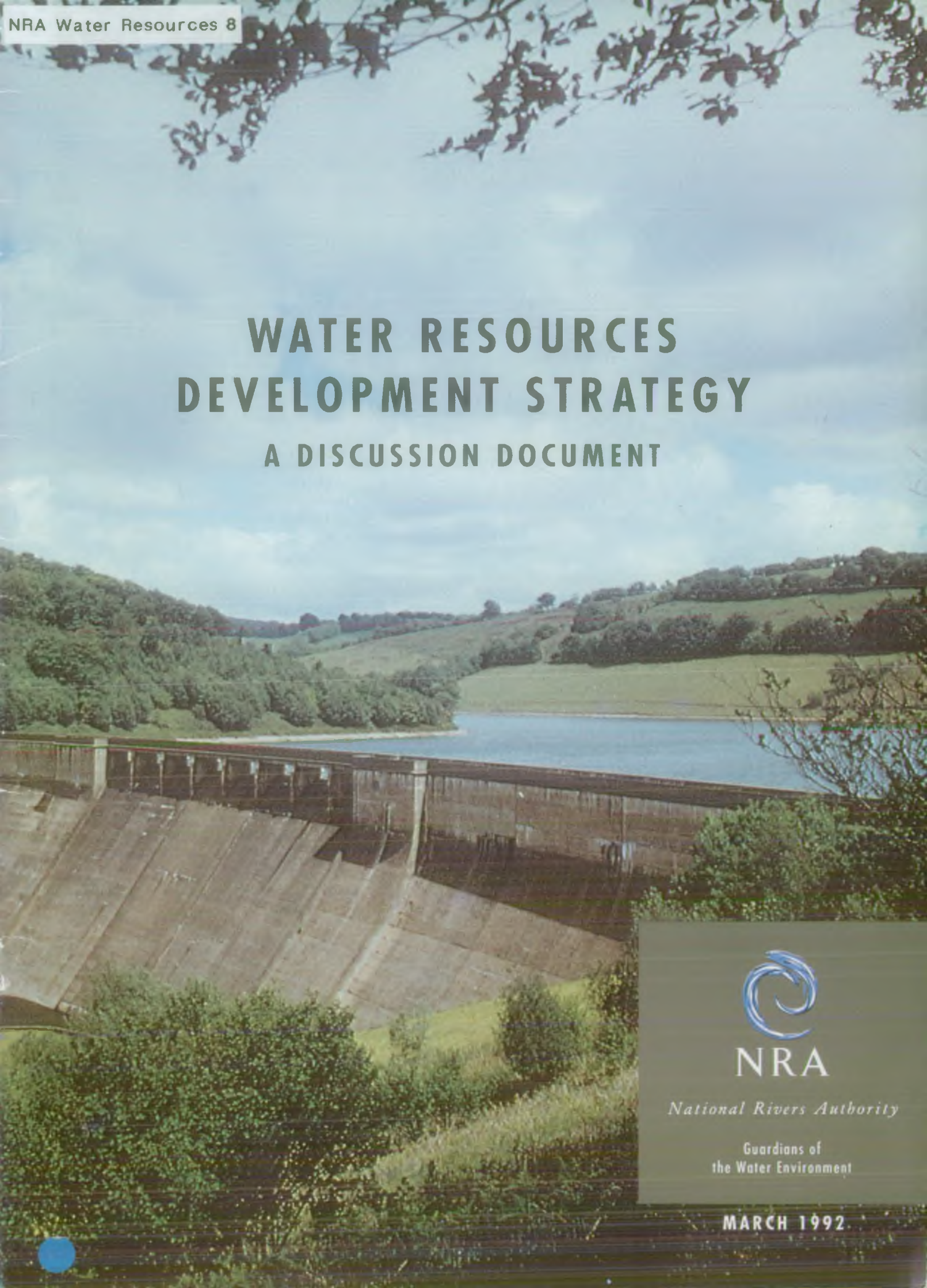
WATER RESOURCES DEVELOPMENT STRATEGY

A DISCUSSION DOCUMENT

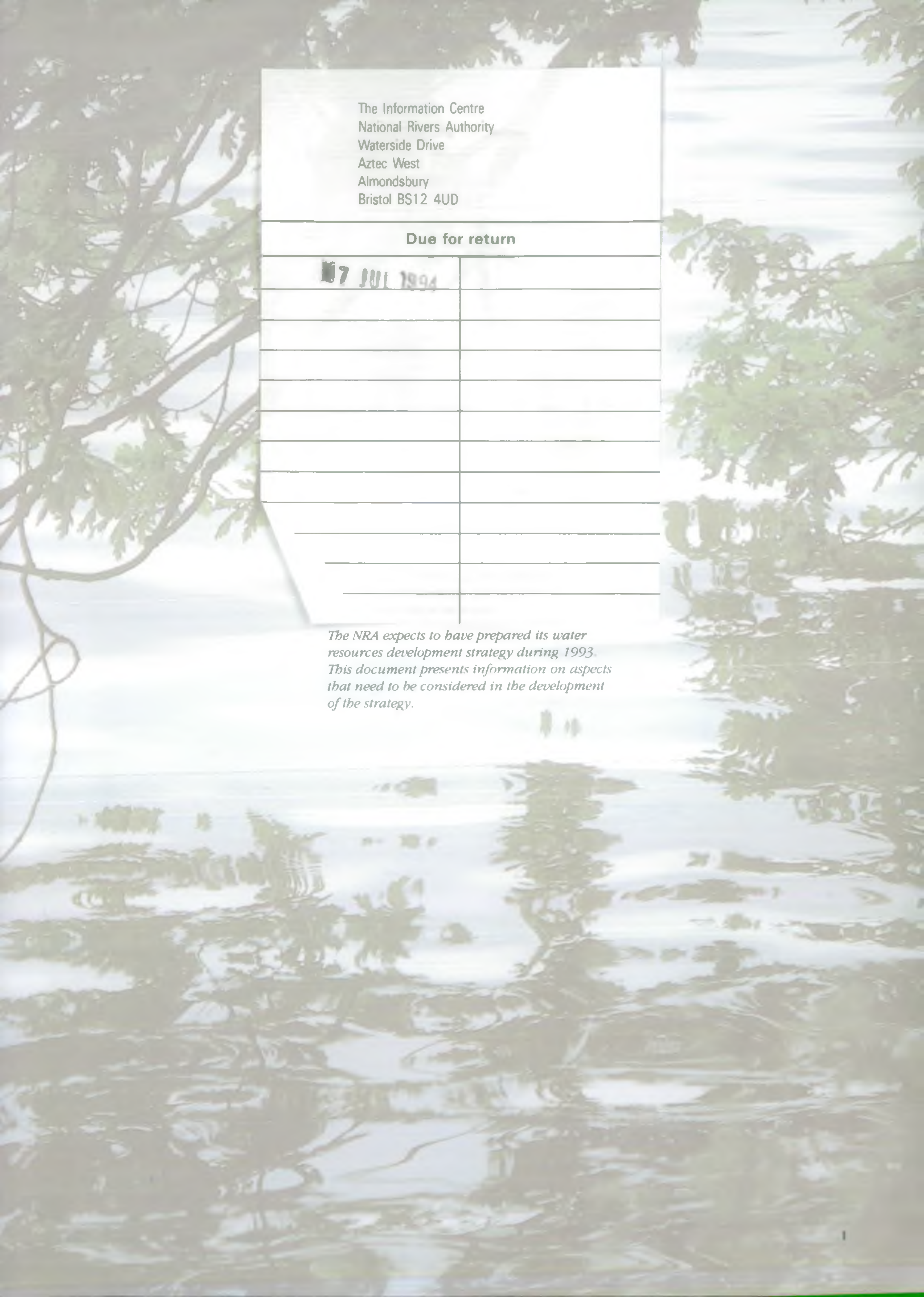


NRA

National Rivers Authority

Guardians of
the Water Environment

MARCH 1992



The NRA expects to have prepared its water resources development strategy during 1993. This document presents information on aspects that need to be considered in the development of the strategy.

WATER RESOURCE PLANNING - ORGANISATIONAL ROLES

Water resource planning has been actively and professionally carried out for many decades. Under the present legislation water undertakers and the NRA have important roles to play in the resource planning process. Water undertakers need to plan their capital expenditure to meet future demands, whilst the NRA is required to manage abstractions from surface and groundwaters through the abstraction licensing system, and to take action to conserve, redistribute and augment water resources and secure their proper use. It is also required to take appropriate action to conserve and enhance the environment.

In carrying out its water resource activities the NRA must also meet its general duties for environmental conservation and have particular regard to the statutory obligations of the water undertakers.

Proper use of water resources includes meeting not only the legitimate demands of abstractors but also the important demands of aquatic life within the river system itself.

In most instances these demands are in competition and the NRA has the job of striking the right balance between the two. However abstractors can help in achieving the appropriate balance. Where water resources or the environment are under potential stress there are strong

arguments to ensure that the amount of water taken from the environment is kept to an acceptable level. In particular, demand management and reduction of leakage can have a significant influence on the need for new resources.

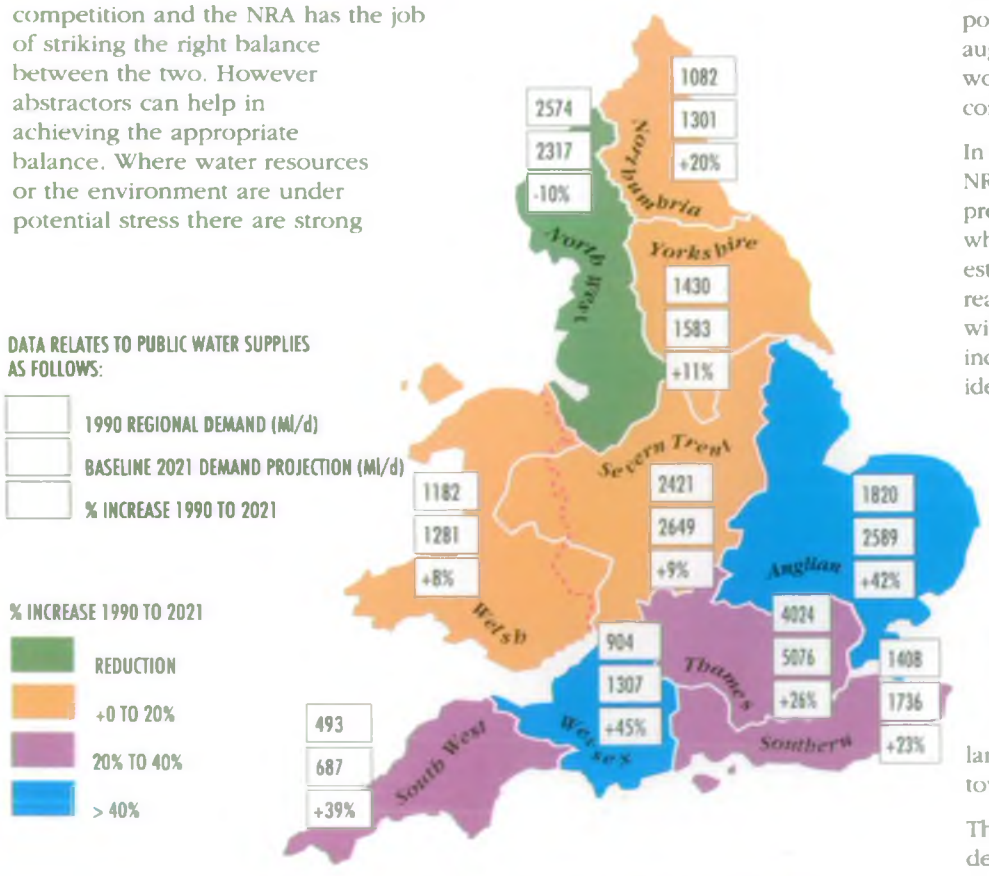


FIGURE 1: PUBLIC WATER SUPPLY BASELINE AVERAGE DEMAND PROJECTIONS TO 2021

The NRA abstraction charges are not often a significant incentive in minimising water use and will not become so under present legislation which limits overall charges. However water undertakers have an opportunity to influence the future use of water resources through an appropriate tariff associated with metering. The NRA is supportive of such initiatives especially in areas where water resources or environmental stress is apparent or likely.

Experience in this and other countries indicates that significant savings can be made through a variety of demand management measures and there is an increasing realisation in England and Wales that water on demand cannot be taken for granted. It makes sense to explore alternatives to the way we make use of this precious resource.

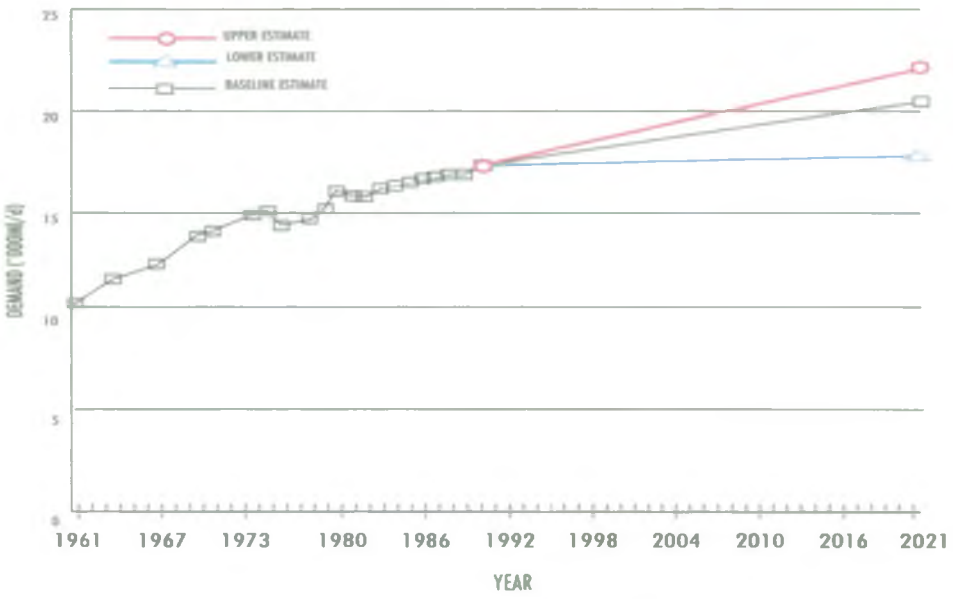
The magnitude of abstraction is not always the most important aspect when considering whether it can be authorised. In some instances the location of the abstraction and discharge can be equally important. For example abstractions near the tidal limit are likely to be favoured more than upstream abstractions which remove water along the whole length of a river. Similarly abstractions which return treated effluent at or above the points of abstraction, or which augment other stressed resources, would receive more favourable consideration.

In relation to resource planning the NRA will expect most abstractors to prepare their own forecasts of demand which will be audited to ensure that estimates of future requirements are reasonable before licences to abstract will be granted. Water undertakers, industry and others are encouraged to identify their preferred options for the development of resources, but the NRA as the only body in a position to maintain an overview of the resource planning process, will have to decide and recommend on the balance of interests and resources allocation.

It is important that the NRA works closely with the planning authorities to ensure that they are aware of the water resources implications of any large scale development, such as new towns.

The role of the NRA in the development or promotion of schemes is not yet fully established. However it is committed to ensuring that suitable schemes are developed to meet the

FIGURE 2: PUBLIC WATER SUPPLY AVERAGE DEMAND PROJECTIONS TO 2021



reasonable demands of its customers. Where schemes benefit a number of potential abstractors or where extensive use is expected to be made of the river system, it is likely that the NRA will play a leading role.

Where the NRA is involved in scheme promotion the question of finance arises. The cost of larger schemes is likely to run into several hundred million pounds and the way in which the NRA would contribute to such schemes is yet to be resolved.

However, it is expected that in most instances, water undertakers will develop and promote their own schemes either separately or in combination with other water undertakers.

Because of competition for water resources between various interests, it is essential that the NRA keeps a firm hold on the management of water resources so that an equitable allocation of water resources is ensured between abstractors and to meet environmental objectives.

DEMANDS OF WATER SUPPLY UNDERTAKERS

Demands for public water supply are those which are met by water undertakers and supplied by them to the general public, commerce, industry and agriculture.

Estimates of future demands of water undertakers have been made up to the year 2021. The year 2021 has been chosen as a planning horizon because most large scale water resources schemes take many years to come to fruition.

There are many uncertainties in estimating future demands but as a base case the demand projection to the year 2011 published in the Section 143 report (Ref 1) has been linearly extrapolated to the year 2021 except where specific forecasts have been made.

These average demand estimates are of a preliminary nature and will be refined as further information and analysis is carried out.

Estimates of average water demand of water undertakers on a regional basis are given in Figure 1. Although the absolute magnitude of demand is influenced by the area and population density of each region it is apparent that the projected rate of increase over the next 30 years is highest in the South and East of England.

The main factors influencing future demands by the water supply undertakers are population growth, consumption per person, losses in the undertakers' mains and consumers premises and the level of economic activity.

There is a growing awareness that water resources are finite and that a proper balance needs to be struck between the impact of water resources development upon the environment and the reasonable use of water by customers.

Increasing consideration is being given to the metering of domestic consumers and the NRA is in favour of such initiatives in locations where water resources are under stress, especially with a rising block tariff which would limit the excessive use of water.

The NRA is intent on ensuring the minimisation of waste of water from supply systems such that a sensible balance is struck between the costs of controlling leakage and the savings achieved. Water undertakers also have indicated their intentions to continue to work towards the same objectives. Considerable progress has already been made towards controlling waste and the possible increase in domestic metering in selected areas would provide incentives for customers to reduce wastes. It would also provide additional information to help quantify actual levels of leakage from the undertakers' systems.

The possibility of climate change adds an element of uncertainty in the estimation of future demand. To date there is insufficient knowledge to enable quantitative incorporation of the impact of climate change on demands for public water supply. However, it is expected that the main impact would be in relation to garden watering.

In making estimates of future demands for water it is usual to indicate a range within which future demands are expected to lie. For present purposes this has been carried out largely subjectively by assuming increases or decreases in forecasts of unaccounted for water, metered demand and per capita consumption. Figure 2 shows for England and Wales, the baseline, upper and lower bound estimates of average demand over the next 30 years.

BALANCE OF RESOURCES AND DEMANDS FOR PUBLIC WATER SUPPLY

EXISTING DEMANDS AND RESOURCES

A comparison between the availability of water resources and the quantity abstracted is given in Figure 3. It is based on the effective rainfall that would be available during a drought to be expected on average once every 50 years. It illustrates the regional variability in available resources together with the relative demand for abstraction from them. The diagram does not account for the environmental demand for water resources nor for the reuse of water within the regions. The latter explains why the Thames region appears to meet a demand in excess of the available resource.

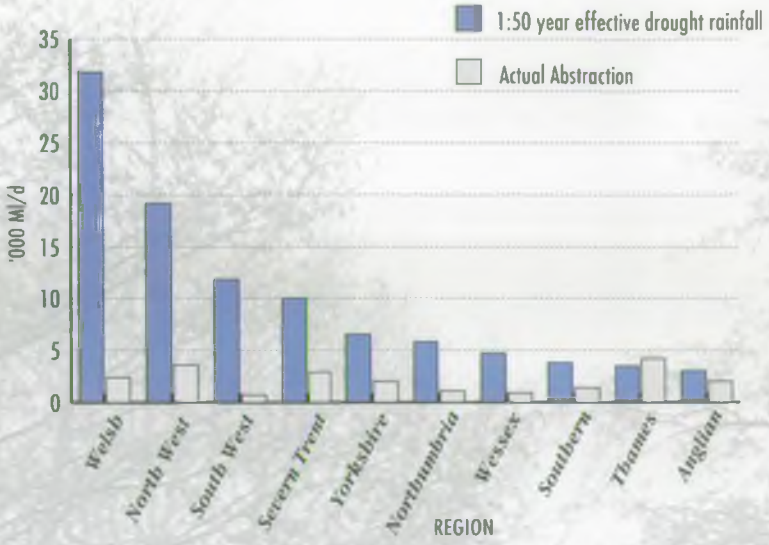
Figure 4 shows the present balance between existing demands and resources for public water supply on a regional basis. The information is only an index of the degree to which existing demands can be satisfied from existing resource developments. For example, a surplus of resources in one part of a region may not be able to meet a shortfall in another part of the region, and indeed it is not likely that it would be economic to meet all regional shortfalls in supply from surpluses in existing resources.

FUTURE DEMANDS AND EXISTING RESOURCES

Taking regional baseline average demand projections for the year 2021 as an indicator of future demands and comparing these with the average reliable yields of schemes which have already been developed for public water supply, gives an indication of the amount of extra water resources development that could be needed over the next 30 years or so, if the projected demands materialise.

The estimated magnitudes of the future imbalances on a region by region basis are given in figure 5. Although these estimates are subject to review it appears that the greatest need for additional resources is in the Anglian, Southern, Thames, Wessex and South West regions.

FIG 3: ACTUAL ABSTRACTION COMPARED WITH EFFECTIVE DROUGHT RAINFALL
Total licensed abstraction for 1987 excluding abstraction by power companies and those for fish farming and watercress growing



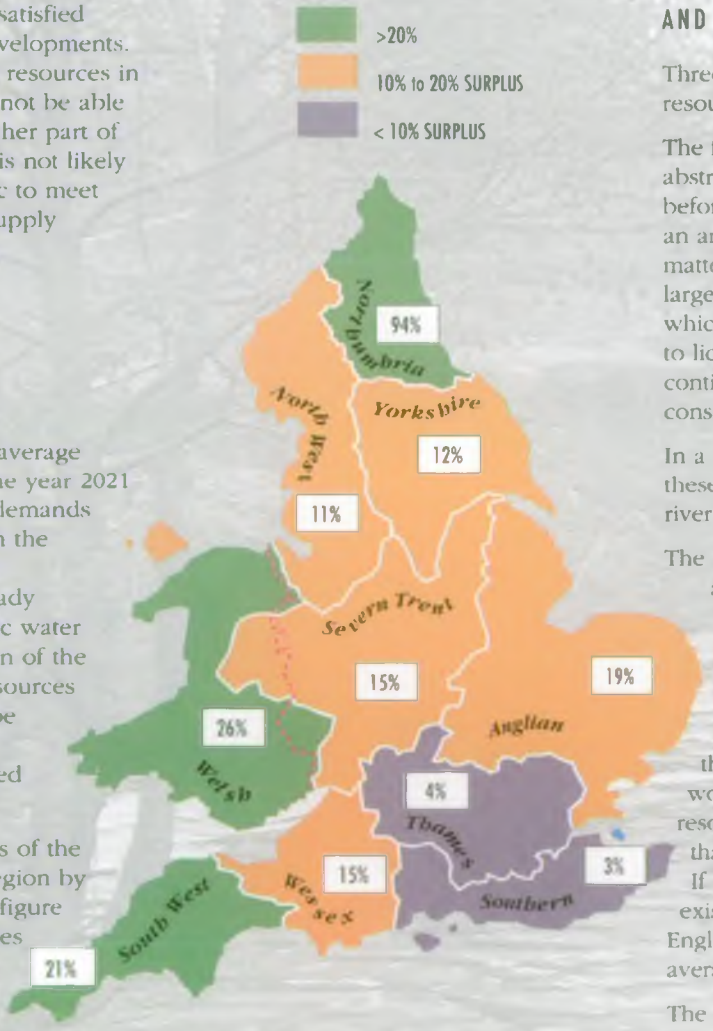


FIGURE 4: PUBLIC WATER SUPPLY: PRESENT REGIONAL SURPLUS OF RESOURCES AS % OF 1990 AVERAGE DEMANDS

FACTORS INFLUENCING EXISTING AND FUTURE RESOURCES

Three factors in particular may limit the resources available to meet demands.

The first is the problem of over abstraction, which was recognised before the formation of the NRA but is an area that the NRA is tackling as a matter of priority. The over abstraction largely results from previous legislation which entitled abstractors at that time to licences authorising them to continue abstraction regardless of the consequences upon the environment.

In a number of locations the impact of these abstractions has been to reduce river flows to unacceptable levels.

The NRA has named 40 such locations and is seeking solutions to them on a priority basis. The solutions may involve the revocation or downward variation of some authorised abstractions and therefore result in a reduction to the reliable yields. This in turn would increase the need for new resources. However, it is important that the problem is kept in context. If all such licences were revoked, existing reliable yields available in England and Wales would reduce on average by about 2%.

The second aspect which may affect the availability of water resources is climate change. Reference has already been made to its possible impact upon demand and the impact on future water resources is equally uncertain.

Various climate change scenarios have been postulated but as yet there is insufficient evidence to have confidence in any particular scenario. However, it is generally expected that if climate change is going to impact upon the availability of water resources it will take place gradually and enable sufficient time to respond to the change.

The third aspect is the potential loss of existing or future resources due to accidental pollution, increasing nitrate levels and pesticides. The NRA has developed a policy framework for groundwater quality protection. In addition, pilot Nitrate Sensitive Areas have been proposed by the NRA and implemented by MAFF and further moves to manage nitrate concentrations to acceptable levels are associated with the forthcoming EC Nitrate Directive.

Information is not available concerning the possible loss of sources due to pollution but it is not anticipated that the overall impact on available resources will be significant and may be more than offset in the longer term by the recovery of water quality in some rivers to standards acceptable for potable abstraction.

DEMANDS AND RESOURCES FOR PRIVATE WATER SUPPLY

EXISTING DEMANDS

Private sector demands relate to abstractions which are made directly from inland waters or groundwaters, rather than from water undertakers' supply systems. Private sector demands mainly comprise water for industry and agriculture. In the agricultural sector it is usual to consider demands for spray irrigation separately, since this particular use represents a total loss to water resources.

Existing private sector demands are based upon records of abstraction in each of the NRA regions. Many do not consume water resources such as hydropower, non-evaporative cooling, fish farming and cress growing. However others such as evaporative cooling and spray irrigation abstractions are almost wholly consumptive.

Table 1 gives estimated abstractions for categories where consumption of resources is likely to be taking place.

FUTURE DEMANDS

Long term forecasts of demands within the private sector are difficult to quantify. A review of demands for each private sector component over the past ten years reveals a general decline in water abstracted for industry and general agriculture accompanied by an increase in demand for abstractions for spray irrigation, fish farming and hydropower.

TABLE 1: PRIVATE SECTOR ABSTRACTIONS IN 1990(Ml/d)
(excluding tidal water abstractions and those giving 100% return)

REGION	Spray Irrigation	Agriculture	Evaporative Cooling in Electricity Industry	Industrial Cooling & Other Industrial Purposes	TOTAL
Anglian	213	18	2	295	**528**
Northumbria	1	-	-	38	**39**
North West	4	5	6	734	**749**
Severn Trent	68	9	244	451	**772**
Southern	29	9	-	1184	**1222**
South West	6	29	-	128	**163**
Thames	14	12	110	167	**303**
Welsh	7	11	-	310	**328**
Wessex	12	20	-	137	**169**
Yorkshire	24	15	-	351	**390**
TOTAL	**378**	**128**	**362**	**3,795**	**4,663**

These data are approximate and should be used only for indicative purposes

The declines are attributed partly to the introduction of more water efficient processes and partly to the shift in the national economy away from production towards the service industries. However it is by no means certain that either trend will continue.

Clearly further work is required to more accurately define future water requirements within the private sector.

SATISFYING FUTURE DEMANDS

The development of surface water resources to meet any increases in private demands for water is likely to depend upon the availability of storage from which water can be drawn during dry periods. Where groundwater resources are available this may prove a viable local option. However the opportunity for further groundwater development in England and Wales is somewhat limited.

It is anticipated that private abstractors will seek licences from the NRA to authorise abstractions to meet their demands. However, where a licence cannot be granted or where there are conditions imposed which would result in an unacceptably low reliability of supply, it may be necessary to construct a scheme to secure a reliable supply.

In such instances, developments might include:-

- individual abstractors or groups of abstractors developing their own schemes, such as the construction of winter storage to permit summer spray irrigation.
- the NRA promoting a scheme for the benefit of a particular group of private abstractors
- the NRA entering into agreements with water supply undertakers to augment water resources for the subsequent benefit of a particular group of abstractors.
- private abstractors benefitting from multipurpose schemes.

A further consideration is whether to develop or reserve 'spare resources' to help in attracting industry to strategically placed locations.

OPTIONS FOR MEETING IMBALANCES

It is not the purpose of this document to propose a strategy for the development of water resources in England and Wales. Such a strategy will not be possible until further work has been carried out. However, one of the objectives is to discount from further consideration certain options which do not appear to warrant more detailed consideration.

Figure 5 is indicative of the imbalance between existing public water supply resources and possible future demands (assuming the baseline average demand forecast) and highlights the pressure on resources in the South and South East of England.

One of the obvious options is to ensure that existing systems are used to their maximum potential. This entails improvements to the operational control of water resources systems such as multi-source systems and significant additional resources have already been achieved in the operation of some river regulating schemes. A further option is to ensure that, where economic, works are constructed so that spare resources are transferred to areas of need.

Other options for meeting the imbalance include:-

- priority being given to the conservation of resources, particularly through the introduction of measures which encourage the wise use of water, mainly by keeping leakage to acceptable levels,
- encouraging savings in household consumption and stimulating more efficient use of water by industry and agriculture,
- development of sustainable surface water and groundwater schemes within each region,
- development of inter-regional transfer schemes bringing water from the wetter North and West to the drier South and South East of the country. Such developments would be expected to meet the requirements of many classes of abstractor,
- greater re-use of sewage effluents,
- desalination of sea water or brackish water,
- national water grid, and
- miscellaneous options, including water from France, water by ship and icebergs.

TABLE 2: RANKING OF OPTIONS

INDICATIVE COST £million/Ml/d	OPTION	COMMENTS
0.1 - 0.5	• Demand Management including Leakage Control	Some aspects of demand management would lie outside the range of indicative costs.
	• Groundwater Development	Limited potential nationally.
	• Direct River Abstraction	Limited potential.
0.5 - 2.5	• Effluent Re-Use	By indirect methods.
	• Reservoir Schemes	Direct supply and regulation.
	• Inter-Regional Transfer Schemes	Those in the lower range of likely cost.
2 - 5	• Transfers from Europe	Lack of spare resources.
	• Inter-Regional Transfer Schemes	Those not included in the above category.
4 - 6	• National Grid	
	• Desalination	
Much greater than 6	• Transfer by Ship	
	• Icebergs/Drogues	Considered impractical.

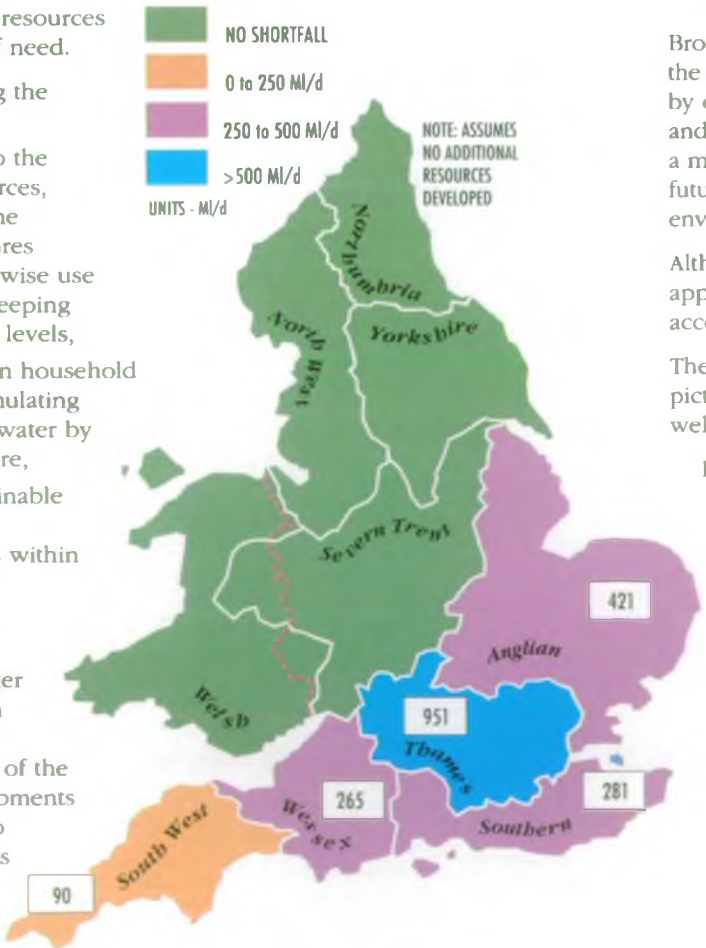


FIGURE 5: PUBLIC WATER SUPPLY - SHORTFALL IN AVAILABLE RELIABLE YIELD IN 2021 BASED ON AVERAGE DEMAND FORECASTS

Broad estimates of the relative costs of the various options have been made by consultants employed by the NRA and the NRA accepts that costs will be a major consideration in selection of future developments, as will be the environmental implications.

Although there may be pitfalls in the approach, Table 2 groups options according to unit costs.

The table represents an over simplistic picture and individual options may well fall outside the range indicated.

Bearing in mind the relative magnitudes of the regional resource imbalances it is expected that future options are likely to include:

- demand management including active leakage control,
- groundwater development,
- effluent re-use,
- reservoir schemes, and
- inter-regional transfer schemes.

SUMMARY OF INDIVIDUAL OPTIONS

REGIONAL AND COMPANY OPTIONS

The NRA report under Section 143 of the Water Act 1989, (Ref l) listed possible resource developments which might be available to meet demands in each region. These options include proposals both of the NRA and of the water undertakers. It was emphasised that the list of schemes was not exhaustive, they had not been considered to a common level of evaluation, nor were they necessarily acceptable either to the water undertakers or to the NRA.

However, they can be considered as being representative of schemes which were in the process of being considered or implemented and therefore are a measure of the extent to which demands in the region might be met from resource developments which were almost exclusively from within the same region.

Regional resource surpluses or deficits for the year 2021 are indicated in Figure 6 assuming:-

- baseline average public water supply demands for 2021
- present resources continue to be available
- additional new sources are constructed in accordance with all those schemes identified in the Section 143 report (but excluding the enhanced Trent-Witham-Ancholme and Great Bradley reservoir which is considered under inter-regional transfers below).

The resulting resource surpluses and deficits can be considered only as indicative because the analysis overlooks factors such as:-

- needs for meeting peak demands,
- within region imbalances, and resources being unavailable due to failure of one form or another.

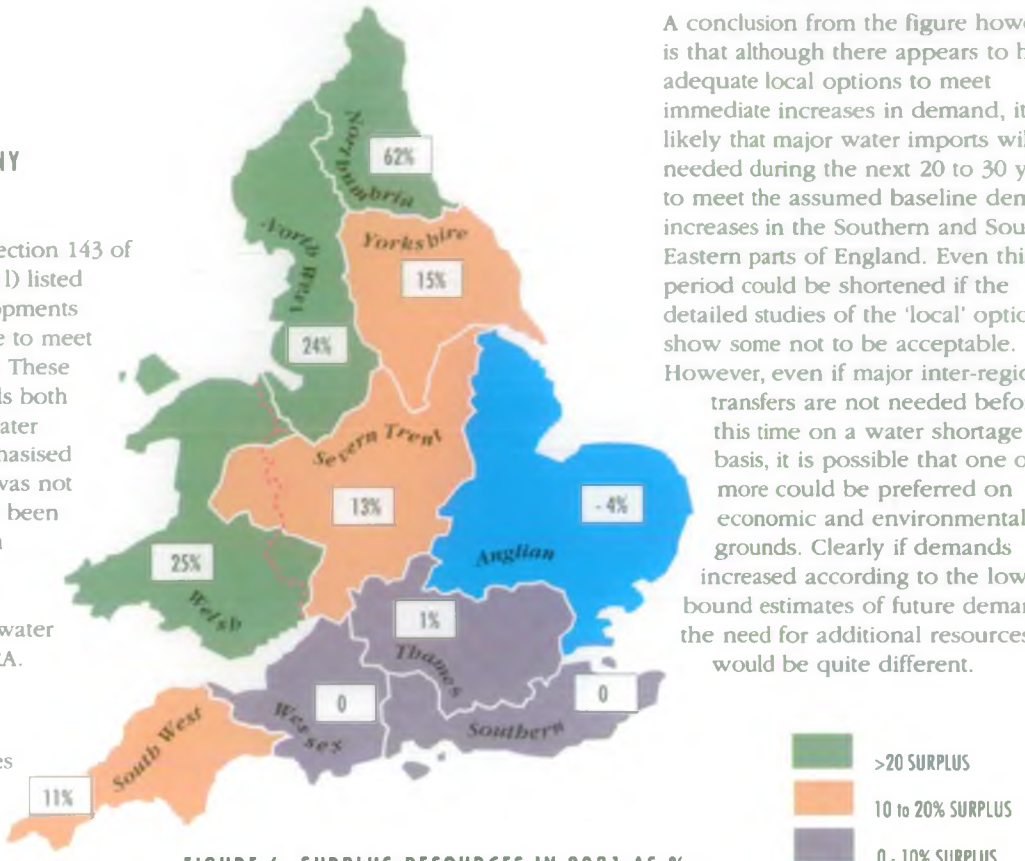


FIGURE 6: SURPLUS RESOURCES IN 2021 AS % OF AVERAGE DEMAND IN 2021
Note: Assumes present resources are available together with schemes identified in S.143 report

A conclusion from the figure however, is that although there appears to be adequate local options to meet immediate increases in demand, it is likely that major water imports will be needed during the next 20 to 30 years to meet the assumed baseline demand increases in the Southern and South Eastern parts of England. Even this period could be shortened if the detailed studies of the 'local' options show some not to be acceptable. However, even if major inter-regional transfers are not needed before this time on a water shortage basis, it is possible that one or more could be preferred on economic and environmental grounds. Clearly if demands increased according to the lower bound estimates of future demand, the need for additional resources would be quite different.

EXAMPLES OF INTER-REGIONAL TRANSFERS

Consideration has been given to four inter-regional transfer schemes as examples of how water could be moved from the wetter parts of the country. Schematic representation of examples of such schemes is shown in figure 7.

MID-CAMBRIAN TRANSFERS

The mid-Cambrian region represents a possible focus for the provision of additional water resources to meet the anticipated demands in Southern and South Eastern England.

In the 1960's a scheme was proposed by the Water Resources Board (WRB) for the construction of a large new dam at the site of the existing Craig Goch reservoir. It was planned to provide water for the River Severn and River Wye and also to transfer water from the River Severn to the River Thames and the Wessex Region. A maximum yield of around 1200Ml/d was contemplated if refill was increased by pumping from the River Wye and River Severn during high flow periods.

Clearly the construction of a major reservoir enlargement would have major implications and an alternative could be the transfer of any surplus water from the River Severn during high flow periods. Such a scheme would require the transferred water being put into storage and therefore this option would need suitable sites to be available, probably within the Thames basin. Transfer into storage would also help assist water quality management.

FIGURE 7: MAJOR TRANSFER OPTIONS - EXAMPLES OF INTER-REGIONAL TRANSFERS

Another possible Mid-Cambrian source could be the existing Vyrnwy reservoir located in the headwaters of the River Severn. It is estimated that at present the North West region has a resource surplus which is likely to increase due to falling regional population, the proposed implementation of active leakage control measures and a probable decline in industrial demand. If Vyrnwy reservoir could become surplus to requirements in the North West region, it could be used to regulate increased abstractions from the River Severn, either to meet the demand in the West Midlands or to be transported to the Thames basin. Some 210Ml/d is presently transferred to the Merseyside area and a greater yield is likely to be realised if it could be used to regulate the River Severn.

A further resource consideration, if demands reduce in the North West region, is that surplus resources may become available within the River Dee and could be considered as a possible transfer to the River Severn for onward transmission to Southern and South Eastern England.

A number of options appear to be possible for the transmission of Mid-Cambrian sources to the areas of demand.

The WRB Severn-Thames transfer scheme considered water being abstracted from the River Severn near Tewkesbury and transferred by pipeline into the River Thames at Lechlade. However, whether or not transfers should be made directly to storage or into the River Thames, would be influenced by the needs for water quality management, costs and operational considerations. Transfer rates would depend upon the need and the resource availability, but rates of transfer around 400Ml/d could be contemplated by using surplus flows in the River Severn rising perhaps to around 1000Ml/d if the enlargement of Craig Goch was undertaken. Consideration could be given not only to meeting demands in the Thames region, but also in the Anglian and perhaps Southern regions. In addition the need to provide additional supplies into the Wessex region would be a further consideration.

Other possible transfer options could be considered. For example an extensive canal network exists through the Midlands and consideration could be given to abstraction of Severn water for transfer to the Trent and Mersey canal near Stafford. Further transfers could be considered into the Grand Union Canal, Oxford canals for the Thames region and subsequently transferred to regulate the Rivers Nene and Ouse in Anglian region.

Clearly any of the above transfers are not without their problems and full appraisal would be needed to assess their feasibility in terms of economics, ecology, water quality, hydraulics and operational feasibility.

TRENT-WITHAM AND ELY OUSE-ESSEX SCHEME

The River Trent is a significant resource in the centre of England. Part of the available resource comprises flow augmentation derived from effluents discharged from the Birmingham conurbation, largely derived from sources in Wales. At present only limited abstraction for public water supply occurs in the lower Trent although the power industry abstracts large quantities for cooling water. Water is transferred by the NRA via the Trent-Witham-Ancholme scheme both for industrial use and public supply in Scunthorpe and Grimsby.

The option proposed for consideration is to link two existing schemes - the Trent-Witham Link and the Ely Ouse-Essex scheme - and transfer up to 600 Ml/d from the Trent to the Anglian and Thames regions.

The concept of the scheme is to provide a large scale north to south transfer facility enabling resources supplying the southern part of the region to be backed up and augmented by River Trent water. Major works required for this option would be a new pipeline from the River Witham to the beginning of the Ely Ouse-Essex transfer scheme.

In addition, a new storage facility could be required at the head waters of the River Stour to allow blending of Trent water and regulation of the rivers Stour, Colne and Blackwater and a transfer to the Lee Valley. The Essex River Authority in the 1960's commissioned a feasibility study of Great Bradley reservoir on the River Stour, and which could on its own increase reliable yields by 200 Ml/d. This scheme is already being reconsidered as an option either independently or as a component of the 'Trent southwards' option to meet the demands of Suffolk and Essex and perhaps Thames region. Further consideration could be given to the transfer of water from the Anglian region, across the Thames Estuary into the North Kent area of Southern region.

KIELDER - YORKSHIRE OUSE TRANSFER

The Kielder reservoir was completed in 1982. It was originally planned to meet the predicted industrial and public water supply deficiencies in Newcastle and Teeside in the North-East region. These shortages did not materialise and the potential yield of 900 Ml/d of Kielder is a large undercommitted resource.

At present the reservoir is used to meet the water supply requirements in the North Tyne, Derwent, Wear and Tees catchments.

The original planning studies considered a further connection between the Rivers Tees and Swale with regulation of the Yorkshire Ouse in order to meet forecast demands in Yorkshire. The possible option is to construct the Tees/Swale transfer to regulate the River Ouse in Yorkshire and then to pump water from the River Ouse into the River Witham in Anglian region for subsequent transmission to Lincolnshire, Suffolk and Essex.

In many ways the Kielder transfer scheme is similar to the Trent-Witham scheme referred to above but rather than augmenting the River Witham with Trent water, it is augmented with Kielder water. Particular consideration will need to be given to the use of Kielder water, not only to ensure that adequate provision is made to meet possible future demands in the Northumbria region, but also the possible use of Kielder water by British Nuclear Fuels Limited in the North West region.

RE-USE OF EFFLUENTS

Effluent re-use can be either:

- direct, whereby treated effluent is put straight back into the supply system via a pipe-to-pipe connection to a water treatment works, or discharge to a direct supply raw water reservoir
- indirect, whereby effluent is discharged to a river system, underground aquifer or to a reservoir and subsequently re-abstracted and treated for water supply.

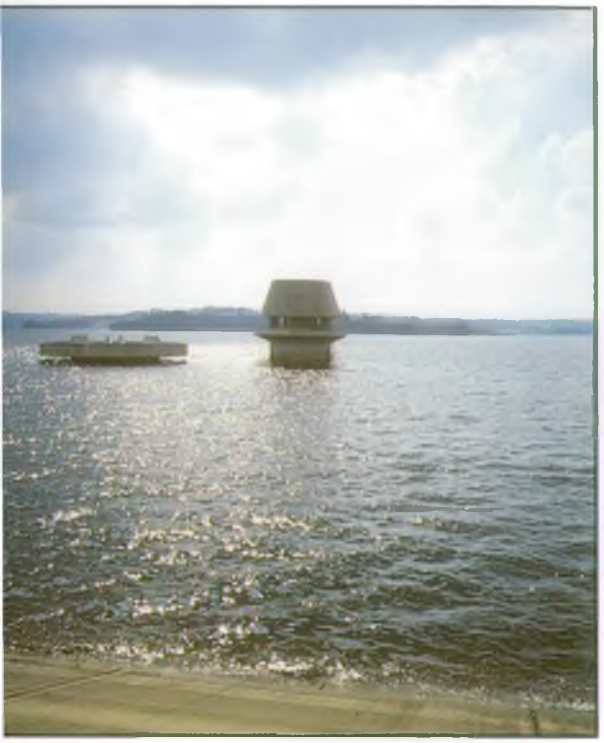
There are no direct re-use schemes in the U.K., but examples exist overseas. Pipe-to-pipe connections, although technologically feasible, leave little room for human error and are rare.

Indirect re-use of effluent occurs widely in some regions of England. For example in the Thames basin, analytical studies have shown that, on average, treated water effluent represent 13% of river abstractions used for public water supply.

The long term health implications of effluent re-use are not well understood and consequently it is expected that, any scheme would be by indirect use, until such time as the implications are understood and suitable safeguards are available to protect public health.

DESALINATION

At present the only public water supply desalination plant in the U.K., is located in the Channel Islands. It is used during the summer periods to meet peak summer demands. A small facility was in existence until recently at the Channel Tunnel, and was used



to supplement water supplies provided by the Folkestone Water Company. This plant has now been decommissioned and sold.

In the early Seventies, the prospect of desalination plant producing large quantities of cheap freshwater was considered to be a distinct possibility. Although the size of plants has increased, with facilities in Saudi Arabia capable of producing up to 800 Ml/d, the unit cost of water production has not fallen.

Membranes for the reverse osmosis (RO) process have been developed to allow sea water to be demineralised at a lower energy cost than the estimated multistaged flash plant. Unfortunately the semi-permeable membranes used in the RO process are expensive and, although reducing, this cost at present cancels out any energy savings made over the multi-stage flash (MSF) process.

Energy is the main production cost component in MSF plant. Savings may be possible by locating plants close to power generation facilities in order to take advantage of off-peak generation capacity and exhausted turbine steam.

The capital and operating costs are not the only limitations on desalination. The plant must be able to receive a reliable supply of sea water at all times and in this country, where large tidal ranges are experienced, extensive intake works may be required. Desalinated water has a very, low concentration of salts and as such has an insipid and unpalatable taste. The water has to be mixed with water from conventional sources which involves pumping to existing storage facilities.

In addition, disposal of the more concentrated brine effluent from desalination plants with minimal impact on the coastal environment can pose problems which are costly to overcome.

There are indications that desalination of brackish water can be achieved with lower capital and operating costs than using seawater, but although perhaps having some local potential it would not appear to be a viable strategic option.

At present desalination of sea water does not appear to be a realistic alternative to conventional water resources developments except in special circumstances. Neither can it be described as an environmentally friendly solution to water shortages, since either directly or indirectly, it burns fossil fuels to produce water.

FIGURE 8: NATIONAL WATER GRID

NATIONAL WATER GRID

The idea of a National Water Grid dates back to the 1940's. Within the context of this document it is defined as a widespread network of large pipelines transferring treated water to every part of the country, rather than a network using rivers or canals. The concept of a grid has been considered only in broad terms.

As a starting point, only the skeleton of the grid has been examined (see Figure 8).

The main link of the grid is defined by the cities of Birmingham to the West, Cambridge to the East and Bristol and London in the South. Connected into this is an east coast main transferring water from the Kielder reservoir and a west coast main bringing surplus water from North West region.

In the west a new aqueduct connects an enlarged Craig Goch reservoir into the Midlands Spur mains from the cities of Cambridge, London and Bristol would feed Suffolk and Essex, Southern region and Wessex region respectively. Norwich is fed from a spur off the East coast main at Peterborough.

The grid is composed of mainly new aqueducts and pipelines, and its path has been chosen so as to minimise the pipeline elevation. It is appreciated that in selecting a route there is an optimum balance between the capital cost of the pipeline and the revenue costs of pumping to overcome static and friction head. However, detailed investigations have not been carried out.

The grid has been assumed to meet additional demands totalling around 2000 Ml/d, mostly in the Anglian, Thames, Southern and Wessex regions.

The main sources of water for the grid would be derived from Kielder reservoir, enlarged Craig Goch scheme and 'spare' resources in the North West region and the grid would distribute treated water to the areas of need.

The capital cost of such a grid would be several billion pounds and when considered alongside other options it is not considered to be viable.

WATER FROM EUROPE

The construction of the Channel Tunnel and the single European market in 1992 has heightened the awareness of the proximity of Europe and the possible import of resources. Enquiries in the Pas de Calais region suggest that there is at present a small surplus; however, with the area being declared an economic zone, this water will be required to supply new industrial and commercial developments associated with the Channel Tunnel.

Without the possibility of a developable resource, close to the coast, which could be guaranteed by the French authorities during drought periods, a pipeline becomes even less attractive. Installation of a water main inside the Channel Tunnel is not viable, due to restricted space.

TRANSFER BY SHIP

The two options included are the shipping of treated water and the towing of icebergs from Arctic waters. The destination of water obtained by either option would be expected to be the South-East and Southern ports of England.

To transfer the water from the docks, pipelines would need to be laid, linking handling facilities to storage reservoirs. In the South-East this may not be a problem, since reservoirs exist close to the coast, but in the South and South West pumping to inland storages may be impractical and reservoirs may have to be constructed.

Northumbrian Water Group plc have developed the capability to ship either untreated or treated water from the dedicated loading facility at Teeside. The company have the capacity to supply up to 45 Ml/d treated and above 70 Ml/d untreated water using vessels of up to 80,000 tonnes. Although they have not undertaken shipment within the United Kingdom, during the Eighties they successfully shipped water to Gibraltar while the colony's border with Spain was closed.

The harvesting of the fresh water contained within icebergs by towing them from Arctic waters is an option which has a certain media notoriety. Although theoretically feasible, any scheme would be fraught with difficulties and does not make economic sense even compared with using tankers.

The problems and limitations include;-

- return journey distances and times,
- multiple vessels requirements to manoeuvre the iceberg,
- need for secure towing anchorages,
- limitations on size of iceberg that can be received into U.K. ports due to the large drafts, and thus the necessity for offshore handling,
- the physical dismantling of the iceberg, and
- environmental impact.

Neither the shipment or iceberg options appear to be viable long term solutions.

OTHER OPTIONS

The development options given in the preceding sub-sections are extensive but not exhaustive. For example it is known that individuals and organisations are giving consideration to different large scale options for moving water around the country and the NRA would be pleased to receive specific suggestions.

Mention has not been made of the additional resources than can be made available by the conjunctive operation of individual resources although it is suspected that the opportunity for additional gains in this area is limited.

An extensive canal network exists across the country and although canals have been referred to in this document it is felt that the full potential has yet to be evaluated. The NRA is in preliminary, discussion on this matter with the British Waterways Board.

The artificial recharge of groundwater has previously been considered as a feasible option for meeting new demands and is already practised to a limited extent. Although this option offers some potential it is unlikely to yield sufficient resources to meet large scale demand increases.

Others have made reference to the use of flexible storages (drogues) at sea which would be filled with fresh water. One can envisage such storages being filled from surplus winter water or utilising spare resources and utilised in areas of need. Such options have not been considered, but are not thought likely to be remotely economic.

MAIN CONSIDERATIONS

On average the demand for water both for the purposes of meeting requirements for abstraction and to meet environmental needs is only some 10% of the water resources available from average rainfall. However, the distribution of available resources in space and time is insufficient to sustain a reliable supply of water for all purposes at all times in all places.

Over the past 150 years reliability of supply has been achieved by the progressive development of groundwater and reservoir storage. Sustainable abstractions from surface waters have been achieved by the construction of reservoir storage or by augmentation from natural groundwater storage. In both instances the use of storage is to sustain supplies during dry periods.

A broad assessment on a regional basis shows that available resources are adequate to meet existing needs.

Clearly regional assessments mask the variability of resource demand balances within regions. However it is not the purpose of this document to consider sub-regional deficiencies. A possible exception to the adequacy of resources is abstraction for spray irrigation, for which the greatest need occurs when water resources are least available.

The public water supply industry has prepared capital expenditure plans associated with the need for new water resources developments to meet anticipated future demands. The NRA has also considered water resources development options. Before plans are firmed up there is much more detailed work to be carried out, but it would appear that subject to development options proving to be environmentally acceptable, there are sufficient opportunities for meeting anticipated demands over the next 20 to 30 years.

The South and South East of England are of particular concern in terms of water resources development. It is the part of the country:-

- which is anticipated to have the highest rate of increase in demand over the next 20 to 30 years,
- which receives the lowest rainfall,
- where available resources are already most utilised, and
- where most of the low flow problems associated with over-abstraction are located.

There is little doubt that urgent consideration needs to be given to major interbasin water transfers in order to satisfy the demands of Southern England but in the short term local developments are expected to meet rising demands.

On the basis that future schemes will be licensed by the NRA only if environmental criteria are satisfied, the selection of a particular water resources development from the range of environmentally acceptable options is normally a matter for the water undertakers, who no doubt will take into account efficiency, reliability and financial considerations. However, where major schemes are involved it is likely that environmental considerations will mean that one option is clearly preferred over another and the NRA will need to form its own view of the preferred development having also taken account of other factors such as cost and operational matters.

In parallel with considerations of new water resource developments, the water supply undertakers, industry, agriculture, the NRA and others are examining the possibilities and options for demand reduction.

Consideration has been given to a wide range of new resource development options. Groundwater development is often an attractive option due to low treatment costs, the juxtaposition with the centres of demand and the opportunity to develop resources as the need arises. Although there are still some potentially significant further groundwater development options to be investigated, the likelihood is that groundwater development will not comprise a major proportion of additional water resources yields in England and Wales .

The development and promotion of surface water resources will be dependent upon the availability of surface water storage. In the areas of greatest need, the environmental acceptability and opportunity for additional storage is also limited.

Indirect re-use of effluent is likely to offer potential in suitable catchments, especially where abstraction is at the downstream end of the catchment and effluent discharge is at the uppermost part of the catchment.

It would appear that 'novel' water resources developments have limited potential over the foreseeable planning period. Desalination may have economic application in certain areas, but is not thought to offer significant strategic potential. A national water grid utilising piped transmission systems is not considered to be viable due to the enormous capital costs. Similarly, developments such as use of icebergs, freshwater filled drogues moored at sea, raw water transhipment and piped import from France are discounted for the foreseeable future.

Major development is expected to be inter-basin transfers where the river and/or canal networks are used as much as possible to move water from areas of surplus to areas of need. It is perhaps not surprising that most options are based on those already considered by predecessor bodies but not implemented largely because anticipated demands did not materialise. All major inter-basin transfers are likely to rely on storage to achieve the required reliability of supply.

The NRA will be carrying out further work over the next 2 years to evaluate options in more detail and welcomes comments and ideas associated with the need for and development of further water resources schemes for public water supply, industry and agriculture.

Detailed discussion needs to take place to establish feasible funding options for major water resource developments especially where more than one water company is involved.

NEXT STEPS

During 1992 and 1993 further work will be carried out, leading to the publication of a water resources development strategy for England and Wales.

The objective is to refine and develop information concerning demands and resources, so that a clear way forward is apparent to those seeking both the development and conservation of water resources.

It is likely that the strategy will include:-

- improved quantification of the benefits of demand management,
- more detailed consideration of the feasibility and possible timing of interbasin transfers,
- preferred options for meeting demand for water in each region,
- refinement of demand projections, particularly for industry, and agriculture.

In parallel, further work will be carried out to define the legislative and financial framework within which a strategy can be developed.

REFERENCE:

1 Demands and Resources of Water Undertakers in England and Wales (NRA, March 1991)

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