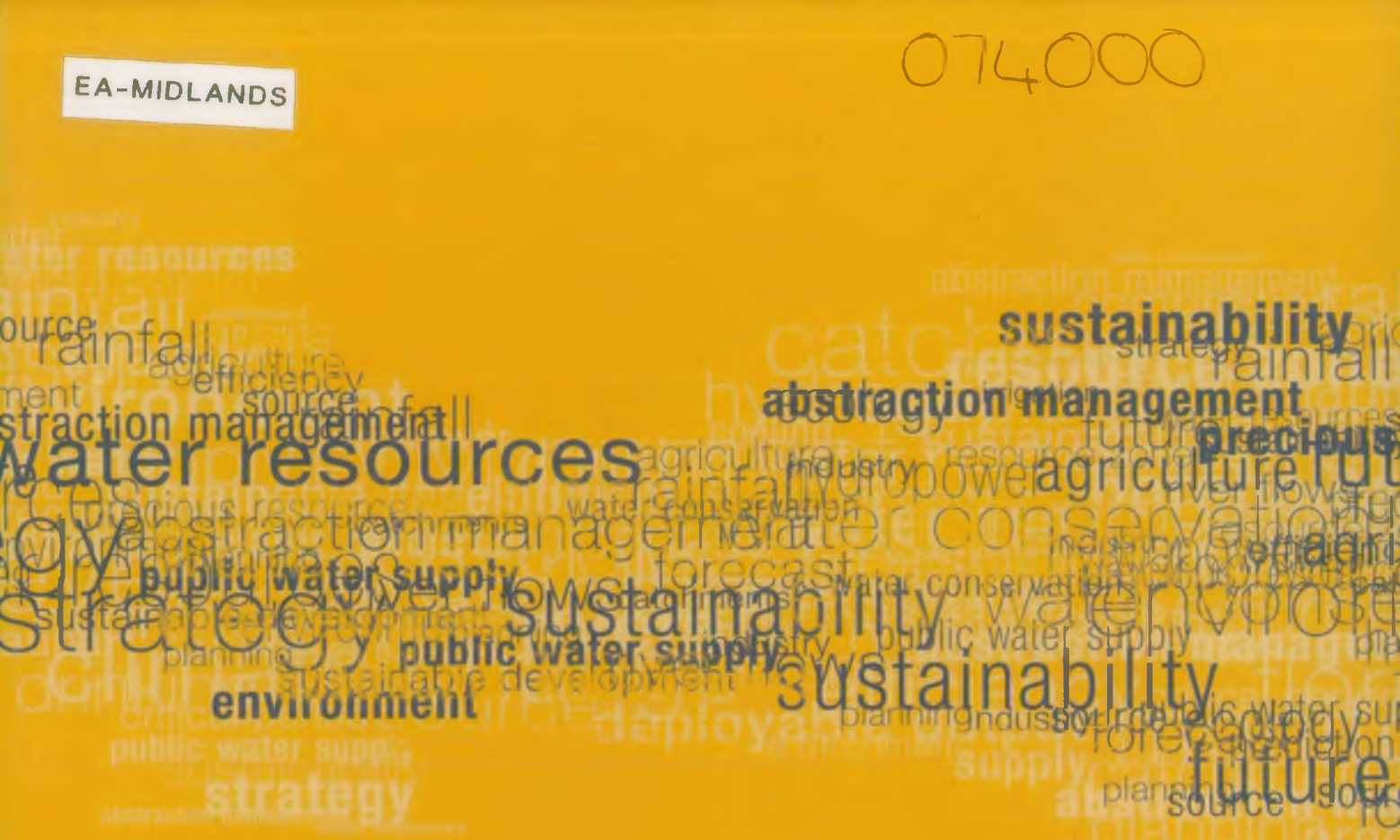

Water resources for the future

A STRATEGY FOR MIDLANDS REGION

March 2001

ENVIRONMENT AGENCY

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Foreword

Water is vital to life. We all use it in our homes and gardens, and it is essential to farmers to irrigate the crops we eat. The industrial processes and commercial operations supporting our economy need water. The wildlife of our rivers and wetlands depends on it. Water is a magnet for recreational activity and quiet relaxation, adding value to the quality of life in both urban and rural areas. Water is a precious resource, particularly during times of drought, and must not be taken for granted.

Our aspiration for water resources in the Midlands Region is that our rivers and wetlands should support a healthy and diverse wildlife which people can enjoy, whilst also providing reliable water supplies for use in our homes, industry and agriculture. We acknowledge the magnitude of this challenge. In the Midlands, we face pressures of rising water abstraction demands from continued economic growth, new housing developments, increased crop irrigation, and the uncertain future impacts of climate change. Yet we have a valuable water environment with many nationally and internationally important conservation sites in need of our protection, and we are already working to restore or enhance historically-impacted sites.

This water resources strategy sets out how we believe our aspirations can be achieved. We advocate a 'twin track' approach, where sensible management of our demands, combined with some further water resource developments, will enable us to meet all our needs in a sustainable manner.

The strategy sets out a framework, but its success depends on action by many different organisations and individuals. Water companies, planning authorities, farmers, environmental organisations, businesses and all of us as consumers have a part to play. The publication of this document is an important step in an ongoing process. We look forward to working with others over the coming months and years to jointly deliver the actions it recommends and to achieve our water resources vision.

Dr David P F King
Regional Director, Environment Agency Midlands Region

The Midlands has a valuable water environment, in need of our protection. Warwick Castle on the banks of the River Avon

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Introduction

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

The Environment Agency is the statutory body with a duty to secure the proper use of water resources in England and Wales. In accordance with this duty, we have prepared this water resources strategy for the Agency's Midlands Region. The region stretches from the Humber to the Severn Estuary, and includes the Birmingham conurbation and the major towns and cities of Nottingham, Derby, Leicester, Stoke on Trent, Coventry, Shrewsbury, Worcester and Gloucester. This strategy forms part of a suite of eight strategies that are consolidated in the Agency's national strategy for England and Wales. The strategy looks 25 years ahead. It considers the needs for water both of the environment and of society, and examines 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 the Midlands, water is becoming a scarce resource. In many places, further improvements to the water environment are necessary to restore sustainable levels of abstraction. We believe that this may require recovery of around 200 million litres per day (Ml/d).
- Continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 285 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.
- Agriculture must continue to use available water to best effect. Spray irrigation of crops is an important water use in the Midlands. In most agricultural areas, little further summer water is reliably 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 the present resource situation, identifying areas where abstraction needs careful management to ensure future sustainability and to improve the environment. In the Midlands, the picture shows large areas where no further water is available with a reasonable level of reliability during summer, or where damage is already occurring. We estimate that, in total, further environmental reductions in abstraction will be necessary of about 200 Ml/d by 2025, mainly by reducing groundwater abstractions. Some of this claw-back is already planned by water companies.

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

The scenarios show that demand for water is highly dependent on societal choice and governance. In two of the scenarios, total demand for water rises 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 the Midlands, the scenarios suggest that summers will be drier while winters will be wetter. Resource systems dependent on summer river flows, or river abstractions that are unsupported, may become more unreliable. These possible reductions could be offset by increased aquifer recharge and greater reservoir inflows in winter.

Climate change will affect not only water availability but also demand. Over the next 25 years, we believe the effects can be managed within the 'twin-track' strategy that we propose. 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 that we will keep under review. In facing climate change, adaptation strategies are the key, and our recommendations prefer options that are flexible to the range of possibilities encompassed in present climate change scenarios.

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

Conclusions

Our strategy takes a 'twin-track' approach, combining some further water resource developments with sensible management of our demands.

We recognise that the development of new resources that total 285 Ml/d by 2025 may be required. Much of this can be achieved by the enhancement of existing resource systems. For example, we will review the River Severn Control Rules to clarify the sustainable abstraction quantities in drought periods following commissioning of Phases 4 and 5 of the Shropshire Groundwater Scheme (currently under development). However, we also recommend some additional abstraction, in particular, further use of the River Trent supported by water returned after treatment and by development of groundwater sources in Birmingham to provide flow support in dry weather. All resource development schemes will need careful investigation to ensure that their environmental impacts are acceptable.

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 complete the review of authorisations affecting Habitats Directive sites and ensure actions are taken to modify or revoke abstraction licences where necessary to maintain international sites in favourable conservation status. Water companies should complete the investigations and actions required of them under the National Environment Programme for 27 sites in the Midlands. The Agency will continue to work with English Nature and others on the investigations and actions summarised in our recent review of water abstractions on Sites of Special Scientific Interest (SSSIs). We will prioritise and monitor progress on these and other abstraction related concerns through our Restoring Sustainable Abstractions Programme (RSAP) within the context of our Catchment Abstraction Management Strategies (CAMS) process.

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; in this area, continued regulation 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. We believe that water efficiency needs active promotion and that the best way to achieve this is through an independent organisation specifically funded for this purpose. The Agency will seek views on this proposal, and if we find support, will encourage its further development. Whatever the outcome, we will continue with our partnership approach to promoting water efficiency in the Midlands, in combination with other waste minimisation initiatives. We will work directly with water companies and abstractors in agriculture and industry, and will strive to set best practice standards in our own offices and facilities. We will influence the planning process to ensure that future developments in the Midlands recognise the limited availability of water and incorporate efficiency measures and sustainable drainage systems.

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

Agriculture should also work to make effective use of existing supplies, while considering opportunities to work with others to develop new sources of water. The development of storage may be required to ensure

reliable supplies. Trading of licences may prove fruitful. The Agency will seek discussion with supermarkets and food processors whose requirements may influence the use of water.

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

Future review

We have considered the risks that may arise in following this strategy. Our approach accommodates the range of demands that may arise in the future. It also allows for current scenarios of the effects of climate change. As new scenarios of climate change are developed, we will review the timing of the actions that we propose. It is possible that further investigation could disqualify some of our preferred options. For this reason, we believe that the appropriate studies should be started in good time. Similarly, the demand management options carry some risks. Some may require support or facilitation by Government and regulators, as well as activity from water users; we will review progress.

We will report on progress against this strategy annually. We plan to review the strategy completely in a few years. This strategy provides an appropriate framework for long-term water resources planning in the Midlands and contributes directly to the Agency's water resources strategy for England and Wales.

Actions

Our recommended actions are summarised on the next page, and are nationally applicable. In many cases, we seek co-operation across sectors and between different organisations. We will work to facilitate such activities. More local details for the Midlands are given in this strategy.

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.	✓							✓

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 natural life and for 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 Midlands.

While the Midlands is often considered to be wet, particularly in the upland areas, our valuable natural environment and high population density mean that the careful management of water resources is essential.

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

This strategy relates to the Environment Agency Midlands Region (Figure 1.1). Our Midlands Region boundary generally follows district council boundaries, extending westward to the Welsh border. However, water does not respect such administrative boundaries, and we need to work within natural river catchment boundaries for water management purposes, so that the impact of upstream water-related activities can be accounted for. This strategy is therefore concerned with the Rivers Severn and Trent, and all of their sub-catchments, principally the Rivers Vyrnwy, Tern, Teme, Warwickshire Avon, Sow, Tame, Dove, Derbyshire Derwent, Soar and Idle, and all of the underlying groundwater resources. The total land area of the Severn and Trent catchments is 21,600km^2. This strategy includes the upper reaches of the River Severn catchment situated in mid Wales (also covered in the strategy for Wales), and we exclude those parts of the Herefordshire River Wye catchment situated in England (covered exclusively in the strategy for Wales). For public water supply, we have concentrated on Severn Trent Water and South Staffordshire Water, whose supply distribution areas lie predominantly or exclusively within these river catchment boundaries, however, other neighbouring water companies are also discussed where appropriate.

The Severn and Trent catchments comprise of a diverse range of natural and human-influenced environments, from the mountains and uplands of mid Wales and the Peak District, to the agricultural plains particularly dependent on irrigation (Shropshire, the Vale of Evesham in Warwickshire and Worcestershire, and the low-level artificially-drained lands towards the lower end of the River Trent catchment in Nottinghamshire, Yorkshire and Lincolnshire). The catchments also contain major urban areas supporting major industry and commerce, such as the Birmingham conurbation, Coventry, Stoke on Trent, Leicester, Nottingham and Derby.

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

As well as managing water resources, the Environment

Figure 1.1 **Regional boundaries in the Midlands**

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 new '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 provides an overview of the regional water resources strategies. This water resources strategy for the Midlands 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. Both the national and regional strategies are self-contained documents.

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 'Environmental Vision', showing how the thematic approach to improving our environment translates into tangible actions affecting a specific sector. In water resources, actions in one place have implications elsewhere, making the direct consideration of links especially appropriate.

1.3

Consultation

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

This strategy promotes the value of water to society and the environment. The club-tailed dragonfly relies on clean, undisturbed waters

A national consultation response document was produced in September 2000, summarising the replies received (Environment Agency, 2000c). Of the 270 responses, 24 were specifically from the Midlands. We have taken all these views into account in the preparation of this strategy. We had a good spread of responses across the main sectors with interests in water in the Midlands, and have received additional feedback at stakeholder workshops.

Responses from consultees broadly reflected many of the national trends, but also highlighted some strong local concerns amongst stakeholders. These included that water is undervalued and many water users are unaware of the impact they have on the water environment. This is further exacerbated as water is often consumed far from where it is collected.

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

- the need for more education on water resources, efficient use and environmental impacts;
- the importance of water efficiency and demand management across all sectors to make best use of our existing resources;
- the view that demand management alone will not be sufficient to manage all future needs; a 'twin track' approach comprising demand management and some resource development is required;
- additional winter storage, especially for agriculture, is seen as sensible response to the limited availability of water resources and the predicted impacts of climate change. The environmental opportunities of such reservoirs were recognised, however, concerns were expressed about costs, the need to consider environmental impacts and local authority planning considerations;
- the need to remedy existing environmental damage by over-abstraction of water resources; but achievement is subject to funding of replacement supplies;
- the need for flexible and robust planning in the face of uncertainties regarding future demands and climate change;
- support for inclusion of water efficiency advice and constraints in planning guidance. The need for closer liaison between planners, the Environment Agency and water companies to anticipate future water supply problems and to seek their resolution;
- acceptance of customer water supply restrictions in extreme drought circumstances.

Divergent views were particularly evident on:

- whether the environment should have first call on water resources, particularly when public water supplies are scarce in drought situations;
- whether environmental protection and sustainable development can be compatible with facilitating economic growth;
- the need for, and sustainability of, water transfers and constructing more reservoirs;
- the extent of compulsory consideration of water availability and efficiency (through building regulations, planning conditions, power to veto developments, removal of water company duty to supply). The practical application of efficiency targets for all major water users;
- potential future changes to the abstraction charging systems.

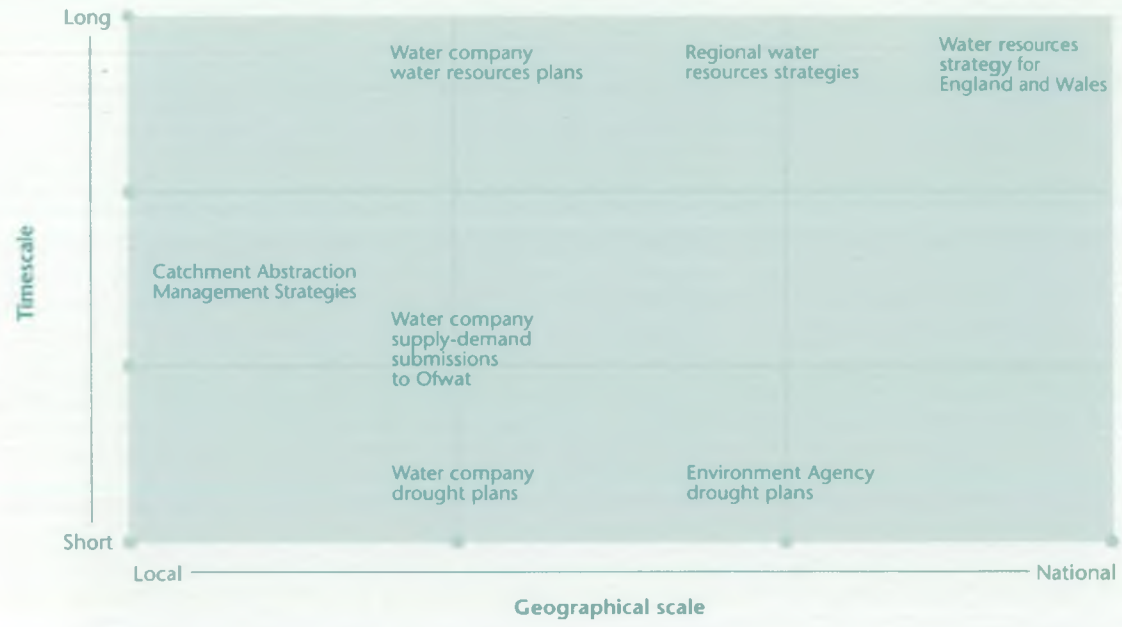
We have tried to take these views and many other details into account as we have formulated this strategy. The issues we consulted on are fundamental ones, where differing views are not unexpected. It is inevitable that some people will be disappointed. There are also areas of genuine uncertainty that 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 Midlands to look for ways of reconciling the differences to achieve mutual gain.

Consultation does not end with the publication of our strategies. The published documents are part of an ongoing process. We welcome views on the contents of this document or on any other aspects of water resources management that are of interest. If you wish to comment, please write to the Midlands Regional Water Resources Manager, Dr Paul Crockett, at our Solihull address, or Email on:
midlands.water.resources@environment-agency.gov.uk

1.4 Links with other water resources planning initiatives

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

Figure 1.2 Scales of water resources planning activities



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

Water companies produce plans that contain detailed actions for a 25-year period, based on each company's assessment of what is needed, on the basis of present information, to maintain an adequate balance between their customers' supply and demand. These actions are necessarily most clearly defined for the first few years of the plan, with more uncertainty in following years. They are to be kept under annual review, and modified as necessary to meet changing circumstances.

The Agency's role in this strategy is to set the bounds within which decisions will be reasonable. This means that we must develop a good understanding of the values of society and Government, and combine these with a rigorous assessment of future demands and pressures to provide a framework for decision-making.

In some cases, these values will mean that there is an obvious course of action. In others, limited time will mean that a single course of action will have to be chosen and acted upon. Our approach must be sufficiently robust to deal with all sorts of uncertainty and still meet the objectives that we have identified for our strategies. In providing strategies, it is not our intention to constrain the commercial decisions of water companies and other abstractors, but to provide a way forward that ensures that decisions meet the wider objectives of society as a whole, and any statutory obligations in the process. This strategy sets a broad framework within which detailed plans for action by water companies and other abstractors can be drawn up.

1.5 Structure of the report

In this document we describe the 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.

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; and
- navigation on some rivers.

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

Our water resources duties extend to all abstractors, including water suppliers, agriculture, industry, commerce and those who abstract for amenity, sports or leisure uses. With a few exceptions, any organisation or individual who wants to abstract water in England or Wales needs an abstraction licence from the Environment Agency. This authorises the abstraction of a given volume of water. In exercising this regulatory role the Agency has additional duties under the Environment Act 1995 to contribute to sustainable development and to promote the conservation and enhancement of the natural environment. It also has 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 the local framework for sustainable management of the environment;

- drought plans, setting out the Agency's role in managing droughts;
- regular review of water companies' water resources plans and drought plans;
- this regional water resources strategy, setting out the Agency's vision for the long-term management of water resources in the Midlands;
- a national water resources strategy, setting out the Agency's vision for the long-term management of water resources throughout England and Wales.

2.1.2 UK Government and National Assembly for Wales

In England, the Secretary of State for the Environment, Transport and the Regions determines drought orders and deals with appeals against the Agency's abstraction licensing decisions. The Minister for the Environment is responsible for water regulations to control the waste of water. The National Assembly for Wales has statutory and policy responsibility for matters related to the water industry in Wales, although there are special powers for the Secretary of State to intervene in matters concerning the cross-border rivers - the Severn, the Dee and the Wye.

2.1.3 Water companies

Public water supply in England and Wales is provided by private water companies. Their water abstractions and effluent discharges are regulated by the Environment Agency. The Agency is 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 companies operating in the Midlands are principally Severn Trent Water and South Staffordshire Water. Dŵr Cymru, North West Water, Yorkshire Water, Anglian Water, Thames Water and Bristol Water also operate to a lesser extent within the boundaries of the River Severn and Trent catchments.

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 the Office of Water Services (Ofwat). The Director General reviews water company prices to customers in his five-yearly price review (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.

Ladybower Reservoir in the Peak District providing water supplies to the East Midlands

2.1.6 Planning and local authorities

Strategic planning authorities and local authorities are responsible for the land use planning framework and planning decisions. Water resources is currently the subject of much interest in the revisions to East Midlands Regional Planning Guidance, and will similarly feature in the forthcoming West Midlands review. We anticipate a need to work increasingly closely with planning authorities to ensure that the water resources implications of new developments in the Midlands are understood and managed sustainably. This not only covers the impact on water resources of new housing, but also mineral extraction activities that de-water (pump groundwater) and affect local rivers and streams. Local authorities and Regional Development Agencies have a general duty to promote sustainable development. Local authorities also regulate the quality of private drinking water supplies through their environmental health duties.

2.2 Competition and economic instruments

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

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

We take the view that introduction of competition, and possible restructuring of water companies, must be controlled so that it encompasses good practice and innovation, without putting at risk environmental protection or delivery of water efficiency. We consider that accountabilities for promoting water efficiency, currently a duty of water undertakers, 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 that affect water resources management. This means that we must identify a way forward that is robust yet flexible 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 perhaps economic impacts.

3 State of water resources

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

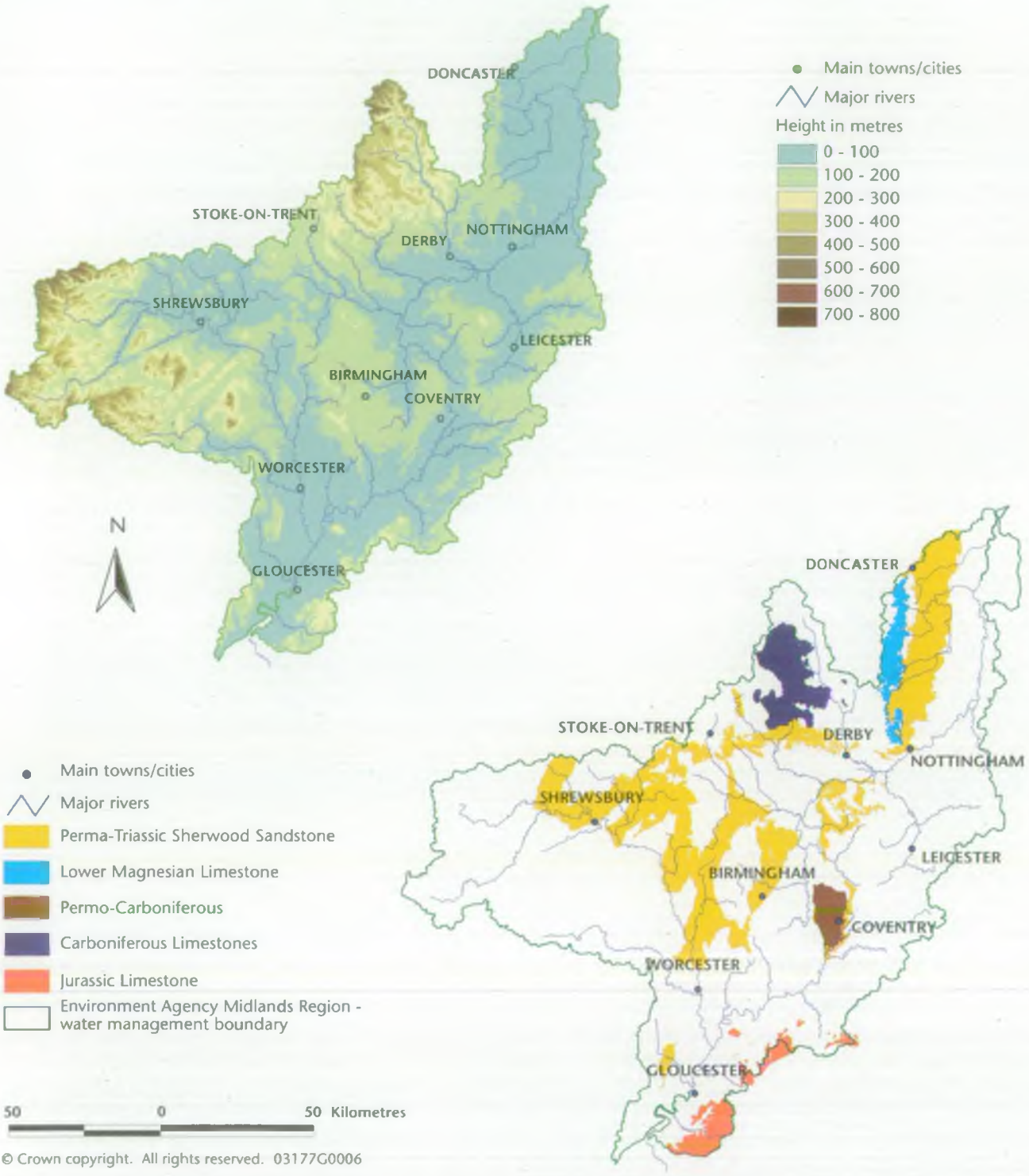
The water environment in the Midlands has developed from the combined influences of the natural hydrological cycle, and human intervention (Figure 3.1). Some of the notable features are:

- Flows on the River Severn are 'regulated' in dry weather with reservoir and groundwater releases, to protect the ecological habitats whilst meeting abstraction demands. The upper reaches of the Severn catchment and its tributaries support salmon spawning grounds, otters and pearl mussels. The Severn Estuary has the second largest tidal range in the world (14.5m), and the funnel shape of the estuary gives rise to a natural tidal wave known as the 'Severn Bore' that travels up the river during high tides. The estuary is noted for providing mudflat habitat for over-wintering birds, and it has been designated a Special Area of Conservation, Special Protection Area and Ramsar (internationally important wetland) site;
- The River Trent is characterised by artificially enhanced flows, due to water returned after treatment, particularly from the urbanised tributary rivers like the River Tame (Birmingham). Its quality has seen significant improvements in recent years and the ecology is diversifying. Some tributaries are designated SSSIs (Rivers Blythe, Lathkill, Eye and Mease);
- To the east of Doncaster, the low lying areas (particularly the Isle of Axholme system) are intensively farmed and artificially drained and managed by pumping stations. The drains are home to a wide variety of species of wetland plants;
- Flow from groundwater supports rivers, streams and wetland sites across the Midlands. This is particularly true of our major aquifer, the Permo-Triassic Sherwood Sandstone. Limestone derived springs in the Peak District also feed important local wetland areas and support a great biodiversity, such as Derbyshire feather moss;
- Canals are a major part of the water environment in the Midlands. The canals are variously utilised for agricultural, commercial, and recreational purposes as well as for water transfers. They support aquatic plant populations such as the scarce floating-leaved water plantain in addition to native crayfish and extensive fish populations;
- The man-made reservoirs in the Midlands not only support public water supplies, but their extensive open waters and adjacent lands also offer habitats to birds and other species, for example, goosander and great crested grebes breed at Lake Vyrnwy;
- The Midlands has some rare lowland acidic peat bogs and associated small meres in hollows formed after the last ice age. They are rich in plant species and invertebrate life, and both water quality and quantity are critical to the maintenance of their ecological value. An internationally important example is Aqualate Mere in Staffordshire, with a varied fish population supporting a large heronry, otters and several species of waterfowl.

3.1 The water resource

Water is a renewable resource; water reserves held in our rivers, wetlands and aquifers are replenished by rain and snow. However, it is not an infinite resource; the amount that is available for use depends on the quantity that falls, the amount lost back to the atmosphere, and the amount needed by the water dependent ecology.

Figure 3.1 Topography and major aquifers in the Midlands

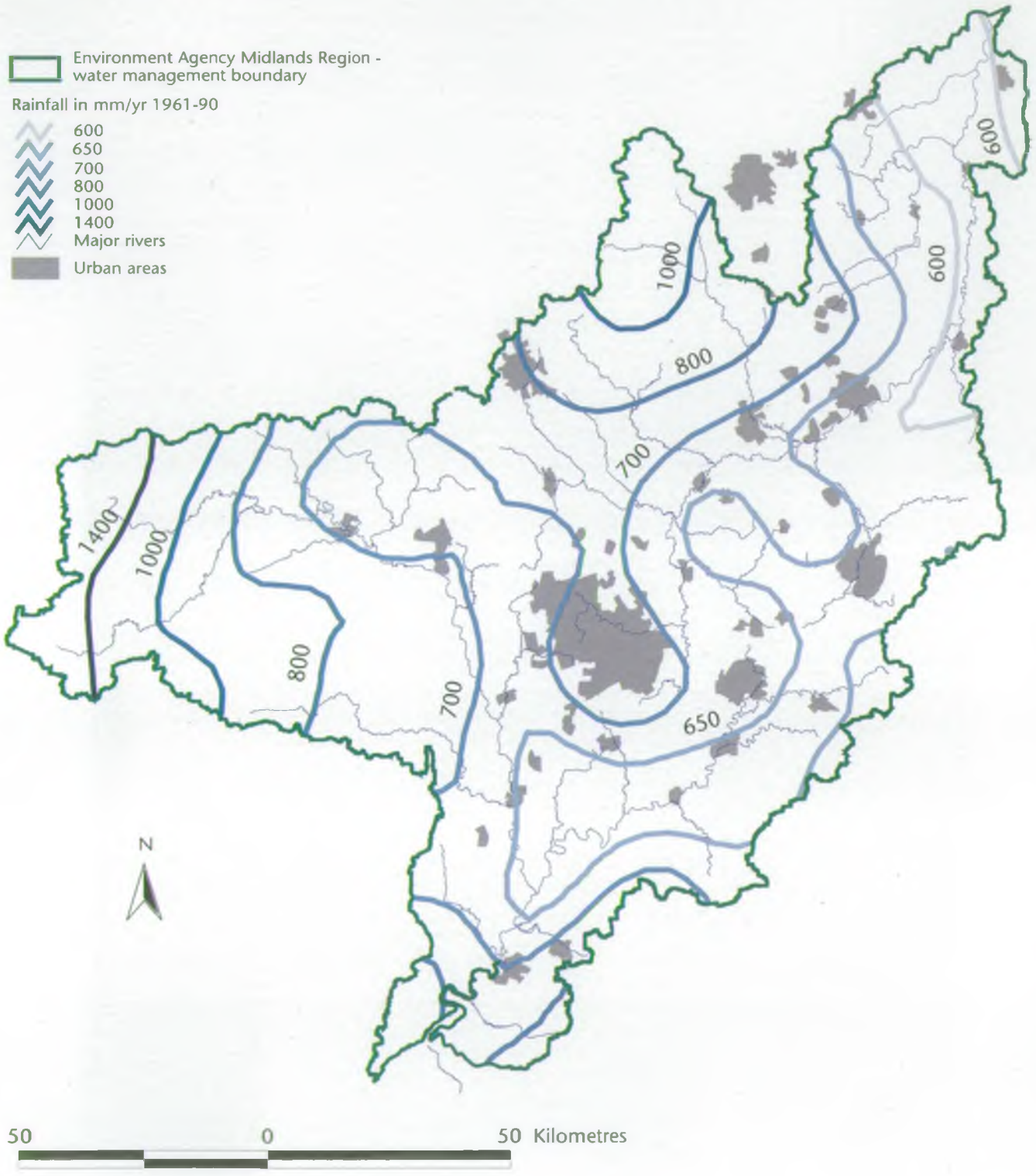


3.1.1 Rainfall

The average annual rainfall over the Severn and Trent catchments is 754 mm per year (standard period 1961 to 1990 average), compared to the England and Wales average of 897 mm. However, there are marked variations across the Midlands as shown on Figure 3.2. Most of our country's weather systems come from the west, and this means that the higher land in the west receives more rain than the flatter land in the eastern rain-shadow. Annual average rainfall ranges from over 2600 mm at the headwaters of the River Severn (Afon Hafren) and River Vyrnwy, to below 600 mm in the lower reaches of the Trent catchment (Nottinghamshire, Lincolnshire, and Yorkshire) and parts of the Avon catchment (Warwickshire).

The distribution of rainfall is fairly even throughout the year across the Midlands. However, much of the rainfall is lost to evaporation and transpiration by vegetation, especially in the hotter summer season, so the remaining effective rainfall that feeds the rivers and

Figure 3.2 Rainfall Distribution across the Midlands

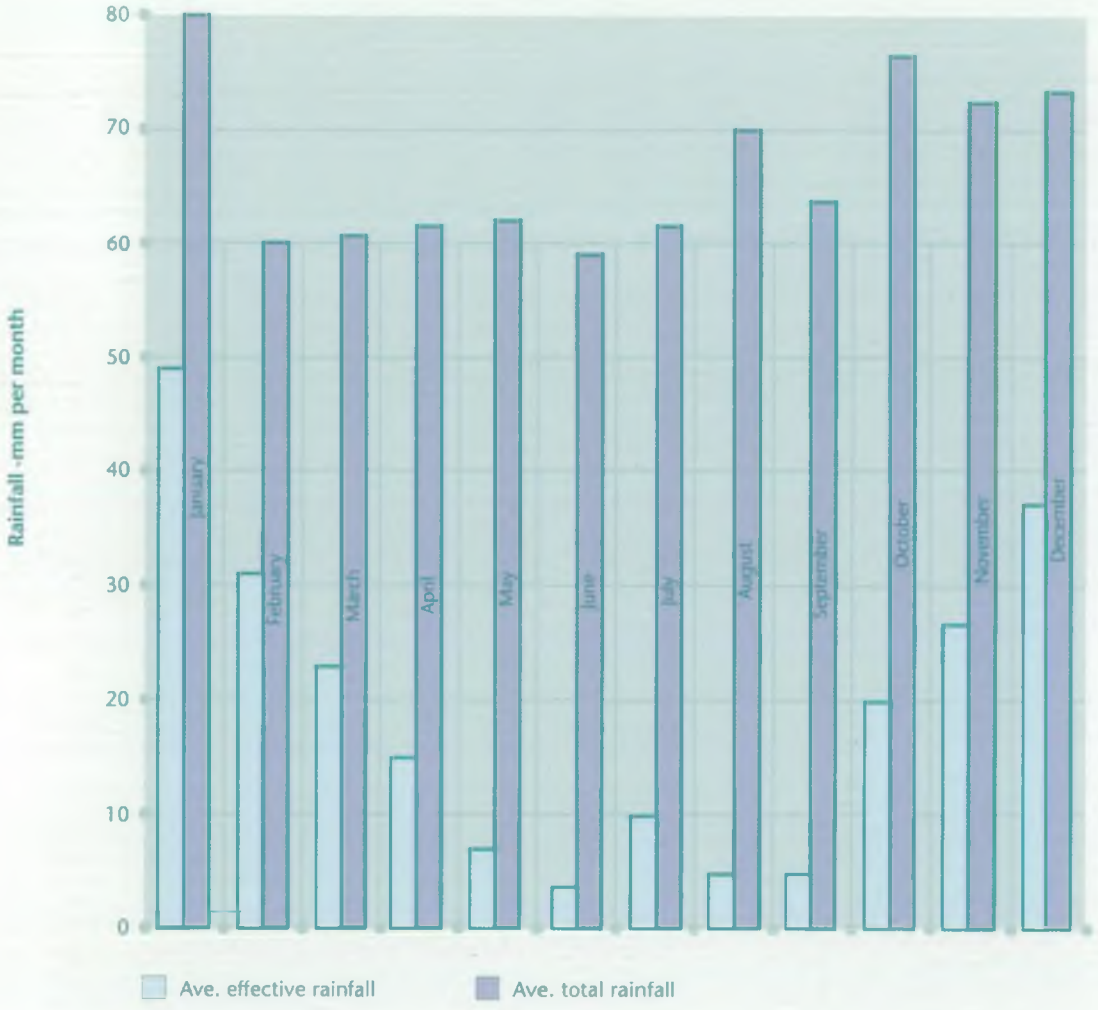


recharges groundwater is much lower and shows a marked seasonal variation (Figure 3.3). The average effective rainfall in the Midlands is 286 mm, less than 40% of the total precipitation received.

3.1.2 Rivers, groundwater and wetlands

Our soils tend to dry out in summer, as growing plants use the water, and replenish their moisture in winter. Where the rocks underneath are suitable (aquifers) they can store large amounts of water in pores and cracks. Aquifers usually start to refill 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.

Figure 3.3 Long term average monthly total and effective rainfall in the Midlands



The main aquifers in the Midlands are the Permo-Triassic Sherwood Sandstone (Nottinghamshire, Yorkshire, Shropshire, West Midlands, Derbyshire and Staffordshire), the Lower Magnesian Limestone (Nottinghamshire, Derbyshire and Yorkshire), the Permo-Carboniferous strata (around Coventry) and the Jurassic Limestone (Cotswolds). Throughout the Midlands, less significant aquifers are locally important water sources, such as the Carboniferous Limestone (Derbyshire), the Devonian Old Red Sandstone, the Coal Measures (and mined voids), the Derbyshire Millstone Grits and the river and glacial sands & gravels.

Unconfined aquifers (those not overlain by virtually impermeable strata) support wetlands and rivers, and the different aquifer characteristics influence river flow regimes and the chemical composition of the water.

With very few exceptions, abstractions from surface or groundwater resources require an abstraction licence from the Agency so that we can protect the environment, other water users needs and existing abstractors' rights. We put limits on instantaneous and cumulative abstraction rates at a given location. In the Midlands, we also control the timing of the abstraction by including 'Hands-Off-Flow' licence conditions that prevent abstraction when river flows are naturally low. We also put conditions on pond and reservoir impoundments, ensuring that minimum flows are released downstream to meet the ecological needs.

Large parts of the River Teme and upper River Severn catchments are exempt from the need for a licence to abstract groundwater (through Section 27 of the 1963 Water Resources Act) although the river gravels within that area are not exempt. These exemptions were granted in areas deemed not to have substantial groundwater resources, based on parish boundaries. However, the exempt areas do include areas that contain major springs, and water company groundwater abstractions that are locally significant. The issue of exemption orders is currently being reviewed as part of the Government's Abstraction Licensing Review.

The natural groundwater regime of the Midlands has been altered extensively. Mining activities associated with coal, metal and minerals have left interconnected

shafts and adits. Groundwater levels were artificially lowered to enable mining, so with the closure of many mines, groundwater levels have risen. The shafts and adits provide discharge points for this groundwater, in many cases outside the natural groundwater catchments. For example, almost horizontal tunnels were carved into the Derbyshire limestone for drainage, to give miners access to the metal and mineral veins. These 'soughs' continue to flow today, and support abstractions for public water supply (in particular, the intake at Meerbrook Sough, near Matlock, Derbyshire). Many of the minewater discharges are of very poor quality. The minerals within underground rocks oxidise when exposed to air, and the subsequent rising water after the mine closes brings all these polluting substances, such as iron or copper salts, to the surface. The quality and impact of rising groundwater levels are of concern to the Environment Agency. We are working jointly with the Coal Authority to monitor rising minewaters in the Midlands coalfields and, where necessary, to control or mitigate their effects.

3.1.3 Drought

Variability in rainfall between years can be significant, as shown in Table 3.1. The droughts of 1933-34, 1959, 1976, 1989-90 and 1995-96 are the most noteworthy for the Midlands, but the last few years have been markedly wetter. 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.

These extended dry periods affect many rivers. Groundwater and wetlands maintain river flows long after the last rain has fallen. When water supplies are not replenished, wetlands dry up and river flows drop to very low levels. Low river flows affect water quality through higher water temperatures, less dilution of effluent and lower oxygen levels. They expose areas of the river channel, such as fish spawning grounds and this can lead to their damage or disruption. Droughts often lead to water supply difficulties, both in terms of the availability of water for abstractions (from reservoirs, rivers or groundwater), and water treatment and distribution strains (to meet high peak demands). Droughts also greatly increase the need for agricultural 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. Long dry periods that span several years can also be significant. While these droughts may appear less intense, they are especially important where water is usually stored for long periods. Long droughts are usually the result of two or more dry winters in succession; the intervening summers may not be especially dry.

The Agency produces drought contingency plans specifying procedures to monitor, report and mitigate the impacts of the drought. In the Midlands, we also have responsibility for the co-ordination of the drought plan for the River Severn. Water companies also provide drought plans, stating the measures they will take to maintain supplies in the event of a drought.

Although we are perceived as a wet country, we have

Table 3.1 **Average and drought rainfall in the Midlands**

Area	Average annual rainfall (mm)	Average summer rainfall (mm)	1995 summer rainfall (mm)
Severn & Trent Catchments	**754 (286 effective)**	**357 (51 effective)**	**210 (2 effective)**
Welsh Mountains	1266	501	300
Shropshire Plain	715	348	209
Mid Severn & Terne	782	360	217
Avon to Evesham	654	331	204
Lower Severn	697	337	231
Upper Trent	741	361	200
Tame	683	337	194
Dove	868	399	233
Derwent	992	432	243
Soar	642	327	188
Lower Trent	622	315	151

Note: 'average' rainfall relates to period 1961-1990: 'summer' relates to April to September

a high population density. In the Midlands the annual average effective rainfall equates to around 730 m³ per person per year, or 2000 litres per person per day, which is low in comparison to the rest of the country, Europe and America, as illustrated in Table 3.2. This is an important fact, and one which is not often recognised.

Table 3.2 International comparisons of water resources

	Annual internal renewable water resources	
	Total (cubic km)	Per capita (cubic metres)
England & Wales	68.17	1334
Region		
Anglian Region	4.14	691
Midlands Region	6.12	727
North East Region	9.33	1299
North West Region	10.97	1643
Southern Region	3.73	921
South West Region	11.17	2740
Thames Region	3.09	266
Wales	19.61	6419
Europe		
France	180.00	3065
Germany	96.00	1165
Italy	159.40	2785
Netherlands	10.00	635
Portugal	38.00	3878
Spain	110.30	2775
North America		
Canada	2849.50	94373
United States	2459.10	8983

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

3.2 Distributing water

3.2.1 Abstractions

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

Water is abstracted from surface and groundwater sources either for use directly by the end user, or for treatment and distribution by water companies. In many parts of the Midlands, 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 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.

Public water supply distribution in the Midlands is managed within water company supply zones, although there are often interconnections between the zones. Within each zone, the supply systems allow transfers of water from multiple sources and treatment works, such that water customers within each zone experience the same level of service. Within the Midlands, Severn Trent Water has three zones and South Staffordshire Water has only one. Yorkshire Water and Anglian Water zones also cover the periphery of the Severn and Trent catchments, along with Dwr Cymru and Thames Water to a lesser extent.

Figure 3.4 illustrates the current major public water supply sources and systems in and around the Midlands. These are summarised below :

- The River Severn supports public water supply abstractions of over 1000 Ml/d down its length during normal flow conditions. In dry weather, natural river flows are supplemented by regulation releases from three support sources: Clywedog Reservoir, Lake Vyrnwy and the clusters of boreholes comprising the Shropshire Groundwater Scheme, where three phases of borehole development are currently fully operational, with phases 4 and 5 currently being constructed.
- Other rivers supporting abstractions for public water supply include:
  - River Derwent for abstraction to Carsington and Ogston Reservoirs during high flow periods and at intakes with releases from Carsington Reservoir to support abstraction during low flows
  - River Dove with water transferred to Foremark and Staunton Harold Reservoirs
  - River Blythe
  - River Blithe to augment flows to Blithfield Reservoir
  - River Trent, recently established as a source of public water supply
  - River Leam with water pumped to Draycote Reservoir during winter in addition to the direct abstraction at Leamington supported by releases from Draycote Reservoir during low flow periods.

Figure 3.4 Major transfers and water resource schemes

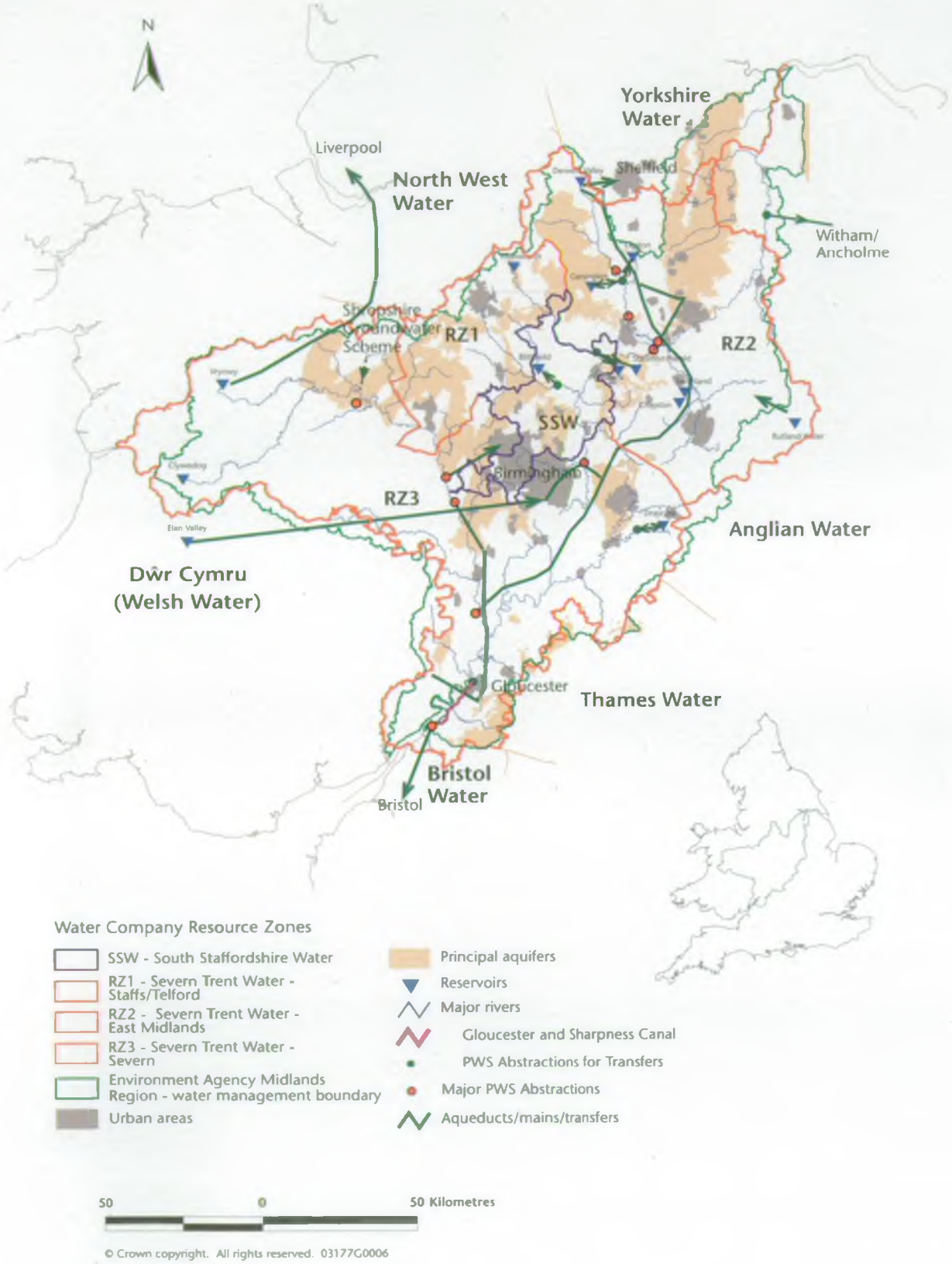


Table 3.3 Water company leakage

	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 Staffordshire	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

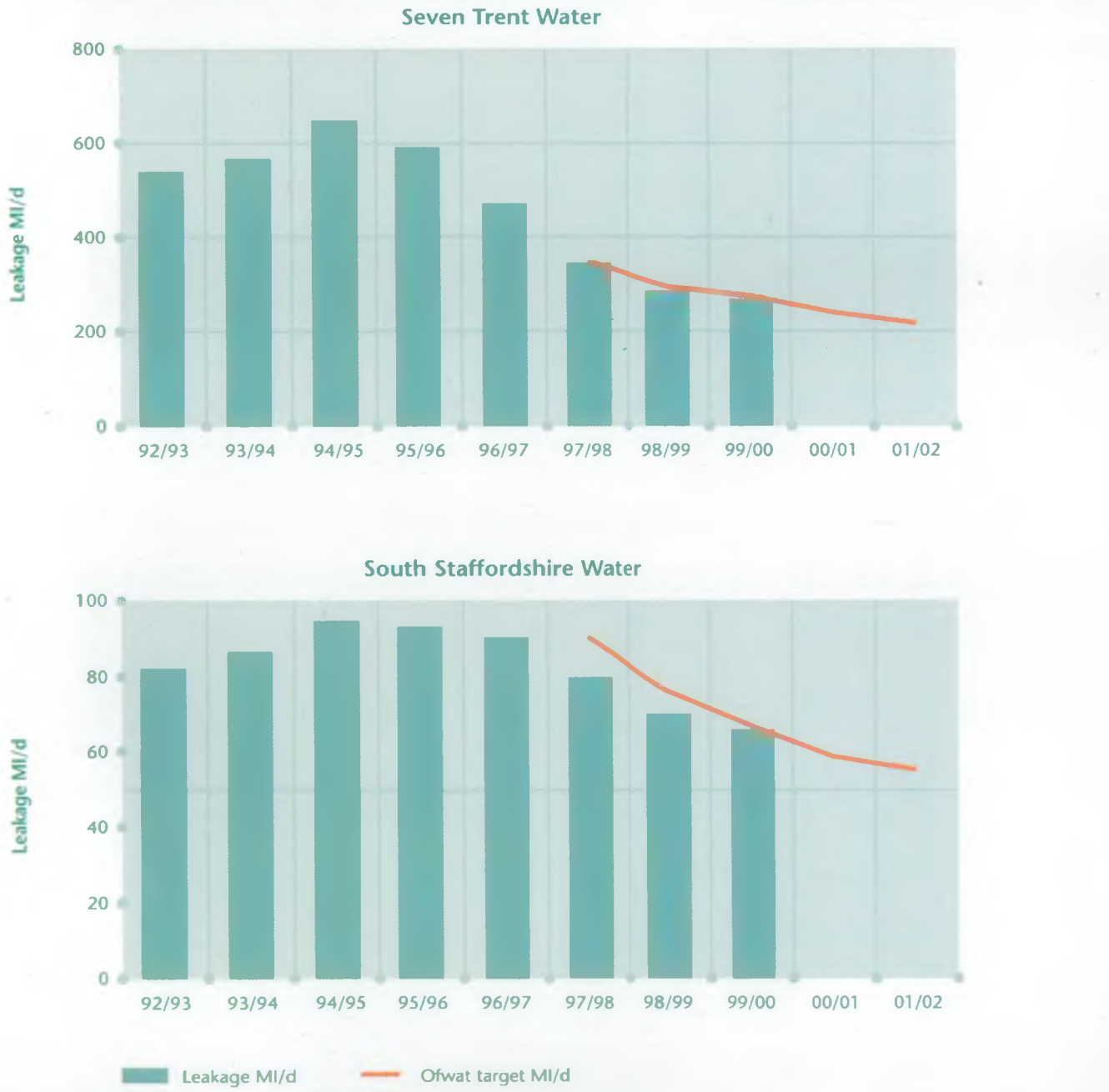
- Major public water supply reservoirs in the Midlands include:
  - the Derwent Valley Reservoirs in the Peak District, providing supplies to the cities of the East Midlands via the Derwent Valley aqueduct
  - Ogston Reservoir, Charnwood Reservoirs, Foremark and Staunton Harold Reservoirs also supplying the East Midlands
  - Tittesworth Reservoir near Leek, supplying water to Stoke-on-Trent
  - Draycote Reservoir providing water supplies directly in addition to releases to support abstraction from the River Leam during low flows
  - Blithfield Reservoir meeting demands in the South Staffordshire water company area.
- Groundwater sources provide over 40% of all public water supplies in the Midlands, including some for the Yorkshire and Anglian Water Companies. The principal aquifer in the Midlands is the Permo-Triassic Sherwood Sandstone, which outcrops most notably in large parts of Nottinghamshire, South Yorkshire, Shropshire and the West Midlands, as well as Derbyshire and Staffordshire.

3.2.2 Leakage

A significant proportion of water abstracted for public water supply is lost through leakage from the distribution and mains systems, and supply pipes on customers' premises (Table 3.3). In the Midlands, leakage represents around 20% of the total volume abstracted for public water supply. Some geographical variation in leakage levels can be expected due to differences in age of the pipework, length of pipework (rural areas) and higher operational water pressures (hilly topography). Shrinkage of clay soils in summer and ground movement due to winter frosts can result in mains and pipe bursts that further increase leakage levels.

Prior to the 1995 drought, leakage levels were gradually rising, but the drought caused difficulties in meeting customer needs. This led to a significant change in the perception of leakage by Government and the general public. Compulsory leakage control targets were introduced after the Government's 1997 water summit. Water companies have since shown a strong commitment to reducing leakage levels and have achieved significant savings in the Midlands in recent years, as illustrated in Figure 3.5. In 1999/2000, leakage represented 19% of Severn Trent Water's total supply, and 23% of South Staffordshire Water's supply. Targets are set by Ofwat based either on the company's

Figure 3.5 **Leakage trends and targets**



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

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 its movement can consume much energy, although many of the existing transfers operate by gravity. Construction of pipelines may be disruptive. The use of rivers and canals for transfers may be constrained by the effect on the receiving waters in terms of level, flow or water quality, and the potential movement of species or diseases between different catchments.

Many water companies supply water to, or receive water from, other companies. Such bulk transfers can be for either treated or untreated water. Principal public water supply transfers in the Midlands are shown on Figure 3.4. The land-locked Midlands is situated between the wetter north and west of the country and the drier south and east, and there are many examples of water transfer schemes of varying scale, type and purpose including:

- river regulation schemes to support river abstractions:
  - River Severn supported by Llyn Clywedog, the Shropshire Groundwater Scheme (phases 1 to 3) & Lake Vyrnwy
  - River Derwent supported by Carsington Reservoir
  - River Leam supported by Draycote Reservoir
- gravity transfers by aqueduct or pipeline:
  - Elan Valley Reservoir (Environment Agency for Wales) import to Birmingham
  - Lake Vyrnwy export to Merseyside (Agency's North West Region)
  - Derwent Valley Reservoirs to East Midlands and export to Sheffield (Agency's North East Region)
  - Carsington Reservoir to Ogston Reservoir

River Severn flows are regulated by releases from Llyn Clywedog near Llanidloes, Powys

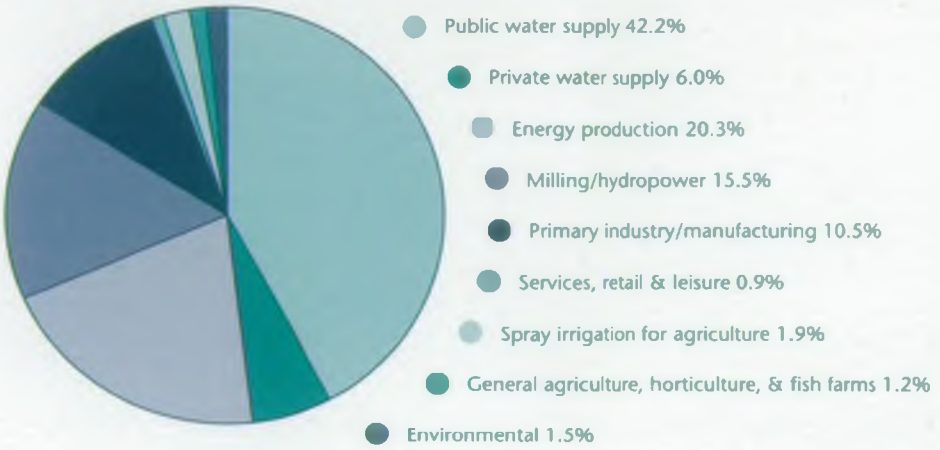
- canal transfers:
  - River Severn to Gloucester & Sharpness Canal for export to Bristol (Agency's South West Region)
  - Trent - Witham - Ancholme Scheme via Fossdyke Canal to North Lincolnshire (Agency's Anglian Region)
- pumped storage schemes:
  - River Dove to Foremark and Staunton Harold Reservoirs (known as the Dove Reservoirs)
  - River Derwent to Carsington Reservoir
  - River Leam to Draycote Reservoir
  - River Blithe to Blithfield Reservoir
- strategic distribution mains; examples include:
  - Severn Valley strategic main
  - Hampton Loade to South Staffordshire & Wolverhampton supply zones
  - Leicester to Coventry link main
  - Rutland Water (Wing Treatment Works in the Agency's Anglian Region) to East Midlands link for drought contingency use.

3.3 Uses of abstracted water

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

Within the Agency Midlands Region, 75% of all water abstracted is from surface water sources (although for public water supply abstractions, surface waters account

Figure 3.6 Licensed abstraction uses in the Severn and Trent catchments



for around 60% of the total). The remaining 25% of water abstracted comes from groundwater sources such as the Permo-Triassic Sherwood Sandstone, the Permo-Carboniferous Sandstone and the Lower Magnesian Limestone. Figure 3.6 breaks down licensed abstraction into its constituent uses. Public water supply represents the largest volumetric use of water (42%). Energy production utilises large volumes (20%), but much of the water is returned to rivers shortly downstream of the point of abstraction.

Actual abstraction rates are lower than annual licensed quantities due to seasonal and weather dependent demand fluctuations, licensed quantities beyond current reasonable needs, insufficient pump capacity or poor yielding aquifers, or because licence conditions prevent abstractions during periods of low river flows. Total actual abstractions are typically 60 to 70% of licensed quantities for public water supply; 15 to 60% for spray irrigation depending on the weather.

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.

3.3.1 Household water use

In the Midlands, household water use represents 52% of the total volume abstracted for public water supply. Present levels of unmeasured household water consumption do not vary markedly across the Midlands. In 1999/2000, average individual use (per capita consumption or PCC) was 140 litres per head per day (l/h/d) for Severn Trent Water Company and 142 l/h/d for South Staffordshire (Figure 3.7). The level of water metering, however, does vary quite considerably across the Midlands. Currently (1999/2000), Severn Trent Water meters 17% of household customers while South Staffordshire meters 9% (Figure 3.8). These rates are relatively low compared to the national average, which reflects the higher metering rates in those parts of the country experiencing the greatest water stress.

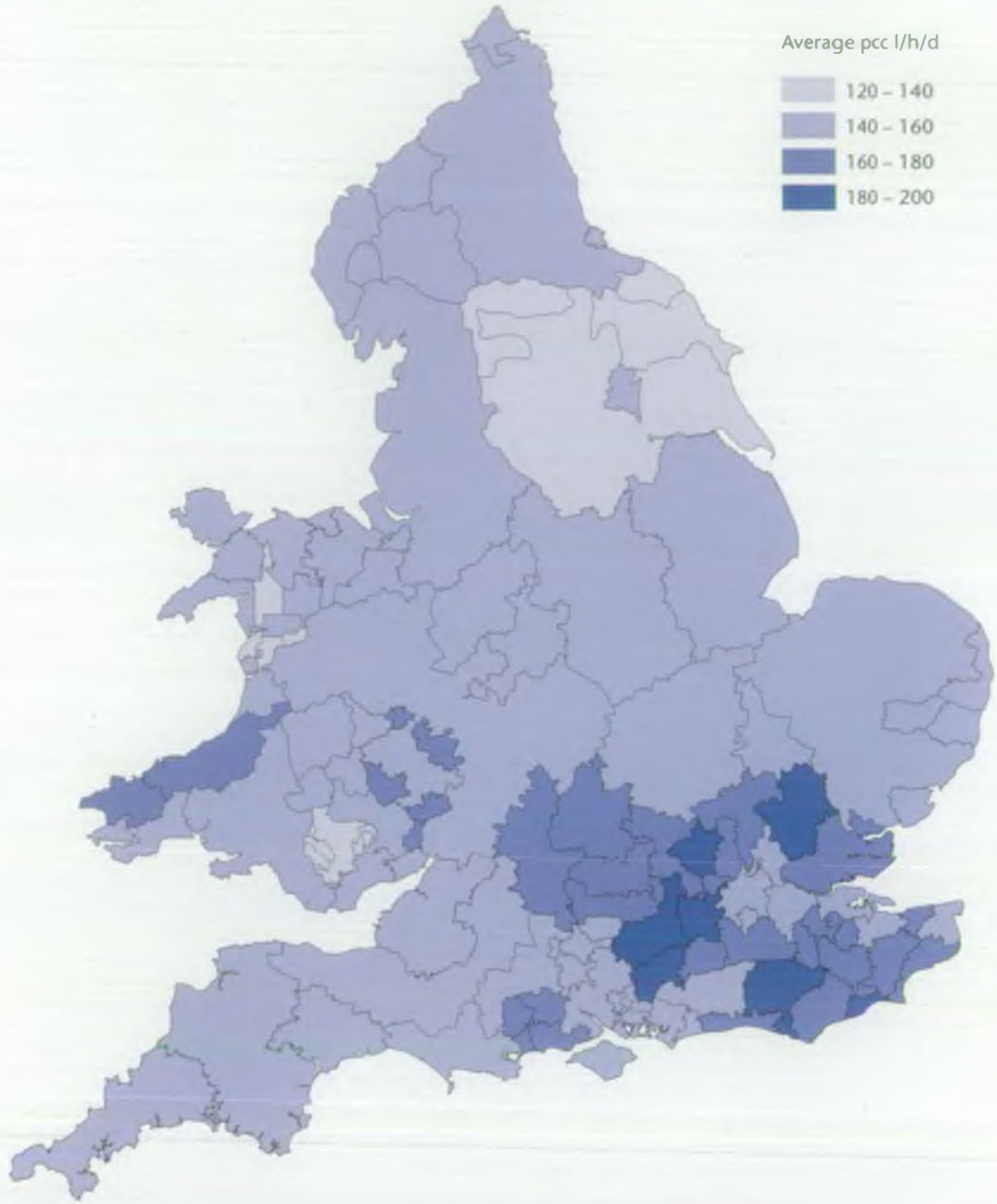
In the land-locked Midlands, around 70% of the water used in households is returned to rivers through the sewerage network after appropriate treatment. However, its return may be some way from the original point of abstraction, or even in another catchment. For example, much of the water used by the Birmingham conurbation population derives from the River Severn and the Elan Valley Reservoirs in Wales, but is mainly returned after treatment to the River Tame, a tributary of the Trent.

Private wells and boreholes are important sources of domestic drinking water in sparsely populated, rural areas, where they may form the only viable source of water. Examples in the Midlands include the Peak District and Staffordshire Moorlands, Powys and Shropshire. Most of the water is returned close to the point of abstraction after use, often through soakaways.

3.3.2 Industry

Non-household use of water for industrial and commercial uses (excluding power generation) accounts for 590 Ml/d (26%) of public water supplies from Severn Trent Water and South Staffordshire Water. Public water supply represents for industry a more costly supply of high quality water. Business and service sectors are the largest industrial and commercial users of mains water.

Figure 3.7 1997/98 per capita consumption of water



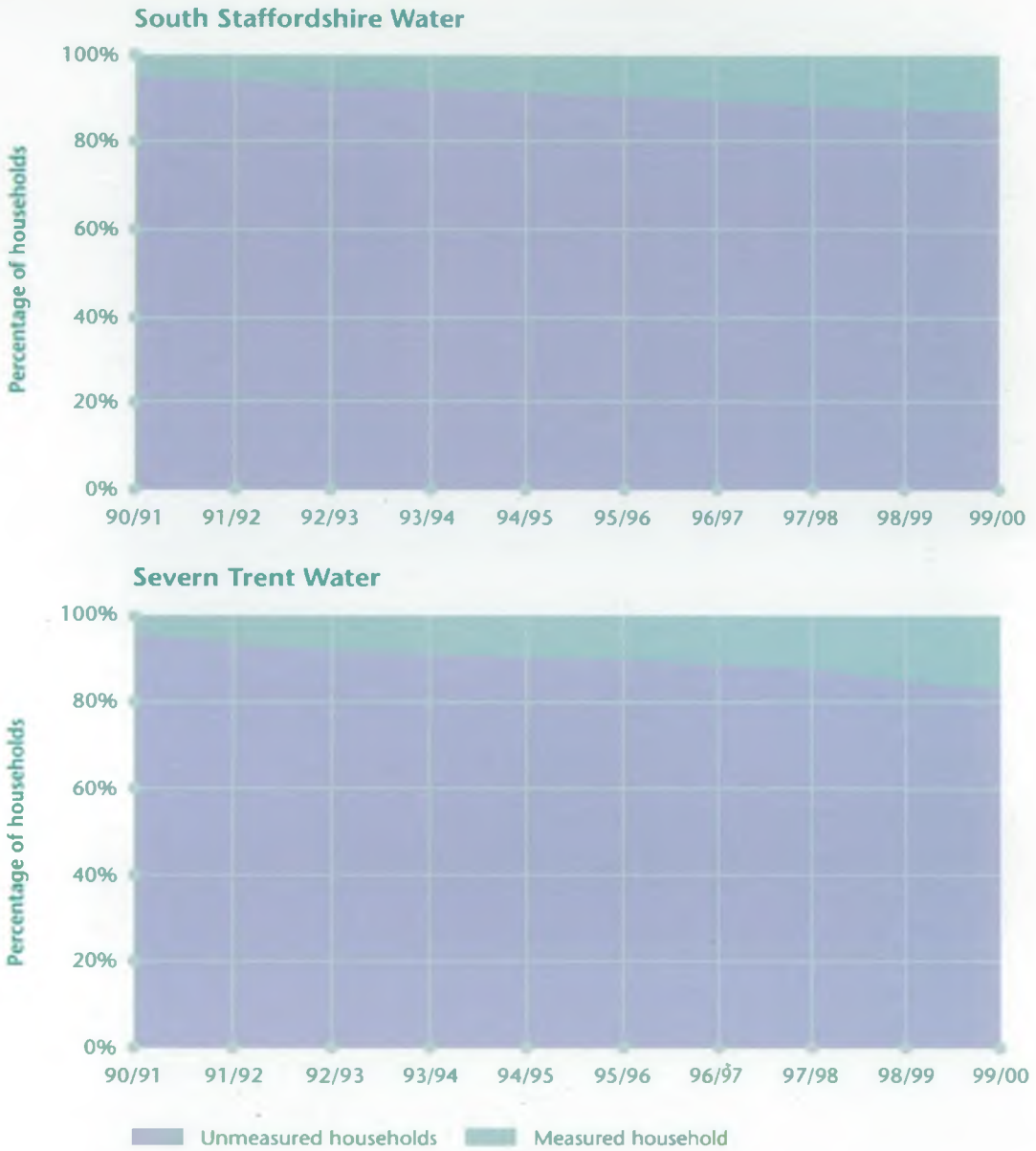
Primary industry and manufacturing sectors largely draw on direct abstraction sources, although it is not of drinking (potable) quality and its availability can be restricted according to the state of the river flows. These abstractions account for around 500 Ml/d (less than 10%) of the total direct abstractions in the Midlands. Direct abstraction represents a relatively cheap source of supply and is largely used for evaporative and non-evaporative cooling purposes. Non-evaporative cooling is mainly non-consumptive, with a large proportion of the water returned to river systems below the point of abstraction. Some water abstracted is used in the manufacturing process and is lost to the local environment. The distribution across the Midlands reflects the industrial geography.

In general, the consumption of water for industry within the Midlands has been in decline since the 1960s, except for the food and drinks industry. The reduction in industrial direct groundwater abstractions has resulted in rising groundwater levels beneath some cities and towns, causing problems with building foundations and infrastructure constructed when the water levels were lower. There is a particular problem in the Birmingham conurbation.

The breakdown of usage between different industrial and commercial user categories is shown in Figure 3.9.

Information on water use and waste minimisation in industry has become widely available in recent years. The Environmental Technology Best Practice

Figure 3.8 Trends in household metering



Programme (now Envirowise) and the Agency's 'Optimum use of water for industry and agriculture dependent on direct abstraction - best practice manual' (Environment Agency, 1998a) project have both demonstrated clearly that there is significant scope for reducing water consumption in industry and business, with considerable cost savings.

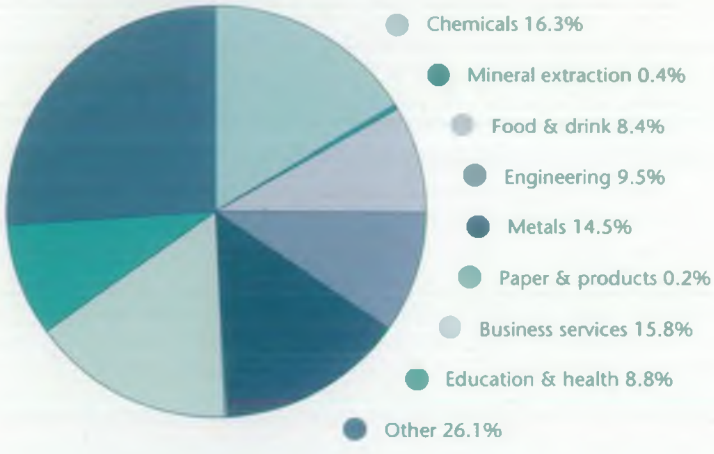
3.3.3 Agriculture

The most significant use of water by the agricultural sector is spray irrigation. This is a highly consumptive use of water with virtually no return discharges to the river system. Although it represents only a small proportion of the annual abstraction (2% in the Midlands), its impact is much more significant. In some places, on a peak day, spray irrigation demand can exceed that for public water supplies. Because it is concentrated in summer months, and periods of exceptionally low rainfall, the demand for water for irrigation places severe stress on ground and surface water sources at a time of the year when river flows are at their lowest.

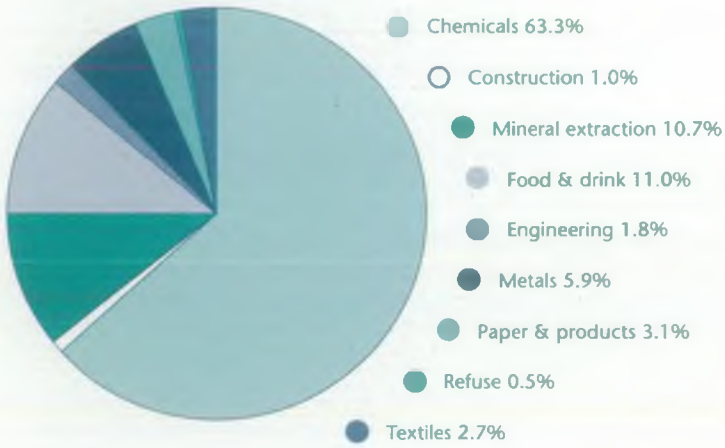
Irrigated areas in the Midlands account for 22% of the total irrigated area in England and Wales, second only to Agency's Anglian Region (53%). Irrigation is concentrated in the Shropshire Plain, the Vale of Evesham in Warwickshire and Worcestershire, and the sunken, artificially-drained land in the lower reaches of the Trent catchment. The cumulative impact of multiple abstractions on river systems is significant in these areas. The most important irrigated crops are potatoes, sugar beet and root vegetables; those crops

Figure 3.9 Industrial and commercial water use breakdown for the midlands

% Non-household public water supply



% Direct industrial abstraction



where there are significant yield and crop quality benefits from irrigation. Irrigation for turf is becoming more important. Over the last 7 years the amount of water licensed for spray irrigation has increased by over 40% in the Midlands.

Irrigation is a vital element of total crop management, ensuring that farmers meet the crop quality criteria set down by their supermarket and food processing customers. Unreliability of 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.

Over the last five to ten years supermarkets and food processing firms have extended their influence over many 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. These specifications may need to change in order for it to prove economically viable for farmers to implement medium-term water efficiency measures.

The majority of recently issued surface water abstraction licences contain 'Hands-Off-Flow' conditions, which prevent abstraction when river flows are low. Throughout much of the Midlands, the Agency is now unable to issue farmers with reliable spray irrigation licences for summer abstraction, due to sustainability constraints. We encourage irrigators to invest in winter storage reservoirs and abstract water during the winter months when water is more plentiful, and store it for reliable summer use. Presently, 15% of the total surface

water licensed for spray irrigation is authorised for the winter months only. Many farmers have utilised natural clay soils as reservoir linings to minimise costs, or, where this is not a viable option, have constructed bunded and butyl rubber-lined reservoirs. The Ministry of Agriculture, Fisheries and Food (MAFF) may provide up to 50% grants towards winter storage reservoirs where environmental benefits are incorporated, through their rural enterprise schemes. However, funding priorities vary across the country.

Trickle irrigation is becoming increasingly common and locally significant in the Midlands, as equipment improves and costs fall. This form of irrigation does not currently require an abstraction licence, and some of the trickle irrigation abstractions are potentially having an adverse impact on the environment and other abstractors. This exemption is likely to be removed following the Governments draft Water Bill (DETR, 2000e).

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.

3.3.4 Power generation

Power generation is a significant use of water, and accounts for around 20% (over 3000 Ml/d) of the licensed volumes in the Midlands. The majority of power stations are located along the Trent Valley and mainly coal-fired utilising evaporative cooling. There has also been a number of gas-fired stations commissioned in recent years accounting for a smaller proportion of total generating capacity.

As part of its response to climate change, the Government has made a commitment to reduce the UK emissions of greenhouse gases. This includes a requirement that, by 2010, 10% of UK electricity will be produced from renewable sources. The specific implications for water resource management relate to the development of hydropower and new crops for bio-fuel.

Some of the Midlands' reservoirs have hydropower facilities that serve the works or produce surplus power for the grid, such as Llyn Clywedog. The River Derwent has a series of weirs and associated hydropower developments along its length, and there is increasing interest on the River Trent. Hydropower is a clean source of energy. However, care is needed to ensure that its impact on the local river environment is acceptable. Where the water is diverted through turbines, a short stretch of river is depleted of flow until the water returns downstream. The most important issue is the volume of water abstracted and the effect of that loss on the deprived reach. Where water is impounded to build up a head of water then released through turbines, this causes rhythmical losses and surges of water. The impact may be on fisheries and the aquatic ecology, water quality where discharges are present, on other abstractors and lawful users of water, or flood defence and land drainage. Low head generation requires abstraction of large volumes of water to generate power and the legal protection of abstraction rights to river flows for hydropower can sterilise the upstream catchment to further abstractions. Fish passage, protection from ingress into turbines, and navigation must also be considered. With sensitive design and operation, the local environmental impact can often be minimised.

3.4 Recreational and other uses of water

3.4.1 Navigation

The rivers and canals of the Midlands have a long history of navigation. Use is now mainly recreational, and many people value the amenity benefits of the waterways. Freight traffic is now largely confined to a few locations in the Midlands, including the Gloucester and Sharpness Canal and the River Trent.

Navigation is an important use of water. While it is non-consumptive, navigational needs affect water resources in many ways. Important navigation rivers such as the Severn (from Stourport to Gloucester), the Warwickshire Avon and the Trent rely on maintaining sufficient water levels to allow the passage of boats, and sufficient flows to limit sedimentation and minimise dredging activities; this is an important constraint on abstraction in some locations. Complex weir and lock arrangements have been constructed to facilitate navigation.

The dense network of navigable canals in the industrial Midlands (Figure 3.10) allows the movement of water from one catchment to another through the use of locks. If canal traffic increases, 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 water demands.

Figure 3.10 Canals and navigable rivers

3.4.2 Angling

Fish are an integral part of the aquatic environment and often provide the best indicators of a well-balanced ecosystem due to their position towards the top of the food chain. More than 1200 km of rivers in the Midlands are EC designated as salmonid fishery (salmon and trout), primarily the Rivers Severn, Vyrnwy, Teme, Dove and Derwent. Another 1900 km are designated as coarse fishery, notably the Trent, Idle and Avon.

The number of stillwater fisheries has been increasing in the Midlands in recent years.

Fish rely on the right flow regime throughout their life cycle. Of particular importance is the effect of water flow on the migrations of salmon and sea trout, both downstream as smolts and upstream as adults from the sea. Generally, increases in river flow known as spates, stimulate these movements and are important in enabling adult fish to negotiate obstructions.

Angling is an important and hugely popular use of rivers, lakes and canals. The Agency's Coton Hall Lake near Kingsbury, Warwickshire

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

3.4.3 Wildlife conservation

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

The Environment Act 1995 gives the Agency a duty to promote the conservation and enhancement of the natural beauty and flora and fauna of inland and coastal waters and associated land. The Agency has lead responsibility for specific species and habitats of wetland character under the UK Biodiversity Action Plan (UKBAP) (UK Government, 1994). The UKBAP identifies the need to take opportunities for enhancing wetland habitats. In its lead role, the Agency will need to explore with others how such opportunities can be supported.

The agency must ensure that habitats and associated wildlife are not harmed by abstractions. Thorne Moors SSSI in South Yorkshire, of designated European importance

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

3.4.4 Other recreation and amenity

Water is an important resource for a variety of sports and recreation, including canoeing, sailing, windsurfing and rowing. It has an important value as a landscape and amenity feature enjoyed by the millions who visit rivers, canals, lakes and reservoirs for relaxation. The requirements for water often conflict, calling for careful management, especially in areas dependent on tourism where growth may be desirable to sustain local communities but where there is a risk of damaging the essential nature of the environment on which tourism is built.

The white water canoe slalom on the River Trent at Holme Pierrepont near Nottingham is a nationally important recreational facility. The River Severn is one of the premier canoeing rivers in England and Wales, and releases from Clywedog and Vyrnwy reservoirs are enjoyed by canoeists.

There are a number of river-related long distance footpaths in the Midlands, including the Severn Way and the Tame Valley Way. Other trails including river corridor sections form part of the National Cycle Network. The Severn Bore tidal wave that travels up the estuary is a public attraction.

3.5 Water resources and the environment

3.5.1 Indicative availability maps

The present environment of the Midlands is the result of many factors, including climate, geology and topography. Water is an essential part of our natural

Rafters enjoying the white water canoe slalom on the River Trent at Holme Pierrepont near Nottingham, a nationally important recreational facility

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 3.11), winter surface water availability (Figure 3.12) and groundwater availability (Figure 3.13). It is not appropriate to separate an assessment of groundwater availability between summer and winter, because the characteristics of most aquifers mean that rainfall stored in the winter is released to rivers and wetlands gradually throughout the year.

Each map shows three categories. These are:

- unsustainable or unacceptable abstraction: current actual abstraction is causing definite or probable environmental problems, or problems are anticipated if abstraction reaches full licensed volumes;
- no additional water available: licensed abstraction does not pose a significant 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 across the Midlands, based on licensed quantities. They are not intended to prejudge licensing decisions. For any proposed abstraction, various considerations would be needed, including an appropriate evaluation of the environmental impacts of the proposal. Within each mapped area there will be local variations, so the map cannot be used to reach a conclusion for a specific site. The maps are based on the average conditions across large areas. Individual locations may have further environmental needs for water. Likewise, selective further abstraction in otherwise fully allocated areas may be possible for uses where most of the water is returned to the stream locally, or where abstractors will accept low reliability.

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 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.

The strategic availability of water resources in the Midlands, illustrated on these maps, is summarised below.

3.5.2 Surface Water

- The majority of the Midlands has 'no water available' in the summer season. Whilst we would consider licence applications in some of these areas, the 'Hands-Off-Flow' conditions applied would be severely restrictive. The River Severn itself is flagged as 'unavailable in summer', as the current licences already utilise the regulation support schemes under maximum regulation conditions, according to the current control rules. However, some additional abstraction may be available outside the most critical low flow periods. We will be consulting on how abstractions from the River Severn should be managed in future in the CAMS process.
- There are very few locations where further summer water is reliably available. The map presents a broad overview, and sites where water resources are available in summer are elaborated below:
  - part of the Leicestershire River Soar catchment.
  - parts of the River Tame catchment including the Birmingham conurbation, but excluding the River Blythe catchment (SSSI).
  - the River Trent itself, downstream of the Tame confluence. Flows here are raised significantly above natural flows by the return of treated water from the urban areas. The original source of much of this flow returning to the Trent, particularly via the River Tame, is from other catchments, most notably the River Wye (by water transferred from Elan Valley Reservoirs in Wales) and the River Severn. The future policy for the River Trent,

confirming the extent to which abstraction could be allowed without some form of flow support, will be subject to consultation as part of the forthcoming CAMS process.

- The majority of the Midlands has 'water available' in the winter season. However, even winter abstraction licences will be subject to a 'Hands-Off-Flow' restriction so water may not be available every day. Some on-site storage will normally be required to utilise such resources.
- Areas where water is unavailable in winter, not illustrated on this strategic scale map, include:
  - catchments upstream of major reservoir sites
  - the River Strine and upper River Meese catchments in Shropshire which are subject to severe 'Hands-Off-Flow' restrictions.
- From a strategic viewpoint, there are no 'unacceptable' surface water catchments, other than those where improvements are underway or planned. The majority of the identified over-abstraction problems in the Midlands are due to groundwater over-abstraction (reflected in the groundwater map 'unacceptable' classifications) although they primarily manifest themselves as an unacceptable impact on the surface watercourses. Solutions to most of these problems are being dealt with through the National Environment Programme (see Section 4.1), and other abstraction changes or mitigation measures have been negotiated directly with abstractors and actions are being implemented. Other problems are very localised, and have not been shown, but will be dealt with through the CAMS process by reducing licence volumes or adding new 'Hands-Off-Flow' conditions.

3.5.3 Groundwater

The groundwater availability map of the Midlands (Figure 3.13) illustrates the outcrop area of the major aquifers, where aquifer recharge occurs (where the aquifer is covered only by permeable glacial drift, river gravels and soils). It also includes an approximate representation of the extent of significant confined aquifers (where the aquifer is overlain by other virtually impermeable rocks) that are currently utilised for public water supply. Less significant aquifers, such as the Derbyshire Millstone Grits, Coal Measures Sandstone (and mined voids), and river gravels are not shown on this strategic map, but nonetheless represent locally important water sources.

- Major aquifers are only present beneath around a fifth of the Midlands. The Welsh Uplands and south west of our region are dominated by non-aquifer hard rocks, while the east and south are characterised by non-aquifer clays and marls.
- The principal aquifer in the Midlands is the Permo-Triassic Sherwood Sandstone, most extensive in Nottinghamshire, South Yorkshire, Shropshire and the West Midlands. Much of this has been classified in the 'unacceptable' category as abstractions are in excess of the sustainably licensable proportion of recharge, particularly throughout its Nottinghamshire extent and beneath the upper River Worfe, Stour and Salwarpe catchments in the West Midlands. These 'unacceptable' areas are our priorities for action, and are reflected in the National Environment Programme schemes (see section 4.1).
- The Derbyshire Carboniferous and the Cotswolds Jurassic limestone aquifers are both licensed to the sustainable limit. While the Lower Magnesian Limestone of South Yorkshire and Nottinghamshire still has resources available, borehole yields tend to be poor and protection of baseflows to the rivers draining eastward is essential.
- Declining industrial abstractions around the city of Birmingham have allowed groundwater levels to recover from their historic lows and have caused problems with building foundations; abstractions here are encouraged.

Figure 3.11 **Current indicative availability map: summer surface water**

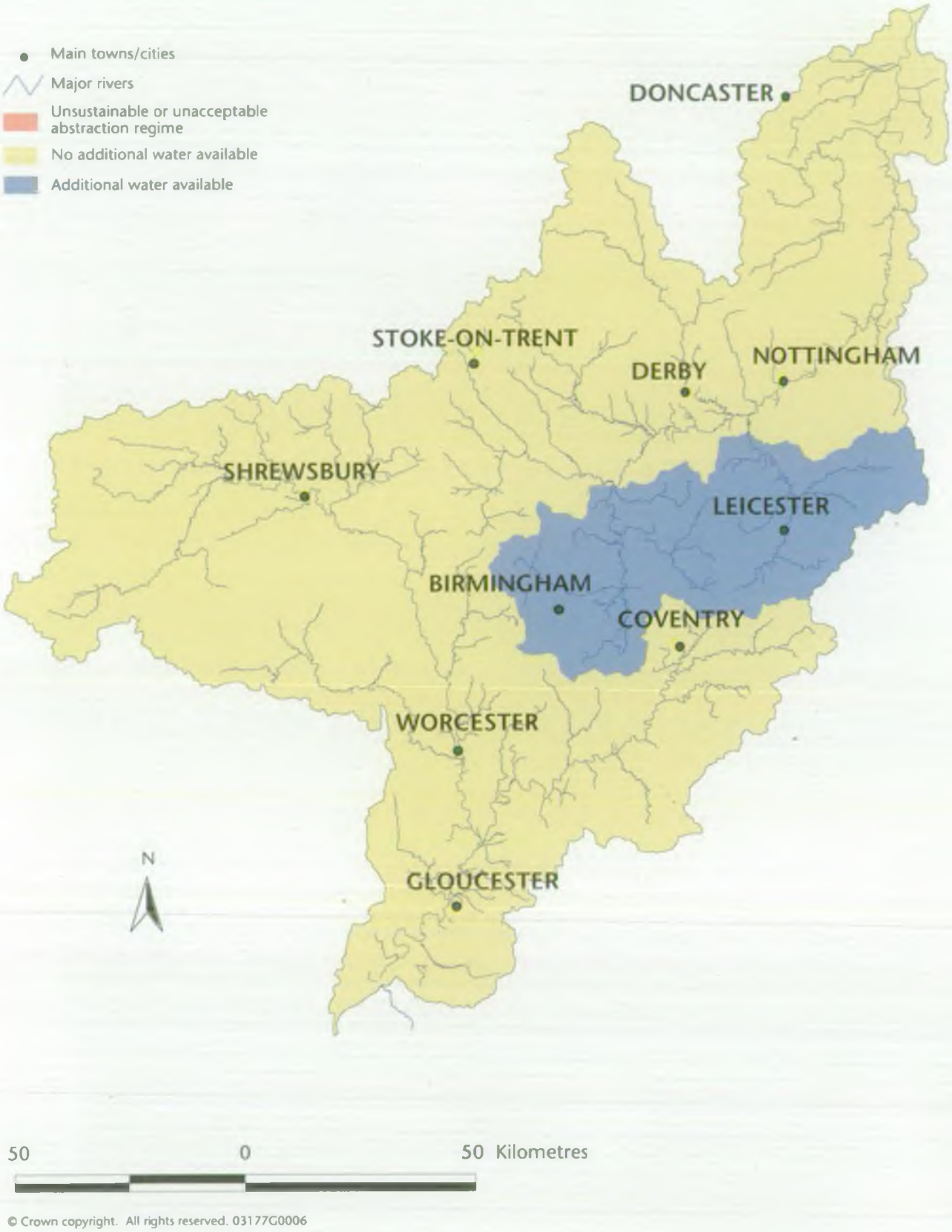
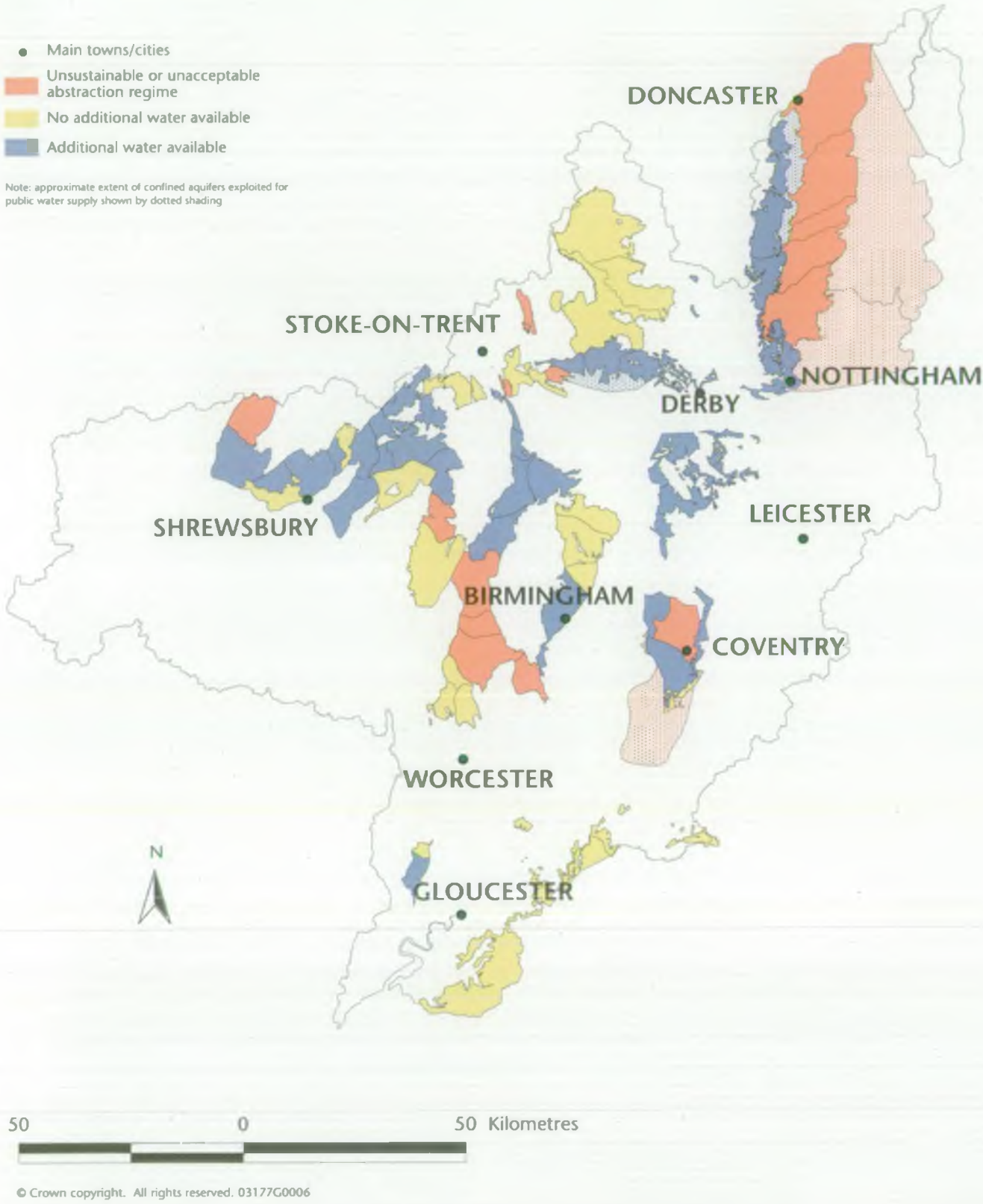


Figure 3.12 **Current indicative availability map: winter surface water**

Figure 3.13 Current indicative availability map: groundwater



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 land-use, population and societal behaviour. How society values the environment and chooses to use water in future will determine the type and size of demands placed on water resources. While it is an important part of everyday life, the consequences for water and the environment are still rarely considered when making choices.

4.1 Environmental needs

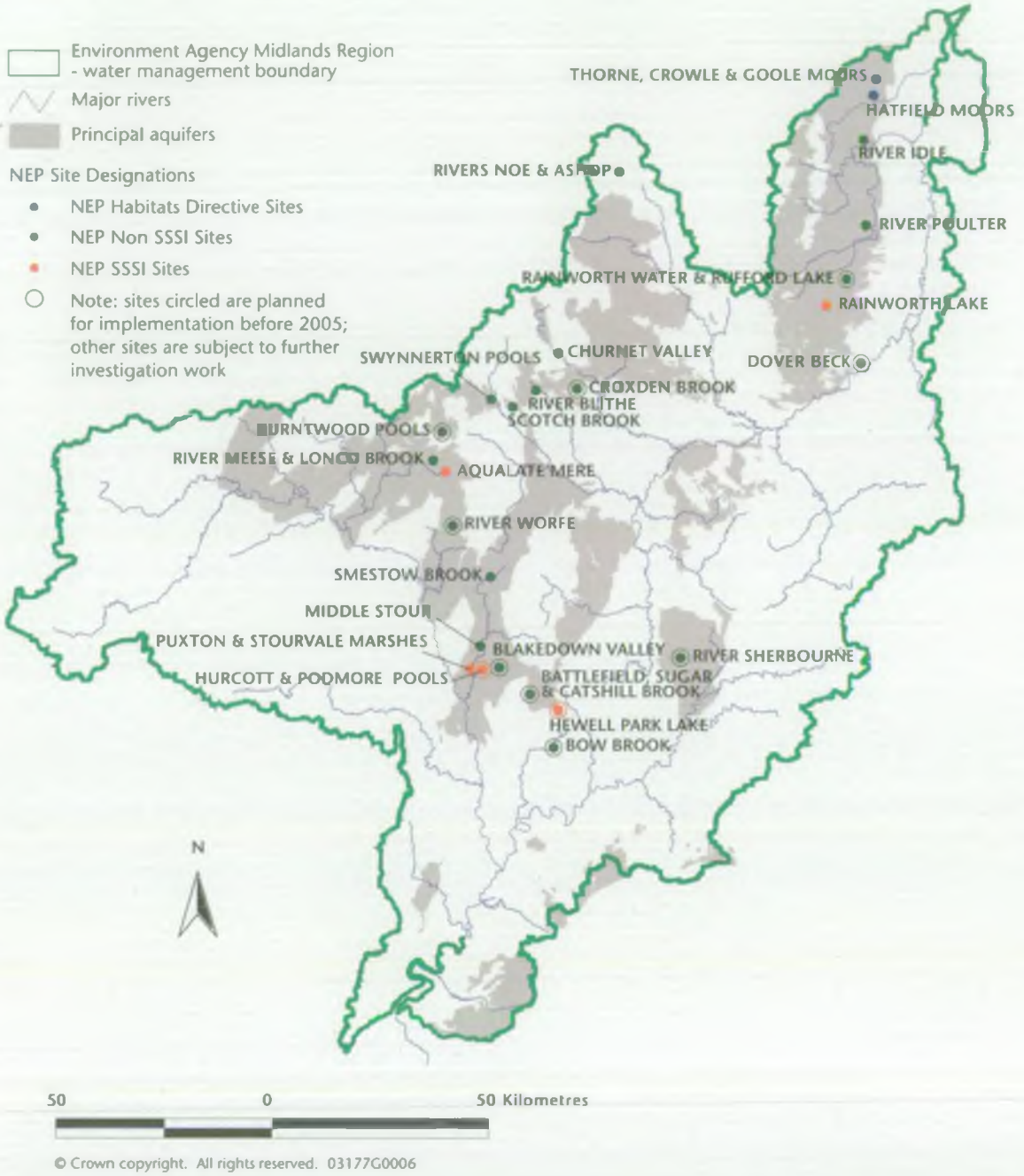
Some existing historically authorised abstractions are already causing low river flows and environmental problems, or would do so if they were fully utilised, as shown in Section 3.5 and associated maps. This happens where the volume of water legally abstracted exceeds the sustainable limit, or where 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 coming years. This will involve changing or revoking abstraction licences, through the process of Catchment Abstraction Management Strategies (CAMS). Reductions to licensed quantities or additional conditions will be implemented over a period of time, depending on the risk of impact. Where practical, some abstractions will be redistributed to where resources are sustainably available nearby. For example, the River Worfe catchment suffers low flows in its upper reaches as a result of over-abstraction of the Cosford groundwater unit; re-location of abstractions to the adjacent Worfield and nearby Longdon units are underway. The benefits will have to be weighed against the costs in a way that takes into account the needs of abstractors and society as a whole, particularly the economic and social well-being of rural areas, as well as the benefits to the water environment.

In the land-locked Midlands, water returned after treatment provides a valued resource for our rivers. Minworth sewage treatment works discharging to the River Tame, Birmingham

We have begun addressing these over-abstraction problems. The Environment Agency's current National Environment Programme (NEP) is a five-year plan to resolve problems at sites where water company activities are known, or thought to be, causing an unacceptable impact on their immediate environment (Environment Agency, 1998b). There are 23 abstraction-related sites in the Midlands requiring action or investigation, shown on Figure 4.1. Most of the NEP water resources sites are due to groundwater abstractions. Identifying and funding the most cost effective implementation in each location will be a matter for the abstractor(s) concerned and the Agency, with input from Ofwat and/or Government as necessary. These 'claw-back' needs are considered as an additional environmental demand as we develop the strategies (see Section 5.4).

Figure 4.1 **Water resources sites in the National Environment Programme**



We have also developed the Restoring Sustainable Abstraction Programme (RSAP), addressing issues associated with other abstractions thought to be adversely affecting the environment. We will prioritise our investigations and actions, and monitor progress on resolving problems. In the Midlands, this programme is supported by our wetlands monitoring strategy to install water level monitoring devices at key wetland sites and review impacts of abstraction. We 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.

We are currently carrying out reviews to assess the impact of abstractions on our SSSI conservation sites designated of European importance in accordance with recent European 'Habitats Directive' legislation. We are aiming to resolve any problems identified through these reviews, by modifying or revoking abstraction licences where necessary to maintain international sites in favourable conservation status.

We will take into account local stakeholders' views on the local water environment needs, from the LEAPs and CAMS process, aiming to improve understanding and build consensus. The Agency is committed to enhancing biodiversity, and, in all of our work, we consider opportunities to contribute to the success of the UK Biodiversity Action Plan (UKBAP) (UK Government, 1994). Water resources issues will also feature in the local Fisheries Action Plans being piloted by the Agency.

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

It is vital that the quality of water in rivers and streams is protected, as the aquatic ecology depends on both the quality and quantity of water. Treated effluent from sewage works, together with water processed by industrial or commercial users, is returned to the environment. In the land-locked Midlands, effluent has to be mainly discharged to rivers. Pressures to abstract greater quantities of water will reduce the remaining river flows available to dilute the effluent received, although this can be mitigated by improving the quality of the effluent itself before it is returned.

Water returned after treatment to the River Trent, including the large contribution from the Birmingham conurbation, results in river flows downstream of the confluence with the River Tame being more than double the natural amount in dry weather. However, in assessing future abstractions proposals we must take into account that the ecology and navigational users in the river may have come to rely on these additional flows to some extent.

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 Future' scenarios developed for the Government's Department of Trade and Industry (DTI, 1999). 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. Details of the approach can be found in Figure 4.2 and Table 4.1 and Appendix 2. The result is a set of four scenarios, each of which characterises one way in which 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

Figure 4.2 **Foresight scenarios**

Table 4.1 **Foresight scenario characteristics**

	World Markets	Global Sustainability	Provincial Enterprise	Local Stewardship
Values	Consumerist	Conservationist	Individualist	Conservationist
Governance	Globalised	Globalised	National	Regional/National
UK GDP (pa)	3%	2%	1.5%	1%
Equity	Declines	Improves	Declines	Improves
Fast growing sectors	Health care, leisure, financial services	Business services, IT, household services	Private health care and education, maintenance services	Small-scale intensive manufacturing, locally based financial and other services, small-scale agriculture
Declining sectors	Manufacturing, agriculture	Resource intensive agriculture and manufacturing	High-tech specialised services, financial services	Retailing, leisure and tourism
Water demand	Increases	Declines	Stable	Declines
Environmental issues and priorities	Environmental improvement not a priority. Emphasis on issues which impact on the individual or local area	Sustainable development accorded high political priority. Resource use efficiency drives policy	Low priority placed on the environment. Low levels of investment create significant environmental problems	Sustainable development closely integrated into all areas of decision making. Effective community action resolves local environmental problems

Source: DTI, (March 1999) Environmental Futures, Office of Science and Technology, London.

little concern for social equity. The environment is perceived as a low-priority issue, despite the increased pressures placed on natural resources.

- **World Markets Scenario:** a future in which a highly developed and integrated world trading system generates high levels of economic growth. Although average personal affluence rises, there is little concern for social equity. Awareness and concern for the environment is low, particularly among the less well-off.
- **Global Sustainability Scenario:** a future where global institutions play a central role resolving social and environmental problems. High levels of investment in research and development result in the development of innovative clean technologies, which benefit the environment.
- **Local Stewardship Scenario:** a future dominated by regional and local systems of government. Working at the local level, environmental problems are resolved through collective action.

All are possible pictures of the future. They are intended to define a broad contextual framework of social, economic, political and technological change. 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 (see Table 4.1).

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

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

4.3 Using scenarios

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

- Some of the scenarios lead to patterns of future behaviour that do not sit easily with the Environment Agency's values. 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 involve unnecessary or inadequate solutions.

4.4

Global warming and climate change

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

There is more confidence in some aspects of climate change than others. For example, there is some confidence in the predicted 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 the Midlands. 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 and Appendix 1.

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 the Midlands there will be on average more autumn and 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

Climate change could affect both water demand and availability, and have an impact on water dependent ecology. Agency staff rescuing stranded fish in dry weather on the River Teme at Stanage

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 about the possibility of longer droughts is unclear; the best available view appears to be that increased variability makes droughts that last over several years slightly less likely. However, it is important to note that the understanding of changes in extreme events is more limited than that of changes in average climate.

In this strategy, we will assume, based on the results from Arnell (Arnell, 1999) (see Appendix 1), 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 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.

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

4.5

Population and household size

In developing the strategies, the Agency has used a nationally consistent population and household data set obtained from CACI Limited for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025. This data was based on the 1996 population projections, building on the 1991 census information. These forecasts show an increase of 0.5 million households in the Midlands between 1997 and 2025. This is largely due to the trend towards smaller household size. Total population is also predicted to increase by 0.5 million over the same period.

4.6

Land use

The way in which we use land has a significant impact on the water in our environments. Urbanisation, land drainage, upland grazing and mining of minerals have all altered the run-off characteristics of an area. Future changes in land use and drainage can exert further, or new, pressures.

Urban areas have a high proportion of impermeable surfaces and drainage systems that are designed to remove water quickly. This impermeable 'capping' minimises the infiltration of water into soils and underlying aquifers, which normally sustain river baseflows in dry periods. Watercourses that flow through such areas respond quickly to rainfall and may present a flood risk. Sustainable Urban Drainage Systems (SUDS) aim to reduce the run-off problems in the urban environment by increasing the presence of permeable surfaces, filter strips, swales and ponds (see Environment Agency, 1997 and 1999c). Towns and cities also create their own micro-climates, with higher temperatures than the surrounding countryside that can trigger summer thunderstorms.

The impact of forestry depends on soil type, the type of tree planted, and the vegetation being replaced. For example, afforestation with deciduous trees may in the long-term help to store winter rainfall, by the development of deep soils rich in organic matter. Coniferous forests may reduce infiltration; when above an aquifer, this may be undesirable.

Mining and quarrying activities can have major impacts on surface flow and groundwater. Groundwater pumping (de-watering) may be required to keep the water levels low enough to facilitate dry workings. This depletes natural water movements, causing low river flows and wetland levels in the vicinity. The discharge of the pumped water to a nearby watercourse may cause water quality problems. Sand and gravel quarries, for example, produce silty water that, if not properly settled before discharge, can deplete oxygen levels in the receiving watercourse and have serious consequence for stream ecology. De-watering activities are not currently subject to Environment Agency abstraction licence requirements, but it is proposed to bring these under our control in the Government's draft Water Bill (DETR, 2000e).

Major construction work, such as highways and railways, may interfere with the groundwater flow path and intercept natural surface water drainage routes. Landfill sites may impede groundwater flow and

recharge, and pose a threat to groundwater quality.

Drainage of agricultural land increases the rate at which rainfall reaches rivers and streams. Land-use changes also affect the natural quality of the water in rivers and streams, potentially changing the species that thrive within the watercourses. Intensive arable farming can increase soil erosion and consequent silt pollution of rivers, perhaps covering river gravels that would otherwise be valuable spawning grounds for some fish species. It also increases fertiliser and pesticide inputs to the rivers.

The Agency has defined groundwater source protection zones around public water supply sources and some supplies used in food and drink industries. These zones identify areas of land which are less suitable for certain activities and processes that pose a significant threat to groundwater quality. The main issues facing groundwater quality in the Midlands are rising nitrate levels from agricultural fertilising activities, pesticide disposal, hydrocarbon contamination from oil storage and usage, chlorinated solvent pollution from industry, disposal of liquid or solid wastes to land and the redevelopment of contaminated land.

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

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. We have not quantified the incremental demand for hydropower in the Midlands, as this is primarily a local rather than strategic issue since the water is returned to river.

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.

An overview of our approach to developing scenarios is given below. Further details are provided in Appendix 2.

5.2.1 Household demand

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

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

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)	Increase UK Government support	Removal	Full reform	Increase national & regional support
	Role of supermarkets & food processing firms	Continued role	Expansion	Realign position	Marginal role
	Crop quality premia (potatoes)	High	Very high	Medium	Low
	Drought tolerant crop varieties	Low uptake	Low uptake	Very high uptake	High uptake
	Organic production	Low	Low	High	Very high
	Irrigation efficiency	Medium	High	Very high	High

5.2.2 Leakage

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

5.2.3 Industry and commerce

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

5.2.4 Spray irrigation

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

Figure 5.1 Midlands regional sector demands by scenario in 2010 and 2025

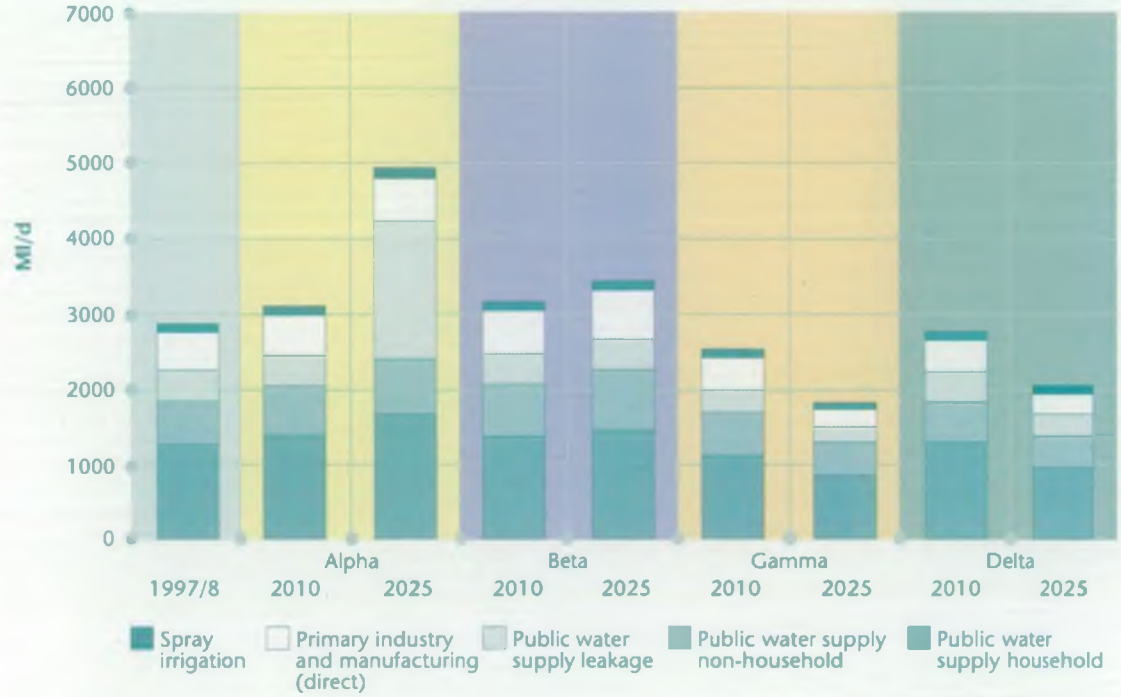
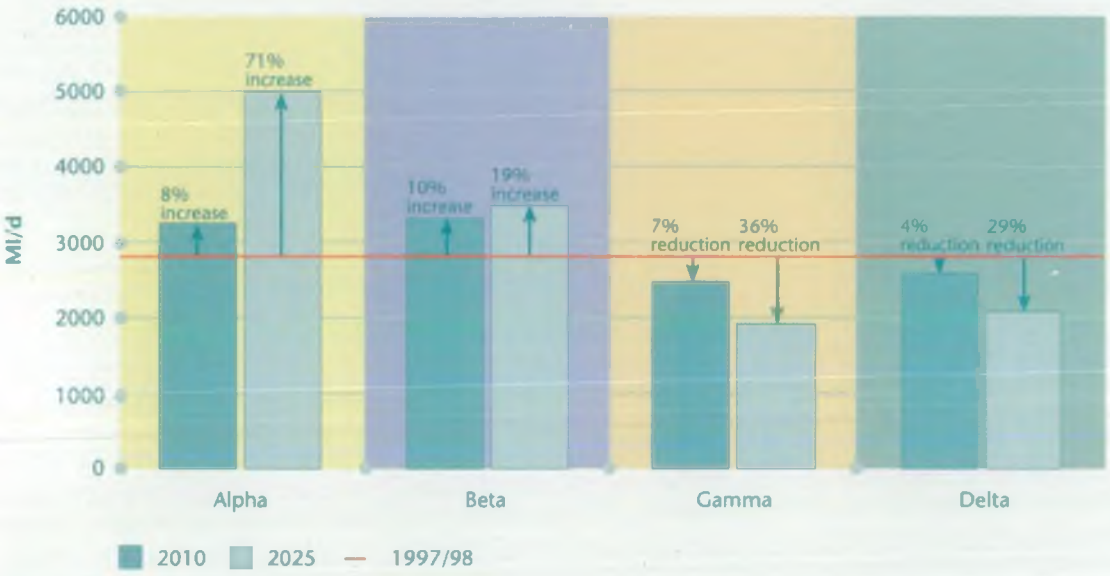


Figure 5.2 Midlands regional total demand by scenario in 2010 and 2025



5.3

Scenario demand in 2010 and 2025

5.3.1 Differences in demand

Figures 5.1 and 5.2 show the results of this forecasting work in 2010 and 2025 for the Midlands. Further details are given in Appendix 2. It can be seen that by 2010, the differences between scenarios are small, reflecting the slow rate of divergence from today's values. 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.

5.3.2 Household demand

Household water use is projected to increase under scenarios Alpha and Beta by 38% and 21% respectively by 2025 from the 1997/8 baseline. The lower increase under scenario Beta is partly explained by the higher degree of metering assumed. The reductions in water use under scenarios Gamma and Delta illustrate the

range of potential savings that could be made in the home and the garden by different attitudes to water use and conservation.

5.3.3 Leakage

The large rise in leakage under scenario Alpha after 2010 illustrates the possible outcome if a passive approach was taken to leakage control which would rapidly result in a threat to the security of water supplies without large scale resource development. The projections under scenarios Gamma and Delta give an indication of the scope of further savings that could be achieved beyond the current targets set by Ofwat.

5.3.4 Industry and commerce

The growth in demand in this sector is most marked in scenario Beta with a 33% increase by 2025 largely driven by assumptions made to support a higher rate of economic growth. The projected reductions under scenarios Gamma and Delta approaching almost 40% compared to 1997/8 give an indication of the potential savings in water use in this sector by widespread implementation of water use minimisation.

5.3.5 Spray irrigation

The increased demands for irrigation water under scenarios Alpha and Beta of 35% and 15% by 2025 reflect the assumptions made for a continued need for high quality crops influenced by supermarkets and food processing firms. The lower growth rate projected for scenario Beta is partly explained by the result of greater competition in international markets. The 18% reduction projected by scenario Gamma reflects the lower importance of high quality produce combined with a greater willingness to grow drought resistant crop varieties and implement efficient methods of irrigation.

Agricultural water usage can be reduced by growing drought resistant crop varieties and implementing efficient irrigation methods

5.3.6 Climate change

Our approach to quantifying the effect of climate change on the scenario demands is summarised below and detailed in Appendix 1.

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 garden watering, which has been added to the incremental demands for each scenario. The total effect on public water supply demands in the Midlands is an increase of 1.6% in household water use by 2025, amounting to about 24 Ml/d.

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. 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 needs would increase at the six study sites considered. Over the next 25 years, climate change will be one of many challenges facing agriculture. Given that our results are preliminary, we have not included climate change in the assessment of incremental demand. We will revise our forecasts in light of the results of the DETR climate change and demand study.

5.4 Environmental need

We have said that a number of sites or catchments are being harmed as a result of current levels of (licensed) abstraction. 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 Midlands. This 'claw-back' is almost entirely by reducing groundwater abstraction. We estimate that a reduction in licensed quantities of up to 400 Ml/d may be required to achieve a sustainable resource allocation for the Severn and Trent catchments. In practice, the impact of these changes on abstractors would be smaller, amounting to a reduction in abstraction capability of up to 200 Ml/d including reductions identified for Anglian Water and Yorkshire Water. Details will be refined as assessments

The National Environment Programme seeks to restore sites which have been harmed by historic mainly groundwater, abstractions.
Swan Pool in the Blakedown Brook catchment, Worcestershire, before and after a flow augmentation scheme

are completed and as the CAMS process develops. Some of these reductions were included in water resources plans recently published by water companies.

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.

5.5

Determining incremental demand

We have now indicated how a set of scenario-based incremental demands has been assembled. These have been compared with currently available 'spare' resources (surplus of water available over average dry weather demands) 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 was identified in a water company's water resources plan.

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

For public water supply, deficits emerge by 2010 for both scenarios Alpha and Beta for all company resource zones. The East Midlands is the most critical zone with the current surplus of resources above dry year demands below an acceptable headroom. By 2010 the deficit for the Staffordshire/Telford resource zone becomes significant, driven by potential claw back to meet environmental needs. There is also a theoretical deficit to be met for the Severn resource zone, but this is dependent upon the assumptions made on the reliability of abstractions from the River Severn during an exceptional drought. By 2025 for scenario Alpha the deficits are great, driven by the assumptions for leakage control. For scenario Beta, the deficits identified by 2010 continue to grow to 2025, requiring actions to be implemented for all resource zones.

For direct abstractions for agriculture and public water supply, potential deficits are identified under both scenarios Alpha and Beta. Although there is some spare capacity within existing licences which can be taken up to meet increased demands it is likely that, under these scenarios, there would be a shortfall in available resources, particularly where abstractions are from rivers with established 'Hands-Off-Flows'.

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

6 Options and option appraisal

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

6.1

Identification of options

We have 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 and mapped on Figure 6.1.

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

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

The Agency is a competent authority under the Habitats Directive (Section 4.1). 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 appropriate assessment under the Habitats Directive.

6.2

Tools for considering options and strategies

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

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

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

6.3

Risk and uncertainty framework

It is important to consider the different risks, uncertainties, opportunities and constraints 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. To help us to think about the different characteristics of different options, we have developed a tabular approach that provides a framework for the inevitably subjective analysis of this area. The approach considers:

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

Table 6.2 applies this framework to different resource management options. We have used this framework in conjunction with sustainability appraisal to help us to understand the different characteristics of different options.

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 before, 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.

6.4

Sustainability appraisal

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

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

In the assessment of strategic options, each of the sustainability themes was sub-divided into criteria against which each option was assessed. The appraisal was carried out by an independent assessor. The criteria are outlined in Table 6.3 and results are shown in Table 6.4.

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, shown in the risk and uncertainty Table 6.2. In the longer term, we will seek to ensure that more cost information is placed in the public domain.

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

Table 6.1 **Options for managing water resources**

Resource enhancement or development

No.	Option	Ml/d	Comments
R1	Local groundwater options	up to 50	
R2	Conjunctive use of surface and groundwater	25 +	
R3	Severn Control Rules and Shropshire groundwater scheme 4 & 5	up to 100	
R4	Trent Control Rules	up to approx. 100	
R5	Churnet abstraction rules review	0 to 5	
R6	Derwent abstraction rules review	up to 10	
R7	Leam abstraction rules review	up to 5	
R8	Birmingham groundwater	50	Trent flow support option
R9	Trent abstraction at Little Haywood	20	
R10	Trent abstraction at Shardlow	80	development in 2 phases
R11	Bankside storage on Trent	up to approx. 20	Trent flow support option
R12	Shropshire Groundwater Scheme 6 & 8	35 to 45	Severn flow support option
R13	Vyrnwy Res. partial re-deployment	approx. 40	Severn flow support option
R14	Vyrnwy Res. assisted refill	approx. 50	Severn flow support option
R15	Bankside storage on Severn	approx. 30	Severn flow support option
R16	Severn in-river storage	approx. 30	Severn flow support option
R17	Trent abstraction at Newark	approx. 40 to 60	
R18	Mine drainage options	up to approx. 30	Trent flow support option
R19	Use of marginal PWS sources	up to approx. 20	Trent flow support option
R20	Other groundwater support	up to approx. 20	Trent flow support option
R21	Severn to Trent transfer	approx. 100	Trent flow support option
R22	Cropston / Swithland Res. assisted refill	up to 10	
R23	Derwent Valley Res. partial re-deployment	up to approx. 40	proposed drought contingency option
R24	Craig Goch Res. enlargement	200+	
R25	De-salination	approx. 50+	
R26	Aquifer storage and recovery	approx. 25+	
R27	Winter storage reservoirs for farms	up to approx. 50	

Transfers beyond the region

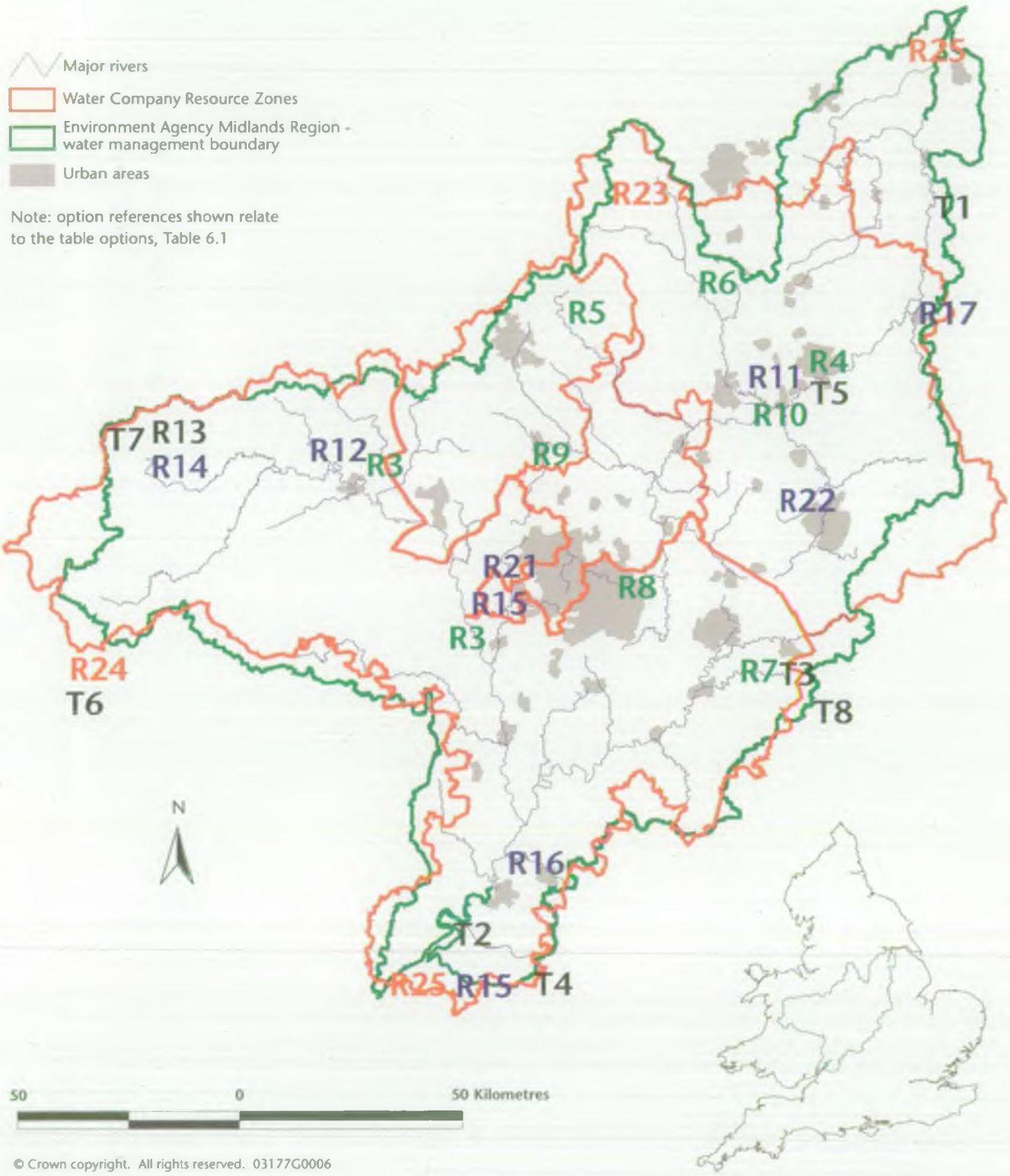
No.	Option	Ml/d	Comments
T1	Trent-Witham-Ancholme transfer	up to 30	
T2	Severn to Wessex transfer	up to 30	
T3	Canal transfer to Banbury	approx. 15	
T4	Severn to Thames transfer	30 to 50	
T5	Trent to Rutland transfer	100 +	
T6	Elan Valley toTeifi supply	approx. 5	to meet peak demands in Cardiganshire
T7	Vyrnwy / Dee / Severn conjunctive use	up to approx. 50	
T8	Canal transfer to Nene / Gt.Ouse	up to approx. 20	

Demand management

No.	Option	Ml/d	Comments
D1	Leakage reduction	up to 165	Potential saving against current Ofwat targets by 2025
D2	Household metering		Quantities shown are the additional savings that could be potentially achieved under some of the scenarios examined.
	i) increased	up to 70	
	ii) higher level	up to a further 80	
D3	Domestic water efficiency options		
	i) toilet retrofit	up to 10	
	ii) rainwater / grey water re-use	up to 20	
	iii) household water audit	up to 125	
	iv) white goods subsidies	up to 65	
D4	Water use minimisation by industry	up to 90	

Note: option numbers relate to the map of options, Figure 6.1

Figure 6.1 Future resource enhancement or development options



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 (Figure 6.2) involving the following steps:

- 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;

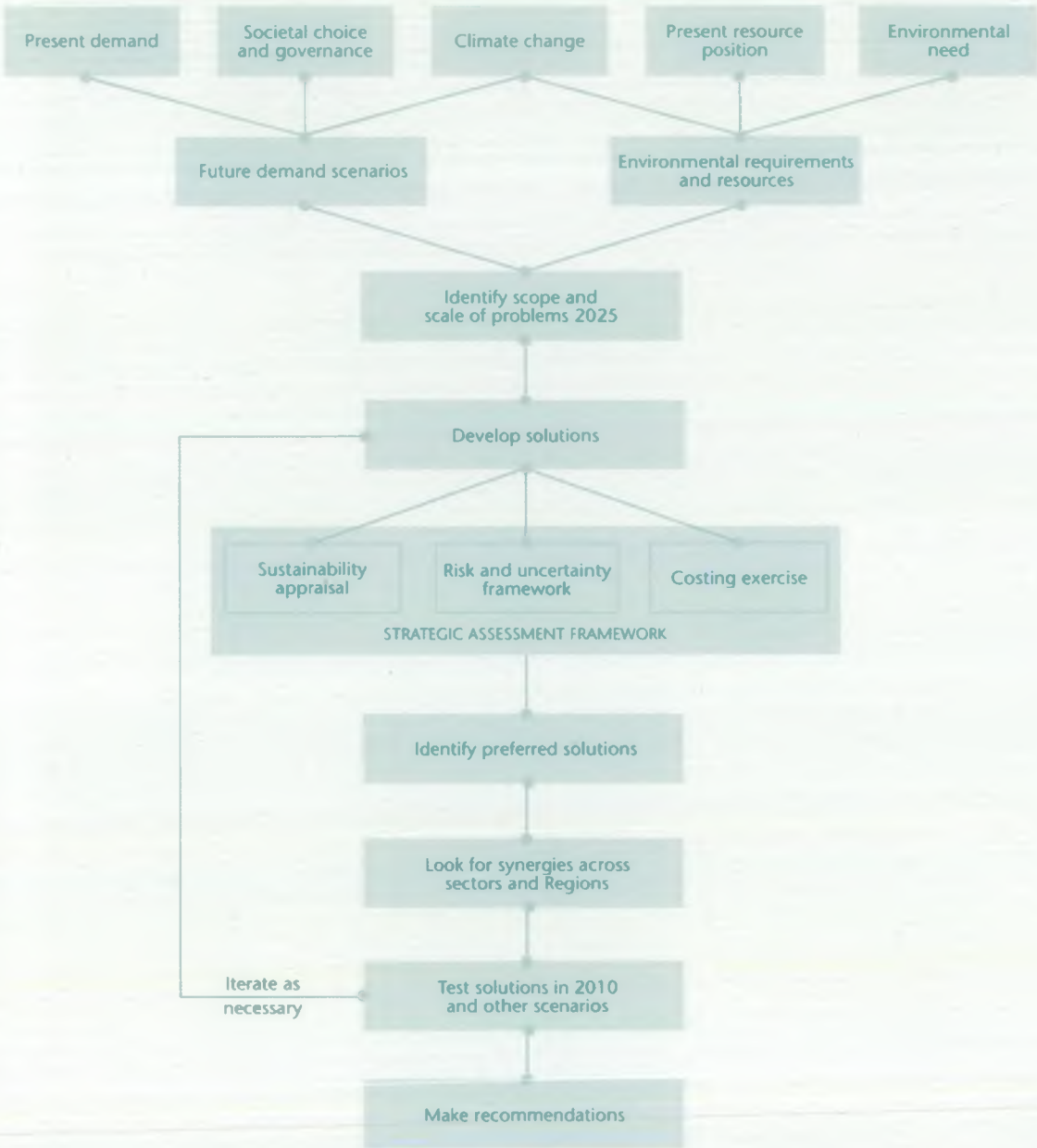
Table 6.2 **Risk and uncertainty matrix for regional options**

Option			Flow support value [Ml/d]	Resource value [Ml/d]	Component cost	Total cost	Time to implement [yr]	Renewal period [yr]	Uncertainties: Technology and investigation	Uncertainties: Promotion time	Uncertainties: Construction/implementation time	Uncertainties: Resource value	Uncertainties: Cost	Constraints: Policy & legislation	Constraints: Public & stakeholders	Constraints: Environment	Constraints: Energy use	Opportunities: Flexibility in implementation	Opportunities: Environmental enhancements	Opportunities: Resilience to climate change	Opportunities: Meeting other needs	Opportunities: Amenity & recreation
Demand mangement		Improved leakage control		up to 165		○/●[1]	1-5	-	○	○	○	◐	◐	○	○	○	○	●	○	●	○	○
		Metering (domestic)		up to 70		●	10	10	◐	●	○	●	○	●	●	○	○	●	○	●	○	○
		Tariffs for measured charges (inc. social safeguards)				●	10+	-	●	●	○	●	○	●	●	○	○	●	○	●	○	○
		Rainwater use (new development, non-potable)		up to 20		●	1-3	15	◐	◐	○	◐	○	◐	●	○	○	○	○	○	○	◐
		Greywater use (new development, non-potable)				●	1-3	15	●	●	○	○	○	●	●	○	○	○	○	●	○	○
		White goods subsidies		up to 65		●	1-3	10	○	●	○	●	○	◐	◐	○	○	●	○	●	○	○
		Toilet retrofit to dual flush/interruptible flush		up to 10		◐	-	15	◐	◐	○	◐	○	◐	●	◐	○	●	○	●	○	○
		Waste minimisation of industrial/commercial		up to 90		○/●[1]	1	-	○	○	○	◐	○	⊙	◐	○	○	●	○	●	○	○
Resource enhancement or development	Reservoir	Reservoir pumped refill: Vyrnwy winter pump-back scheme	~50		○	◐	10-15	15-20	●	◐	◐	◐	◐	●	●	●	●	◐	◐	◐	○	○
		Reservoir redeployment (partial): Vyrnwy	~40		◐	●	10-15	>30	◐	●	●	◐	●	◐	●	◐	◐	●	◐	◐	◐	◐
		Reservoir raising: Craig Gogh plus pipeline to Severn for regulation support	>200		◐	●	10-15	>50	●	◐	○	◐	●	●	●	●	○	○	○	◐	○	◐
		Bankside storage	up to ~50		○	◐	5	>30	◐	◐	○	◐	○	◐	◐	○	○	●	●	◐	●	◐
		Winter storage reservoirs (single farm)		up to ~50		○	1-2	15-30	○	○	○	○	○	○	○	○	○	○	○	●	○	○
		Winter storage reservoirs (farm consortium: 10-15)		up to ~50		○	3-5	15-30	○	◐	○	○	◐	○	○	○	◐	○	◐	●	○	◐
	Groundwater	Local groundwater options (PWS)		<50		○	<5	15-20	○	○	○	◐	◐	○	◐	◐	◐	●	○	◐	○	○
		Shropshire Groundwater Scheme phases 6 & 8	35-45		○	◐	3-5	15-20	○	○	○	○	○	○	○	◐	◐	●	◐	◐	○	○
		Aquifer artificial recharge & recovery		>25		○	5-10	15-30	●	◐	◐	◐	◐	◐	◐	◐	●	●	○	●	◐	○
		Birmingham rising groundwater to support River Trent abstractions	40		○	◐	5-7	15-20	◐	○	○	○	○	○	◐	◐	◐	●	●	◐	●	○
	River abstraction	River Trent abstraction		>100	◐		3-5	30	○	○	○	○	○	○	○	○	◐	●	○	◐	○	○
		River Severn abstraction		>100	◐		3-5	30	○	○	○	○	○	○	○	◐	◐	◐	○	◐	○	○
		River Wreake abstractions & transfer to Cropston Reservoir (winter)		<10		○-◐	5-10	15-20	◐	◐	◐	◐	●	◐	◐	◐	●	◐	○	●	○	◐
	Control rules review	Severn control rules review (inc. Shropshire groundwater Scheme phases 4 & 5)		<100		○	5	7-15	◐	○	○	◐	○	◐	◐	◐	○	◐	●	●	◐	○
		Prescribed flow reviews of Derwent, Leam & Churnet		<15		○	5	7-15	◐	○	◐	◐	○	◐	◐	◐	◐	◐	◐	◐	◐	◐
		Conjunctive use of groundwater/surface water		>25		○-◐	?	3-5	◐	◐	◐	●	●	○	◐	○	◐	●	●	●	●	○
	Transfer	Severn to Trent transfer (also requires flow support for Severn abstraction)	~100		○	◐-●	5-10	15-20	◐	◐	◐	◐	◐	◐	○	◐	●	◐	◐	◐	○	○
	Other	In-river storage	<30		○	◐	5-10	20	●	●	○	◐	◐	◐	●	◐	○	◐	◐	◐	◐	◐
		Utilisation of water returned after treatment	>50		○	◐	3-5	30	○◐	◐	○	◐	◐	◐	◐	◐	○◐	●	◐	◐	◐	○
		Controlled pumping of mine drainage	<50		○	◐	5	15-20	◐	◐	○	●	◐	◐	◐	◐	◐	●	◐	◐	◐	○
		Re-deployment of marginal PWS sources	up to ~20		○	◐	5	15-20	◐	○	○	●	○	○	○	◐	◐	●	◐	◐	◐	○
		Desalination		~50		◐-●	2-5	10-20	◐	◐	○	○	○	◐	◐	●	●	◐	○	●	○	○

● High ◐ Medium ○ Low

[1]Costs vary from high to low, depending on activity level required.

Figure 6.2 The strategy development process



- look at the strengths and weaknesses of this solution, as indicated by the sustainability appraisal, application of risks and uncertainties framework, and 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.

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

Table 6.3 **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.

Table 6.4 Sustainability appraisal of regional options

Region Proposed options	Sustainability themes							
	Effective protection of the environment		Prudent use of natural resources		Social progress which recognises the needs of everyone		Maintenance of high and stable levels of economic growth and employment	
	Positive impact	Negative impact	Positive impact	Negative impact	Positive impact	Negative impact	Positive impact	Negative impact
Midlands								
Leakage reduction	+	(-)	++	0	+	0	+	-
Increased household metering	+	0	+	0	+	(-)	+	-
Rainwater & greywater use	+	0	+	0	0	0	+	-
Domestic water efficiency /audits	+	0	+	0	+	0	+	0
Washing machine subsidy	+	0	+	0	+	0	+	-
Water use minimisation (industrial/commercial)	+	0	++	0	0	0	+	0
Shropshire groundwater and review of Severn Control Rules	+	0	+	0	+	0	+	0
River Derwent and Leam increased winter abstraction - control rules review	+	0	+	0	+	0	+	0
Raising Craig Goch and pipeline to Severn	+	-	+	--	0	-	+	-
Winter refill of Lake Vyrnwy	+	-	+	-	+	-	+	-
Partial redeployment of Lake Vyrnwy	+	-	+	-	+	-	+	-
Partial redeployment of Derwent Valley Reservoirs	+	-	+	-	0	0	+	-
Variable weirs on lower reaches of Severn	++	-	+	0	+	-	+	-
Bankside storage Gloucester & Sharpness Canal	+	-	+	-	+	-	+	0
Agricultural winter storage resevoirs	(+)	0	++	0	+	0	+	0
River Trent abstraction at Little Haywood	0	-	0	-	0	0	+	0
River Trent abstraction at Shardlow (current and further)	0	-	0	-	0	0	+	0
River Trent to Rutland (winter)	+	-	+	-	+	-	+	-
Shropshire Groundwater Scheme Phases 6 & 8 for Severn Regulation	++	-	+	-	(+)	0	0	(-)
Discharge of Birmingham groundwater - needed for Trent abstractions (above)	+	-	++	-	0	0	(+)	-
Local groundwater options	(+)	0	(+)	0	0	0	+	0
Aquifer Artificial Recharge and Recovery (AARR)	+	0	+	-	0	0	+	0
Conjunctive use of surface and groundwater	+	-	+	0	0	0	0	(-)
Utilisation of water returned after treatment - needed for Trent abstractions (above)	+	-	++	0	0	-	+	-
Seven to Trent bulk transfer (canal, river or pipeline)	+	(-)	+	(-)	0	0	0	0

++ 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

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 the Midlands

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

For the Midlands, our recommendations consist of a combination of resource developments and demand management (Table 7.1) This is a genuine 'twin track' approach which we believe can be achieved by:

- expansion of domestic metering;
- water efficiency and waste minimisation initiatives around the home, in industry and agriculture;
- further leakage savings beyond current targets;
- further conjunctive use of resources (combining different sources) incorporating infrastructure improvements;
- review of operating rules on major resource rivers, in particular for the River Severn;
- local groundwater resource developments and abstractions from rivers to winter storage reservoirs;
- abstraction from the River Trent, supported by development of Birmingham groundwater.

Figures 7.1and 7.2 show our proposed solutions for the Midlands 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 for either 2010 or 2025, with the top section of the column representing the resource development or enhancement that we are proposing. The next four columns show the demands for the four different scenarios for the same year. The top section of the bars for scenarios Alpha and Beta represents the saving that we expect from the demand management components of our strategy. These are the same demand management measures, but they deliver different savings in different scenarios as some measures are already included within the raw scenario assumptions.

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 the Midlands 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 catchments, the provision of water for spray irrigation is becoming increasingly problematical. The strategy also provides additional water to deal with the possible impact of climate change on domestic demand, and to restore sustainable abstraction regimes in those areas currently considered to be adversely affected. This combination of prudent demand management and development of additional resources is a twin track approach.

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

Table 7.1 **Strategy for the Midlands**

For public water supply, by 2010

We expect to see water savings of up to 70 Ml/d and have allowed for resource developments of up to 235 Ml/d.

- Demand management options including metering and water efficiency measures.
- Local, mainly groundwater options of up to 45 Ml/d. Most have been included in water companies' water resources plans.
- Commissioning of Shropshire Groundwater scheme phases 4 and 5 (currently under development), plus review of Severn control rules. This will give greater reliability to existing River Severn licences in a drought year and increase the previously assessed water availability by up to 100 Ml/d.
- Review of prescribed flows and operating rules on the Rivers Derwent and Leam to allow increased abstraction during higher flow periods to boost refill of pumped storage reservoirs to increase yield by up to 15Ml/d in total.
- Some additional development of conjunctive use of surface and groundwater including new supply links to partly offset reduction of groundwater licences by 25 Ml/d. This is a minimum value and there is potential to increase this after further investigation.
- Continue with existing temporary scheme to abstract up to 50 Ml/d at Shardlow from the River Trent with flow support provided by development of Birmingham groundwater.

For public water supply, by 2025

We expect to see further water savings of up to 220 Ml/d and have allowed for additional resource developments of up to 50 Ml/d.

- Demand management options including leakage control, metering and water efficiency measures.
- Extension to the River Trent abstraction at Shardlow to increase capacity to 80 Ml/d.
- A new River Trent abstraction at Little Haywood above the Tame confluence of 20 Ml/d.

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

Note: Abstractions from the River Trent would be supported by discharges of Birmingham groundwater and by water returned after treatment from upstream catchments.

For agriculture, by 2025

- Applications for direct river abstractions would be considered. However, with the exception of the River Severn and River Trent, reliability would generally be low as abstraction would be restricted during low flow periods.
- Development of winter storage reservoirs.
- Groundwater developments where resources are available.
- Conjunctive use of surface and groundwater resources.
- Promotion of co-operative use of licences between farmers to make optimum use of scarce resources.
- Promotion of efficient use.

For industry and commerce, by 2025

- Future increase in demand could largely be met by water use minimisation plus development of new sources where there are local resources available. There is probably scope for some reallocation of existing licences.

For the environment, by 2025

- Estimates of reductions in groundwater licences required to achieve sustainable levels of abstraction have been included and amount to approximately 200 Ml/d region wide. This will be subject to revision following planned investigation work.

Other options under consideration

- For all zones there is probably further potential for conjunctive use and aquifer artificial recharge and recovery.
- Further phases of Trent development at Shardlow or a new site at Newark to supply the East Midlands.
- Larger Trent abstraction at Little Haywood to supply Staffordshire/Telford zone.
- Increased River Severn abstractions at existing sites with flow support provided from the following range of options: Shropshire Groundwater phases 6&8, Lake Vyrnwy partial re-deployment or assisted winter re-fill, plus development of bankside reservoirs or Lower Severn in-river storage.

Other significant uncertainties

There is some uncertainty regarding the outcome of the review of the Severn control rules. The Habitats Directive review of the Severn Estuary could result in additional environmental needs, bringing forward the need for additional flow support for the River Severn.

Figure 7.1 **Proposed solutions for the Midlands for 2010**

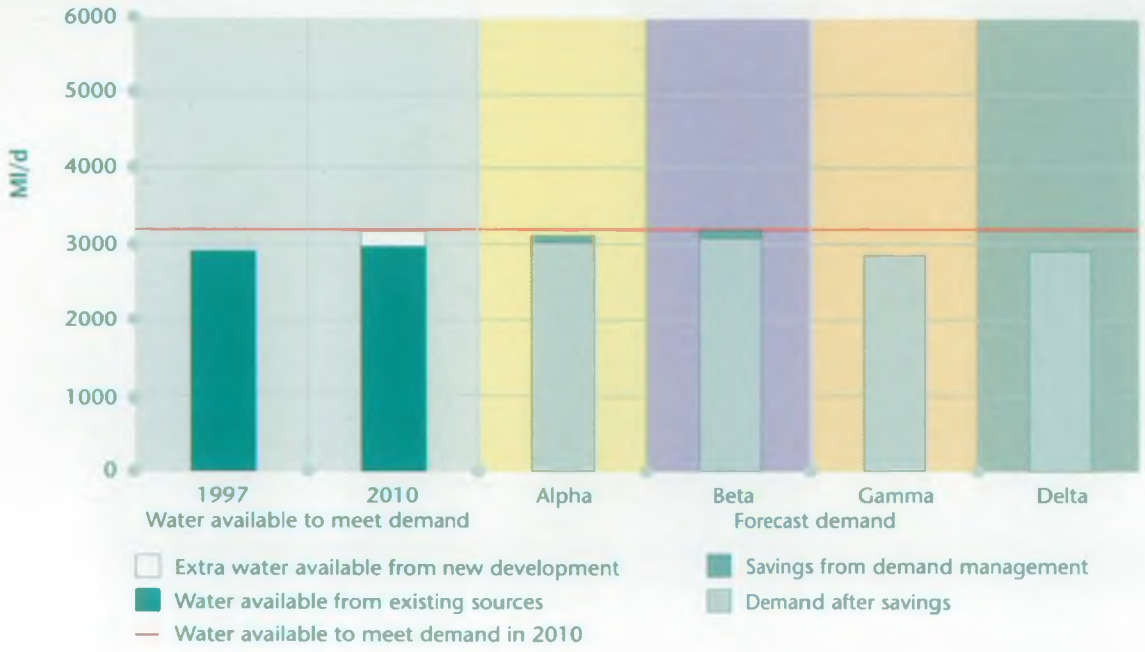
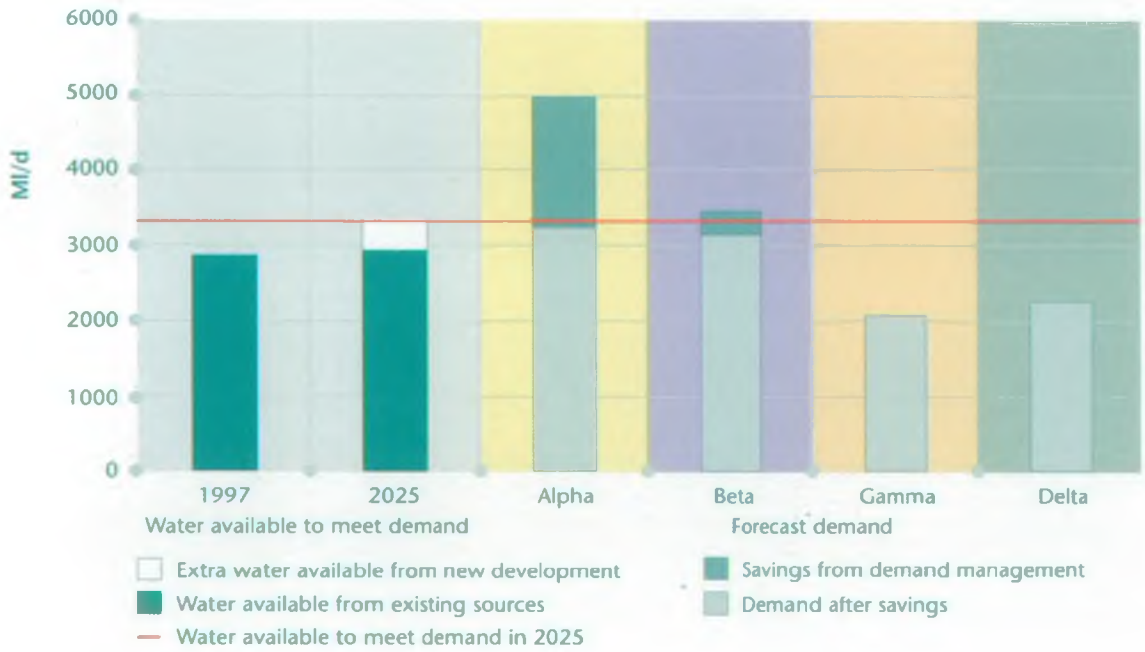


Figure 7.2 **Proposed solutions for the Midlands for 2025**



water resources. It would be unwise to base a water resources strategy on the possibility of such changes. However, these scenarios do illustrate that there is real potential for further efficiencies in water use.

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

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

7.2 Public water supply

This strategy for the Midlands is designed to make best use of available water supplies and water resources through the proposals we have put forward for demand management, leakage control, conjunctive use (combining different sources), review of operating rules, and re-use of resources. Resource proposals include development of the River Trent as a strategic source of supply, plus a number of local options which are required in the immediate future to ensure reliable

supplies are maintained. We also recognise that there are some uncertainties that cannot presently be resolved and we have therefore included a number of alternative options that may have to be considered.

7.2.1 Enhancing resources

We consider that water companies in the Midlands will need to make developments to enhance resources over the period of this strategy. Many of our resource-side recommendations involve making the most of existing schemes. These include conjunctive use of resources, review of control rules, further integration of supply systems, and improvement of machinery and equipment to reduce temporary interruptions to supply (outage). **We recommend that where new or existing developments are not fully utilised, water companies should consider sharing this water with others (Action A1).** In the Midlands, this is already a feature of the Shropshire Groundwater Scheme which provides low flow support to the River Severn and benefits other users in addition to public water supply abstractors.

River Trent resource proposals

With the significant improvements in water quality achieved over recent years, abstraction from the River Trent has been identified as a preferred resource option for the East Midlands and Staffordshire/Telford resource zones. There are now firm plans to develop groundwater sources in the Birmingham area as part of a staged approach to provide flow support for Severn Trent Water's existing River Trent abstraction at Shardlow, which could provide an additional resource of around 40 Ml/d for the East Midlands. There is also potential for further development of the Shardlow abstraction and associated treatment works at Church Wilne to meet new demands after 2010.

We have also included in this strategy the option to abstract from the River Trent upstream of the River Tame confluence to provide a new resource for the Staffordshire/Telford resource zone. A possible location has been identified at Little Haywood near Stafford with the abstraction initially sized at around 20 Ml/d. At this stage we have not considered how this abstraction would operate and whether or not flow support would be required. The Agency will be consulting on options for future water resource management of the River Trent as part of the CAMS process. The objective will be to establish control rules to ensure that existing uses and the river environment have adequate protection. This will clarify to what extent flow support is required for abstractions from the Trent.

Drilling of a Shropshire Groundwater Scheme borehole to provide additional flow regulation support for the River Severn

River Severn proposals

The River Severn plays a key role in this strategy to meet public water supply needs in the Midlands over the next 25 years. If the measures we advocate in this strategy for demand management and leakage control are successful, there is a real possibility that future abstraction needs for the Severn and South Staffordshire resource zones can be met by existing licences and associated river regulation flow support. Key to this is a forthcoming review of control rules for the River Severn, on which we intend to consult as part of the CAMS process. This review will focus on how river regulation is managed, including location of control points and target maintained flows. An important area will be to develop revised procedures and contingency measures for management of river regulation and abstractions in drought periods so that timely action can be taken to reduce the impact on the environment. It will also review how the Shropshire Groundwater Scheme is deployed, following commissioning of the latest phases (4&5) in 2001 which will contribute an extra 65 Ml/d (net) regulation support. We believe this review will improve protection of the river and estuary environment and will give greater certainty in assessing resource availability. In particular, we anticipate that this will enable Severn Trent Water to revise its conservative design estimates of water availability under existing licences from the River Severn by up to 100 Ml/d. We recognise that there are uncertainties with these assumptions, and have considered the range of possible resource options for River Severn flow support which are referred to at the end of this section.

Review of licence conditions and operating rules

Some proposals and assumptions in this strategy are dependent on the outcome of reviews of licence conditions and operating rules which will be completed when the Agency develops its Catchment Abstraction Management Strategies (CAMS) commencing April 2001. Specific proposals affecting water companies in addition to the Rivers Severn and Trent include:

- Derwent Resource System (enhanced winter pumped refill of Carsington Reservoir)
- Upper Avon and River Leam (enhanced winter pumped refill of Draycote Reservoir)
- River Churnet and Tittesworth Reservoir (compensation release review).

One of the objectives of the reviews will be to consider ways of managing these systems more flexibly to make optimum use of water resources and identify the scope for delivering environmental benefits. Some preliminary work has been carried out, indicating that the total extra yield that may result is fairly modest, amounting to no more than 15 Ml/d in total.

Local groundwater resource options

Allowance for minor local development of groundwater has been included in this strategy where it can be carried out sustainably without causing damage to the environment. The scope for developing new groundwater resources for public water supplies in the Midlands is now fairly limited and is unlikely to amount to more than 50 Ml/d from aquifers where water quality and yields are favourable. This includes proposals in water company plans, some of which are currently being licensed.

Conjunctive use of resources, artificial recharge, and integration of supplies

We believe there is further potential to operate surface and groundwater resources conjunctively to make better use of available resources for water supplies. The basic principle is to abstract from surface reservoirs and rivers when resources are plentiful, and to conserve groundwater storage to meet demands when water from surface sources is limited during dry periods. We recognise that there are a number of practical issues that need to be investigated before the full potential of conjunctive use can be realised including: environmental impacts, water quality, customer acceptance, and confirmation of costs. Consequently, we have taken a conservative approach in assessing the future role of conjunctive use as part of this strategy and have assumed a minimum figure of 25 Ml/d across the Midlands. Ultimately, greater benefits may be realised following future investigation work. This may include assessment of the scope for artificial recharge of aquifers in periods of surplus, and subsequent recovery.

Reservoir enlargement and transfers

The enlargement of Craig Goch Reservoir in the Elan Valley and associated inter-basin transfer to regulate the River Severn is an option strongly favoured by Severn Trent Water. However, it is not included in this strategy as it is a higher cost option providing more water than appears to be needed to meet future demands in the Midlands. In addition, no major transfers of water are identified as part of the national strategy that would require a development of this size. There are also concerns regarding the potential environmental impacts of the scheme. We have identified in this strategy a range of other measures and options that would enable a more flexible and adaptive approach to any future climate change impacts on public water supply. We recommend that this position should be kept under review as uncertainties regarding the environmental flow needs for the rivers Severn and Wye are resolved, and better information becomes available and a consensus reached on the likely impact of climate change on resource availability.

Other options that may have to be considered

We accept that there is a range of possible outcomes that could arise over the next 25 years which could require our proposed strategy to be modified including:

- proposed resource developments may not deliver the assumed yield or may require modification to be acceptable;
- developments may be required to support future transfers of water to meet demands outside the Midlands;
- uncertainties in future environmental demands which could reduce planned water availability arising from:
  - review of Severn and Trent control rules
  - Habitats Directive reviews, in particular those for the Severn and Humber Estuaries and the River Wye
  - review of catchment resource availability as part of CAMS
- loss of source yield from deterioration in water quality that could not be overcome by treatment or blending;
- climate change could have a greater impact on water consumption than forecast;

Table 7.2 Further resource enhancements

Option type	Details
Demand management	Further integration of supplies could allow extra demand and leakage savings in less stressed areas to provide water to parts where there is a shortfall of resources.
Conjunctive use and artificial recharge	Further potential for conjunctive use following investigation work.
River Severn options	Further resource options could be developed to provide flow support for new abstractions from the River Severn including: • Complete remaining viable phases of Shropshire Groundwater Scheme • Partial redeployment of Lake Vyrnwy for river regulation • Assisted winter refill of Lake Vyrnwy in dry winters • Extension to existing or construction of new bankside storage reservoirs • Modification of existing weir structures by incorporating variable controls to provide in-river storage.
River Trent options	Abstraction from locations other than referred to in preferred strategy e.g. Newark. The requirement for low flow support for new abstractions from the River Trent is not yet defined but possible options include: • Controlled pumping and discharge of drainage water from abandoned coal mines • Use of existing sources of marginal quality for water supply • Small groundwater support scheme where resources are available • Development of bankside storage reservoirs • Transfer of water from Severn catchment.
Enhanced winter refill of existing reservoirs	Limited scope, however possible option to transfer water from River Wreake or River Soar to Cropston/Swithland reservoir system.
Re-deployment of existing reservoirs	Re-deployment of Derwent Valley Reservoirs supply to Sheffield for use in East Midlands could be considered if acceptable alternative supplies could be found.

- climate change may have a more significant impact on water availability if mitigation and adaptation measures are not sufficient to compensate for any reduction in source yields;
- water consumption could be higher than anticipated if proposed demand management and water efficiency measures (Section 7.2.2) are not as successful as forecast;
- it may not be feasible to reduce leakage to the degree assumed (Section 7.2.3) either because of practical problems or if the costs prove to be excessive.

Based on sustainability, risk and cost considerations, the additional options most likely to need consideration should further resources be required are listed in Table 7.2.

7.2.2 Water efficiency and water use minimisation

We believe that water efficiency and water minimisation should make a significant contribution to effective water resources management over the next 25 years. In the Midlands 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:

- toilet use can be reduced by almost 10 l/h/d by introduction of dual-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.

Currently in the Midlands we each use around 140 litres of water each day, which is slightly below the average figure for England and Wales (see Section 3.3). An increase of waste minimisation 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.

We have calculated that waste minimisation in our homes could save as much as 60 Ml/d over the next 25 years in the Midlands. Under scenarios where demand is forecast to increase, it would be essential that this saving is delivered and maintained to protect the security of public water supplies.

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

Conversion of urinals to waterless operation at the Agency's Lichfield offices, in the drive to reduce water consumption

in this, and the draft Water Bill asks companies to consider water conservation in their own operations (DETR, 2000e). The Government has recently extended the Market Transformation Programme to look at household appliances' water use. The programme consists of a sector review process, conducted in partnership with business, consumers, experts and other bodies. This establishes a pool of information, market analysis and current working assumptions, and then examines the potential for change, policy options and the priority actions. The approach has successfully delivered improved energy-efficient projections, and the Agency will participate fully in this new application to water efficiency.

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 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 the Midlands, about one 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. In the Midlands, the Agency, in conjunction with partners from various sectors, has carried out a number of successful projects. These have proven the potential for water saving at a number of local government, educational and office premises. All showed water savings were achievable at little or no cost, with further savings achievable over a two year payback period. Additional savings were also made in relation to reduced discharges and energy costs. We have calculated that water conservation in commerce and industry using public water supply can save up to 90 Ml/d over the next 25 years in scenario Alpha. It is essential that this saving is delivered and maintained to protect the environment and to secure appropriate water use for everyone. We recommend the further implementation of water conservation schemes across industry and commerce as a low-cost and effective way of managing water over the next 25 years. **Water companies should actively promote waste minimisation schemes among their industrial and commercial customers in compliance with their statutory duty to promote the efficient use of water (Action A3).**

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

The Agency's National Water Demand Management Centre will continue to support and encourage water efficiency initiatives. **The Agency will work nationally and locally with water users and water companies to ensure that water efficiency is delivered (Action A5).** We will continue to lead by example and apply a partnership approach.

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. **Government should ensure that any steps towards competition and restructuring in the water industry will 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. In the Midlands, savings of 300 Ml/d have been made by Severn Trent Water and South Staffordshire Water on a total of over 700 Ml/d lost by leakage in 1995/96.

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 the Midlands, we believe that in the longer term further progress on leakage control will be appropriate, in particular in those areas where pressures are greatest for new resource development such as the East Midlands. 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 (see Appendix 3). 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).**

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).**

Where there is less pressure for new resource developments, leakage reduction beyond present targets is unlikely to be essential. We propose that water companies in these areas must not let leakage rise and so will need to maintain leakage control, taking advantage of any new technical developments that may present opportunities for further reductions.

7.2.4 Metering

We believe that metering can make a significant contribution to the effective management of water resources. Most non-household customers of water companies are already metered and charged for water by the volume that they use. In the Midlands approximately 16% of household customers are already metered. 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.

There is, of course, a cost associated with the introduction of meters to household water customers. This includes the cost of the meter itself, the work required to adapt the existing pipework to allow the meter to be installed, and an ongoing revenue cost in collecting meter readings and producing bills. This must be set against the tangible and intangible benefits of a well-organised and understood system of water resource management. Metering may also enable household customers to benefit more readily from any increase in competition in the provision of household

supplies. Charging for metered supplies by tariffs that give incentives to the efficient use of water will also benefit customers who are in a position to save on their water bills by sensible discretionary uses of water. Such tariffs can be designed to aid environmental protection and will also help to manage water resources in the face of climate change. The Agency believes that householders should understand all of the potential benefits in metering for themselves, 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).**

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 0.5 million new homes that are envisaged in the Midlands between by 2025 will all have meters.

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

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 have indicated in previous chapters 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 needing local solutions. Unfortunately, much of the current and future demand for irrigation water is in parts of the Midlands where local resources, both surface and groundwater, are very stretched. In most places where farmers may need significant extra irrigation water, none is reliably available.

One option to consider is the potential for agriculture, as well as commerce and industry, to benefit from schemes that are developed principally for public water supply. The prime example in the Midlands is the River Severn system that has traditionally supported abstractions for spray irrigation with a high level of reliability. 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. For example, future developments of the Shropshire Groundwater Scheme could potentially be partially utilised by irrigators. Alternatively, when authorising new public water supply developments, a portion of the total available resource could be reserved for future non public water supply abstractors, as in, for example, the River Leam catchment. Where possible, **the Agency will seek to identify opportunities to make water available for agricultural purposes from existing and new developments (Action A13).**

The Agency will encourage farmers to adopt good practice in water use around the farm (Action A14). We will work in partnership with the National Farmers Union, central Government and the National Assembly for Wales. This work needs 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).** In the Midlands, we are already involved in projects with various farming groups to promote efficient use of water in agriculture.

The Government has said that it considers that the Agency should use its own existing powers to apply abstraction licence conditions in order to deal with profligate water use. The Agency will develop licence

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

However, our conclusion more generally 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' (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 may be available from MAFF under the Rural Enterprise Scheme for the construction of water storage facilities and the provision of associated equipment, but funding priorities vary locally.

There may also be opportunities for more imaginative schemes, such as proposals for using surface abstractions conjunctively with borehole sources, and for artificial recharge of aquifers to enhance available resources.

Winter storage reservoirs can provide reliable water supplies for summer irrigation of crops

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 himself; in such a circumstance, a trade would make sense to both. **The Agency will assist trading of abstraction licences between abstractors, provided the trade is not doing any harm to the environment (Action A18).** We believe that this means trades that are for essentially the same body of water. **We recommend that farmers should consider the possibility of trading of abstraction licences to meet their needs (Action A19).** No specific areas have been identified in the Midlands at this stage, however, there may be opportunities for farmers to work together to put forward proposals for co-operative use of existing licences to make best use of scarce resources. 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 (DETR, 2000c) in relation to water abstraction and 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).**

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. Use of a canal is another conceivable option, if one is nearby and if British Waterways can find a reliable source of supply further away. Also, taking into account non-consumptive uses of water such as for cooling, where water is returned back to the environment, the impact

on the overall catchment water balances is likely to be relatively modest for the demand scenarios examined.

Where abstraction comes directly from rivers or groundwater we make the same recommendation as in Section 7.2.2 above: **water efficiency should be positively encouraged (Action A4).** Future increase in demand could largely be met by water use minimisation. In the Midlands, implementing these water minimisation initiatives should ensure that no more water is abstracted by commerce and industry in 2025 than is taken today. Many commercial and industrial sites could also benefit from consideration of rainwater harvesting. Based on water efficiency measures including good housekeeping, management, water saving technology and re-use, we have calculated that waste minimisation in commerce and industry using direct abstraction can save up to 150 Ml/d over the next 25 years in the Midlands, compared to the Beta scenario raw forecasts (see Appendix 2).

The economics of waste minimisation for direct abstractors 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, but they too face effluent treatment charges as well. 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 and energy costs, 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.

7.4.2 Hydropower

By their nature, hydropower proposals often require the resolution of conflicts of interests between the requirements of developers and protection of the environment. 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. Understandably developers are eager to take advantage of the opportunities offered by UK Government policy. In the Midlands, a new hydropower installation has recently been commissioned at Beeston Weir, Nottingham, on the River Trent.

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).**

These aspirations will only be met if developers recognise that they in turn must approach us and others at an early stage, and maintain the dialogue. They will need to respect the fact that we cannot compromise our statutory duties and they will need to maintain a flexible approach to the proposed scheme in respect of measures to mitigate its impact, even where this may be at the expense of some generating capacity.

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.

Our initiatives to improve our understanding of the environment's water needs and to restore sites that are suffering from the impacts of abstraction in the Midlands are identified in Section 4.1. These include our Catchment Abstraction Management Strategies, National Environment Programme, Restoring Sustainable Abstractions Programme, Wetland Monitoring Strategy and Habitats Directive reviews.

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).

7.6 Navigation

Ensuring that water levels are maintained 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).

The restoration of disused canals or the creation of new navigations can present a significant challenge for the provision of water. The Agency has a Navigation Restoration Policy and works with those considering restorations to ensure that the provision of water supplies to the canals does not have a detrimental impact on the environment or other abstractors.

7.7 Transfers

One important question concerns the need for the large-scale transfer of water around England and Wales. Existing cross-regional or internal 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. Within the Midlands there is further potential for the use of canals to transfer water to parts of the country where new demands are identified. The feasibility of these schemes will partly depend on identifying a suitable source of supply adjacent to the canal network. Some of the potential options are referred to in Table 7.3. **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 considered the options, but found no compelling reasons for recommending major new inter-regional transfer or significant changes to existing schemes and arrangements. However, possible water transfers beyond the Midlands are listed in Table 7.3.

7.8 Overarching issues

Previous sections have shown the specific actions that we believe necessary for the Agency Midlands Region and nationally.

The Agency believes that the legal, institutional and financial framework for water resources management should support sustainable development and the sustainable use of water. First in 'Taking Water Responsibly' (DETR and Welsh Office, 1999) and more recently in the draft Water Bill (DETR, 2000e), the Government has set out its intentions in various ways to improve water abstraction licensing and related issues.

To facilitate the successful implementation of the specific actions, we propose the following overarching actions:

7.8.1 Access to information

Access to information is essential to ensure that best practice can be shared, and the open exchange of views promotes confidence that the management of resources is being carried out to best effect. While some progress has been made on information exchange, much water company information is not in the public arena and some is not available to the Agency. In particular, there is a need for clear information on leakage control methods and their costs, and the effectiveness of water efficiency measures. Measures proposed in the draft Water Bill (DETR 2000e) promise to improve this situation.

7.8.2 Further integration of the water resources planning system

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 Planning Policy Guidance Notes (PPG11 and PPG12) (DETR, 2000f and DETR, 1999d) make clear. The location and timing of new building developments in relation to water supply developments and infrastructure should be a consideration in the planning system. **The Agency will work with planners to identify opportunities for water efficiency in new developments (Action A27).** There are often opportunities for water efficiency measures and sustainable drainage schemes to be incorporated at low-cost at the design and planning phase. Installing water-efficient devices and appliances in new buildings will further water conservation with no disruption to lifestyles or commerce. In the Midlands, we are currently seeking to incorporate consideration of water supply constraints, efficient water use, and sustainable urban drainage systems in the Regional Planning Guidance (RPG) review for the East Midlands, and will seek the same for the forthcoming West Midlands RPG review. We will also seek to influence and inform the Regional Government Offices, the Regional Sustainability Frameworks and the Regional Development Agency plans.

Table 7.3 Possible water transfers beyond the Midlands

Transfer	Agency Region	Description
Trent-Witham-Ancholme transfer scheme	Anglian	An increase in the Agency managed transfer by up to 30 Ml/d to meet agricultural, industrial and public water supply demands in Lincolnshire. Any increase authorised in the River Trent abstraction at Torksey would incorporate a review of operating practice to minimise the impact of abstraction during the most environmentally sensitive periods.
Bulk supply from Bristol Water	South West	An option to meet demands in Wessex Water supply area from an increase in the bulk supply. This would be likely to involve an increase in abstraction from the Gloucester and Sharpness Canal at Purton by up to 30 Ml/d. Any increase in abstraction would need to be supported during periods of River Severn regulation. The favoured option for further investigation would be to develop bankside storage alongside the Gloucester and Sharpness Canal which would allow abstraction from the River Severn at Gloucester to be minimised during critical low flow / high spring tide periods.
Severn to Thames	Thames	Two alternative options involving a 30 to 50 Ml/d transfer have been identified for further investigation. One option is a pipeline transfer to Farmoor Reservoir near Oxford. The other is the possibility of transferring water from the Gloucester and Sharpness Canal via a restored Cotswold Canal link to the River Thames. The requirement for resource development in the Severn catchment would be included as part of the investigation; it could include, for example, consideration of bankside storage to support abstraction during critical periods.
Trent to Rutland	Anglian	A winter transfer from the River Trent upstream of Nottingham has been identified for investigation as a possible future alternative option. This option has not been looked at in any detail however there is the potential to transfer significant volumes of water to boost refill of this reservoir.
Elan Valley	Welsh	No significant changes have been proposed to the existing Elan Valley supply to Birmingham. However, a possible option has been identified that may need to be considered to provide a bulk transfer via pipeline from Claerwen Reservoir into the Teifi catchment to meet peak demands generated by tourism and agriculture in Cardiganshire. The maximum size of transfer would be around 12 Ml/d which would take up around 5 Ml/d of the yield of the Elan Valley system.
Vyrnwy	North West	There are no definite proposals to significantly change the way Lake Vyrnwy resources are deployed as part of this strategy. However, partial re-allocation of storage for River Severn regulation would be investigated as a possible option if the need for additional resource development became necessary. Also for future consideration is the possibility to explore opportunities for conjunctive use of Lake Vyrnwy with sources in the Dee catchment. More immediately, we recommend that the current arrangements for the existing water bank should be reviewed to explore the scope for greater flexibility during critical droughts.
Derwent Valley Reservoirs	North East	We have not proposed any changes to the current arrangements for the Derwent Valley supply to Sheffield supply area as part of this strategy, although re-deployment of this supply is a possible alternative option to meet future demands in the East Midlands. However, we believe there could be some benefit in Severn Trent Water and Yorkshire Water reviewing arrangements to provide mutual support in the event of a serious drought.
Canals	Thames Anglian	There is also further scope to explore ways of making use of canals for transferring water in addition to those examples described above. In particular, a transfer of water in the order of 15 Ml/d via the Grand Union and Oxford Canals has been identified as a preferred option to meet demands arising in the Banbury area before 2010. Further investigation will be required to confirm how this transfer would be supported. In the longer term the feasibility of transferring water via the Grand Union Canal to the upper reaches of the River Nene and Great Ouse to meet potential demands in Anglian Region could be explored. The critical issue will be to identify sources of water to support these potential transfers.

7.8.3 Time taken for the development of major new schemes

It can take many years to develop a large water resources scheme, such as a reservoir. **The Agency will work with Government to identify opportunities for streamlining the process of approval for essential water resources developments while maintaining full public accountability (Action A28).** We will also work with planners to promote the use of local storage reservoirs for agriculture and industry.

7.8.4 Water efficiency body

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 the idea of an independent water efficiency body, we will encourage its further development (Action A29).** Whatever the outcome, we will continue our own efficiency promotion initiatives.

7.8.5 Further research and development

The thinking that has gone into developing our strategies has identified areas where further research is required. A full list of research topic areas can be found in Appendix 4. **The Agency will work with others to prioritise and take forward appropriate research and development (Action A30).**

7.9 Conclusions

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

Development options and demand management options all require action 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 scheme 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 Figure 7.3. It shows that the contribution to sustainable development is generally positive.

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.

In developing this strategy for the Midlands, we have sought to take into account the needs of the environment and water users. We have also been careful to take into account the likely requirements for transfers of water between the Midlands and neighbouring regions. We recognise that there are a number of uncertainties affecting water resources and demands, such as the potential impact of climate change, and we have attempted to present a strategy that is both flexible and robust, and that recognises the need to keep alternative options under review.

Figure 7.3 **Water Resources Strategy for the Midlands - sustainability appraisal summary**

The Midland's Strategy generally makes a positive contribution to sustainable development. The strategy makes significant use of demand management measures, such as metering, water efficiency, water minimisation & leakage below current target levels (which together represent ~50% of the total strategy); combined with better use of existing water resources, such as control and prescribed flow review, conjunctive use and winter storage for sectors such as agriculture (together representing ~25% of the total); and resource development options (representing ~25% of the total).

Many of the options within the strategy will bring benefits in terms of environmental protection and prudent use of natural resources - particularly the demand management measures. However, some possible negative environmental and natural resource impacts are linked to options involving river and groundwater abstraction (though these may be minimised through effective controls during the 'construction' and operation of these measures).

In terms of 'social progress', the proposed measures have largely positive impacts, though with some potential negative effects associated with increased household metering and utilisation of water returned after treatment required to support the River Trent abstractions. Economic effects of the options are generally positive, for example, in providing resources to meet the needs of different sectors; though some costs are to be expected in relation, for example, to metering, leakage control and River Trent abstractions. It is important to note, however, that in many cases these potentially negative impacts can be offset by benefits in terms of environmental protection and resource use.

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

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. 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. Appendix 4 indicates 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 the Midlands.

Table 8.1 Actions

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

Table 8.1 **Actions** *continued*

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

Appendix 1
Climate change

A1.1

Overview

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

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

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

A1.2

Climate change predictions

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

Predictions for the Midlands suggest mean annual temperature increasing by 0.5 to 1.4°C by 2020, and an overall annual rainfall increase by up to 5% by 2020. Autumns and winters are forecast to be wetter by up to 10% and summers drier by up to 6% on average by 2020 with summer droughts occurring more frequently.

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

Over the next few years, we expect that the understanding of climate change will improve. It is most likely that this will involve refining existing results, adding detail and reducing uncertainty in the present scenarios. However, it is quite possible that new predictions could be quite different from those that we have now. It must also be acknowledged that we do not understand fully all of the possible effects of global warming. For example, it has been suggested that there could be a change in the behaviour of the Gulf Stream, resulting in the cooling of north-western Europe. While the best available information suggests that this is not likely, we must be aware that present assessments may

change. We cannot rely on their accuracy, which means that we need ways to deal with climate change that are flexible. However, we must balance our concern about the possible effects of climate change against other potential changes, and produce a measured response that allows society to adapt to accommodate the new climate as it evolves.

A1.3

The impact of climate change on water resources

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

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

A1.3.1 Demand for water

Climate change will affect the demand for water in many different ways. Our understanding of the relationship between weather and water use is not perfect, so it is not possible to be absolutely certain about how climate change will affect demand. The 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 be published 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 (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 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, so we have applied the value calculated for the scenario Beta to the other scenarios as well. This is a precautionary assumption, as this scenario represents a worst case and it is anticipated that outdoor water use under the other scenarios would be lower. We have added this climate change demand to the incremental demands for each scenario. The total effect on public water supply demand nationally is about 190 Ml/d for 2025. This impact is distributed so that it is greater in the south and east than in the north. In the Midlands, this has a total effect on public water supply demand of 24 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 needs.

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 agroclimatic 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. In Shropshire, for example, the increase above current optimal levels varies between 11 and 16% for sugarbeet, although for main crop potatoes the variation is smaller at 13 to 15%. The DETR study on 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.

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

Other factors that influence demand may be affected by climate change. For example, higher winter temperatures may mean less frost-heave and therefore lower winter mains burst rates. However, the impact of such effects is probably small and at present almost impossible to quantify. Ignoring such secondary factors is reasonable in the context of this strategy.

A1.3.2 Availability of water

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

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

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

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

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

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

Different water supply systems will respond in different ways, according both to their physical characteristics and to the way in which they are operated. The yield and reliability of public water supply systems depends on the magnitude and duration of dry periods, as well as the frequency of occurrence of such events. The increased variability associated with present scenarios suggests that long dry events will be no more frequent than at present, which implies no loss of yield 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.

In the Midlands, some work has been carried out, mainly by water companies, to assess the potential impact of climate change on source yields. Some resource systems appear to be more resilient with negligible impact on water availability for the scenarios examined. Other systems that are dependent to a greater extent on summer river flows appear to be more susceptible. However, this reduction could be offset to some extent

by increased aquifer recharge and reservoir winter refill potential from higher winter rainfall, although it is by no means certain. The healthy mixture of different types of sources (groundwater, reservoir, and river) in the Midlands provides some resilience against potential adverse impacts of climate change on water availability.

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

A1.3.3 Impact on the natural environment

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

Changes in river flows and wetland levels as a result of climate change will have an impact on the plants and animals that rely on the water environment. Some species will be better suited to the new conditions, while others may find it harder to thrive. The water requirements of different species are hard to establish, partly because factors other than water availability determine current species distribution. Many species can tolerate a certain level of stress due to occasional drought.

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

A1.4

Adaptation strategies

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

The Agency has a significant role in helping to mitigate climate change by regulating major industries that emit greenhouse gases. While water resources has little impact on this, it is important to take into account the energy use of different scheme options. 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. Regional options such as Vyrnwy Reservoir pump-back scheme are less favourable in energy use terms.

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

While all sectors suffer from dry weather, the impact on the availability of public water supply is especially important. Experience during the 1995 drought shows that failures in public water supply would be unacceptable, and that it is essential that we plan to maintain basic supplies through all types of drought. As a result, all water companies have developed drought plans, setting down the steps they will take to maintain

supplies as a drought progresses. We reported to Government on these in June 2000 (Environment Agency, 2000b). In this strategy we prefer options that provide maximum security of supply during different types of drought. Different water company systems have different characteristics, depending, for example, on the proportion of water stored in reservoirs or taken from groundwater.

A1.5

Climate change in context

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

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

Appendix 2
A scenario approach to water demand

A2.1

Overview

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

A2.2

The Foresight 'Environmental Futures' scenarios and water demand

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

A2.3

Household demand

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

To establish base year values for Ownership, Frequency and Volume (OFV) for the relevant micro-components we drew on information supplied by eight of the water companies in their water resource plan submissions. The data supplied by these companies was reclassified into our fourteen 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 fourteen micro-components to generate an unmeasured per capita consumption for each resource zone.

A2.3.1 Metering scenario assumptions

Metering gives customers the opportunity to pay for the volume of water used, offering an element of choice to the consumer, and also providing an incentive to manage demand. It is likely that different tariff structures would be developed under different scenarios; we have not considered these in detail because our general assumptions about water use within each scenario have a similar effect. Generalised savings based upon the results of the National Metering Trials have been used to guide our assumptions

Table A2.1 Household demand micro-components

Component	Micro-component	Component percentage*	
		Un-metered	Metered
Toilet use	Toilet use	24.7	27.2
Personal washing	Bath	33.4	29.5
	Standard shower		
	Power shower		
	Hand basin		
Clothes washing	Clothes washing by machine	14.5	15.2
	Clothes washing by hand		
Dish washing	Dish washing by machine	8.4	8.8
	Dish washing by hand		
Car washing	Car washing	0.6	0.6
Garden use	Sprinkler use	5.0	5.0
	Other garden use		
Direct heating system	Combination boilers	0.1	0.1
Miscellaneous	Miscellaneous	13.3	13.6

* for Severn Trent Water and South Staffordshire Water

Table A2.2 Metering assumptions for each scenario

	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Alpha	Likely water company rates following Ofwat final price determination	No additional metering in the Midlands			
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			

(National Metering Trials Working Group, 1993). The greatest reduction in demand is delivered in scenario Gamma (Global Sustainability). The proportion of metering also varies across the scenarios to reflect differences in the degree of social acceptability and regulatory influence. This differentiated approach is presented in Table A2.2.

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

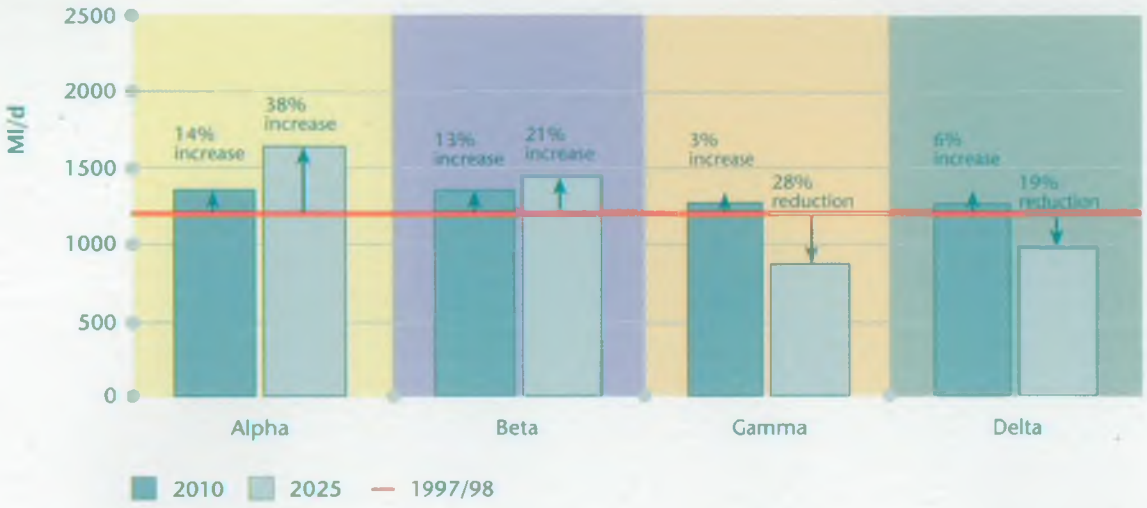
To complete the forecasts, a nationally consistent population and household data set was obtained from CACI for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025. This data was based on the 1996 population projections (building on the 1991 census information), adjusted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

Results for the Midlands are presented in Figure A2.1, based on forecasts at the water company resource zone level.

A2.3.2 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

Figure A2.1 Midlands public water suply household demands by scenario in 2010 and 2025



increases with more power jetters, power showers and swimming pools.

- **Scenario Gamma (Global Sustainability):** By 2010, measures to manage demand within existing regulation 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. Rain water collection for garden watering is the norm where some form of watering is required.

A2.4

Leakage demand

For our strategy, the formulation of the four leakage scenarios has focused in particular on the political and regulatory framework likely to influence the setting of leakage targets, and the consequent impacts for total leakage at water company level (see Table 5.1 in the main report). High level changes in political and social attitudes will affect the priority given to leakage by Government, and therefore will influence the formulation of targets. This in turn will affect water companies' leakage control philosophy and subsequent find-and-fix activity, pressure management levels, and service and mains replacement rates.

A2.4.1 The leakage scenario approach

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

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

Scenario Alpha (Provincial Enterprise) leakage assumptions

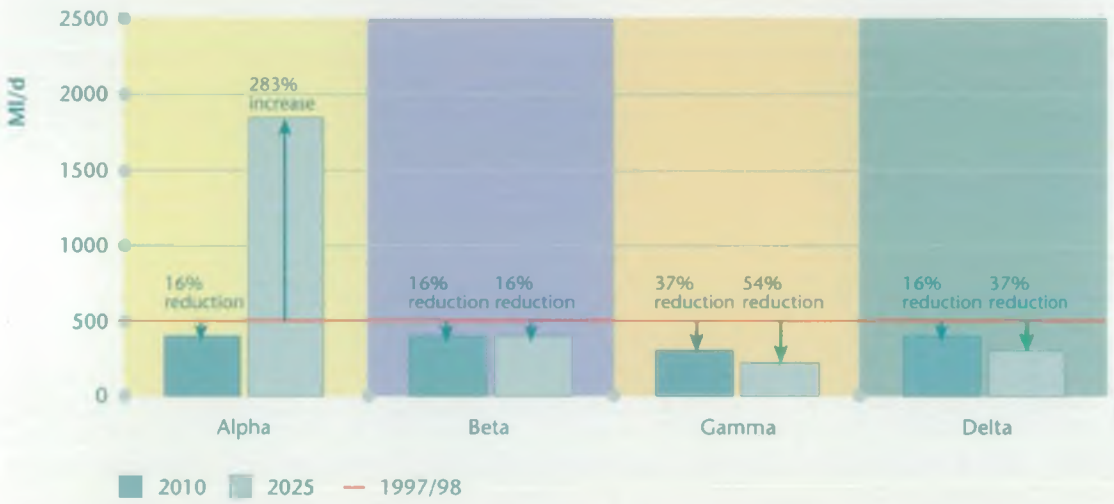
Given the lack of investment and short-termism that characterises this scenario, leakage levels are forecast to increase in line with the Natural Rate of Rise (NRR). The Natural Rate of Rise relates to the average rate at which leakage rises when a water company practises passive leakage control, when 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 per 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

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

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

Figure A2.2 **Midlands public water supply leakage by scenario in 2010 and 2025**



Note: 'Midlands' taken as Severn Trent Water and South Staffordshire Water

leakage in a less regulated scenario. The rate of rise may look extreme. It is possible to postulate a mechanism of relaxed control that allows leakage to rise more slowly but has the same result by 2025, the time horizon of this strategy.

Scenario Gamma (Global Sustainability) leakage assumptions

The implementation of improved leakage control methods forms the cornerstone of leakage targets in this scenario, based on the assumption that techniques currently available are developed slightly. We have identified a level of leakage that would be achievable with the application of today's best practice and the most advanced technology. This is described in detail in Appendix 3. Results for the Midlands are presented in Figure A2.2, based on forecasts at the water company resource zone level.

A2.4.2 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 inhibited by the decentralised system of regulation. Capital constraints curtail investment in research and development, slowing development of innovative leakage control technologies. Leakage targets are based on a political judgement that 10% of water put into supply is an appropriate level.

A2.5

Non-household and primary industry demand

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

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

A2.5.1 Forecast methodology

Availability of base year water consumption data, disaggregated by industrial sector, played an important role in determining our forecast methodology. Owing to the limited amount 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 pay back period. Hence for production and manufacturing industries five water efficiency measures have been defined:

- good housekeeping;
- management;
- reuse;
- recycle;
- redesign.

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

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

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

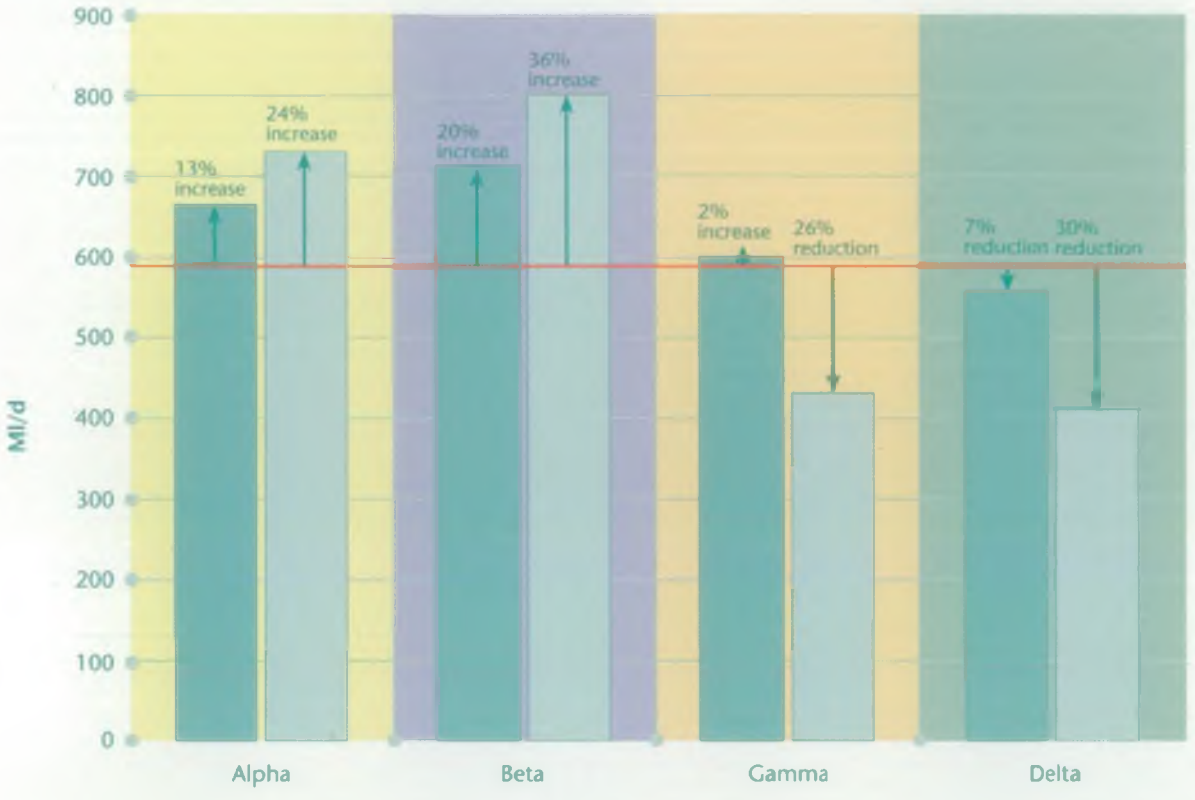
The water efficiency reductions employed in this analysis are all technically feasible today, and these values have been held constant across all four scenarios. Variability between scenarios is introduced through the level of uptake by businesses of relevant water efficiency measures. Results for the Midlands are presented in Figure A2.3.

A2.5.2 Industrial demand: scenario outcomes

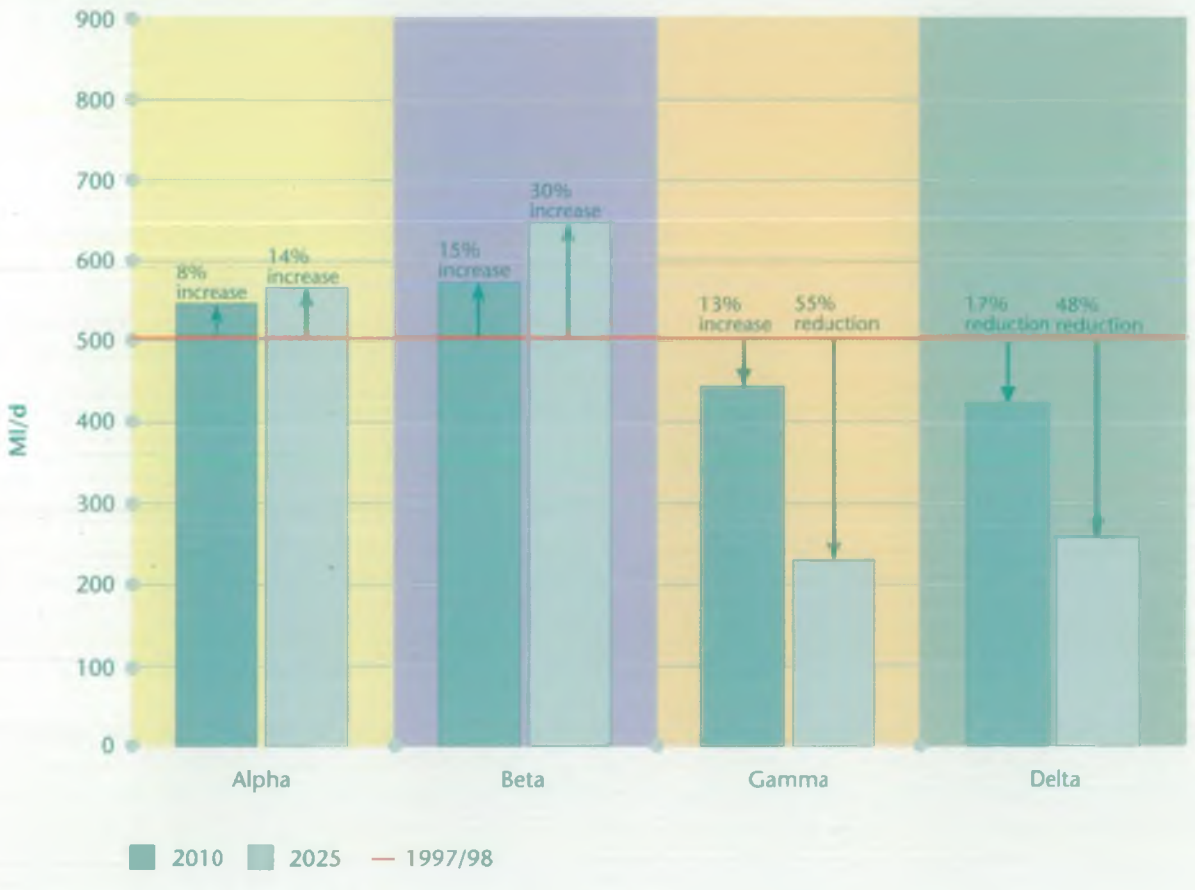
- **Scenario Alpha (Provincial Enterprise):** The political climate results in a decline in the levels of both imports and exports. Sectors such as chemicals, business services and electronics face slower rates of growth from 2005, reflecting the reorientation of production to meet domestic demand. This 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

Figure A2.3 **Midlands industrial and commercial demands by scenario in 2010 and 2025**

Public water supply



Direct abstraction



Note: 'Midlands' taken as Severn Trent Water and South Staffordshire Water for public water supply; Severn and Trent catchments for direct abstraction

across all sectors will implement low-cost water efficiency measures such as good housekeeping, management and reuse 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 2009/10 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.

A2.6

Spray irrigation demand

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

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 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 (NFU). 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.

A2.6.1 Forecast methodology

Previous forecasts of spray irrigation demand have been based on the concept of theoretical crop water requirements to maximise crop yield and quality. Such approaches fail to take into account the costs and benefits of irrigation, which play a critical role in determining the actual level of irrigation. For example,

in some situations the benefits of irrigating a crop, although positive, may not be sufficient to justify the investment and risk. In other cases, decreasing returns to irrigation may only justify investment in a lower level of irrigation capacity.

The new Environment Agency forecasts, undertaken by Cranfield University at Silsoe, have developed the concept of economic demand, reflecting the costs and benefits of irrigating different crops. The methodology draws on the dry year 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.

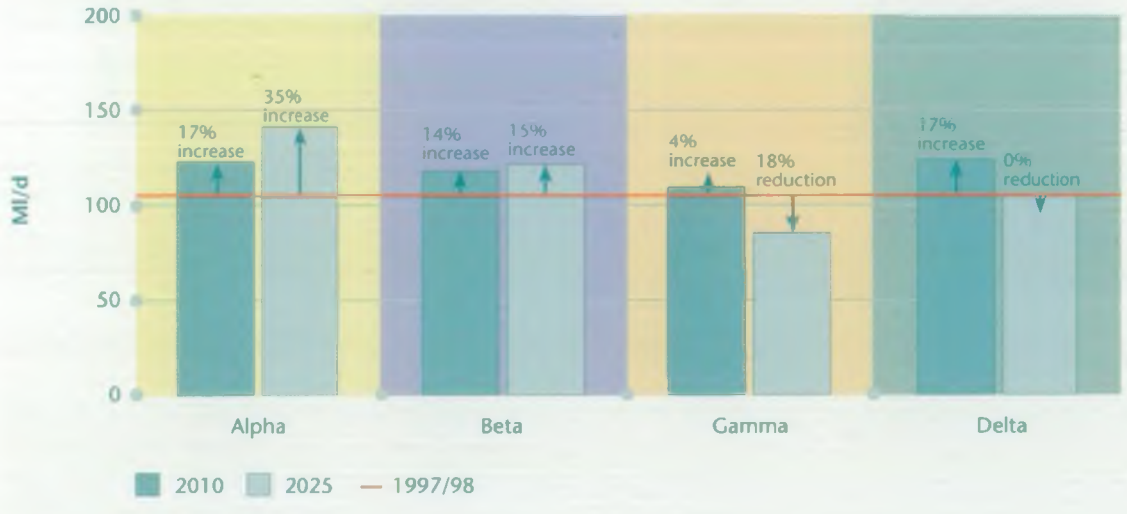
This approach marks an important development. Comparison with 'baseline' crop irrigation forecasts based on theoretical and economic demand highlights a number of important issues. The methodology confirms that for high-value crops, such as potatoes, vegetable and fruit crops, economic and theoretical 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.

Results for the Midlands are presented in Figure A2.4. Annual demands are expressed as an average daily volume for comparison with other sector demands, but we recognise that the irrigation is applied over a shorter time-span and actual application rates on a dry day will be much higher.

A2.6.2 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

Figure A2.4 **Midlands spray irrigation demands by scenario in 2010 and 2025**



Note: 'Midlands' taken as Severn and Trent catchments

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 3
Calculating possible leakage levels in 2025

A3.1

Introduction

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

A3.2

General Approach

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

A3.3

Method

We have considered three components of leakage:

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

The duration of a burst depends on:

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

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

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

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

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

A3.4

Assumptions

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

A3.4.1 Find-and-fix activities

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

A3.4.2 Pressure management

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

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

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

A3.4.3 Service pipe and mains replacement

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

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

A3.5

Conclusions

This appendix describes how we have calculated a possible leakage level for each water company and resource zone. By assuming a modest extension of existing good practice, we may assume that achieving this calculated level should not be excessively expensive. Whether this level of leakage activity is necessary depends on the relative merits of other options. The area of leakage control attracts much attention, and it is to be expected that our results will be refined as the result of further studies over the next few years. The current tripartite leakage study being carried out by Ofwat, the DETR and the Agency will help to clarify the potential for progress.

Appendix 4
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. The Agency will work with others to prioritise and take forward an appropriate programme of Research and Development. Issues include:

- Environmental requirements of plant and animal species - there is scope for further work on the requirements of different species and species assemblages.
- Implementation of recent work on reconciling surface and groundwater resource yields - this would improve future plans.
- Impact of land use changes, including forestry, on water availability and on 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.

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Glossary of terms

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

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

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

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— Area Administrative Boundaries

— Regional Boundary

● Area Office

▲ Regional Headquarters

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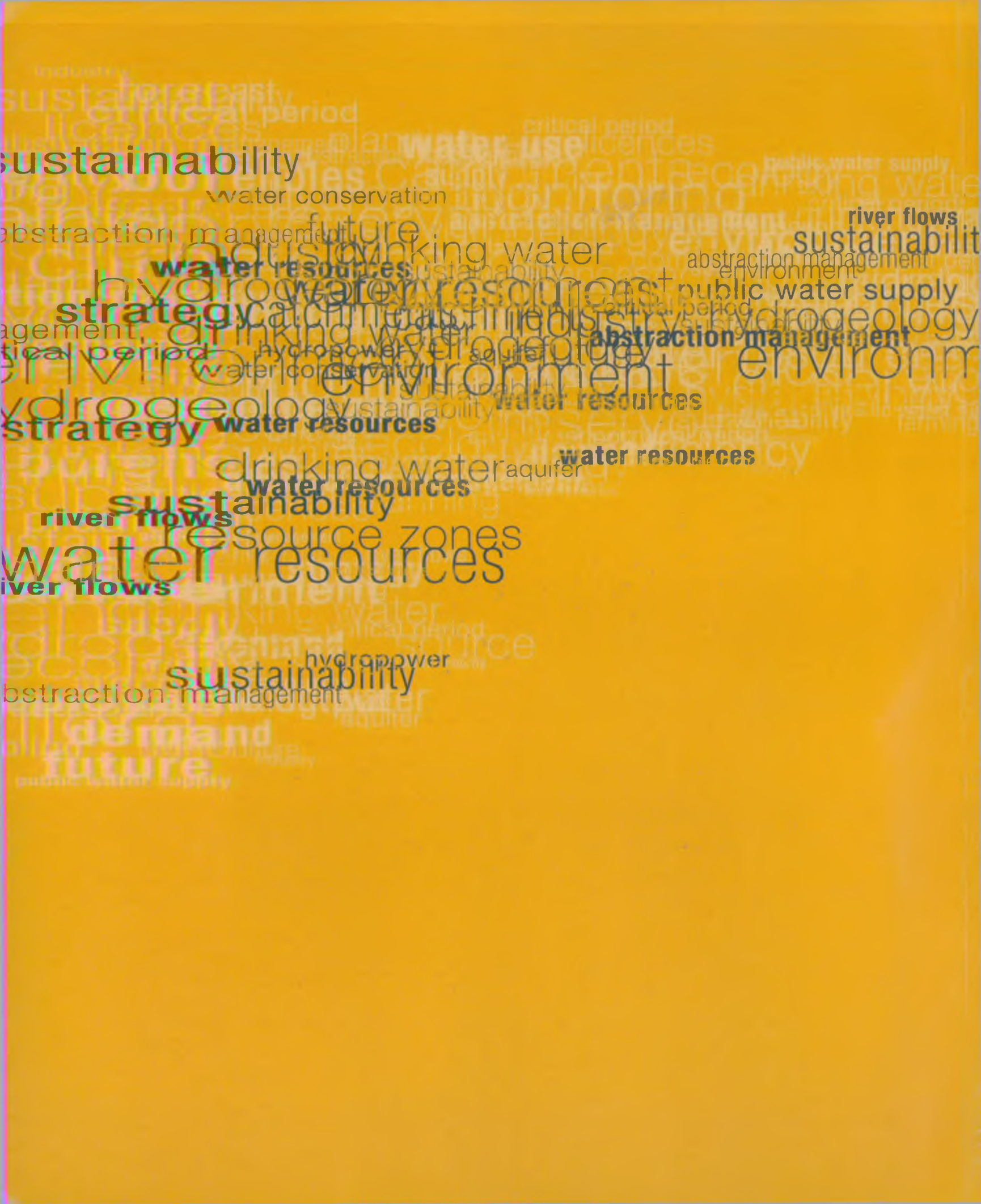
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