YORKSHIRE WATER SERVICES LTD

PERIODIC REVIEW 2009

DRAFT WATER RESOURCES MANAGEMENT PLAN

ISSUE	DATE	FILENAME	ORIGINATOR	MANAGER
ISSUE 1	14/03/2008	Draft Water Resource Management Plan.doc	Suzanne Dunn Clare Dunlop Miranda Foster Helen Lally Ian Stevens	Neil Dewis

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1. SUMMARY

1.1 Overview

1.1.1 The Draft Water Resources Management Plan sets out Yorkshire Water's plans to maintain a balance between supply and demand for the 25 year period from 2010/11 to 2034/35.

1.1.2 Following a period of public consultation Yorkshire Water will receive feedback of representations on the draft plan. The Company will then produce a statement detailing the consideration given to all representations received and describing any planned changes to the plan as a result of the consultation. A Final Water Resources Management Plan will be produced and published in July 2009.

1.1.3 The Draft Water Resources Management Plan has been prepared in accordance with the Environment Agency planning guideline. The plan incorporates future pressures on supply and demand driven by predicted changes to the climate. It also incorporates future changes to the Yorkshire population, its housing and future water use and metering trends.

1.1.4 In addition, the plan takes into account the Company's aspirations from its Strategic Direction Statement and the potential environmental impacts of schemes, by reference to our Strategic Environmental Assessment.

1.1.5 The plan provides a response to development and growth within Yorkshire that is balanced and sustainable, whilst maintaining a minimum level of service of 1 hosepipe ban per 25 years, in line with the Company's Drought Plan. It takes into account future greenhouse gas emissions, the potential impact of abstraction on the environment and the volume of water lost through leaks.

1.1.6 The potential for changes in demand and supply due to climate change have been taken into consideration. The impact of climate change out-paces the reduction in demand caused by customers opting to pay by meter and by increasing efficiencies in water use in both household and commercial use.

1.1.7 The plan provides solutions to meet a forecast supply demand deficit of 65 Mega litres/ day (Ml/d) by the end of the planning period in 2034/35. These solutions have been identified by an economic analysis of options, which includes social, environmental and carbon costs in addition to capital and operating costs.

1.1.8 The solutions represent a balance of demand reduction options (additional leakage control) and the development of existing assets (Swale groundwater source, and the River Ouse water treatment works).

1.1.9 The development of the River Ouse water treatment works follows the completion of extensive investigations by the Environment Agency into the sustainability of Yorkshire Water's river abstraction licences as a part of the review of consents for the Habitats Directive.

1.1.10 The River Ouse water treatment works extension provides a cost efficient additional resource and will be part of a required rebuild of the existing works. The treatment works is linked directly to the Yorkshire Water supply grid and the extension will provide additional support to meet supply / demand deficits within Yorkshire, additional resilience to flooding and offers potential future grid strengthening and expansion.

1.1.11 This twin track approach of demand reduction, through additional leakage control, and utilisation of existing abstraction capability achieves a balance to meet the Company's Strategic Direction Statement aspirations for service, leakage and carbon emission reduction.

1.2 Development of the Water Resources Management Plan

1.2.1 The Draft Water Resources Management Plan is presented for the three resource zones which make up the Yorkshire Water region. These are; the Grid Surface Water Zone, which makes up over 95 percent of the supply area and two smaller zones, the East Surface Water Zone and East Ground Water Zone.

1.2.2 Each zone represents a group of customers who receive the same level of service from either groundwater or surface water sources.

1.2.3 The plan is built up from a number of components which include;

- Demand forecast
- Supply availability
- Calculation of the supply demand deficit
- Selection of options to meet any deficit
- Consultation and communication

1.3 Demand Forecast

1.3.1 A 25 year demand forecast has been produced taking into consideration factors which result in either an increase or decrease in demand. The key components are described below:

1.3.2 **Domestic Meter Options**: the Company has stated its intention to maintain a customer demand led approach to metering. A forecast of 30,000 domestic optants per annum has been calculated with support from industry experts.

1.3.3 **New homes:** in line with the Government initiative to build sustainable homes the plan assumes that from 2010 all new domestic properties will have a per capita consumption of 120 litres/head/day.

1.3.4 **Population growth:** has been estimated in line with regional spatial strategies. The population is set to increase over the period.

1.3.5 **Commercial demand**: industry experts Experian have been employed to produce a commercial demand forecast which reflects an expected decline over the 25 year period. This will be reviewed for the final plan to reflect the sharp decline in demand that has been exhibited over the past two years.

1.3.6 The impact of **Climate Change** is predicted to lead to behavioural change which will increase demand by 0.6 Ml/d in 2007/08, rising to an increase of 22.49 Ml/d by 2034/35.

1.4 Supply Availability

1.4.1 A 25 year supply forecast has been produced taking into consideration the factors which either increase or decrease the deployable output. The key components are described below:

1.4.2 The principle change on the supply side is the loss of Deployable Output in the Grid Surface Water Zone (51.8 Ml/d) by 2024/25 due to the climate change scenario that has been applied. A further 5.8 Ml/d is lost in the Grid Surface Water Zone due to the closure of minor treatment works to address water quality issues.

1.4.3 Our abstractions have been assessed as part of the Habitats Directive investigations and are considered to have no detrimental impact on the environment.

1.4.4 An element of outage has been built into the plan to take account of resource and treatment availability.

1.4.5 Headroom has been incorporated into supply to allow for uncertainties of resources and supply and demand forecasts.

1.5 The Supply Demand Balance

1.5.1 The supply - demand balance has been calculated using the Company's water resource simulation model. The model has been used to assess the demand and supply forecasts and calculate where there is a surplus or deficit, while maintaining a level of service of 1 hosepipe ban per 25 years across the three resource zones.

1.5.2 This process identified a forecast deficit of 15Ml/d by 2014/15 and 65.6 Ml/d by 2034/35 in the Grid Surface Water Zone. The gap is primarily driven by inclusion of the climate change scenario which has an impact on both demand, in terms of additional water use, and supply availability.

1.5.3 The existence of a supply demand gap would cause a decrease in the level of service to below the Company standard in the Grid Surface Water Zone.

1.5.4 No deficit is forecast in either the East Ground Water or East Surface Water Zone throughout the 25 year planning horizon.

1.6 Option Selection to Meet the Deficit

1.6.1 An economic analysis of options has been used to select options to address the deficit, which include:

- *Demand reduction*
  - Leakage control
  - Mains replacement
  - Pressure control
  - Water conservation
- *Resource development*
  - Reservoir dam height raising
  - New resources (e.g. Tees transfer)
  - New or refurbished water treatment works

1.6.2 Each option has been defined through the level of deficit it can meet and the cost in terms of capital, operational, social, environmental and carbon costs.

1.6.3 A number of scenarios to meet the forecast deficit have been considered. An appraisal of the available solutions has been carried out to establish which option delivers the most benefit to the Company against the following criteria:

- Meets the supply demand deficit whilst maintaining the current level of service (1 in 25 year hosepipe ban)
- Represents a cost efficient solution
- Aligns with the aspirations within the Strategic Direction Statement
- Minimises environmental impacts as determined by the Company's Strategic Environmental Assessment

1.6.4 The preferred solution to meet the forecast supply demand deficit in the Grid Surface Water Zone represents a balance of demand reduction options and the development of existing or new assets. Details of the preferred solution are given in the table below:

Table 1.1: Grid Surface Water Zone preferred solution

Option	Build Start	Yield Start	Beneficial Completion	Yield Ml/d
Leakage reduction 5 Ml/d	2009	2009	2009	5
Leakage reduction 5 Ml/d	2010	2010	2010	5
Swale groundwater source	2010	2011	2011	2
Leakage reduction 5 Ml/d	2012	2012	2012	5
River Ouse treatment works extension option 1	2012	2015	2015	22
Leakage reduction 5 Ml/d	2024	2024	2024	5
Leakage reduction 5 Ml/d	2026	2026	2026	5
Leakage reduction 5 Ml/d	2028	2028	2028	5
Leakage reduction 5 Ml/d	2029	2029	2029	5
Leakage reduction 5 Ml/d	2031	2031	2031	5
Leakage reduction 5 Ml/d	2033	2033	2033	5
			Total Yield	69

1.6.5 The solution has been determined as the preferred option based on the ability to meet the above criteria. There is a 45Ml/d contribution to the Company's aspiration to *'halve existing levels of leakage',* as described in the Strategic Direction Statement. The Company believes that this reduction in the level of leakage is achievable within the planning period.

1.6.6 A proportion of the leakage reduction is required later in the 25 year period. This has the benefit of allowing time to develop lower cost leakage control solutions.

1.6.7 The major component of the solution is the development of the existing treatment works on the River Ouse. This expansion will provide increased resilience and flexibility of the grid supply system.

1.6.8 The River Ouse water treatment works extension provides a cost efficient additional resource and will be part of a required rebuild of the existing works. The treatment works is linked directly to the Yorkshire Water supply grid and the extension will provide additional support to meet supply/demand deficits within Yorkshire, additional resilience due to flooding and potential future grid strengthening and expansion. This will support the Company's aspiration to '*have no water restrictions*', as detailed in the Strategic Direction Statement.

1.6.9 The development of the River Ouse water treatment works follows the completion of extensive investigations by the Environment Agency into sustainable abstraction of Yorkshire Water's river licences as a part of the review of consents for the Habitats Directive. The Environment Agency has assessed the impacts of this solution and believes that utilising the full licence on the River Ouse is sustainable.

1.6.10 The preferred solution is not the least cost solution as determined by economic modelling. The identified least cost solution included additional leakage control (15 Ml/d) plus development of a River Ouse to Derwent raw water transfer with a yield of 52 Ml/d.

1.6.11 The least cost solution is, however, the most limited in terms of achieving the Strategic Direction Statement aspirations to 2035 of halving leakage and achieving no water restrictions.

1.6.12 In addition to increased grid flexibility, the strengthening of the River Ouse treatment works in the preferred solution spreads the risk across two treatment sites and meets our Company aspiration of maintaining supplies at all times.

1.6.13 The preferred solution has a higher overall cost than the least cost option. However, the additional cost will not have a material cost on customer charges within the Company's Business Plan.

2. INTRODUCTION

2.1 The Draft Water Resources Management Plan

2.1.1 The Draft Water Resources Management Plan sets out the Company's plans to maintain a balance between supply and demand for the 25 year period from 2010/11 to 2034/35.

2.1.2 This report has been prepared in response to the Water resources planning guideline issues by the Environment Agency and is consistent with the Office of Water Services (Ofwat) PR09 Information Requirement Part B5, Maintaining the Supply-Demand Balance.

2.1.3 In preparing the demand forecasts the agreed industry approach to demand forecasting, the *Demand Forecasting Methodology* (UKWIR/ NRA 1995) report has been used throughout.

2.1.4 The supply section of the report covers the changes to the Company's water supply including the re-assessment of deployable output, outage and headroom in line with industry-standard methodologies. In addition, climate change has been reviewed using the Environment Agency and UKWIR recommended methodology, incorporating the updated UK Climate Impact Programme issued in 2002.

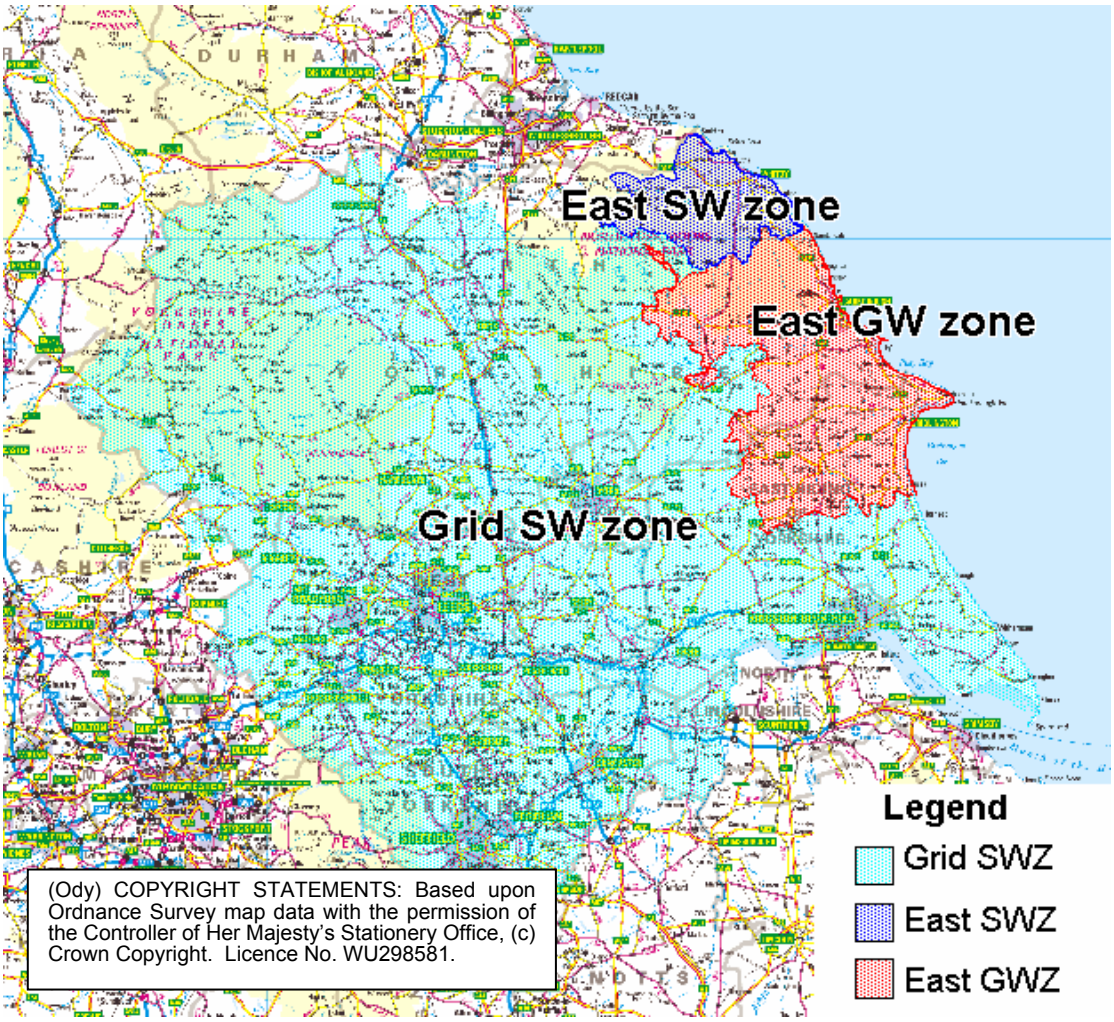
2.2 Water Resource Zones

2.2.1 The Company's Water Resources Plan 2004 presented the strategy for the five water resource zones within the Yorkshire Water supply area. Following additional infrastructure linkages since the 2004 plan, the Dales Ground Water Zone and York Surface Water Zone are now part of the Grid Surface Water Zone.

2.2.2 The Draft Water Resources Management Plan is therefore presented for three resource zones, as shown in Figure 2-1, which now make up the Yorkshire Water region:

- Grid Surface Water Zone (SWZ)
- East Surface Water Zone (SWZ)
- East Ground Water Zone (GWZ)

Figure 2-1: Yorkshire Water Resource Zones



2.2.3 Each zone represents a group of customers who receive the same level of service from either groundwater or surface water sources.

2.2.4 The Grid Surface Water Zone represents a highly integrated surface and groundwater zone that is dominated by the operation of rivers and reservoirs.

2.2.5 Digitised boundaries have been produced for each of the resource zones based on collections of Distribution Management Areas (DMAs). These were provided to the Environment Agency in 2007.

2.2.6 Where the DMA boundaries are not contiguous (e.g. the East Surface Water Zone and Grid Surface Water Zone), where there are large areas of "no-supply", the defining limit of the zone is based on the river catchment boundaries (watershed). For example, the East Surface Water Zone is based on the DMAs in Whitby and the Esk catchment.

2.3 Approach to the Analysis

2.3.1 The following planning scenarios have been considered:

Table 2.1: Planning Scenarios

Water Resource Zone	Normal Year Annual Average	Dry Year Annual Average: Baseline	Dry Year Annual Average: Final Planning	Dry Year Critical Period: Baseline	Dry Year Critical Period: Final Planning
East GWZ	√	√		√	
East SWZ	√	√		√	
Grid SWZ	√	√	√		

2.3.2 In accordance with the Environment Agency's Guidelines, the Normal Year Annual Average Planning Scenario will be provided for Table WRP9 only. All other tables are provided for each water resource zone for the planning scenarios as defined in Table 2.1 above.

2.3.3 The Critical Period has been defined as the average day demand in the peak week for the East Ground Water Zone and East Surface Water Zone. These two zones have only groundwater or run-off river sources with limited storage. In addition, they are prone to increases in summer population through tourism and hence are susceptible to peak summer demands.

2.3.4 The final planning scenarios upon which the overall Draft Water Resources Management Plan is based are as follows:

Table 2.2: Final Planning Scenarios for each resource zone

Water Resource Zone	Final Planning Scenario
East GWZ	Dry Year Annual Average
East SWZ	Dry Year Annual Average
Grid SWZ	Dry Year Annual Average

2.4 Supply Demand Balance

2.4.1 The supply-demand balance has been appraised at Production Management Zone (PMZ) level within the East Ground Water Zone and East Surface Water Zone resource zones. This assessment was undertaken to highlight any deficits that would not have been identified at a Regional or Resource Zone level and where typically the solution is the increase in capacity of a main or pumping station, as opposed to a new source.

2.4.2 PMZ level supply-demand balance appraisal has also been carried out for PMZs that were previously in the Dales Ground Water Zone, for which a deficit had been identified in the Water Resources Plan 2004.

2.4.3 Yorkshire Water has received indication from the Environment Agency that sustainability reductions are not required within the region following the Habitats Directive Review of consents.

2.4.4 Following guidance from the Environment Agency the effect of climate change on supply capacity and forecast demand have been included in the draft plan.

2.4.5 The supply-demand appraisal has been undertaken for each of the three water resource zones for the Dry Year Average Annual planning scenario. The Critical Period has also been assessed for the East Ground Water Zone and East Surface Water Zone. Additionally, the supply-demand balance has been appraised at Production Management Zone (PMZ) level in the East Ground Water Zone and East Surface Water Zones to identify inter-zonal deficits due to distribution management issues.

2.4.6 Deficits have been identified in the Grid Surface Water Zone in the Annual Average scenario from 2009/10. No deficits have been identified for the East Ground Water and East Surface Water resource zones in either the Dry Year Annual Average or Critical Period scenarios. Similarly, no deficits were identified in the part of the Grid resource zone previously in the Dales Ground Water zone. Further analysis at PMZ level identified no deficits within these two zones in either the Dry Year Annual Average or Critical Period planning scenario.

2.4.7 The identified supply-demand deficits for the three resource zones are set out below in Table 2.3

Table 2.3: Forecast Supply-Demand Deficit (Ml/d)

Water Resource Zone	Planning Scenario	2007/08	2008/09	2009/10	2010/11	2015/16	2020/21	2025/26	2030/31	2034/35
East SWZ	Annual Average	0	0	0	0	0	0	0	0	0
	Critical Period	0	0	0	0	0	0	0	0	0
East GWZ	Annual Average	0	0	0	0	0	0	0	0	0
	Critical Period	0	0	0	0	0	0	0	0	0
Grid SWZ	Annual Average	0	0	2.38	7.99	16.99	32.31	42.11	55.46	65.54

2.4.8 An economic appraisal has been undertaken for the Grid Surface Water Zone to determine the preferred solution for meeting the forecast deficit. Details of this economic appraisal are presented in Section 7.

2.4.9 The resulting supply capacity forecasts have been revised to take account of the changes from the economic appraisal and are incorporated into the final planning tables.

2.5 Competition

2.5.1 There are currently no licensees operating in any of the three resource zones in Yorkshire. The Company is not aware of any planned licensed suppliers, either retailed or combined in the supply area in the future. Therefore competition is not considered as an issue in this plan.

3. SUPPLY CAPACITY

3.1 Water Resources

3.1.1 Yorkshire Water is bounded in the west and north by the Pennine Hills and the North York Moors. The southern and eastern parts of the region are low lying. Annual average rainfall in the region is highest in areas of the Pennines whilst low lying areas average less than half as much rainfall each year with little seasonal variation.

3.1.2 Urban areas in the west and south are principally supplied from reservoirs in the Pennines. The Pennines and the valleys of the River Don, Aire, Wharfe, Calder, Nidd and Colne are the largest upland source of water in the region. Yorkshire Water operates over 100 impounding reservoirs of which two are major pumped storage reservoirs. The total storage capacity of all the supply reservoirs is 160,431 Ml.

3.1.3 Yorkshire Water has an agreement with Severn Trent Water to abstract 21,550Ml from the Derwent Valley Reservoirs in Derbyshire. This water is used to supply part of Sheffield.

3.1.4 In the eastern and northern parts of the region, boreholes and river abstractions, chiefly from the rivers of the North York Moors and the Yorkshire Wolds, are the major water sources.

3.1.5 The majority of these water resources are now connected together by a grid network. This enables highly effective conjunctive use of different water resources, which mitigates risk and allows optimal planning, source operation and resilient sources of supply both in drought and during floods.

3.1.6 Approximately 45 percent of supply is from impounding reservoirs, 25 percent from boreholes and 30 percent from rivers. This varies from year to year depending on weather conditions.

3.1.7 The region is divided into three water resource zones for planning purposes. Each zone represents a group of customers who receive the same level of service from either groundwater or surface water sources.

(a) The Grid Surface Water Zone represents a highly integrated surface and groundwater zone that is dominated by the operation of lowland rivers and Pennine reservoirs.

(b) The East Ground Water Zone represents a number of zones in the Yorkshire Wolds, Bridlington Scarborough and Pickering, which are loosely interconnected and supplied solely from borehole sources.

(c) The East Surface Water Zone is supplied by a river abstraction and springs in the Whitby Area.

3.2 Resource Developments

3.2.1 Yorkshire Water has 121 abstraction licences for public water supply. These have been subject to review as part of the Environment Agency's Catchment Abstraction Management Strategies (CAMS). The purpose of the CAMS process is:

(a) to inform the public on water resources and licensing practice

(b) to provide a consistent approach to local water resources management

(c) to help to balance the needs of water users and the environment

(d) to involve the public in managing the water resources in their area.

3.2.2 No changes to Yorkshire Water's abstraction licences were proposed as a part of the first cycle of CAMS reviews.

Table 3.1: CAMS Review Dates

CAMS Name	Published	Next CAMS End Date
Swale, Ure, Nidd, Upper Ouse	October 2003	~2010
Don & Rother	October 2003	~2010
Wharfe & Lower Ouse	March 2005	~2011
Aire & Calder	May 2007	~2012
Hull & East Riding	March 2006	~2013
Derwent	March 2006	~2013
Idle & Torne	March 2007	~2013
Esk & Coast	August 2007	~2014

3.2.3 Yorkshire Water holds 15 Time Limited Licences (TLLs). All existing TLLs have been renewed by the Environment Agency, at current abstraction conditions, until their appropriate CAMS cycles end-dates. A list of the licence time limits is shown below. It is presumed that all TLLs will be renewed on expiry and no uncertainty related to renewal is included in this plan, in accordance with Agency guidelines.

Table 3.2: Time Limited Licences

TLL Expiry Year	AMP Period	No. Of Licences
2008	AMP4	1
2013	AMP5	1
2015	AMP5	2
2017	AMP6	7
2018	AMP6	4

3.2.4 Since 2004, a total of six sources have been closed, with an additional three due to close by the start 2010/11. These sources are listed in Table 3.3. Gorpley Reservoir is no longer used for supply, but is operated as a flood storage reservoir by the Environment Agency.

3.2.5 Grid network extensions have ensured the continued security of supply in these areas and have also enhanced the security of supply in other rural areas on the fringe of the Grid Surface Water Zone. This has been reflected in agreed changes to the water resource zone boundaries for the East Ground Water Zone and the Grid Surface Water Zone.

Table 3.3: Minor sources closed since the 2004 Water Resources Plan

Source	Date of closure	Deployable Output (Ml/d)
Gorpley IRE	Oct 2004	2.923
Langthwaite Adit	Aug 2006	0.519
Elslack Impounding reservoir /Borehole	Dec 2006	2.846
Hodge Clough Borehole		
Bleara Moor Spring		
Elslack Borehole		
Angram Borehole (Thorpe Arch WTW)	Jan 2007	5.78
Studforth Borehole	Due to close Dec 2009	5.576
Lower Dunsforth/Bogs Bridge Borehole (Marton cum Grafton)		
Total (Dec-09)		**17.644**
Total (current)		**12.068**

3.3 Levels of Service

3.3.1 The Company's current Level of Service was formally adopted in Yorkshire Water in April 2000 and delivered by 2001. This level of service is the basis for this Draft Water Resources Management Plan.

Level of Service

Restriction	Frequency of Restriction
Rota cuts/Standpipes	1 year in 500
Drought Order Implementation	1 year in 80
Hosepipe Restrictions	1 year in 25

3.3.2 As part of Yorkshire Water's approach to the next Periodic Review the Company has undertaken a comprehensive customer 'willingness to pay' survey. The results indicate that customers are neither willing to accept a reduced level of service nor willing to pay for a greater level of service. Therefore, no further changes to the Level of Service are considered.

3.4 Deployable Output

3.4.1 The determination of deployable output for the Draft Water Resources Management Plan follows the methodology as defined in Annex E of the Department of the Environment Report, 1996, *Water Resource and Supply: Agenda for Action* and in accordance with the Environment Agency, 1997, *Re-assessment of Water Company Yields*.

3.4.2 Yorkshire Water maintains an ongoing programme of work to step test its operational boreholes and, as part of this work, the deployable output of the Yorkshire Water groundwater sources have been reassessed. The average output figure that a groundwater source can be relied upon to produce in a drought year is termed the *average demand condition.*

3.4.3 In the East Ground Water Zone and East Surface Water Zone, the critical period is the *peak week demand condition* in a drought year. The peak demand condition Source Reliable Output (SRO) figure is therefore used for these zones and this represents the output that a groundwater source can be relied upon to produce for a 7 day period in a drought year. This has resulted in a slight variation in deployable output for the East Ground Water Zone.

3.4.4 The deployable output for the region as a whole, and for the Grid Surface Water Zone, is derived using water resource simulation modelling of the Yorkshire Water supply system. The model incorporates 87 years of historical data, from 1920 to 2006. The model is specifically calibrated to ensure that the deployable output, or maximum demand in the model, is determined at the Company's Level of Service.

3.4.5 The highly interconnected nature of the Grid Surface Water Zone means that it is not appropriate to divide it up into separate water resource zones, as inter-zonal transfers are complex and extensive. Instead, Levels of Service are assessed at Regional level, as well as five operational areas: Central, East, South, South-West and North-West.

3.4.6 The critical periods of drought are found to vary from one area to another, with the 1929, 1959 and 1995/6 events being dominant in Yorkshire. However, over the long-term each of the areas will fail an equal number of times for at least one of the restrictions (see Section 3.3.1).

3.4.7 The water resource simulation model was extensively updated in the autumn of 2007 for the following components: extension of inflow records, review of the demand profiles, update to hydraulic and treatment capacities, update of groundwater source reliable output studies and abandoned sources.

3.4.8 The deployable output for the East Surface Water Zone is currently constrained by the licence availability.

3.4.9 The changes to the Yorkshire Water water resource simulation model deployable output since the Water Resources Plan 2004 are outlined below:

Table 3.4: Changes to Water Resource Simulation Model Deployable Output

Reason	Change in DO (Ml/d)	Deployable Output (Ml/d)
Water Resources Plan 2004		1435* excluding York
		1496* including York
Minor source closures	-17.64	
Re modelling and recalibration	+18.0	1498*
*including Severn Trent import		

3.4.10 These figures are based upon a modelled water resource simulation, which achieves the Company Level of Service. The water resource simulation model demand includes the Grid Surface Water Zone, and small areas of 'locked-in' yield in the East Ground Water Zone and East Surface Water Zone.

3.4.11 The deployable output for each resource zone is shown in Table 3.5. The Grid Surface Water Zone deployable output is calculated from the water resource simulation model, and the East zones are the sum of the deployable outputs in those zones, which include any "locked in yield" not utilised in the water resource simulation model. Sensitivity analyses were carried out, and increasing the demand of the water resource simulation model run by just 5Ml/d resulted in failure of Levels of Service in four years (rather than the three allowed) in both the north-west and south-west areas of the Grid.

Table 3.5: Deployable Output of Yorkshire Water Resource Zones

Resource Zone	DO 2007/08 Ml/d
East Ground Water Zone	72.36
East Surface Water Zone	14.00
Grid Surface Water Zone	1368 (1362.42 following planned closures)

3.4.12 The deployable outputs by source are provided in the Dry Year Annual Average Table WRP5 for all zones, and the Critical Period for the East Ground Water and East Surface Water zones. The deployable outputs for the Grid Surface Water Zone have been determined using a water resource simulation model and have therefore been reported, where necessary, in their modelled source groups.

3.4.13 The behavioural analysis described above details the methodology applied to determine the deployable output under the annual average planning scenario. The water resource simulation model does not, however, simulate the critical period demands and local resource issues that are forecast to affect the East Ground Water Zone and East Surface Water Zone.

3.4.14 Additional analysis has therefore been undertaken using a resource planning model for the East Ground Water Zone and East Surface Water Zone. This analysis has assessed the supply-demand balance, including the target headroom, for the critical periods derived for each of the zones. The critical period demands have been determined by applying critical period factors to the dry year annual average demand for each of the areas based upon Production Management Zones (PMZs) within the resource zones.

3.4.15 The supply-demand gap determined for each of the zones is discussed in detail in Section 7.

3.5 Climate Change

3.5.1 Since the *Climate change scenarios for the United Kingdom: The UKCIP02 scientific report.* (Hulme et al., 2002), was released in 2002, UKWIR and the Environment Agency have funded several research projects to inform new guidance to water companies for the 2009 water resources management plans. The Water resources planning guidelines 2007 and the associated supplementary guidance (Arnell and Reynard, 2007) state that a company's plan should consider the impact of climate change on baseline supply at resource zone level.

3.5.2 The guidance includes a number of methods for incorporating climate change and hydrological uncertainty in supply forecasts. It is recommended that, where appropriate, rainfall-runoff methods are used. Due to the nature of inflow calculations for the water resource simulation model, Yorkshire Water has used flow factor methods 1a for catchments modelled in the UKWIR study, and 1b for other catchments.

3.5.3 Lancaster University was commissioned by Yorkshire Water to assess the extent to which river flows and reservoir inflows in Yorkshire had already been affected by climate change. Their analysis followed the methodology developed for the UKWIR project CL\04\C (Report Ref. No CL\04\C\Task7). The study is fully described in the supplementary document*, Climate Change Studies: Trend analysis of River Flows in Yorkshire (*Romanowicz, Tych and Beven, 2006.)

3.5.4 In summary, the results indicate that there is no evidence for any statistically significant trend in flows in the analysed data, with the one exception of summer period flows in the River Wharfe, which shows a decline in flows. The results of these analyses back up the hypothesis that there is no evidence of climate change having already occurred in the Yorkshire region, so it is valid to apply the climate change factors to the entire period of record as per the UKWIR recommendations.

3.5.5 The flow factor estimation methods provide 'average' monthly flow factors based on six Global Circulation Models. Method 1b calculates flow factors at a catchment level based on regression equations with parameters dependent on Base Flow Index and Catchment Abstraction Management Strategy (CAMS) catchment. Methods 1a and 1b result in climate change flow factors which generally show a decrease in summer flows, and an increase in winter flows for the mean scenario.

3.5.6 For each of the 'mean', 'wet' and 'dry' scenarios, the water resource simulation model is run for the entire period of record, with the flow factors applied to the water resource simulation model inflow files. The deployable output of the system is recalculated by adjusting the demand on the system until the Levels of Service are only just met.

3.5.7 Following the guidelines, the mean scenario is used to calculate supply for the 2020s, and the 'wet' and 'dry' scenarios show the uncertainty, and are incorporated into headroom, and the impact of this to the supply-demand balance is discussed in Section 7.

3.5.8 It is necessary to interpolate between the current estimated deployable output and the deployable output estimated for the 2020's to estimate values in each year. This interpolation, to produce a smooth time series, is necessary in order to avoid step changes in estimated deployable output which might affect the timing of investment decisions. These interpolations are carried out as shown below.

3.5.9 From 2020/21 to 2039/40, estimate deployable output in each year according to the underlying trend in climate change. Scaling the change in deployable output by Equation 1, where *Year* is the year of interest, and adding the scaled change to the present deployable output.

$$ScaleFactor = \frac{Year - 1975}{2025 - 1975}$$ Equation 1

3.5.10 To avoid a step change in 2007/08 between observed deployable output and the underlying trend, interpolate linearly between 2007/08 and 2020/21. This can be done by scaling the change in deployable output using Equation 2:

$$ScaleFactor = \frac{Year - 2007}{2021 - 2007}$$ Equation 2

3.5.11 These equations were used to calculate deployable output for all years from 2007/08 until 2035/6 for all resource zones.

3.5.12 Table 3.6 summarises the loss of yield for each of the resource zones due to climate change

Table 3.6: Loss of Deployable Output due to Climate Change

Resource Zone	DO 2007/08	Loss of Deployable Output caused by Climate Change by 2035		
		Mean scenario	Dry scenario	Wet scenario
	Ml/d	Ml/d	Ml/d	Ml/d
East Ground Water Zone	72.36	1.29	2.86	0
East Surface Water Zone	14.00	0	0	0
Grid Surface Water Zone	1362.42* (1368)	62.41	231.01	-39.64

*current deployable output is 1368, it will reduce to 1362 when future closures are implemented

3.5.13 In order to assess the implications, the uncertainty in relation to climate change has been investigated by carrying out sensitivity analysis on the climate change scenarios. The mean scenario predicted a loss of deployable output of 62.41 Ml/d in 2035. Table 3.7 shows sensitivity analyses increasing and decreasing the inflows by 5 percent resulted in markedly different yield losses in 2035.

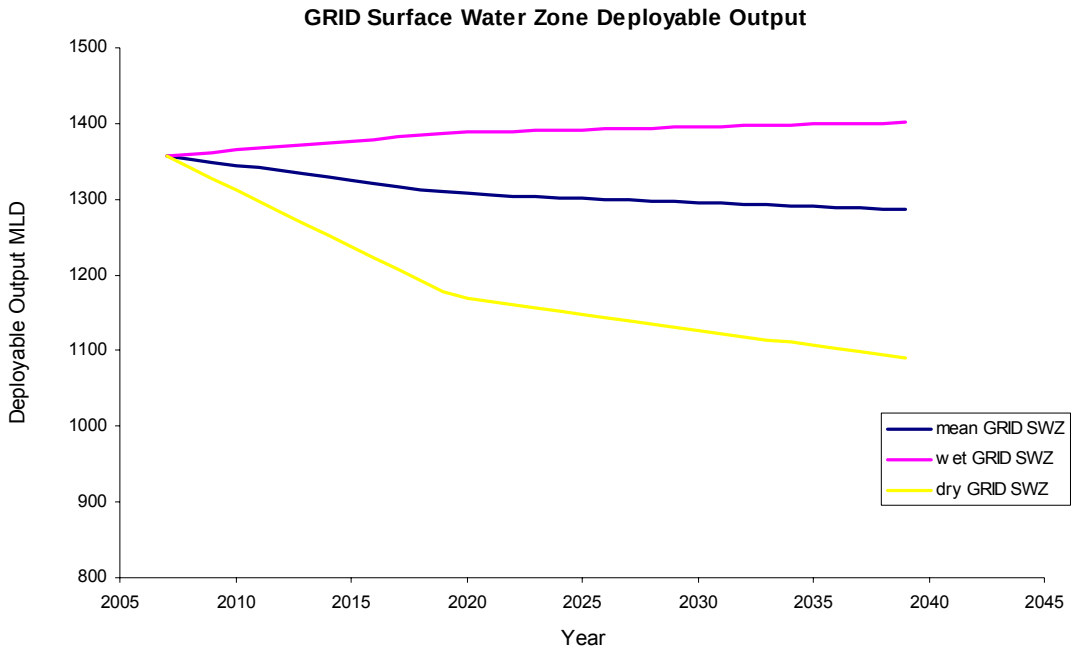
3.5.14 Further analyses investigating the effect of climate change on deployable output, including rainfall runoff modelling for some sources, will be carried out prior to the final Water Resources Management Plan.

Table 3.7: Sensitivity of Loss of Deployable Output due to Climate Change

Resource Zone	DO 2007/08 Ml/d	Loss of Deployable Output caused by Climate Change by 2035		
		Mean scenario Ml/d	Mean scenario + 5% Ml/d	Mean scenario – 5% Ml/d
Grid Surface Water Zone	1362.42 * (1368)	62.41	45.99	144.52
* current deployable output is 1368, it will reduce to 1362 when future closures are implemented				

Figure 3.1 shows the climate change effect on deployable output for the Grid Surface Water Zone

Figure 3-1: Climate Change Effect on Deployable Output: Grid Resource Zone



3.6 Sustainability Reductions

3.6.1 The investigation of the impact of groundwater abstraction from the Sherwood Sandstone on Hatfield Moors continued until December 2007. The investigations found that abstraction did not affect the wetland and the Environment Agency propose to affirm the abstraction licence consent. No reduction in deployable output has been identified.

3.6.2 Reviews of the River Idle Washlands (IW1) and Newbald Becksies (under the CROW Act and SSSI's IW3) have also been completed. These show no adverse impact on the wetlands and no reductions in deployable output are expected.

3.7 Outage

3.7.1 In accordance with the Environment Agency's guidelines, outage has been assessed using the methodology: *UKWIR, 1995, Outage Allowances for Water Resource Planning*. For this plan an outage allowance has been derived from outage events recorded between 1998 and 2007.

3.7.2 Outage is defined as the temporary loss of deployable output due to planned and unplanned events (UKWIR, 1995). The method assumes that past performance is a good indicator of future performance. Information on previous outage events is used to derive an outage allowance for each zone. Outage allowances are assessed at resource zone level. For the Grid Surface Water Zone outage is assessed for unplanned events, planned events, reservoir safety events and licence margins. For the East Surface Water Zone and East Ground Water Zone outage is assessed for unplanned and planned events.

3.8 Unplanned Outage

3.8.1 Yorkshire Water has calculated outage for unplanned events and reservoir safety events using a probabilistic software model. Unplanned outages are unforeseen events which occur with sufficient regularity that the probability and severity of the outage event can be predicted from previous events. The methodology defines the following categories as unplanned outages: pollution of source, turbidity, nitrates, algae, power and system failure.

3.8.2 The methodology prescribes a probabilistic approach to assessing unplanned outage, which considers the duration and magnitude of previous outage events. Yorkshire Water has modified this approach to include the frequency of events and therefore make an allowance for the risk of the event reoccurring.

3.8.3 Data on previous unplanned outage events was collated from Yorkshire Water operational databases and consultations with operational personnel. To derive unplanned outage the model multiplies magnitude, duration and frequency of individual events to give an overall distribution of the outage. The model then uses probabilistic methods to combine outage data for individual events and determines an unplanned outage figure for each water resource zone.

3.9 Reservoir Safety Outage

3.9.1 Statutory requirements of reservoir maintenance require reservoirs to be periodically drawn down for inspection and repairs. An outage allowance for loss of yield due to reservoir safety schemes has been incorporated into the Grid Surface Water Zone outage. This is not a requirement for the East Surface Water and East Ground Water Zones as there are no impounding reservoirs in these zones. A probabilistic model was used to calculate a total outage allowance for reservoir safety schemes based on loss of yield recorded for previous draw downs. Data on previous draw downs was obtained from Yorkshire Water databases.

3.10 Planned Outage

3.10.1 Outage due to planned events has been assessed for all three water resource zones. Planned outages result from a requirement to maintain the serviceability of assets. Maintenance of assets, such as water treatment works, river water abstraction works and raw water transmission mains, has potential to lead to a temporary reduction in deployable output. The majority of maintenance is scheduled for periods when demand is low and alternative sources can be made available. However, this is not always possible and on occasion planned events do lead to a reduction in deployable output. Planned maintenance is scheduled within Yorkshire Water using the Key Asset Management System (KAMS). KAMS is a database used to record information on necessary maintenance requirements.

3.10.2 Planned outage is estimated from the loss in deployable output recorded in the KAMS database for individual maintenance events. For each zone, outage due to individual maintenance events is combined to provide the planned monthly outage, for all the years that data are available. The average monthly planned outage is then calculated to provide a monthly forecast of planned outage for each zone.

3.10.3 Outage allowance due to licence margins is calculated for the Grid Surface Water Zone. Licence margins represent the difference between volumes theoretically available under the abstraction licence conditions and volumes that are operationally feasible. Complex licence conditions or group licence can make it difficult to maintain licensed abstractions within the daily and annual limits. Consequently, Yorkshire Water considers licence margins at critical source works. The licence margin planned for in the Grid Surface Water Zone outage calculation is based on an assessment of loss of yield during the 1995/96 drought.

3.10.4 Once all outage components are calculated they are added together to give a total outage figure for each month for each resource zone. The final outage combines planned and unplanned events and results in a reduction in deployable output. This is termed a planning allowance. Further losses are planned as a result of untreated water and water treatment processes. In accordance with Environment Agency guidelines (Environment Agency, 2007) these are excluded from the outage assessment and reported separately, see section 3.12 Raw Water Losses and Operational Use and section 3.15 Treated Water Losses and Operational Use.

3.10.5 For each of the three resource zones, outage has been calculated for the Dry Year Annual Average scenario. For the East Surface Water and East Ground Water Zones outage has also been calculated for the Dry Year Critical Period scenarios. Outage is assumed to remain constant throughout the planning period.

Table 3.8: Total Resource Zone Outage

Water Resource Zone	Annual Average Ml/d	Critical Period Ml/d
East GWZ	0.3	0.3
East SWZ	0.2	0.2
Grid SWZ	57.7	n/a

3.10.6 The East Surface Water and East Ground Water Zone outage values have not changed since reported in the Water Resource Plan 2004 and subsequent annual reviews.

3.10.7 The Grid Surface Water Zone outage should be compared to the combined outage for the Grid Surface Water, Dales Ground Water and York Surface Water Zones in the Water Resource Plan 2004, as all three of these zones now make up the Grid Surface Water Zone. The combined total outage for the three zones in the Water Resource Plan 2004 was 100.54 Ml/d. The majority of the reduction in the current Grid Surface Water Zone outage estimate is due to a loss at the River Ouse water treatment works. This is because restrictions due to limited pesticide treatment at the site are no longer included in the outage assessment.

3.10.8 Excluding this outage at the River Ouse water treatment works, the combined outage for the three zones in the Water Resource Plan 2004 would be 58.4 Ml/d. The decrease of 0.7Ml/d is a result of the reassessment of the outage calculation.

3.11 Raw Water Exports and Imports

3.11.1 Yorkshire Water does not have any exports of raw water and therefore report zero for all water resource zones. There is a raw water import into the Grid Surface Water Zone from Severn Trent Water from their Derwent Valley sources, which supports the demand in the Sheffield area. This import is incorporated into the water resource simulation model of the Yorkshire Grid and is dependent upon both the reservoir storage and the current demand. Based on Severn Trent Water's modelling simulations, this is determined to be 43.68Ml/d for a Dry Year Annual Average planning scenario. This is consistent with the assessment by Yorkshire Water using the water resource simulation model.

3.11.2 There is a small raw water import into the East Surface Water Zone, from Northumbrian Water to Scaling Dam which supports demand in Whitby. As a result of the capital improvements at Esk water treatment works, and the subsequent robust resource position in this zone, Yorkshire Water has reviewed the future agreement with Northumbrian Water. It was agreed that from April 2004 the import would reduce to a maximum of 0.24 Ml/d for a period of 8 years. This import will cease from 2012 onwards.

3.12 Raw Water Losses and Operational Use

3.12.1 The component of demand from the raw water source to the distribution system includes the component Raw Water Collected. This is made up of Raw Water Losses, Raw Water Operational Use and Non-Potable Supplies (Refer to Section 3.13.)

3.12.2 A review of raw water transmission systems (raw trunk mains, tunnels and aqueducts) indicates that there is more ingress (11.16Ml/d) than loss (zero Ml/d) accounted for within the raw water system. The estimation of losses (or ingress) is reliant upon meter data and therefore there is potential for these data to be inaccurate due to meter uncertainties.

3.12.3 Yorkshire Water concluded that raw water losses should be reported as nil, in line with previous water resource plans. Yorkshire Water will continue to develop its approach to a total water audit and its measurement and analysis of raw water losses.

3.12.4 The most significant element of Raw Water Operational Use is the water used when cleaning raw water mains. Investigations showed that cleaning occurs every 2-3 years on Yorkshire Water's largest raw water transmission systems, within the Grid Surface Water Zone, where sedimentation resulted in a loss of supply capacity. Other raw water mains are cleaned on an adhoc basis. The estimated use is 0.25Ml/d within the Grid Surface Water Zone.

3.12.5 The raw water mains loss has been deducted from the deployable output within the Water Resource Planning tables as part of the Water Available for Use calculation. Additionally, the losses are also identified specifically for each resource zone in line 9 of the water resource planning table WRP1-BL.

3.13 Non-Potable Supplies

3.13.1 Yorkshire Water does not have any non-potable supply transfers between zones or to adjacent water companies. There are some non-potable supplies to farm properties from the East Ground Water and East Surface Water Zones but these volumes are minor and have been excluded from this Draft Water Resource Management Plan.

3.14 Treated Water Exports / Imports

3.14.1 Yorkshire Water has one minor treated water export from the Grid Surface Water Zone to Anglian Water, at Finningley. In line with previous years it has been assumed that the export through the planning period is 0.31Ml/d.

3.15 Treated Water Losses and Operational Use

3.15.1 Yorkshire Water has assessed the amount of water lost through the treatment process, known either as process or washwater, and water lost through sludge disposal. Within Yorkshire Water, the percentage of water lost through these varies considerably from site to site. The review determined the following treated water operational use for each water resource zone, based on a review of 2006/07 data.

3.15.2 Without further evidence, it has been assumed that these losses will remain consistent throughout the 25-year planning period in all zones.

Table 3.9: Treated Water Losses and Operational Use

Zone	Washwater Loss	Sludge to Sewer Loss	Total Treated Water Ops Use
East GWZ	0.232	1.73	1.96
East SWZ	0.00	1.17	1.17
Grid SWZ	0.11	7.31	7.42

3.15.3 Water lost through structural leaks and overflows is minimal and Treated Water Losses have therefore been reported as zero.

3.16 Impact of Process Losses and Outage on Deployable Output

3.16.1 Raw and treatment works water losses and operational use are summed for each water resource zone in line 4 of the water resource planning table WRP1-BL to give Process Losses. The losses are specifically identified in table WRP1-BL, lines 9 and 11. The process losses along with outage are deducted from the Deployable Output to give the Water Available for Use (WAFU). The table below summarises the impact of outage and process losses on the Deployable Output for 2009/10.

Table 3.10: Impacts of Outage and Process Losses on Deployable Output

Water Resource Zone	Scenario	DO at 2009/10 (Ml/d)	Outage at 2009/10 (Ml/d)	Process Losses (Ml/d)	WAFU at 2009/10 (Ml/d)
East GWZ	Annual Average	72.20	0.3	1.96	69.94
	Critical Period	87.45	0.3	1.96	85.19
East SWZ	Annual Average	14.00	0.2	1.35	12.45
	Critical Period	14.00	0.2	1.35	12.45
Grid SWZ	Annual Average	1358.26	57.7	7.67	1292.89

3.17 Headroom

3.17.1 Headroom is an accepted term in the water industry, used to define a planning allowance that companies include in the supply demand balance. Headroom allows for uncertainties that could either decrease the forecast water available for use or increase the forecast demand. The headroom planning allowance differs to the outage planning allowance in that the headroom uncertainties could result in a permanent impact on the supply demand balance, whereas outage accounts for temporary reductions in supply.

3.17.2 To ensure that demand will be met over the 25 year planning period companies calculate target headroom and actual headroom. Target Headroom is defined as the minimum buffer that a water company should allow between supply and demand to cater for specified uncertainties, except those due to outages, in the overall supply-demand balance (UKWIR, 2002). Companies need to ensure that actual headroom is greater or equal to the target headroom throughout the planning period. If actual headroom is less than the target headroom, measures are taken to ensure the deficit will be met.

3.17.3 Headroom is expressed as a function of water available for use. The following equations describe how actual headroom is calculated in the supply demand balance.

Deployable Outage	-	Outage	-	Sustainability Reductions	-	Process Losses	=	Water Available for Use

Water Available for Use	-	Demand	=	Headroom

3.17.4 Yorkshire Water's target headroom is based on the UKWIR, 2002 methodology, *A Re-evaluation of the Methodology for Assessing Headroom*. The methodology prescribes a probabilistic approach to assessing headroom, applying probability distributions to individual headroom components. A probabilistic simulation model is used to derive the target headroom for the 25 year planning period.

3.18 Headroom Components

3.18.1 There are two categories of headroom components, those that represent the uncertainties in the supply forecast and those that represent the uncertainties in the demand forecast. Headroom components are considered for each resource zone individually to provide target headroom at a resource zone level. For all zones target headroom has been calculated for the Dry Year Annual Average scenario. For the East Ground Water Zone and East Surface Water Zone target headroom has been calculated for the Dry Year Critical Period scenario. For the Grid Surface Water Zone, where a solution are required to met a forecast deficit, headroom has been calculated for the final planning scenario.

3.18.2 Supply related components assessed as headroom include; vulnerable surface and groundwater licences; bulk transfers; pollution of sources; uncertainties around data accuracy; uncertainties in the impact of climate change and uncertainty in new resource developments. Demand related components include; uncertainties around data accuracy; uncertainties in the impact of climate change; variation in the demand forecast and the effectiveness of assumed demand management measures.

3.18.3 No uncertainty is included for schemes under CAMS (Catchment Abstraction Management Strategies), sustainability reductions or time-limited licences, in accordance with Environment Agency guidelines.

3.18.4 The impact of climate change on source yields is included in the Grid Surface Water Zone and East Ground Water Zone headroom estimates. Climate change impact on supply is included in accordance with Environment Agency Supplementary guidance to Chapter 8; *Climate change implications in estimates of water resource zone deployable output*.

3.18.5 In the Grid Surface Water Zone headroom calculation this component could increase Water Available For Use by up to 102 Ml/d or decrease Water Available For Use by up to 169Ml/d by 2034/35. In the East Ground Water Zone the climate change impact on target headroom is estimated to decrease water available for use by up to 1.6Ml/d or increase it by up to 1.3Ml/d.

3.18.6 Headroom uncertainty for the impact of climate change on source yields has not been calculated for the East Surface Water Zone. This zone is predominantly supplied by a river abstraction that has a licensed capacity of 21Ml/d. The deployable output is constrained by the treatment works to 14Ml/d and the climate change effect based on the current methodology would not reduce the water available for use.

3.18.7 Uncertainty of the demand forecast has a significant impact on the headroom estimates in all zones, which is most relevant in the Grid Surface Water Zone as it includes the majority of Yorkshire Water's supply area. Yorkshire Water has assumed demand forecasts could be up to 5 percent less than predicted or 10 percent greater. In the demand forecast, Yorkshire Water has assumed the number of new homes will be as predicted in the Yorkshire and Humber Regional Spatial Strategy and per capita consumption of water efficient new homes will be 120 l/h/d. Greater uncertainty has been applied to the maximum distribution as there is the potential that water efficient new homes will not achieve such a low per capita consumption and the number of new homes could be greater than predicted.

3.18.8 Data accuracy also has an impact on the overall headroom for each zone. In the Grid Surface Water Zone and East Surface Water Zone it is estimated in 20010/11 the uncertainty due to supply data accuracy could increase or decrease water available for use by up to 15 percent. By 2034/35 the uncertainty decreases to 10 percent of water available for use. Supply data accuracy uncertainty in surface water zones is due to measurement errors in river flow data and climatic variations. The uncertainty is forecast to decrease over time as the yield estimates are anticipated to become more accurate, due to available inflow records increasing with time and an expectation that naturalisation calculations will improve.

3.18.9 In the East Ground Water Zone accuracy of supply side data is estimated to increase or decrease water available for use by up to 2 percent. Lower uncertainty is applied to this zone because groundwater sources are mainly constrained by the permitted abstraction licence rather than by climate.

3.18.10 The uncertainty applied to demand data accuracy is attributed to measurement error. For each zone demand data accuracy is estimated to increase or decrease water available for use by up to 2 percent throughout the planning period.

3.18.11 To test the sensitivity of individual components, uncertainty due to data accuracy for both the supply and demand components in the Grid Surface Water Zone were removed from the headroom calculation for the year 2015. This resulted in a 13 percent reduction in the headroom calculated from the probabilistic model, proving the data accuracy components have a significant impact on the target headroom.

3.18.12 The component that has the greatest impact on the East Ground Water Zone target headroom is a vulnerable groundwater licence. The Environment Agency is investigating the borehole as part of a study on the River Derwent and the results may resolve the uncertainty of this component.

3.18.13 Components for the uncertainty of new schemes are included in zones where options are required to ensure demand is met. In this Plan uncertainty of new schemes has been incorporated into the target headroom calculations for the Grid Surface Water Zone final planning scenario.

3.19 Target Headroom Calculation

3.19.1 The uncertainties of each headroom component are defined as probability distributions in a probabilistic simulation model. The model is set up to calculate target headroom for five year intervals from 2010/11 to 2034/35. The model combines the probability distributions to produce headroom estimates for levels of certainty between 0 and 100 percent. For example, a headroom estimate with a zero percentile risk would provide no certainty that supply will meet demand over the planning period. Whereas, a 100 percentile risk would mean there is no risk supply would not meet demand.

3.19.2 The UKWIR methodology does not include guidance on the percentile risk water companies should plan for in the supply demand balance. The Environment Agency (Environment Agency guidelines, 2007) does not expect water companies to plan for 100 percent certainty as it is neither practical nor affordable.

3.19.3 Yorkshire Water has chosen to plan for the 50 percentile target headroom estimate, unless this is below 5 percent of Water Available For Use (WAFU). Since 1996, Yorkshire Water has invested to provide a minimum target headroom of 5 percent of WAFU. This follows recommendations from the Uff Enquiry (Uff, 1996) to increase the supply demand planning margin following the impacts of the 1995/96 drought.

3.19.4 For this Water Resource Management Plan the 50 percentile target headroom derived from the probabilistic model is below 5 percent of WAFU for all zones, in all years, except for 2030/31 and 2034/35 in the East Ground Water Zone Dry Year Annual Average scenario. Therefore, target headroom has been calculated as 5 percent of WAFU for each year of each scenario except for 2026/27 onwards in the East Ground Water Zone Dry Year Annual Average scenario. Target headroom estimates between 2026/27 and 2034/35 in this zone have been extrapolated based on the values derived from the probabilistic model for the years 2029/30 and 2034/35.

3.20 Headroom Assessment Results

3.20.1 Table 3.11 provides a summary of the target headroom for all zones Dry Year Annual Average scenarios and Critical Period scenarios for the East Ground Water Zone and East Surface Water Zone. In the Grid Surface Water Zone it also shows final headroom, which includes additional uncertainty for new schemes.

Table 3.11: Target Headroom (Ml/d)

Water Resource Zone	Demand Scenario	Estimate of Headroom						
		Scenario	2010/11	2015/16	2020/21	2025/26	2030/31	2034/35
East GWZ	Average	Baseline	3.50	3.48	3.46	3.45	3.53	3.68
	Peak	Baseline	4.26	4.23	4.21	4.20	4.19	4.19
East SWZ	Average	Baseline	0.62	0.62	0.62	0.62	0.62	0.62
	Peak	Baseline	0.62	0.62	0.62	0.62	0.62	0.62
Grid SWZ	Average	Baseline	64.64	63.53	62.59	62.26	62.00	62.73
		Final	64.64	63.63	63.79	63.46	63.20	62.93

3.20.2 The 5 percent of WAFU values given in Table 3.11 provide target headroom values varying in certainty between 90 percent and 50 percent. This varies depending upon the zone and the planning scenario.

3.20.3 Since the Water Resources Plan 2004 the headroom results for each zone have not changed significantly, although individual components have altered. For both this plan and the Water Resources Plan 2004 the target headroom in the majority of years was calculated as 5 percent of WAFU, which has not changed significantly since the previous plan.

3.20.4 The number of resource zones in Yorkshire Water's supply area has decreased from five to three. Therefore, the current Grid Surface Water Zone target headroom should be compared to the combined headroom for the Grid Surface Water Zone, Dales Ground Water Zone and York Surface Water Zone, reported in the 2004 Plan as 66 Ml/d.

3.20.5 The Grid Surface Water Zone headroom components for this plan include uncertainty of climate change on supply and demand, which was not included in the 2004 Plan. However, components on vulnerable surface and groundwater licences have been removed. This is due to the Environment Agency's decision that no reductions to supply will be made to Yorkshire Water's licences as a result of the Habitats Directive, and that reductions due to the Water Framework Directive should not be included in water companies' 2009 plans.

3.20.6 The East Ground Water Zone headroom in the previous Plan was 3 Ml/d for the Dry Year Annual Average scenario and 3.5 Ml/d for the Critical Period scenario. The increase to target headroom for this plan is due to an increase in WAFU following an increase in the East Ground Water Zone area. The only significant changes in the headroom components of this zone are the addition of uncertainty of climate change on supply and demand.

3.20.7 The East Surface Water Zone headroom was reported as 0.69 Ml/d. This has not changed for the current plan as it is reported as 5 percent of WAFU and WAFU in this zone has remained the same. The only significant change to the components for the East Surface Water Zone is the addition of uncertainty of climate change on demand.

3.20.8 The supply-demand balance presented in this plan is determined at a target headroom which ensures that the security of supply is maintained at the current Level of Service. This assessment is in line with the Intermediate Approach presented in the UKWIR, 2003, *Economics of Balancing Supply and Demand Methodology*.

3.20.9 The supply-demand balance will achieve a 100 percent Security of Supply Index for Ofwat Performance Measurement, in all three zones.

4. DEMAND FORECAST

4.1 Introduction

4.1.1 The demand forecast has been prepared in line with the best practice methodology set out in the *Demand Forecasting Methodology* (UKWIR/NRA, 1995).

4.1.2 The methodology follows the forecast of the separate components of customer demands, which are:

- Unmeasured household water delivered
- Measured household water delivered
- Unmeasured non-household water delivered
- Measured non-household water delivered

4.1.3 Each component has its own set of demand drivers and assumptions for future growth rates. These include population projections, customers switching to paying by meter (domestic meter optants), new domestic connections and the economic environment.

4.1.4 The following key data sources and assumptions have been included in the forecast:

- Policy based population forecast
- The effect of climate change on demand
- The use of the Regional Spatial Strategy in household projections
- Assumed demand in new properties in accordance with the *Code for Sustainable Homes* (Communites and Local Government, 2007)
- Micro-component based household demand forecasts

4.2 Changes from the June Return to Base Year

4.2.1 The following amendments have been made to the June Return to form the Base Year:

- The sample bias of the Domestic Consumption Monitor was reviewed by Leeds University in 2006/07, and has increased from 3 percent in the June Return to 4 percent.

- Further to a study undertaken by the University of Leeds into the hidden & transient populations in the Yorkshire Water region, (*Hidden and Transient Populations. An analysis of the Yorkshire Water Supply Area,* McDonald, 2007) Yorkshire Water has incorporated an additional population of 69,511. This population has been assumed to have a conservative per capita consumption of 100 litres/head/day. This per capita consumption will be reviewed for the Final Plan following further analysis.

- 2006/07 was considered to be a Partial Dry Year, with an effect of a 10 Ml/d increase in demand, therefore the Base Year has been normalised.

4.3 Population

4.3.1 Trend based population forecasts for the 25 year planning horizon have been produced by the market and information analysts Experian Business Strategies.

4.3.2 Yorkshire Water's Planning department have used information from regional planning authorities to develop a policy- based forecast from the trend based forecast provided by Experian Business Strategies.

4.4 Experian Methodology for Estimating Regional Population

4.4.1 The basis of the Experian population forecast is the Office of National Statistics projections of future year population. These projections take account of trends in fertility, mortality and migration trends. This data is available by gender and for detailed age bands. However, it is only available at local authority level.

4.4.2 The following are the broad steps taken by Experian to update the 2001 Census data (based on Office of National Statistics 2005 mid-year estimates and 2004 based projections) to give local area estimates and projections :

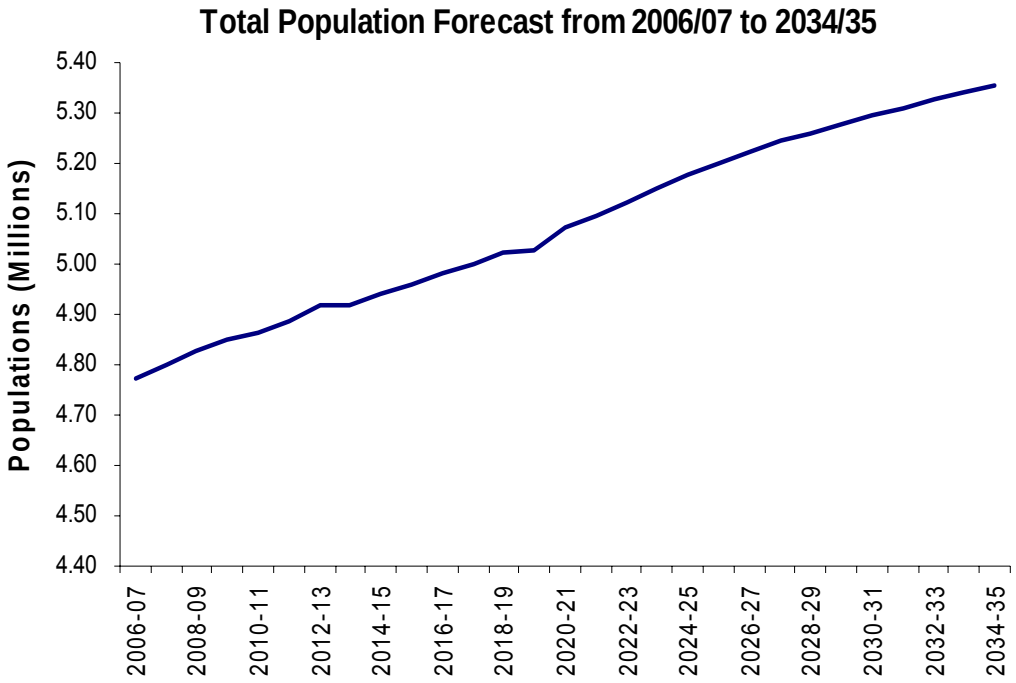
- The Mid-Year Estimates are used to enhance the Office of National Statistics projection for the current year at Local Authority/Unitary Authority level.
- The 'communal population' (retirement homes, prisons etc.) is subtracted from this enhanced projection to give a population living in households. Regional Trends in household size are then applied to this figure to give current year household projections at Local Authority/Unitary Authority level.
- The Electoral Roll, Postcode Address File (PAF) and Census variables are used to produce the current year Baseline Projections at postcode level.
    - These Baseline Projections are aggregated to larger geographical areas and verified against the other Joint Industry Committee for Population Standards (JICPOPS) suppliers.

- The 20 age bands of the previous years JICPOP's population projection are 'aged' by one year and then applied to the Baseline Projection to give the definitive current year population projection by age and social class at postcode sector level.

- The postcode level current year projections are aggregated to Enumeration District level and factored based on trends in the Government Mid-Year Estimates to give projections for future years. These "communal populations" are then added back into the figures to give overall populations figures.

Figure 4-1: Total Population Forecast shows the total population forecast for the Yorkshire region

Figure 4-1: Total Population Forecast



4.5 Population Trends in Resource Zones

4.5.1 As the Office of National Statistics data is only available by local authority level Yorkshire Water supplied Experian with a digitised map of the three resource zones boundaries. This allowed Experian to produce individual population estimates for each area, taking into consideration trends in key factors, such as births and deaths etc.

4.5.2 All three resource zones in the Yorkshire Water region show a similar increase in population over the forecasting period of 12 percent. The East Ground Water Zone showed the smallest increase of 0.40 percent per annum whilst the East Surface Water Zone showed the largest increase of 0.43 percent per annum. In the Grid Surface Water Zone the population trends follow that of the whole region, showing an increase in population of 0.41 percent per annum.

4.5.3 Table 4.1: Population Projections for the three resource zones

Table 4.1: Population Projections

Year	East GWZ	East SWZ	Grid SWZ
2007-08	171,320	26,506	4,600,966
2008-09	172,299	26,658	4,627,266
2009-10	174,932	26,710	4,648,251
2010-11	175,637	26,869	4,663,062
2011-12	175,702	26,902	4,684,870
2012-13	177,494	27,054	4,713,556
2013-14	177,110	27,204	4,715,277
2014-15	177,194	27,222	4,735,067
2019-20	180,140	27,910	4,819,750
2024-25	183,240	28,532	4,963,885
2029-30	187,120	29,149	5,061,523
2034-35	190,707	29,696	5,132,902

4.6 Allocating Population to Customers Base

4.6.1 The methodology used to estimate the Base year (2006/07) customer group populations is presented below

Unmeasured Household occupancy rate x Billed Unmeasured Households = Unmeasured Household Population.

Measured Household occupancy rate x Measured Household = Measured Household Population

Unmeasured Household occupancy rate x Unmeasured Non-Households = Unmeasured Non-Household Population.

Total Population minus (Unmeasured Household Population plus Measured Household Population plus Unmeasured Non-Household Population) = Measured Non-Household population

Note:
Unmeasured occupancy rate is obtained from Yorkshire Water's Domestic Consumption Monitor (DCM)
Measured occupancy rate is based on a sample of metered customers on the DCM and an occupancy rate survey conducted in 2006.

4.6.2 The number of unmeasured household properties is multiplied by the average occupancy to derive the unmeasured household population. In the Grid Surface Water Zone the occupancy rate is taken from the Yorkshire Water Domestic Consumption Monitor of approximately 1000 properties, of which 950 are in the Grid Surface Water Zone.

4.6.3 For the two smaller resource zones, East Ground Water Zone and East Surface Water Zone, an occupancy rate survey was conducted by Yorkshire Water in 2007 and this occupancy rate has been used.

4.6.4 The number of measured households is multiplied by the average occupancy to derive the measured household population. Yorkshire Water use an occupancy rate intended to be representative of the installed meter base, meter optants and new connections during the year, which are all metered.

4.6.5 The occupancy rate for the measured properties in the Grid Surface Water Zone is a weighted average of the measured properties on the Domestic Consumption Monitor and an occupancy rate survey of measured properties undertaken in 2006. The East Surface Water Zone and East Ground Water Zone occupancy rate was obtained from an occupancy rate survey conducted by Yorkshire Water in 2007.

4.6.6 Yorkshire Water applies the unmeasured household occupancy rate to unmeasured non-household properties. These are properties such as lock-up garages, scout huts and churches, but also include mixed-use properties that are occupied but below the consumption level that automatically requires a meter. The occupancy assumption is a best estimate.

4.6.7 For the future years, measured and unmeasured non-household population is kept constant over the planning horizon in all three resource zones. These populations are then subtracted from total zonal populations to give total household population. Total household population is then divided by the projected total household properties to give average household size for each year to 2034/35.

4.6.8 Trends in the average household size (i.e. year on year percentage change) are then used as the basis for forecasting future levels of unmeasured household occupancy rates. These occupancy rates are multiplied by unmeasured household properties to give unmeasured household populations for each to 2034/35.

4.6.9 Measured household population is calculated as the difference between total household population and unmeasured household population. Measured household occupancy rates are calculated by dividing measured household population by the number of measured households for each year over the planning horizon. Use of Yorkshire Water's own calculation of average household size, rather than an external source, to forecast future unmeasured occupancy rates is considered to be more reliable as it is based on the Company's own projections of billed properties and population in each zone.

4.6.10 The population forecast has been amended to include any population that may not be incorporated in the Office of National Statistics population estimates. Further to the study undertaken by the University of Leeds into the hidden & transient populations in the Yorkshire Water region, Yorkshire Water has incorporated an additional population of 69,511, the mid range of the reported hidden & transient population.

4.6.11 The study took account of the populations not included within the Office of National Statistics population that will be using water not currently unaccounted for in the forecast. These include visitors, tourists, students, second home owners, migrants, asylum seekers, illegal or undocumented populations such as rejected asylum seekers, victims of human trafficking and homeless people.

4.6.12 In all three resource zones the trend in average household size declines over the forecast period to 2034/35 which aligns with evidence gained from the Communities and Local Government department. Unmeasured Household size follows the same trend. As measured household population is calculated as a residual, the year-on-year movements vary with annual changes in Experian's population estimates.

4.6.13 Yorkshire Water estimate measured non-household population as a residual in the Base year. For the future years measured non-household population has been kept constant at 2006/07 level.

4.7 Properties

4.7.1 All billed base year property data is provided by Yorkshire Water's Tariff Team.

4.7.2 Property projections at resource zone level are based on assumptions regarding domestic meter optants and new properties.

4.7.3 The number of properties in each customer category e.g. unmeasured households, is extracted from Yorkshire Water's billing file. To project the property numbers, the number of domestic meter optants is subtracted from the unmeasured households and added to the measured households. In addition, the number of new properties forecast each year has been added to the measured households.

4.8 New Domestic Connections

4.8.1 The Regional Spatial Strategy for Yorkshire and the Humber as presented in *The Yorkshire and Humber Plan* (Yorkshire and Humber Assembly, 2007), provides guidance on the development and use of land in Yorkshire and the Humber to 2016 and beyond. The key aims of the Regional Spatial Strategy for Yorkshire and the Humber are:

- To ensure that development is focussed in the main urban areas and regeneration priority areas are identified in the spatial strategy
- To provide wider housing opportunity and choice to ensure that a decent quality of housing can be made available to the households likely to require accommodation in the region
- Support the contribution made by the existing stock, and specify the distribution of additional housing
- Relate this to the broad spatial pattern of employment, to demand for services such as public transport, health, shopping and leisure, the need for infrastructure such as roads, water, gas and electricity supplies; and to environmental and other constraints
- Further the principles of sustainable development

4.8.2 Yorkshire Water has determined the number of new properties being developed across the region from the Regional Spatial Strategy for Yorkshire and the Humber, as provided in September 2007. The Regional Spatial Strategy for Yorkshire and the Humber gives details of projected property demolitions in each Local Authority, allowing a forecast of new connections net of demolitions to be determined.

4.8.3 The Regional Spatial Strategy for Yorkshire and the Humber gives a projection of 407,160 new properties by 2026.

4.8.4 The development of new properties across the region is assumed to be constant, therefore a forecast of 22,620 new properties per year has been incorporated into the demand forecast.

4.8.5 Yorkshire Water has continued the assumptions of 22,620 new properties per year to the end of the planning period in 20034/35.

4.8.6 Recent reports suggest that the predicted number of new properties within Yorkshire may be underestimated and that a more realistic figure may be 29,000 properties per annum. Sensitivity analysis has been undertaken to assess the effect of these additional properties on forecast demand. The results of this analysis showed that the effect of these additional properties would be an increase in total demand of 3.15 Ml/d in 2009/10 rising to 39.80 Ml/d in 2034/35.

4.9 Domestic Meter Optants

4.9.1 A forecast of meter optants has been produced by consultants ICF International, (*Forecasting Domestic Meter Optants for PR09* ICF International, 2007) which takes into account recent trends in optant numbers and the potential impact of price rises going forward. The expectation is that the number of meter optants will rise as the unmeasured price rises.

4.9.2 The domestic meter optant forecast model shows a decrease in the number of optants from 30,503 in 2007/08 to 15,754 in 2034/35 with a maximum of 34,955 in 2009/10.

4.9.3 Yorkshire Water believe that the forecast provided by ICF for the first five years of the planning period may be an over estimate. The number of domestic meter optants in 2006/07 was significantly higher than previous years, rising by 38.7% from 2005/06. Prior to 2006/07 the number of domestic meter optants had been consistently between 20,000 and 25,000 per annum. Yorkshire Water predict that the increase in 2006/07 will have artificially influenced the domestic meter optant forecast, resulting in a larger than expected forecast in the initial years of the planning period.

4.9.4 The reported number of meter optants for the period 2002/03 to 2006/07 is given in Table 4.2 below

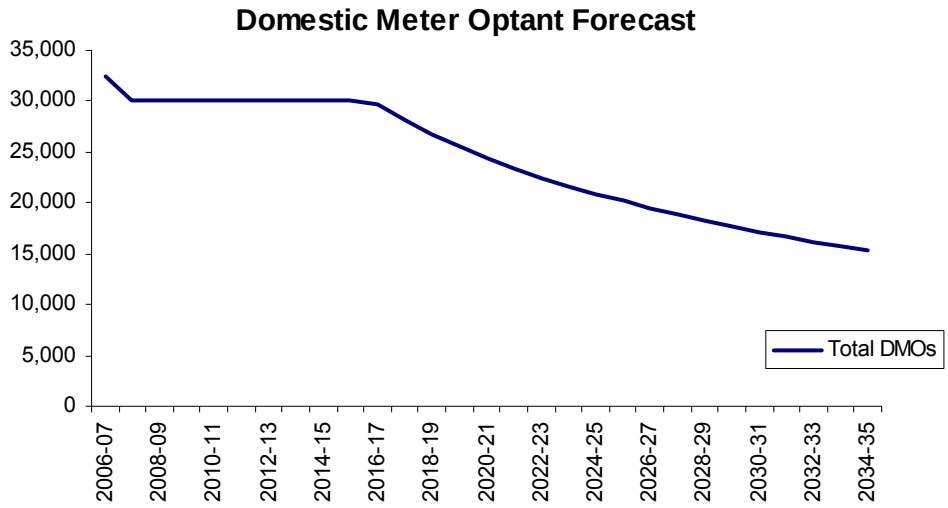
Table 4.2: Historical Domestic Meter Optants

	2002/03	2003/04	2004/05	2005/06	2006/07
Domestic Meter Optants	21,266	25,593	22,076	21,990	30,503

4.9.5 A stable level of 30,000 households switching to a metered supply has been projected until 2015/16. Beyond this period, the 2.69 percent average annual decline as determined from the ICF model has been assumed.

4.9.6 The number of meter optants predicted for the planning period is shown in Figure 4.2 below:

Figure 4-2: Domestic Meter Optant Projections

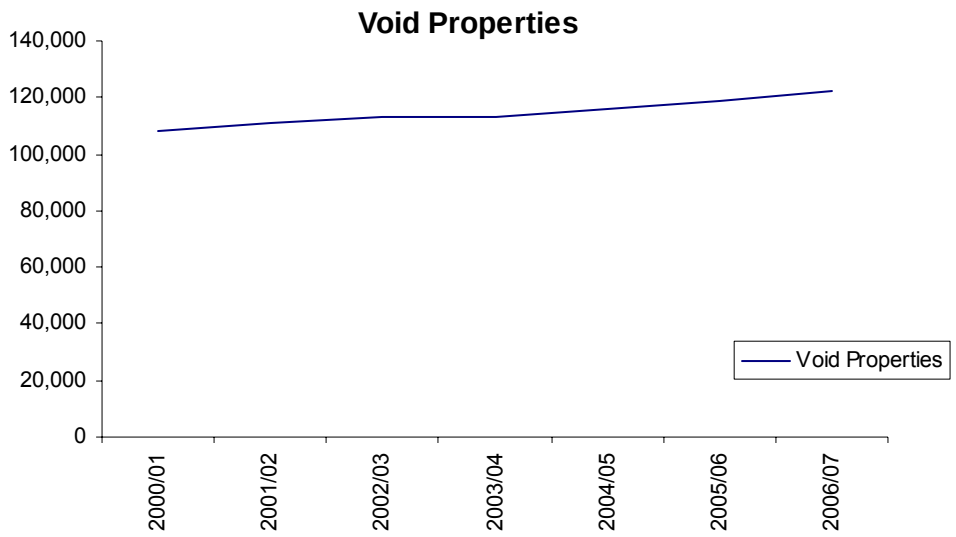


4.10 Void Properties

4.10.1 Yorkshire Water has forecast a constant level of void properties over the planning period.

4.10.2 Figure 4-3 shows the number of void properties for Yorkshire Water for the 7 years from 2000/01 to 2006/07. This shows the number of void properties has been comparatively stable.

Figure 4-3: Forecast Void Properties



4.10.3 Yorkshire Water is currently investigating the proportion of new properties that are not occupied. This will be used to adjust the estimate of demand of new properties in the Final Plan.

4.11 Household Demands

4.11.1 The main factors determining household demand trends are:

- Growing population throughout the planning period. Population is forecast to grow from 4,849,893 in 2009/10 to 5,353,305 in 2034/35, an addition of 503,412
- The impact of climate change on measured and unmeasured household consumption has been fully incorporated in future demand
- Domestic meter optants are projected to run at an average of 30,000 per year until 2015/16, after which the predicted number declines in line with a forecast obtained from an external consultant
- Growth in new domestic connections at an annual rate of 22,620 per year as determined from the Yorkshire and Humber Regional Spatial Strategy. All new connections in Yorkshire Water are metered.
- Water use by new properties is forecast to align with the Code for Sustainable Homes, *(Code for Sustainable Homes*, CLG, 2007) with a per capita consumption of 120 litres/head/day.

- Micro-component analysis has been used to determine forecasts of measured and unmeasured household consumption. This forecasts household consumption from 706.33 Ml/d in 2007/08 to 755.77Ml/d in 2034/35.

4.12 Impact of Climate Change

4.12.1 Yorkshire Water have used the Defra report *Climate Change and Demand for Water* (CCDeW, 2003) to determine the impact of Climate Change on the demand forecast. This report revisits and updates the benchmark study by Paul Herrington (1996) using new data sets, regional coverage of demand projections and new methodologies for climate change assessment. Domestic demand, industrial and commercial water use and the agricultural sectors are covered in this project.

4.12.2 The CCDeW analysis for the Yorkshire Water region shows a 1 - 1.5 percent growth in domestic demand due to climate change in the period up to 2020.

4.12.3 Results for industrial and commercial water demand, based on the same scenario as domestic demand, show an impact of climate change on water demand of 1.4 - 3.0 percent in the period up to 2020.

4.12.4 Following consultation with the University of Leeds, Yorkshire Water have adopted a Beta Low scenario, as described in the CCDeW analysis, to calculate the effect of climate change on demand due to the following:

- Building Research Establishment (BRE) evidence that 30 percent of homes are not achieving the current standard
- Slow movement to water efficiency in existing homes
- Move to low occupancy housing with subsequent increase in per capita consumption
- Evidence that in time water efficient properties regress, with increased water use as water efficient appliances are replaced or removed

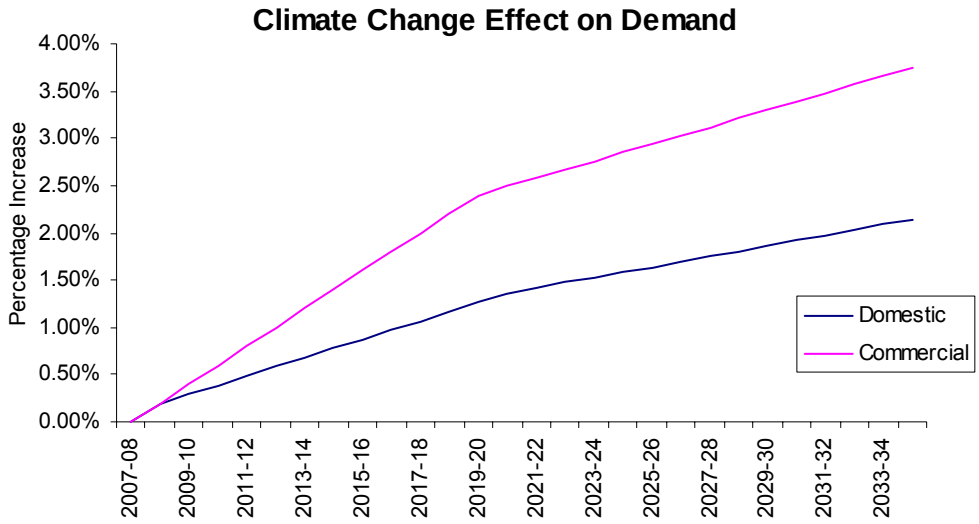
4.12.5 In the Beta Low scenario there is an increase in water demand, brought about through consumerist values and globalised governance. There is an implementation of water efficiency measures, however, these are restricted to low cost initiatives. Health care is a fast growing sector, along with leisure and financial service, whilst manufacturing and agriculture are in decline. Environmental responsibility stretches only as far as a focus on the individual or local area.

4.12.6 Assuming a Beta Low scenario, the effect of climate change on domestic demand is an increase of 7.96 Ml/d in 2019/20 (1.26 percent increase in per capita consumption) and 14.16 Ml/d in 2034/35 (2.14 percent increase in per capita consumption). The effect of climate change impacts on all micro-components of per capita consumption.

4.12.7 Yorkshire Water has assumed the effect of climate change on commercial demand to be the mid point of the Beta Low scenario. This gives an increase of 2.4 percent by 2020, as recommended in the CCDeW report. The effect of climate change is an increase of non-household demand of 5.43 Ml/d by 2019/20 (2.4 percent increase in commercial demand) and 8.16 Ml/d by 2034/35 (3.8 percent increase in commercial demand).

4.12.8 Figure 4.4 below shows the percentage increase in demand due to climate change

Figure 4-4: Percentage Increases in Demand due to Climate Change



4.12.9 As the majority of agricultural activity in Yorkshire uses non potable water supplies, Yorkshire Water has assumed no increase in demand as a result of climate change.

4.13 Micro-component Model

4.13.1 The household demand has been forecast using a micro-component approach in line with industry best practice (UKWIR/Environment Agency, 1997 and Environment Agency, 2001).

4.13.2 Yorkshire Water has used a Yorkshire specific micro-component model produced by Experian Business Strategies.

4.13.3 The model produces a per capita consumption for a range of water using appliances and projects future use through assumptions around the effects of changes in water efficiency, regulations and social trends on per capita consumption. The possible emergence of more water efficient appliances in the future has also been taken into account.

4.13.4 The majority of information on appliance ownership within the model has come from a Yorkshire Water survey. Where this was unavailable Experian has used data from previous micro-component models and national research sources including the Environment Agency and TGI market research data.

4.13.5 Results from the survey on appliance ownership were coded by ACORN classification. This grouping has then been used to project appliance ownership in the future using techniques developed by Experian Business Strategies, based on forecasts of employment, occupation and demographic change.

4.13.6 As appliance ownership and per capita consumption are affected by occupancy rate and property numbers these have been taken into account when forecast per capita consumption in the model.

4.13.7 The micro-component model provides the per capita consumption in the following categories:

- Toilet Use
- Bath Use
- Shower Use
- Hand Basin Use
- Clothes Washing
- Dish Washing
- Garden Use
- Other Use

4.13.8 The climate change impact on household demand, detailed in Section 4.12, is built into the micro-component model and this can be modelled for a Normal Year or Dry Year scenario.

4.13.9 The per capita consumption estimates from the micro-component model are applied to the population forecasts to derive the total household demand forecast.

4.13.10 The micro-component model is built for a Normal Year and Dry Year scenario. The Dry Year model assumes that there will be an increase in the personal washing and garden use elements of the micro-component model in line with work carried out by Herrington (1996).

4.14 Unmeasured Household Demand

4.14.1 Data for forecasting unmeasured household demand is obtained from the Company's Domestic Consumption Monitor (DCM). The monitor gives estimates of average unmeasured household consumption and occupancy rates. Historical monthly trend data from the monitor is used to estimate growth rates in demand and movements in occupancy rates.

4.14.2 The Base Year per capita consumption is estimated from validated flow readings from the DCM, using a 12-month rolling average and estimates of unmeasured average occupancy rates also provided by the DCM.

4.14.3 The average occupancy rate is multiplied by the average number of billed unmeasured households during the year to give total unmeasured household population. The product of base per capita consumption and unmeasured population then gives total unmeasured household volumes delivered.

4.15 Yorkshire Water's Domestic Consumption Monitor

4.15.1 Since 1996 the University of Leeds has undertaken a number of reviews regarding the statistical robustness of the Yorkshire Water's Domestic Consumption Monitor. This includes an assessment of the degree to which the properties on the monitor are representative of the unmeasured customer base and the extent of sample bias.

4.15.2 In 2004/05, a full review of the properties on the Domestic Consumption Monitor was undertaken by University of Leeds to verify that the survey remains representative of Yorkshire properties in terms of property type, occupancy level, age profile etc. Data from the 2001 Census was used as a comparison. The property sample is still considered to be statistically representative of the Yorkshire housing stock.

4.15.3 There are currently 1,054 unmeasured properties on the DCM survey throughout the Yorkshire Water region with 950 in the Grid Surface Water Zone, 69 in East Ground Water Zone and 35 in East Surface Water Zone.

4.15.4 The sample bias of the DCM was reviewed by University of Leeds in 2006/07, to assess the validity of the bias remaining at 2 percent. The report recommended an increase in bias of to 4 – 5.65 percent due to a number of factors including an increase in the frequency of contact from Yorkshire Water and a deficit of high user population within the Domestic Consumption Monitor (DCM). Following these recommendations Yorkshire Water has increased sample bias to 4 percent.

4.15.5 Sensitivity testing was carried out on the effect of the 4 percent sample bias by reducing the bias to 3 percent. This reduced demand by 5 Ml/d.

4.15.6 Base Year average unmeasured household consumption is calculated from consumption readings of all DCM properties in each resource zone; these are determined by locating property postcodes.

4.15.7 The Experian micro-component model produces unmeasured household per capita consumption estimates for each year in the planning period including the Base Year. Each micro-component is then re-based in line with the unmeasured household per capita consumption from the Domestic Consumption Monitor reported in the Base Year.

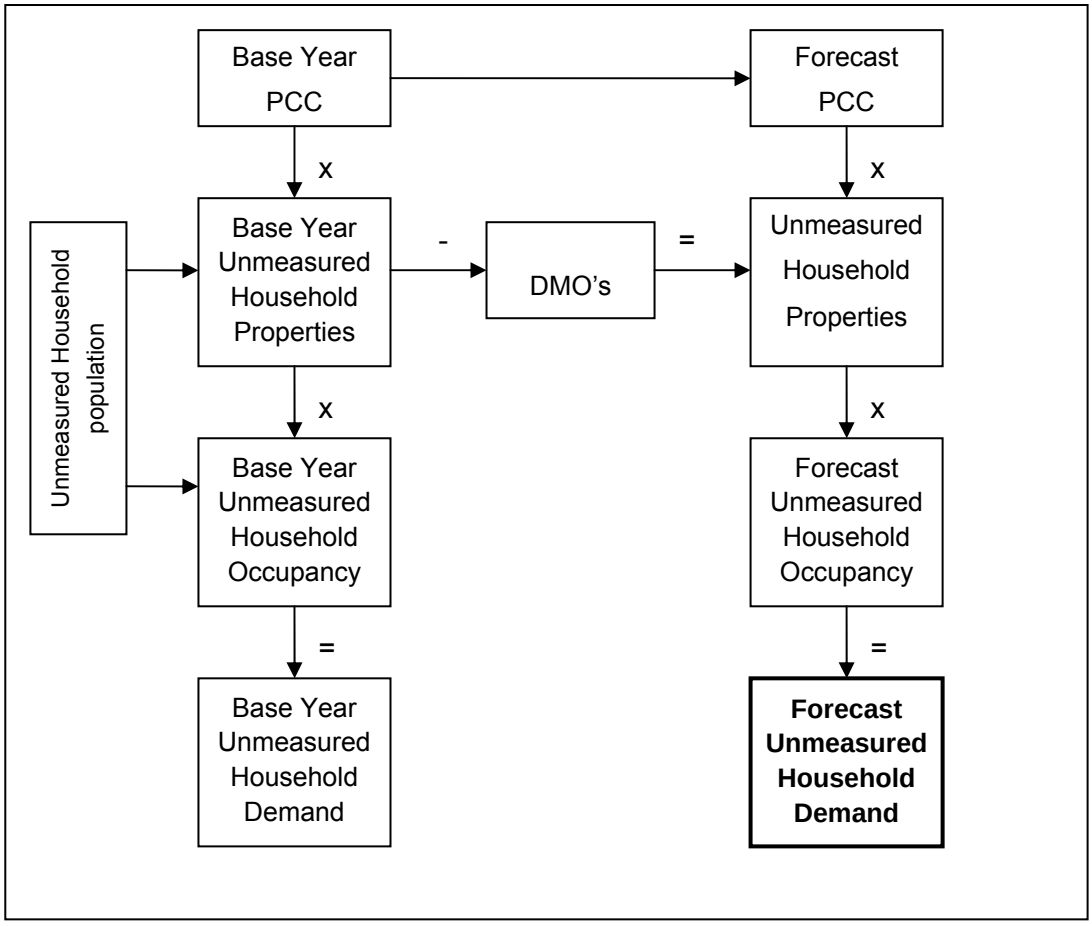
4.15.8 The rebased per capita consumption estimates are applied to the population forecasts to derive the total unmeasured household consumption.

4.15.9 A regional unmeasured household per capita consumption has been applied to each resource zone.

4.15.10 A meter under registration value of 1 percent has been applied to unmeasured household consumption. This value was determined by flow testing of randomly selected, statistically representative meters undertaken in 2002/03 and 2003/04. The meter under registration for unmeasured households is lower than that for measured households as analysis on the Domestic Consumption Monitor meters show a age range of 1 – 10 years where the measured property meters range from 1 – 40 years old.

4.15.11 The methodology used to forecast unmeasured household demand is shown in Figure 4.5 below.

Figure 4-5: Unmeasured Households Demand



4.16 **Measured Household Demand**

4.16.1 Measured household demand is influenced by both the number of domestic meter optants and the number of new connections per year.

4.17 **Domestic Meter Optants**

4.17.1 The water consumption of properties electing to paying by meter is considered to reduce upon switching from an unmeasured supply.

4.17.2 Yorkshire Water collaborated with UKWIR in a study, *The Impact of Household Metering on Consumption: Further Analysis,* UKWIR, 2003, to investigate the impact of household metering on consumption. This study looked at household consumption with respect to the decision to opt onto metering charges and the impact of opting on consumption.

4.17.3 The study showed that meter optants typically use 35 percent less water prior to switching than non-meter optants and that there is a 5 percent reduction in consumption upon switching to a meter.

4.17.4 In line with the study Yorkshire Water has assumed that domestic meter optants will use 35 percent less water than unmeasured households for the first year after switching. After the first year they are assumed to have the same per capita consumption as the current measured households base.

4.17.5 The consumption per year from domestic meter optants ranges from 7.34 Ml/d in 2007/08 to 3.17 Ml/d in 2034/35.

4.18 New Connections - Code for Sustainable Homes

4.18.1 The Code for Sustainable Homes has been developed to bring about a change in sustainable building practice for newly built homes. It is intended as a single national standard to guide the house building industry, and looks to build upon BRE's (Building Research Establishment) current 'Eco Homes' system.

4.18.2 The areas of focus with regard to water efficiency are internal and external potable water consumption. The code gives guidance on best practice to limit internal water consumption to a range of below 80 to 120 litres/head/day. External consumption guidance relates to providing systems to collect rain water for use in external irrigation.

4.18.3 A number of local construction and building companies were contacted to determine information of their current position regarding the Code for Sustainable Homes, and their proposed plans for new housing under the scheme. A number of matters were discussed with the contacts from each company, including current policy on water use in new homes, installation of water efficient appliances, and the proposed standard of compliance with the Code.

4.18.4 From the findings of these communications it is apparent that a compliance standard of 120 litres/person/day, otherwise classified as Level 3 compliance, is being incorporated by the numerous companies.

4.18.5 The house builders advised that a variety of water efficient appliances are to be fitted as standard within new homes, including Grade 'A' washing machines and tap flow restrictors. Water butt units and water retentive materials are also being implemented to reduce external potable water consumption and are being fitted throughout a number of properties. Two companies are currently working with the BRE's Eco Homes System on a number of sites, and are familiar with the nature of such sustainable building and development schemes.

4.18.6 The type of properties planned for development and implementation of the Code are varied; they range from 1 bedroom apartments in predominantly urban areas, to larger family homes with higher occupancy. Plans are also in place to implement a standard of 105 litres/head/day in some smaller low occupancy properties, such as townhouses and apartments. 'Lifetime Homes' are also to be developed on some sites, although it is not clear exactly how many at this point in time.

4.18.7 As a result of this investigation, the Company has taken the decision to assume a per capita consumption of 120 litres per head per day for new properties throughout the planning period.

4.18.8 Sensitivity testing of the demand forecast was carried out by assuming that for new properties the per capita consumption matched that of the current measured households. This resulted in an increase in total demand of 0.4 Ml/d in 2007/08 rising to an increase of 15.86 Ml/d in 2034/35.

4.19 Forecasting Measured Demand

4.19.1 Base measured household demand is calculated from billed volumes obtained from the billing file and dividing by average billed measured households during the year. This is shown in Figure 4.6 Measured Household Water Demand below.

4.19.2 The Experian micro-component model produces measured household per capita consumption's for each year in the planning period including the Base Year. Each micro-component is then rebased inline with the measured household per capita consumption reported in the Base Year.

4.19.3 The micro-component model takes into account the increase in population and gives the overall per capita consumption for measured households. A per capita consumption of 120 litres/head/day has been assumed for new properties in line with the Code for Sustainable Homes. In line with the UKWIR 2003 study Yorkshire Water has assumed that domestic meter optants use 35 percent less water than unmeasured households. The current measured household and domestic meter optants after the first year are the balancing item.

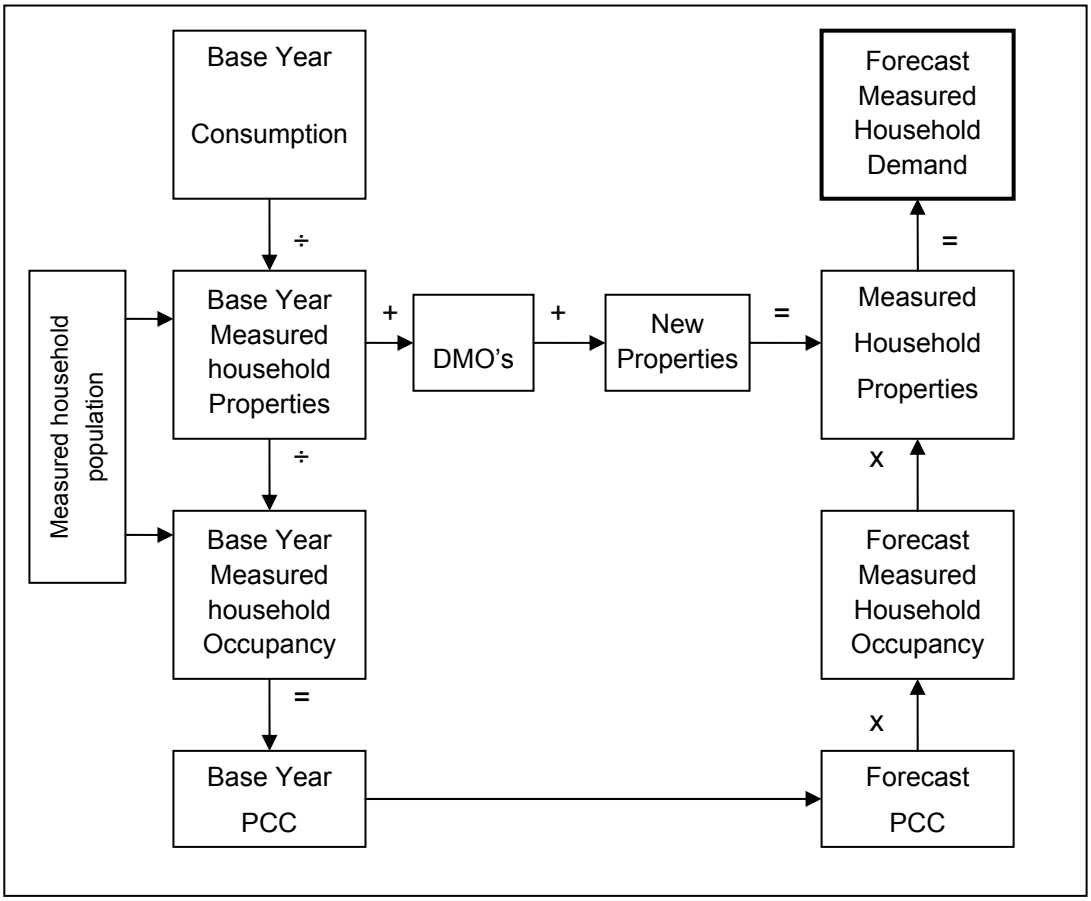
4.19.4 The overall per capita consumption estimates are applied to the population forecasts to derive the total measured household consumption.

4.19.5 A regional measured household per capita consumption has been applied to each resource zone.

4.19.6 A meter under registration value of 3 percent has been applied to measured household consumption. A meter under registration project is underway and due for completion in April 2008. The meter under registration percentage will be updated to reflect the results of this project in the Final Water Resources Management Plan.

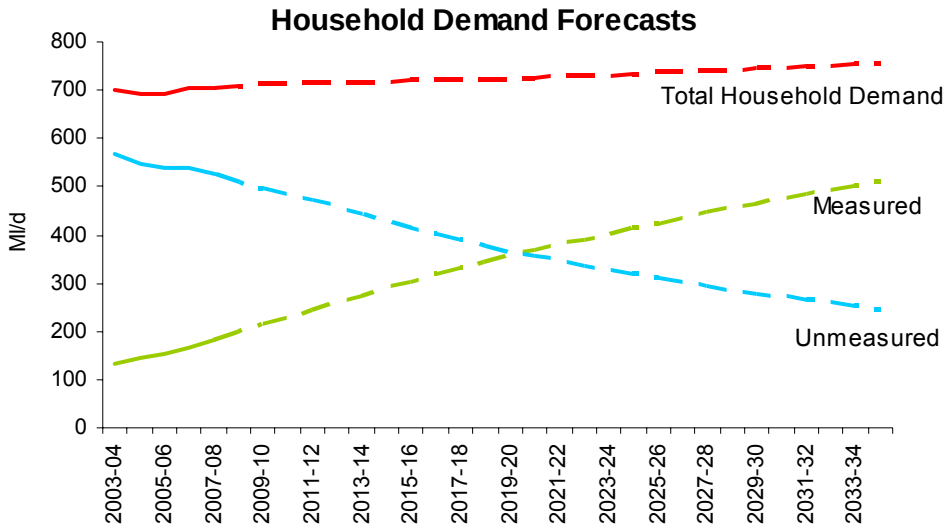
4.19.7 The methodology for estimation of measured household water demand is given in Figure 4-6: Measured Household Water Demand below.

Figure 4-6: Measured Household Water Demand



A graph showing forecast measured and unmeasured household demand is given in Figure 4.7 below

Figure 4-7: Water Delivered to Households



4.20 **Unmeasured Non-Household and Measured Non-Household Demands**

4.20.1 A forecast of measured household demand has been provided by Experian. This gives forecast demand by Standard Industry Classification (SIC) code at a resource zone level for the 25 year planning period.

4.20.2 Experian undertook econometric analysis to identify the historical relationship between non-household water demand and economic factors such as industrial output and employment.

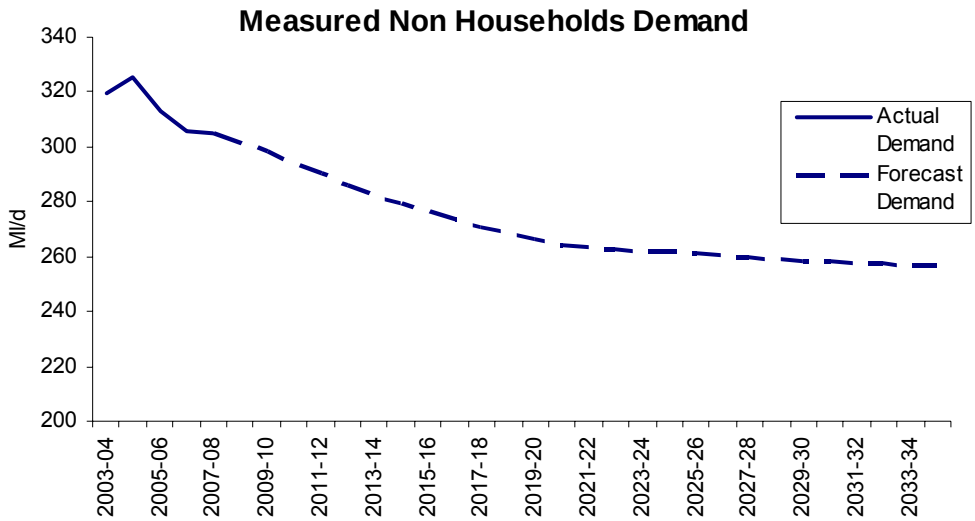
4.20.3 Yorkshire Water provided Experian with measured non-household water delivered figures for the Yorkshire Water region disaggregated by SIC code for the periods 1995/96 to 1998/99 and 2003/04 to 2005/06.

4.20.4 The results of this analysis were then combined with data provided by Yorkshire Water on the measured non-household water delivered and estimations of full-time equivalent employees provided by Experian to model the measured non-household water demand.

4.20.5 As the forecast was produced by Experian before figures for 2006/07 were available the forecast was then rebased to align with the Base Year. The forecast will be reviewed before the final plan to include actual consumption figures for 2006/07 and 2007/08.

4.20.6 Figure 4-8: Non-household Water Demand Forecasts shows the forecast measured non household demand for the 25 year planning period.

Figure 4-8: Non-household Water Demand Forecasts



4.20.7 All three resource zones show the decline in measured non-household demand.

4.20.8 The trend towards water efficiency is becoming increasingly evident in Yorkshire. Combined with a financial incentive, the Integrated Pollution Protection and Control (IPPC) Directive has introduced new environmental controls in several areas including waste management in water use.

4.20.9 During the past decade Yorkshire Water has assisted numerous business customers to reduce water use by promotion of the efficient use of water, through activities such as leakage detection and water audits at customer sites.

4.20.10 The reduction in water use at non-household sites due to demand management initiatives by Yorkshire Water are incorporated in the demand forecast.

4.20.11 The decline in non-household use observed in recent years is forecast to continue, with non-household demand showing a reduction of 1.24 percent per year from 2006/07 to 2013/14. A further reduction of 0.42 percent per year was then shown from 2014/15 to 2034/35. This is an overall reduction of 49.29 Ml/d in 2034/35.

4.20.12 Water delivered to unmeasured non-households is based on an assumed 82.2 litres/property/day. This assumption is based on a survey of unmeasured non-household properties carried out for fixed charging purposes. These properties pay a fixed charge assuming an annual consumption of 30 cubic metres.

4.21 Overall Water Balance

4.21.1 Independent estimates have been made for each component of distribution input for the Base Year 2006/07. The Maximum Likelihood Estimation (MLE) technique has been used to allocate this discrepancy across all the components. This has been done at a regional level as shown in Figure 4-9: Regional Maximum Likelihood Estimation.

Figure 4-9: Regional Maximum Likelihood Estimation Table

2006/07	Base Ml/d	Accuracy + or -	Confidence Range	% of Total Var	Adjustment	Final figures rounded	Post Mle Ml/d	Partial Dry Year effect	Base Year Ml/d
Measured Households	162.06						166.99	-0.70	166.29
Consumption	147.69	5.00%	14.77	7.19%	3.48	151.18			
SPL internally metered	6.09	7.50%	0.91	0.44%	0.22	6.31			
SPL externally metered	3.60	7.50%	0.54	0.26%	0.13	3.72			
Meter Underregistration	4.68	50.00%	4.68	2.28%	1.10	5.78			
Measured Non-Households	297.86						307.79	-2.30	305.49
Consumption	283.26	5.00%	28.33	13.79%	6.68	289.94			
SPL	0.96	7.50%	0.14	0.07%	0.03	0.99			
Meter Underregistration	13.64	50.00%	13.64	6.64%	3.22	16.86			
Unmeasured Households	531.85						546.10	-7.00	539.10
Consumption	478.17	5.00%	47.82	23.28%	11.28	489.45			
SPL	48.37	7.50%	7.26	3.53%	1.71	50.08			
Meter Underregistration	5.32	50.00%	5.32	2.59%	1.25	6.57			
Unmeasured Non-Household	2.08						2.26	0.00	2.26
Consumption	1.43	25.00%	0.72	0.35%	0.17	1.60			
SPL	0.64	7.50%	0.10	0.05%	0.02	0.66			
Water taken illegally	10.64	50.00%	10.64	5.18%	2.51	13.15	13.15	0.00	
Water Taken legally	12.80	50.00%	12.80	6.23%	3.02	15.82	20.83	0.00	
Void SPL	4.49	25.00%	2.24	1.09%	0.53	5.01			
Distribution Op Use	4.13	50.00%	4.13	2.01%	0.98	5.11	5.11	0.00	
Total Water Delivered (excl DOU)	1021.78					1050.55	1057.12		
Distribution Losses	216.50	7.50%	32.47	15.81%	7.66	224.16	224.16	0.00	
Distribution Input	1290.86	0.73%	18.85	9.18%	-4.45	1286.41	1286.41		
Water accounted for	1242.42						1286.39		
Difference	48.44						0.02		
as % of DI	3.75%						0.00		
Total spl (inc void spl)	64.14						66.77		
Total Leakage	280.64	21.74%					290.93		
Dist losses per Int Flow method	216.50						224.16		

4.21.2 The MLE adjustment has been assigned to each resource zone proportionally by population.

4.22 Changes in Total Demand

4.22.1 The total water delivered increases by 10 Ml/d (0.78 percent), to 1288.50 Ml/d by the end of the forecasting period. The total demand decreases for the first half of the forecasting period to 1263.63 Ml/d in 2019/20 due to the assumptions in the micro-component model of the introduction of water efficient appliances. In 2019/20 the micro-component model assumes that the transition to water efficient appliances is complete and the downward trend of per capita consumption is reversed. This leads to an increase in total demand during the second half of the plan.

4.23 Dry and Critical Period Demands

4.23.1 The Normal Year forecasts are based on average weather conditions. The Dry Year effect on customer demand is based on analysis of monthly DCM data (i.e. per capita consumption data) since 1995, which was considered to be a dry year. This analysis suggests an increase in demand of 50 Ml/d above a normal year demand. Analysis showed that 77 percent of the increased water usage in a dry year is attributable to household demands. The remaining increase in demand is attributed to non-household use.

4.23.2 The household demands in the Dry Year are calculated using the micro-component model in line with the 38.5 Ml/d increase in water use during a dry year. The increase in household demand is attributed to an increase in personal washing and garden use.

4.23.3 For Critical Periods the same proportions as above, i.e. 77 percent of the increase in total demand is attributed to households and 23 percent to non-households, are assumed to hold.

5. WATER EFFICIENCY

5.1 Background

5.1.1 Since 1996, water companies have had a duty to promote the efficient use of water by all their customers. In addition to meeting this requirement, water efficiency is an integral part of the Company's water resource planning. Yorkshire Water continues to actively promote water saving through household and non-household water efficiency activities. The water savings achieved as a result of this activity are incorporated into household and non-household demand forecasts.

5.1.2 The key themes of Yorkshire Water's water efficiency plan are:

- Delivery of water efficiency at an economic level
- Commitment to offer customers opportunities and benefits of water efficiency
- Communicating the water efficiency message to customers
- Promotion of water efficiency in line with the Ofwat Good Practice Register
- A continued drive for innovation and best practice

5.1.3 Activity will be undertaken to ensure the Company meets water efficiency targets for the remainder of the current planning period and throughout the future planning horizon to 3034/35.

5.1.4 Customer side management options have been included in the economic appraisal of the supply-demand balance. Increased customer water efficiency through increased metering, including metering on change of occupancy, and use of water saving devices have been included as options to meet the forecast supply demand deficit in the economic model. This allows future additional water efficiency activity to be planned at an economic level. Full details are given in Section 7 Economic Appraisal.

5.1.5 Yorkshire Water is committed to promoting the benefits of water efficiency to our household and non-household customers. Details of Yorkshire Water's current strategy are given below.

5.2 Promotion of Efficient Use in Households

5.2.1 Household water efficiency is promoted by the following activities. Further details of these are:

- Free supply pipe repair policy
- Free cistern devices
- Self water audit packs
- Promotion of water saving equipment

- Metering policy
- Innovative water efficiency communication campaigns

5.3 Free Supply Pipe Repairs

5.3.1 Yorkshire Water continues to offer a free supply pipe repair policy ensuring losses through these apparatus are kept to a minimum. This continues to contribute to a reduction in demand.

5.3.2 In June 2006 the policy was restructured following a successful pilot study carried out the previous year. The new policy is aimed at raising customer awareness of supply pipe ownership and gives options to manage the associated responsibility.

5.3.3 Under the new policy, a leaking supply pipe is repaired free of charge for domestic customers, however further repairs will be at the customer's own expense for a two year period following repair.

5.3.4 Following repair the customer is advised of their responsibility to maintain and repair the supply pipe and given the choice of replacing the pipe, taking out an insurance policy or taking no action. If the customer chooses to replace the pipe Yorkshire Water will contribute 50 percent of the costs up to a set limit.

5.4 Future Supply Pipe Strategy

5.4.1 A further review of the policy is currently being undertaken to build on the principles of the existing strategy. The aim of the review is to understand the benefits of replacing supply pipes rather than undertaking repairs.

5.4.2 The review will take into account considerations such as removal of lead pipe, impact on customers and innovative techniques to reduce the cost of replacement.

5.5 Free Cistern Displacement Devices

5.5.1 The Company continues to offer free cistern devices to customers on request. This initiative has been in operation since September 1997. Following problems with double flushing associated with the larger devices Yorkshire Water now promote the use of smaller save-a-flush bags that reduce the cistern volume by 1 litre.

5.5.2 Customers are made aware of the availability of cistern devices through the 'Clear' customer guide (received with annual billing), the Yorkshire Water website and community initiatives.

5.5.3 Cistern devices are also promoted at Communication Campaign events. These events allow the distribution of significant numbers of devices throughout the region. As the cistern devices are given out on request, this strategy has proved more effective than mailshot distribution as the fitting rate by customers will be considerably higher.

5.6 Self Water Audit Packs

5.6.1 Yorkshire Water distribute a water audit pack to customers containing water saving information and a cistern device. The pack is designed to have a visual impact and is written in a consumer friendly style to increase customer engagement with the water efficiency message. It contains a self audit questionnaire in which customers can determine their own level of water efficiency.

5.6.2 Customers are made aware of the availability of water audit packs through the 'Clear' customer guide, received annually with customer bills, the Yorkshire Water website and community initiatives.

5.7 Promotion of Water Saving Equipment

5.7.1 Yorkshire Water offer discounted water butts through a mail order agreement with a local supplier. As around 85,000 litres of rainwater fall on the average house each year, encouraging our customers to use this water as an alternative to tap water for garden watering and car washing is seen as an excellent water efficiency opportunity.

5.7.2 The water butt offer is available in the 'Clear' customer guide, the Yorkshire Water website and advertised at campaign events throughout the year.

5.7.3 Additional water saving equipment, such as hose trigger guns, will continue to be offered free or at a discounted price to customers on the company website.

5.8 Metering

5.8.1 Yorkshire Water operates a free meter option scheme, which is promoted in the 'Clear' customer guide. A forecast of domestic meter optants per annum has been included in the demand forecast, in line with the numbers discussed in Section 4.9.

5.8.2 Savings of approximately 5-10 percent of water used are typically seen after the installation of a meter. These savings are a major contribution to water efficiency and are incorporated into the demand forecasts.

5.8.3 At present approximately 30 percent of the domestic customers within the Yorkshire Water area have a metered supply. This is forecast to increase to 35 percent by 2010. If domestic meter options continue to increase at the current level this could reach 65 percent by 2035.

5.8.4 Metering is instinctively the most appropriate method of charging for water and sewerage, based on payment for use. It may also result in better management of water resources. However, Yorkshire is considered to be an area of relatively low water stress and in the absence of a resource issue it does not make economic sense to rapidly increase meter penetration over and above customer led demand.

5.8.5 Metering is expensive compared to unmeasured billing and puts significant pressure on customers' bills; there is the capital cost of the meter, a replacement cost every 10 years and the ongoing operating costs of servicing a measured account. The cost of metering coupled with a policy of maintaining an element of customer choice, results in a demand led move to domestic metering in Yorkshire.

5.8.6 The impact of tariff structures is considered to be a potential route for future demand management. However, the use of tariffs is currently limited by the relative size of the unmeasured and measured customer base. Different tariff structures will have no effect on the behaviour of unmeasured customers, which make up the vast majority of the current domestic base, and will remain a majority over the foreseeable future. Different tariff structures, therefore, will not have an impact on the water use of the majority of the domestic customer base and therefore will not have a significant impact on the total customer base as whole.

5.8.7 Additionally, consideration needs to be given to the issue of fairness in targeting the minority (i.e. measured element) of the customer base with a different tariff structure while the majority of customers, who are unmeasured, would remain unaffected.

5.9 Communication Campaigns

5.9.1 Yorkshire Water's approach to the promotion of water efficiency is to undertake high profile interactive customer campaigns. The aim of these campaigns is to raise public awareness of the importance of conserving water and to encourage the use of water saving devices. The campaigns are run in association with the Company's Public Relations and Marketing departments to maximise the use of media and customer interaction, hence taking the water efficiency message to a wider audience.

5.9.2 Key messages of the campaigns are that:

- Water efficiency is easy and everyone can save water through simple lifestyle changes
- Predictions are for drier summers therefore water saving will be increasingly important
- Water efficiency is important all year round, even when it's raining.

5.10 Promoting Water Efficiency to Non-household Customers

5.10.1 Non-household water efficiency is promoted by the following activities:

- Self water audit packs
- Water audits and efficiency surveys
- Leakage detection surveys
- Flow monitoring

Further details of these are given below:

5.11 Self Water Audit Packs

5.11.1 A number of self audit initiatives are carried out annually, aimed at specific target groups of businesses to allow relevant information to be provided. Typically water efficiency information will be provided and details of self assessment forms available on the company website.

5.12 Water Audits and Efficiency Surveys

5.12.1 Yorkshire Water utilise various service partners in addition to in-house expertise to carry out domestic water efficiency audits, providing advice and potential solutions for reducing water and wastewater costs.

5.13 Leakage Detection Surveys

5.13.1 Potential leakage at a customer site may be identified by remote flow logging carried out by Yorkshire Water. When identified, leakage detection surveys are carried out using a variety of methods to detect leaks. Accurate leakage detection minimises unnecessary trial excavations, reducing cost, time and disruption.

5.13.2 Leakage detection surveys and repair consistently account for the largest proportion of estimated non-household water efficiency in Yorkshire.

5.14 Flow Monitoring

5.14.1 Yorkshire Water provides a service to remotely monitor water consumption by installation of flow loggers on revenue meters. Data from the loggers are downloaded on a daily basis and made available to customers via a personal website. Anomalies in normal daily water consumption caused by leakage or inefficient operation of process equipment can be identified and remedied, resulting in increased water efficiency at the site.

5.14.2 Projected demand reductions as a result of water efficiency initiatives and waste minimisation are incorporated into the demand forecasts presented in Table WRP2.

5.15 Water Efficiency Research

5.15.1 A household water audit project is currently underway to assess potential water savings through the retro fitting of water efficient appliances in domestic properties. The 18 month project involves the fitting of appliances such as tap aerators, cistern devices and efficient shower heads at 500 properties in the Yorkshire region. Logged water usage before and after fitting will be analysed and an assessment of water saving achieved as a result of this activity will be made.

5.15.2 The results of the research will be reported in the Final Water Resources Management Plan in 2009 and considered as a potential option for meeting any forecast supply / demand deficit.

6. LEAKAGE CONTROL

6.1 Total Leakage

6.1.1 Since 1995 Yorkshire Water has reduced total leakage by 45 percent. This is as a result of increased leakage detection and repair and a programme of distribution pressure management.

6.1.2 Total leakage is estimated as the sum of distribution losses plus leakage from customer owned supply pipes.

6.1.3 In 2006/07 the actual leakage reported was 293.4Ml/d, against a target of 297.1Ml/d. The volume of distribution losses was 226.05Ml/d, whereas reported customer supply pipe leakage was 67.4Ml/d.

Table 6.1: Components of Total Leakage reported in 2006/07

	Component	Volume Ml/d
Distribution losses	Distribution Main leakage	183.85
	Trunk Main leakage	40.43
	Service Reservoir losses	1.77
Customer supply pipes		67.44
Total		293.4

6.2 Distribution Losses

6.2.1 Distributed losses are estimated as the sum of leakage from distribution mains, trunk mains and service reservoirs. Leakage from customer owned supply pipes is excluded from this estimation.

6.3 Distribution Mains

6.3.1 Yorkshire Water undertakes an assessment of distribution mains losses on a continuous basis through daily monitoring of flow in Distribution Management Areas (DMAs).

6.3.2 The distribution network has been divided into approximately 2,100 DMAs, with an average size of approximately 1000 properties.

6.3.3 Approximately 96 percent of properties are within "Category 1" DMAs. These are discrete areas that are permanently metered and have flows in and out of the area recorded every 15 minutes, from which a nightline can be derived.

6.3.4 Monitoring of night-time flows within DMAs, when usage is at its lowest, allows derivation of leakage estimates. Permanent loggers are installed on DMA meters, these loggers are downloaded on a 2 weekly basis and the data processed by a company system which calculates the level of leakage in each DMA. The average of each day's lowest 15 minute value is calculated to produce the average gross nightline.

6.3.5 Leakage targets have been established for each DMA, based on the lowest achievable night flow or modelling to establish background night flows. The target is based on a night time flow in each DMA calculated as litres per property per hour and excludes an estimate of legitimate night time use by domestic and commercial customers.

6.3.6 Leakage detection prioritisation is based on identification of DMAs with night flows that exceed the established target level.

6.3.7 Where properties are not within an established DMA and are therefore not monitored, the Company undertakes a full sounding of the area on an annual basis to identify potential leakage

6.3.8 Subtraction of domestic and commercial allowances from the average gross nightline produces the average net nightline, which is the best estimate of all the leakage within the leakage control zones, including underground supply pipe leakage.

6.3.9 At the time when the nightlines are measured, however, with flows at their lowest, pressures in the system tend to be at their highest, so nightline flows measured in litres per hour would slightly overestimate the daily average. To deal with this over-estimation, the conversion of nightlines from litres per hour to litres per day has been made by multiplying the nightline by an estimated hour to day factor, which is currently 21.9 hours, rather than 24 hours.

6.3.10 Leakage from Yorkshire Water distribution mains is estimated as leakage within DMAs minus an estimate of leakage attributed to customer owned supply pipes.

6.4 Trunk Mains

6.4.1 Trunk mains are defined as all those mains between the water treatment works outlet and the inlet to DMAs. Losses from trunk mains are not measured but are estimated as 3 percent of distribution input.

6.5 Service Reservoir Leakage

6.5.1 There are two components of service reservoir leakage; structural losses and losses due to overflow.

6.5.2 Location of service reservoir leakage forms part of the Company's service reservoir maintenance programme. This is a rolling programme of service reservoir cleaning and inspection. A points system is used to determine the schedule of cleaning and inspection, based on a number of factors including water quality compliance, asset age, date of last refurbishment and known structural faults.

6.5.3 Following cleaning and inspection a drop test is carried out on the refilled service reservoir to assess leakage. The reservoir is filled, inlets and outlets are shut off, and changes in water level over 24 hours are recorded, any drop in level will indicate a leak.

6.5.4 Under the rolling inspection programme, all service reservoirs are assessed for leakage every three to eight years. The larger capacity reservoirs, with the greatest potential leakage, are assessed every three years.

6.6 Service Reservoir Overflow

6.6.1 As well as losses through the structure of service reservoirs, ineffective water level control can lead to losses via overflows. The volume of water lost through a period of overflow is estimated from the duration of 'high alarm events' at service reservoir sites.

6.7 Customer Supply Pipe Leakage

6.7.1 The total volume of supply pipe leakage is estimated to be 26.7 percent of leakage within DMAs. This was calculated from an assessment of undetected losses, background losses and burst losses determined from properties on the Company's DCM and by the modelling of supply pipe leakage flow rates.

6.8 Future Leakage Targets

6.8.1 The economic level of leakage was last determined in June 2007 and current leakage targets are based on this assessment. A similar approach has been adopted in the re-assessment of the economic level of leakage within this plan.

6.8.2 Options for leakage reduction have been included in the supply / demand appraisal process which compares all of the options for balancing supply and demand in the resource zones. These options include additional 'find and fix' activity and leakage reduction through a programme of mains repair and replacement. The results of the appraisal indicate how much further leakage should be reduced in each resource zone, beyond existing targets, as part of the economic solution.

6.8.3 This process is used to determine the economic level of leakage for each resource zone, i.e. the point at which to increase leakage control activity would cost more than alternative options to bridge the deficit gap between supply and demand.

6.8.4 The sum of the economic level of leakage for each resource zone gives a revised company level economic level of leakage and future leakage strategy. Details of future leakage targets determined through the economic level of leakage assessment are given in Table 7.7: Leakage Targets at Resource Zone Level.

7. ECONOMIC APPRAISAL

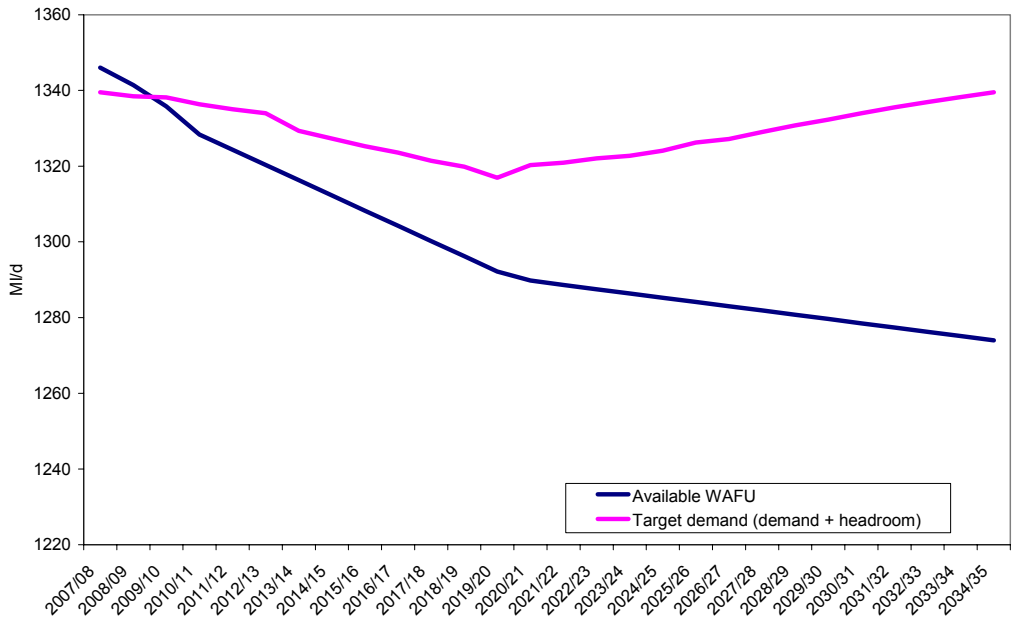
7.1 Resulting Surplus/Deficit

7.1.1 A supply-demand appraisal has been undertaken for each of the three water resource zones for the Dry Year Average Annual planning scenario. The Critical Period has also been assessed for the East Ground Water and Surface Water resource zones. Additionally, the supply-demand balance has been appraised at Production Management Zone (PMZ) level in the East Ground Water and Surface Water resource zones to identify inter-zonal deficits due to distribution management issues.

7.1.2 Deficits have been identified in the Grid Surface Water Zone in the Annual Average scenario from 2009/10. No deficits have been identified for the East Ground Water or East Surface Water zones in either the Dry Year Annual Average or Critical Period scenarios throughout the planning period. Further analysis at PMZ level identified no deficits within these two zones in either the Dry Year Annual Average or Critical Period planning scenarios.

7.1.3 The baseline supply-demand balance for the Grid Surface Water Zone is shown in Figure 7-1 below.

Figure 7-1: Baseline Dry Year Annual Average Grid Surface Water Zone Supply-Demand Balance



7.1.4 Summaries of the resulting deficits at zonal level are given in Table 7.1 Forecast Supply-Demand Deficit (Ml/d) below.

Table 7.1 Forecast Supply-Demand Deficit (Ml/d)

Water Resource Zone	Planning Scenario	2007/08	2008/09	2009/10	2010/11	2015/16	2020/21	2025/26	2030/31	2034/35
East SWZ	Annual Average	0	0	0	0	0	0	0	0	0
	Critical Period	0	0	0	0	0	0	0	0	0
East GWZ	Annual Average	0	0	0	0	0	0	0	0	0
	Critical Period	0	0	0	0	0	0	0	0	0
Grid SWZ	Annual Average	0	0	2.38	7.99	16.99	32.31	42.11	55.46	65.54

7.1.5 An economic model has been used to optimally schedule Resource, Distribution, Production and Customer side investment options to meet the projected deficit within the Grid Surface Water Zone at minimum net present cost.

7.2 Economic Model

7.2.1 Following the production of the Economic Level of Leakage report in 1997, Yorkshire Water, in association with the consultants NERA, developed an economic model for economic analysis.

7.2.2 The model has been used to optimally schedule Resource, Distribution, Production and Customer side conservation investment options to meet any projected deficit at minimum net present cost.

7.2.3 The model utilises a programming approach as described in the report, *The Economics of Balancing Supply and Demand*, (Environment Agency and UKWIR, 2002).

7.2.4 This takes account of all available supply and demand options for meeting any deficit. In addition to developing a minimum net present cost solution to meet future deficits, this process is also used to determine the economic level of leakage, i.e. the point at which to increase leakage control activity would cost more than alternative options to bridge the deficit gap between supply and demand.

7.2.5 Options are characterised by all financial and physical parameters. Financial details include all capital, operational, environmental and social costs; physical parameters refer to yield, load and capacity ramp-up. The model also allows the first practical 'year available' to be specified.

7.2.6 The model has the capability of scheduling options with a wide range of physical and cost characteristics e.g. interdependent, mutually exclusive and time specific. The model also has a wide range of facilities for sensitivity testing.

7.2.7 The IRP model utilises a linear/integer programming approach as described in the UKWIR report, *The Economics of Balancing Supply and Demand*, (Environment Agency and UKWIR, 2002). This is an alternative technique to the AISC (average incremental social cost) approach for option selection.

7.2.8 Where there are only variable costs and no option dependencies the AISC and integer programming methodologies will give the same solution. If there are dependencies between options the AISC approach may not give the optimal ranking without 'fine tuning', which may result in an alternative solution being overlooked.

7.2.9 The integer programme technique selects a schedule of options that will, in aggregate, meet total demand in each year from the base year across the 25 year planning horizon. The selected schedule of options has the least net present cost (NPV). All option costs are specified in base year terms and discounted using the real cost of capital.

7.2.10 The output from the model includes AIC, AISC and NPV costs as defined in the *The Economics of Balancing Supply and Demand*, (Environment Agency and UKWIR, 2002), based on the output of the scheme.

7.3 Types of Options Available to Meet the Deficit

7.3.1 Options for bridging a supply-demand gap deficit can be grouped into four categories:

(a) **Resource management**, policies that affect yield

(b) **Production management**, policies targeted at activities between the points of abstraction and distribution input

(c) **Distribution management**, policies targeted at activities between the points of distribution input and consumption

(d) **Customer side management**, policies targeted at customers' consumption, comprising supply pipe and plumbing losses and customer end use.

7.4 Development of Potential Options

7.4.1 The Water Resources Plan 2004 identified a range of resources schemes for bridging a supply-demand deficit. These schemes have been re-appraised to determine viable and practical options for inclusion in the economic model. Additional options, which are now possible because of changes in technology and research and development, have also been included.

7.4.2 Unit costs for the resource investment projects identified in the Water Resources Plan 2004, have been updated in line with inflation using the Construction Output Prices Index (COPI). New schemes were identified within a workshop in February 2007 and the feasible schemes have been costed by the consultants Arup.

7.4.3 During the workshop the options identified were reviewed against scoring criteria for technical, environmental and social attributes. The scoring criteria in this options review is similar to that used in the 2004 Water Resources Plan, based on a system used by the Environment Agency in '*Water Resources for the Future: A Strategy for the North-East Region*' (March 2000, Environment Agency). The method assigns options with scores for estimates of four technical attributes; yield quantity, cost of scheme, time to implement and asset life of infrastructure.

7.4.4 The current Environment Agency Guideline (April 2007) requires water companies to consider further implications of scheme selection, including environmental, social and carbon costs. For the 2009 Plan two qualitative scores were added to the scoring methodology to reflect the environmental and social impacts of each option. Carbon was excluded from the scoring as there was not sufficient information to make an estimate on the potential carbon impacts.

7.4.5 The scores were used in the determination of which schemes were feasible options. Appendix A gives a list of all potential options considered i.e. the unconstrained list of options.

7.4.6 The options considered to be feasible potential solutions to meeting a deficit have been assessed and costed by the consultants Arup. A brief description of the feasible options for the Grid Surface Water Zone is provided below.

7.5 Description of Feasible Options for the Grid Surface Water Zone

7.5.1 Customer Side Management

CO1 & C02: Conservation – Savaflush Option 1 & 2

This conservation measure involves the distribution of cistern devices to be placed in customer toilets to reduce the volume of water used per flush. There are two savaflush options; Option 1 is predicted to lead to a reduction in water usage of 1.8 Ml/d after 5 years, while Option 2 is predicted to lead to a 3.6Ml/d reduction after 5 years.

C03: Urinal Controllers

This scheme involves voluntary replacement of urinal systems, within commercial properties, with new Passive Infra Red (PIR) urinal controllers. The scheme would be offered to businesses in the Yorkshire Water region and aims to reduce water usage by 4.5Ml/d after the first year.

C04: Metering on Change of Occupacy

A meter would be installed in unmeasured households on change of occupancy. It is estimated demand would reduce by 12.5Ml/d after five years.

C05: Conservation – Metering 50,000 Properties (Domestic Meter Optants)

This scheme involves additional promotion of metering to encourage 50,000 unmetered households to opt to have a meter installed. The scheme aims to reduce water consumption by 0.61Ml/d after a five year implementation period.

7.5.2 Distribution Side Management

D01 to DO9: Leakage reduction

Leakage reduction aims to reduce the demand for water by reducing the number of leakage events in the supply network, through active leakage control measures. This scheme aims to reduce previous leakage targets by up to 45Ml/d. Leakage reduction would be implemented in 5Ml/d phases, each taking a year to complete.

D10 to D12: Mains Replacement/Re-lining Phase 1 to 3

This scheme aims to reduce leakage by replacing / relining pipes considered having the greatest potential to leak. The scheme is to be implemented in three phases. Each phase is estimated to reduce leakage by 5Ml/d and will take two years to implement, with a total implementation period of six years.

7.5.3 Resource Side Management

R01: Swale Groundwater Source

This scheme involves an application for an increase to an existing groundwater abstraction licence in the Swale area, which would increase yield by 2Ml/d, and be operational after one year.

R02: East Yorkshire Treatment Works Optimisation

This scheme involves the construction of a new pumping station and pipeline in order to transfer 25Ml/d between two treatment works in the East Yorkshire area. The scheme would be operational after 1 year.

R03: Re-use Abandoned Industrial Licences

This scheme incorporates the usage or adoption of existing abstraction licences in private ownership. There is currently a borehole source in the Halifax area under consideration, with a potential yield of 1Ml/d, to be implemented in one year.

R04: Ouse Raw Water Transfer

This scheme involves installing a new water main between an existing abstraction on the River Ouse and existing water treatment works. This is estimated to increase yield by 52Ml/d using the current abstraction license, and is to be implemented after three years.

R05 to R07: Tees to Derwent Pipeline Option 1 Phases 1 – 3

Scheme involves construction of a pumping station on the River Tees and a new water main to import water from an existing Northumbrian Water abstraction on the Tees, to an existing water treatment works in the Derwent area. The yield is estimated to be up to 150Ml/d. The scheme would be operational after three years.

R08 to R10: Tees to Derwent Pipeline Option 2 Phases 1 - 3

This scheme is similar to the above but would involve Yorkshire Water applying for its own abstraction licence on the River Tees instead of importing from Northumbrian Water. The yield is estimated to be up to 150Ml/d. The scheme would be operational after three years.

R11: Bankside Storage on the River Ouse

This scheme would involve the construction of a pumping station, water main and storage reservoir in an area west of York. During periods of higher flow water abstracted from the River Ouse using an existing licence could be stored in the reservoir. At low flows the abstraction could cease and stored water could be put into supply. The abstraction would require a 150Ml/d license, and is expected to increase deployable output by 120Ml/d, allowing for a potential 30Ml/d loss to evaporation. This scheme will be implemented over three years.

R12: *River Ouse Water Treatment Works Extension Option 1*

This scheme involves extension of an existing water treatment works on the River Ouse to provide an average yield of 49Ml/d. This would increase the current yield by 22Ml/d and be implemented after three years.

R13: River Ouse Water Treatment Works Extension Option 2

This scheme involves extension of an existing water treatment works on the River Ouse. The scheme is similar to R12 but would provide an average yield of 96Ml/d, which is an increase of 69Ml/d over the current yield, and is to be implemented after three years.

R14 & R15: River Extension Stage 1 & 2

This reservoir raising scheme involves the extension of an existing reservoir in the North Yorkshire area. The scheme would occur in two stages (stage 1 providing an additional 40Ml/d and stage 2 an additional 130Ml/d), and is expected to increase deployable output by 170Ml/d, and be operational after ten years.

R16: Dales Pipeline

This scheme involves construction of a new pipeline in the Yorkshire Dales area. The scheme is expected to provide 6Ml/d and be implemented after three years.

R17: Increased River Ouse Pumped Storage Capacity

The scheme involves construction of a new transfer main and pumping station between the River Ouse and water treatment works in the West Yorkshire area. The scheme could be used to maximize the existing abstraction license on the Ouse. This would provide a potential additional yield of 10Ml/d within 12 months.

R18: River Aire Abstraction Option 1

A new abstraction on the River Aire would involve the construction of a pumping station and water main in order to abstract and then transport water to an existing water treatment works. The scheme considers a potential yield of 10Ml/d, to be operational after three years.

R19: River Aire Abstraction Option 2

A new abstraction from the River Aire requiring construction of a pumping station and water main in order to abstract and transport water to an existing water treatment works. For this scheme there is a minimum of 13.8Ml/d available, potentially up to 50Ml/d. The scheme is to be operational after one year.

R20: River Aire Abstraction Option 3

A new abstraction from the River Aire, involving construction of a pumping station, new water main and bankside storage reservoir. This scheme could also require construction of a new treatment works or the upgrading of an existing treatment works. The scheme estimates a potential yield of 20Ml/d, and aims to be operational after three years.

R21: New Pumped Reservoir Refill Scheme

This scheme involves the construction of a new pumping station and pipeline in order to abstract from the River Wharfe at periods of high flow and store at an existing reservoir, for release at periods of low flow. The additional compensation flow would allow existing abstraction to continue, increasing total yield by 5Ml/d at low flows. The scheme would be operational after 1 year.

R22: River Calder Abstraction

A new abstraction from the River Calder involving construction of a pumping station and water main, and transport of water to an existing water treatment works. This could potentially involve expansion of an existing works. The scheme is expected to yield 10Ml/d, and to be operational after four years.

R23: *Supply Dales from Tees Option 1*

This scheme involves supplementing the Dales supply area from the River Tees. The water from the Tees would be supplied by an import from Northumbrian Water. A new main from the abstraction to a storage reservoir would be required. The scheme would also involve constructing a pumping station and new water treatment works in the Dales area. The yield is estimated at 20Ml/d and could be implemented in three years.

R24: Supply Dales from Tees Option 2

This scheme is similar to the above scheme but Yorkshire Water would apply for its own licence on the Tees instead of importing from Northumbrian Water. This scheme could provide 20Ml/d and could be constructed over three years.

R25: Minewater Scheme 1

This scheme involves the construction of two pumping stations, two pipelines, a lagoon and reedbeds in order to treat and use discharged minewater. It is estimated that the scheme would increase deployable output by 2Ml/d, being implemented over 1 year.

R26: Minewater Scheme 2

This scheme involves the construction of pumps, a new pumping station, a pipeline between existing water treatment works and additional treatment facilities at the works. It is estimated that the scheme would increase deployable output by 10Ml/d, and be implemented over two years.

R27: River Trent Abstraction

A new abstraction on the River Trent would incorporate a new pumping station, bankside storage reservoir and water treatment works. The estimated yield is 32Ml/d and the scheme would be operational in one year.

R28: Extended Groundwater Scheme

Existing borehole licenses in the York area could be used to augment flow in the River Ouse. The additional flow would support existing abstraction from the River Ouse. The scheme is estimated to provide 44Ml/d and be operational after five years.

R29: Pennine Dam Raising Scheme 1

This reservoir scheme involves increasing the height of the existing dam of a reservoir in the Pennines. The scheme is expected to increase deployable output by 2Ml/d, and be operational after 3 years.

R30: Pennine Dam Raising Scheme 2

This scheme involves raising the height of the existing dam wall of a reservoir in the Pennines. The scheme is expected to increase deployable output by 0.28Ml/d, and be operational after one year.

R31: Pennine Dam Raising Scheme 3

This scheme involves raising the height of the existing dam wall of a reservoir in the Pennines. The scheme is expected to increase deployable output by 0.05Ml/d, and be operational after two years.

R32: Desalination

This scheme involves extensive construction of a water treatment works on the East Yorkshire coast. The scheme involves construction of; pumped beach wells for seawater abstraction, water mains from the wells to the water treatment works, and water mains from the water treatment works to the Grid Surface Water Zone supply network. The scheme would employ reverse osmosis as a 'lower-energy' method of desalinisation. The water treatment works would include pre-treatment, post-treatment and energy recovery, and is predicted to increase deployable output by 20Ml/d. The scheme is to be implemented after six years.

R33: Reservoir De-silting

This scheme aims to increase the capacity of 26 reservoirs by dredging and desilting. The silt would be taken to a landfill site. The scheme is estimated to increase deployable output by 22Ml/d. The scheme is expected to be fully operational after 7 years.

R34: Washburn Dam Raising

This scheme involves raising the height of the existing dam wall of a reservoir in the Washburn area. The scheme is expected to increase deployable output by 2.2Ml/d, and be operational after one year.

R35 & R36: Wensleydale Dam Raising Option 1 & 2

This scheme involves raising the height of the existing dam wall of a reservoir in the Wensleydale area by either 0.5m (option 1) or 0.9m (option 2). The scheme is expected to increase deployable output by either 0.37Ml/d (option 1) or 0.64Ml/d (option 2), and be operational after one year.

R37: River Water Recharge

This scheme involves the creation of sand and gravel spreading basins, pre-treatment areas such as settlement lagoons and reedbeds in the Doncaster area. Water from a nearby water source would be passed through the basins, lagoons and reedbeds for treatment, then transferred to the Sherwood Sandstone aquifer. The scheme is expected to increase yield by 25Ml/d, and be operational after 3 years.

R38 to R40: Tees to Swale River Transfer Option 1 Phases 1 – 3

This scheme is similar to the Tees to Derwent pipeline option 1 but uses river courses to transfer water instead of a pipeline. The scheme requires construction of a water main and pressure tank to enable water to be transferred from an existing River Tees abstraction, owned by Northumbrian Water, to the River Swale. This water would be passed from the Swale, via the Ure, to the Ouse to support an existing licence. The yield is estimated to be up to 150Ml/d and could be implemented in phases. This scheme would be operational after three years.

R41 to R43: Tees to Swale River Transfer Option 2 Phases 1 – 3

This scheme is similar to the Tees to Derwent pipeline option 2 but uses river courses to transfer water instead of a pipeline. The scheme differs to the above option in that it would involve Yorkshire Water applying for its own licence on the River Tees, instead of importing from Northumbrian Water. The yield could be up to 150Ml/d, with the scheme becoming operational after three years.

R44: River Intake Optimisation

Intakes on the River Nidd would be transferred to an existing reservoir. The additional yield to the reservoir is estimated to be 6Ml/d. This scheme would be operational within 12 months.

R45: Aquifer Storage and Recovery Scheme 1

This scheme involves the use of five new pumped boreholes to artificially 'charge' the Sherwood sandstone aquifer, allowing the use of this water supply during drier periods. The yield is estimated to be 25Ml/d, providing an average yield of 12.5Ml/d, implemented after five years.

R46: Pumped Storage Reservoir

The construction of an earth embankment dam, reservoir, water main and additional raw storage capacity would allow flows from a local tributary to be stored before released into the River Swale, or used for local water supply. Flow transferred into the Swale could support existing abstraction on the Ouse. The storage reservoir is expected to increase deployable output by 35Ml/d. Implementation would be over a ten year period.

7.6 Environmental Economics

7.6.1 Environmental and social costs of water resource schemes have been reappraised since the 2004 Water Resources Plan submission for inclusion in the economic assessment for this plan. A desktop assessment has been undertaken for all of the possible schemes. In addition to the last submission, a Strategic Environmental Directive assessment has occurred in parallel to this assessment (see Section 7.7).

7.6.2 The Water resources planning guideline, 2007 recommends using the Risk and Policy Analysts Ltd (RPA) methodology, *Benefits Assessment Guidance,* (Environment Agency 2002) to estimate the environmental and social costs for the Final Water Resources Management Plan submission. The guidelines also recommend referring to the *Economics of Balancing Supply and Demand Methodology,* (UKWIR 2003) guidelines for the inclusion of environmental and social costs. The RPA methodology is an updated version of the methodology recommended in the UKWIR guidance. All costs from this report have been inflated to current prices using the retail price index or RPI.

7.6.3 The assessments are supported by several further reports and studies. The atmospheric carbon impact of each potential solution is based on the shadow price of carbon, as recommended in the Water resources planning guideline. However, the operational impacts have been derived from the *Workbook for Quantifying Greenhouse Gas Emissions* (UKWIR 2005) and the embodied carbon emissions have been derived from a Yorkshire Water based methodology. This methodology will align with the forthcoming UKWIR methodology for embodied carbon.

7.6.4 In addition, social costs in relation to traffic have been developed from a Yorkshire specific study *Lane Rental Charging – A Way Forward,* Stone and Webster, 2002.

7.6.5 The net effect of including the environmental and social costs, or benefits, is to marginally change the overall total cost of the scheme. These additional costs have been incorporated within the economic appraisal and are included within the optimisation procedure of the economic model. Sensitivity testing showed that there was minimal impact on the preferred solution.

7.6.6 Environmental, social and carbon costs for the Grid Surface Water Zone options are given in Appendix B.

7.7 Strategic Environmental Assessment

7.7.1 A Strategic Environmental Assessment (SEA) has been undertaken by environment consultancy Scott Wilson for all feasible options identified in the Draft Water Resources Management Plan. This assessment involves identification and evaluation of the impacts of the proposed plan on the environment.

7.7.2 This activity is a requirement under the English legislation 'Environmental Assessment of Plans and Programmes Regulations 2004 (the 'SEA Regulations'). This requires a high level of protection of the environment and integration of environmental considerations into the preparation and adoption of plans and programmes, with a view to promoting sustainable development.

7.7.3 Within the SEA the impact of the feasible options have been assessed against the following range of environmental criteria:

- Human Health
- Water (including water resources, water quality and flood risk)
- Soil
- Biodiversity
- Climate
- Cultural heritage
- Landscape

7.7.4 The environmental effects of each option have been investigated and recommended mitigating and monitoring activity for potential impacts included within the assessment.

7.7.5 A seven point impact assessment scale was used, with effect categories: major adverse, moderate adverse, minor adverse, neutral/negligible, minor beneficial, moderate beneficial and major beneficial.

7.8 Grid Surface Water Zone Preferred Solution

7.8.1 A preferred solution to meet a forecast deficit of 65 Mega litres/ day (Ml/d) by the end of the planning period in 2034/35 has been identified by an economic analysis of options and reference to the Strategic Environment Assessment.

7.8.2 The solution represents a balance of demand reduction options (additional leakage control) and the development of new or existing assets (Swale groundwater source and the River Ouse water treatment works.)

7.8.3 This twin track approach of demand reduction through additional leakage control and utilisation of existing abstraction capability achieves a balance to meet the Company's Strategic Direction Statement aspirations for service, leakage and carbon emission reduction.

7.8.4 The following table summarises the preferred solution of options to meet forecast deficits in the Grid Surface Water Zone.

Table 7.2: Optimum solution of options for Grid SWZ

Option	Build Start	Yield Start	Beneficial Completion	Yield Ml/d
Leakage reduction 5 Ml/d	2009	2009	2009	5
Leakage reduction 5 Ml/d	2010	2010	2010	5
Swale groundwater source	2010	2011	2011	2
Leakage reduction 5 Ml/d	2012	2012	2012	5
River Ouse treatment works extension option 1	2012	2015	2015	22
Leakage reduction 5 Ml/d	2024	2024	2024	5
Leakage reduction 5 Ml/d	2026	2026	2026	5
Leakage reduction 5 Ml/d	2028	2028	2028	5
Leakage reduction 5 Ml/d	2029	2029	2029	5
Leakage reduction 5 Ml/d	2031	2031	2031	5
Leakage reduction 5 Ml/d	2033	2033	2033	5
			Total Yield	69

7.8.5 The solution has been determined as the preferred plan based on the ability to meet the following criteria:

- Meets the supply demand deficit whilst maintaining the current level of service of 1 in 25 year hosepipe ban
- Represents a cost efficient solution
- Aligns with the aspirations within the Company's Strategic Direction Statement
- Minimises environmental impacts as determined by the Strategic Environmental Assessment.

7.8.6 The preferred solution will contribute 45 Ml/d to the Company's aspiration to '*halve existing levels of leakage*', as described in the Strategic Direction Statement. A proportion of the leakage reduction is required later in the 25 year planning period. This has the benefit of allowing time to develop more cost efficient leakage reduction solutions.

7.8.7 The major component of the solution is the development of the existing treatment works on the River Ouse. This expansion will provide increased resilience and flexibility of the grid supply system.

7.8.8 The River Ouse water treatment works extension provides a cost efficient additional resource and will be part of a required rebuild of the existing works. The treatment works is linked directly to the Yorkshire Water supply grid and the extension will provide additional support to meet supply/demand deficits within Yorkshire, additional resilience due to flooding and potential future grid strengthening and expansion. This will support the Company's aspiration to have no water restrictions, as detailed in the Strategic Direction Statement.

7.8.9 The development of the River Ouse water treatment works follows the completion of extensive investigations by the Environment Agency into the sustainability of Yorkshire Water's river abstraction licences as a part of the review of consents for the Habitats Directive. The Environment Agency has assessed the impacts of this solution and believes that utilising the full licence on the River Ouse is sustainable.

7.8.10 The preferred solution is not the least cost solution as determined by economic modelling. The identified least cost solution included additional leakage control (15 Ml/d) plus development of a River Ouse to River Derwent water transfer with a yield of 52 Ml/d. The small Swale groundwater source development is also required early in the planning period.

7.8.11 The least cost solution is, however, the most limited in terms of achieving the Strategic Direction Statement aspirations to 2035 of halving leakage and achieving no water restrictions.

7.8.12 In addition to increased grid flexibility, the strengthening of the River Ouse treatment works in the preferred solution spreads the risk across two treatment sites and meets our Company aspiration of maintaining supplies at all times.

7.8.13 The preferred solution has a higher overall cost than the least cost option. However, the additional cost will not have a material cost on customer charges within the Company's Business Plan.

7.8.14 A number of low AISC schemes included in the model were not selected in either the least cost or preferred solution. For example, the Tees transfer options would provide significant additional resource at relatively low cost. Due to the large yield these schemes have not been selected by the model, which operates by the selection of small incremental increases in yield to optimally meet the forecast deficit.

7.8.15 Reference to the Strategic Environmental Assessment has resulted in the omission of a number of schemes from the preferred solution. These include numerous reservoir dam raising schemes, where potentially negative impacts on environmentally sensitive areas have been identified. These include areas with environmental designations such as Site of Special Scientific Interest (SSSI), Area of Natural Beauty (AONB), Special Areas of Conservation (SAC) and Special Protection Areas (SPA).

7.8.16 A Strategic Environmental Assessment of the options included in the preferred solution has been undertaken. This showed that the planned demand reduction and resource development options would have a neutral or negligible effect on all assessed criteria, with the exception of water resources. For water resources the effect is considered to be moderately beneficial due to the water savings through increased leakage reduction.

7.8.17 A number of the feasible options involve maximising existing Yorkshire Water licensed abstractions or applying for new abstraction licences. Any new abstractions would be subject to licensing by the Environment Agency and existing licences could be amended under the Water Framework Directive. The CAMS status was considered in the assessment of options involving abstractions. CAMS give an indication of the availability of water in catchments and any constraints that are likely to apply to new licences.

7.8.18 The Water Framework Directive environmental objectives for surface and groundwater bodies will not be established until the Environment Agency publishes the Draft River Basin Management Plans. In accordance with Environment Agency guidelines the CAMS status has been used as an indication of which water bodies could be classed as not meeting the environmental objectives. None of the options selected by Yorkshire Water in this plan impact on a CAMS water resource management unit currently defined as over abstracted or over licensed, therefore it is assumed the options are not likely to impact on ecological status.

7.8.19 The costs of the preferred solution to meet the forecast deficit in the Grid Surface Water Zone are given in Table 7.3 below.

Table 7.3 Costs associated with the preferred solution

Selected Scheme	From Year	NPV WAFU (Ml)	AISC (p/m³)	Scheme NPC (£m)
Leakage reduction 5 Ml/d	2009	41,156	9.97	3.21
Swale groundwater source	2010	16,462	2.30	0.26
Leakage reduction 5 Ml/d	2010	41,156	11.77	3.56
Leakage reduction 5 Ml/d	2012	41,156	13.86	3.72
River Ouse treatment works extension Option 1	2012	165,361	28.02	28.82
Leakage reduction 5 Ml/d	2024	41,156	16.30	2.07
Leakage reduction 5 Ml/d	2026	41,156	19.18	2.09
Leakage reduction 5 Ml/d	2028	41,156	22.62	2.11
Leakage reduction 5 Ml/d	2030	41,156	26.78	2.10
Leakage reduction 5 Ml/d	2031	41,156	31.89	2.28
Leakage reduction 5 Ml/d	2033	41,156	38.26	2.26

7.8.20 Average incremental social cost (AISC) can be used to compare the relative cost per a unit of output, of different options. The AISC of each option is the net present value of the option costs divided by the net present value of the option output. This is the equivalent of WAFU.

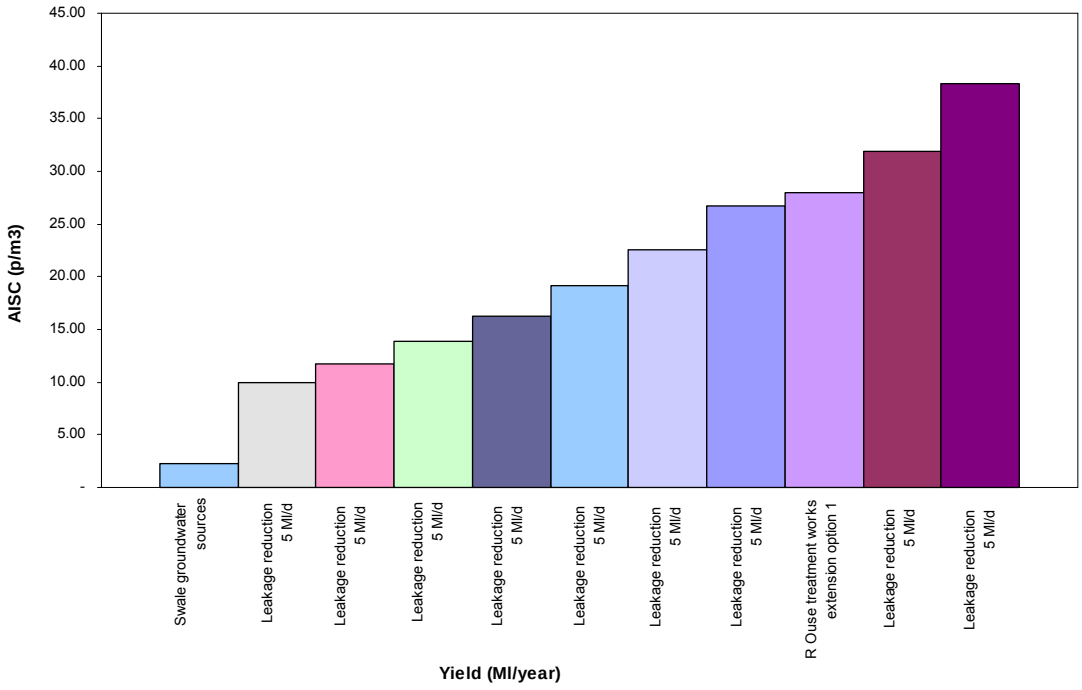
7.8.21 The net present value of option output (WAFU) is the sum of the yield gained from each year an option is utilised. A 4.5 percent discount rate is applied each year.

7.8.22 Net present values (NPV) for each solution are calculated in the economic model for an 80 year period starting in 2006/07. The discount rate of 4.5 percent is applied each year. Year on year costs are summed to give the NPV of capital, operational, environmental and social costs for each year the scheme is implemented.

7.8.23 The Grid Surface Water Zone Dry Year Annual Average Table WRP 2, provided in the attached tables, shows calculated AISCs and NPVs starting with the earliest feasible start data. Table 7.3 shows AISCs and NPVs calculated for the date the solutions would be implemented to meet the deficit.

7.8.24 Figure and Table 7.4 show the preferred solutions ranked by average incremental social cost.

Figure Figure 7.2 Preferred solution AISCs



7.8.25 Table 7.4 shows ranking of selected schemes by AISC

Table 7.4 Ranking of Selected Schemes

Selected Scheme	Ranking	AISC (p/m³)
Swale groundwater source	1	2.30
Leakage reduction 5 Ml/d	2	9.97
Leakage reduction 5 Ml/d	3	11.77
Leakage reduction 5 Ml/d	4	13.86
Leakage reduction 5 Ml/d	5	16.30
Leakage reduction 5 Ml/d	6	19.18
Leakage reduction 5 Ml/d	7	22.62
Leakage reduction 5 Ml/d	8	26.78
River Ouse treatment works extension Option1	9	28.02
Leakage reduction 5 Ml/d	10	31.89
Leakage reduction 5 Ml/d	11	38.26

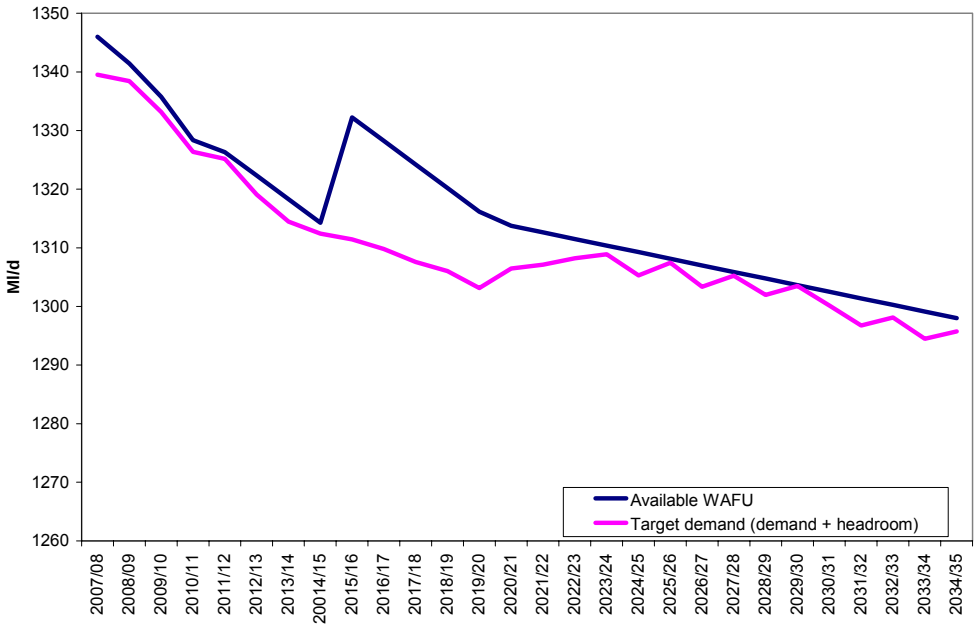
7.8.26 Table 7.5 below shows the effect of the estimated cost of carbon on scheme AISC

Table 7.5: Effect of the cost of carbon on AISCs

Selected Scheme	AISC (including carbon costs) (p/m³)	AISC (excluding carbon costs) (p/m³)
Swale Groundwater Sources	2.31	2.06
Leakage reduction 5 Ml/d	10.68	10.92
Leakage reduction 5 Ml/d	12.51	12.72
Leakage reduction 5 Ml/d	14.64	14.81
Leakage reduction 5 Ml/d	17.13	17.25
Leakage reduction 5 Ml/d	20.07	20.14
Leakage reduction 5 Ml/d	23.58	23.58
Leakage reduction 5 Ml/d	27.83	27.75
River Ouse Licence Optimisation Option 1	28.17	27.47
Leakage reduction 5 Ml/d	33.05	32.86
Leakage reduction 5 Ml/d	39.55	39.24

7.8.27 The final supply-demand balance for the Grid Surface Water Zone Dry Year Annual Average scenario is shown in Figure 7.3. The Water Available for Use (WAFU) is shown to be greater than the forecast demand due to the additional deployable output and reduction in demand achieved from the solutions.

Figure 7-3: Grid Surface Water Zone Final Planning Supply-Demand Balance



7.9 Sensitivity Analysis of Supply Demand Balance

7.9.1 The preferred solution to meet the forecast deficit includes leakage reduction and extension of an existing water treatment works. The treatment works extension will result in a works with an average yield of 49 Ml/d and maximum treatment capacity of 70 Ml/d. The abstraction licence on the raw water source is 96Ml/d.

7.9.2 If the demand in the Grid Surface Water Zone increases above that forecast, the treatment works can be operated more frequently at a higher flow than the planned average to meet the increased demand.

7.9.3 Additionally, if planned leakage reduction is not achieved in a particular year due to adverse weather conditions causing higher frequency of burst, the output of the treatment works could be increased to meet the demand.

7.10 Future Leakage Targets

7.10.1 The results of the economic appraisal indicate how much further leakage should be reduced, beyond existing targets, as part of the economic solution.

7.10.2 As part of the economic solution the following options are selected, in addition to the base activity required to deliver the current leakage target of 297.1Ml/d in 2008/09.

7.10.3 Additional leakage saving required for the 25 year planning period are given below:

Table 7.6: Additional leakage savings

Resource Zone	Option	Yield Ml/d	From Year
Grid Surface Water Zone	Leakage Reduction	5	2009/10
	Leakage Reduction	5	2010/11
	Leakage Reduction	5	2012/13
	Leakage Reduction	5	2024/25
	Leakage Reduction	5	2026/27
	Leakage Reduction	5	2028/29
	Leakage Reduction	5	2030/31
	Leakage Reduction	5	2031/32
	Leakage Reduction	5	2033/34

7.10.4 The leakage targets set for the 25 year period are reduced only when extra resource is needed and have not been smoothed to give a steady decrease in leakage. Leakage targets at resource zone level are given in Table 7.7 below:

Table 7.7: Leakage Targets at Resource Zone Level

Year	Leakage Target Ml/d			Total Leakage Ml/d
	East GWZ	East SWZ	Grid SWZ	
2008/09	10.7	1.6	284.8	297.1
2009/10	10.7	1.6	279.8	292.1
2010/11	10.7	1.6	274.8	287.1
2011/12	10.7	1.6	274.8	287.1
2012/13	10.7	1.6	269.8	282.1
2013/14	10.7	1.6	269.8	282.1
2014/15	10.7	1.6	269.8	282.1
2015/16	10.7	1.6	269.8	282.1
2016/17	10.7	1.6	269.8	282.1
2017/18	10.7	1.6	269.8	282.1
2018/19	10.7	1.6	269.8	282.1
2019/20	10.7	1.6	269.8	282.1
2024/25	10.7	1.6	264.8	277.1
2029/30	10.7	1.6	254.8	267.1
2034/35	10.7	1.6	239.8	252.1

8. BIBLIOGRAPHY

1 Arnell and Reynard, 2007, *Supplementary guidance to Chapter 8; Climate change implications in estimates of water resource zone deployable output*

2 ARUP, 2007, *Water Resources Management Plan Options Review*

3 CLG, 2007, *Code for Sustainable Homes*

4 Defra, 2002, *UKCIP: Climate Change Scenarios for the UK*

5 Defra, 2003, *Climate Change and Demand for Water* (CCDeW, 2003)

6 Department of the Environment, 1996, *Water Resource and Supply: Agenda for Action*

7 Downing, T.E. et al, 2003, *Climate Change and the Demand for Water*

8 Environment Agency, 1997, *Re-assessment of Water Company Yields*

9 Environment Agency, 2000, *Water Resources for the Future: A Strategy for the North-East Region*'

10 Environment Agency, 2002, *Benefits Assessment Guidance*

11 Environment Agency, 2007, *Water resources planning guidelines*

12 Experian, 2007, *Household and Population Estimation and Projections: Methodological Guide*

13 Experian, 2007, *Commercial Water Demand Projections*

14 Experian, 2007, *Forecasting Household Demand for Water: A Micro components Approach*

15 Herrington, 1996, *Climate Change and the Demand for Water*

16 Hulme, M., Jenkins, G.J. et al. 2002, *Climate change scenarios for the United Kingdom: The UKCIP02 scientific report.*

17 ICF International, 2007, *Forecasting Domestic Meter Optants for PR09*

18 McDonald, A, 2005, *An Evaluation of the Domestic Consumption Monitor and its analysis*

19 McDonald, A, 2007, *The Management and Operation of the Yorkshire Water Domestic Consumption Monitor*

20 McDonald, 2007, *Hidden and Transient Populations. An analysis of the Yorkshire Water Supply Area*

21 Reynard and Young, 2002, *Effect of climate change on river flows and groundwater recharge: a review. Report for UKWIR / Environment Agency.*

22 Romanowicz, Tych and Beven, 2006, *A8693 Climate Change Studies: Trend analysis of River Flows in Yorkshire*

23 Scott Wilson, 2007, *Strategic Environmental Assessment of the Water Resources Management Plan*

24 Stone & Webster, 2002, *Lane Rental Charging – A Way Forward*

25 Uff J , Mawer P , Herrington P, 1996, *Water supply in Yorkshire. Report of the independent commission of inquiry*

26 UKWIR, 1995, *Outage Allowances for Water Resource Planning*

27 UKWIR/NRA, 1995, *Demand Forecasting Methodology report*

Bibliography Continued

28 UKWIR/EA, 2000, *A Unified Methodology for the Determination of Deployable Output from Water Sources*

29 UKWIR, 2002, *A Re-evaluation of the Methodology for Assessing Headroom*

30 UKWIR, 2003*, Economics of Balancing Supply and Demand Methodology.*

31 UKWIR, 2003, *The Impact of Household Metering on Consumption: Further Analysis*

32 UKWIR, 2005, *Workbook for Quantifying Greenhouse Gas Emissions*

33 UKWIR, 2007*, Effects of climate change on river flows and groundwater recharge, A Practical Methodology: A Strategy for Evaluating Uncertainty in Assessing the Impacts of Climate Change on Water Resources*

34 UKWIR/NRA, 1995*, Demand Forecasting Methodology*

35 Yorkshire and Humber Assembly, 2007, *The Yorkshire and Humber Plan*

9. GLOSSARY OF TERMS

AISC	Average Incremental Social Cost
AMP4	Asset Management Plan (PR04 submission)
BRE	Building Research Establishment
CAMS	Environment Agency's, Catchment Abstraction Management Strategy
CCP	Constraint Challenge Process
COPI	Construction Output Prices Index
CROW Act	Countryside and Rights of Way Act 2000
DCL	Drought Control Line
DCM	Domestic Consumption Monitor
Defra	Department for Environment, Food and Rural Affairs
DMA	Demand Management Area - YWS leakage control zone
DO	Deployable Output
EA	Environment Agency
GCM	Global Circulation Models
GWZ	Ground Water Zone (Environment Agency Water Resource Zone)
KAMS	Key Asset Management System – YWS reporting system
l/h/d	Litres per head per day
LoS	Level of Service
Ml/d	Mega litres per day
MLE	Maximum Likelihood Estimation
MSL	Marginal Storage Line
NCL	Normal Control Line
NPC	Net Present Cost
NPV	Net Present Value
PCC	Per Capita Consumption
PMZ	Production Management Zone – YWS operational planning zone
PR04	Periodic Review submission to Ofwat 2004
SDS	Strategic Direction Statement
SEA	Strategic Environmental Assessment
SRO	Source Reliable Output
SSSI	Site of Special Scientific Interest
SWZ	Surface Water Zone (Environment Agency Water Resource Zone)
TLL	Time Limited Licence
UKCIP	United Kingdom Climate Change Impacts Programme
WAFU	Water Available For Use
WRZ	Water Resource Zone
YWS	Yorkshire Water Services Limited

10. APPENDICES

Appendix A: Yorkshire Water unconstrained list of options

Option Scheme Name	Feasibility
Customer side management	
Cistern devices - savaflush option 1	Feasible
Cistern devices - savaflush option 2	Feasible
Domestic meter optants	Feasible
Metering on change of occupancy	Feasible
Compulsory metering	Unfeasible The Environment Agency does not consider Yorkshire Water to be a water stressed area and the company's current policy is to not compulsory meter customers
Urinal controllers	Feasible
Large scale water efficiency	Under investigation - to be reviewed for the final plan
Distribution management	
Pressure management	Unfeasible A pressure management scheme has been undertaken in the Yorkshire Water region and there is limited scope for further significant savings.
Leakage Reduction	Feasible
Mains replacement and relining	Feasible
Reduce water into supply (trunk main losses)	Unfeasible
Production management	
Reduction in water treatment works process losses	Under investigation - to be reviewed for the final plan
Resource management	
Tankering to Rural Areas	Feasible
East Yorkshire Main 1	Feasible
East Yorkshire Main 2	Feasible
Aquifer Storage and Recovery Scheme 1	Feasible
Aquifer Storage and Recovery Scheme 2	Feasible
Supply Dales from the Tees Option 1	Feasible
Supply Dales from the Tees Option 2	Feasible
Dales Pipeline	Feasible
Swale groundwater source	Feasible
River Ouse Treatment Works Extension Option 1	Feasible
River Ouse Treatment Works Extension Option 2	Feasible
Bankside Storage at River Ouse	Feasible
Ouse Raw water Transfer	Feasible

Appendix A: continued.

Option Scheme Name	Feasibility
Resource management continued	
Increased River Ouse storage capacity	Feasible
River Trent Abstraction	Feasible
River Aire Abstraction Option 1	Feasible
River Aire Abstraction Option 2	Feasible
River Aire Abstraction Option 3	Feasible
River Calder Abstraction	Feasible
River abstraction and bankside storage	Unfeasible Excluded as will impact on River Derwent flows
Pumped Storage - River Hull	Unfeasible Considered to be unfeasible as large storage would be required for a relatively small yield.
River Ure Gravel Pits	Unfeasible Insufficient information available
Increase existing abstractions	Unfeasible This option is dependent on the availability of water in individual catchments and would be considered in consultation with the Environment Agency. Yorkshire Water is not currently considering any variations to current licences.
Use of canal water	Unfeasible Not considered a viable option as water quality is very poor and the available yield would be low.
River Intake Optimisation	Feasible
River Water Recharge Doncaster	Feasible
Re-use of Abandoned Industrial Sources	Feasible
Extended Groundwater Scheme	Feasible
Licence trading from private boreholes	Unfeasible Yorkshire Water will consider this option if a potential source becomes available
Groundwater – Doncaster Rising Groundwater	Unfeasible Boreholes no longer available
Use minewater rebound after pumping has stopped	Unfeasible Further investigation required
Work with Internal Drainage Board to increase abstractions	Unfeasible Scheme is in the Hatfield area, which was investigated under the Habitat Directive and it is assumed no water is available
Minewater scheme 1	Feasible
Minewater scheme 2	Feasible
New Pumped Reservoir Refill Scheme	Feasible
Pumped Storage Reservoir	Feasible
Reservoir Extension Stage 1	Feasible
Reservoir Extension Stage 2	Feasible

Appendix A: continued.

Option Scheme Name	Feasibility
Resource management continued	
Pennine Dam Raising Scheme 1	Feasible
Pennine Dam Raising Scheme 2	Feasible
Pennine Dam Raising Scheme 3	Feasible
Wensleydale Dam Raising Option 1	Feasible
Wensleydale Dam Raising Option 2	Feasible
Washburn Dam Raising	Feasible
Embankment raising	Unfeasible A number of reservoir embankment schemes in addition to the dam raising schemes listed above were considered. Those not considered to be feasible were due to one or more of the following; - the location is within a SSSI (site of special scientific interest) and the scheme has potential to impact on the protected site - scheme considered to be technically more complex than other embankment raising schemes and therefore there is less certainty the yield could be achieved
Reservoir De-silting	Feasible
Use compensation reservoirs for supply	Unfeasible Insufficient information is available to use as a feasible option
Reservoir Compensation Licence Review	Under investigation - to be reviewed for the final plan
Utilise a tidal barrage at Hull	Unfeasible This is not considered to be a viable option. Previous proposals have been rejected at the preliminary review phase
East Yorkshire Treatment Works optimisation	Feasible
Import – Severn Trent Water	Unfeasible Yorkshire Water currently receive an import from Severn Trent Water and there is no scope to increase the import at present
Import – United Utilities Water	Unfeasible Yorkshire Water has previously received imports from United Utilities and an increase in the capacity was considered. However, the treatment works that would receive one of the two sources has now closed and United Utilities is currently using the other source .
Import – Northumbrian Water	Unfeasible The current import from Northumbrian Water to the East Surface Water Zone is being phased out, therefore there is no scope to increase
Tees-Wiske Transfer	Unfeasible Option not acceptable due to land drainage issues

Appendix A: continued.

Option Scheme Name	Feasibility
Resource management continued	
Tees - Swale River Transfer Option 1	Feasible
Tees - Swale River Transfer Option 2	Feasible
Tees - Derwent Pipeline Option 1	Feasible
Tees - Derwent Pipeline Option 2	Feasible
Desalination	Feasible
Effluent reuse	Unfeasible Not considered a viable option due to water quality issues
Greywater supply to industrial customers	Unfeasible Not considered a viable option due to water quality issues

Appendix B: Environmental, Social And Carbon Costs For Grid Surface Water Zone Options

OPTION	Environ -mental Costs	Social Traffic Costs	Social Costs	Carbon Costs	Carbon Costs
	Annual Impact £000s/yr	Build Cost £000s	Annual Impact £000s/yr	Build Cost £000s	Opex £/Ml/d
Customer Side Management					
Conservation Save a Flush Option 1	-9.07	0	36.06	4.79	-6.89
Conservation Save a Flush Option 2	-16.77	0	72.12	9.11	-6.89
Urinal Controllers	-24.84	0	90.15	37.56	-6.95
Metering on Change of Occupancy	-59.26	0	250.43	94.80	-6.95
Metering 50,000 Domestic Meter Optants	-7.75	0	12.22	1082.62	-6.95
Distribution Side Management					
Leakage reduction 5Ml/d	-40.93	0	0	8.24	-6.95
Leakage reduction 5Ml/d	-40.93	0	0	8.86	-6.95
Leakage reduction 5Ml/d	-40.93	0	0	9.74	-7.01
Leakage reduction 5Ml/d	-40.93	0	0	10.56	-7.01
Leakage reduction 5Ml/d	-40.93	0	0	11.75	-7.07
Leakage reduction 5Ml/d	-40.93	0	0	12.90	-7.07
Leakage reduction 5Ml/d	-40.93	0	0	14.54	-7.13
Leakage reduction 5Ml/d	-40.93	0	0	16.54	-7.20
Leakage reduction 5Ml/d	-40.93	0	0	19.01	-7.26
Mains Replace/ Re-line Phase 1	-25.40	32.13	0	839.77	-6.95
Mains Replace/ Re-line Phase 2	-24.02	21.26	0	1143.57	-7.07
Mains Replace/ Re-line Phase 3	-18.32	23.00	0	949.40	-7.20
Resource Management					
Swale Groundwater Sources	0.00	0	0	0.56	2.49
East Yorkshire Treatment Works Optimisation	0.00	0	0	25.09	5.00
Reuse of abandoned industrial licences	0.00	0	0	12.34	5.54
Ouse Raw Water Transfer	303.02	14.98	0	80.20	5.38
Tees -Derwent Pipeline Option 1 Phase 1	918.36	6.65	0	887.94	28.99
Tees -Derwent Pipeline Option 1 Phase 2	770.53	0	0	0	28.99
Tees -Derwent Pipeline Option 1 Phase 3	1452.08	0	0	0	27.24