Water resources for the future

A STRATEGY FOR WALES

March 2001

ASIANTAETH YR AMGYLCHEDD CYMRU
ENVIRONMENT AGENCY WALES

Published by:

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ISBN 1857055101

Foreword

The natural environment of Wales is one that we can all feel justly proud of. It is rich in wildlife and natural beauty and is one of our major assets. Water is an important component, defining the essential character of the landscape and countryside of Wales. It is unique amongst our natural resources in that it is renewable, and has been consistently undervalued For too long we have polluted our water-courses and wasted the water we have taken. As climate change starts to impact on our lives we are only now beginning to understand how important it is to value this natural resource.

The Environment Agency has a principal duty to promote sustainable development. This duty underpins all of its activities and is very much in evidence within this strategy. As a consequence, even where demands are forecast to rise above resource capacity, the strategy makes it clear that all solutions are carefully considered. These may involve finding new resources or alternatively making better use of the water we already have. In many cases it will be a bit of both. The historic solution of "building" our way out of a water resources problem is simply no longer acceptable in Wales. The sustainable approach is not a radical one; it is common sense. Environment Agency Wales, in partnership with many others stakeholders in Wales, has been instrumental in testing, proving and reporting on water efficient technology. The assistance given to ensure water efficiency in the new Assembly building is but one example. By using any resource more efficiently the cost of use and disposal are reduced. This is an important message for the Welsh economy.

This document is a 25 year water resources strategy for Wales which identifies a wide range of potential demands, and takes into account the potential impact of climate change. It proposes minimal resource development balanced with water conservation. Solutions for areas known to be suffering from over abstraction are also included. All these measures help to protect our water environment and add to its value.

Our environment is continually changing; as will this strategy. Environment Agency Wales intends to publish an annual bulletin reporting on progress against the strategy presented here, and to review it completely in five years' time. It will be vitally important for all the organisations listed in the "Actions" table to play their full part in implementing this strategy.

I am happy to endorse this document as it forms a firm basis on which to build towards fully sustainable management of water resources and is consistent with the objectives we have set out in the National Assembly's Sustainable Development Scheme.

Sue Essex AM
Minister for the Environment
The National Assembly for Wales

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Summary

Introduction

Water is essential for natural life and for human use. We use it in our homes and gardens, in commerce and industry, and in agriculture. The way we use water has a direct impact on the natural environment. This means that we must have in place a secure framework for the management of water which 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 resource strategy for Wales. It covers the whole of Wales and also parts of the Dee and Wye river catchments that lie in England. This strategy forms part of a suite of eight strategies that are consolidated in the Agency's national strategy for England and Wales. This strategy looks some 25 years ahead. It considers the needs for water both of the environment and of society, 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 we can refine these plans, allowing them to meet the wider objectives of society. The Agency will be active in encouraging initiatives that contribute to sustainable development.

Our strategy concludes that:

- although Wales is often considered to have abundant water resources, there are some areas where improvements to the water environment are necessary. We believe this may require the recovery of some 13 Ml/d from existing licensed abstractions;

- continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 7 Ml/d above present levels by minor resource development and infrastructure improvement to move water from areas of surplus to areas of need. 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;
- farmers must continue to use available water to best effect. Wales is predominately rural and agriculture is a major water user in these parts. We have found that in some of these areas, little water is available for abstraction during the summer months. Careful management of water around the farm is an important facet of this strategy. Farmers should also consider crop suitability and the possibility of increased winter storage in those areas where spray irrigation is important;
- 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 and so contribute to long term profitability and viability. 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.
- We will work with others to better understand the needs of the water environment of Wales.

Many of these solutions are focussed on areas within Wales that may experience shortages of water over the next 25 years. When applied throughout Wales the quantity of water involved is much higher. We have considered a number of additional options in case our recommendations fail to deliver. These comprise further small resource developments and some limited transfers of water including pumped storage of existing schemes.

Basis of the strategy

Our 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 a few small areas where abstraction needs to be reduced to correct damage and improve the environment. We have also considered demands in those parts of England currently supplied from Wales.

In Wales, the picture shows only a few isolated sites where no further water is available during summer or where damage is already occurring. We estimate that in total, further reductions in abstraction beyond those already planned will amount to about 13 Ml/d by 2025.

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

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, as well as by technological innovation.

Climate change will be 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 southern half of England and all of Wales summers will be drier, while winters will be wetter throughout England and Wales. Climate change will affect not only water availability but also demand. Over the next 25 years, we believe the effects can be managed within the twin-track strategy that we propose. However, we don't yet have enough information about extreme events to be able to assess 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

We recommend the development of a combination of resource developments and demand management. We see no need for new large schemes to support demand from within Wales. 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.

We have identified an unacceptable flow regime in the Yazor gravel aquifer in the Wye Catchment. Here we have taken steps to provide better management of this resource and a programme of water use minimisation amongst the key abstractors in the area is under consideration.

Continued attention to leakage control will be essential for all water users including public water supply. We believe that applying best practice techniques can contribute significantly to the management of water resources. The achievements of recent years have been driven by the UK 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 not only provide social safeguards but also encourage responsible use of water.

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. The Agency has been very active in Wales in promoting water conservation. We will build on our partnership approach to ensure all water users achieve sustainable water management. Part of this will be achieved through the training of Agency staff who can then disseminate water conservation advice to our customers.

Commerce and industry could save water and money by taking simple actions. The uptake of schemes for water conservation has been generally slow so far, and work is needed to facilitate the adoption of these approaches.

Agriculture should also make more effective use of existing supplies, while considering opportunities to work with others to develop new sources of water. Trading of licences may prove fruitful. The Agency will seek discussion with retail chains, where their expectations may be increasing water use.

Hydropower is viewed by many as an important renewable energy source. Within Wales there may be potential for further development. The Agency will work constructively with hydropower developers.

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

Future review

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

Further investigation might 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 risks. Some may require support or facilitation by the 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 Wales and contributes directly to the Agency's water resources strategy for England and Wales.

Actions

Table 8.1 summarises our recommended actions. In many cases, we seek co-operation across sectors and between different organisations. We will work to facilitate such activities.

Table 8.1 Actions

Action Ref	Action	Agency	Water companies	Agriculture	Industry	NAW and central Government	Ofwat	Planning bodies	NGO's and others
A1	Where new or existing developments are not fully utilised water companies should consider sharing this water with others.		✓						
A2	The Water Supply (Water Fittings) Regulations should be kept 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, the National Assembly for Wales, central 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	The National Assembly for Wales and central 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 the National Assembly for Wales, central 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, the National Assembly for Wales, central Government and the water industry in the provision of accessible information to householders about metering. This includes the development of tariffs that encourage water efficiency while having regard to the Assembly's and central 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, commercial and industrial 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 harming 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	NAW and central Government	Ofwat	Planning bodies	NGO's 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 within Wales 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 the National Assembly for Wales to identify opportunities for streamlining the process of approval for essential water resources development while maintaining full public accountability, and having regard to the views of the Assembly.	✓				✓			
A29	The Agency will explore with others the idea of an independent water efficiency body; if we find support, we will encourage its further development.	✓							
A30	The Agency will work with others to prioritise and take forward appropriate Research and Development.	✓							

1 Introduction

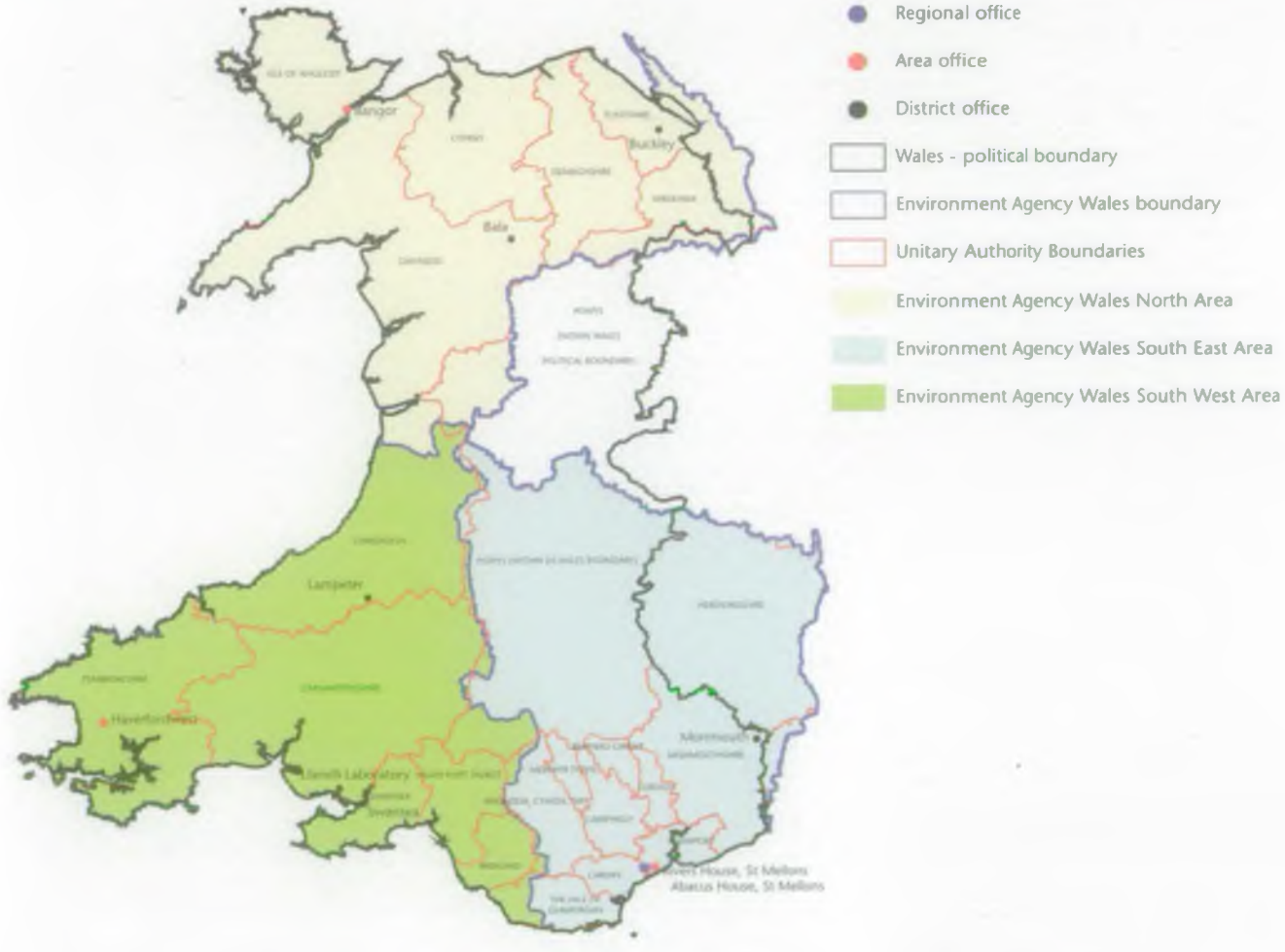
1.1 The need for a strategy

Water is essential for natural life and for human use. We use it in our homes and gardens, in manufacturing industry, and in agriculture. Of our natural resources, water is unique in that it is renewable, but the way we use it 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 Wales.

Wales is often considered to have abundant water resources, but they are an essential component of our natural landscape. To maintain this valuable environment it is essential to manage them in a sustainable way.

The Environment Agency is the statutory body with a duty for strategic water resources planning and management in England and Wales. This strategy is our plan for water resource management for Wales. It covers the whole of Wales and also parts of the Dee and Wye river catchments that lie in England. It

Figure 1.1 EA Wales regional boundaries



comprises the whole of Environment Agency Wales and the upper reaches of the River Severn situated in Wales (also covered in the Midlands Region Strategy). This is a total area of 25,246 km^2. Environment Agency Wales and the Environment Agency are referred to as the Agency throughout this document.

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 water resources strategy for Wales to be developed 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 that follow, from both within and outside the Agency.
- promotes the prudent use of natural resources.

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

This strategy forms part of a suite of documents representing the water resources strategy for England and Wales. The national water resources strategy deals with overarching policy, approaches and techniques. It considers national issues and an overview of the seven English regional and the Welsh water resources strategies. This water resources strategy for Wales 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.

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;

Water users are unaware of the impact they have on the environment!

- 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 demand management and other 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 we have taken complements the vision, showing how the thematic approach to improving our environment translates into tangible actions affecting a specific sector. In water resources, actions in one place have implications elsewhere, making the direct consideration of links especially appropriate.

1.3

Consultation

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

A national consultation response document was produced in September 2000, summarising the replies received. Of the 270 responses received many covered issues important to Wales. (Environment Agency, 2000c) We have taken these views into account in the preparation of this strategy.

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

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

- the importance of water efficiency and demand management across all sectors to make best use of our existing resources, despite the perception generally held of ample resources in Wales;
- an expectation that demand management alone will not be sufficient to manage all future needs;
- support for some form of "twin track" approach to demand management and resource development, although details differed;
- additional winter storage, especially for agriculture, as a response to the predicted impacts of climate change. Concerns were, however, expressed about costs, the need to consider environmental impacts and local authority planning considerations;
- a widespread desire for better understanding of environmental water needs, although perspectives differed on how to manage the continued uncertainties in this area. Environmental organisations favoured greater precaution for the environment while abstractors saw time-limited licences and monitoring as a solution. The value of consensus-based approaches and consultation were often flagged as a positive way forward for all.

Divergent views were particularly evident on:

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

We have tried to take these views and many other details into account in this strategy. We consulted on fundamental issues, 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 Wales to look for ways of reconciling the differences to achieve mutual gain.

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

1.4

Links with other water resource planning initiatives

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

This strategy looks 10 to 25 years ahead, and 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 Agency for review. The plans detail the actions that water companies intend to take, and are an important part of the water resources planning process. This strategy has used water company plans as the basis for the consideration of future public water supply. Further updates of water company plans will in turn be informed by this strategy.

The Agency's role in this strategy is to set the bounds within which decisions will be reasonable. This means that we must develop a good understanding of the values of society and Government, and combine these with a rigorous assessment of future demands and pressures to provide a framework for decision-making. In some cases, these values will mean that there is an obvious course of action. In others, limited time will mean that a single course of action will have to be chosen and acted upon. Our approach must be sufficiently robust to deal with all sorts of uncertainty and still meet the objectives that we have identified for our strategies. In providing strategies, it is not our intention to constrain the commercial decisions of water companies and other abstractors, but to provide a way forward that ensures that decisions meet the wider objectives of society as 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 summarises 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 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 UK Government published a draft Water Bill outlining legislation, that it intends to introduce when there is time in the parliamentary timetable. This will strengthen the Agency's role and powers in respect to water resources management.

Our water environment

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 that wants to abstract water in England or Wales needs an abstraction licence from the 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 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 Water Resources Manager at our Cardiff address.

The Agency is responsible for:

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

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 develop-ment in meeting the requirements of the Directive.

2.1.2 The National Assembly for Wales and central Government

The National Assembly for Wales sponsors the Agency for its activities in Wales. It determines drought orders and deals with appeals against the Agency's abstraction licensing decisions. The Secretary of State for the Environment, Transport and the Regions has statutory and policy responsibility for matters related to the water industry in England. 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 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 manage-ment do not relieve the companies of that obligation. The four major companies operating within Wales are Dŵr Cymru/ Welsh Water, Dee Valley Water, Severn Trent Water and North West Water.

Water companies are responsible for:

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

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

2.1.4 Ofwat

Economic regulation of the water companies of England and Wales is carried out by the Director General of Water Services through his Office of Water Services (Ofwat). The Director General reviews water company prices to customers in a 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 are considered to be justified.

2.1.5 Drinking Water Inspectorate

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

2.1.6 Planning and local authorities

The National Assembly for Wales and local authorities are responsible for the land use planning framework and planning decisions. We anticipate a need to work increasingly closely with planning authorities to ensure that the water resources implications of new developments in Wales are understood and managed sustainably. This not only covers the impact on water resources of new housing, but also mineral winning activities that dewater and affect local rivers and streams. Local authorities also regulate the quality of private drinking water supplies through their environmental health duties. Private wells and boreholes are still important sources of domestic drinking water, particularly in rural Wales.

The Agency, through operating agreements with water companies, also manages 8 river regulating reservoir schemes and groundwater river support schemes in Wales. These are carried out as part of our duty to redistribute and augment supplies of water.

2.2 Competition and economic instruments

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

Different modes of competition are being considered. In this strategy we are concerned with the long-term future of our water supply. We base much of our analysis on data related to existing water companies, although we cannot 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, not in the commercial structure of the supplying company. The structure of the water industry could however seriously effect our 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.

Central 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 trading 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.

2.3

Principles underpinning the Agency's approach to water resources planning

The Agency's approach to water resources planning is based on the following four main principles.

2.3.1 Sustainable development

The National Assembly for Wales is committed to ensuring that sustainable development lies at the heart of all its activities. It has a duty under section 121 of the Government of Wales Act to promote sustainable development and is the only government in Europe to have such a constitutional duty. In early 2000 it published its strategic plan for Wales (NAW, 2000). This gives a high priority to sustainable development.

The Agency has a principle legal duty to contribute to sustainable development. In May 1999 central 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. Sustainable development 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 associated with many of the factors affecting water resources management. This means identifying a way forward that is flexible and robust to a range of possible futures. To do this, we need to understand the implications of the different changes that could happen. For this reason, we have taken a scenario approach, looking at the different ways that society may use and value water in the future. Uncertainties include specifically social values and systems of governance, and climate change. We explain in Chapter 5 how we have allowed for them.

Adoption of a scenario-based approach also makes it easier to discard the "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 consequences, decisions should be cautious and 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 The state of our 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 for recreation.

Many rivers in Wales radiate from high ground inland and flow swiftly to the sea. Most of the uplands have thin soil cover, or extensive peat-covered moorland. The underlying geology is generally impermeable, resulting in few water-storing aquifers. The better agricultural land is restricted to the larger valley floors and the narrow coastal strip.

Wales is rich in wildlife and scenic beauty, and this is recognised in the extensive areas designated as National Parks, Areas of Outstanding Natural Beauty, Sites of Special Scientific Interest and other areas of conservation importance.

Many wildlife and landscape features, which contribute to the natural beauty of Wales, have developed in

Figure 3.1 Map of regional geology

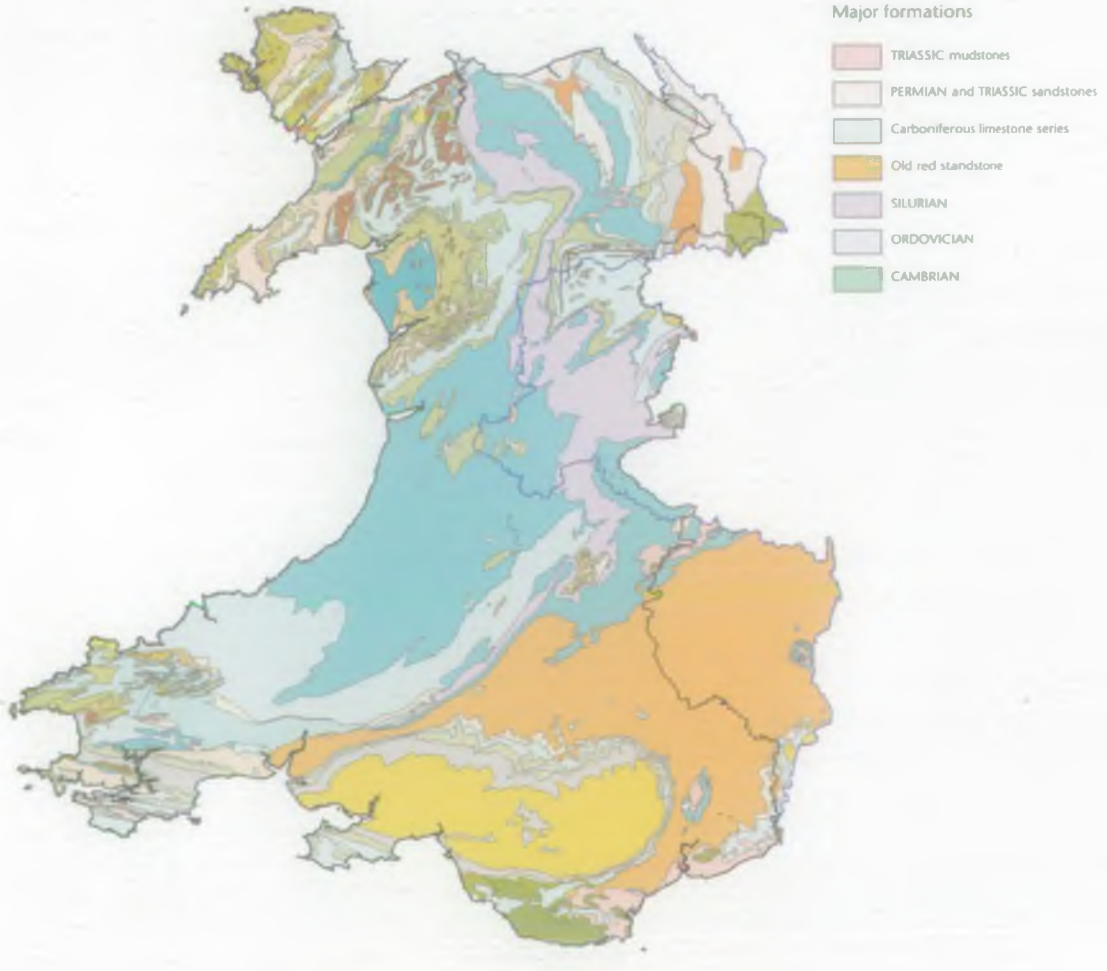
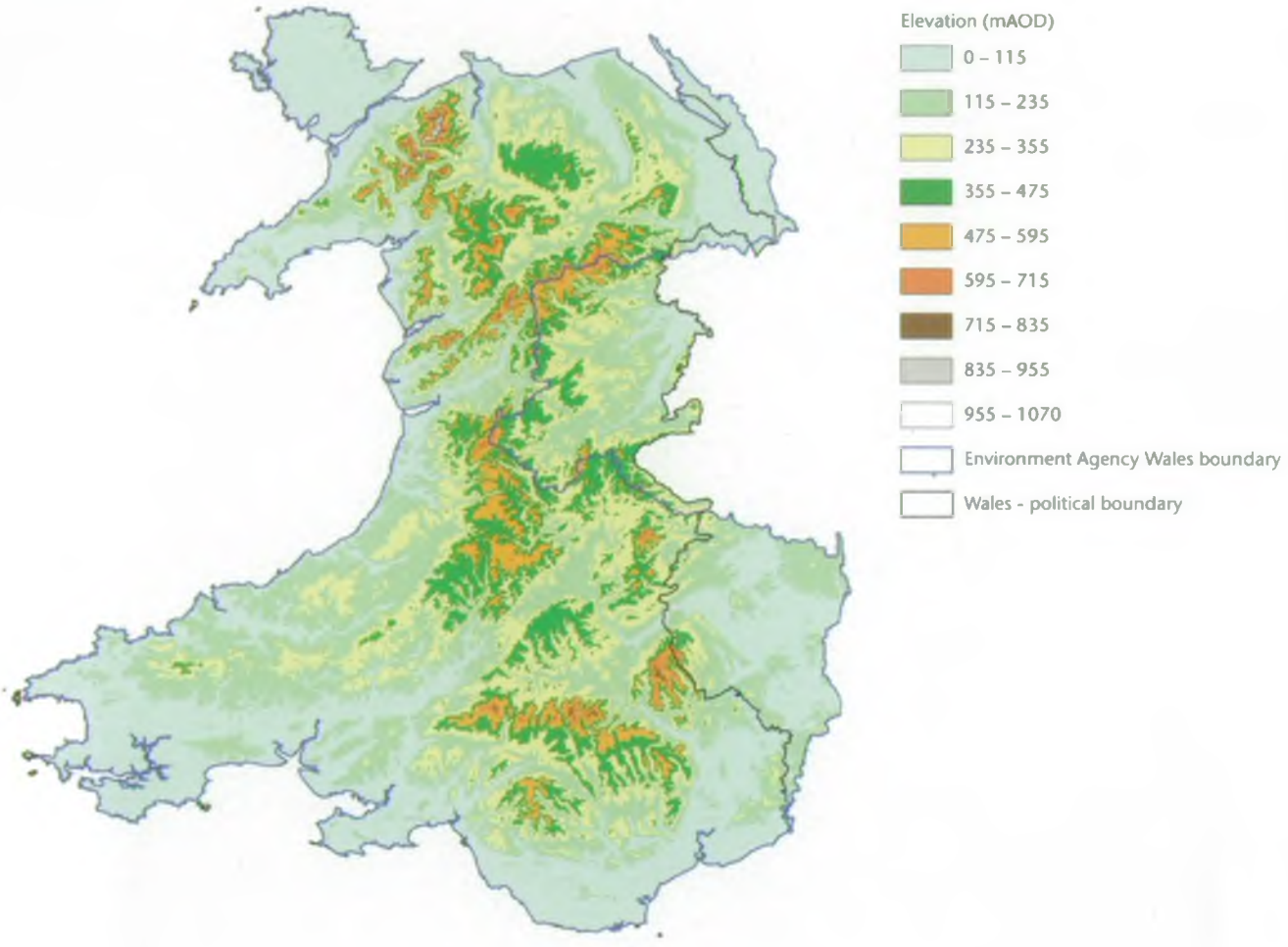


Figure 3.2 Map of regional topography



response to the climate and high rainfall. These include:

- major rivers such as the Upper Severn, Wye, Usk, Dee, Tywi and Teifi which, as well as being features of natural beauty in their own right, harbour important species;
- the deep, cold mountain lakes of Snowdonia, mid-Wales and the Brecon Beacons;
- fast-flowing mountain streams which support fragile plant communities dependent on a moist environment;
- extensive areas of blanket bog (the mid-Wales uplands) and lowland bog (Tregaron and Borth bogs) with unique plant communities dominated by sphagnum moss.

Many of these habitats are rare and important on a European or even global scale, and are protected by international obligations such as the Ramsar convention and the European Community Birds Directive. They rely on the continued availability of water. Their needs and requirements have to be fully considered when it comes to deciding the best use of water resources in Wales.

3.1 The water resource

3.1.1 Rainfall

Our water environment depends on rainfall. Wales receives more than the English regions, equivalent to 1,310 mm depth of rain in an average year. This ranges from less than 700 mm in the Welsh Borders to over 4,000 mm in Snowdonia (Figure 3.3). It is fairly evenly spread throughout the year, but varies with periods of drought and wetter interludes. About 45 per cent of the rainfall is evaporated or used by plants, so that useful or effective rainfall is far less, especially in summer. This is shown in Figure 3.4.

On reaching the ground, rainfall quickly finds its way to rivers and then to the sea. Rivers rise and fall quickly in response to rainfall and in dry weather flows will naturally be low. Some rainfall is stored through infiltration into soils and rocks, or in lakes and reservoirs. It is then released to rivers at a much slower rate and helps maintain flows during dry periods, particularly in summer.

Figure 3.3 Regional rainfall distribution

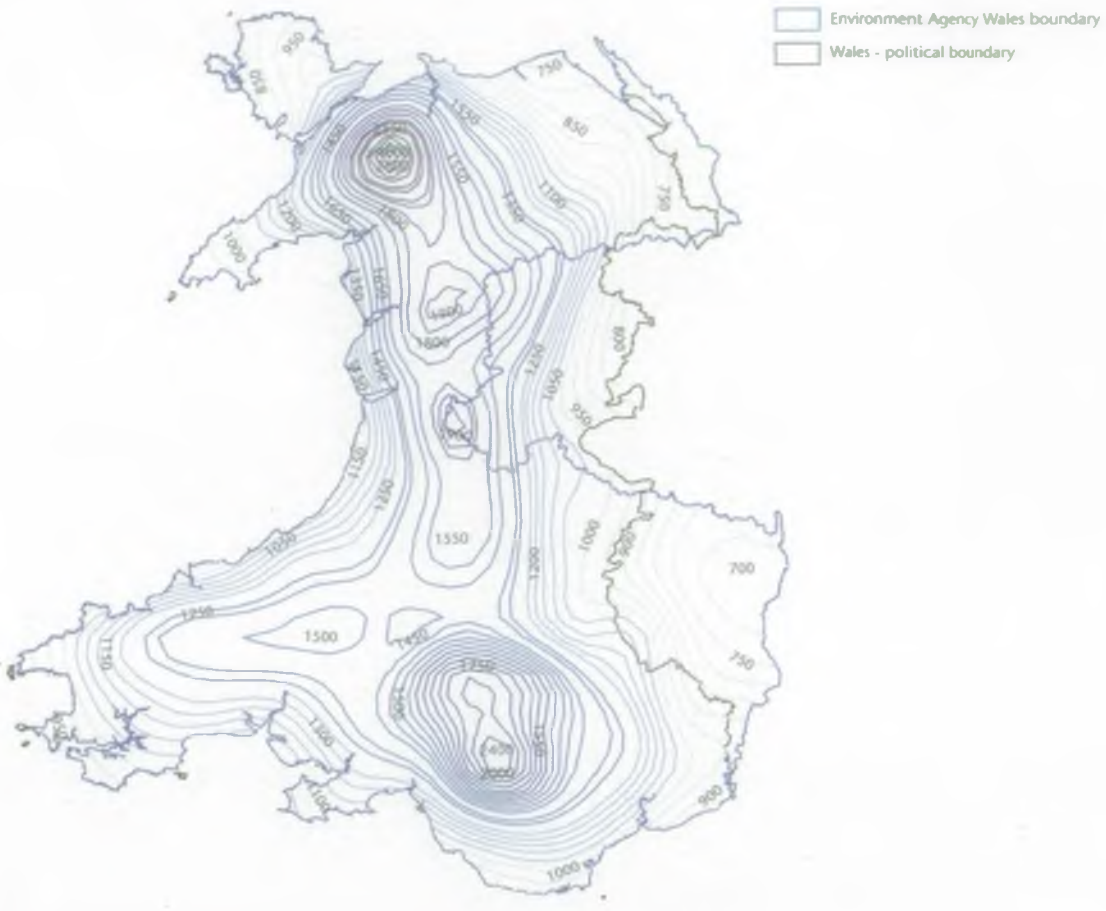
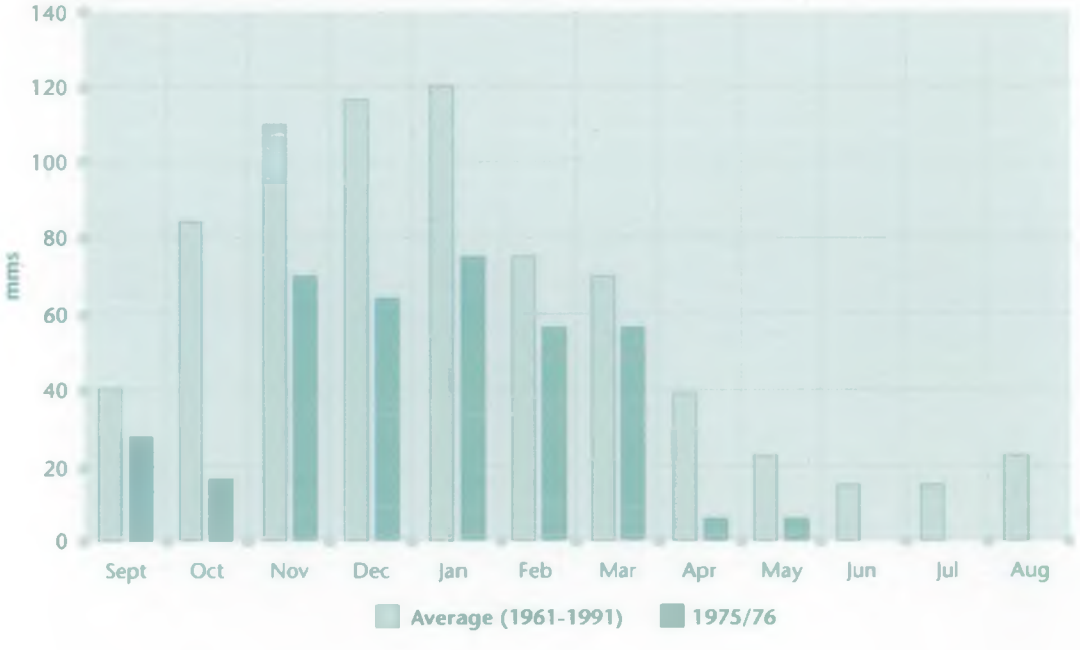


Figure 3.4 Annual distribution of effective rainfall



This natural storage is limited. As a consequence, over 150 reservoirs have been constructed across Wales to store rainfall. These range from the modified natural lakes such as Llyn Tegid near Bala, to purpose-built reservoirs used for river regulation (for example Llyn Brianne) to direct supply reservoirs (for example Talybont). In total they provide more than 550,000 Ml of water storage for a variety of uses.

3.1.2 Groundwater and wetlands

Our soils tend to dry out in summer, as growing plants use water. In winter they refill. Suitable rocks, known as aquifers, can store large amounts of water in pores and cracks. These usually start to refill only when the soil water store is full. When this groundwater reaches the surface it may emerge as springs or form wetlands. Often, these springs and wetlands are the starting points of rivers. Their contribution keeps rivers and streams flowing during dry periods. They also form important water supplies, particularly for private domestic sources, and many are of historical and religious importance.

The main aquifers comprise the Carboniferous Limestone of southwest, southeast and northeast Wales, the Permo-Triassic Sandstone of northeast Wales and the Old Red Sandstone of south Wales and the Borders. Supplies from valley gravels are also of local significance.

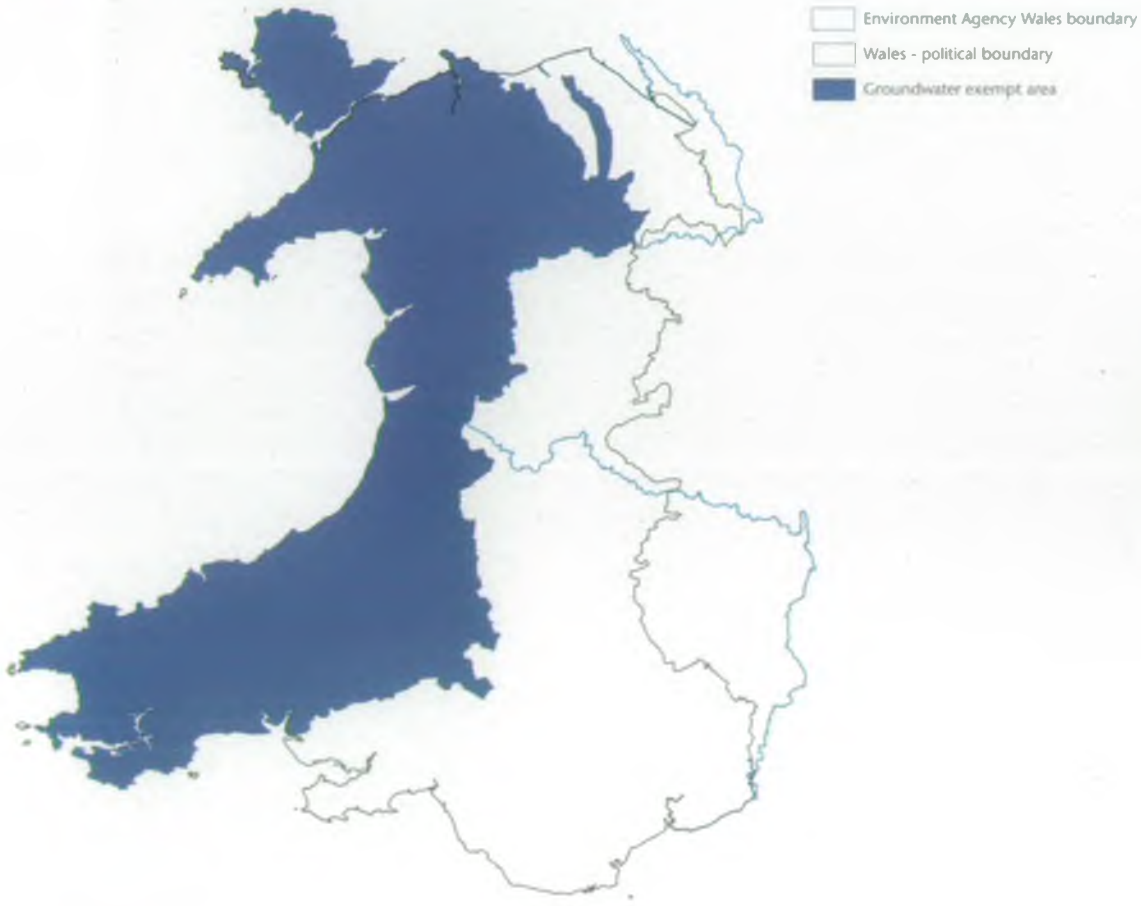
Large parts of north and west Wales are, through parliamentary orders, exempt from the need for a licence to abstract groundwater (Figure 3.5). These were granted in 1965 in areas deemed not to have substantial groundwater resources. However, the exempt areas include some major springs and groundwater abstractions. The issue of exemption orders is currently being reviewed as part of the UK Government's draft water bill.

The natural groundwater regime of Wales has been altered extensively. Mining activities associated with coal, metal and minerals have left interconnected shafts and adits. Groundwater levels were artificially lowered to allow mining, and since 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. Many of these minewater discharges are of very poor quality. The quality and impact of rising groundwater levels are of concern to the Agency, but not our direct responsibility.

3.1.3 Drought

Droughts are natural phenomena caused by long periods of low rainfall. During such periods the effective rainfall may be halved due not only to the lack of rainfall, itself, but to higher plant use and evaporation. Dry periods may continue over several years, creating a cumulative deficit in water resources, particularly in groundwater. Droughts have occurred in 1933-4, 1959, 1975-6, 1984, 1989-90 and 1995-6.

Figure 3.5 Groundwater licence excempt areas in Wales



These extended dry periods affect many rivers. Groundwater and wetlands maintain river flows long after the last rain has fallen. When these supplies are not replenished, river flows drop to very low levels. Welsh rivers are prone to this impact. Low river flows affect water quality through their higher temperatures, less dilution of effluent and lower oxygen levels. They expose areas of the river channel, such as fish spawning grounds leading to their damage or disruption.

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 occurs. 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.

In order to reduce the impact of droughts on society and the environment the Agency has prepared detailed drought contingency plans. These identify the actions we can take to help mitigate the impact of a drought on the water environment. Water companies have also prepared drought plans, to identify how they will respond to shortages of water for supply.

3.1.4 Flood management

Flood prevention and management is an important issue as heavy rainfall, particularly during the winter, may lead to flooding. Following severe flooding events in October 1998 and the autumn of 2000 the issue of using existing reservoirs to provide flood storage was raised. The Agency looked closely at this and concluded that surface reservoirs have a very limited impact in reducing flooding in downstream catchments. They can, however, help reduce flooding immediately downstream of reservoirs. The current operation of reservoirs already ensures a degree of flood storage, although relatively small, to enhance reservoir safety. Only the reservoirs of the River Dee regulation scheme are currently operated specifically to manage floodwaters downstream.

Further flood storage is possible, but at a cost. Water supply yields are reduced leading to future summer shortfalls. These lost yields would need to be matched by new resource development. The limited downstream benefit of enhanced flood storage is not a cost-effective solution. The upland location and small contributing catchments also means that most reservoirs are too far away to protect the areas at risk of flooding.

3.2 Distributing water

3.2.1 Abstractions

In order to have enough water for us to use, we need to ensure that water is available at the right place at the right time, while 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 Wales local sources are insufficient, or provide inadequate security of supply in dry spells. This has led to the development of a wide variety of public water supply systems. Most are based on conjunctive use of abstractions from different types of resources. Water from reservoirs, direct abstractions 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.

Water distribution in Wales is characterised by the large number of supply zones. These are defined as areas in which customers experience the same level of service from the water undertaker. The water company water resources plans published in 1999 show 128 supply zones for England and Wales, of which 43 are in Wales. The large number of zones reflects the difficult topography and the often-rural nature of Wales. These factors prevent the straightforward interconnection of zones as seen in much of lowland England.

3.2.2 Leakage

A significant proportion of water abstracted for the public water supply is lost through leakage from the distribution and mains systems, and supply pipes on customers' premises. Losses vary across Wales. This is due to the length of pipe in rural areas, the high pressures required due to the topography, and the age of the system. Less obvious factors such as shrinkage of clay soils in summer and ground movement as a result of winter frosts cause mains and pipe bursts that further increase leakage levels.

Over the last 10 years there has been a significant change in the perception of leakage by government and the general public. This has prompted a change in leakage control policy. After the 1997 Water Summit, mandatory leakage control targets were introduced and this has resulted in a marked reduction in total levels of leakage (Table 3.1). Current targets are set by Ofwat,

Figure 3.6 Main elements of regional water resources

Table 3.1 Water company leakage rates

	Total leakage (Ml/d)			Leakage targets
	1992-93	1995-96	1998-99	1999-00
Dwr Cymru	383	413	306	292
Dee Valley	13.9	14.6	11.9	11.8
Severn Trent	570	632	344	342
North West	945	789	510	489

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

In 1998 leakage accounted for 34 per cent of the distribution input of water put into supply by water companies in Wales. Studies have shown that up to a third of leakage occurs on the customer's service pipes, which falls outside the water company's control. Work undertaken by water companies on their distribution network should reduce leakage across Wales to 29 per cent by 2001.

3.2.3 Transfers

A transfer of water from one place to another requires:

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

Transferring water from one place to another is relatively expensive. Water is heavy and bulky, which means its movement can consume much energy, although many of the existing transfers operate by gravity. Water transfer has long been a feature of water resources in

Wales. The topography and rainfall of much of Wales, matched by relatively low population density, has led to many transfer schemes. The largest of these are shown in Table 3.2. Around half the water abstracted in Wales for public water supply is exported to England.

The removal of water from a catchment is a loss to the river. Additionally, if the transfer is then used to regulate another river, it could have environmental impacts such as the transfer of alien species, diseases and chemicals. None of the Welsh transfers impact directly on another catchment's ecology.

3.3

Uses of abstracted water

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

There are about 4,300 licences in force in Wales. These authorise the abstraction of some 20,336 Megalitres per day (Ml/d) from surface and groundwaters, as shown in Figure 3.7, and a further 5,633 Ml/d from tidal waters. There are also very many small unlicensed abstractions, which, although important, are not significant users of water.

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

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

These categories cover the most important uses of water.

Table 3.2 **Water transfers in Wales**

Transfer	Type	Destination	Licence quanity (Ml/d)
Upper Severn (Clywedog)	River regulation	West Midlands and Bristol	600
Upper Severn(Vyrnwy)	Pipeline	Merseyside	210
Lower Dee	River regulation	Merseyside	686
Lower Dee	Canal	Crewe	47
Upper Dee (Alwen)	Pipeline	Deeside	45
Upper Wye (Elan)	Pipeline	West Midlands	359
Lower Wye (Monmouth)	River regulation	South Wales	136
Lower Wye (Lydbrook)	River regulation	Forest of Dean/Ross	45
Upper Usk	Pipeline	South Wales	73
Lower Usk	River regulation	South Wales	189
Upper Taff	Pipeline	South Wales	203
Lower Tywi	Pipeline	South Wales	227

Figure 3.7 **Licence abstraction quantities by use**

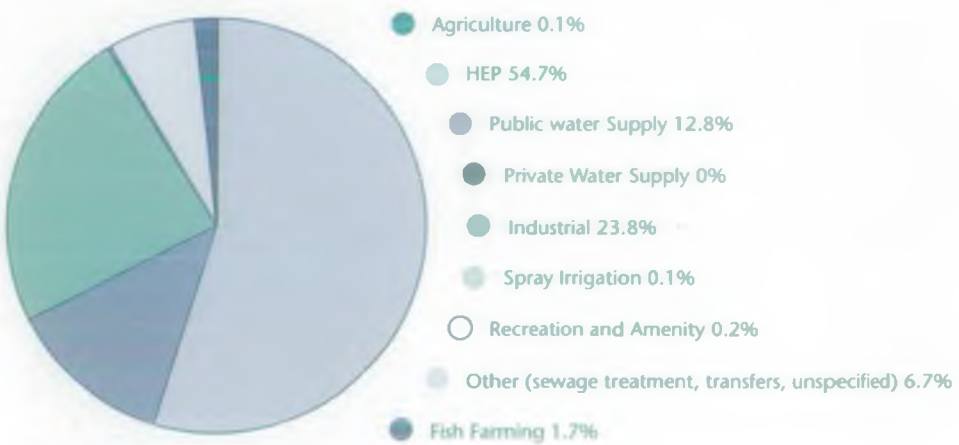


Table 3.3 **Breakdown of public water supply use in Wales**

	Sector	%age	%age
Water delivered			100
Total leakage	Distribution Losses	24	29
	Underground supply pipe leakage	5	
Households			46
Industry	Agriculture	2.5	25
	Food and drink	2.3	
	Oil, chemicals, coal and mineral extraction	2.8	
	Metal manufacture	2	
	Engineering	1.2	
	Other production and construction	2.7	
	Wholesale and retail distribution	1.4	
	Catering and tourism	3.1	
	Public administration and defence	1.3	
	Education	1.4	
	Health	1.3	
	Other service sectors and transport	3	

Figure 3.8 **1997/98 per capita consumption of water**

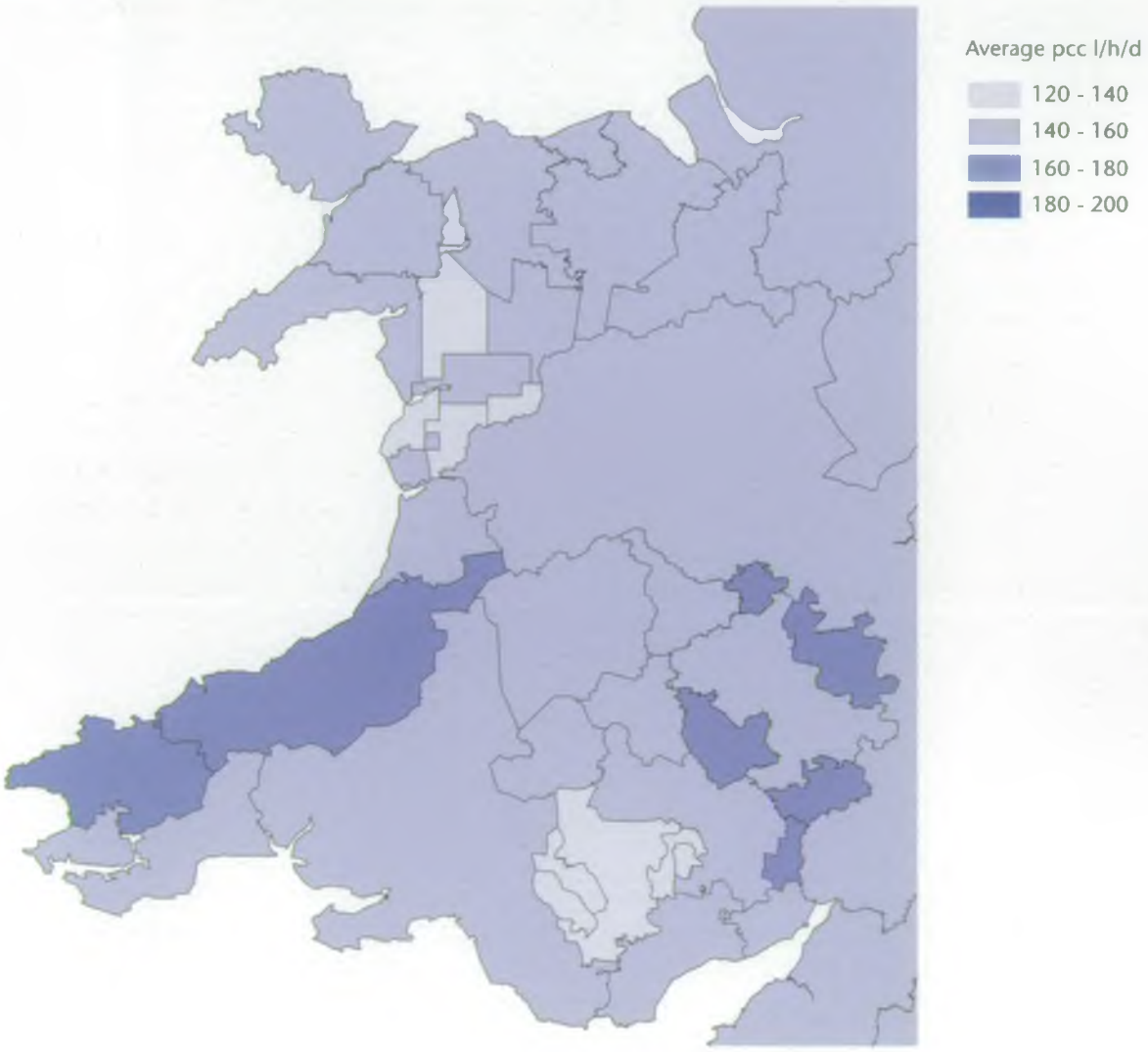
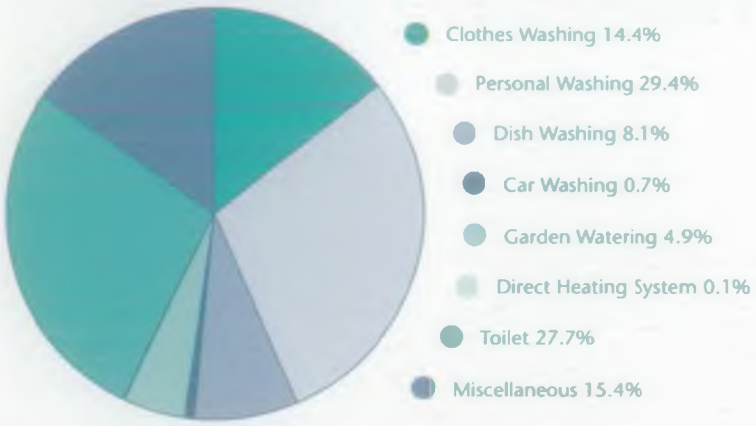


Figure 3.9 Micro-components of household demand 1997/98



3.3.1 Household water use

Present levels of unmeasured household water consumption vary quite markedly across Wales. In 1998 average consumption ranged from 134 litres per person each day in the South Wales valleys to 170 litres per person in Monmouth (Figure 3.8). The numbers of metered households in Wales is generally low, at about 11 per cent. Average consumption for these households is around 133 litres per person each day, but this varies markedly across Wales, as those opting for meters have often done so because they are low water users. Overall within Wales we each use an average of 146 litres of water a day.

Water companies are licensed to abstract around 3,327 Ml/day of water to supply domestic households, commercial buildings and industry. This accounts for about 13 per cent of the licensed total in Wales, or 28% percent if hydropower is excluded. The reliable yield in a drought is less, at around 2,610 Ml/day. Wales is a net exporter of water to England, with 1,642 Ml/day licensed for transfer.

Typically, most water used in households is returned to rivers or the sea through the sewerage network. However, in Wales less than a third is returned to the river systems. This is due to the large volumes exported, and to the concentration of population and industry around the coast of Wales, which results in effluent being discharged into the sea.

Most of the 146 litres we each use daily in the home is used to flush toilets (28 per cent), take baths and showers (29 per cent) and run washing machines (22 per cent) (Figure 3.9). Garden watering significantly increases domestic use during hot dry summers. Summer peak water use can increase weekly demands by as much as 30 per cent. Peak hourly rates are even higher. Tourism can bring a further 300,000 people to Wales during summer months, creating additional demands, particularly to the rural coastal supply zones.

Within Wales it is estimated that almost 2 per cent of the population rely on their own water supply. This ranges from less than 1 per cent in the urban areas of South Wales to 20 per cent in parts of Snowdonia. Private domestic supplies are therefore particularly important in rural areas where they form the only viable source of water. Most of the water is returned close to the point of abstraction after use, often through soakaways.

3.3.2 Industry and commerce

There is a variety of direct abstraction for industrial water use within Wales, ranging from the low-loss uses such as mineral washing, through direct manufacturing, to high-loss uses such as evaporative cooling. All industrial sectors have seen major declines in water use sine the 1970s. Since the publication of *Water for Welsh Region* (NRA, 1996) the demand for industrial water has dropped by 4 per cent. The reasons for this decline are complex, but include the contraction of heavy industry, and the fall in industrial production. Today directly abstracted industrial use accounts for around 24 per cent of the licensed total in Wales. Typically, actual abstraction is around two-thirds of the licensed quantities.

Water for industrial purposes is also provided by water companies and is normally metered. Water may be supplied directly to industrial customers, either untreated where quality is not a constraint, or as potable water through the public supply mains. Such supplies make up about 22 per cent of the total public mains supply in Wales. Water has a perceived low value

Table 3.4 **Industrial and commercial water use**

%age	Non-household PWS %	Direct abstraction %
Chemicals	11.30	0.75
Minerals/extractive	0	2.34
Food and drink	10.03	3.16
Machinery & electronics	9.52	0.13
Metals	8.71	86.77
Paper & printing	0	5.01
Refuse & recycling	-	0.03
Rubber	0	0.15
Textiles	0	1.67
Utilities	0	-
Education and health	11.36	-
Business services	38.00	-
Other	11.10	-

in comparison with other raw materials even though it may be a large proportion of industrial utility costs with considerable potential savings. As a consequence, there is a culture of general water use inefficiency in industry and commerce. Studies across Wales have identified the potential industry has to save water and save money. A project jointly funded by Hyder and the Agency showed how eight companies could reduce water supply costs by 22 per cent, waste water disposal costs by 44 per cent and reduce other associated costs by 36 per cent. This would provide savings in the order of £875,000 within two years.

There is minimal use of water for power station cooling within Wales. The largest site, Trawsfynydd nuclear power station in North Wales, was decommissioned in 1995. This has been accompanied by a major reduction in the requirements for cooling water from its adjacent lake. The other power stations in Wales rely on tidal abstractions for their cooling water. These are located at Aberthaw, Wylfa and Queensferry. The recommissioned Uskmouth station will use treated effluent discharges for cooling purposes.

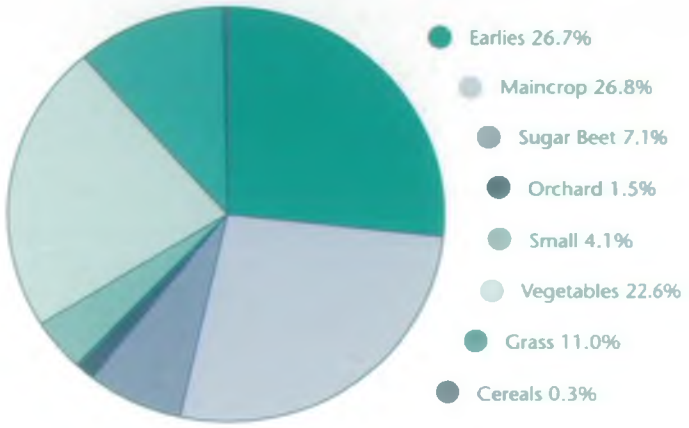
3.3.3 Agriculture

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

Despite the perceived climate of Wales, there are over 697 irrigation abstraction licences currently in force. Most of these abstractions are concentrated in southwest Wales and in the River Wye catchment, where the main crop is potatoes. More than half the quantity licensed for spray irrigation in Wales is for this purpose. The remaining amount is used for a variety of crops, from vegetables and sugar beet to grass and cereals. This is shown in Figure 3.10.

Over the last 5 to 10 years, supermarkets and food processing firms have extended their influence over all areas of on-farm decision making, through the development of farm assurance schemes and integrated crop management protocols. Within the context of these schemes and protocols farmers have limited flexibility to incorporate water efficiency measures into their farm management practices. Only when these specifications change will it prove economically viable

Figure 3.10 **Irrigated areas by use**



for farmers to implement medium-term water-efficiency measures.

Apart from spray irrigation there are a number of other uses of water on the farm. These range from animal watering, dilution of chemical sprays, vehicle washing, cleaning of yards and equipment, and specialist process such as dairying. Farmers draw on both public water supplies and direct abstraction from rivers and groundwater. Most abstractions are small and do not usually need a licence. Almost 2,200 licences are held for this use, mainly authorising abstraction from springs and boreholes. Many of the smaller sources are unreliable, particularly during dry weather. As a consequence, these shortfalls are made good by reverting to supplies taken from the public mains. This in turn adds to dry weather peak demands in rural areas. Most of the water taken is returned to the environment close to the point of use.

To date, limited attention has been paid to quantifying these uses of water. The Agency's *Optimum use of water in industry and agriculture dependent on direct abstraction* project (Environment Agency, 2000e) has developed benchmark water consumption values for a range of livestock systems. We have taken steps to understand water use on farms through a research project undertaking water audits. These have identified the potential to save water on several dairy farms in West Wales. The project reveals the potential to save up to 30 per cent of water consumption in addition to reducing slurry production and associated energy and treatment costs. The project has been supported by the NFU in Wales and Dŵr Cymru Welsh Water. A second phase will be conducted as a partnership project between NFU, farmers and the Agency and will implement water-saving options.

The Agency is a partner in the development of the new Farming Connect service in Wales, which will provide underpinning advice to agriculture in Wales on an array of environmental measures to support environmentally sustainable farming. This will develop the use of demonstration farms for environmental best practice techniques. This provides the opportunity to show water-saving options and management methodologies directly to farmers.

Fish farm numbers, mainly for trout for the table or restocking, have grown rapidly to around 75 in recent years. They now account for 84 per cent of the non spray irrigation agricultural water use in Wales. Fish need an adequate supply of fresh water so, if no recirculation systems are employed, large volumes of reliable flow are required. Careful siting of intake and discharge locations is required as these large abstractions can impact severely on the stretch of river in between. However, nearly all water taken is returned after use. Welsh rivers are not ideal for this purpose because of the natural low summer flows.

3.3.4 Hydropower Generation

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.

The energy of flowing water may be harnessed to provide power. Wales has 50 hydropower licences in operation. Five of the larger schemes use upland storage to advantage by relating generation to peak electricity demand times when tariffs are at their highest. Since high electricity demand is, in general, associated with cold wet winter periods when rivers are also high and less vulnerable, these schemes do not usually cause environmental problems downstream. The existence of storage can have positive benefits, particularly in dry years, with discharges supplementing natural low river flows. Turbines have been installed on six public water supply reservoir discharges, where "compensation release" water provides regular discharges of water prescribed by statute. Water supply remains the primary purpose of these reservoirs.

Two specialised "pumped storage" schemes were built in Snowdonia: at Ffestiniog in 1964, and Dinorwig in 1983. They transfer water between an upper and lower reservoir to meet large and instantaneous surges in demand for electricity. Water discharged into the lower reservoirs is reused by being pumped to the top reservoir using "spare" power when demand slackens off. As a result these two schemes alone account for 55 per cent of the total licensed quantity authorised in Wales. The quantities of water used are large, but the same water is reused many times.

Interest in small-scale hydropower generation has increased in Wales, following initiatives to promote alternative means of producing energy. "Run of river" sites operate directly from river flows. There are two types – "high head" and "low head"; each of which has particular effects on rivers.

Across Wales the main interest for "high head" generation has centred on Snowdonia. Operation involves the diversion of anything from 50 per cent to

80 per cent of an upland catchment's natural flow into a pipe and through a turbine. The water is discharged back into the same river some distance downstream, or into another river. These schemes potentially affect rivers of very high ecological, fisheries, amenity and landscape value, particularly between the points of abstraction and discharge where the natural flow may be severely depleted.

A number of "low head" river or tidal sites have also been considered. These comprise turbines built into weirs, in bypass channels or tidal barrages. Their impact on lowland rivers is different, though potentially no less significant. Low head generation requires abstracting large volumes of water to generate power. As a consequence sites can only be located in the lower reaches of rivers. Their impact in such situations can be felt far upstream, affecting river regulation requirements, flood defence and land drainage operations. Fish passage, protection from ingress into turbines, and navigation must also be considered. The only site so far developed in Wales is at the Swansea tidal barrage.

Although hydropower schemes are non-consumptive in their use of water, their requirements for water are otherwise extremely large. The impact of schemes of different configurations can also impose different and very significant problems for river interests including implications for upstream developments. Normally, once a licence is granted, the holder is entitled to expect that subsequent licences issued upstream will not reduce the availability of water. Due to the large volumes of water normally reserved for hydropower, this would often mean that no further upstream abstractions could be authorised. In such cases, rather than refuse a hydropower application, it is the policy of the Agency to include provisions to permit further upstream abstractions up to a fixed maximum value. This value would normally be a small proportion of the turbine flow capacity. The average loss of energy production would be small, giving no loss of energy production when flow exceeds turbine capacity.

Infrequently, it may be necessary to make provision to amend how much upstream water can be licensed to other abstractors; this would be achieved by reviewing the licence when its time limit expired.

3.4 Recreational and other uses of water

3.4.1 Navigation

During the late 18th and early 19th centuries the industrial revolution used water as its primary source of transport. Navigable waterways were developed to link industrial areas and provide routes to coastal ports. Parliamentary Acts were passed in most cases to enable construction. These also gave rights to provide impounding reservoirs and to take water directly from rivers to feed canals and many of the newly developed coastal ports. This water maintained canal and dock levels for navigation and made good the water lost from them through leakage and the operation of locks. Over the years canals and docks fell into decline. Many fell into disuse and disrepair, some were filled in and others simply abandoned.

Despite this, many still exist, although they are now used for pleasure craft rather than commercial traffic. They are operated both by British Waterways and private companies. Canals and docks, which are both artificial waterways, often take water from one catchment and move it to another or to the sea, through the use of locks. If canal traffic rises and docks

The Tennant canal has many uses today

become more active for pleasure craft, more water may be needed. Central Government has signalled in the draft Water Bill (DETR, 2000e) its intention to bring abstractions to canals and docks into the licensing system. The exact duties of the Agency and navigation authorities such as British Waterways will need clarification. This points to the need in the future for good forecasts of canal traffic.

Some Welsh canals are used to transfer water and act as a source of water for abstraction. The Llangollen canal, in northeast Wales, is used to transport around 47 Ml/day of water from the River Dee eastwards to Nantwich in Cheshire for public water supply purposes. The Neath and Tennant canals provide water to the petrochemical industries around the Neath estuary. A further six abstractions are licensed to British Waterways to take water from canals to supply mainly industrial customers. Licences also exist to abstract water from Cardiff and Port Talbot docks.

Besides their obvious navigational use, canals and docks are an important water habitat and are used for recreational activities such as walking, angling and watersports. The waterways and their associated works and buildings also form a rich source of archaeological interest dating back 200 years. Canals in Wales that provide navigation potential include the Swansea, Neath, Tennant, Monmouthshire and Brecon, the Montgomeryshire and the Llangollen branch of the Shropshire Union canal. Reclaimed dock areas around our coast, such as in Cardiff and Swansea, now provide important marina developments that form the focus for major urban redevelopment schemes.

Proposals are well advanced to reclaim derelict sections of the Swansea, Neath, Tennant, Montgomeryshire, and Monmouthshire and Brecon canals and to open the completely derelict Hereford and Gloucester canal. The Agency has a Navigation Restoration Policy and works with those considering restorations to ensure that water will be available and no detrimental impact on the environment or other abstractors occurs.

The Agency has various legal responsibilities for inland navigation and is the navigation authority for the River Dee estuary in North Wales.

In developing our strategies it is important to recognise the goals of the key organisations such as British Waterways and Cardiff Harbour Authority.

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. The fisheries resource of Wales is extensive, diverse and valuable. Salmon and sea trout are found in 7,000 km of river with 20,000 km of rivers and streams providing habitat for brown trout and other species. Coarse fish are restricted to the slower flowing lower reaches of rivers and canals. Still waters, ranging from small upland lakes to larger lowland reservoirs, add to this diversity and provide important natural and intensively managed fisheries.

Fish rely on an adequate supply of water throughout their life cycle. Of particular importance is the effect of water flow on the migrations of salmon and sea trout, both downstream as smolts and upstream as adults from the sea. Generally, increases in river flow, known as spates, stimulate these movements and are important in enabling adult fish to negotiate obstructions. The Agency, through its management of river flows in some catchments, specifically release quantities of water to initiate spates at times when river flows are low.

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, with a total economic value of around £65 million a year.

3.4.3 Wildlife conservation

As the main organisation with responsibility for pollution control and water management in 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. Wales has a relatively rich biodiversity, although between 10% and 20% of our native species are considered to be threatened in some way. The Agency has lead responsibility for 39 species and five habitats of wetland character under the UK Biodiversity Action Plan (UKBAP) (UK Government, 1994). The UKBAP identifies the need to take opportunities for enhancing wetland habitats. In its lead role, the Agency will need to explore with others how such opportunities can be supported.

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

3.4.4 Other recreation and amenity

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

3.5 Water resources and the environment

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

To understand the present status of water resources, we need to identify how much water we need 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;

Figure 3.11 Resource availability map – summer surface water

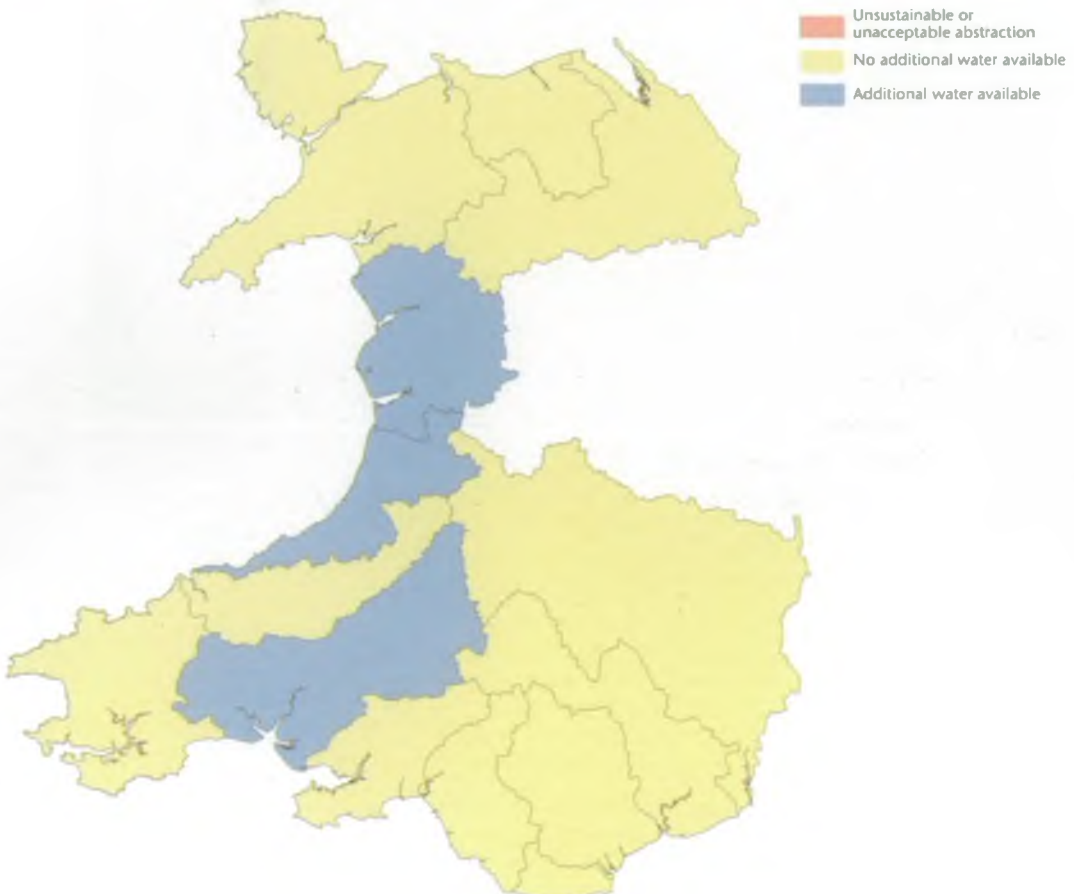


Figure 3.12 Resource availability map – winter surface water

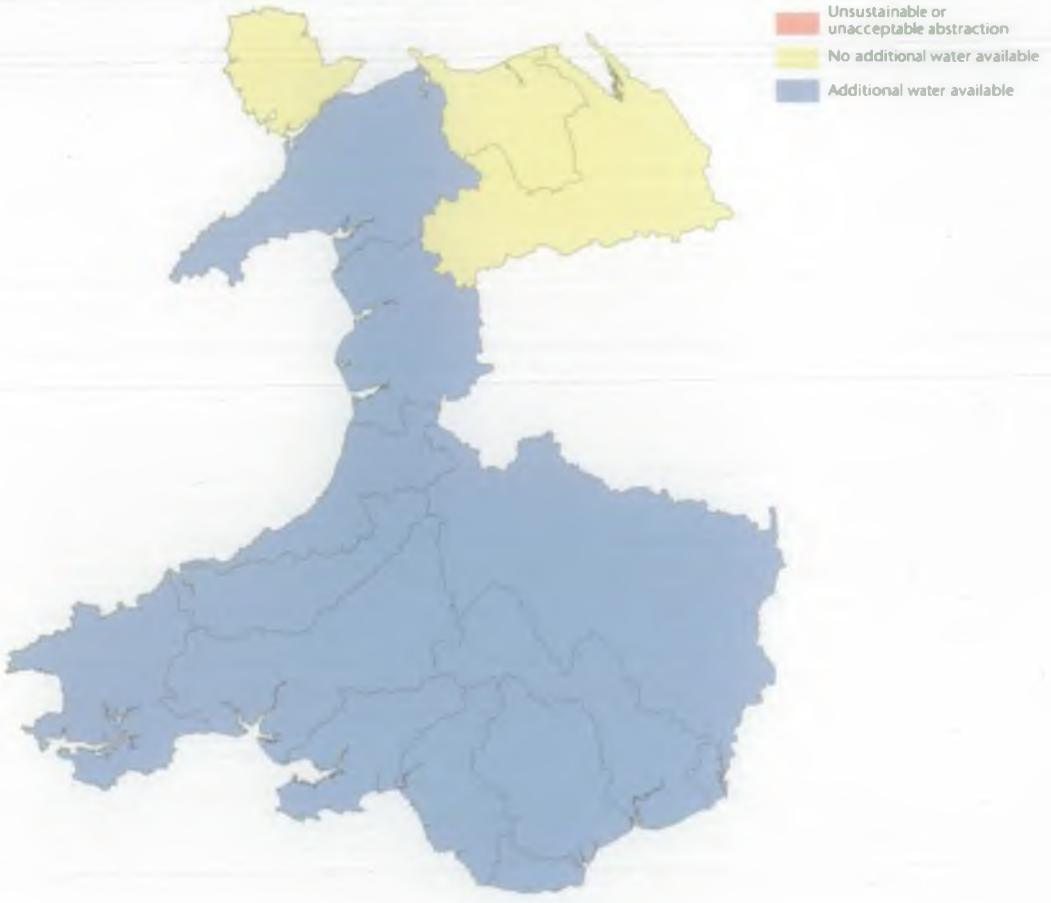
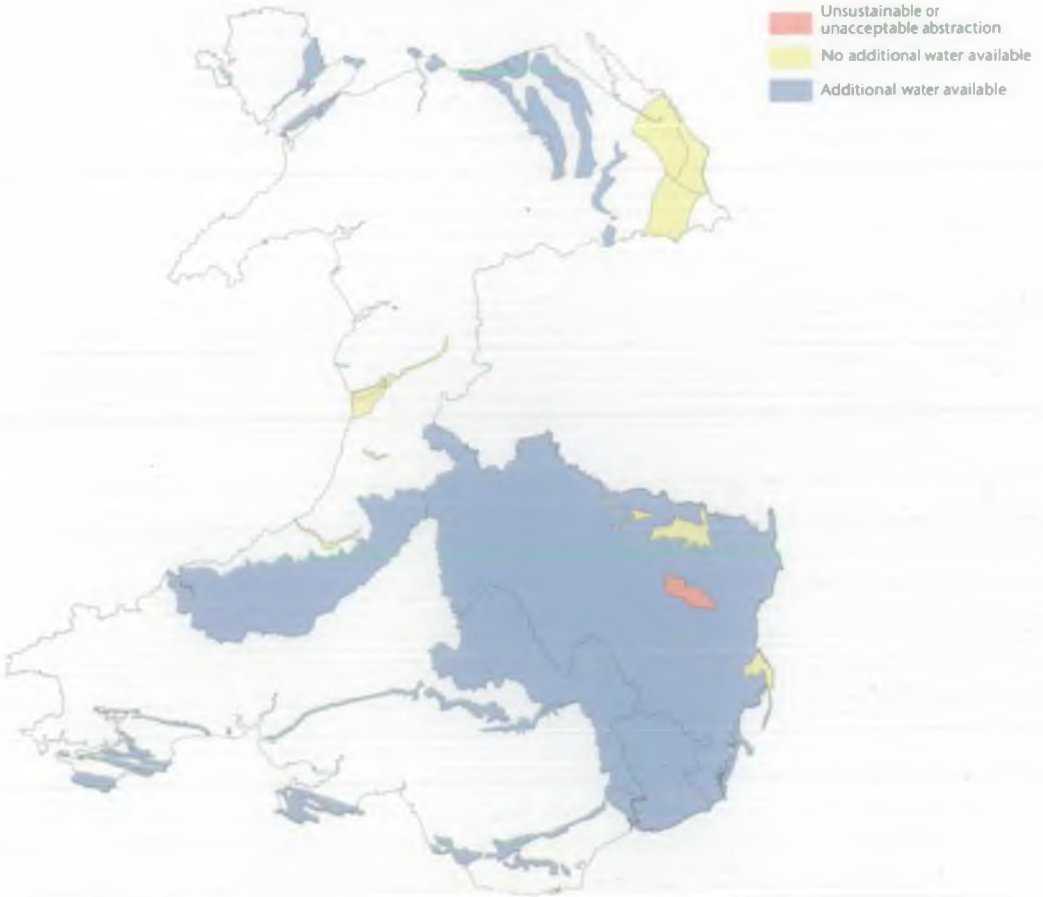


Figure 3.13 Resource availability map – groundwater



- no additional water available: licensed abstraction does not pose a threat to the environment, but it is considered that there is little scope for further abstraction;
- additional water available: additional water may be available, although at any specific site its volume may be small and reliability low.

These maps represent the strategic position across Wales. They are not intended to prejudge licensing decisions for any proposed abstraction. Various considerations would be needed, including an appropriate assessment 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.

3.5.1 Summer surface water

The map of Wales shows that summer surface water is already fully committed over much of the country. Only the Tywi catchment and the Cardigan Bay rivers of the Mawddach, Dysynni, Dyfi, Rheidol and Aeron show potential additional summer water at a catchment level. No unacceptable catchment flow regimes exist and so existing abstractions are not causing widespread environmental harm. With surface water so heavily dependent on regular rainfall events to maintain flows, these results are not unsurprising.

3.5.2 Winter surface water

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

In some parts of Wales winter surface water is not reliably available. This applies to Ynys Môn, the Dee, Conwy and Clwyd catchments. These catchments are already utilised heavily for public water supply and power generation and so already contain major resource developments. No unacceptable catchment flow regimes exist and so existing abstractions are not causing widespread environmental harm.

3.5.3 Groundwater

The majority of Welsh aquifers have available resources. Many, like the Old Red Sandstone, do not locally contain large quantities of water but are nonetheless important water sources in a mainly rural country.

There are, however, some aquifers where either the current flow regime is unacceptable, or no additional water is available. The Triassic sandstone aquifer of the lower River Dee has no additional resources. Recent research on this aquifer has shown that existing legal abstractions are close to the aquifer yield. As a consequence, further work is under way to refine our knowledge of the groundwater resource. Our future licensing policy will be based on the results of this work. The valley gravels of the Dyfi, Rheidol and Aeron rivers in mid and west Wales are small ribbon aquifers. These are exploited locally for public water supply and would appear to be currently at the limit of water availability. Again studies are under way on the resource management.

In the Wye catchment, local gravel aquifers and units of the Old Red Sandstone aquifer are heavily exploited by industry and by public water supply needs. Again further research is under way. The Yazor gravel aquifer in the Wye Catchment has been classed as having an unacceptable flow regime.

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

4 Pressures on water resources

While we know most of the current pressures on water resources and the environment many aspects of the future are uncertain. These include, for example, the effects of climate change and societal change. 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 rarely considered when making choices.

4.1 Environmental needs

Section 3.4 and associated maps indicate that the majority of surface and groundwater resources across Wales are in a healthy state. Only in a small number of localised aquifers do we consider that current licensed groundwater abstractions are causing environmental problems. The most serious of these is within the Yazor gravels aquifer in the Wye Catchment where there is already evidence of a harmful affect. Here industrial abstractions and quarry de-watering have lowered the local groundwater levels extensively. Research is under way to provide better management of this resource. A programme of water efficiency promotion among the key industrial abstractors in the area is one of the options under consideration.

Our strategy allows for the resolution of established problems. Where these affect sites designated under the Habitats Directive and other SSSIs, we will deal with these by 2004. The Agency's current National Environment Programme is a five-year plan to resolve problems at sites where water company abstractions are known, or thought to be causing an unacceptable impact on their immediate environment. (Environment Agency, 1998b). These sites are shown in Figure 4.1. We have also developed the Restoring Sustainable Abstraction Programme (RSAP), addressing issues associated with other abstractions thought to be adversely affecting the environment. The Agency is committed to enhancing biodiversity, and in all of our work we consider opportunities to contribute to the success of the UK Biodiversity Action Plan (UK Government, 1994).

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

Where we have identified unsustainable or unacceptable abstractions we propose that they should be restored to a sustainable level within the time frame of this strategy, although we have not stipulated exactly when. We have identified, in broad terms, a small volume of water required to achieve this for Wales, and considered this additional environmental demand. Identifying and funding the most cost-effective implementation in each location will be a matter for the abstractors concerned and the Agency.

4.2 Societal change

To take account of the uncertainties that surround the ways in which society may evolve it is appropriate to examine different scenarios for societal change. To help us in formulating a robust set of scenarios for water use and resource management we have been guided by the Foresight "Environmental Futures scenarios" developed for central Government's Department of Trade and

Figure 4.1 Regional environmental sites

Figure 4.2 The Foresight quadrant

Industry (DTI). These scenarios are intended to inform and stimulate debate among businesses, regulators, and government departments about the environment, and to encourage them to develop strategies and policies which will prove robust to a range of "possible environmental futures". They look at the future by considering two aspects of development: social values and systems of governance. Details of the approach can be found in the Foresight "quadrant", (Figure 4.2.) 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 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 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.

Table 4.1 **Foresight Environmental Futures**

The Foresight programme, sponsored by the Department of Trade and Industry (DTI), sets out to identify innovative market opportunities and new technologies, which will enhance the competitive advantage of businesses in the UK. In 1999, the Energy and Natural Environment Panel published a set of scenarios focussed on the environment (DTI, 1999). These scenarios are intended to inform and stimulate debate among businesses, regulators, and Government departments about the environment and encourage them to develop strategies and policies that will prove robust to a range of "possible environmental futures".

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

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

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

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

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).

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. Our 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 we must recognise:

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

One of the main objectives of this strategy is to illustrate choices and options, and their implications. We can then identify the actions that we and others need to take to reduce uncertainty in water resources management over the next 25 years.

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, we follow three basic principles:

- 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;
- we must finalise decisions about actions at the right time, since 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, at least in part, as a result of manmade 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 20th century. This is part of a world picture of warming. Globally, 1998 was the hottest year since records began in the middle of the 19th century. It is thought that the 1990s may have been the warmest decade of the last millennium.

We are able to predict some aspects of climate change more confidently than others. For example, there is some confidence in being able to predict 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 increase during 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 grown and their distribution across Wales. Higher temperatures will also affect livestock production systems. We have outlined how we have estimated the effect of climate change on household demand in Chapter 5.

Changes in climate will also change groundwater and river flow regimes and therefore the availability of water for abstraction. Current estimates of climate change suggest that by the 2020s there will be on average more winter rainfall and less summer rainfall. Higher temperatures mean that potential evaporation rates will probably increase. There is also evidence that climate change will increase the year-to-year variability of rainfall. Effectively, this means that the climate will be less predictable, with both more dry years and more wet years. This in turn means that low flows will probably occur more often. Evidence about the possibility of longer droughts is unclear; the best available view appears to be that increased variability makes droughts that last longer than several years slightly less likely. Our understanding of changes in extreme events is, however, more limited than that of changes in average climate.

In this strategy, we will assume, based on the results from Arnell (1999), that over the next 25 years most public water supply systems will retain their existing yields. This is a reasonably conservative assumption, as most systems depend to a great extent on the storage of winter water 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.

Altered 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 keeping existing controls on abstraction, except where we know that these need improvement for other reasons. The environment that we protect will be dynamic, with species changing over time with climate changes.

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

4.5

Population and household size

The latest Government projections show an increase of around 140,000 households in Wales between 1996 and 2016. This is largely due to the trend towards smaller household size. Total population is also predicted to increase by 42,000 over the same period. As a consequence, the average household occupancy rate will drop from 2.3 people per house in 1998 to 2.1 by 2016.

In developing this strategy, we have used a nationally consistent population and household data set obtained from CACI Limited for each water company resource zone for the period from 1997 to 2019, extrapolated to 2025.

4.6

Land Use

The way in which we use land has a significant impact on the water environment. Urbanisation, land drainage, upland grazing and mining of minerals have all altered the quality of water and runoff characteristics of our river catchments. Future changes in land use and drainage can exert further, or new, pressures. It has been shown that certain types of forestry and urbanisation can reduce the yields of sources, as well as altering the flow pattern, sedimentation and quality of rivers.

Urban areas make up 5 per cent of the land area of Wales. Their impermeable surfaces, such as roads, force rainwater to simply run off the land without percolating through into groundwater. This impacts on the longer-term availability of water. Watercourses that flow through such areas are often designed to remove rainfall quickly, and this may present a flood risk further downstream. The Agency has co-operated with other bodies in investigating more sustainable approaches. This has resulted in the publications *A guide to sustainable urban drainage* (Environment Agency, 1997) and *Sustainable urban drainage* (Environment Agency, 1999c). 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.

Flooding has been a major concern in Wales over recent winters

Woodland covers around 12 per cent of Wales. 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, however, reduce infiltration when above an aquifer. The estimates of the potential change resulting from urbanisation and forestry are not yet sufficiently reliable to make it worth including an allowance in the assessments used in this report. However, we would include it in any analysis of the need for major new sources.

Land-use changes, such as intensive upland grazing, also affect the natural quality of the water in rivers and streams, potentially changing the species that thrive within the watercourses. For example, sedimentation may cover river gravels that would otherwise be valuable spawning grounds for some fish species.

Human activity can also reduce or render unusable the available water resource. Pollution is a continuing threat. Initiatives such as the River Dee Protection Zone will, with an ongoing and active programme of public information and education, reduce the potential for pollution incidents.

However, diffuse pollution from nitrates, pesticides and other substances poses a more insidious threat.

The Agency's Groundwater Protection Policy and improved land management techniques will reduce the risk, but there is always the danger that water sources may be decommissioned because of a rise in contaminants. The Agency has taken steps to identify possible risk areas. In Wales the development of a petrol station database is a good example of our pro-active risk assessment approach. The need to meet rigorous European Community water quality standards at all times has provided the stimulus to close many small public water supply sources where treatment to the required standard would be expensive. This shortfall is made good through transfers of water from other sources.

Discharges of treated effluent return water to the environment. Standards are set to ensure that this treated water is of a suitable quality for the receiving watercourse. Discharges from sewage treatment works tend to be reasonably constant throughout the year, and therefore support river flows during the summer by providing more water than would otherwise be there. This can be to the benefit of the environment or other downstream abstractors.

Within Wales more than 63 km of river are affected by at least 80 discharges of coal minewaters. When the minewater enters surface waters, iron is deposited on the riverbed, leading to severe discoloration and poor survival of fish and other river life. The Agency has been involved in a number of projects that have helped treat these discharges, thereby reducing the impact to surface waters.

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 the preceding chapters we have set out the frameworks in which water resources are managed and the principles underpinning 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. The way we have chosen to do this is by estimating incremental demand, defined as the extra water needed compared to that used now.

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 scenario at 2010 and 2025. We consider the additional demand under the following headings:

- household demand
- leakage
- industry and commerce
- spray irrigation
- hydropower generation

The flexibility of this approach allows us to consider additional demands as further elements become important. By using the concept of incremental demands, 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. The task is particularly difficult, because it depends on value judgements about different uses and users of water. Put simply, if the need is judged to be great enough, water can be made available, either by costly technological solutions or at the expense of existing water uses.

5.2 Developing the scenarios

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

5.2.1 Household demand

For household demand, we broke down household consumption into its micro-components (such as toilet flushing, 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, for each. We have generated unmeasured per capita consumption for each resource zone on this basis.

Metering, and its likely extent and impact, was also considered for each scenario. Using the results of the national metering trials to guide our assumptions, metering of households provided reductions in consumption ranging from 3 per cent to 21 per cent (National Metering Trials Working Group, 1993). The proportion of metering also varied across the scenarios.

Table 5.1 **The key drivers of water demand**

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

5.2.2 Leakage

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 identified 19 different sectors to which we applied sector-specific assumptions. By differentiating between large companies and small and medium-sized enterprises the forecasts reflect the 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.

5.2.5 Hydro-electric power generation

A number of factors will influence future HEP scheme development. These include appropriate site availability, distance from markets, the view of society, and the cost of energy. Our forecasts have considered where potential commercial sites exist, and their likely development. Small community-scale schemes have also been considered.

Appendix 2 gives more detail on our water demand forecasting approach. The Agency will also publish further information on its work in 2001.

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 respectively. 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, the incremental demands vary significantly, with increases in total demand for water in two of the scenarios, and decreases in the other two. Within this, the different components behave in different ways.

The picture is far more complicated if we include forecasts of hydropower generation. Here the push for a more sustainable society also requires more hydropower generation to match its emphasis on a renewable lifestyle. The highest demands for hydropower occur when other sector water uses are reducing. Additionally, the potential demand for hydropower could be very high in comparison with other water uses. To avoid overshadowing other sectors, hydropower forecasts are not included in figures 5.1 and 5.2. Appendix 2 gives information on hydropower forecasts.

There are distinct differences across Wales. These are the result of differential rates of growth and regional differences in the geography of water use. For example, hydropower generation is the dominant component in parts of North and Southwest Wales. Industrial water use is most significant in south Wales as a consequence of the high water-using industries such as steel manufacture. Agricultural water use, including spray irrigation, is highest in the rural areas of the Wye catchment. For public water supply, the impact of large exports to England ensure that they are a major water use in southeast and northeast Wales.

5.3.2 Climate Change

Climate change will affect the demand for water in many different ways. For this strategy we have used the best information available at present from the UKCIP programme. Appendix 1 gives further information on our analysis.

We have calculated a likely increase in household demand caused by climate change, on the basis of the 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 demand from within Wales is about 1 per cent, or 9Ml/d, by 2025. A further similar volume is generated from the impact on demands from those areas in England dependent on Wales for water supplies.

Figure 5.1 Total demand scenarios for 2010 and 2025

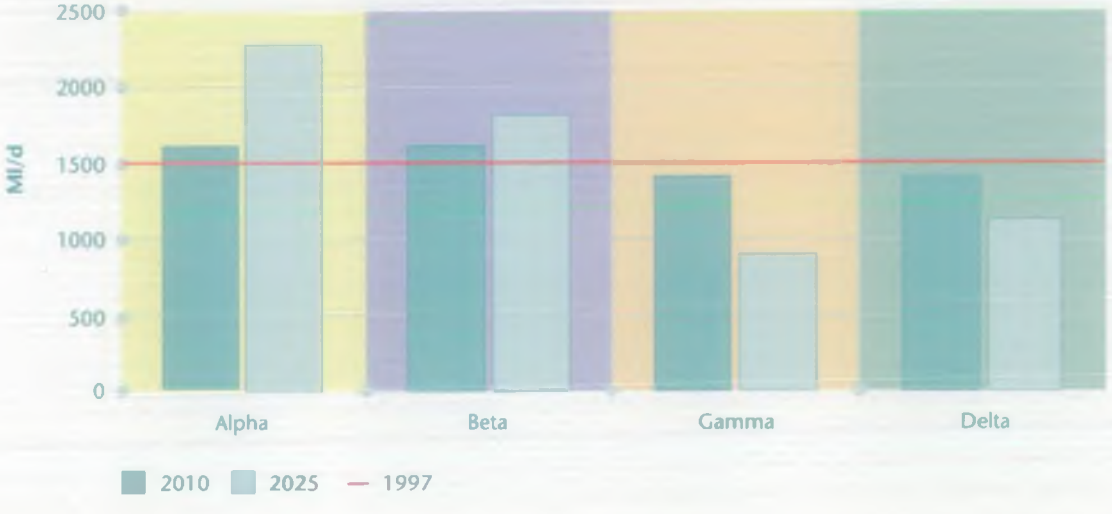
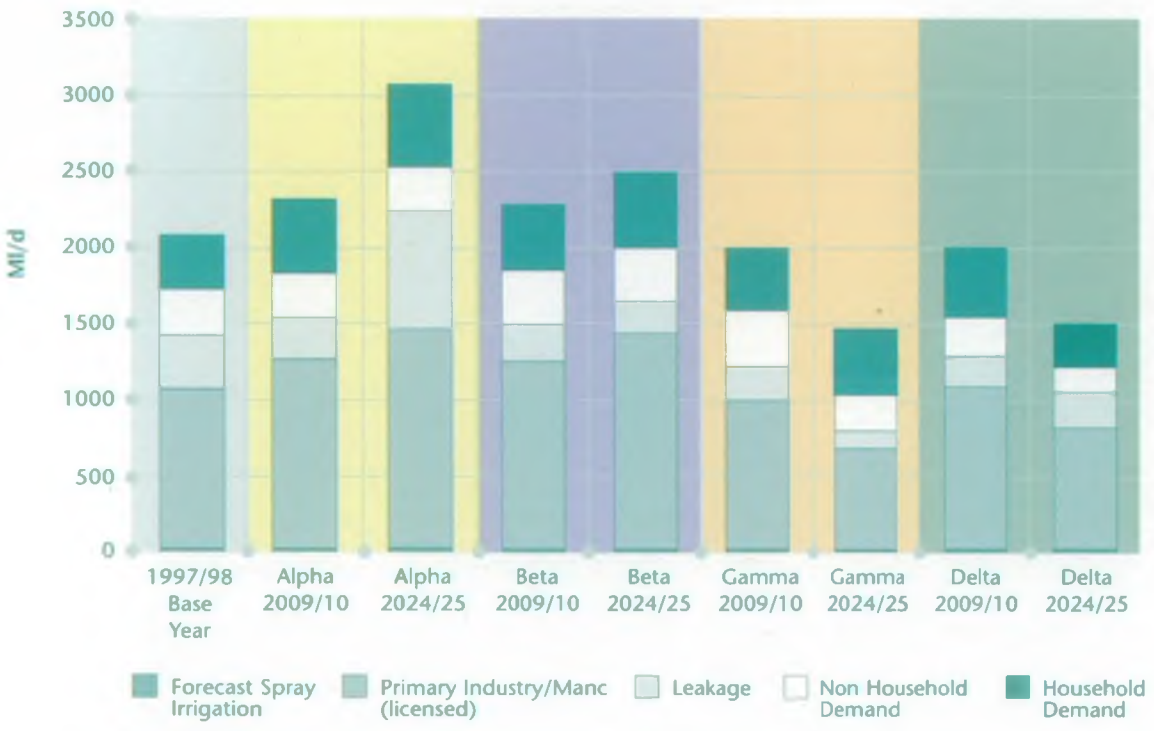


Figure 5.2 Demand scenarios by use for 2010 and 2025 (excluding HEP)



Given the diverse range of industrial uses of water, vulnerability to climate change is likely to vary considerably between sectors. 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.

Energy demand will be directly affected by climate change. However, the proportion of the demand met by hydro-electric power generation is likely to be influenced by general economic considerations rather than climate.

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 need would increase at the six study sites considered. The magnitude of the increase varies quite markedly in relation to the climate change scenario. For example, for maincrop potatoes in Wales, the increase above current optimal levels is between 13 and 15 per cent.

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 only a few isolated sites are being harmed as a result of current levels of 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 Wales.

The "claw-back" is entirely for groundwater abstraction. We estimate that a reduction in licensed quantities of up to 13Ml/d from the Yazor gravels aquifer in the Wye catchment may be required to achieve a sustainable resource allocation. All these abstractions relate to industrial and quarry de-watering activities. Details will be refined as assessments are completed and as the CAMS process develops.

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

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

Existing resources have been compiled from water companies' calculation of yield, and the current licensed abstractions for industry and agriculture. The latter may not be reliably available, for example in a drought, but are appropriate to compare with existing demands.

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

6 Options and options 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 consider for any set of options, costs, benefits, risks, uncertainties and contribution to sustainable development.

6.1

Identifying the options

We have considered a range of options for managing water resources. These include options that increase supplies and those that reduce demand. Table 6.1 lists the types of option considered.

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 the resource options considered need further specific investigation if they are to be progressed.

Table 6.1 Generic types and regional options list

Resource Development	Demand Management
New reservoir	Improved leakage control
Reservoir raising	Rainwater use (new development, non-potable)
Winter storage reservoirs (single farm)	Greywater use (new development, non-potable)
Winter storage reservoirs (farm consortium: 10-15)	Waste minimisation of industrial/commercial
Surface water abstraction (unsupported for pws)	White goods subsidies
Groundwater abstraction or enhancement	Retrofit of toilets to dual flush/interruptible flush
Desalination	Increased household metering
Wastewater re-use (direct - pws)	Tariffs for measured charges
Wastewater re-use (direct - non-pws)	
Wastewater re-use (indirect - pws)	
Wastewater re-use (indirect - non-pws)	
Aquifer artificial recharge and recovery	
Canal transfer	
River transfer	
Pipeline transfer	
Operational improvements	

Summer flow in the River Wye, a candidate SAC

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. 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.
- 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 think about the components that should make up the strategy, and then to consider the strengths and weaknesses of the strategy as a whole. Together, they help us to meet two of the Agency's duties: to have regard for costs and benefits, and to contribute to sustainable development.

6.3

Risk and uncertainty framework

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

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

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

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), the National Assembly for Wales's *Better Wales* (NAW, 2000), 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;

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

Option				Uncertainties					Constraints				Opportunities				
Type		Time to implement [yr]	Renewal period [yr]	Technology and investigation	Promotion time	Construction/implementation time	Resource value	Cost	Policy & legislation	Public & stakeholders	Environment	Energy Use	Flexibility in implementation	Environmental enhancements	Resilience to climate change	Meeting other needs	Amenity and recreation
Resource Development	New reservoir – Craig Goch	15-20	100	○	◐	○	●	○	●	●	●	○	○	○	●	●	◐
	Existing reservoir pumped refill Celyn & Brenig	1-3	100	○	◐	○	●	○	●	●	●	○	○	○	●	●	◐
	Winter storage reservoirs (single farm)	1-2	15-30	○	○	○	○	○	○	○	○	○	○	○	●	○	○
	Winter storage reservoirs (farm consortium: 10-15)	3-5	15-30	○	◐	○	○	◐	○	○	○	◐	○	◐	●	○	◐
	River Wye at Hereford (increased take from river)	1-3	30	○	○	○	○	○	◐	◐	◐	◐	◐	○	○	○	○
	River at Wye at Builth (increased take from river)	1-2	30	○	○	○	○	○	◐	◐	◐	◐	◐	○	○	○	○
	Leintwardine (existing licence increase)	1	30	○	○	○	◐	◐	○	○	○	◐	●	○	◐	○	○
	Vowchurch (existing licence increase)	1	30	○	○	○	◐	◐	○	○	○	◐	●	○	◐	○	○
	Whitbourne (existing licence increase)	1	30	○	○	○	◐	◐	○	○	○	◐	●	○	●	○	○
	North Ceredigion (existing licence increase)	1	30	○	○	○	◐	◐	○	○	○	◐	●	○	◐	○	○
	Conjunctive use of surface and ground-water Triassic Sandstone - Vyrnwy – River Dee	1-3	100	○	◐	◐	◐	◐	○	○	○	◐	●	●	◐	○	○
	Road tankering at peak times – Capel Curig and Dinas Mawddwy	1	10	○	○	○	○	◐	○	○	○	◐	◐	○	○	○	○
	Claerwen reservoir to Teifi Pools	2-5	30	●	◐	◐	◐	◐	◐	●	●	●	○	○	○	◐	○
	Severn Trent to Ross-on-Wye transfer (PWS)	1-2	30	○	◐	◐	○	○	◐	◐	◐	●	○	○	○	○	○
Demand Management	Improved leakage control	1-5	-	○	○	○	◐	◐	○	○	○	○	●	○	●	○	○
	Rainwater use (non-potable)	1-3	15-30	◐	◐	○	◐	○	◐	●	○	○	○	○	○	○	◐
	Waste minimisation of industrial/commercial	1	15-30	○	○	○	◐	○	○	◐	○	○	●	○	●	○	○
	Domestic water management audits	1	15	○	○	○	◐	○	○	◐	○	○	●	○	●	○	○
	Metering (domestic 2/3 penetration	10	10	◐	●	○	●	○	●	●	○	○	●	○	●	○	○

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

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

We subdivided each of the sustainability themes into criteria against which we assessed each option. These are outlined in table 6.3. The appraisal is carried out by an independent assessor.

Given that the climate is changing, all sectors of society and the economy will have to respond to new climate conditions. Adaptation strategies will be driven by changes both to long-term climate and to extreme events. However, as indicated above the exact nature of climate change is uncertain. Assuming the worst can be very expensive, especially where decisions have to be taken many years in advance. One of the keys to a

Table 6.3 **Sustainability criteria applied to the water resources strategy**

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

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

successful adaptation strategy is to ensure that it is sufficiently flexible to deal not only with current scenarios but at least to some extent with events that are less likely. In the context of the water resources strategy, this means that schemes that improve the management of water use, or developments that can be phased, will be more appropriate than schemes that are inflexible.

6.5

Costs

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

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 of the development of schemes to implement our recommendations. Sustainability appraisal considers the components of environmental cost alongside other aspects in a way that is appropriate at this stage.

6.6

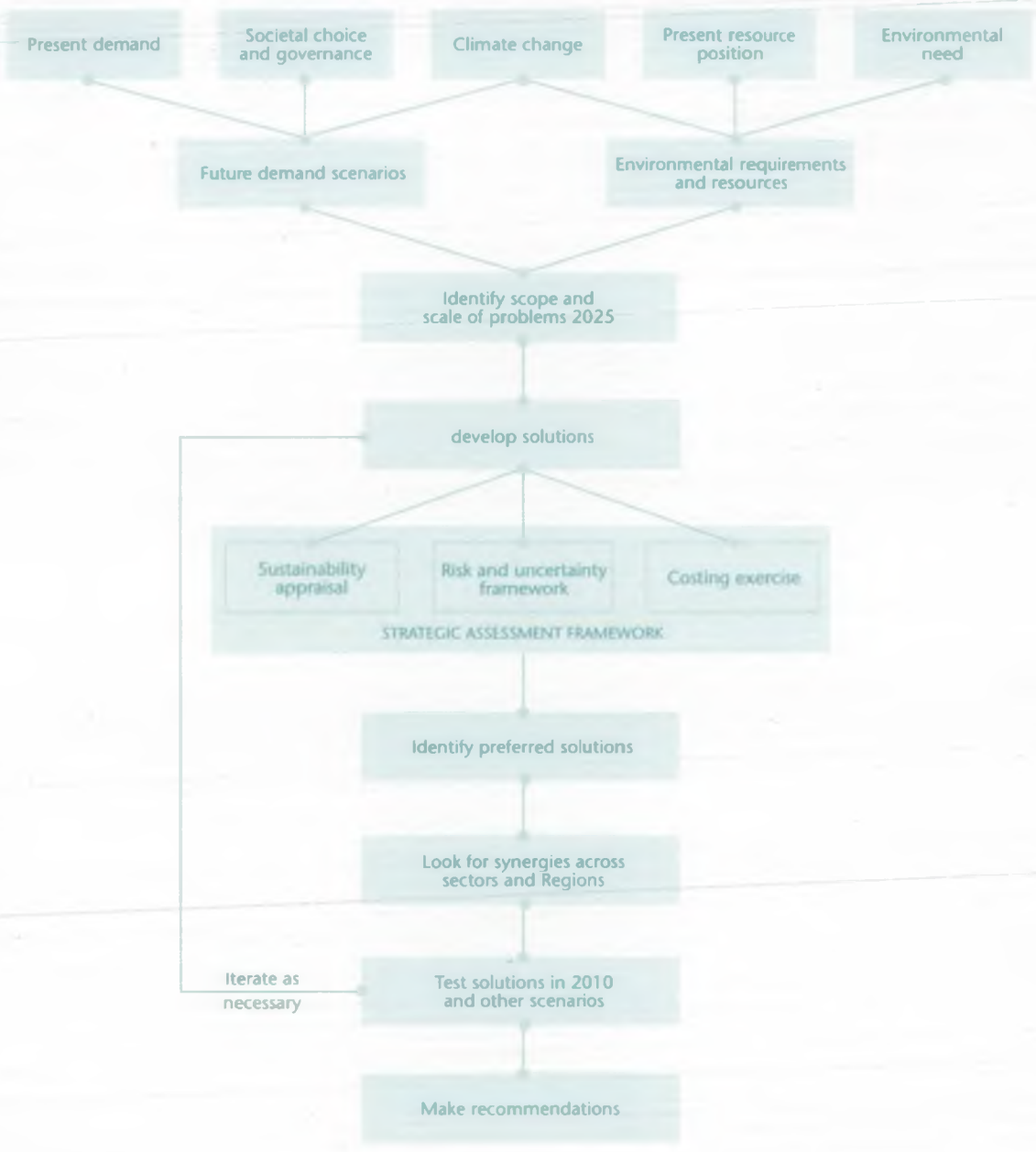
Building a strategy

The process we have followed to combine these approaches recognises the significance of costs but also takes account of the other elements in a logical and consistent manner. It is an iterative approach involving the following steps:

- identify the options available for meeting any gap between supply and demand. These include both demand management and resource development;
- for 25 years ahead, consider the biggest incremental demand;
- identify a first solution (made up of a set of options) for this incremental demand;
- look at the strengths and weaknesses of this solution as indicated by the sustainability appraisal and application of risks and uncertainties framework, which included robustness to climate change: how does the set of options perform?
- consider the weaknesses and constraints of the individual options identified. Could other options improve the contribution to sustainable development, increase resilience to climate change or reduce uncertainties?
- look at the effectiveness of this solution 10 years ahead;
- consider the effectiveness and appropriateness of this solution in the other three scenarios;
- refine and review the set of options; identifying a robust solution and the necessary timing of actions.

Since costs will influence the delivery of any strategy, we have taken likely costs into account in considering different strategy options. We have not calculated the financial cost of this strategy in detail. However, it will be for the organisations who promote schemes in line with the 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.

Figure 6.1 The strategy development flow chart



7 Conclusions and proposals

In preceding chapters, we have considered how a scenario approach can be used to build a robust strategy for the management of water resources, how water is used by society, and the effect of existing abstraction on the environment. We have outlined our approach to identifying and selecting options, and how it has been used to identify the way forward in the face of real uncertainties. In this chapter we indicate the broad nature of our conclusions and of our strategy for developing and managing water resources sustainably.

7.1 A water resources strategy for Wales

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

For Wales, our recommendations consist of a combination of resource developments and demand management (Table 7.1). This is a genuine "twin track" approach. We propose, by 2025:

- minor resource development to satisfy public water supply, industrial and agricultural needs; and infrastructure improvement which could move 6 Ml/d from areas of surplus to areas of need;
- expansion of metering to provide 6 Ml/d; and water conservation and rainwater harvesting initiatives around the home, in industry and agriculture, which could deliver a further 21 Ml/d.

Many of these solutions are focused on areas within Wales which may experience water shortages over the next 25 years. When applied throughout Wales the quantity of water involved is much higher. We have considered a number of other options in case our recommendations fail to deliver. These comprise further small resource developments and some limited transfers of water including pumped storage of existing schemes.

Of course, some actions need to be started well in advance to achieve success by the dates shown. We have also identified some alternative actions that we could consider if our preferred options prove inappropriate in some way.

Figures 7.1 and 7.2 show the balance of our proposed solutions across Wales in 2010 and 2025. In these figures we show first the water taken for public water supply, industry, spray irrigation and hydropower 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 demand management. These are the same demand management measures, but they deliver different savings in different scenarios.

We are proposing a single set of actions that is robust enough to manage water resources through all the scenarios we have considered. Our proposed strategy ensures that supply meets demand through all four scenarios in Wales for both 2010 and 2025. This does not mean that water can be made available for all uses at all times of year: for example, in some areas the provision of water for spray irrigation is becoming increasingly problematical. The strategy also provides additional water to deal with the possible impact of

Table 7.1 EA Wales proposals

For public water supply, by 2010

We expect to see water saving of up to 16 Ml/d and have allowed for resource and infrastructure developments of up to 6 Ml/d.

- Industrial and commercial water-use minimisation
- Domestic water audits
- Rainwater harvesting
- Small groundwater schemes in the Wye catchment and in mid Wales.
- Small surface water abstraction increases in the Wye catchment
- Infrastructure improvements to allow isolated rural resource zones in mid and north Wales to utilise surplus water in neighbouring zones.

For public water supply, by 2025

We expect to see water saving of up to 27M1/d and have allowed for resource and infrastructure developments of up to 7 Ml/d.

- Industrial and commercial water-use minimisation
- Domestic water audits
- Rainwater harvesting
- Leakage reduction programmes
- Infrastructure improvements to allow isolated rural resource zones in mid and north Wales to utilise surplus water in neighbouring zones.

For agriculture, by 2025

Predicted demand levels under all scenarios fall below current licence quantities in all catchments.

- Provision of winter storage would improve reliability in the lower and eastern Wye catchments.
- The Agency will review the current operation of regulated rivers to assess the extent to which they could increase the reliability of spray irrigation abstractions.

For industry and commerce, by 2025

- Predicted demands fall below current licence limit quantities in all catchments. Environment Agency Wales will promote water use minimisation.

Other options under consideration

- Small increased abstractions from existing river sites in south east Wales.
- Transfers to the Teifi catchment via pipeline. As the supply zone has high summer demand generated by tourism and agriculture, this option may still be required to meet summer demands.
- Small groundwater and surface water abstractions, along with enhanced infrastructure to connect isolated areas, have been considered in many rural locations.
- Winter pumped refill of storage reservoirs has been considered to enhance the existing reliability of the regulated River Dee.
- Conjunctive use of the Lower Dee groundwater resources with Vyrnwy reservoir.

Other significant uncertainties

The promotion of sustainable energy production may create increased interest in new hydro-electric generation sites.

climate change on domestic demand, and to restore sustainable abstraction regimes in 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 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.

Figure 7.1 Regional balance for 2010

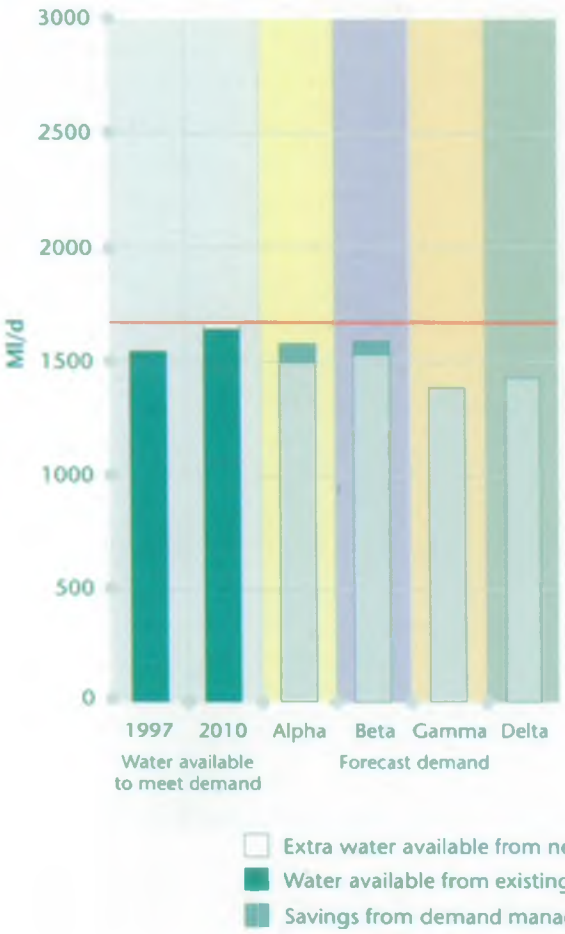
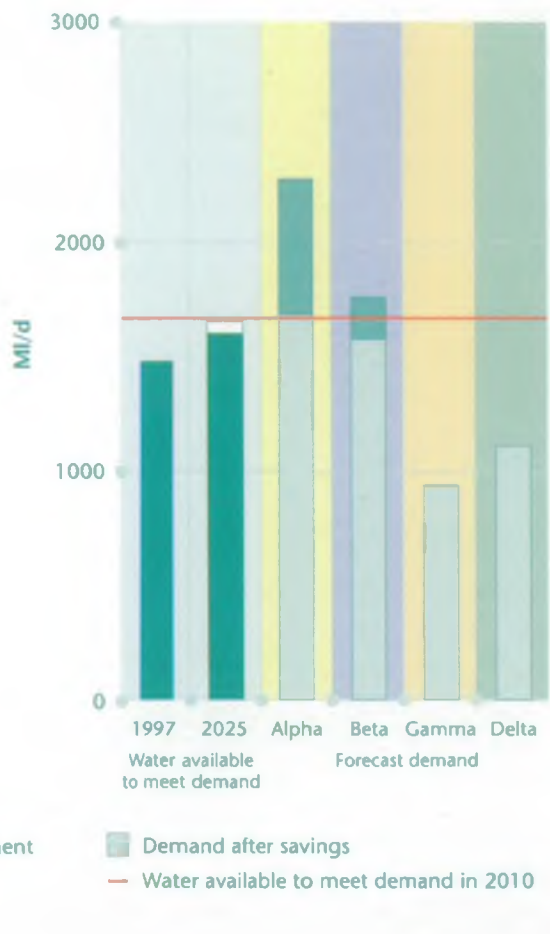


Figure 7.2 Regional balance for 2025



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 it is essential to monitor progress.

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

7.2 Public water supply

7.2.1 Enhancing resources

We consider that water companies will need to make developments to enhance resources over the period of this strategy. Many of our resource-side recommendations involve making the most of existing schemes. These include further integration of supply systems. We recommend that **where new or existing developments are not fully utilised, water companies should share this water with others (Action A1).**

Wales has many small rural supply zones. Development of small-scale reliable sources in these zones is possible, and we suggest this as an option at a number of sites. However, water quality issues often make this an expensive solution. To overcome this we anticipate further integration of supply zones. Water will be transferred within Wales from zones with surplus water to those experiencing or forecasting shortages.

Large transfers of water have been considered in this strategy. These could deliver solutions to existing water resource management issues in areas such as the Teifi and Dee catchments. However, we believe these may not be needed if demand management measures are fully employed. This would require development of metering, leakage control, water conservation measures, and rainwater harvesting.

The enlargement of Craig Goch reservoir in the Elan Valley is an option that has been strongly favoured by Seven Trent Water. This is not included in our strategy as it is a higher cost option providing more water than appears to be needed to meet future demands in the Midlands.

Winter storage options are resilient to current climate change scenarios that suggest wetter winters. However, long promotion and implementation times for reservoir enlargements will mean that they will need to be promoted soon if they are needed before 2025. The time needed to develop a major source can be problematical, given the considerable uncertainties. Our recent work also suggests that refilling reservoirs during dry winters is a bigger constraint than storage capacity. Additional storage is of little use if it cannot be reliably filled. Within Wales we already have many reservoirs. Enhanced refill of some of these reservoirs, through pumped storage schemes, will often provide a better alternative to increased storage.

With an average rainfall in excess of 1,300 mm a year in Wales, the Agency has been investigating the potential of rainwater harvesting. It could enhance resources throughout Wales by replacing the need for potable treated water for non-potable applications around the home and in the workplace. Additionally it may have a role to play in mitigating storm water runoff in urban areas. This approach is commonplace in Europe.

In domestic use a rainwater storage of around 1,000 litres is usually sufficient to provide water for most of the year for some non-potable uses. These include toilet flushing, garden watering and possibly clothes washing. It could meet up to 90 litres of daily mains supply per household if used to meet toilet-flushing demand.

The Agency regulates the River Dee to meet many demands

Many commercial, industrial and agricultural sites have large areas of roofing and available space for water storage. Drainage from these sites is often seen as an issue rather than an opportunity but the rainwater could be collected for toilet flushing, vehicle washing and process water.contributions, particularly if it can be stored effectively. Projects that include detailed monitoring are currently under way at a number of sites across Wales.

We have calculated that rainwater harvesting in our homes could replace public water supplies of up to 3 Ml/d over the next 25 years. Industrial and agricultural sites have the potential to replace at least 30 Ml/d of mains supplies. When applied to areas of need, our strategy requires less than 1Ml/d of this potential to be tapped. Use of rainwater does not necessarily reduce water consumption, but it does provide additional resources and reduces the need to treat and transport water.

7.2.2 Water efficiency and water-use minimisation

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

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

- reducing per capita toilet use by almost 10 l/h/d, by introducing dual-flush and low-flush systems;
- reducing average washing machine volumes to 50 litres per cycle;
- reducing average dishwasher volumes to 20 litres per cycle;
- using efficient showerheads/flow restrictors as part of water audit, which would limit the impact of the growth of power showers/high-volume showers.

All of these initiatives are possible and available today, within existing technology and regulations.

Currently in Wales we each use around 146 litres of water every day. This compares to consumptions ranging from 132 litres to 181 litres of water per person each day in England. 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, providing that appropriate tariffs are set.

Increasing use of water by society imposes a greater stress on the aquatic environment of England and Wales. It will take time and effort to change behaviour so that responsible efficient use of water, a test for sustainability, becomes the norm. Water companies already have a duty to take an active role in this and we expect them to pursue it with vigour. The draft Water Bill proposes also that they consider water conservation in their own operations, including leakage control (DETR, 2000e).

We have calculated that water conservation in our homes could save as much as 39 Ml/d over the next 25 years. Applied only to areas of Wales with potential shortfalls in supply, this option would deliver 4 Ml/d by 2025. It is essential that this saving is delivered and maintained to protect the security of public water supplies.

The Water Supply (Water Fittings) Supply regulations continue to be important, as they provide a legal limit on the water consumption of devices and appliances. These are set by central Government and the National Assembly for Wales but enforced by water companies. While the regulations have to be set within the context of the European single market, it is essential that **they are kept 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 Wales the Agency will discuss with the National Assembly of Wales the potential role that the regulation may play in controlling water demand.

In Wales, about a third of the water supplied by water companies goes to commerce, industry and agriculture. Almost all this is metered, but many independent studies have shown 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 discharge of water and therefore their water bills. We propose simple water efficiency measures that would pay for themselves in less than one year. This provides what we believe is a conservative estimate of the potential water that could be saved. Longer payback periods could deliver further substantial savings.

We each use 146 litres of water per day – or 16 buckets

To date the uptake of schemes for water conservation has been generally slow. Here in Wales, however, 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 over 20 industrial sites, a number of hotel and office premises, and in the agricultural sectors of dairy farming and glasshouses. Demand reductions averaged around 25% but some as high as 60 per cent were recorded. All showed water savings were achievable at little or no cost, and with additional measures further savings were achieved with a two-year payback. Additional savings were also made in relation to reduced discharges and energy costs. In total the studies provided potential cost savings in excess of £1,500,000.

We have calculated that water conservation in commerce, industry and agriculture could save as much as 152 Ml/d over the next 25 years. Restricted only to areas in Wales where potential deficits occur, this option would deliver a 20Ml/d saving. 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 use over the next 25 years. In Wales we have

developed a water-use minimisation strategy, in liaison with other partners, to help focus our effort. These will deliver case studies in areas of Wales where current water resources are stretched. **Water companies should actively promote this amongst their industrial and commercial customers in compliance with their statutory duty to promote the efficient use of water (Action A3).**

Water efficiency is important in all sectors that use public water supply. To deliver the savings that we propose in this strategy will require widespread adoption of water saving techniques by commerce (including amenity, sport and leisure uses), industry and agriculture. This can be achieved by building on water companies' water efficiency plans, and publicity campaigns such as DETR's "Are you doing your bit?". **Ofwat, National Assembly for Wales, central Government, water companies, trade associations and the Agency should vigorously promote water efficiency and monitor the results of this work (Action A4).** The approach to water conservation should be collaborative, targeted and based on an understanding of costs and outcomes from information reported in the public domain.

The Agency's National Water Demand Management Centre will continue to support and encourage water efficiency initiatives. The opportunities provided through initiatives such as European structural funding also provide important opportunities to further water conservation. **The Agency will work with water users and water companies to ensure that water efficiency is delivered. (Action A5).** The Agency has worked closely with the National Assembly for Wales to ensure that water-use minimisation has been incorporated into the criteria for European structural funding bids. In Wales, Agency staff work closely with the National Water Demand Management Centre to promote water-use minimisation effectively throughout Wales.

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

7.2.3 Leakage

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

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

In compiling this strategy, we have had to take an informed view on how leakage can be managed over the next 25 years. In much of Wales we believe that in the longer term further progress on leakage control will be appropriate. This will provide environmental protection by preventing the waste of valuable water resources and reducing the need for new resource development. For planning purposes, we have identified a level of leakage that would be achievable with the application of today's best practice and most advanced technology (Appendix 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 the National Assembly for Wales, central Government, Ofwat and others how the current regulatory framework and the new legislation proposed in the draft Water Bill can assist in achieving good leakage control (Action A10).**

There are a few parts of Wales where leakage reduction beyond present targets is unlikely to be essential. We also recognise the impact that leakage levels outside Wales may have on Welsh resources. We propose that water companies in these areas must not let leakage rise and so will need to maintain leakage control, taking advantage of any new technical developments which may present opportunities for further reductions. This is applicable to companies who provide supplies within, or obtain supplies from, Wales.

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 they use. The Agency advocates more use of household metering within a regulatory framework that has regard to the government's broader social and environmental policies including the protection of vulnerable households.

Metering of households encourages people to consider their use of water, partly by allowing them to understand how much they are using. It raises awareness directly, when the bill arrives. Provided that appropriate tariffs are charged, metering of households encourages high users of water to reduce their water use. In the longer term, it should lead to changes in attitude, so that, for example, when new appliances or bathrooms are needed, people will choose devices that are water-efficient. Studies support this decline in water use following installation of meters. To better understand why these reductions occur the Agency and Dee Valley Water are monitoring water use in selected properties both before and after the installation of meters.

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, the National Assembly for Wales, central Government and the water industry in the provision of accessible information to householders about metering. This includes the development of tariffs that encourage water efficiency while having regard to the Assembly's and central 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 140,000 new homes envisaged in Wales between 2000 and 2016 will all have meters.

We believe that in most of Wales, metering should reach between half and three-quarters of households by 2025, from a base figure of around 11 per cent today. This level of household metering across Wales could deliver water savings of 26Ml/d by 2025. However, our strategy focuses on supply zones where need is greatest, resulting in a proposed saving of 6Ml/d. By making it normal for water use to be measured, a culture of awareness will be developed. This will place Wales in a strong position to face the challenges of the future, including societal and climate change and it can contribute to, or be driven by, competition in the water industry. **Water companies should take a positive attitude towards targeted household water metering where this is appropriate and where opportunities arise. (Action A12).** These opportunities include new homes, unattended sprinkler users and targeted metering of potentially large water users when properties change hands.

7.2.5 Summary

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

7.3 Agriculture

We indicated in Chapters 3 and 5 some of the broad uncertainties facing farming over the next 25 years. In particular, changing economic frameworks and global warming may make for substantial change. Agricultural demand for irrigation is likely to increase.

For general agricultural use, there is undoubtedly scope for water saving. Wales is predominantly rural, and in rural areas general agricultural use is a major component of the demand for water. This is accessed from both the public mains and from direct abstraction on the farm. Often the quality of the water required is non potable, being used for, among other things, stock watering and cleaning purposes. As a consequence, farmers tend to use local direct abstractions such as springs and shallow boreholes. Many of these are unreliable and will dry up during the summer, forcing farmers on to the more reliable, but higher cost mains supply. This in turn contributes to higher summer demand in rural areas that may already have supply difficulties. The current economic pressures on farming, which have led to larger farm holdings, have not yet reduced the lengthy rural supply pipe network. As a consequence farm supply pipe bursts are a major water demand.

Demand can exceed supply in some parts of West Wales. The Agency investigated efficient water use on dairy farms, and identified a number of potential demand management opportunities, including water reuse and rainwater harvesting (Environment Agency Wales, 2000). Careful management of water around the farm not only cuts water bills, but also reduces the disposal cost through adding less water to slurry and other wastes on the farm. As a consequence the farmer saves water, saves money and reduces the impact that farming can have on the environment.

Agricultural demand for irrigation is likely to increase in the future but it is uncertain by how much. The cost of

Dairy farming is an important water use

irrigation will be critical. Large joint schemes requiring substantial pipework and pumping are unlikely to be economic. Agricultural demand for water will therefore remain essentially a matter needing a local solution.

We have found that in some of the areas traditionally associated with spray irrigation, little water is available for abstraction during the summer months. This will come as no surprise to many of those involved in parts of the Wye catchment. In these areas, there is scope for further abstraction of winter water, but this would need to be stored for use during summer. The construction of farm reservoirs can be expensive, especially in areas where they need to be lined to prevent leakage.

One option to consider is the potential for agriculture, commerce and industry to benefit from schemes that are developed principally for public water supply. Given appropriate agreements, it may be possible for agriculture to benefit in the short term from public water supply schemes before they are fully utilised. Where possible, **the Agency will seek to identify opportunities to make water available for agricultural use 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 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).**

The Government has said that the Agency should use its existing powers to apply abstraction licence conditions in order to deal with profligate water use. The Agency will develop licence conditions accordingly. We may require abstractors to seek regular certification that their processes have undergone a water waste minimisation audit. Conditions will be included in new licences; we will want to see existing licence holders co-operating voluntarily with similar good practices.

The general conclusion, however, is that the farming industry must review its own resources, recognising that water may be 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, 2000e) should assist farmers. We consider that **farmers should actively seek ways of minimising their water use (Action A16).** To help with this, farmers could consider the installation of meters to help them to understand better their use of water around the farm.

Traditional methods, in particular individual or joint development of winter storage, can provide reliable supplies in 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 for the construction of water storage facilities and the provision of associated equipment.

The trading of abstraction licences can be of particular benefit to agriculture. Farmers may be able to acquire access to additional water without affecting the natural environment. If an individual farm finds that a neighbour values use of some of its licensed abstraction more highly than it does, a trade would make sense to both. **The Agency will assist trading of abstraction licences between abstractors, provided the trade is not harming the environment (Action A18).**

We believe that this means trades that are for essentially the same body of water. We recommend **that farmers consider the possibility of trading of abstraction licences to meet their needs (Action A19).** Trading can take place now, but provisions in the draft Water Bill would facilitate it (DETR, 2000e). Central Government proposed other facilitation measures in its April 2000 consultation paper on economic instruments in relation to water abstraction. Its decisions on those are expected early in 2001 (DETR, 2000c).

The Agency also recognises that the big retail chains and food processors are making product quality demands on farmers that involve more irrigation and on farm use. **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).** We are working with the National Assembly for Wales and other partners, including local food processors and farmers, to understand better the external influences that affect agricultural water use.

7.4 Industry and commerce – direct abstraction

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 or other canal operators can find a reliable source of water further away.

Even where abstraction comes directly from rivers or groundwater, we make the same recommendation as in 7.2.2 above: **water efficiency should be positively encouraged (Action A4).** The economics of this are less immediate, because the cost of raw water is lower than that of public water supply. The monetary savings will depend partly on the degree to which the water has to be treated before use, but they also face effluent treatment charges. However, studies have shown that most direct abstractors can make savings that pay for themselves within a year. Saving water in this way can have the added benefit of reducing other raw material

costs and associated energy savings as well as the volume of water that has to be discharged.

Most commercial and industrial sites could also benefit from rainwater harvesting, for those uses where drinking water quality was not required.

As for agricultural abstractors, **the Agency will seek to identify opportunities to make water available for agricultural, commercial and industrial purposes from existing and new developments (Action A13).** Again in line with or proposals 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

Hydropower generation is already an important aspect of Welsh water resources. The topography and rainfall make further developments attractive, and this is particularly relevant if society focuses more towards renewable energy production. Our scenario forecasts suggest a mix of outcomes with both increases and reductions from current levels of hydropower operation.

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 central Government initiatives encouraging the greater use of renewable sources. Understandably developers are eager to take advantage of the opportunities offered by government policy.

For hydropower schemes, as with all other abstraction proposals, we will work closely with planning authorities and conservation organisations in order to try and prevent conflicts or duplication between regulators. **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. A flexible approach to a proposed scheme must be maintained in respect of measures to mitigate its impact. This must occur even at the expense of some generating capacity.

Using the energy in water

7.5 Environment

In Chapters 3 and 4 we showed the importance of water for the environment, fisheries, navigation and recreation.

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

The Agency will promote greater understanding of the value of the water environment, by providing clear information to the public on how water use affects the natural environment (Action A23). The users of water are often far removed from where it is sourced. Recognising the impact our water use has on this distant environment, as well as on our immediate doorstep, is an important aspect we must address in Wales.

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 water within the expected new legislative framework (Action A24).** This is particularly relevant where proposals exist to restore canal navigations.

We support these initiatives as long as their impact on the environment and other existing water rights is acceptable.

7.7

Transfers

Transfers of water already feature in parts of our strategy. There may be further proposals for new transfers; we will consider these where they can make a positive contribution to prudent water resources management. In particular we will consider carefully any specific proposals that British Waterways put forward. **We will encourage the development of more local transfers within Wales 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, where this happens, the volume transferred 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. Increased flows could interfere with canal navigation and infrastructure.

7.8

Overarching issues

To facilitate the successful implementation of the specific actions that we believe necessary for Wales, we propose the following actions:

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

New developments need water. **The Agency will work with planners to identify opportunities for water efficiency in new developments (Action A27).** New homes and other developments could be water efficient by making this a condition of the planning consents. Installing water-efficient devices and appliances in new buildings, as well as looking at opportunities for other sources of water, will further water conservation with no disruption to lifestyles or commerce. In Wales we have already been proactive in this field. We will build on our links with the National Assembly for Wales and our unitary authorities to promote water conservation through the planning process.

Although it can take many years to develop a large water resource scheme, **the Agency will work with the National Assembly for Wales to identify opportunities for streamlining the process of approval for essential water resources development while maintaining full public accountability and having regard to the views of the Assembly (Action A28).** This is important even though this strategy has found no need for new large schemes in Wales.

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 funded for the purpose. The Agency will seek views from Ofwat and the National Assembly for Wales, the water industry, farming and industrial organisations, and environmental and consumer groups. **If we find support for this idea, we will encourage its further development Action A29).**

The thinking that has gone into developing our strategies has identified areas needing further research. 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

Conclusion

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

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

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

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

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

Table 7.2 **Sustainability appraisal summary**

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	
	Water figures (Mld)	Opport.	Constr.	Opport.	Constr.	Opport.	Constr.	Opport.	Constr.
Wales									
Water use minimisation (industrial / commercial)	50 & 59	+	0	++	0	0	0	+	0
Local groundwater schemes	1	(+)	0	(+)	0	+	0	+	0
Infrastructure improvements in Dŵr Cymru in mid- & North Wales	1.6	+	(-)	+	0	+	0	+	-
Leakage reduction	120	+	(-)	++	0	+	0	+	-
Increased household metering	10.5	+	0	+	0	+	-	+	-
Domestic water efficiency/audits	1	+	0	+	0	+	0	+	0
Non-household rainwater reuse	0.5	+	0	+	0	0	0	+	-

++ = very positive contribution to the theme
+ = positive contribution to the theme
0 = the option is neutral
- - = very negative contribution to the theme
- = negative contribution to the theme

If the opportunity is considered only as an indirect outcome, the score is placed in brackets eg. (+)

Sustainability appraisal

The availability of water in Wales means that future increases in demand can mainly be met out of demand management schemes such as water use minimisation and leakage control, without the need for major new infrastructure developments.

Sustainability appraisal of the proposed Welsh strategy shows that all options identified would have positive impacts on the four key themes of environmental protection, prudent use of natural resources, social progress, and economic growth and employment. This is particularly true for leakage control and water use minimisation.

Social benefits are likely to arise from demand management measures because these are likely to reduce the need for new infrastructure developments and may thereby reduce costs to the consumer. However, there may also be some potential social impacts such as road congestion during leakage reduction work and increased costs to some households of domestic water metering.

Economic effects are likely to be generally positive, though with some potential economic costs associated with infrastructure improvements in mid- and North Wales, household metering and non-household rainwater harvesting. However, these costs are considered to be relatively low compared to the likely costs of major new infrastructure investments which are avoided by the demand management measures.

8 Actions and the way forward

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

8.1 Overview

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

The conclusions we drew in Chapter 7 will require action and commitment from various parties if we are to achieve our vision. 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. Chapter 7 indicated a number of opportunities for research and investigation to contribute to better-informed decisions during the life of this strategy.

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

8.2 The 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 Wales.

Table 8.1 **Actions**

Action Ref	Action	Agency	Water companies	Agriculture	Industry	NAW and central Government	Ofwat	Planning bodies	NGO's and others
A1	Where new or existing developments are not fully utilised water companies should consider sharing this water with others.		✓						
A2	The Water Supply (Water Fittings) Regulations should be kept 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, the National Assembly for Wales, central 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	The National Assembly for Wales and central 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 the National Assembly for Wales, central 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, the National Assembly for Wales, central Government and the water industry in the provision of accessible information to householders about metering. This includes the development of tariffs that encourage water efficiency while having regard to the Assembly's and central 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, commercial and industrial 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 harming 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	NAW and central Government	Ofwat	Planning bodies	NGO's 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 within Wales 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 the National Assembly for Wales to identify opportunities for streamlining the process of approval for essential water resources development while maintaining full public accountability, and having regard to the views of the Assembly.	✓				✓			
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.	✓							

Kidwelly Castle

Appendix 1
Climate change

A1.1

Overview

There is mounting evidence that our climate is changing, at least in part, as a result of man-made atmospheric emissions. The DETR's UK Climate Impacts Programme (UKCIP) has reported that UK temperatures have increased by about 0.7°C over the last 300 years, with about 0.5°C of warming during the 20th century. This is part of a world picture of warming. Globally, 1998 was the hottest year since records began in the middle of the 19th century. It is thought that the 1990s may have been the warmest decade of the last millennium.

Wales has experienced this warming trend, with five of the nine warmest years occurring in the last decade. The warming has been greatest in autumn and winter; summer temperatures have shown little trend over the century. Annual precipitation has increased only very slightly over the same period. However summer precipitation has fallen by up to 15 per cent since the early 1900s. To compensate, winter precipitation has increased by 10 per cent. Rainfall intensity has also shown signs of increasing during winter, while summer storms appear to be less intense (Institute of Environmental Science, 2000).

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. We are able to predict some aspects of climate change more confidently than others. For example, there is some confidence in being able to predict the sea-level rise and global temperature increase induced by a given change in carbon dioxide concentrations.

This part of the report looks 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

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 these scenarios suggest that by the 2020s, throughout the Midlands and all of Wales, there will be more winter rainfall and less summer rainfall.

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 variability. Climate change is superimposed on this natural variability which may either magnify or reduce the effect of climate change. Work carried out for the Agency (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

We are uncertain about tomorrow's climate

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 to improve our understanding of climate change. It is most likely that this will involve refining existing results, adding detail and reducing uncertainty in the present scenarios. It is quite possible that new predictions could be quite different from those we have now. We do not understand fully all the possible effects of global warming. For example, 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 unlikely, present assessments may change. We cannot rely on their accuracy, which means that we need to be flexible when dealing with climate change. 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 imperfect, so it is not possible to be absolutely certain about how climate change will affect demand. The DETR has commissioned a study to investigate the impact of climate change on domestic, industrial and agricultural water use. This will report in 2002. For this strategy, we have used the best information available at present.

With hotter summers, household water use is likely to increase. This extra water will be for garden watering and additional personal washing. Herrington (1996) carried out the definitive study of this, and showed that 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 Scenario Beta to calculate an incremental demand as a result of climate change. Our calculation is based on the probable increase in garden watering, as this scenario already includes increased personal washing. Of course, under different Foresight scenarios society would respond to climate change in different ways. It would be possible to make an assessment of the different impact on garden watering in different scenarios. However, the quality of the data on changes in water use is poor, and does not warrant such sophistication. We have applied the value calculated for Scenario Beta to the other scenarios as well. This is a precautionary assumption, as this scenario represents a worst case and it is anticipated that outdoor water use under the other scenarios would be lower. We have added this climate change demand to the incremental demands for each scenario. The total effect on public water supply demand within Wales is about 1 per cent, or 9Ml/d. A further similar volume is generated from the impact on demands from those areas in England dependent on Wales for water supplies.

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.

Energy demand will be directly affected by climate change. However, the proportion of the demand met by water power generation is likely to be influenced by general economic consideration rather than climate.

Climate change will certainly have an effect on agriculture. It will affect not only planting and

harvesting dates, but also the crop varieties grown and their distribution across England and Wales. Climate change may allow an extension of the area given to crops that are presently marginal, such as lupins, sunflowers and navy beans. In combination, these changes will influence crop water requirements and irrigation need.

Livestock production systems will also be affected by higher temperatures, with increases in animal drinking and water wallowing sites for outdoor pigs. Indoor livestock units may require cooling, creating an additional demand for water.

To provide indicative estimates of the potential impact of climate change on current optimum irrigation needs, we commissioned Cranfield University at Silsoe to develop and apply a new methodology. This builds on the concept of 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. For example, for maincrop potatoes in Wales, the increase above current optimal levels is between 13 and 15 per cent. 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 the General Agreement on Tariffs and Trade (GATT), as well as changes in consumer preferences. It is within this context that the impact of climate change on spray irrigation demand should be assessed.

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

A1.3.2 Availability of water

Changes in climate will change flow regimes and therefore the availability of water for abstraction. All the UKCIP scenarios suggest on average more annual rainfall throughout Wales, with less summer rainfall. 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.

As most of our rivers are not dominated by groundwater contributions, Wales can expect lower river flows in July, August and September. Flows increase in the rest of the year in all scenarios.

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

The above refers to the average effect of climate change. It implies that climate change can be considered against 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 a 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 the way in which they are operated. The yield and reliability of public water supply systems depends on the magnitude and duration of dry periods, as well as the frequency of such events. The increased variability associated with present scenarios suggests that long dry events will be no more frequent than at present, which implies no change from present yields for large

reservoirs and groundwater-fed systems. However, this result is by no means certain.

In this strategy, we have assumed, that over the next 25 years most public water supply systems will retain their existing yields. This is a reasonably conservative assumption, as most systems in Wales 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.

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.

One of the most likely consequences of global warming is a rise in mean sea-level. This occurs primarily because warmer ocean water expands and because ice sheets and land glaciers melt. Climate-induced sea-level rise could be in the range of 25 to 35cm by 2050. Sea-level rises could impact on sources close to the tidal limit on the coast or in estuaries. Some, such as the lower River Dee water intakes, are already affected when tides are high. On these occasions water intakes are closed until the saline water retreats. With higher sea levels the frequency and the length of shutdown may increase. Where aquifers are affected the saline intrusion may prevent further abstractions at that location. Abstractors at risk from sea water will need to assess the impact these changes may have on their business and take appropriate actions.

A1.3.3 Impact on the natural environment

The impact of climate change on the natural environment 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 suggests that 10 per cent of the UK's internationally designated areas could be at risk of permanent inundation or gradual loss of conservation value as a result of sea-level rise, temperature rise and changes in water availability (DETR, 2000d). We expect to develop further information and strategies to enable the protection of sensitive species 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.

Climate change will alter the water environment

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 need improvement for other reasons. The environment that we protect will be dynamic, with species changing over time as the climate changes.

A1.4 Adaptation strategies

All sectors of society and the economy will have to respond to new climatic conditions. Adaptation strategies will be driven both by long-term climate changes and by changes in extreme events. However, since the exact nature of climate change is uncertain, it is difficult to plan, especially where decisions have to be taken many years in advance. Some decisions may involve significant investment but 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 inflexible schemes.

The Agency has a significant role in helping to mitigate climate change by regulating major industries that emit greenhouse gases. While water resources have little impact on this, it is important to take into account the energy use of different schemes. Pumping large volumes of water around uses significant amounts of energy, and therefore contributes to total emissions.
For this reason, both our risk and uncertainty framework and our sustainability appraisal (Chapter 6) consider energy use.

Climate change is an important element of uncertainty in water resources planning. Over the next 25 years or so, it is not, however, the greatest source of uncertainty in such aspects as water use. In Chapter 5 and Appendix 2, we show that societal values and economic growth will also play an important role. Given the increase in average annual rainfall predicted by the climate change scenarios, it would be difficult to justify new water resources development solely because of climate change. Nevertheless, any water resources management initiatives should 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 the National Assembly for Wales on these in June 2000 (Environment Agency, 2000b). In this strategy we will tend to 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

Although we must consider climate change carefully in water resources planning, many other factors also affect our use of water and the natural environment. In Chapter 5 and Appendix 2, we show how 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 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. 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

Chapter 5 outlined the role that scenarios play in the development of our strategy for Wales. 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.

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 other 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 6.3 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. Within the same scenario some components of demand may increase while others decrease. To track such changes and fully illustrate their impact, we have built on up-to-date information and methodologies to develop forecasts of water demand for the following components:

- household
- leakage
- non- household
- primary industry and manufacturing
- spray irrigation
- hydropower generation

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. The drivers of spray irrigation demand have been assessed in the Agency's *Optimum use of water for industry and agriculture best practice manual (W254) and technical report (W243)* R&D project (Environment Agency, 2000e).

In developing our forecasts, we have assumed that the key drivers of demand will be the same 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 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 Chapter 5 and in Table 5.1. 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 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 chapter.

Table A2.1 **Household forecast micro-components**

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

Each section includes an indication of the scenario outcomes for each component at a Wales level, for each scenario in 2010 and 2025.

We have adopted a micro-component approach in our household demand scenarios, breaking down consumption into 14 discrete micro-components 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.

A2.3

The household demand methodology

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

A number of sources of information inform projections of future changes in OFV values. The OFV values reported in Herrington (1996) have been updated for example in light of changes introduced in the Water Supply (Water Fittings) Regulations. We assesses technological innovation in the volume of water used by white goods and other appliances by reviewing manufacturers' information, and discussed changes in the rate of uptake of sanitaryware with representatives from the British Bathroom Council. We commissioned a new study of the flow rates associated with different types of shower.

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.

Using all this information, we have developed scenario-specific assumptions for each of the 14 micro-components to generate an unmeasured per capita consumption for each resource zone across Wales.

Household water demand: scenario outcomes

Scenario Alpha: 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 sanitaryware is retained.

Scenario Beta: With high economic growth, technological innovation leads to improvements in the water efficiency of white goods and average washing machine use reduces to 50 litres by 2025. Discretionary uses of water increase with more pressure washers, power showers and swimming pools.

Scenario Gamma: 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: Consumer attitudes shift markedly with a major impact on water-using behaviour. The use of water for discretionary purposes such as garden watering declines from 9 l/h/d to less than 3 l/h/d by 2025. There is widespread uptake of demand management measures, and a shift to low-water using appliances. Community initiatives become more widespread. Rainwater collection for garden watering is the norm where some form of watering is required.

A2.3.1 Metering scenario assumptions

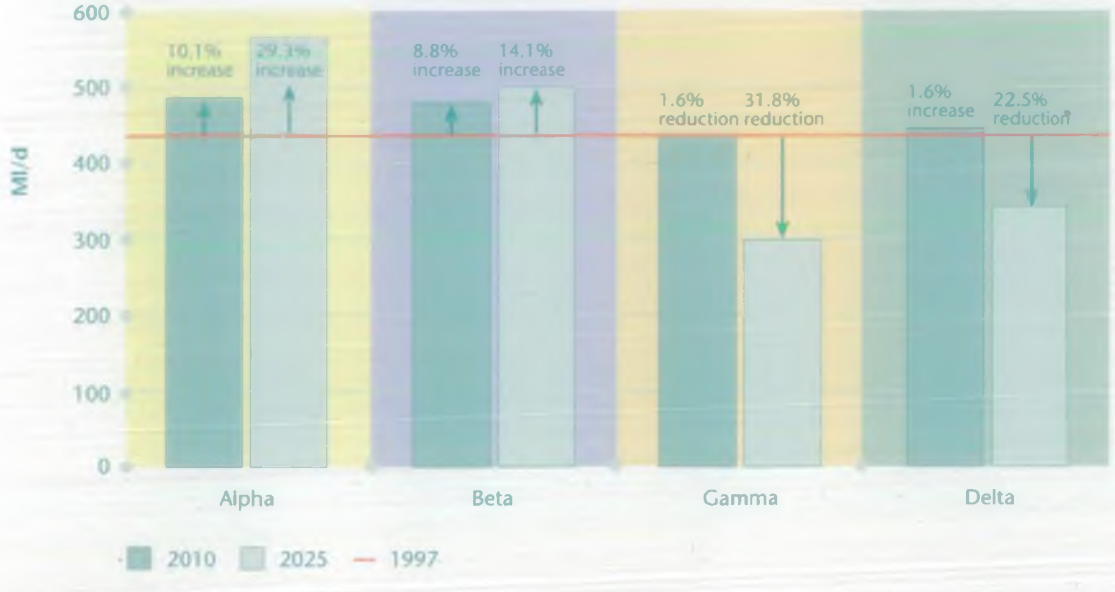
Metering gives customers the opportunity to pay for the volume of water they use. This offers an element of choice to the consumer and provides an incentive to manage demand. It is likely that different tariff structures would be developed under different scenarios. We have not considered these in detail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

Table A2.2 Metering within scenarios

	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Alpha	Likely water company rates following Ofwat final price determination	No additional metering			
Beta		Water company rates	Metering to a maximum of 95% of all properties		
Gamma		Water company rates	Metering to a maximum of 95% of all properties		
Delta		Water company rates			

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.

Figure A2.1 PWS household demand by scenario in 2010 and 2025



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 information was based on the 1996 population projections (building on the 1991 census information), adjusted to incorporate 1997 mid-year estimates.

A2.4

Leakage

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 (Table 5.1). High-level changes in political and social attitudes will affect the priority given to leakage by the Government, and will therefore influence the formulation of targets. This in turn will affect water companies' leakage control philosophy and subsequent find-and-fix activity, pressure management levels, and service and mains replacement rates.

A2.4.1 The leakage scenario approach

Our four leakage scenarios reflect differential approaches to setting leakage targets. Three scenarios reflect recent UK and overseas experiences, and draw on information from the recent past to inform the development of company leakage targets. Only one scenario has necessitated detailed modelling, to reflect the impact of new technologies. Table A2.3 details the calculation methods and associated timings for each scenario.

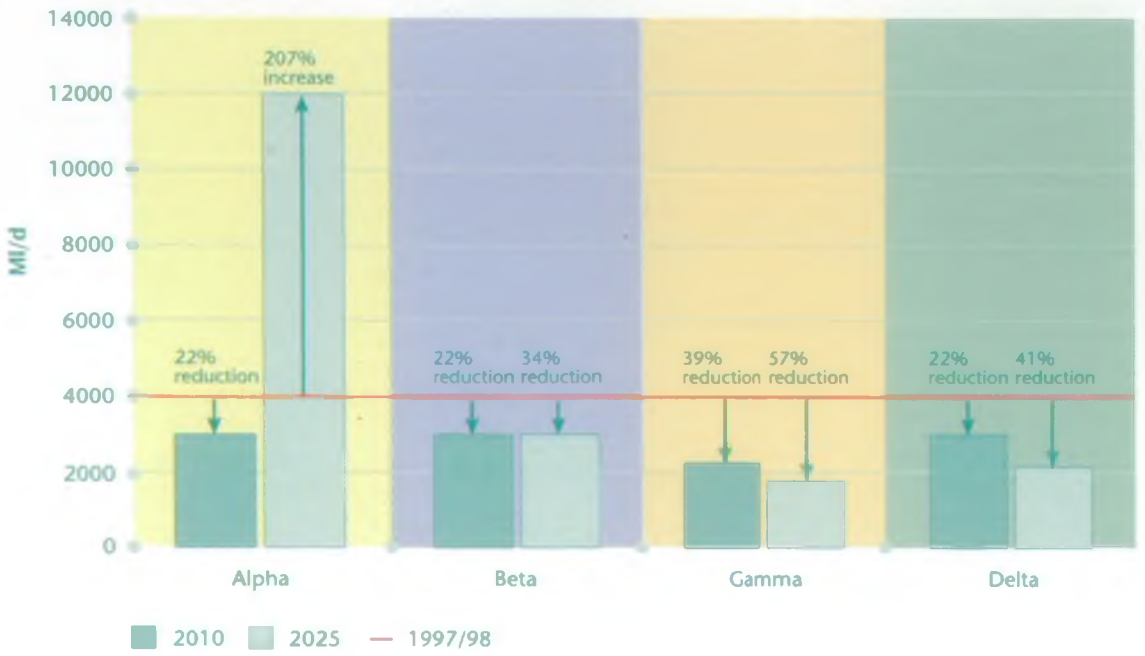
Leakage : scenario outcomes

Scenario Alpha: 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.

Table A2.3 **Leakage calculations 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 **Leakage by scenario in 2010 and 2025**



Scenario Beta: The water industry is subject to light levels of regulation. Given the primacy of market forces, leakage targets are not considered necessary, 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 gains in supply pipe leakage achieved through universal metering.

Scenario Gamma: 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 water industry is subject to strong regulation, with the leakage target-setting process reflecting innovative technical solutions.

Scenario Delta: 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 per cent of water put into supply is an appropriate level.

Scenario Alpha 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 practices 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 zero to over 20 litres / property / hr each year.

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

Scenario Gamma leakage assumptions

The implementation of technically proficient leakage-control methods forms the cornerstone of leakage targets in this scenario, based on the assumption that techniques currently available are developed slightly. These techniques will reduce the run time of bursts, reduce the pressure in the distribution system and accelerate mains renewal rates. The forecast draws on the demonstrated benefits of the recently developed acoustic loggers that permanently "listen" for bursts and emit signals to a patrol unit housed in a moving vehicle. In future years, it is assumed that further technological development of the loggers will take place, reducing response times further.

This information has informed the modelling exercise that has been carried out using the Bursts and Background Estimates (BABE) model. Drawing on data published by Ofwat, three policies are included within the model:

- find and fix activity
- pressure management
- services and mains replacement

For each of these policies there are three levels of application that reflect the resource position of the company. For companies with the least headroom, political and public expectations would pressurise them to place greater emphasis on leakage control. Find-and-fix policies would be introduced more quickly, and annual rates of pressure management and mains replacement would accelerate.

In 25 years, other technologies are almost certain to offer further opportunities to reduce leakage. Such unknown technologies are not considered in the forecast. It may therefore be considered to be a conservative estimate of how far leakage control could proceed in a favourable social and economic environment.

A2.5

Non-household and primary industry demand

Each of the drivers of non-household demand identified in Table 5.1 plays a critical role in shaping the use and management of water within industry.

Industrial demand : scenario outcomes

Scenario Alpha: 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 after 2005,

reflecting the reorientation of production to meet domestic demand. This is counterbalanced by growth in primary industry/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 minimisation activity, compounded by lack of investment in manufacturing infrastructure.

Scenario Beta: The removal of all international trade barriers results in a reduced level of gross output and employment within UK-based primary manufacturing industries such as textiles, machinery and metals. This decline is balanced by an increased level of output and employment within business services, chemicals and biotechnology. Given the drive towards technological innovation we assume that by 2025, 20 per cent of firms 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: Resource-intensive systems of production such as paper, minerals, rubber, textiles, metals and fuels are subject to stricter environmental regulations after 2010. These emphasise water efficiency and 90 per cent of businesses within these sectors are affected. Other industrial and business sectors adopt voluntary measures to minimise their impact on the environment. By 2025, 50 per cent of businesses within retail, business services and construction implement water efficiency..

Scenario Delta: From 2009/10 retail and business services and the 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 per cent 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.

To address these issues and avoid applying blanket assumptions, our forecast model draws two key distinctions. Firstly, to allow application of sector-specific assumptions, the forecast has broken down water consumption by industrial sector. Linked to the Standard Industrial Classification (SIC 1992), we have broken down public water supply non-household demand into 19 sectors, while direct abstraction includes 11 sectors. 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 minimisation options.

A2.5.1 Forecast methodology

Availability of base-year water consumption data in Wales, disaggregated by industrial sector, played an important role in determining our forecast methodology. With this 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 Envirowise (formerly the Environmental Technology Best Practice Programme) and other published sources, we devised sector-specific water savings which reflect differences in cost and pay back period. Hence we defined five water efficiency measures for production and manufacturing industries:

- good housekeeping
- management
- reuse
- recycle
- redesign

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

Reflecting the different nature of water use in the business and service sectors and education and health, we defined three water efficiency measures once again ranging from the cheapest to the most expensive. 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. The level of uptake by businesses of relevant water efficiency measures between scenarios will vary.

Figure A2.3 Direct abstraction by scenario in 2010 and 2025

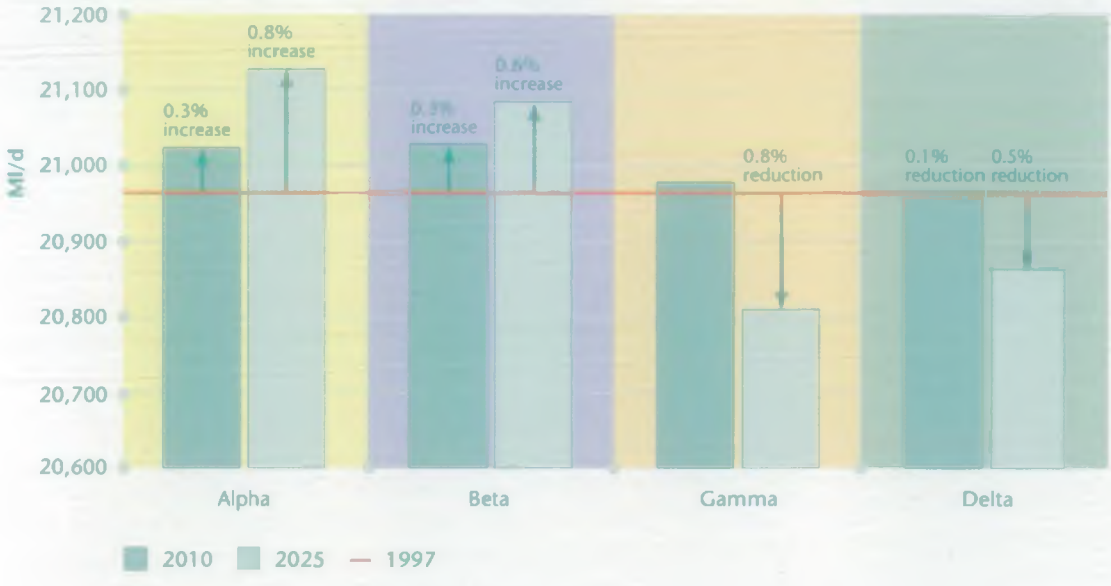
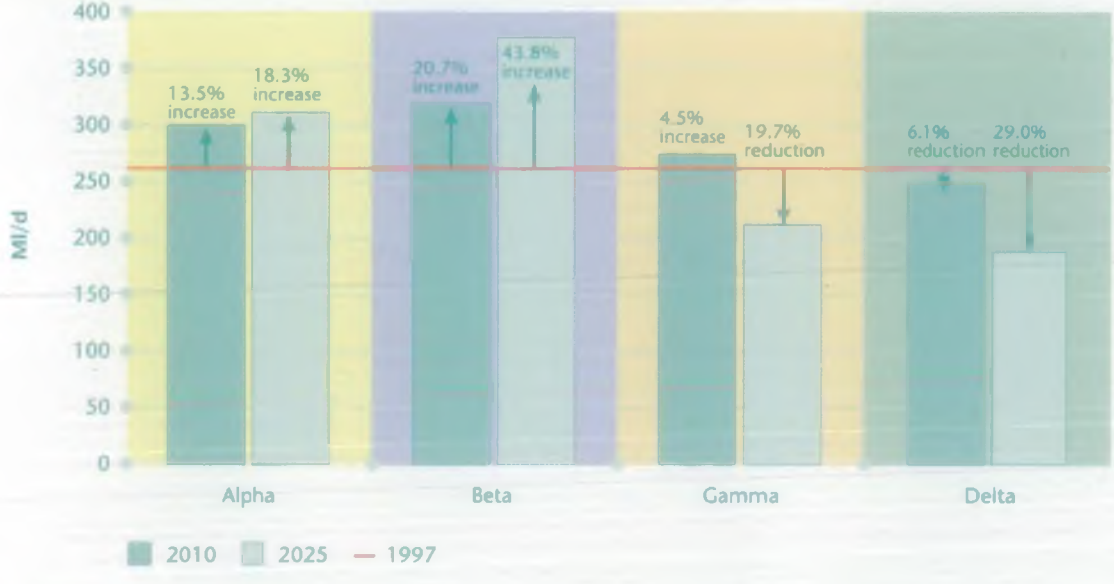


Figure A2.4 PWS non-household demand by scenario in 2010 and 2025



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, noted in table 5.1, impact on 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 (MAFF, 1995) irrigation survey, 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, and other crops.

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, the British Potato Council, the National Institution of Agricultural Botany, the Soil Association, the National Farmers Union. Two core assumptions underpin the development of scenario specific assumptions at crop level:

- increases in supply of a crop, through high yields, will affect its selling price. If high yields result in over-supply of the market, the prices are likely to fall
- 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.

Spray irrigation : scenario outcome

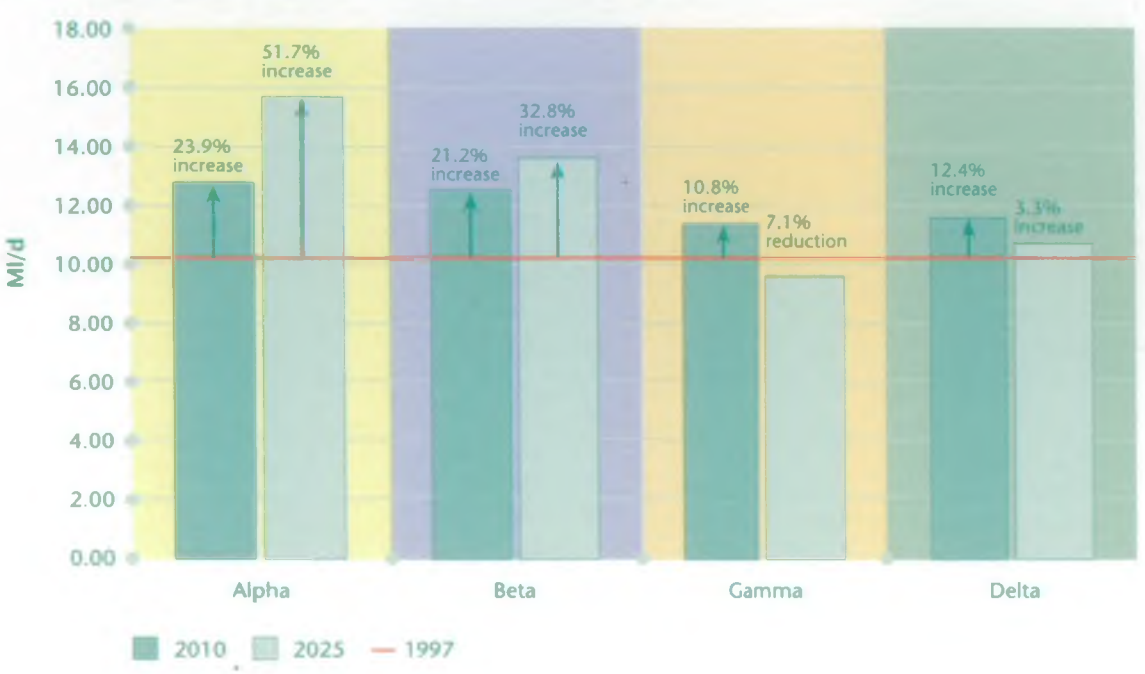
Scenario Alpha: There is strong emphasis on home produce and self-sufficiency, with a reduction in the level of food imports. This serves to increase the total area of crops such as potatoes, sugar beet, field-scale vegetables and horticulture, although as yields gradually increase the total area under 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: 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: The level of imports increases, with a consequent reduction in the total areas of potatoes, sugar beet and orchard fruit. Supermarkets realign their approach to agriculture, using their influence to promote and support environmentally sensitive systems of production. Price premiums for irrigated produce fall, with less emphasis placed by consumers on the appearance of produce. This, combined with the wide-spread 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: Significant emphasis is placed on food self-sufficiency, with a movement away from reliance on supermarkets to local shops and farmers' markets. Less emphasis is placed on appearance, reducing the incentive to irrigate. The area under organic or low external-input systems increases, with a consequent increase in total crop areas. Average yields reduce, average farm commodity prices rise and input costs fall. Water is used wisely because of its associated public good, rather than its commercial value, leading to high irrigation efficiencies.

Figure A2.5 **Spray irrigation demand by scenario in 2010 and 2025**



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 (see NRA 1994, MAFF 1996). 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 Agency forecasts, undertaken by Cranfield University at Silsoe, have developed the concept of economic demand, reflecting the costs and benefits of irrigating different crops. The methodology draws on the optimum irrigation water requirements developed under the Agency's *Optimum use of water for industry and agriculture best practice manual (W254) and technical report (W243)* R&D project (Environment Agency, 2000e). 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.). Depending on each year's weather pattern, these constraints then limit irrigation, with the greatest effect occurring in years with highest demand.

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

A2.7

Hydropower generation

Developing forecasts for hydropower generation is particularly difficult. Scheme types such as low or high head, site availability, distance from markets, the view of society, and cost of energy are just some of the factors that influence development.

Interest in hydropower generation has been rekindled through the Non Fossil Fuel Obligation (NFFO) and Renewables Obligation. This mechanism guarantees a price for up to 15 years in some cases, and a market outlet into the grid. Additionally, the UK Government is committed to reducing emissions of greenhouse gases and to having 10 per cent of our electricity produced from renewable sources by 2010.

Across Wales we have identified a comprehensive list of potential sites from research undertaken for the Energy Technology Support Unit (ETSU) and discussions with HEP operators and developers. Well over 70 potential sites have been identified. These include high and low-head sites of varying sizes, as well as sites where existing structures, such as reservoirs, could accommodate power generation. To this we have added conservative estimates of likely small community-scale schemes.

Hydropower generation: scenario outcomes

Scenario Alpha: Fossil fuels are in plentiful supply and so no new hydropower developments are promoted. There is a strong tendency to preserve existing sources of energy. As a consequence, existing hydropower sites are preserved and their operational life extended. The pursuit of energy efficiency is limited due to lack of available capital and the low priority attached to environmental investment. Public concern is generally low. Current proposals are adopted but post 2005 there are no increases in hydropower sites or generation capacity.

Scenario Beta: Fossil fuels dominate the energy market. The low priority attached to environmental problems precludes the widespread adoption of renewable energy, including hydropower. Overall, energy demands increase, prices remain low and there is little concern for energy efficiency. Current proposals are adopted but after 2005 there is a gradual running down as lack of investment closes older sites.

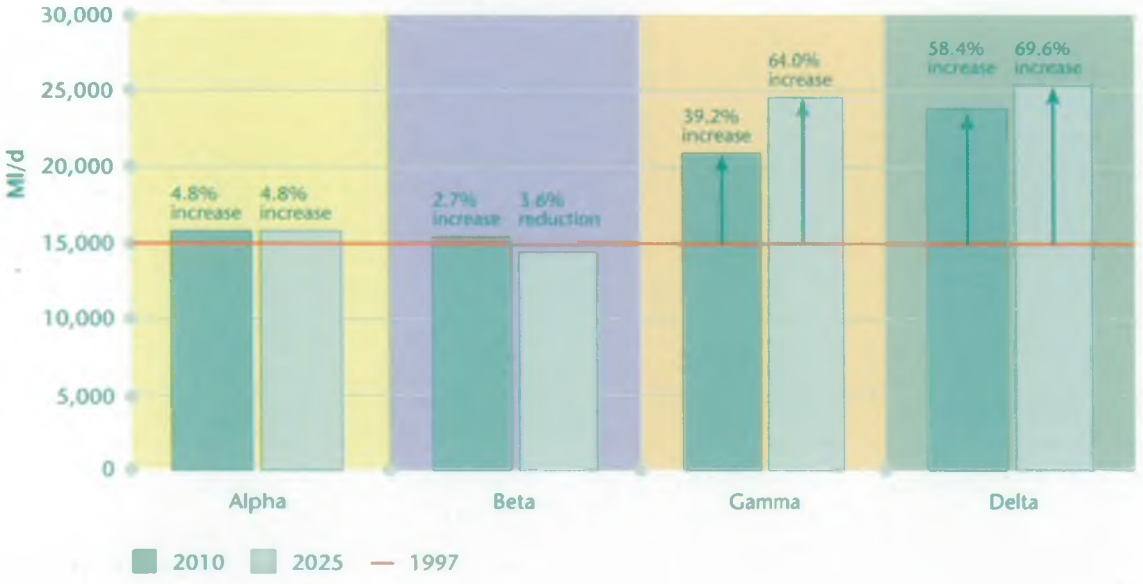
Scenario Gamma: Renewable energy sources, such as hydropower, gain a large market share after 2010. Most potential sites are developed rapidly from this period with a slowing of development after 2015, as fewer sites are available. This growth is driven by the need to reduce carbon emissions coupled with a willingness to invest in technology. There is a major takeup of energy efficiency techniques and energy prices are high.

Scenario Delta: The exploitation of a wide range of local, often small-scale, renewable energy is a particular feature of this scenario. Current hydropower proposals are adopted and between 2005 and 2010 there is a rapid development of known sites. After this time very small-scale hydropower is developed to meet community-scale demands. Energy is costly in this scenario, which leads to efficiency measures and, unlike the other scenarios, energy demand falls.

A2.7.1 Forecast methodology

The forecasts used have been based on the installed generating capacity of the realistic potential hydropower sites. For this strategy we have assumed that existing proposals, such as those agreed through the NFFO route and the Renewables Obligation, will progress during the next five years. After 2005 development is influenced according to the path society follows. Unlike the other water-use sectors considered under the Foresight approach, hydropower follows an almost opposite path. Under the Gamma and Delta scenarios the emphasis on renewable and local energy production increases the number of hydropower developments and hence the need for water. Where demand for water increases for other sectors in the Alpha and Beta scenarios, the limited concern for the environment and low energy costs result in minimal growth or even a reduction in hydropower use. The majority of potential hydropower sites tend to be concentrated in the more mountainous areas of Wales. As a consequence development would be concentrated in just a few areas. Such a saturation of sites would impact greatly on the river environments in these areas.

Figure A2.6 HEP demand by scenario in 2010 and 2025



Appendix 3
Calculating possible leakage levels in 2025

A3.1

Introduction

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

A3.2

General Approach

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

A3.3

Method

We have considered three components of leakage:

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

The duration of a burst depends on:

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

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

To calculate the effect of leakage practice for 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 nigh 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 by2025:

- 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 per cent and 3 per cent 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 per cent each year.

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

A3.5 Conclusions

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

Appendix 4
R & D 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.

Issues include:

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

The Agency will work with others to prioritise and take forward and appropriate programme of Research and Development.

Bibliography

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

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

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

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

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

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

DETR (1999e) *Water Supply (Water Fittings) Regulations 1999.* Department of the Environment, Transport and the Regions: London.

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

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

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

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

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

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

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

Environment Agency (1977) *A guide to Sustainable Urban Drainage.* Environment Agency.

Environment Agency (1998a) *The Environment Agency's Proposal for the National Environment Programme for Water Companies 2000 – 2005, A Submission to Government.* Environment Agency: Bristol. May.

Environment Agency (1998b) *Water Resources Planning Guidelines.* Environment Agency: Bristol.

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

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

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

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

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

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

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

Environment Agency (2000e) *Optimum use of water for industry and agriculture best practice manual (W254) and technical report (W243).* Environment Agency.

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

Environment Agency Wales (1999) *A Working Environment for Wales.* Environment Agency Wales: Cardiff.

Environment Agency Wales (2000) *Dairy Farm Audits South West Wales.* Environment Agency Wales: Cardiff.

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

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

Institute of Environmental Science, (2000) *Changing Climate, Challenging Choices – a scoping study of climate change impacts in Wales.* University of Wales, Bangor.

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

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

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

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

National Assembly for Wales (2000) *www-betterwales.com.* NAW: Cardiff.

National Rivers Authority (1994) *Water – Nature's Precious Resource.* HMSO: London. March.

National Rivers Authority (1996) *Water for Welsh Region – A strategy for sustainable water resources management.* NRA Cardiff.

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

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

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

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

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

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

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

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

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

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 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 measure 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 condition.
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 form 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" help 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 percolated downward from the surface into groundwater.
Regulated river	A river where the flow is augmented through the addition 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 operation 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 to future generations to meet their own needs.
UKCIP	UK Climate Impacts Programmes
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 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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