NORTHUMBRIAN WATER *living water*

FINAL WATER RESOURCES MANAGEMENT PLAN 2014

DOCUMENT CONTROL SHEET

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Exclusions on the Grounds of National Security

Northumbrian Water Limited has excluded Apendix A from this plan on the grounds that the information would be contrary to the interests of national security.

Under Section 37B(10)(b) of the Water Industry Act 1991, as amended by the Water Act 2003 ("the Act"), the Secretary of State can direct the company to exclude any information from the published Plan on the grounds that it appears to him that its publication would be contrary to the interests of national security.

Northumbrian Water is a trading division of Northumbrian Water Limited which is a group company of Northumbrian Water Group

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1.0 INTRODUCTION

1.1 Overview

This Final Water Resource Management Plan has been prepared in accordance with the Water Resources Planning Guideline issued by the Environment Agency, Defra, and Ofwat. The plan looks across the period from 2015 to 2040 starting from the baseline position from 2012/13 and includes changes from the consultation on the draft version.

Since the 2009 WRMP we have reviewed all components of supply and demand using the appropriate method recommended in the Guidance for the situation within Northumbrian Water (NW).

In previous WRMPs we have prepared the plan around the two Water Resource Zones (WRZ) of Kielder and Berwick. We have confirmed the integrity of these two WRZs which is detailed in Appendix A (this appendix is not available as we were required to remove it on the grounds of National security).

For the Kielder WRZ the planning scenario remains the Dry Year Annual Average (DYAA). The deployable output of the WRZ remains consistent with the previous plan as there have been no additions or loses of either abstraction licenses or treatment works capacities. A range of climate change scenarios have been modelled but climate change has a minimal effect on the deployable output of the system. This is because the Kielder reservoir Tyne-Tees transfer easily compensates for any increased drawdown of the other storage reservoirs as a result of climate changing rainfall patterns or amounts. The dry year DO reduces by 1.1% due to climate change but a significant surplus DO remains throughout the planning horizon and beyond.

The level of outage, the occasions when a water treatment works cannot meet its full deployable output, has also reduced as a consequence of improved method application. Target headroom remains similar to that in the previous plan.

The Berwick WRZ has been moved to a single planning scenario, DYAA, with the critical period Average Day Peak Week no longer applicable to this zone. Since the area has changed to a virtually year round holiday destination, from its 20^{th} century association with the Glasgow national shut down period, excessive summer peaks are no longer experienced. For the present the deployable output also remains the same as the previous plan but may be significantly reduced from 2020. This possible reduction is due to a “likely” sustainability reduction to its licensed abstraction volumes from the Environment Agency.

The “likely” sustainability reduction is purely precautionary at this stage and reflects the lack of understanding of the long term effects of abstracting from the Fell Sandstone in this area. Conceptual modelling, allied to a limited amount of actual data, suggests that even the current levels of actual abstraction may not be sustainable over the longer term. However, during the AMP6 (2015/16 – 2019/20) period NW and the EA, with specialist external help, intend to carry out comprehensive monitoring and modelling studies so that an informed decision can be made as to whether or not permanent changes to licenses may be needed post 2020.

Outage for the Berwick WRZ remains similar to the previous plan but target headroom has increased due to the uncertainty of the future licenses..

The demand forecasts begin with new estimations of property and population forecasts. The chosen population forecast this time is the Sub National Population Projection based on the Office of National Statistics 2010 population revision. This now shows a base year population approximately 30,000 lower than previously estimated and a lower population growth rate than that adopted for WRMP 2009. This sees the 2035 population growing from a current 2.514m to 2.691m as opposed to the previous 2035 projection of 2.747. However, when the ONS2011 census data is released in its final form these numbers are highly likely to change again.

Fortunately with the large supply surplus in the company, these orders of change to population do not drive any investment in new water resources.

Property numbers are more difficult to forecast going forward this time as the Regional Spatial Strategies (RSS) no longer exist and the forecast relies on information from the Local Authorities (LA), many of whom do not have completed development frameworks. However, as has been seen in this current AMP period the numbers of properties forecast in the various RSSs have been hugely undershot as the number of new properties is a function of the housing market, not a LA's plan. We are forecasting a lower number of new homes over the planning horizon than the number in the previous plan.

Household per capita consumption (pcc) is forecast to decline across the planning horizon from a combination of a continued increase in the number of measured customers and the effects of water efficiency activity promoted with our customers. The current metering strategy is for optant only metering to continue for the next 10 years at the annual rate of 14,000 optants, followed by a currently proposed mixture of optant meters and selective meters (metering on change of occupier of an unmetered property) from 2025. This would see over 65% of properties being metered by 2040. The water efficiency activity of the company is aimed at reducing pcc by 0.28 litres/head/day annually over the 25 years. Whilst we are confident of this level of opportunity being available for the next 10 years, we may lower this figure from 2025 in a future WRMP.

Non-household total consumption is forecast to continue the previous 20 years decline in demand across the planning period. However, the future decline is more modest and could easily result in demand from the non-households virtually flat lining over the period.
Leakage will reduce from this AMP outturn of 141Ml/d to 137Ml/d from 2016/17.

Overall for Kielder and Berwick the total dry year demand will reduce across the whole planning horizon. Kielder WRZ by approximately 6Ml/d (0.9%) and in the Berwick WRZ by 0.08Ml/d (1.0%). This follows an already significantly lower demand in both WRZs for 2014/15 to that forecast in the 2009 WRMP.

This leaves the Kielder WRZ with an even larger surplus supply to forecast demand. In accordance with the WRMP Guidance we have "advertised" this available surplus on our website and spoken with our neighbouring water companies about sharing some of the spare resource. Whilst we have held discussions and provided the volumes and costs to other water companies, none of them has yet come back to us to begin negotiations for a supply.

Given the companies supply demand surplus there are no options within this WRMP to develop any new water resources or to meter our customers beyond the legal requirement to provide a free meter to any domestic customer that requests one.

1.2 Regulatory Framework

WRMPs are produced as part of a statutory process, as reflected in the Water Resources Management Plan Regulations 2007 and the Water Resources Management Plan Direction 2012. This Final WRMP has been produced with reference to the following guidance:

- Water Resources Planning Guideline, Environment Agency, Ofwat and DEFRA, 2012
- The Water Resources Management Plan Regulations 2007
- The Water Resources Management Plan Direction 2012

Additional detailed guidance/methodologies on specific aspects of the plan are referenced in relevant sections of this document.

This document is supported by the Company's Drought Plan. The Drought Plan shows how the company intends to manage a future drought, what trigger levels can be used to identify when action is required, and what measures are available to support supplies when levels of service are compromised.

Our draft WRMP has been the subject of a Strategic Environmental Assessment (SEA) screening, resulting in a SEA being scoped out. Both Water Resource Zones have a surplus of water across the full planning horizon to 2040. Consequently, no new water resource options are required and so a full SEA is not required.

1.3 Consultation

1.3.1 Pre-draft Water Resources Management Plan Consultation

NW recognises the value of early communication with the many stakeholders potentially affected by and involved in the water resources management planning process.
Prior to production of the draft WRMP, and as required under Section 37A (8) of the Water Industry Act 1991, NW wrote to the following organisations on 25th July 2012 seeking their views on what should be included in our draft Water Resources Management Plan:

- Secretary of State/ Defra: C/O Adrian Brookes
- Environment Agency
- Natural England
- OFWAT
- Consumer Council for Water
- Other Water Undertakers: Yorkshire Water Services, United Utilities

Additionally, NW has had regular progress meetings with the Environment Agency's regional planning team.

Representations focused on the potential to trade supply surplus with neighbouring water companies, to refine WRZ deployable output assessments and to robustly consider the effects of climate change on both future supply and demand.

1.3.2 Draft Water Resources Management Plan Consultation

The following statutory consultees were invited to comment on this Plan:

- Ofwat
- Environment Agency
- Secretary of State (c/o Defra)
- All local authorities in the area of the plan..
- Natural England
- The Historic Buildings and Monuments Commission for England.
- Any navigation authority in the area of the plan.
- United Utilities
- Yorkshire Water Services
- The Consumer Council for Water

NW also welcomed comments and representations from the wider community, including customers and any other interest groups.

1.4 Making Representation

The consultation period on the draft document covered an eight week period, commencing on Monday 13th May 2013 and closing on Sunday 4th August 2013. The start of this consultation coincided with publication of the draft plan on the Company's website (www.nwl.co.uk). A Statement of Response to the representations received was published on our website on Monday 11th November 2013.

2.0 BACKGROUND INFORMATION

2.1 Planning Period

In accordance with the Environment Agency's Water Resources Planning Guideline (Environment Agency, 2012) NW is planning ahead until 2039/2040 in its Water Resources Management Plan (WRMP). The company has used 2012/2013 as the base year for its Final WRMP.

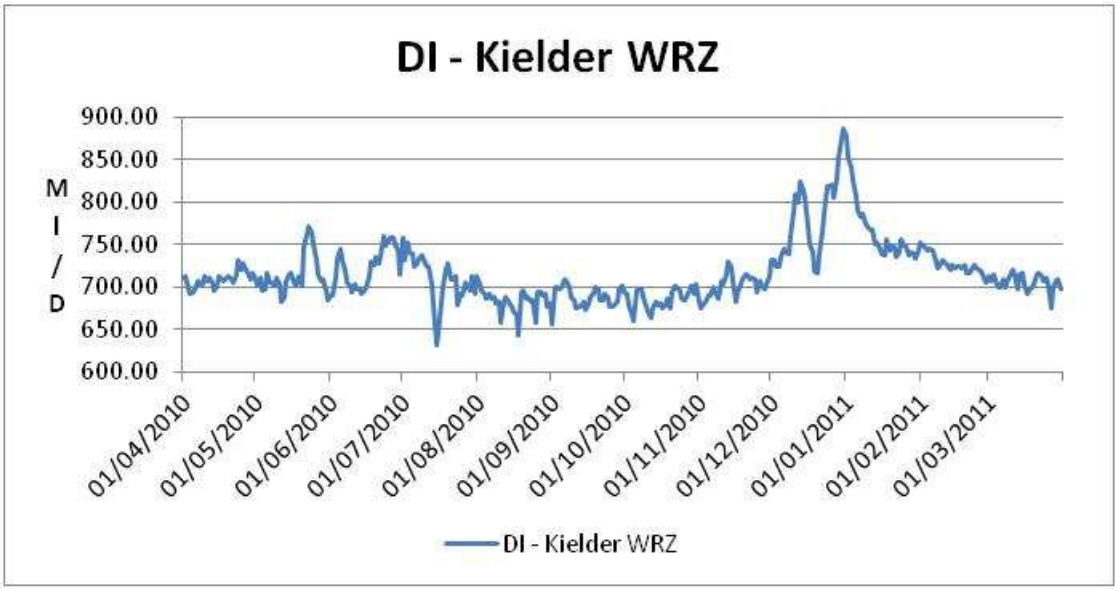
2.2 Strategic Environmental Assessment (SEA)

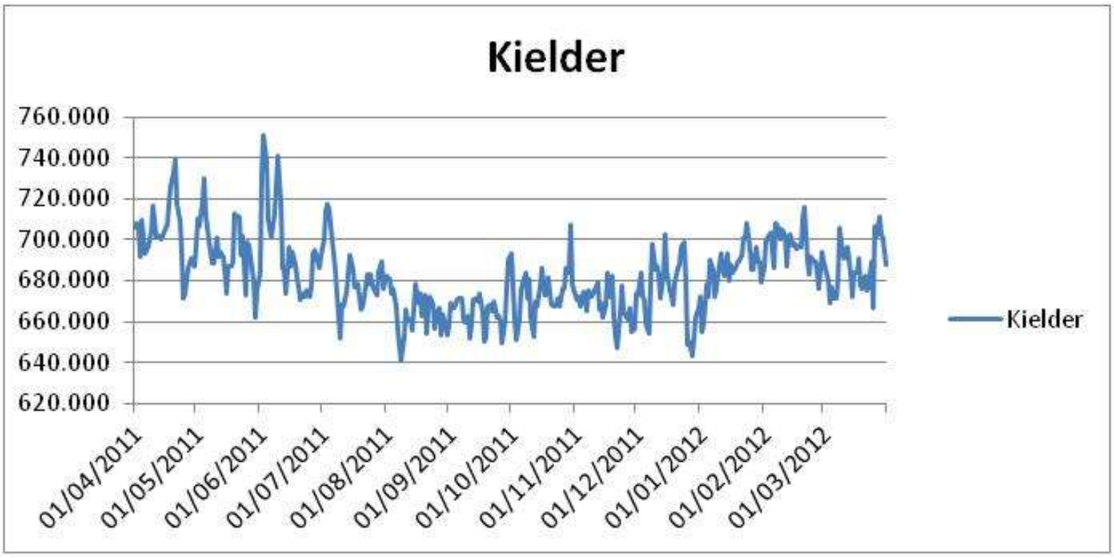
The company produced a SEA screening document showing why a SEA was not required as part of this plan. The report is attached as **Appendix B**.

2.3 Planning Scenarios

Kielder WRZ

Kielder WRZ has always used the Dry Year Annual Average as the planning scenario. This still remains relevant as no high peak demand is driving investment in the WRZ. The daily distribution input for the WRZ for 2010/11 and 2011/12 is shown below demonstrating a low summer peaking factor with the significant peak actually during the severe winter of 2010/11 and caused by leakage.





The DYAA remains the planning scenario for Kielder WRZ in this plan.

Berwick WRZ

The planning scenarios for Berwick have historically been the DYAA and a Critical Period (average day peak week). Whilst the DYAA is still pertinent for water resource planning we will no longer be using the critical period for this WRZ. The peak week was important in the past when the Berwick area was the favourite holiday destination for, mainly, Glasgow industrial workers during the National shut down week for Industry. The last time any evidence of this occurring was in the mid 1990s. Since then a number of things have changed to remove the high, short period summer demand for water. These are:-

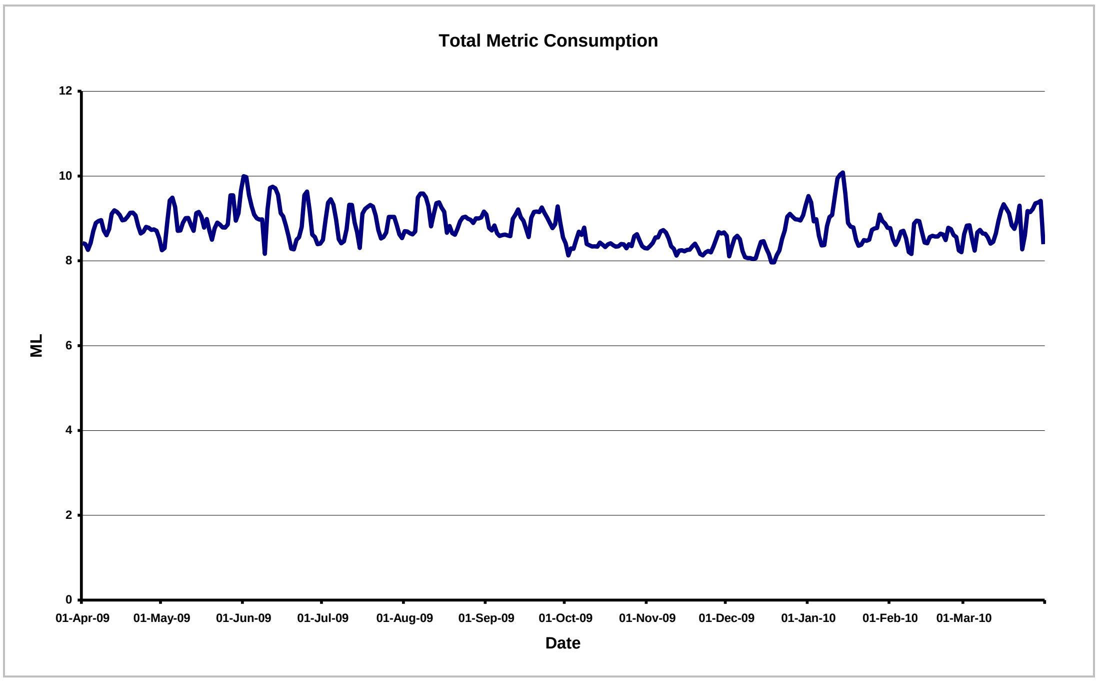
- Large parts of the heavy industries have been lost to Glasgow
- National shut down weeks are no longer used by the majority of industry
- Berwick, with its very large caravan sites has become an, almost, year round touristic area, smoothing the number of visitors to the area.

During the mid 1990s the daily average distribution input (DI) for the year was around 7.5Ml/d with the peak week annual daily average reaching 11Ml/d, with the highest day being 11.3Ml/d. This meant the average day peak week was approximately 50% above the annual daily average DI. Meeting this 50% increase in demand for the one week made this period critical for supplying the WRZ.

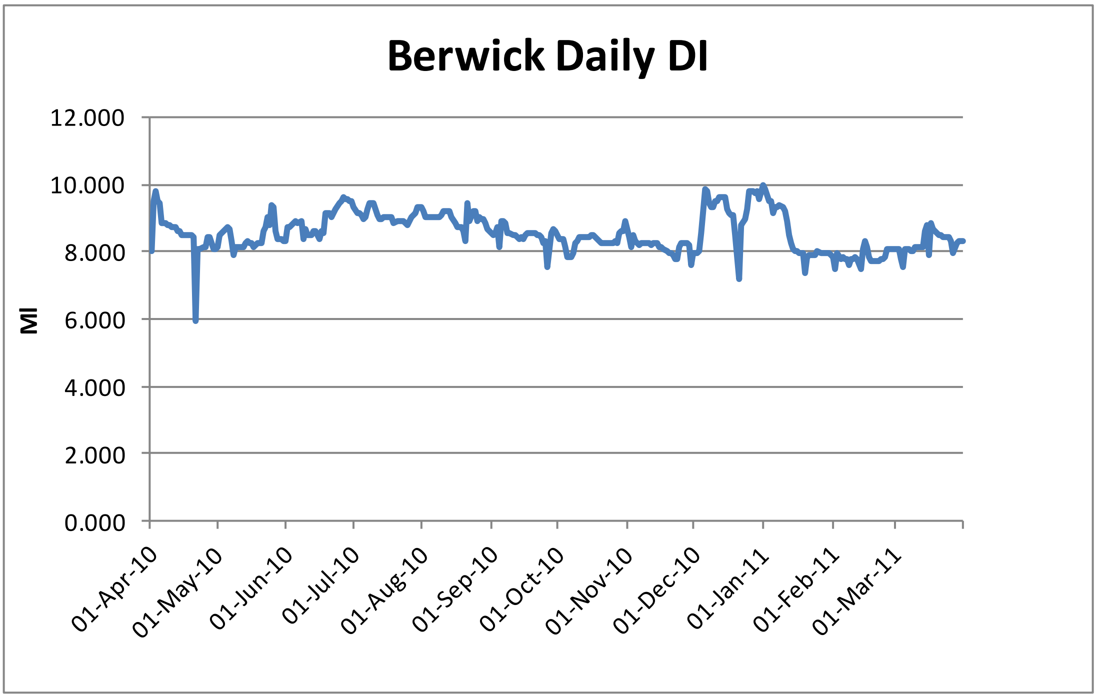
The graphs below show the recent daily distribution inputs to the WRZ clearly showing the lack of high summer peaks. This relatively constant distribution input has been observed since at least 2000. The graphs show that there is no specific week with high demand and the “peaks” seen are below 20% of the annual daily average DI. A variation of +/- 20% of the annual daily average

DI is well within the range seen in a DYAA scenario and does not define a critical period.

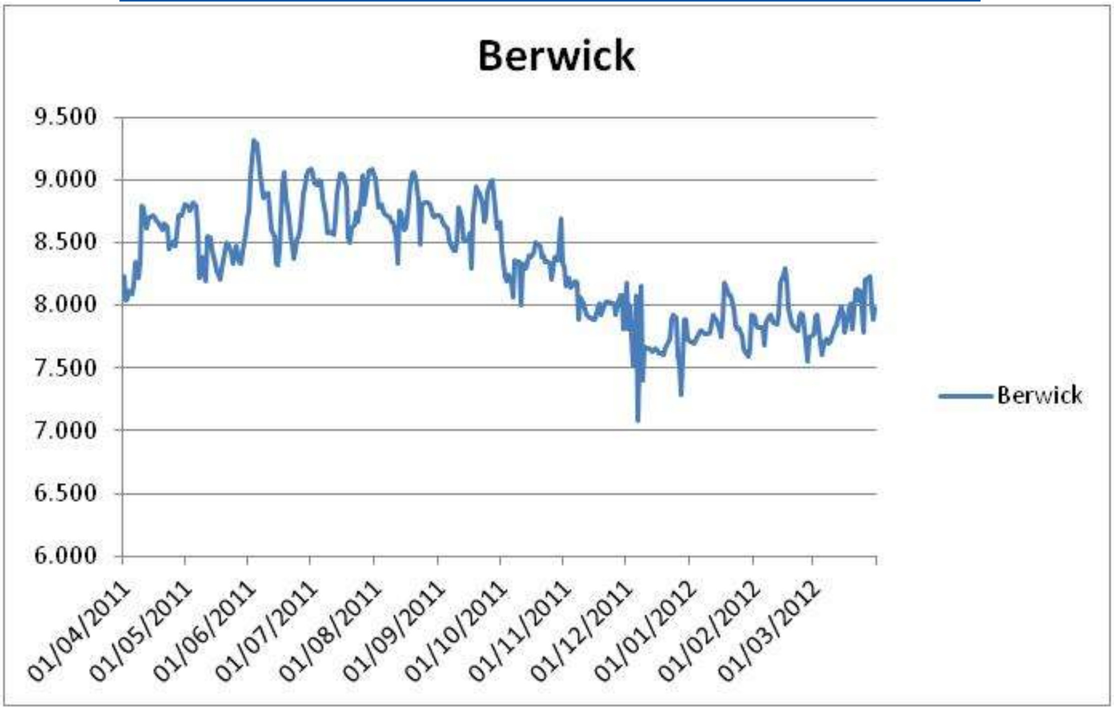
Berwick / Fowberry WRZ Daily Distribution Input 2009/10



Berwick / Fowberry WRZ Daily Distribution Input 2010/11



Berwick / Fowberry WRZ Daily Distribution Input 2011/12



The planning scenario used for the Berwick WRZ for this plan will be the DYAA only.

2.4 Water Resource Zones

Water Resource Zone Integrity

The Water Resource Zone (WRZ) is the basic building block of a Water Resource Management Plan. Companies will have a variable number of WRZs making up their total supply area. A WRZ is the largest area of a company's supply area where supply infrastructure and demand centres are generally integrated to the extent that customers in the WRZ should experience the same risk of supply failure due to climatic conditions.

Northumbrian Water has 2 WRZs covering its supply area. These are the Berwick WRZ in the far North of the supply area and covering about 1% of the customers and the Kielder WRZ covering the remaining 99% of customers. The Berwick WRZ has 2 well fields centred around Berwick and Fowberry. There is some integration between the 2 areas of the WRZ and a further link between the 2 was due to be installed during this current AMP5 period. However recent modelling of the area has now cast some doubt on the sustainability of some of the licenses serving the WRZ and until this is resolved the work has been deferred.

The Kielder WRZ has been the subject of dialogue with the Environment Agency as they required us to demonstrate more fully how it is a single WRZ rather than 3 WRZs. This has resulted in the production of *Appendix A* which shows how water is integrated to such an extent over the whole WRZ, mainly by being supported by Kielder reservoir and the Tyne- Tees tunnel transfers, that it is a single WRZ and complies with the definition of a WRZ.

Assessment of WRZ against Stage 1 of WRMP Guidance Appendix 1.

The WRMP Guidance document from the regulators sets out the steps a water company should take in assessing the integrity of its current WRZs.

Step 1
Early discussions with the regional EA planners led to them raising concerns as to whether the Kielder WRZ was 1 WRZ or should be 3 WRZs. This led to the production of *Appendix A* of the NW draft WRMP which fully describes the WRZ and how its integrity is assured by the ability of all areas of the WRZ to benefit from Kielder reservoir and the Tyne – Tees transfers. A number of iterations of the Appendix were produced to bring greater clarity about its operation and the volumes of water, raw and potable, capable of being transferred around the WRZ.

Step 2
Appendix A was prepared to answer the questions in this step. However it should be recognised that no group of customers within the Kielder WRZ has ever been subject to temporary restrictions on their use of water. This includes the severe drought of 1996/97 as well as the dry periods in autumn of 2003 and the very recent 2011/12 dry period. This demonstrates practically how all customers experience the same level of service within the Kielder WRZ. The very small number of customers supplied within the Kielder WRZ by isolated spring supplies still receive this level of service by the company using road tankers to supply water into the associated service reservoirs during dry periods. However the number of customers served by each of these supplies is much less than the 5,000 customer de-minimus level in the guidance.

Step 3
Appendix A demonstrates that there are no isolated groups of customers, excluding those spring supplied customers below the de-minimus level, whose supply cannot be supported either directly by raw water from Kielder reservoir, potable water backed up by Kielder reservoir or have their supply substituted by water derived from Kielder reservoir. The Appendix shows the treatment works and capacity, and how it can be supported by Kielder reservoir, the demand centres and the potable water surpluses and means of transfer across the region.

Step 4
We now believe that the regional EA accept that Kielder is a single WRZ.

Step 5
There is no investment needed within any part of the WRZ to overcome any supply deficit across the whole planning horizon. As such Step 5 recognises the low risk to customers' supply and we are able to conclude that the risk is not great enough to warrant a full review of the WRZ.
This also means that there is no requirement to carry out a Stage 2 WRZ review.

Conclusion
No area of the company has ever been subject to restrictions on their use of water due to drought conditions. We recognise that the Kielder WRZ and Berwick WRZ are completely separate from each other although the company's Level of Service to both WRZs is the same. There is a considerable surplus of supply within the Kielder WRZ that, as demonstrated in *Appendix A* can be adequately moved across all of the major customer centres.

The use of only 2 WRZs remains appropriate.

Figure 1: Water Resource Zones

2.4.1 Kielder Water Resource Zone

There are three main supply zones within the Kielder WRZ, these being the "Northern", "Central", and "Southern", which incorporate the major urban conurbations of Tyneside, Wearside and Teesside respectively. They are virtually discrete in terms of treatment capacity, but they can all be supported from Kielder. As such they all have the same theoretical risk on restrictions of use and are considered as a single water resource zone.

In the last year NW have undertaken a series of Bathymetric surveys, previous levels of sedimentation had been estimates. The six reservoirs that were surveyed showed significantly less sedimentation build up than had been estimated. As a result it was decided that the potential loss of storage in the remaining reservoirs in the WRZ should be re-assessed. The Halcrow Water report 'Sedimentation in Storage Reservoirs' 2001 was used as a basis for this piece of work. It takes into account various properties of the reservoirs such as catchment type, catchment area, age of reservoir, capacity, and method of inflow. The results of this study can be seen in the table below.

Reservoir	New Estimate		Previous Estimate		Bathymetric Survey	
	Capacity Lost, Ml	%	Capacity Lost, Ml	%	Capacity Lost, Ml	%
Balderhead	292	1.5%	508	2.6%	809	4.1%
Blackton	325	15.5%	500	23.8%		
Burnhope	945	14.7%	2124	33.0%	204	3.2%
Catcleugh	326	3.1%	2120	20.2%	298	2.8%
Colt Crag	112	2.3%	326	6.7%		
Cow Green	720	1.8%	6401	15.6%		
Derwent	221	0.4%	1047	2.1%		
Fontburn	239	7.3%	489	14.9%	80	2.4%
Grassholme	170	2.8%	1388	22.9%		
Hallington	169	2.6%	371	5.7%		
Hisehope	101	20.9%	169	35.1%		
Hury	195	5.0%				
Hury Subsidiary	26	41.0%				
Kielder	579	0.3%	4218	2.1%		
Little Swinburne	8	5.3%	31	19.9%		
Selset	1081	7.1%	1533	10.0%	457	3.0%
Smiddy Shaw	112	8.3%	181	13.4%		
Waskerley	461	22.5%	819	40.0%	52	2.5%

2.5 Update on change from *i-think* model to Aquator model

The company has decided to move the Kielder WRZ system model from the current *i-Think* model to the more widely used *Aquator* model. The outcome on Deployable Output (DO) from changing models is likely to be modest, and with such a significant surplus of headroom over demand, will not cause any changes to our current plans for the WRZ. However, with the recent requirement to examine a number of different climatic scenarios, and to model the effects of sharing water with neighbouring companies, the current model has been found to be too cumbersome.

The Aquator model will need to be built, staff trained on its use and test model runs undertaken prior to this model being used to define the company's Kielder WRZ DO. Discussion have begun between the company's modelling consultant and the Regional EA water resource planners to ensure the data to be input into the model satisfies the EA's requirements for a system model. Agreement has been reached that the data in *i-Think* is suitable for transfer up until 1998 but the post 1998 data needed re-evaluating. The post 1998 "in flows to reservoirs" data had been put out to a consultant to derive and was immediately used in the *i-Think* model for deriving the DOs for the draft WRMP. This new data also satisfies the requirements for Aquator post 1998 data and will be used to build the Aquator model.

Outputs from Aquator are not available for this Final WRMP. However, it should be available for future Drought Plans and the 2014 WRMP Annual Update. As previously stated the effect on DO from changing models will be modest and will not cause any changes in our proposed actions in the WRMP. The outcome from changing models will be detailed in the 2014 WRMP Annual Update.

The Kielder Water Supported Systems

The scheme consists of the Kielder Reservoir and Dam (associated headworks including release valves and hydropower plant), Bakethin Dam (a weir upstream of Kielder Reservoir) and a pumping station at Riding Mill on the River Tyne. The pumps deliver into a rising main from Riding Mill to Letch House. A gravity pressurised tunnel flows from Letch House into Airy Holm reservoir, onto Frosterley discharge into the River Wear and to Eggleston discharge into the River Tees (hereafter referred to as the Tyne – Tees tunnel). Licensed abstractions from the tunnel allow support to Mosswood water treatment works and to Honey Hill water treatment works.

Associated Water Resources

Associated water resources include those that may be deficient in times of drought to meet demands, and may therefore be required to call upon the strategic resource provided by the Kielder Water Scheme. These resources have been grouped as follows.

- North Tyne and Northumberland resources
- River Wear and Associated Mid Durham resources
- Tees Resources

These groups are described as follows:

North Tyne and Northumberland Resources

The northern part of this system is supplied from Warkworth Water Treatment works, Fontburn reservoir and treatment works and Tosson springs and treatment works. These are linked to the Tyne system with a major potable water trunk main and full flow from Warkworth can be replaced with potable water from the Tyne water treatment works.
Fontburn reservoir is silted at its upper levels due to pine needle falling and trapping the sands and silts which do not migrate to the treatment works. Previously the amount of storage lost at Fontburn Reservoir due to siltation had been estimated to be 489Ml. Following a recent bathymetric survey the overall storage lost due to siltation has been re- assessed as 80Ml and confined to the area around the inlet of the reservoir.
The reservoir yield cannot support flows approaching yearlong deployable output through the summer dry periods even in a wetter than normal year.
The dry year reduces the flow to an average of about 10Mld potable water supply and in a normal year to 15Mld. The licence is for 30Mld, which the works and distribution system can only sustain for short-term emergencies.

In addition there is a linear sequence of reservoirs supplying raw water to Gunnerton, Whittle Dene and Horsley water treatment works.
Catcleugh reservoir in Redesdale feeds Hallington reservoirs by gravity which in turn connecst to the Whittle Dene group of reservoirs drawing in, on the way, part of the natural flow from the upper catchment of the River Pont. Two additional reservoirs, Colt Crag and Little Swinburne contribute flow to the Hallington reservoirs.
The direct supply reservoir cannot reliably meet the raw water requirements and river abstractions are made at Barrasford on the North Tyne and Ovingham on the Tyne. The pumped abstraction at Ovingham is used to supply Horsley water treatment works or to support the Whittle Dene reservoirs, whilst the abstraction from Barrasford is pumped into the Hallington reservoirs. Kielder releases are made to regulate the River North Tyne or River Tyne when required.
Storage at other reservoirs is balanced to ensure that water is not wasted through spillage, especially at Whittle Dene, whilst higher level reservoirs are still drawn down.

Water treatment is provided at seven works, three very small works, Otterburn, Rochester and Byrness, supplying the Redesdale area. Gunnerton and Birchtrees supply the area west of Hexham. The remaining treatment works at Whittle Dean and Horsley jointly meet part of Tyneside and SE Northumberland demands.

Catcleugh Reservoir Operation

The treatment works at Otterburn, Rochester and Byrness are dependent on Catcleugh reservoir for sole supply and theoretically the needs of this demand zone should limit the rate of transfer to Hallington and Whittle Dean.

However, in practice, the capacity of the Rede pipeline restricts the rate of drawdown such that, even in extreme drought the needs of Redesdale do not act as a constraint. Transfers from Catcleugh to the Hallingtons can therefore operate continuously at full pipeline capacity. The Rede pipeline from Catcleugh to Hallington is limited (by construction) to 55Mld when the reservoir is full, and therefore normally operates at full capacity.

Colt Crag, Hallington and Whittle Dean Reservoir Operation

The linear configuration of the remaining reservoirs permits them to be considered as one, with the total storage balanced between reservoirs under the company's control within the constraints imposed by the licence. The aim should be to avoid unnecessary losses by spillage, whilst maintaining throughput for treatment. Control rules for the group of reservoirs have been agreed between the Environment Agency and the company.

The Tyne – Tees Tunnel Transfer System

The Tyne - Tees Tunnel (TTT) transfer system comprises a pumping station at Riding Mill on the River Tyne, a rising main and gravity tunnel carrying water (when required) to Airy Holm reservoir, the River Derwent, Mosswood W.T.W., Waskerley airshaft, the River Wear and the River Tees.

At Riding Mill pumping station six pump units, each with a nominal fixed capacity of 1.05cumecs (90Mld), are installed. However an agreed supply capacity with CEGB limits maximum abstraction flow to three pumps, about 270Mld. All six pumps remain in commission and are tested periodically.

The steel rising main from Riding Mill to Letch House is 6.2km in length and 2m in diameter and the pumping head is approximately 205 metres. The concrete lined gravity tunnel from Letch House to Eggleston on the River Tees is 34km long and 2.91m in diameter. The rising main and tunnel are designed to remain charged and have a capacity of 230,000 m3. Airy Holm reservoir forms a header tank on the tunnel system to correct any imbalance between rates of pumping and outlet discharge. It has a capacity of 220,000m3 and inflow to and draw-off from the tunnel is by means of a 5m diameter shaft connected to the reservoir floor. Airy Holm will normally be maintained near to full level in order to provide a reserve for releases. However, no spillway discharge should occur as a direct result of pumping at Riding Mill.

A direct connection links the tunnel with the Mosswood Treatment Works and can provide full substitution for the Derwent Reservoir resource and thus support the water resources for mid-Durham.

Provision has been made for a licensed abstraction from Waskerley airshaft with an annual total of not more than 3,200Ml. This water can be abstracted from the TTT into Waskerley northern catchwater.

The Tyne-Tees transfer system also supports the Rivers Wear and Tees to ensure that prescribed minimum maintained flow conditions are met and the system operation is set out in the Kielder Operating Manual.

River Wear and Associated mid-Durham Resources

The strategy for operating to the River Wear and mid Durham resources is:

- To regulate the River Wear to maintain flow rates above a prescribed minimum flow rate as measured at Chester-le-Street gauging station.
- To regulate the River Wear to support abstractions, including the public water supply abstraction at Lumley.
- To provide water in emergency for flushing the Rivers Derwent and Wear, following major pollution incidents.
- To support associated water resources in mid-Durham in times of drought by making direct transfers from the Tyne-Tees tunnel to Mosswood treatment works and from Waskerley airshaft to support Honey Hill treatment works.

River Regulation for Prescribed Flow and Abstraction

The outlet from the Tyne-Tees Transfer System to the River Wear is located near Frosterley. The maximum discharge capacity of the outlet valves is 2.0cumecs. (173Mld). Tunstall reservoir now acts as a regulatory reservoir following the abandonment of the treatment works at this site.

Water for public water supply is abstracted from the River Wear at Chester-le-Street to Lumley W.T.W, the maximum licensed daily abstraction is 45.4Mld.

A prescribed minimum maintained flow is set at Chester-le-Street gauging station of 2.0cumecs (173Mld). Both the Environment Agency and NWL have access by telemetry to levels and flows measured at the station.

Mine water discharges to the River Wear and tributaries cause small variations in flow. However, eventually minewater pumped discharges are expected to cease.
An outlet close to Derwent reservoir allows releases to be made from the TTT in the River Derwent. However, as there are no public water supply abstractions or prescribed flows on the River Derwent, releases are reserved for use in supporting compensation flows and alleviating pollution.

Waskerley Air Shaft allows licensed abstractions of 24Mld or 3200Ml per annum to be abstracted from the TTT into Waskerley.

Mid –Durham Associated Water Resources and Support.

An operating policy for the timing and magnitude of Kielder support is agreed to provide guidance in ensuring that public water supply requirements can be met in a drought in all parts of the mid-Durham demand area.

System Assumptions

Given the complex interlinked network linking sources and demands a large number of options exist for operating the system. The control policies described later are based on the following key assumptions:

- Priority is given to meeting public water supply requirements and the needs of the rivers, as reflected by minimum maintained flows and compensation flows.
- Where either of the requirements above can be met only from a single source, sufficient water has to be retained in the relevant storage to supply these without reduction except under severe droughts, until the anticipated end of a drought.
- Other uses of water, such as for fisheries, recreation and amenity are recognised and provided for where appropriate.
- The policies provide a broad but well defined framework within which the undertaker may operate the system to meet their own needs and interests.
- The policies have been defined to minimise the operating costs for the Environment Agency and the company within the constraints above.

Water Resources System Structure

The key mid-Durham resources are:-

The abstraction from the River Wear at Lumley, two main reservoirs Derwent and Burnhope, three smaller reservoirs Smiddy Shaw, Hisehope and Waskerley, Tunstall river regulatory reservoir, groundwater sources (mainly from the Magnesian limestone aquifer in the Sunderland area), and two small spring sources, and the TTT system as previously described.

Derwent Reservoir

Mosswood Treatment Works supplies its demand centres by abstracting raw water from Derwent reservoir or from the TTT scheme. Abstraction from the tunnel to Derwent/Mosswood is licenced to an annual total of 21900Ml and a peak daily rate of 164Mld.

Smiddy Shaw, Hisehope and Waskerley Reservoirs

Smiddy Shaw, Hisehope and Waskerley reservoirs, nearby small spring sources, Waskerley air shaft and associated Honey Hill WTW are treated as a group. Water can be transferred under gravity from Waskerley, Hisehope and Smiddy Shaw to Honey Hill WTW. The required output of Honey Hill WTW cannot be fully met from these reservoirs year round but support is available from Burnhope reservoir. Burnhope raw water may be transferred under gravity to Waskerley, Smiddy Shaw or direct to Honey Hill at a maximum rate which depends on the level in Burnhope.
In addition water can be pumped into Waskerley reservoir from the Waskerley airshaft (part of the TTT). A maximum of 24Mld can be pumped from the airshaft while the total annual abstraction may not exceed 3200Ml.
Control rules have been derived using the detailed drought sequence for the period 1988-1995 and simulated inflows for 1926-1996.

Burnhope Reservoir

Water from Burnhope can be used to supply Wear Valley treatment works and the raw water pipeline to the Waskerley, Smiddy Shaw or Honey Hill WTW. Wear Valley treatment works and compensation water can only be provided from Burnhope and therefore, sufficient resources are retained at all times to provide for these two demands. Burnhope reservoir is small for the catchment area and can be resource restricted in the summer months.

Control rules have been derived using the detailed flow sequence for the period 1985 to 1995 and simulated inflows for 1926-1996.

Groundwater Supply

The coastal ground water sources and shafts supplying groundwater towards Sunderland have their pump low level protection set conservatively to alleviate the problem of disturbing sediment at the lower levels. Sediment creates turbidity, which is used as a surrogate for possible cryptosporidium pollution and results in pump shut down. A programme of ground water source cleaning is in progress to ensure supplies can be maintained.

River Tees and Associated Tees Resources Objectives

Within the general framework of ensuring proper use of resources, objectives for the River Tees and the operation of local resources within the Tees catchment are:

- To regulate the River Tees to maintain flow rates above a prescribed minimum flow rate as measured at Broken Scar gauging station.
- To regulate the River Tees to support at Broken Scar, Blackwell and Low Worsall and hence to support associated water resources in the Tees catchment in times of drought.
- To provide water in emergency for flushing the River Tees, following major pollution incidents.

River Regulation and Prescribed Flows and Abstractions

The principal regulating reservoir on the Tees catchment is Cow Green providing the full support required for prescribed flows and abstractions under normal conditions. In conditions of dry weather or future higher abstractions, releases may be made from Balderhead reservoir or the Tyne-Tees transfer system.

Associated Tees Water Resources and Support

The principal objective in the design of the Kielder Scheme was to augment the water resources of the Tees basin to meet the then rapidly increasing demand for water, primarily for industrial use. Although the forecast industrial demands have not materialised, recent droughts have illustrated the advantages of a strategic regional resource. Whilst the volume of transfer through the tunnel to the Tees has been limited to small amounts, the availability of support has enabled the cheaper local sources to be used more effectively, and to be drawn down further, without the necessity to place restrictions on water use.

System Assumptions

Given an inter-linked network linking sources and demands, a large number of options exist for operating the system. The control policies described below are based on the following key assumptions.

- Priority is given to meeting public water supply requirements and the needs of the river are reflected by the minimum maintained flow and compensation flows from reservoirs.
- Other uses of water such as for fisheries, recreation and amenity are recognised and provided for where appropriate.
- The policies provide a broad but well defined framework within which the company may operate the system to suit its own needs.

Cow Green Reservoir

Cow Green is the principal river regulating reservoir on the River Tees, and is used to support the minimum maintained flows in the River Tees to allow abstractions from the River downstream. River regulation demand can normally be met from Cow Green but can be augmented when necessary by releases from Lune and Balder reservoirs or the Kielder transfer system.

In-river needs in the upper Tees are met by the compensation flow and by the requirement to reserve water such that at least one third of regulation releases at a given time come from Cow Green, when additional regulation releases are being made from the Lune and Balder reservoirs, as specified in the Tees Valley and Cleveland Water Act 1967. That Act also requires that 1818Ml be reserved in the reservoir for freshet releases for fishery purposes, at a maximum additional discharge rate of 45.45Mld.

Cow Green has a flood control role during winter months with the level of the reservoir being drawn down to provide flood storage. Control rules have been derived using the results or the 'Agenda for Action' document and previous operational policies.

Lune and Balder Reservoirs

The Lune and Balder reservoirs consist of Selset, Selset Weir and Grassholme on the River Lune and Balderhead, Blackton, Hury Subsidiary and Hury on the River Balder. The two cascades of reservoirs are used conjunctively by means of a tunnel connecting Selset reservoir to Hury reservoir.

The Lune and Balder reservoirs directly support Lartington WTW. Water may be available for regulation releases to support the River Tees when the reservoirs are in the surplus zone. The normal minimum release to the River from these reservoirs is compensation water (44Mld) and the flow to meet the requirement of Lartington WTW.

In-stream flow needs for the Lune and Balder Rivers are met by the compensation releases from Grassholme and Hury reservoirs respectfully.

There is significant recreational use of some of the reservoirs. Control rules have been derived using the detailed flow data for 1970 to 1996 and simulated inflows for 1926-1996.

2.5.1 Berwick and Fowberry Water Resource Zone

The Berwick WRZ is a small zone in the North East of Northumberland serving the towns of Berwick-upon-Tweed and Wooler. The area has a small indigenous population of about 25,000 people but is a very popular tourist area. It is a discrete zone in terms of both water resources and treatment capacity and cannot be supported from Kielder. The resources comprise a number of ground water sources, sunk into different layers of the Fell Sandstone Aquifers.

2.6 Company Policies including Level of Service

Northumbrian Water currently has the following Levels of Service (LoS) in both of its Water Resource Zones (WRZs).

Appeal for restraint	1 in 25 years
Hosepipe Ban	Never
Restriction on non-essential use	Never
Rota cuts	Never

As part of the pre-consultation process for producing the draft Water Resource Management Plan the Environment Agency included the following request:

We would encourage you to consult customers regarding your planned Levels of Service. We appreciate that in the short term you are committed to a "No Restrictions" level of service, however we believe that it would be valuable for you to consider and consult with your customers on a range of levels of service in the longer term. Section 2.9 of the technical guideline sets out that all companies should include a "reference " level of service of 1 in 10 years for temporary water restrictions and non-essential use restrictions of 1 in 40 years. We recommend you include this reference level of service in your plan, in addition to any other appropriate change to levels of service.

Any change that introduces restrictions on the use of water, both under the Temporary Water Use Ban and Drought Order Bans, would have serious consequences on our customer's perception of the company and could be detrimental to inward investment into the North East.

Additionally in accordance with the WRMP guidance we are talking with neighbouring companies about using a proportion of our surplus supply to help balance their own supply deficits. Should a bulk supply agreement result from these discussions, we believe our customers would struggle to understand why we are “giving away” their water to other water companies and then introducing restrictions on their own use.

Before contemplating such a change to our Level of Service we sought further clarification from the Environment Agency as to why such a change would be either necessary or desirable. During various correspondences between ourselves and the Regional EA it was suggested that our customers should be consulted on their willingness to pay for the current LoS, have an option to have a reduced water bill for a lower LoS, or accept a lower LoS for an improved riverine environment. Because no new water resource option is required for at least the next 25 years, the option of allowing us ask customers to accept a lower LoS to avoid increases to bills due to resource development was not an option. These points have been addressed with the EA and detailed below.

Customer consultation

The company is undergoing qualitative and quantitative research with its customers as part of the Periodic Review of Prices 2014 (PR14). The qualitative research has been completed and the quantitative (Willingness to Pay) research is now underway. Like all water companies at this Periodic Review, and in accordance with Ofwat guidance, we have set up a Customer Challenge Group. This Group is made up from a range of stakeholders and independently chaired. Because they will be advising the company and Ofwat on the content and suitability of the company’s Business Plan from the customer perspective, they have been heavily involved in the content and wording of the customer research. This Group, which includes a member of the Regional EA senior management, all agreed that it would not be worthwhile asking NW customer’s questions on restrictions on their use of water, as the need to introduce restrictions in the area was so remote.

The water resource situation in the Kielder WRZ (>98.5% of customers) with a predicted surplus of 150Ml/d in 25 years time, does not warrant restrictions being introduced. The situation in Berwick WRZ may prove to be different when the investigations into the actual sustainability of our licenses are completed, but at the present moment this area also has a significant licensed surplus supply. This situation means that a sensible choice could not be put to our customers in a willingness to pay survey.

No new water resource scheme is needed, or planned, for at least 25 years and in reality much longer. Therefore lowering the current LoS, ie introduce some form of restriction on use, does not result in the deferment of any costs.

This situation would result in the following 2 options being put to customers:-

- *Do you wish to maintain the current LoS which does not require an increase to your water bill?*

  Or

- *Do you wish to have a reduced LoS for no reduction in your water bill?*

This “choice” is nonsensical.

Discussions with the Regional EA team suggested that if we reduced our current licensed volumes, by having a lower LoS, then the saving in abstraction charges could be passed on to our customers. However we pointed out that the EA’s Water Resource account is full EA cost recovery and, with NW paying about 95% of the region’s abstraction charges, then having fewer licenses would result in the remaining licenses costing more so the same amount of money would be paid to the EA. This results in no saving to pass on to customers. This was accepted by the EA.

A further suggestion from the EA was that even if no cost saving could be passed on to customers they may accept a lower LoS for environmental improvement to the area. The following demonstrates that it is doubtful that any environmental improvement would result as the NW river system is so highly modified and regulated that the effects of our abstraction are nullified.

Practicality of introducing restrictions on the use of water

To introduce a meaningful LoS, where temporary restrictions on the use of water are needed every 10 or 20 years to ensure a company can continue to supply essential water through a drought period, requires a water company to have a fairly evenly matched supply demand balance. There is no point in introducing a LoS with temporary water restrictions when the restrictions will never need to be enacted. In the case of NW, at the company level, there is likely to be a surplus of supply over demand of at least 150Ml/d over the whole planning horizon (25 years). Introducing any form of temporary restriction on the use of water by customers with such a supply surplus would be pointless as temporary restrictions would never be needed.

The only option for the company would be to relinquish approximately 150Ml/d of its current licensed volumes of river abstractions to achieve a more finely balanced supply demand balance. As pointed out previously due to the way the EA’s Water Resource account operates, this does not result in any financial saving.

The other effect from voluntarily reducing our abstraction licenses to introduce restrictions on customers use would be the effect on our customer’s perception of the company, and the Environment Agency.

They would have their use restricted whilst Kielder reservoir, for which they continue to pay, would remain relatively full. Our customers in the North East are justifiably proud of Kielder reservoir and are fully aware of its importance to their water supplies. Neither they, nor many other important stakeholders in the region, would accept this situation without very good reason.

In the Kielder WRZ the 3 main rivers from which NW abstract are the Tyne, Wear and Tees with a smaller abstraction from the River Coquet. The Tyne, Wear and Tees flows are all compensated by releases of water from header reservoirs and they are regulated to maintain a Minimum Maintained Flow (MMF) at the bottom of the river.

The river Coquet, although not directly supported from Kielder, if required can have its distribution system supported by potable supplies derived from water treatment works with Kielder support. This replaces potable supplies from the Coquet as its flow reduces.

Under the Kielder Section 20 agreement the MMF must always be maintained, initially from releases from the header reservoirs and, when these deplete, from Kielder and the Tyne – Tees transfer. Therefore, whether the current LoS abstractions are being made from these rivers or abstractions from a lower LoS, the total flow down the rivers remain constant. This means there are no environmental benefits to these rivers whatever the LoS we would operate to. The only conceivable environmental improvement would be on a higher water level remaining in Kielder reservoir. There has never been any suggestion that Kielder suffers environmental harm from its current range of water levels.

Detailing any environmental improvement from a small reduction in dry year demand as a result of introducing Temporary Water Use Bans (TUB), that our customer's would feel is worthwhile, is not possible. With the exception of the river Coquet, where we are currently carrying out a National Environment Programme (NEP) study, no resources in the Kielder WRZ have been in the NEP or the Restoring Sustainable Abstraction programme, nor has the Habitats Directive Review of Consents required any changes to licenses. This shows that environmental damage is not caused by our current or fully licensed abstractions.

We already have a LoS that states the company will appeal for restraint in the use of water 1 in 25 years. Experience of appeals for restraint in the South has shown that it is this drought action that has the largest impact on customers saving water. We conservatively estimate this saving to be 7% of their normal demand on an annualised basis.

A TUB is estimated to save a further 3% on an annualised basis. This equates to about 12Ml/d, which is not a significant volume in terms of the water resources available in the North East.

After fully examining the EA's suggestion to consider working towards the introduction of a lower LoS, we have concluded that it would not be appropriate.

We do recognise that the situation in the Berwick WRZ, when the studies are completed and conclusions drawn on a sustainable abstraction regime, may require a review of the LoS we offer our customer's here.

2.6.1 Use of Emergency Drought Orders

In accordance with our Levels of Service that states Temporary Water Use Bans and Drought Order Bans will never be required, Emergency Drought orders will never be required either.

2.7 Details of Competitors in Each Resource Zone

The Water Act 2003 amended the Water Industry Act 1991 to extend the opportunities for competition within England and Wales. Companies that are interested in supplying customers with water can now apply to Ofwat for a water supply licence. This will allow them to supply water to eligible premises anywhere within England and Wales.
Northumbrian Water has no competitors operating in its supply area under the terms of this Act.

2.8 Linkages with Drought Plan

This document is supported by the Company's Drought Plan (NW, 2012). The Drought Plan considers what measures can be implemented in the short term to address temporary shortages of water resources during drought conditions. By contrast a WRMP focuses on how demand is predicted to change over the next 25 years and what resource options will be required to meet any longer term increases in demand and the company's target headroom requirement. Drought Planning is essentially a prepared response to developing sustained dry weather (drought) conditions that have the potential to detrimentally affect public water supplies. Drought conditions are usually manifested in the form of:

- Reduced raw water availability (eg low river flows, low reservoir storage, low groundwater levels) and/or increased demand (eg due to increased drinking, garden watering, showering etc in dry weather).

There are direct linkages between longer term water resources planning and drought planning in terms of the calculation of all elements relating to the Supply Demand balance, which can be assumed to be consistent.

By contrast, water resources planning is the regulatory process used to determine how water companies intend to maintain the balance between water supply and demand over the long term (usually a 25 year period), and is carried out at water resource zone (WRZ) level. An important aspect of this process is the ‘Supply Demand Balance’ which is essentially a comparison of both forecast raw water availability (supply), against forecast demand. The forecasts are worst case in the sense that dry weather demands are measured against source yields defined by previous drought periods. Any deficits in the ‘Supply Demand Balance’ can be addressed by a combination of reducing demand (e.g. through leakage reduction, metering, water efficiency) and increasing supply (e.g. developing new sources of water). In the case of NW no deficit is forecast in either water resource zone over the next 25 years.

3.0 WATER SUPPLY

3.1 Deployable Output

Deployable Output has been determined in line with the Water Resources Guideline which defines DO as the output of a commissioned source or group of sources or bulk supply as constrained by environment, licence, pumping plant, well, aquifer properties, raw water mains, transfer or output mains, treatment or water quality. All DO is declared downstream of the treatment works, and taking account of process losses. In accordance with Section 3.1.2 of the WRMP Guidelines, NW have not undertaken a review of deployable output as there have been no changes to sources or the supply system since the previous WRMP.

3.1.1 Kielder Water Resource Zone Deployable Output

Source Name	Deployable Output, Ml/d
Whittle Dene	118.00
Gunnerton	11.00
Byrness / Rocester / Otterburn	0.33
Horsley	150.00
Fontburn	19.00
Warkworth	42.50
Tosson	2.62
Stonehaugh	0.04
Slaggyford	0.10
Allenheads	0.03
Birchtrees	0.70
Carr Shield/Currick	0.06
Northern Supply Zone	**344.38**
Mosswood	152.00
Wear Valley	34.00
Honey Hill	45.00
Sunderland GWS	44.00
Lumley	42.00
Central Supply Zone	**317.00**
Lartington	128.00
Broken Scar	180.00
Southern Supply Zone	**308.00**
KIELDER RESOURCE ZONE	**969.39**

3.1.2 Berwick and Fowberry Water Resource Zone Deployable Output

Source Name	Deployable Output, Mld
Berwick	8.64
Fowberry	3.65
BERWICK RESOURCE ZONE	**12.29**

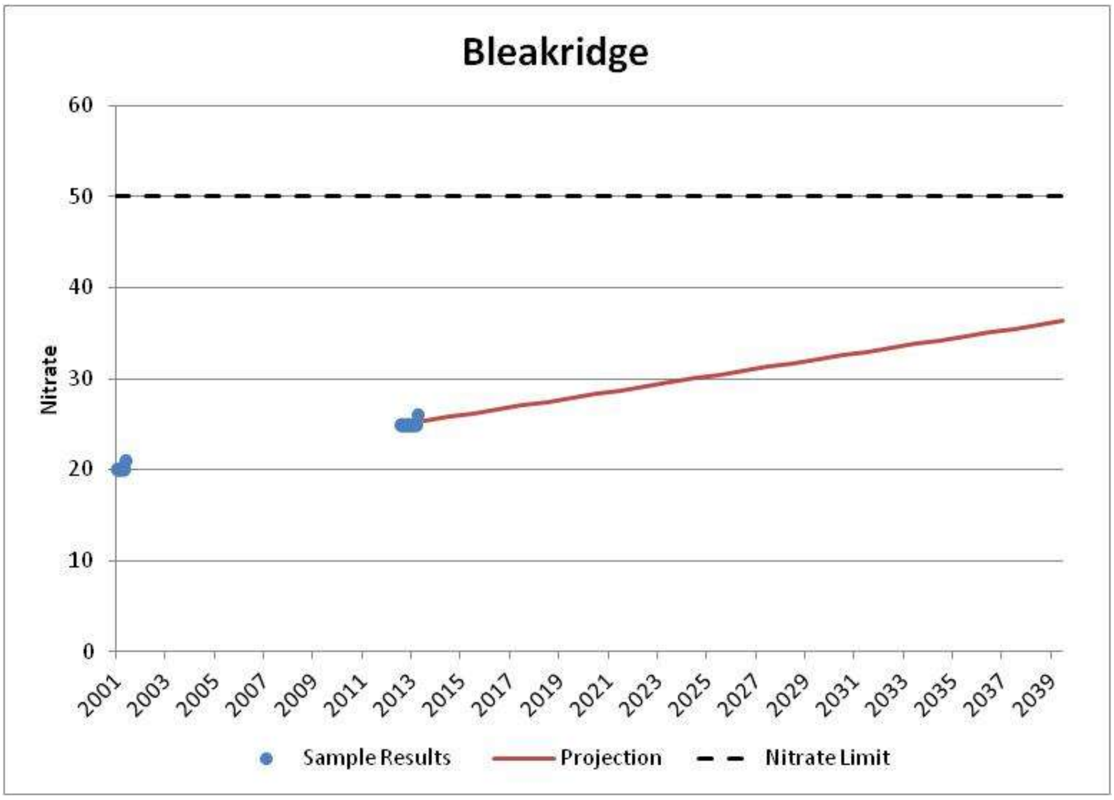
Elevated nitrate concentrations in the groundwater from the Till Fell Sandstone aquifer could, in time, risk failure of the drinking water standard (DWS). Although still well below the DWS, sampling trends for nitrate at Murton, Thornton Bog, Thornton Mains and Bleakridge highlight an upward trend. However the graphs below show that none of the sources, even if nothing was done, would exceed the standard over the 25 years of this plan.

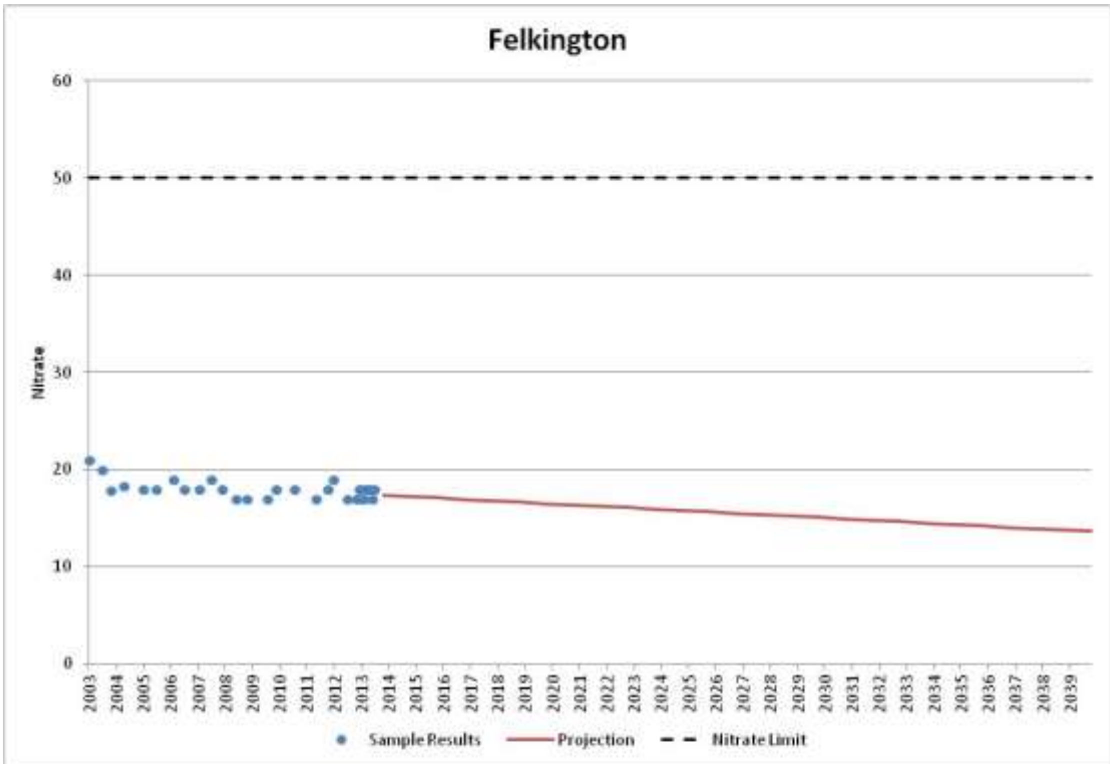
The EA initiated a project, 'Till Catchment Water Management' to, amongst other things, address the nitrate issue in the aquifer. Working in partnership with ourselves and Catchment Sensitive Farming (CSF) a number of activities have been undertaken or are planned. Work is ongoing to identify potential inputs of nitrates other than fertilizer to the Fell Sandstone examples being septic tanks and land spreading activities. A septic tank leaflet has been produced and will be distributed within the catchment along with a septic tank questionnaire and the offer of assistance with septic tank emptying in the main target area.

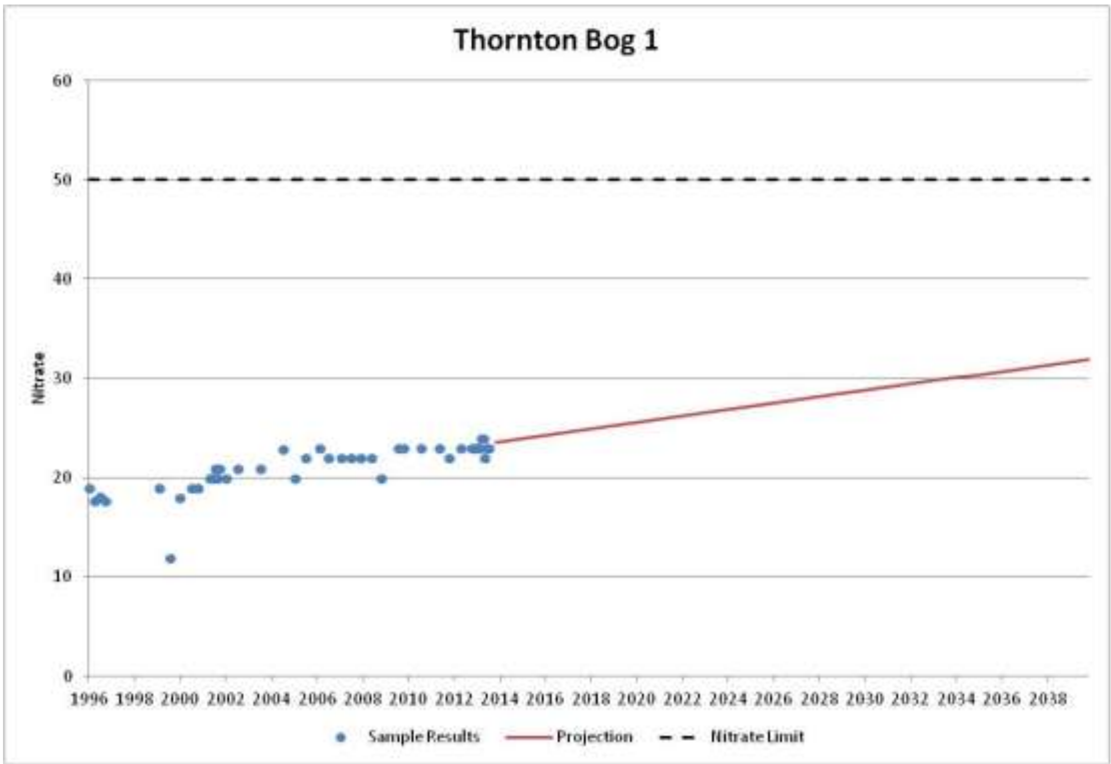
Soil sampling has been undertaken by SAC to determine nitrate losses from the soil through the agricultural year and this is to be repeated next spring. A number of farms in the area have been visited by ADAS as part of the existing CSF engagement programme. These visits are to be followed with a farmer workshop on nitrate awareness in November 2013, the aim being to engage with, influence and inform landowners and farmers to improve activities that could contribute nitrate to groundwater.

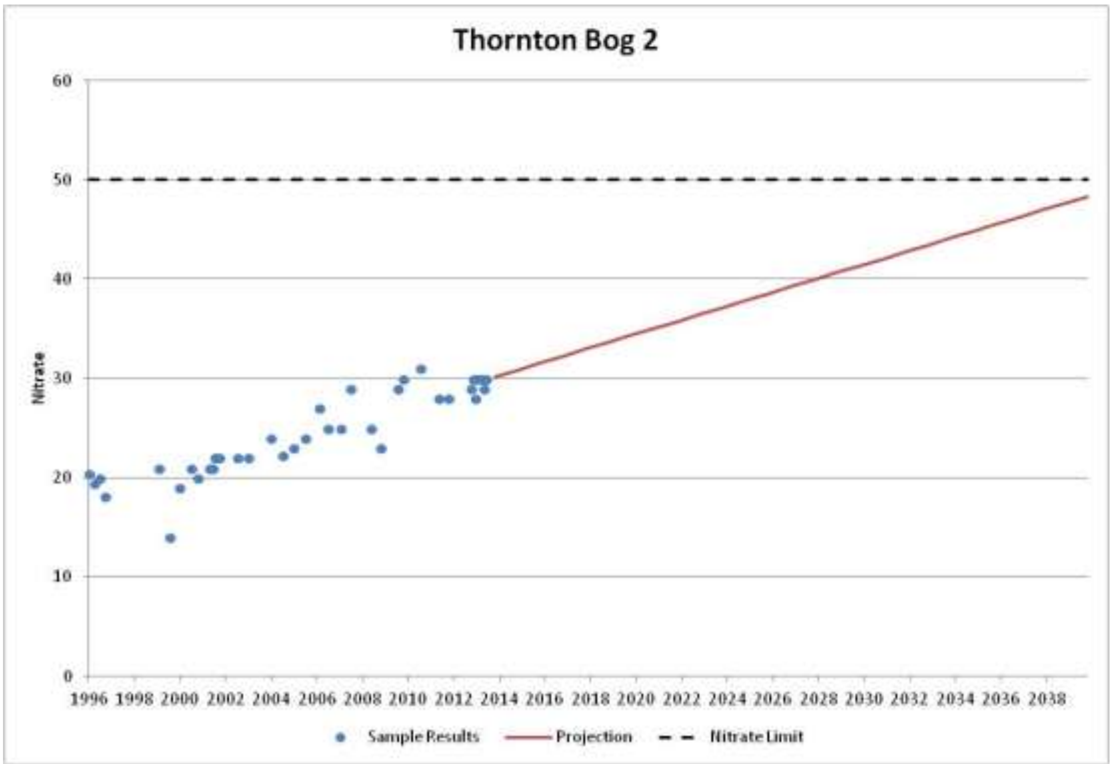
It is hoped that by taking action now we will be able to slow or reverse the increasing trend we are currently seeing in some of our boreholes in order to prevent exceeding the Drinking Water Standard (50mg/l as NO3) in the future.

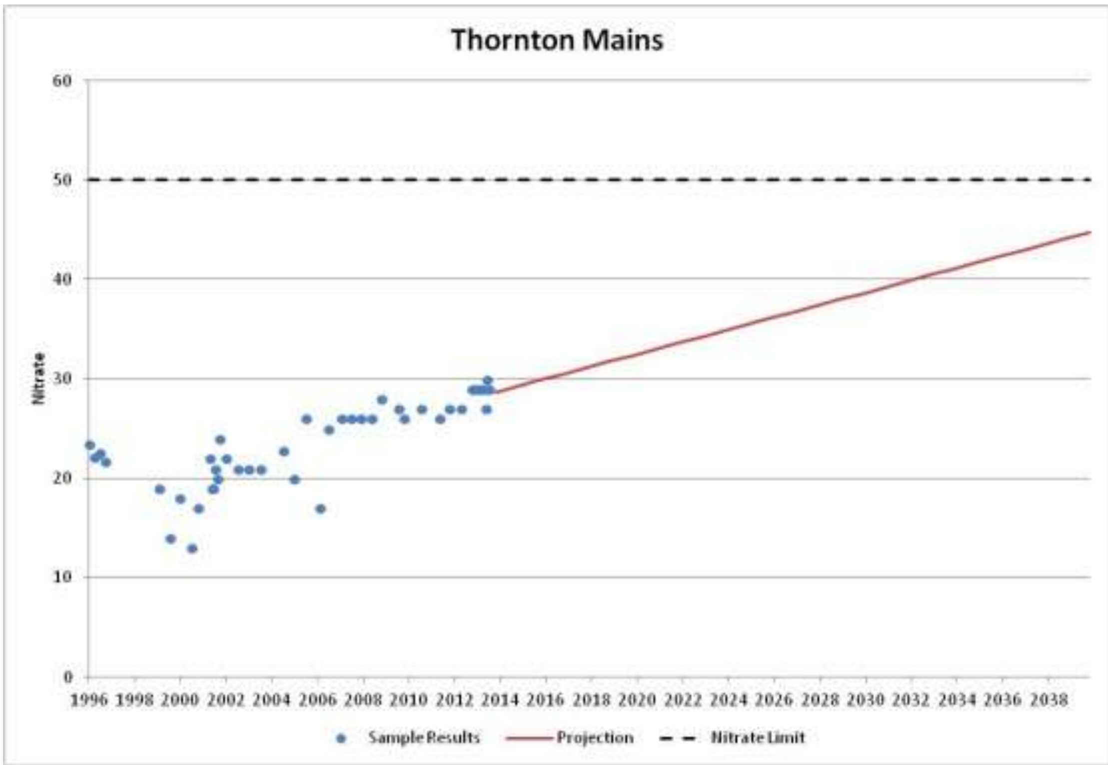
The graphs below show the samples results and an extrapolation of the values expected if the trend continues at the current rate.

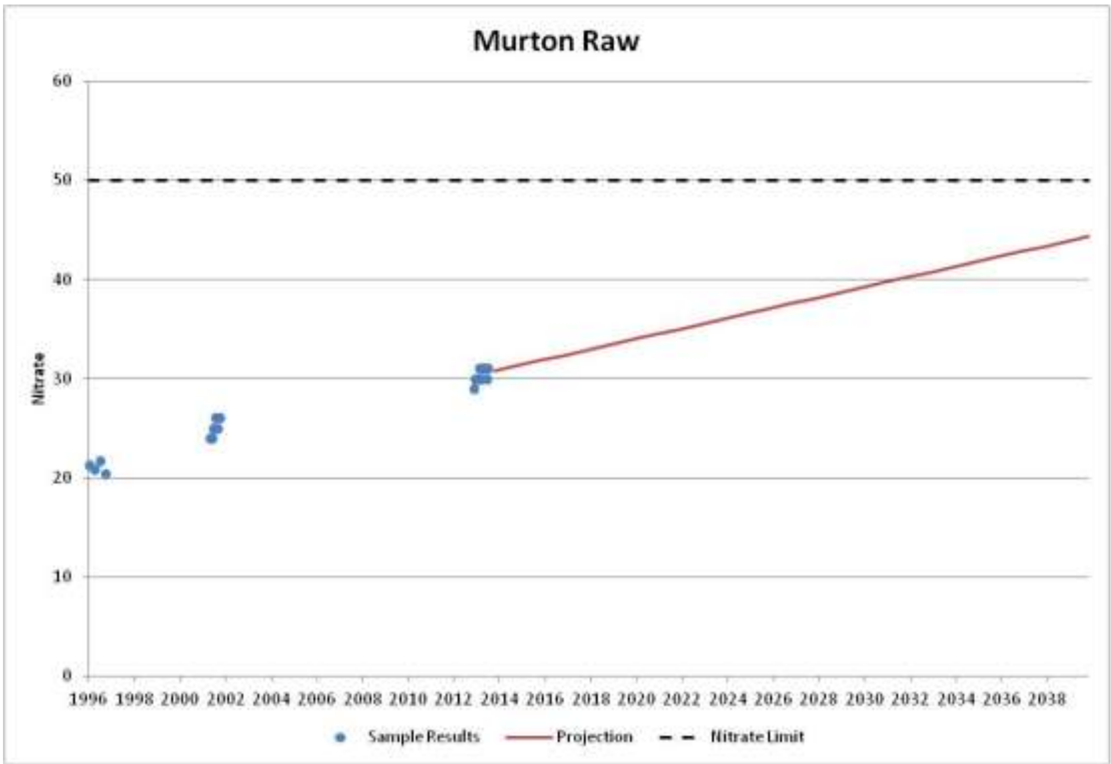

Bleakridge
60
50
40
30
20
10
0
Nitrate
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
Sample Results
Projection
Nitrate Limit

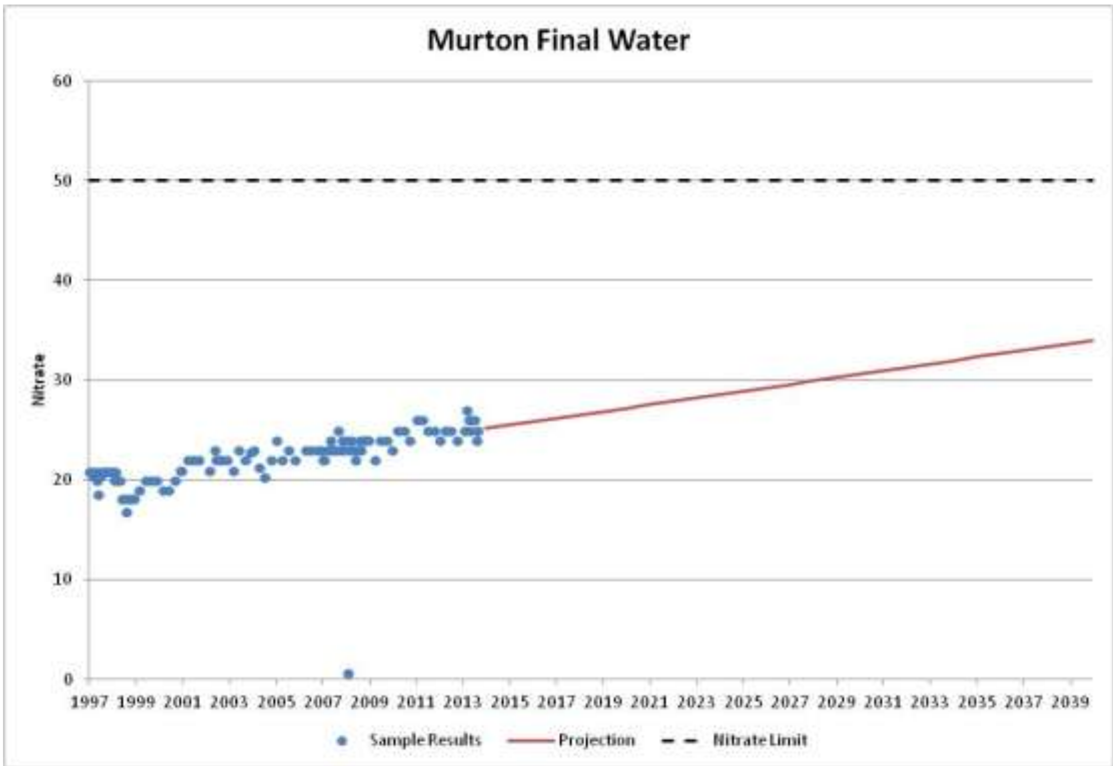

Felkington
60
50
40
30
20
10
0
Nitrate
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
Sample Results
Projection
Nitrate Limit


Thornton Bog 1
Nitrate
60
50
40
30
20
10
0
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038
Sample Results
Projection
Nitrate Limit


Thornton Bog 2
Nitrate
60
50
40
30
20
10
0
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038
Sample Results
Projection
Nitrate Limit


Thornton Mains
Nitrate
0
10
20
30
40
50
60
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038
Sample Results
Projection
Nitrate Limit


Murton Raw
Nitrate
0
10
20
30
40
50
60
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038
Sample Results
Projection
Nitrate Limit



3.1.3 Industrial Water Resource Zone Deployable Output

Based on the definition of deployable output, the DO for the Industrial water system is 438.11 Ml/d. This figure is approximately three times the current and forecast demand for industrial water.

3.2 Reductions in Deployable Output

In the Kielder Zone there has been no change in Deployable Output from our previous WRMP.

In the Berwick and Fowberry Zone we have assumed that the proposed time-limited licence at Fowberry will be renewed at the current volume but this will not be confirmed until the investigation work proposed for 2013/14 has been completed.

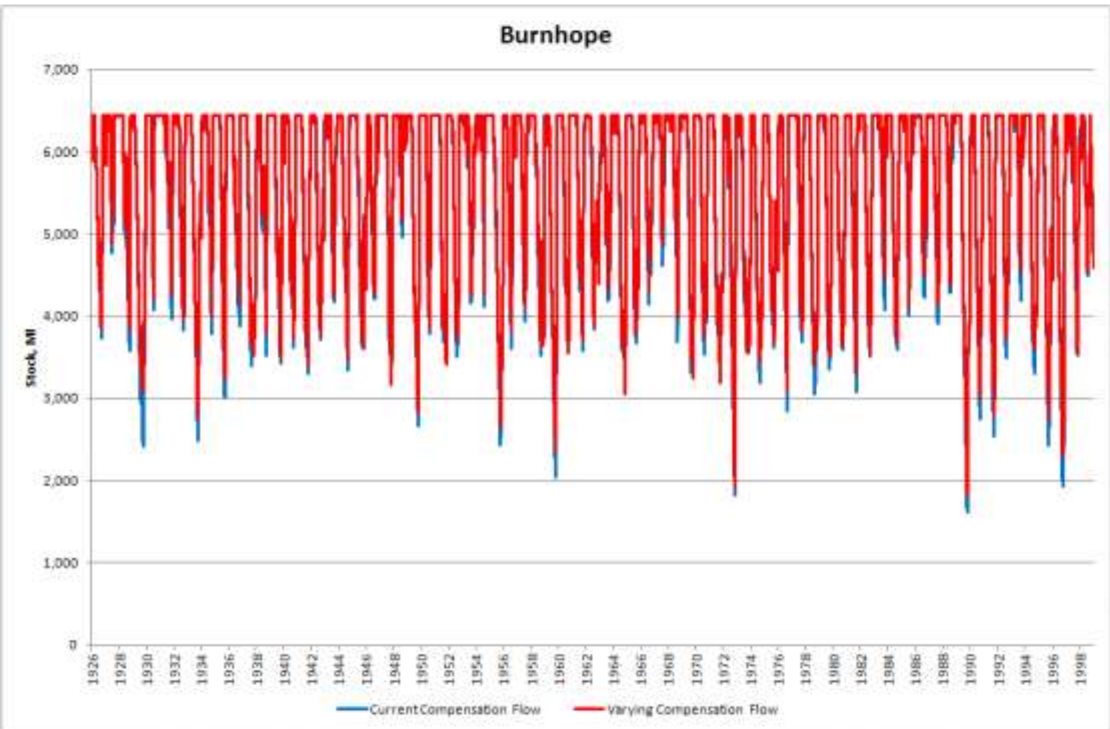
3.3 Sustainability Reductions

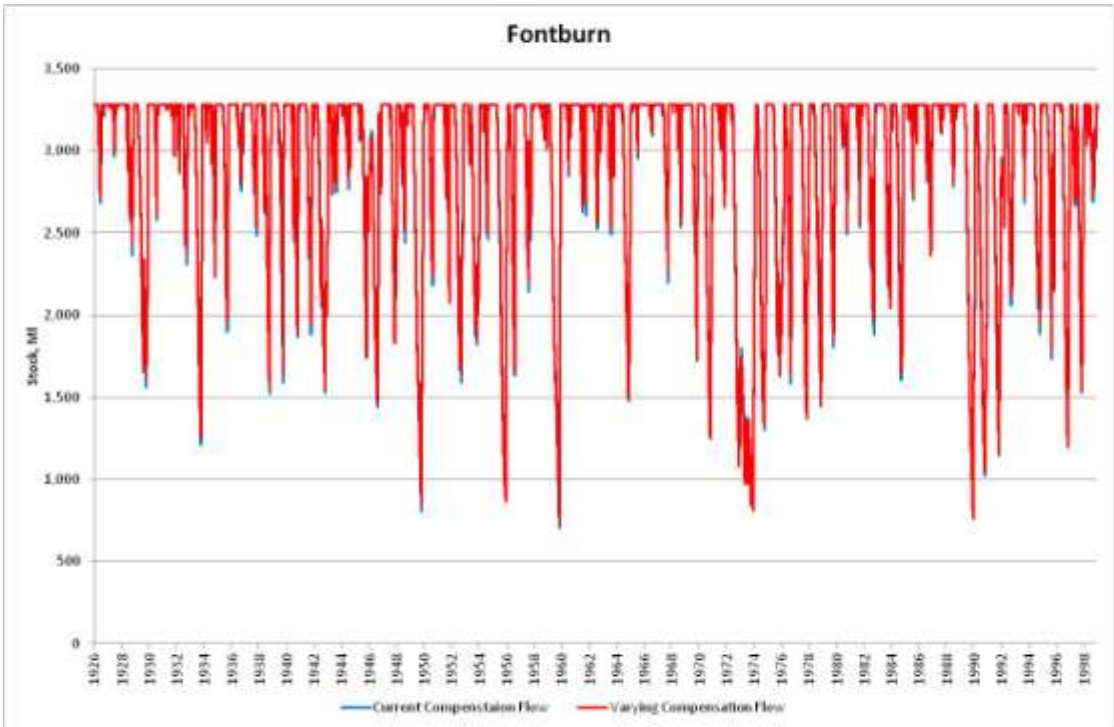
Following work between the EA and NW a list of proposed Sustainability Changes has been produced. Within the Kielder Zone this has concentrated on work for Phase 2 of the National Environment Programme involving Heavily Modified Water Bodies (HMWB) issues. At many of our impounding reservoirs we undertake compensation flows which are made to ensure water enters the river course below where it has been impounded.

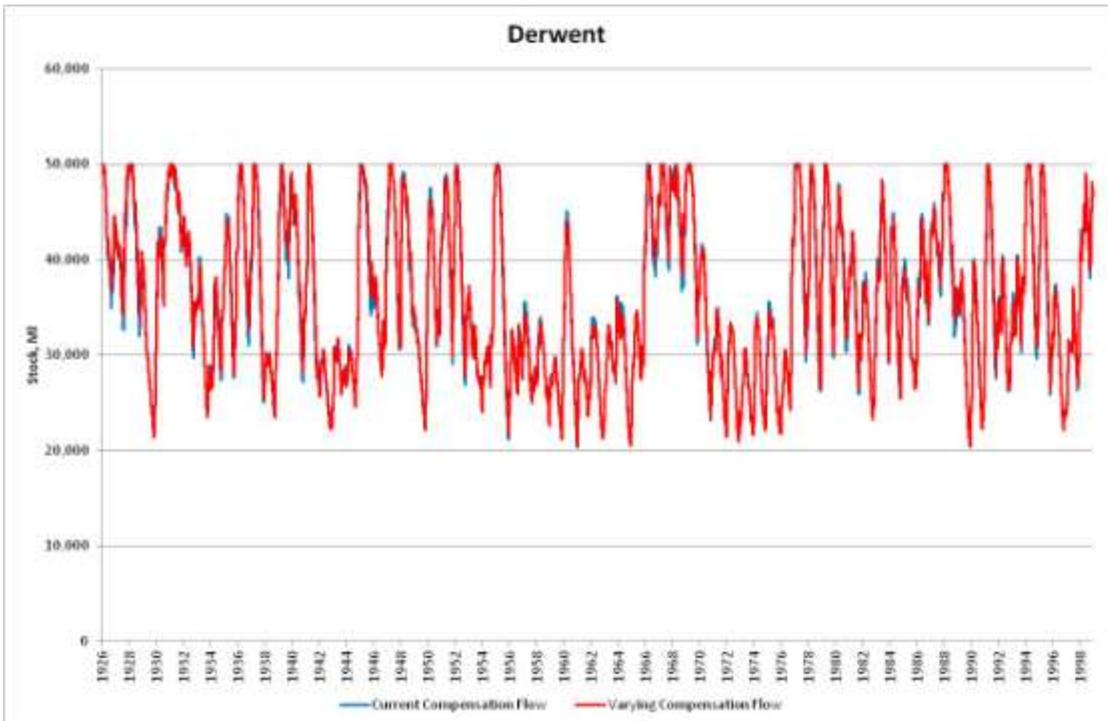
Generally these flows have been at a constant rate and studies have suggested that this is not the best practice as naturally there should be a seasonal variation in the volumes released. The reservoirs investigated in the Kielder Zone were Burnhope, Grassholme, Hury, Fontburn and Derwent. The proposed changes can be shown in the table below.

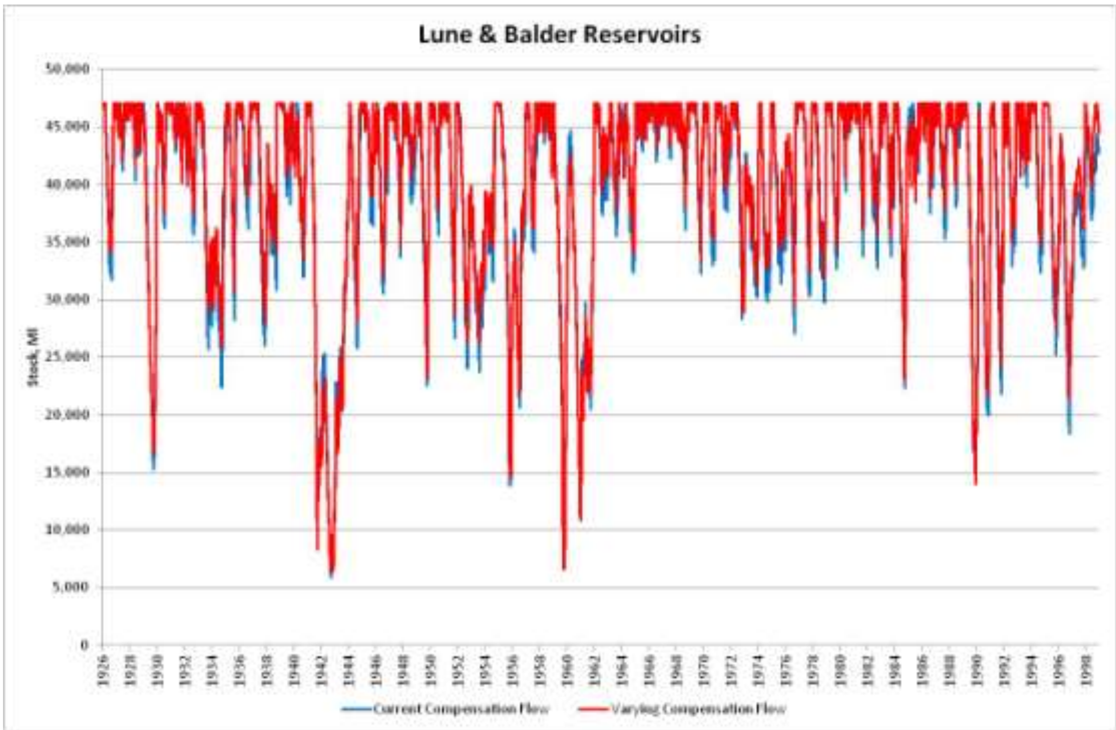
	Fontburn		Derwent		Burnhope		Hury		Grassholme	
	Apr to Sep	Oct to Mar	Apr to Sep	Oct to Mar	Apr to Sep	Oct to Mar	Apr to Sep	Oct to Mar	Apr to Sep	Oct to Mar
Proposed (Ml/d)	1.7	3	13	34.6	5.2	13	8.6	21.6	18.1	38.9
Current (Ml/d)	2.3	2.3	23.9	23.9	9.1	9.1	15.2	15.2	28.4	28.4
Less in Summer	0.6		10.9		3.9		6.6		10.3	
More in Winter		0.7		10.7		3.9		6.4		10.5

To asses the impact of these proposed variations on the stock levels of the impounding reservoirs and any resulting reduction of DO, the *i-Think* models were run with the planned summer and winter variations to the compensation flows. As an example it can be seen in the graph below for Burnhope reservoir the reduction in summer compensation flow results in a lower level of draw down in the summer and the increased flows in the winter result in a slower refill. However the reservoir still spills. This has no impact on the DO of Wear Valley WTW beyond that normally experienced. The results of the analysis on the other reservoirs with proposed variations to compensation flow, follow a similar pattern and these graphs are included below.




Fontburn
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Stock, Ml
Current Compenstaion Flow
Varying Compensation Flow


Derwent
60,000
50,000
40,000
30,000
20,000
10,000
0
Stock, Ml
Current Compensation Flow
Varying Compensation Flow



Under the programme one other reservoir, Waskerley, was investigated. Further work is required by both ourselves and the EA to determine the effect of making a compensation release into a section of river between Waskerley and Tunstall reservoirs. Currently there is no compensation release from Waskerley and the magnitude of such a release has yet to be determined. Depending on the result of this work it may be necessary to alter the abstraction licence at Waskerley Air shaft on the Tyne-Tees Transfer. Initial discussions with the EA have suggested that there will be no issue with such an application and therefore there will be no effect on the DO of Honeyhill WTW which is supplied from Waskerley reservoir. Further updates on this proposal will be detailed in future WRMP annual updates.

As part of the NEP an investigation was carried out on The River Coquet to assess the effects of our abstractions to Warkworth WTW were having on the river ecology. The outcome of the investigation was that no further action was required and therefore there is no reduction in DO at the works.

Investigations and modelling were also carried out into the effect our groundwater abstractions from the Magnesian Limestone aquifer were having on the coastal streams in the Sunderland/Durham area. Again the results showed no further action was required.

3.3.1 Berwick Water Resource Zone

The Berwick and Fowberry supply system lies on the extreme northeast border of the Northumbrian Water operating area. The WRZ supplies two centres of population in Berwick and Wooler (Fowberry). The area is predominantly rural but is also a very touristic area. The resident domestic population in 2012/13, broken down into the two main areas is :-

Fowberry area	2,196 properties (4,838 population)
Berwick area	6,625 properties (15,802 population)

A significant number of these homes are associated with the touristic nature of the area, although we have no reliable way of estimating how many. The use of the homes by tourists manifests itself in two ways. Either by some of the properties being second homes which are only partially occupied during the year, or others, as well as being a primary residence, also being used as guest houses. This makes defining an accurate average occupancy difficult and assigning an average per capita consumption liable to more degree of error than in the Kielder WRZ. However, most of the tourists to the area stay in some of the very large caravan and camping sites within the WRZ. This is evidenced by almost 50% of the distribution input to the Berwick WRZ being used by non-households. Meaning, after allowing for leakage in the zone, non-household demand is twice the domestic demand. Whilst there is other non-household demand associated with non tourist businesses, the majority of this demand is associated with the tourist industry. What is also unusual in the zone is that tourists occupy the area in fairly constant numbers throughout the year. The daily demand for this WRZ is remarkably constant throughout the year apart from in severe winters. In the exceptionally cold winters of December 2010 and January 2012 high increases in leakage were experienced, significantly associated with caravan parks and empty second homes.

There are five pumping stations with a total of six bores in the Berwick area and two pumping stations with a total of four bores in the Fowberry area. As the groundwater is classified as being in pristine condition, only marginal treatment is required, that is to say in this case just disinfection (i.e. no filtration or other physical processes are employed except at one site, where manganese removal is required).

There is some linkage between the Berwick area supplies and those of Fowberry with Holy Island and the Haggerston area of the WRZ capable of being supplied by either source.

Demand plus target headroom remains almost constant across the whole 25 years with a very small decrease in the demand / target headroom line between 2015 and 2040.

Background

Over many years, the clear focus needed to ensure all assets were capable of meeting the needs of customers at that time and into the future was not always maintained to the high standards we aspire to in the Berwick WRZ. The WRZ supply position was, in a way, masked by the large and growing surplus supply in the Kielder WRZ serving 99% of our customers. Internal changes to structure and responsibilities, plus the assets continuing to meet operational needs, resulted in them not always achieving an appropriate priority for maintenance and investment. The natural deterioration that occurs in bores (resulting in sediment build-up) which should trigger refurbishment of the bore was overcome by raising pump levels to avoid drawing these sediments into supply. The regulatory change to a tighter turbidity standard for drinking water was then achieved by the output of individual bores being capped to ensure these quality standards were met. The reduction in an individual bore output was entirely quality driven and not as a result of concerns with the sustainability of the yield from the aquifer.

The overall impact of the sediment build-up and structural deterioration was to incrementally reduce the volume of water available for use from each bore. This creeping reduction at no time resulted in a deficit in supplies required to meet customer demand but it did eventually lead to a position where all bores were required to be in supply for demand to be met during higher demand periods. It was at this point, where the level of redundancy effectively reached zero, that the consequence not fully maintaining the boreholes became apparent. This immediately resulted in a change of priority for maintenance in this WRZ.

Over the past two years, plans have been developed to address the condition of the bores and reduce risk through increasing the level of redundancy and spare capacity by removing the quality issues that are capping outputs. Felkington, one of the supply bores in the Berwick area, has been refurbished and now meets quality standards at flows in excess of 65 m^3/hr, where previously 35 – 40 m^3/hr was all it could manage within quality constraints. All the other bores are to have similar work carried out over the next three to four years and will have full step tests and yield analysis undertaken to aid understanding of the aquifer status and behaviour with respect to the sustainability of the supply.

In conjunction with this, and again as a lack of clear focus, the measurements taken of water levels in the supplying aquifers were not accurate. This resulted in incorrect level data being submitted to the Environment Agency (EA), who then subsequently queried the information it provided, as it seemed to indicate serious deficits in some parts of the aquifers. As a result of this discovery, all bores and their respective measurement points were surveyed and their exact position in relation to ordinance datum established.

Fortunately, the historic data could be corrected and the actual status established, which whilst being a much more positive picture, still gave sustainability concerns to the EA (see ‘The EA review of the Berwick and Fowberry system’ below).

Planned water supply improvements in the Berwick WRZ during AMP5 (2010 – 2015)

In the PR09 Business Plan the company proposed linking more of the Fowberry area of the WRZ to the Berwick supplies. This additional water was required due to summer demands, in very warm summers, causing the daily licensed volumes for the Fowberry system being exceeded on a few days in 2006. An interim solution of varying up the total Fowberry daily licence by 0.5Ml/d was put in place between 2010 and 2015 by varying the existing licence. Since the licence variation was granted in 2010 the original licence volume was marginally exceeded for only a few days in the 3 year period. The proposed pipeline linking Berwick and Fowberry would allow some of the surplus licensed Berwick supplies to feed the Fowberry area, thereby no longer needing the licence variation, and it also more fully integrated the whole WRZ.

Consultants were contracted to carry out a feasibility study into this proposed linking of the areas and their report was finalised in November 2012. Prior to completion of the feasibility report the company met with the EA in 2011 to discuss water resources in the Berwick WRZ. The EA informed us that now a conceptual groundwater model of the Fell Sandstone had been completed there was concern as to the sustainability of our abstractions from the Berwick area sources.

Given that our licensed volumes, and possibly even our currently abstracted volumes, may turn out to be unsustainable, then developing a link between Berwick and Fowberry supplies that required a further 0.5 to 1.0Ml/d from Berwick boreholes may prove to be an abortive investment. Under these circumstances we decided to continue the feasibility study to its conclusion but not to move forward to scheme development. The EA advised that a further variation to the Fowberry licence was a better option to pursue.

The main points from the feasibility study show various combinations of increasing the supply from the Felkington borehole (once refurbished), adding some turbidity treatment to the treatment stream at Berwick and laying a 5.9km pipe between Felkington and Watchlaw Service Reservoir (in the Fowberry system) would be the best feasible option of ensuring all demands could be met.

Depending on the outcome of the NEP work on the Berwick WRZ, this option may be pursued in AMP7.

Proposals to reduce the demand in the Berwick WRZ

With a possibility that some form of sustainability reduction may be the outcome of the NEP work being carried out in AMP6, we have been examining what opportunities exist to manage demand within the Berwick WRZ. These fall into 3 general areas of metering, water efficiency and leakage reduction.

Metering

The opportunity of increasing the level of metering, beyond the current and proposed rate of opting, in the Berwick WRZ is not high. The company is not classed as seriously water stressed therefore a compulsory programme cannot be introduced. However with the relatively low number of properties, and a number of those associated with the tourist trade, water savings from enhanced metering would at best be moderate. No additional meter promotion is planned.

Leakage

The leakage target for Berwick is 2.0Ml/d and Kielder 135Ml/d over the whole planning horizon from 2016/17, giving a NW leakage target of 137Ml/d. Whilst the WRZ levels are set on the Sustainable Economic Levels of Leakage we now consider it appropriate for Berwick to be taken down below this level with a concomitant increase in the Kielder WRZ. Whilst the increase to the leakage target is negligible in the context of Kielder WRZ, the lowering of the target in Berwick has a significant effect on the supply demand balance for this WRZ.
Lowering the leakage target in Berwick WRZ is possible by investing in further pressure management and the creation of additional District Meter Areas. Assuming this investment occurs during AMP6 then the following leakage targets will be set for Berwick:-

	2015/16	2016/17	2017/18	2018/19	2019/2020
Draft WRMP	2.0Ml/d	2.0Ml/d	2.0Ml/d	2.0Ml/d	2.0Ml/d
Final WRMP	2.0Ml/d	1.9Ml/d	1.8Ml/d	1.7Ml/d	1.6Ml/d

Water efficiency

A whole town approach to water efficiency could be applied to Berwick water resource zone. The concept is to carry out all the different types of water efficiency activities in one area. Marketing, promoting and encouraging all initiatives under one overarching banner should encourage a high percentage uptake from the area.

The work that this would involve includes the following:

Audits, Retro-Fitting and Recommendations

Property auditing involves a plumber-led water audit to identify the measures that can be taken to reduce consumption and maximise the provision and fitting of products that will save water. This work on household and commercial properties includes the detection and repair of leaking toilets. The intension is to maximise the water savings that can be achieved by taking opportunity to fit products whenever possible. We collect data to enable water savings to be quantified and all aspects of the project fully evaluated for contribution to water saving, customer satisfaction, economics, reliability/performance of products, plumbing issues and performance

.

The property types could be included as groups of non household types such as:

- Caravan Parks
- Schools
- Local Authority buildings
- Hotels and B&Bs
- Restaurants, bars and other local businesses
- Farms

Water Saving Kit Distribution

The standard and bespoke water saving kits provide a variety of water saving devices that can reduce utility bills and help to reduce water consumption by as much as 95 litres per day. After fitting, the devices will immediately start reducing daily water consumption.

The water saving kit includes the products below:

Universal plug - saves on average 12 litres per day. Universal size to fit all sinks.
Tap insert - saves on average 36 litres per day. Fits most wash basin taps with circular outlets.
Save-a-flush - saves on average 12 litres per day.
4 minute shower time - saves on average 5 litres per day.
Water saving shower regulator - saves on average 30 litres per day.

Promotional Campaigns

Working with local radio to broadcast water efficient messages, and promoting our water saving kits. The response from the public is extremely good, with direct contact from customers and our water efficiency message being received by many more.

<u>Little Green Riding Hood</u>

LGRH is an educational play in which professional actors carry out a play to highlight water efficient ways and water wasting habits which could be avoided. The performance is given to primary schools and a follow up workshop immediately after the play really promotes actual behavioural change towards the children and their families being more water efficient.

PR14 National Environment Programme process

The Environment Agency has undertaken a review of abstraction licences and has identified those which may be causing or could cause environmental damage to specific designated sites. This review is managed through an Environment Agency process called Restoring Sustainable Abstraction (RSA). This seeks to identify, investigate and solve problems caused by unsustainable abstraction licences. Additionally, the Water Framework Directive also requires investigations into water bodies that are failing to meet their environmental objectives (i.e. Good Ecological Status (GES) or for water bodies that are classed as heavily modified, Good Ecological Potential (GEP).

If a water company abstraction is implicated, either via the RSA or WFD process, the Environment Agency will then include the abstraction licence in the water company's National Environment Programme (NEP) which is then fulfilled in the following Asset Management Plan (AMP) period. Each scheme within the NEP will require an investigation where there is insufficient evidence to determine the sustainability of an abstraction. Where the investigation concludes the abstraction is or could cause significant adverse effect, an options appraisal is then undertaken and a preferred solution identified and agreed with both the Environment Agency and Natural England. The cost of the preferred solution is then included in the Company's Business plan submission. If agreed by Ofwat, allowance in funding will be given for implementing the preferred solution in the next AMP period. It may be that the Environment Agency has already undertaken its own investigations. In this case, a water company would then only be required to undertake options appraisal and implementation.

The EA review of the Berwick and Fowberry system

The EA's initial WFD assessment of abstraction from the Berwick and Fowberry sources suggests that there is a year on year reduction in groundwater level. However, inter-action between the various strata from which abstraction takes place and interaction between the aquifer and surface water is not fully understood. While further AMP6 modelling and investigations are undertaken to improve understanding, the company has agreed to include in its WRMP that the daily abstraction rate will be capped at 9.5 Ml/d from 2020. The actual sustainability reduction, if any, to licensed quantities will be determined once the final model outputs have been delivered in AMP6.

Part of the studies will also include options appraisal of ensuring a supply demand balance is met in this WRZ for inclusion in the 2019 WRMP. We already have a rough estimate of the infrastructure requirements and costs of replacing all of the groundwater supplies in the zone with surface waters brought up from Warkworth WTW. This is currently in excess of £50m. It is likely that this very large investment, to this relatively sparsely populated area, would be difficult to prove to be cost beneficial.

Our Action Plan

There are four elements in our plan

- i. Remedial works to existing boreholes to maximise their deployable output;
- ii. an hydro-geological investigation and abstraction sustainability study; and
- iii. the enabling work for the above study.
- iv. Fowberry abstraction licence variation

We are currently preparing a project specification for Prof. Paul Younger of University of Glasgow, a renowned groundwater expert with solid experience of the Berwick and Fowberry system. This specification will cover the investigations and assessments detailed overleaf. Prof. Younger is planning to oversee the hydro-geological investigations which are likely to be undertaken by a full time research hydro-geologist working for him. Once the specification is agreed with the Environment Agency, a project start-up meeting with Prof. Younger, his hydro-geologist, the Environment Agency and NWL will be held, if possible during November 2013.

Borehole remedial works

The deployable output of some sources is currently constrained by groundwater turbidity or iron (i.e. the higher the abstraction rate, the higher the turbidity), not by groundwater level. In some cases the source of the turbidity is from within the aquifer and so remedial measures such as casing out the strata responsible for the turbidity is required. Where turbidity is as a result of bore hole deterioration then remediation work such as acidizing and scrubbing will be required. To do this type of remediation it may only be possible if nearby sources are also taken out of supply. Until recently this was not thought possible because of the narrow headroom between available supply and possible water demands. However, because of the urgency of refurbishing the individual boreholes a plan has been developed to overcome this potential constraint. Initially, a new satellite source was investigated, which would supply demand when another borehole was taken out of supply. This was realised not to be the best option for now as the timescales to design, construct and commission a new bore are incompatible with the overall refurbishment programme and so this option has been discounted.

The plan that has been developed is based around risk management and a wider plan to understand and manage the risks presented by taking each source out in turn. Risk-reducing mitigation actions include activities such as substitution of output from other reliable sources, comprehensive and well-developed project plans, increased leakage find and fix, rapid response teams for bursts and provision for emergency temporary tankering. In addition area-wide co-ordination plans are produced that ensure additional risks are not created by other simultaneous supply-impacting maintenance work.

As each source is refurbished and returned to supply, the quality-driven constraints on abstraction rates will be removed or greatly reduced and an increased output achieved. This in turn will reinforce local resilience by providing even greater substitution potential for the bore refurbishments to follow and will give us more choice over resource selection to support operational or hydrological requirements.

We have already started this programme of works to refurbish the boreholes. Felkington borehole is the first bore to be refurbished and has resulted in an increase in output from 0.96Ml/d to 1.2Ml/d without any deterioration in the turbidity of the water abstracted. The planned refurbishment programme is summarised in the table below.

Programme for Berwick and Fowberry

	2013/14		2014/15		2015/16		2016 +
Area of work	**2013**	**2014 spring**	**2014 autumn**	**2015 spring**	**2015 autumn**	**2016 spring**	
Existing Berwick Boreholes	Thornton Mains refurb	Bleak Ridge refurb	Thornton Bog 1 refurb	Thornton Bog 2 refurb	Murton refurb		
Existing Fowberry Boreholes		Fowberry Treatment 2 refurb		Fowberry Mains A refurb		Fowberry Treatment 1 refurb	
New Fowberry Borehole					Site reconnaissance		Drilling, testing and licensing
Groundwater Monitoring	Commence weekly boredips	Install new level transducers in all bores	Ongoing monitoring	Ongoing monitoring	Ongoing monitoring	Ongoing monitoring	Ongoing monitoring
Stream gauging	Monitoring starts November 2013			Continue if further baseline data is required			
Prof. Younger Studies	To identify locations of new monitoring boreholes		To identify location of New Fowberry Borehole		AMP6 NEP Hydro-geological Investigation and Abstraction Sustainability Assessment		

In terms of the wider sustainability assessment, it is important to understand what the deployable output of each source is once these water quality constraints have been remedied. We plan to carry out test pumping on the refurbished bores to allow a reassessment of their deployable output. The new DOs will allow us to preferentially use certain bores that may be environmentally or operationally more advantageous to use at higher rates than others. The impact of such abstraction plans on aquifer sustainability need to be determined, and this will be supported by the data acquisition and assessment work outlined in the following section.

Study enabling work

Having reliable 15 minute groundwater level data is essential for a robust deployable output assessment and to inform the hydrogeological investigations and sustainability assessment. Consequently, we will be installing new improved level transducers in each of the boreholes. Additionally, we will be commencing weekly spot manual groundwater level measurements. This data will then be used to validate the tele-metered data.

The Environment Agency has identified that there is a lack of groundwater level monitoring boreholes, particularly in the Murton and Thornton area. This lack of data means that there is a greater degree of uncertainty in the initial abstraction sustainability assessment than otherwise would have been the case. To fill in these data gaps, where possible, existing currently unused boreholes will be used else we will construct new monitoring boreholes. The location and design of each of the new monitoring boreholes will be confirmed as part of the investigation overseen by Prof. Younger.

We have already agreed with the Environment Agency that we will undertake stream gauging. Where the Environment Agency is already clear on where stream gauging is required, NWL will commence this at a frequency (weekly or monthly) to be agreed with the Environment Agency during November 2013. Otherwise the locations for stream gauging will be confirmed as part of the investigation overseen by Prof. Younger.

Fowberry abstraction licence variation

The Fowberry annual licensed quantity will reduce in 2015 when a current licence variation expires. NWL plans to apply for a further variation to maintain the current annual licensed quantity. A supporting environmental appraisal report will also be submitted which presents an analysis of available data and information. The scope of this report will be agreed with the Environment Agency in the coming months. This further licence variation was suggested by the EA, as the planned AMP5 pipeline to transfer water from Berwick to Fowberry became unviable when the sustainability of the Berwick abstractions was raised in 2011. The variation has only been partially used for a small number of days over its life and abstraction from the Fowberry bores is currently thought to be more sustainable than the Berwick abstractions.

Hydrogeological study and abstraction sustainability assessment

This project will essentially review the sustainability of NWL's Berwick and Fowberry abstractions. The study will review:

- existing data and conceptual understanding;
- new groundwater level data from both the Production and monitoring boreholes;
- new stream flow data; and
- geological logs obtained during the construction of the monitoring boreholes

This independent sustainability assessment will then inform the Environment Agency's assessment as to whether the abstraction licence can be renewed or whether a sustainability change is required. The outcomes of the Environment Agency's assessment will then feed into the Berwick Water Resources Management Plan Supply Demand Balance Calculation. If there is a supply deficit, an options appraisal will be required to eliminate the deficit. Such a scheme will then feed into our PR19 Business Plan.

3.4 Raw Water Losses

Similarly to the last WRMP a default value for trunk main losses of 200l/Km/day/year of age of main, taken from "Managing Leakage", has been used. Lengths of raw water mains and their average age have been taken from our GIS for the Kielder, Berwick and Fowberry zones and also the Industrial system.

This analysis showed that in Kielder WRZ there are 292 Km of raw water mains with an average age of 63 years at the start of the planning period giving an estimated loss of 3.68 Ml/day rising to 5.31 Ml/day in 2039/40.

Berwick has 35 Km of raw water mains with an average age of 33 years giving losses of 0.23 Ml/day. Given the possibly tight post 2020 supply demand balance in this WRZ, leakage control will be increased on these raw water mains to ensure leakage does not increase above 0.23Ml/d.

The Industrial system has 192 Km of mains with an average age of 33 years giving losses of 1.27 Ml/day rising to 2.38ml/day in 2034/35.

There is only limited operational use on the raw water system within the Kielder zone. On an annual basis the pipeline from Catcleugh reservoir is cleaned and releases are made at Frosterley and Eggleston to maintain water quality in the Tyne-Tees tunnel. These operations were estimated to use the equivalent of 0.62 Ml/day during 2011/12.

An analysis of water onto and out of some treatment works sites has shown that on average the losses across works is around 5.58%. This figure has been applied to the water abstracted value to give overall treatment works losses within the Kielder zone.
In the Berwick & Fowberry area the treatment process involves re-circulation of the water and therefore there is perceived to be no losses across the treatment works.

3.4.1 Further information relating to Berwick WRZ as requested by Defra

Berwick WRZ
In the WRMP of 2009 the Berwick WRZ had a significant overall surplus of deployable out against all future demands for the whole 25 year planning horizon. The WRZ has two population and supply hubs, Berwick and Fowberry. The Berwick area has the majority of the licensed supply with a significant surplus whereas the Fowberry area is smaller and has a tighter supply demand balance. There is some established inter-connection between the two areas but we had intended to further strengthen the links during AMP5 by piping water directly between the Berwick sources and Fowberry sources using some of the spare Berwick licence capacity. As an interim step the Fowberry abstraction licence had been temporarily increased by 0.52Ml/d between 23rd January 2008 and 31st March 2015 to ensure demand could be met without exceeding licence conditions.

During the initial discussions for this linking main project with the EA in 2010 they first raised the issue that modelling suggested that the current Berwick area licences may not be sustainable. Given the uncertainty as to the quantity available from the Berwick sources the company determined that it would not be prudent to carry out the link to the Fowberry area during AMP5. However the EA stated they would consider a further variation to the Fowberry licence variation should the company apply for one.

In addition to the need to determine the sustainability of the Berwick bores, the company also began on a programme of work to better maintain the current boreholes to increase the resilience of the whole WRZ.

The maintenance programmes, sustainability studies, licence variation and general improved understanding of the Berwick WRZ began in 2013 and are scheduled for completion during AMP6.

Fowberry Licence Variation
The Fowberry licence was varied up from 3.12Ml/d to 3.64Ml/d with the annual total increasing from 950Ml to 1,160Ml on 23rd January 2008 time limited until 31st March 2015.

The daily maximum volume of the original licence had been exceeded on seven occasions between the 1/1/08 and 15/1/08 ranging from 0.01Ml/d and 0.27Ml/d above the 3.12Ml/d licensed quantity. The new element of the variation was then only used on one further occasion in 2008 (22/5/08) when 3.15Ml/d was abstracted.

In 2009 the additional volume was utilised on seven occasions. Once on the 22/5/09, volume 3.15Ml/d, and then between 27/5/09 to 3/6/09 with abstraction ranging from 3.18Ml/d to 3.43Ml/d.

In May 2010 the variation was used once on 25/5/10 with 3.15Ml/d abstracted and seven times in September 2010 with 3.13Ml/d abstracted (0.1Ml/d of the variation) between 19/9/10 and 27/9/10.

Since the 27/9/10, to the present day, all abstractions have been within the terms of the original daily licensed volumes. This reduction in abstraction to within the original licence is as a result of a greater focus on Active Leakage Control in the area, swapping some area demand to the Berwick supplies and the general drop in demand experienced everywhere in NWL since 2008. This has come about mainly from a continuing decline in non-household demand as some companies have permanently closed and others have become more efficient in their use of water to reduce overhead costs.

The variation to the annual licence total has been more widely used than the increased daily licensed volume but returned to within the original licence volume during 2013.

Year	Total Annual Abstraction Ml
2008	967.6
2009	978
2010	1,007.9
2011	1,033.6
2012	992
2013	904

The Fowberry Licence Variation supporting report will contain a demand forecast for the Fowberry bores supply area. Sub WRZ demand forecasts do not form part of the WRMP.

This further variation is being sought whilst the sustainable licensed volume of the Berwick borehole system is defined during AMP6. Dependent on the outcome of this appraisal a permanent solution for establishing a sustainable supply demand balance for the Fowberry area will form part of the Berwick WRZ options appraisal. The solution will then be part of the investment required in AMP7 (2020 – 2025).

Timeline for Fowberry licence variation

The current variation expires on the 31st March 2015 and the company, although the variation was not needed last year, would wish to further vary the licence for a further 5 years. This would bring added resilience to the area whilst allowing time for the best environmental and economic solution to be determined during AMP6 for implementation during AMP7. Should the variation not be allowed then should demands above 3.12Ml/d or 950Ml/pa be encountered we would tanker water directly into the Fowberry potable water storage system. This is simply accomplished but is neither particularly economic nor environmentally desirable.

The initial meeting on the further licence variation was held between NWL and the EA on the 4th December 2013. At this meeting the outline of what was required by NWL in terms of a varied licence were discussed and the EA informed the company of what they would need to see in the application report. It was also discussed what monitoring needed to be undertaken to support the application. The agreed report contents page and meeting actions were as follows:-

Contents

No.	Action	Responsibility	Timescale
1	Request NE's evidence of stress that is linked to flow.	NW	28/02/14
2	Provide Cold Martin Lough SSSI report.	EA/NW	28/02/14
3	Confirm SSSI's in vicinity of the Fowberry abstractions.	NW	28/02/14
4	Contact Northumberland County Council to confirm whether there are any private water supplies in the vicinity of NW's Fowberry abstractions.	NW	28/02/14
5	EA to make available the original pumping reports and previous EA application assessment	EA	28/02/14
6	Request NE's assessment of ecological flow index.	NW	Superseded following meeting with NE on 07/02/14
7	Check whether the EA has any old data from Weetwood Bridge.	EA	28/02/14
8	Arrange for the river gauging to be carried out.	NW	31/03/14

No.	Action	Responsibility	Timescale
9	Level in the river gauging points to mAOD and install stilling wells and data loggers. (GW piezometers)	NW	30/06/14
10	Confirm whether the EA gauging boards are being levelled in the mAOD.	EA	Provide update by 28/02/14
11	Compare groundwater level and surface water level data in Fowberry.	NW	31/07/14
12	Amend the top of the pilot/observation boreholes to allow lockable access to manually monitor the groundwater level and install a level data logger.	NW	31/03/14
13	Confirm whether there is a pilot borehole at the Fowberry Tower site.	NW	Provide update by 28/02/14
14	Update environmental report template with EA's comments.	NW	28/02/14

To date all actions are being responded to within the dates established.

A follow up meeting was held on 7th February 2014 that included Natural England (NE) to gather their requirements for monitoring and reporting.

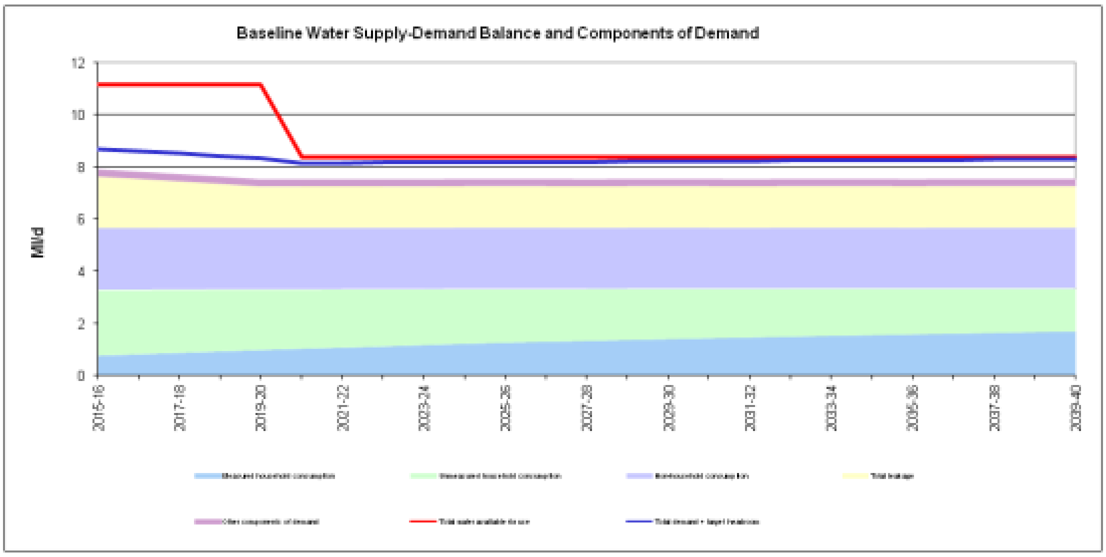
NWL are now carrying out the monitoring and compiling the report for submission as a draft to the EA by 31st July 2014. This allows the EA 6 – 9 months to review the reports content prior to determining the licence variation application.

Berwick WRZ Sustainability Reduction

In 2010 the EA brought to the attention of the company that they suspected that our abstraction from the Fell sandstones may not be sustainable at the licensed or actual abstraction volumes. This was predominantly associated with the Berwick area (Felkington, Thornton, Bleak Ridge) bores. This unexpected news led to the pragmatic decision to not proceed with linking the Berwick source to Fowberry, to enhance the Fowberry supplies, until studies were completed to determine what would be a sustainable abstraction from these bores. Varying up the Fowberry licence temporarily and the company minimising demand in the Fowberry area was chosen as alternative to ensure a supply demand balance was achieved in Fowberry.

The company, following discussions with the EA, agreed to accept as a pragmatic working assumption a reduction from the current Berwick WRZ 12.29Ml/d to a slightly above recent actual distribution input of 9.5Ml/d from 2020. This should be classed as an indicative figure under the NEP, although it is actually down as confirmed, whilst studies are undertaken during AMP6 to define the actual sustainable abstraction licence.

The driver under the NEP is WFDg2, ensuring there is no deterioration to ground waters. The impact of a reduction in licence to 9.5Ml/d can be seen on the baseline supply demand balance re-produced below. As can be seen even with this reduction the WRZ remains in balance over the planning horizon.



However, as stated in the main body of the WRMP 3.3.1, the outcomes of the study are unlikely to come out with a result that shows the sustainable abstraction is 9,5Ml/d. It will most likely be more or less, that is why we carry out the NEP study.
Our intention is to treat this NEP study in the same way that we have carried out all of our previous NEP studies in the Essex & Suffolk (ESW) area. The process we intend to follow is as below.

Task No.	Task Description	Start Date	Target Completion Date	Action by	Comments
1	Confirm environmental receptors to abstraction from Berwick boreholes with EA and NE. Fowberry receptors already agreed as part of licence variation studies.	Jun-14	Jul-14	NWL	Meeting to be arranged.

2	If required, construct additional Berwick monitoring borehole(s)	Jul-14	Apr-15	NWL	The need for new monitoring boreholes is currently being assessed by Prof. Paul Younger (completion date June 2014).
3	Undertake monitoring (groundwater level, spot river flow, groundwater water quality, splot borehole geophysical logging).	Apr-14	Sep-17	NWL	NWL borehole groundwater level monitoring ongoing, River Till spot flow guaging commenced 09/04/14, geophycial logging to be undertaken as required.
4	Undertake borehole test pumping where appropriate to quantify aquifer properties and to confirm deployable output and potential yield.	Apr-14	Sep-17	NWL	NWL remediation programme ongoing. This includes pre and post test pumping. Formal test pumping will also be undertaken where a reliable DO has not been confirmed.
5	Review existing model / calculations and make a recommendation for how the sustainability assessment should be undertaken. The method of assessment will need to be agreed with the EA.	Apr-15	Jun-15	NWL Consultant	An initial review has already been undertaken by Prof. Paul Younger. Recommendation 1 from the review states that such a mathematical modelling exercise recognises the distinct nature of individual sandstone bodies, but also systematically addresses the issue of potential cross-aquitard leakage.

6	Review all validated historical (pre-2014) and new (post-2013) validated data and update the conceptual model. Data includes groundwater levels, river flows, groundwater water quality, borehole geology logs, borehole geophysical logs, aquifer properties from test pumping.	Apr-15	Sep-17	NWL Consultant	To take account of groundwater recession in 2015, 2016 and as much of 2017 as possible.
7	Develop a mathematical model to reassess DO and potential Yield of the sources.	Jul-15	Aug-17	NWL Consultant	
8	Prepare a draft report and consult EA and NE	Jan-17	Sep-17	NWL Consultant	
9	Prepare final report.	Oct-17	Oct-17	NWL Consultant	
10	Undertake Options Appraisal if required.	Jan-17	Dec-17	NWL	Options have already been identified and costed, details of which will be included in the WRMP.

The choice of a permanent solution cannot be defined until the result of the studies has been completed and the sustainable level of abstraction is agreed between EA, NW and NE. Once known an options appraisal will be carried out to find the most environmentally acceptable, economic solution to effect a supply demand balance over the planning horizon. It would not be good use of our customer's money to carry out a number of completely speculative options prior to the outcome of the studies. However we have looked, at a high level, of the consequences of needing to abandon all ground water abstractions in this area. If this was the case then the only source of water sufficient to meet the WRZ's demand is from our Warkworth WTW within the Kielder WRZ.

Fowberry / Murton WTW supplied from Warkworth WTW

Background

Fowberry WTW is located at an elevation of 69m AOD and has a deployable output of 3.7 Mld / 43 l/s. It supplies a mean flow of 2.7 Mld / 32 l/s into the Wooler area and has a peak, over the last 6 months, of 1.5 Mld / 18 l/s.

Murton WTW is located at 65m AOD, has a DO of 8.4 Mld / 97 l/s and supplies the whole of the Berwick, Scremerston and Haggerston areas with a mean daily flow of 5.25 Mld / 62 l/s and a peak flow of 6 Mld / 70 l/s.

Due to reliability and sustainability issues with the Fowberry and Murton supply systems, and their associated boreholes, an option for supplying these areas from an alternative route is being explored.

Plan highlighting the locations of Murton and Fowberry WTWs.

New main from Warkworth WTW

The only viable option to replace the ground waters within the Berwick WRZ, if ground water abstraction is found to be unsustainable to meet the WRZ's demand, would be to lay a new main from Warkworth WTW to Berwick.

The proposal would be to lay a new main from Warkworth WTW, loosely following the coastline, remaining to the East of the railway line and crossing it at a convenient point somewhere before Beal / Holy Island.

The proposal would involve 'picking-up' a lot of the demand to the East of the current Northern Trunk Main (NTM). The spare capacity that this off-set of demand would create in the existing NTM would allow the Fowberry system to be supplied from Warkworth, via an extension from the existing NTM network.

- This new 'coastal main' would need to be approximately **50km** in length and would have to have a minimum internal diameter of **750mm**. This diameter would ensure that all of the water required for the Berwick supply area (max of 8.4 Mld) and the equivalent of Fowberry's max flow (3.7 Mld) could be carried with less than 10m headloss.
- In order to feed the Fowberry supply area from Warkworth WTW (using the existing NTM), **19 km** of **355mm** main would be required. Model suggests that head-losses are 10m+ over this distance and given the difference in elevation, between Hedgeley SR and Wooler, it would be vital that this new main is leveled and routed correctly.
- The existing NTM pumps will have to be upgraded significantly and be able to deliver a minimum of **24.5 Mld** (284 l/s) at **113m** pressure (their current level). Along with this, upgrades at Warkworth WTW may be required in order to supply the levels of demand required.
- In addition to these improvements, there will be multiple river, road and rail crossings to take into consideration (including one crossing of the East Coast mainline, one of the A1 and the river Breamish) and also connections to multiple service reservoirs (where possible) which are currently supplied from the existing NTM (e.g. Harlaw Hill, North Charlton and Elford).
- There are two options for locations to connect the new main at Berwick. The proposed new main can either run to the current location of Murton WTW (this would require a minimum of 45m pressure at this point) or terminate at Springhill SR. The latter of these two options would, however, require further analysis as new mains and / or a new PS would be required.

See rough estimate as to routes of proposed new main.

Estimated possible route of new mains propos… urton and Fowberry WTW supply ar…

Cost Estimates

Cost estimates for the works involved in the proposal are as follows;
50km of 750mm 16-bar rated main @ £500 per meter = **£25,000,000**
19km of 355mm 11-bar rated main @ £500 per meter = **£9,500,000**
2 x 50m rail and road crossings @ £1000pm & 1 x 10m river crossing @ £1500pm = **£115,000**
Upgrade to NTM pumps (3 x new large-scale pumps) = **£900,000**
Total: £35,515,000
Please be aware that these are rough estimates based on previous costs on other completed projects.

Summary

In summary, this option would involve the installation of two separate long lengths of new main and multiple crossings of different types in order to ensure the water reached it's respective destinations at the correct pressure. There would also be a need to upgrade the existing NTM pumps in order to accommodate the additional 12 Mld maximum flow-rate that the Berwick and Wooler areas require. It is also worth noting that the modeled travel time from Warkworth WTW to Berwick is 47.5 hours and therefore, for a travel time of this magnitude, secondary chlorination will have to be installed.

The proposal aims to deliver the required water, at the required pressure to the current locations of the two treatment works to be replaced (Murton and Fowberry). In accomplishing this, the existing infrastructure in these areas can be retained and therefore save on costs.

However this should be seen as very non cost beneficial as the area only serves 7,000 properties equating to £5,000 per customer.

Demand Management

With only 7,000 properties in the WRZ, and approximately 29% meter penetration, there is little opportunity to garner significant volumes of demand savings by near term meter uptake. This is an optant meter only area with no customer approval to introduce selective metering on change of occupier of a property and the area not being Seriously Water Stressed, compulsory metering cannot be introduced. However as part of our concentrated water efficiency activity in the area we do intend to try and stimulate a greater uptake of optant meter customers.

We have already, as stated in the draft Final WRMP reduced the leakage target in Berwick to below the Sustainable Economic Level of Leakage to save a further 0.1Ml/d of water.

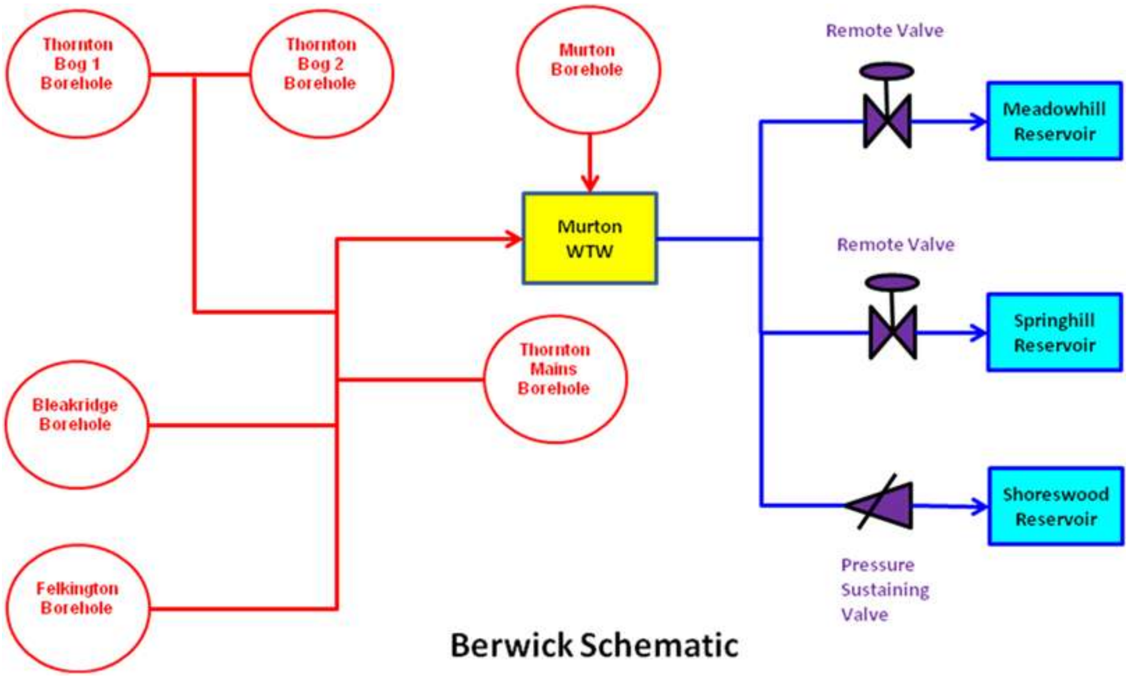
Water efficiency is seen as the best way of ensuring water demand is managed efficiently over the whole of the Berwick WRZ. To this end we are disproportionately concentrating our water efficiency activities in the Berwick WRZ during at least the next 3 years. This is being badged as “Whole Town Berwick” although it is being applied to the whole Berwick WRZ. The idea is to raise the profile of being water efficiency within Berwick by concentrating publicity, audits, and education and behavior changes continually throughout the year to all groups of water users. We also intend to offer water efficiency advice to domestic properties in the area with private water supplies to further ensure the general sustainability of the ground waters in the area..

For 2014 we are concentrating primarily within the Fowberry area and intend to carry out farm audits, giving water efficiency advice and products in addition to domestic audits. We have had discussions with the EA to see if they want to take the experience we gain from farm audits to be used on farms with private water supplies.
The campaigns will continue into 2015 and 2016 if there remain areas which still offer an opportunity for benefitting from water efficiency work.

The distribution input from the Berwick and Fowberry WTWs has also been more closely controlled since mid 2011 with the introduction of our “Aquadapt” system to the Berwick WRZ. Aquadapt controls WTW output to more closely balance immediate supply to demand in the distribution system. This has proved especially useful in the fairly remote Berwick region where sudden changes in demand could not be closely enough matched to WTW output. This resulted in storage reservoirs overflowing and water being lost.

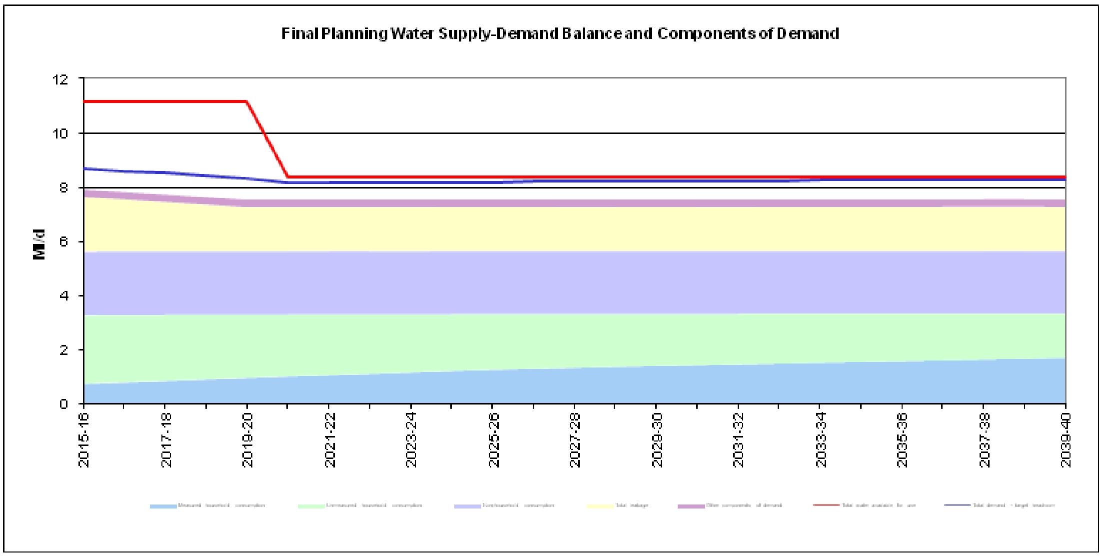
Now operational Aquadapt should demonstrate an overall reduction in the annual abstraction volumes.

The diagram below shows the linkage around the Murton supplies and demand centers.



Demand Forecasts / Supply demand balance

The following supply demand graph shows that whilst the WRZ remains in surplus throughout the planning horizon, should the company be required to accept a licence reduction in the Berwick WRZ and should it be reduced to 9.5Ml/d, then there is little actual headroom after 2035.



The EA wanted to understand how confident we were in our demand forecasts and if there were any scenarios that could be tested to see if a supply demand balance continued to be achieved.

Firstly, as stated in the Berwick NEP section, it is highly doubtful if the actual sustainability reduction will be 9.5Ml/d as this was simply a pragmatic figure to put into the plan. The actual level of sustainable abstraction remains the largest uncertainty but until the studies and final figure are concluded in 2017 any figure is pure speculation. Obviously if the license is greater than 9.5Ml/d more actual headroom is available, and if it is less then a new resource will be required.

The demand forecasts are almost already a “worse case” scenario with the population forecasts taken being Sub National Population Projection numbers. We believe these projections are at the top end of any likely population growth in this area. The Berwick population is forecast to grow steadily from 20,610 in 2013/14 to 22,480 in 2039/40 ie an increase of 9.1%. A scenario for a higher growth level does not appear credible given the areas remoteness and employment opportunities. The area already boasts a significant proportion of second homes that are only partially occupied throughout the year.

The non-household forecasts are not specific for Berwick but a subset of the whole Northumbrian forecasts. Given economic forecasting it would not be credible to create a Berwick only economic forecast that had any reason to vary from that of the rest of Northumbria. However the actual Berwick non-households have been used and their past trend to give the baseline forecast. This area has matched the rest of NW’s non-households by showing a continuous decline for almost 20 years. The forecast shows a starting demand in 2013/14 of 2.42Ml/d almost flat lining to 2.35Ml/d in 2039/40. Even a scenario showing an unprecedented 10% growth over the period would see the start at 2.42Ml/d and 2039/40 at 2.59Ml/d. An increase in demand of 0.17Ml/d over 25 years. This additional growth can still be accommodated with a total licensed quantity of 9.5Ml/d as after 2020 the target headroom reduces by 0.4Ml/d as explained below.

The other main component affecting the supply demand balance is the allowance for target headroom. The 1998 methodology has been used on each WRMP for both NW Water Resource Zones. In the PR09 WRMP the Berwick target headroom allowance ranged from 0.13Ml/d in 2010 to 0.39Ml/d in 2035. In this WRMP we have now included the uncertainty that is associated with vulnerable licenses with the result that target headroom has significantly increased to 0.72Ml/d in 2015 to 0.75Ml/d in 2040. The figures after 2020, should a 9.5Ml/d total license result, should then revert to the lower level previously calculated as the license uncertainty has been resolved. This would add approximately a further 0.4Ml/d to the supply balance, accounting for the target headroom percentage on a lower WAFU.

Given all of the above we remain confident that the supply demand balance shows a worse case and the actual balance will have greater actual headroom than the forecast shows.

Resilience

In 2009 it became obvious that some of the boreholes in the Berwick area were in need of refurbishment. The tighter raw water turbidity standard of 1.0NTU (Nephelometric Turbidity Unit) in 2004 from the previous 4.0NTU standard would be breached on some of the boreholes if full flow was taken. The turbidity within the boreholes was from the gradual build up of sand sediment from the Fell sandstone. To overcome the turbidity issues the maximum pumping rate was reduced and compliant water produced. With such significant headroom in the Berwick bores this outage was accepted as it posed no threat to the company's ability to supply all demands. Over the ensuing years, as the turbidity started to increase, the maximum pumping rates were further reduced. By 2009 it was recognized that continuing to reduce pumping rates could not be a long term solution and that a refurbishment programme for some of the boreholes would be needed in AMP5. A programme has been put in place to refurbish the boreholes over time starting with those that have reduced their yield the most due to increasing turbidity. Whilst the Fowberry bores will be part of the cleaning programme they have not suffered from turbidity increases to the same extent as those in the Berwick area. Following refurbishment, and when operations allow, step tests will be carried out to define the DO of each bore. The timeline for this resilience work is as below:-

Area / Site	Activity	Status
Berwick / Felkington bore	Bore refurbishment	Completed Dec 2012
Berwick / Felkington bore	Step test	Planned Spring 2014
Berwick / Thornton Mains bore	Bore refurbishment	Completed Dec 2013
Berwick / Thornton Mains bore	Step test	Completed Dec 2013
Fowberry / Treatment 2 bore	Bore refurbishment	Planned Winter 2014/15
Fowberry / Treatment 2 bore	Step test	Upon completion of refurbishment
Berwick / Bleak Ridge bore	Bore refurbishment	Planned Sept 2014
Berwick / Bleak Ridge bore	Step test	Upon completion of refurbishment
Berwick / Thornton Bog 1 bore	Bore refurbishment	Planned Winter 2014/15
Berwick / Thornton Bog 1 bore	Step test	Upon completion of refurbishment
Berwick / Thornton Bog 2 bore	Bore refurbishment	Planned Winter 2014/15
Berwick / Thornton Bog 2 bore	Step test	Upon completion of refurbishment
Berwick / Murton bore	Bore refurbishment	Planned early AMP 6
Berwick / Murton bore	Step test	Planned early AMP 6
Fowberry / Treatment 1 bore	Bore refurbishment	Planned early AMP 6
Fowberry / Treatment 1 bore	Step test	Planned early AMP 6
Fowberry / Mains A bore	Bore refurbishment	Planned early AMP 6
Fowberry / Mains A bore	Step test	Planned early AMP 6

3.5 Outage

Since the last Water Resource Management Plan, NW has established a system of recording daily outages at each treatment works. Prior to this the company was not recording outage events as the large surplus of supplies and treatment capacity allowed the company to plan maintenance of treatment plants in low demand periods. Equally pollution events or periods when high algal blooms occurred, given the nature of the water resources available, were not common. However it has now been recognised that all outage, whenever it occurs, must be recorded and used in the calculation of future outage.

This has allowed the outage to be developed using the principles set out within the 'Outage Allowance for Water Resource Planning (UKWIR 1995)' document. Ideally, in future we will carry out our outage calculations on the previous 5 years record of outage. Outage going forward over the Plan remains constant from that calculated on the experience of the previous 5 years.

The outage figure would only be varied over the planning horizon if the company had some very specific changes that it was highly confident would result in a change to the calculated outage figure. We do not have anything of this nature occurring over the life of the Plan that would cause a varied outage figure to be used.

This method of assessing outage comprises the following steps:-

For each Resource Zone identify the 'source works' for which outage needs to be calculated. Source works are defined as assets between and including the point of abstraction and the point at which the water is first fit for purpose, such as:

- Abstraction works
- Raw water mains/pumps and storage
- Water treatment works
- Treated water storage
- Treated water pumping plant

For each source works daily planned and unplanned outages are recorded against one of the categories defined in the methodology:

- Pollution of source (groundwater/surface water)
- Turbidity
- Nitrates
- Algae
- Power failure
- System failure

Legitimate outage events are then calculated for each source works depending on whether the works is a base load plant or not, see Appendix C for methodology of determining legitimate outage events.

A base load plant is a treatment works that would ideally be run at its maximum DO throughout the year for financial optimisation, other treatment works would then make up the difference between what the base load works can produce and demand. For example in the southern supply area of the Kielder WRZ, Lartington WTW (a base load plant) would ideally be run at a constant 128Mld with Broken Scar WTW treating the additional water to meet demand. Currently the typical output from Broken Scar is 80 – 100Ml/d as opposed to its deployable output of 180Ml/d.

The record used was from April 2010 when outage was collected from each water treatment works to enable the outage methodology to be followed. However, the record of planned / unplanned outage was only recorded from April 2011.

The outage amounts used in the methodology are below.

	ALGAE	TURBIDITY	NITRATE	POLLUTION	POWER	SYSTEM FAILURE	OTHER
Allenheads	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Berwick	0.0%	14.2%	0.0%	0.0%	19.0%	58.8%	8.0%
Birchtrees	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BRO	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Broken Scar	0.0%	0.0%	0.0%	0.0%	0.5%	73.5%	26.0%
Carrshields	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fontburn	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fowberry	0.0%	94.4%	0.0%	0.2%	3.7%	0.5%	1.2%
Gunnerton	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
GWS	0.0%	42.8%	0.0%	0.3%	0.0%	44.3%	12.7%
Honey Hill	0.0%	0.0%	0.0%	0.0%	1.2%	6.3%	92.5%
Horsley	0.0%	0.0%	4.4%	0.0%	0.0%	51.0%	44.6%
Lartington	0.0%	0.9%	0.0%	0.0%	0.0%	68.4%	30.7%
Lumley	6.3%	0.0%	0.0%	0.0%	0.0%	27.0%	66.6%
Mosswood	0.0%	0.0%	0.0%	0.0%	0.0%	32.7%	67.3%
Slaggyford	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stonehaugh	0.0%	0.0%	0.0%	54.3%	0.0%	0.0%	45.7%
Tosson	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Warkworth	0.0%	0.7%	0.0%	0.0%	0.0%	12.6%	86.8%
Wear Valley	0.0%	0.0%	0.0%	0.0%	0.4%	20.8%	78.8%
Whittle Dene	0.0%	0.0%	0.0%	0.0%	0.0%	51.9%	48.1%
Grand Total	0.2%	4.9%	1.2%	0.0%	0.3%	57.5%	35.9%

Algae, turbidity, nitrate, pollution and power, accounting for only 6.6% of the total outage are all unplanned events. These are very low in comparison to other water companies that are reliant on low land surface waters and reflect the pristine and oligotrophic nature of the Northumbrian supplies. The remaining 93.4% of outage is from system failures or other and of this 52% was planned.

Probability distributions were defined for the outage magnitude from the legitimate outage events for each works. Duration is already accounted for as the outages are recorded in Ml/d. The UKWIR methodology recommends the assumption of triangular probability distribution curves for simplicity, however due to the limited data available a Normal probability distribution was deemed more appropriate.

Monte Carlo analysis for each source works using the defined normal distributions was carried out over 5000 iterations. The randomly generated outages for each works were then summed for each iteration, giving the total outage for the WRZ. The 90th percentile (1 in 10 year return period) of the combined outage for the WRZ was then taken as the Outage Allowance. A 80th percentile was considered (1 in 5 year return) as this matches the record used to calculate the outage but it was considered too conservative against the actual outages experienced.

The results of the Monte Carlo analysis (see Appendix C) gave the following Outages:-

- Kielder WRZ = 38.64 Mld
- Berwick & Fowberry WRZ = 0.89 Mld

These are lower volumes than those assumed in previous WRMPs

3.6 Carbon emissions from water operations

We report annually on the volume of greenhouse gas for which the company is responsible and have done so since 2008. The trend in these emissions is a falling one though there is some year on year variation in this, mainly due to the impacts of weather and our response to it.

This fall reflects a structured approach to emissions reduction through the implementation of a carbon management plan, initiated in 2009. This plan has the ambition to reduce emissions by 35% by 2020 against a 2008 baseline. If the emissions linked to grid electricity fall as projected by government at that time this should result in a total reduction of 50% in our Company-wide operational emissions by 2020. This is currently forecast to remain stable after 2020 until the end of the planning horizon. Any further decline will be subject to Government’s decisions on electricity generation carbon reduction commitments.

The plan is based on a combination of actions to improve our efficiency in the use of energy and the displacement of grid electricity by the development of renewable energy, in particular the use of biogas from sewage sludge and hydroelectric power generation.

The latest estimate of GHG emissions for operational carbon as a result of providing drinking water to customers in our Northumbrian operating area is 40,285 tonnes CO2e. The Northumbrian region benefits from being able to use gravity in the provision of water services. Combined with effective energy management, the result is that the emissions intensity of the provision of water to customers is the lowest in the country at 165 kg CO2e/Ml.

We have no projects for the further development of water resources in our plan, and no consideration of options or the carbon emissions resulting from them has been necessary.

Drinking Water Emissions Table

	2008	2013	2020	2040
Tonnes CO2e	52,370	40,285	26,185	26,185

3.7 Raw and Potable Water Transfers and Bulk Supplies

Currently there are only very small transfers of potable water between NW and United Utilities The transfer to United Utilities from Wear Valley TW is around 0.65 Ml/day and would be maintained in all scenarios and the transfer of potable water from United Utilities at Reaygarth of $3m^3$/day is also seen as secure in all circumstances.

3.7.1 Sharing and transferring resources

NW calculated its early draft supply demand balance for the Kielder WRZ and Berwick WRZ in August 2012 to determine if there would be any excess supplies available for other companies to consider using. The Berwick WRZ has no available supplies and we propose carrying out studies in AMP6 to better understand our current abstractions and their sustainability. The Kielder WRZ has a minimum dry year raw water surplus, over the planning horizon, of 150Ml/d that could potentially benefit neighbouring companies, or with neighbour's cooperation, water companies further afield.

In accordance with the WRMP guidelines this Kielder WRZ surplus was placed on our website in October 2012 for water companies in deficit to consider as a possible water resource option. We had already had meetings with Yorkshire Water Services (YWS) and United Utilities (UU) to discuss how any NW surplus water could be transferred into each of these companies. The volumes of water discussed with both companies were also modelled in our *i-Think* water resource model both individually and in combination.

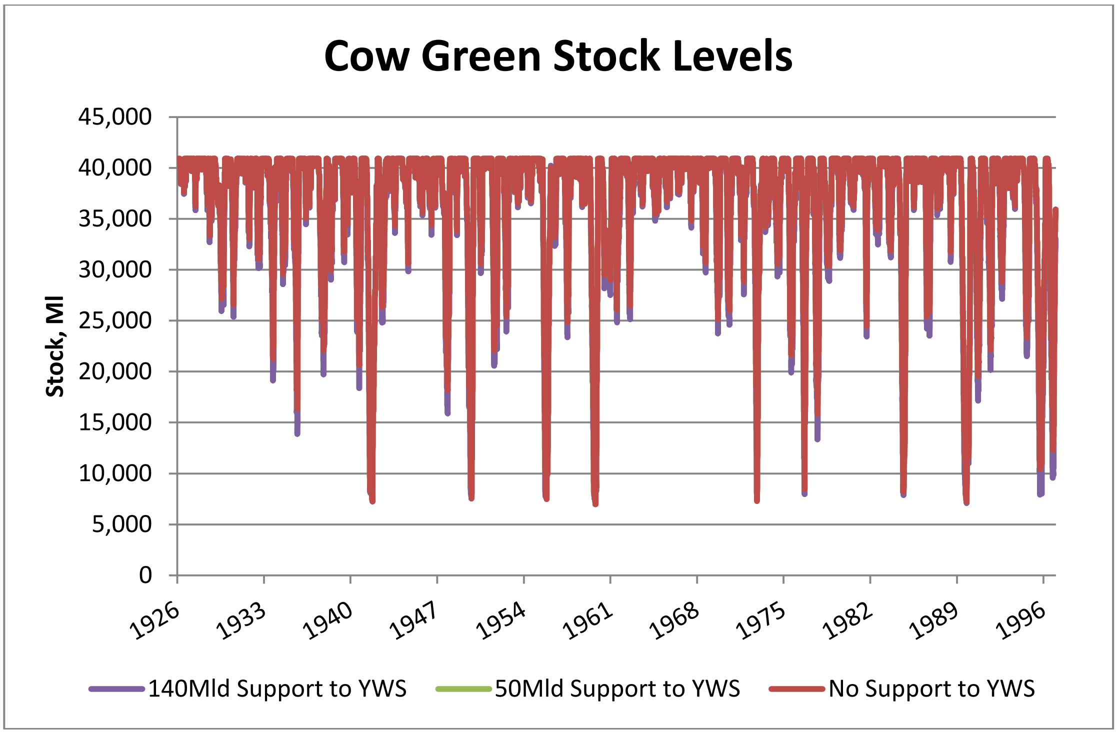
The WRMP discussions are different to the drought plan discussions in the volumes being considered. The 150Ml/d discussed in the draft WRMP context was much higher than the 40Ml/d currently available, should they choose to require it, to YWS in the 3rd year of a drought. The WRMP volumes are calculated looking at the licensed and actual volumes of water available to NW in a dry year, whereas the drought plan volume is determined by the infrastructure currently available to make a supply to YWS without derogating NW's own needs. If any water is required for a long term resource under the WRMP options appraisal, it would require major infrastructure investment to transfer the supply to either company.

YWS

NW met with YWS to discuss what options could be available as new water resource schemes for YWS using transfers of surplus water from NW's current licensed resources. Only 2 options were considered suitable for consideration of further thought.

The first was to look at a potable water supply from NW's Broken Scar WTW being piped by new pipelines into the Whitby area of YWS. A supply of 25Ml/d would be required by YWS and Broken Scar has sufficient spare dry year Deployable Output to make this supply. NW provided YWS with its Large User Tariff rate as a likely charge it would make for the water. YWS, should they choose to look at the option in its appraisal process, would have to look at costing to lay the pipeline between the 2 places and estimate the pumping (energy) costs.

The second option was to look at transferring raw water into YWS area by transferring River Tees water into the existing pipeline running from the Tees almost to the River Wiske, and extending this pipeline to the River Swale. YWS asked NW to cost and model two different volumes of 50Ml/d and 140Ml/d, noting that the 140Ml/d would require the electrical service capacity at Riding Mill to be upgraded and an additional pump installed. The modelling showed the effect on Cow Green reservoir from both volume options.



A permanent bulk supply to YWS, whilst within NW's current abstraction licenses, would be likely to require an environmental impact assessment by YWS and to be considered in their Strategic Environmental Assessment. According to the Environment Agency's newly released guidance on SEAs and transfers reproduced below:

Assessment of proposed transfer options in SEA of WRMPs

Impacts of new transfer options may result from the construction or modification of infrastructure to enable the transfer, the abstraction of the water from the donor company's area and/or the increased volumes of water transferred to the recipient river/catchment. The assessment of impacts may be complex because the water may come from a number of different sources.

Recipient company

The impacts of proposed (new) options to transfer water from another water company or a third party should be considered and appraised alongside all other options in the recipient company's SEA of its WRMP. This is to allow a full and meaningful options appraisal to be undertaken.

Donor company

The donor company should make note of the transfer alongside its feasible options list in its water resources management plan. The donor company should consider the potential environmental impacts of the transfer through its SEA where appropriate. The assessment a donor company may need to carry out will depend on the circumstances of the transfer. For example:

a. *Where there is a definite dependency between a proposed transfer and a new resource(s), i.e. where the transfer is dependent on a new source(s) being developed by the donor company, the environmental impact of the new resource(s) should be assessed, alongside other options, within the SEA of the donor company's WRMP.*

b. *Where there is a surplus in the donor company's water resource zone, and the proposed transfer would operate within existing abstraction licence conditions, the donor company should consider if it is appropriate to assess the environmental impacts of the export within the SEA of its WRMP. For example, using an unused existing licensed source may have an environmental impact.*

NW would not be required to carry out a SEA as no new resource is being developed (a) and we would not be utilising any unused existing licensed resource (b).

At the time of writing this Final WRMP NW has not been made aware which, if any, of these options YWS are taking forward to SEA or options appraisal.

United Utilities

NW met with United Utilities to explore any options that could be available for transferring surplus water from NW's Kielder WRZ into UU's area. A number of options and volumes were considered.

NW currently makes a c1.0Ml/d bulk potable supply from Burnhope reservoir into UU's North Eden WRZ. UU forecast this WRZ to remain in surplus but would like to understand any potential for increasing the current volume of the bulk supply. NW estimated that there was sufficient raw water and treatment capacity (by substituting water within the Kielder WRZ) for a bulk supply of 5 – 6Ml/d to be available. However after investigating the capacity of the current bulk supply infrastructure, we later informed UU that the current infrastructure delivering 1.0Ml/d is at full capacity and the cost of upgrading the pipelines and intermediate pumping stages is likely to make this option unviable. UU did not ask for any further information.

Cow Green reservoir is geographically the nearest large resource NW have close to where UU may need the water. At the initial meeting UU had not yet completed its supply demand balance on its WRZs and had the potential to be in deficit in its Integrated and West Cumbria WRZs and possibly it's Carlisle WRZ. The balance was dependant on the level of sustainability changes the company may be required to make. An option was considered where a pipeline from Cow Green, crossing the Pennines, could connect into a tributary of the River Eden for the Carlisle WRZ or into Haweswater for the Integrated WRZ. UU asked NW to look at the cost and availability of 25, 50, 100 and 180Ml/d being supplied from Cow Green to UU. These costs were provided to UU in October 2012 but the following information to note was also given:-

- A supply above 100Ml/d is unlikely to be available without a large change to NW's current operating regime
- Cow Green is a SSSI and any new abstraction from the reservoir would require a full Environmental Impact Assessment and we would not be sure of the outcome.
- Cow Green is in a remote location without suitable roads or power supplies.

UU requested similar costings for 25, 50,100 and 180Ml/d supplies into UU from Kielder reservoir. Taking water from Kielder is likely to have less environmental impact on the water body but does require the water to be transferred longer distances. At the meeting it was stated the transfer from Kielder would be into the Carlisle or Integrated WRZ. Subsequent to the meeting, but after NW had confirmed the likely costs and water availability, UU looked at the option of transferring water into its West Cumbria WRZ that was forecast to be in deficit. However, this option was discarded on cost grounds compared to other options for the WRZ.

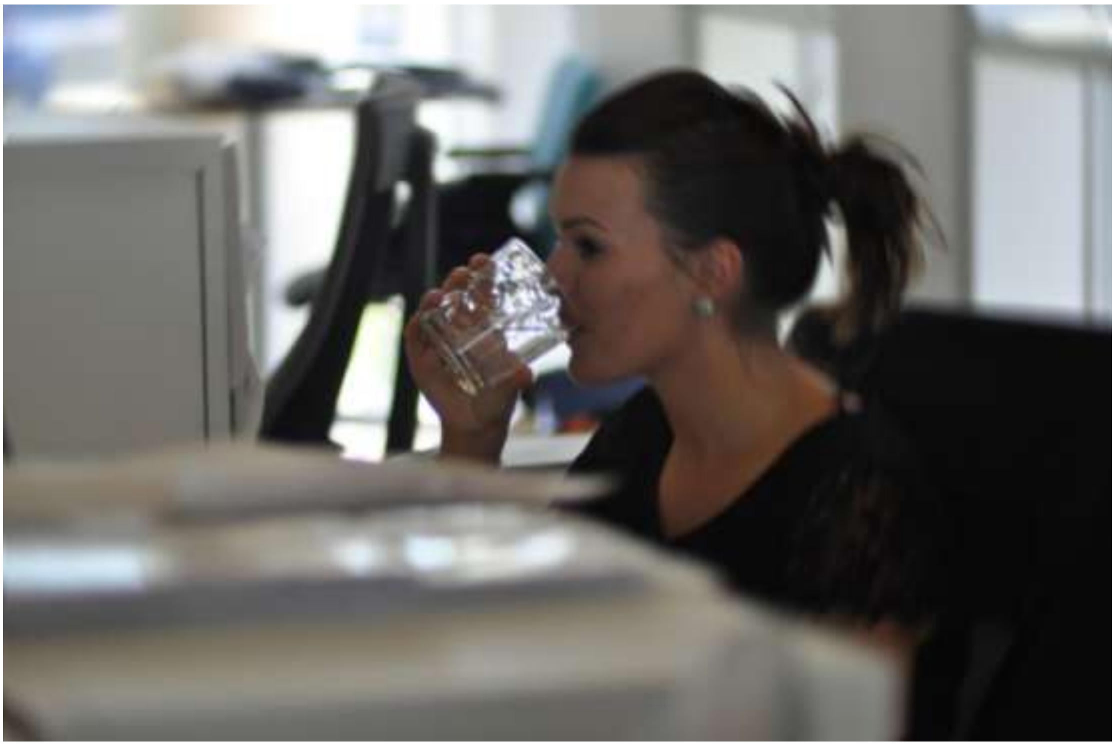
Recent discussions with UU have revealed that they have no direct need for water from Cow Green or Kielder but supplies from Cow Green into their Integrated WRZ could release water from Lake Vyrnwy. This water could then be released into the river Severn and could enhance the yield of an option for Thames Water to build a new Severn abstraction point to enhance the supplies to their SWOX and London WRZs.

At the time of writing this Final WRMP we have not been informed by UU if they wish to pursue any of the options for transferring water between our companies.

3.7.2 Latest position on supplies to other companies

At the latest possible date for inclusion in this Final plan we are not aware that any company wishes to take a bulk supply from us. It is possible that in the future, or even as a result of changes to their options appraisal process a bulk supply may become viable. If such notification is given to Northumbrian Water then we will detail it in the next WRMP annual update to Defra. It will also form discussions with the EA and NE.

4.0 WATER DEMAND FORECAST



4.1 Introduction

The methodologies used to prepare the demand forecasts have followed published best practice as defined in UKWIR (1995c) and UKWIR/Environment Agency (1997), Methods of Estimating Population and Household Projections and Customer behaviour and water use 12/CU/02/11.

Forecasts have been prepared for the Northumbrian supply area. The forecast has then been apportioned into the resource zones, Kielder and Berwick. Normal year forecasts have been made against a 2012/13 normalised base year which has been amended from the published Annual Regulatory report figures. They incorporate the rebasing process for properties as well as normalising the 2012/13 per capita consumptions (pcc). This ensures a smooth projection from the base year into the forecast.

The normal year forecasts have been used as the basis for dry year and weighted average year forecasts.

4.2 Base Year

Normalisation of 2012/13 Base Year components

High rainfall and low temperatures throughout the summer months resulted in 2012/13 being classified as a wet year for both WRZs.

> Extract from Wikipedia:
> A series of low pressure systems steered by the jet stream brought the wettest April in 100 years, and flooding across Britain and Ireland. Continuing through May and leading to the wettest beginning to June in 150 years, with flooding and extreme events occurring periodically throughout Britain.
>
> On 27 and 28 June and again on 7 July heavy rain events occurred from powerful thunderstorms that gathered strength as they travelled across mainland Britain. Severe weather warnings and a number of flood alerts were issued by the UK's Environment Agency, and many areas were hit by flash floods that overwhelmed properties and caused power cuts.

The impact of the demand constraint caused by the weather is considered to only have affected household consumption. No impact is assumed for leakage as this is target controlled – such that the leakage target is met irrespective of the weather and customer-driven impacts e.g. increased or faster leak reporting. Similarly it is assumed that neither wet nor dry weather impacts non-household use.

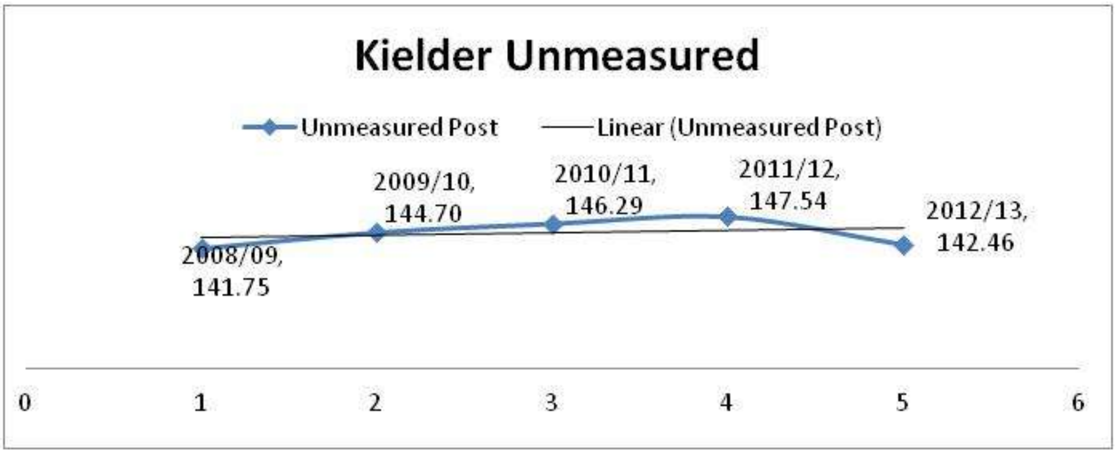
In order to forecast from a normal year the PCC's for both measured and unmeasured customers have been 'normalised' against trend or 2011/12 normal year PCC.

Normalise PCC's Unmeasured

The unmeasured normalised PCC for 2012/13 has been calculated using the previous 4 year reported PCCs in order to obtain a trend line on normal years.

Kielder - Unmeasured PCC
2012/13: 142.46 (wet year)
2011/12: 147.54
2012/13: 147.91 (rebased)
PCC adjustment: +0.37 compared to 2011/12 forecast

To ensure the trend for microcomponents is consistent with the draft WRMP, total PCC has been adjusted by +0.37 across the forecast. For microcomponent reporting this volume was applied to the miscellaneous use section.



Berwick - Unmeasured PCC
2012/13: 154.40 (wet year)
2011/12: 158.73
2012/13: 158.73 (rebased)

For the Berwick WRZ the reported PCC for 2011/12 has been used.

Normalise PCC's Measured

The measured PCC has been rebased by using the 2011/12 reported PCC and adjusting the volume by the water efficiency target for that year

Kielder - Measured PCC
2012/13: 137.62 (wet year)
2011/12: 131.5 (rebased)
2012/13: 131.50 (rebased)
PCC adjustment: +0.0

There have been no changes to measured PCC for Kielder.

Berwick - Measured PCC
2012/13: 154.40 (wet year)
2011/12: 142.20
2012/13: 142.20 (rebased)

For the Berwick WRZ the reported PCC for 2011/12 has been used.

4.2.1 Per Capita Consumption

The Per Capita Consumption (PCC) is provided by our Cul-de-Sac monitor with 3137 properties split into three socio-economic groupings based on Rateable Value. This monitor has remained very stable with the same amount of close management that it has received over the last 10 years.

NW operates the PCC calculation using Netbase and ensures it remains in accordance with the UKWIR best practice for small area monitors.

NW is proactive in our Assessed Fixed Charge Scheme (AFCS) which is offered to customers only where necessary, in order to ensure less than 10% measured households. Our overall figure for meter penetration is maintained at less than 4%. Most of the measured household consumption within the monitor is calculated by weekly meter reading. However, a small number of internally installed meters have proved difficult to read on a regular weekly basis. Their consumption has been assessed using our measured PCC figure multiplied by the number of occupants within each of those properties.

The reported PCC figure is not influenced by any form of MUR as the meters within the PCC area (20 No.) are very high specification EM meters. NW mechanisms for the management of the void properties within the monitored areas is based on regular surveys, the results of which are input to the billing system ICIS.

NW continues to check occupancy rates within the monitor and ensures close comparison with the company figure for unmeasured households. A number of quality procedures are regularly completed to ensure accurate robust data is used in the calculation of this figure. These include the rolling programme of “door knock” for area occupancy rates throughout the accounting year at the rate of one survey per month. This polling rate means that full monitor occupancy is refreshed every 20 months. Other checks include proactive leakage checks of all areas, based on close monitoring of nightlines and boundary valve operations.

NW have clear mechanisms for the management of the void properties within the monitor, based on regular surveys which are input to ICIS and then supplied monthly to an income generation project team that uses the Land Registry website to investigate and validate void properties.

Each PCC monitor area is monitored closely with NW’s own DMA operability which maintains an average above 90%. Any areas that are not operable are not used for their period of inoperability.

Total customer night use (CNU), including plumbing losses, continues to be assessed on a monthly basis from area flows using Smart software from the WRc. Like Smart, the 15-minute flow data are adjusted by one hour between April and October for the calculation of DI and rolling minimum nightline. This is required due to loggers remaining set at GMT throughout the year.

4.2.2 Water Delivered Measured Households

The average water consumption for measured households for 2012/13 has been rebased by using the normalised measured PCC’s. This is then increased to allow for meter under-registration. An estimate of supply pipe leakage for internally metered households is added to this to provide the water delivered figure.

The volume of water delivered to measured households continues to increase, due to the effects of increased metering.

4.2.3 Water Delivered Unmeasured Non-household

NW's estimate of consumption for unmeasured non-household consumption has been based on the review reported eight years ago, in which unmeasured customers were compared with metered properties of the same type (e.g. shops, warehouses) and also compared the rateable values of metered and unmetered properties. It has been assumed that an unmeasured customer consumes 50% of a similar metered property, based upon the relationship between rateable value and consumption and the average rateable value of unmeasured properties being 50% of that of equivalent measured properties.

There are currently only 7,028 unmeasured non household properties in NW. It should be noted that because of the very small number of properties involved this group only accounts for 3.7% Northumbrian non household demand.

4.2.4 Supply Pipe Leakage

NW continues to calculate supply pipe losses for the purposes of the overall leakage calculation as 35% of total losses within the distribution system. However, this figure is now derived from our bottom-up calculation, which is a measured figure, which we feel is an enhancement to our previous approach and mirrors the actual external factors and condition of Underground Supply Pipes (UGSP).

Supply pipe losses are then allocated to the various categories of properties, on the assumption that losses from the typical externally metered household property will be half those of unmeasured or internally metered properties. This assumes that externally metered household customers will notice any unexpected increase in their consumption and will inform us sooner than the other categories of customer.

4.2.5 Meter Under-Registration

The allowance for household and non-household meter under-registration is consistent with the results found in the Review of Meter Under-registration performed by WRc in April 2009.

The results were as follows:

- Under-registration figures for household meters have been calculated based on the data supplied to WRc, as:
    - Northern region: 3.79%
- Under-registration figures for non-household meters have been calculated based on the data supplied to WRc, as:
    - Northern region: 3.83%

4.2.6 Void Properties

Base year property figures are taken from the Company billing database this includes the total number of void properties each year. The forecasted voids are a consistent percentage of the total properties.

	NW Forecast Voids
Unmeasured Households	4.5%
Measured Households	4.3%
Unmeasured Non-Households	26%
Measured Non-Households	14%

4.2.7 Operational Use and Water Taken Unbilled

Operational use continues to be assessed using similar methods in both Northern and Southern Operating Areas. The original methodologies were supported by a consultancy report (Ewan Associates, 2002), these have been used and new data input where it has become available. In addition, individual components have been reviewed and clear methodologies have been developed for determining all aspects of operational use and water taken unbilled and included site measurements for certain parameters. Some improvements have been made generally in data reporting systems and also the standpipes we hire are now metered.

The reported figure for Operational Use includes volumes used for treatment works' use, service reservoir and tower cleaning, third party bursts, flushing, new mains and rehabilitation.

Operational use, water taken legally unbilled and water taken illegally unbilled include the following components:

Distribution System Operational Use

1.1	Sample Taps (Continuous & Non-Continuous)
1.1.1	Continuous
1.1.2	Non-Continuous
1.2	Service Reservoirs & Tower Cleaning
1.3	Tanker Filling/Bowsers
1.4	Bleeds
1.5	Sewer Flushing & Jetting
1.6	Third Party Events
1.6.1	Bursts
1.6.2	*Tyne Only* - STM Charging + GTAS Mains Cleaning + TMC Contract 4
1.7	Flushing
1.7.1	Routine
1.7.2	Planned / Reactive / Water Quality
1.8	New Mains, Diversions, IM and S19
1.8.1	New Mains
1.8.2	Non-Strategic Mains Diversions
1.8.3	Infrastructure Maintenance
1.8.4	Section 19

Water Taken Legally, Unbilled

2.1	Supply Pipe Leakage Unmeasured Voids
2.2	Unbilled Supplies
2.2.1	Treatment Works + Offices
2.3	Standpipes
2.4	Water Donations
2.5	Council Usage
2.6	Metered Allowances
2.6.1	Vulnerable Customers
2.6.2	New Properties
2.7	Waste Water Notices
2.8	Fire Fighting
2.8.1	Fire Brigade
2.8.2	UGSPL On Fire Mains

Water Taken Illegally, Unbilled

3.1	Occupied Voids
3.1.1	Measured
3.1.2	Unmeasured
3.2	Illegal Connections
3.3	Hydrant Vandalism
3.4	Illegal Hydrant Use
3.5	Transient Population Usage

4.2.8 Bulk Supplies

NW water accounting records make use of MIPS Enterprise, a bespoke NWL internal system, channelling the data with the highest level of accuracy for collation.

NW calculate the daily average distribution input, taking account of major service reservoir stock changes and any imports to or exports from the distribution network.

In both Northern and Southern Operating Areas Distribution Input meter verifications are no longer carried out. The verification program which previously existed, attempted to prove the accuracy of our meter stock and quantify the level of accuracy of both our permanent meters and the temporary meter at each site. The accuracy of permanent full-bore electromagnetic meters exceeds that of the temporary meters used for verification. 96% of our DI meter stock is full-bore electromagnetic meters and the remaining type are monitored closely.

4.2.9 Distribution Losses and Service Reservoir and Trunk Main Leakage

No change has been made from last year in the methodology used for determining distribution losses. However, we have changed our approach to the calculation of service reservoir losses, which are now based on drop test results routinely carried out as part of the cleaning programme. This approach shows a reduction in the figure used previously.

The Netbase leakage analysis process provides a calculation of total leakage across the entire mains network for the whole of the Northern Operating Area. In order to achieve this, it must provide calculated values or estimates of leakage for all operable and non-operable DMAs and also for the dummy DMAs. The dummy DMAs are areas which contain mains but which are outside the DMAs. Trunk mains are generally upstream of the district meters and are therefore not included in DMAs.

Consequently, most of the trunk mains are in dummy DMAs and, as a result, a significant proportion of the leakage attributed to the dummies is trunk main leakage. For each DMA or dummy DMA which contains trunk mains, an estimate has been made of the leakage that can be attributed to the trunk mains. This indicates a total trunk main leakage in the Northern Operating Area. This leakage is already included in the overall bottom-up leakage analysis in Netbase.

4.2.10 Re-basing the 2012/13 Figures

The company's work planning database has been analysed to provide figures for the number of households internally and externally metered and for the sub-division into optants, new and pre-existing metered group.

The existing metered customer base will not increase over time within the forecast, in that new customers will not be added until a new forecast is created every 5 years, but the number of households may be expected to change/decrease slightly due to voids, disconnections or demolitions. The customers metered by the 2012/13 base year have been moved into the existing metered base. Customers metered from 2013/14 onwards will join one of the following categories: new or options.

NW believe it is reasonable to regroup the customers every 5 years because changes in occupiers mean that a household metered through one particular metering process cannot be expected to keep those characteristics for all time – low occupier optants will be replaced by "average" occupiers. Equally the differing mixes of houses being built in different market conditions affects the new home assumptions. Any attempt to forecast these uncertain changes beyond 5 years could not be accomplished with reasonable accuracy and therefore such a process would not improve the accuracy of the demand forecast. A compromise position is therefore to re-base every 5 years.

To create the base year figures for the WRMP the following processes took place.

The households in the 2012/13 Regulatory Report new and optants groups were added to the existing metered group. This means for the WRMP, figures for 2012/13 have zero households in the new and optant categories, but from 2013/14 households are added to these groups in line with the metering forecast.

4.3 Populations

Overview

Population for the base year and forecasted years has been commissioned from Edge Analytics.

Edge Analytics were contracted to produce an update to the population and household forecasts by District Meter Areas (DMA) for the Kielder and Berwick areas using the latest ONS 2010 mid-year estimates and 2011 Census populations.

NW has maintained the short term migrant and illegal immigrant populations, likely to be residing in our supply area that was commissioned from Demographic Decisions Ltd for the PR09 WRMP. Although anecdotally it is thought that some Polish migrant workers have returned home, it is also thought that they have been replaced by workers from the recent accession countries.

Edge Analytics used best practice methodology which follows the requirements of the Water Resource Management Plan Guidelines which requires figures to be based on the Office of National Statistics 2010 (ONS) mid-year population estimates. NW has chosen the SNPP - ONS 2010-based sub-national population projection (SNPP) for both population and property forecasts.

The detailed methodology used to determine property growth is provided in appendix F of this plan.

The process followed by Edge is detailed below:-

Northumbrian Water Limited (NWL)

Population, household and property forecasts

Summary

In the development of forecasts for NWL we followed the guidelines detailed in the Environment Agency document 'Methods of Estimating Population and Household Projections: Update 2012'.

For NWL, our chosen geographical areas were DMAs, Drainage Areas, Water Resource Zones and the respective Supply Areas of Northumbrian Water and Essex & Suffolk Water.

We used all available data, collected for local authority areas, lower super output areas (LSOA) and output areas (OA).

We used a projection methodology that is consistent with the Office for National Statistics (ONS) methods and is used by local authority planners across the UK.

We have tested a range of scenarios:

- *Official trend projection (ONS 2008-based projection)*
- *Updated trend projection to take account of more recent information*
- *Plan-based forecasts of future housing growth*
- *A more refined plan-based forecast derived from 'pipeline' planning applications*

Forecasts were provided for individual Drainage Areas and DMA, to allow aggregation to higher geographies.
Forecasts for each DMA and DA have been produced with a 2011-2040 time horizon, with the new 2011 base year consistent with the very latest 2011 Census data released in July 2012.

Assessment against EA guidelines

The EA guidelines identified eight separate steps for the development of forecasts. Each step is considered in turn, with a description of the approach that was taken to deliver the NWL forecasts:

Step 1: Choose level of geography to meet your water resource planning needs
NWL requested forecasts for both DMA geographies and Drainage Areas. Data for these geographies was apportioned from output areas based upon the proportional distribution of properties.

Step 2: Prepare LAUA level population estimates and trend-based projections
The POPGROUP model was used to generate the trend projections of population for each LAUA covered by the respective Northumbrian Water and Essex & Suffolk supply areas. This model uses an industry-standard 'cohort-component' methodology to project population. The POPGROUP model is used by over 100 local authority planners across the UK.

Given that the 2008-based projection was the latest 'official' projection available, an updated trend projection was also produced, taking account of new demographic evidence to enable a more up-to-date 2010-based projection to be derived.

Step 3: Prepare LAUA level household and non-household population estimates and trend-based projections
Using the inputs and assumptions of the official household projection model from Communities and Local Government (CLG), non-household population estimates and projections were derived for each LAUA covered by the combined Northumbrian water and Essex & Suffolk supply area.

Step 4: Prepare LAUA level household estimates and trend-based projections

The CLG's 2008-based household projection model provided the 'household formation rate' assumptions that enabled population projections to be converted to household estimates and projections. These estimates and projections were derived from each of 17 different household types but aggregated to a household total for each LAUA.

Step 5: Prepare LAUA level plan-based population and household projections

With the imminent revocation of previous Regional Spatial Strategies, local authority housing plans were highly uncertain at the time when the forecasts were being generated. Eighteen months later and for the majority of local authorities this is still the case, as new evidence is being compiled to support revised housing targets.

The plan-based scenario that was developed for NWL LAUA, used information from previous housing completion rates to derive future housing growth trajectories. This was a robust and appropriate approach given the information available and given the continued stagnation in the UK's housing market.

For each LAUA, the plan-based scenario involved estimating the population and household impact of a defined trajectory of housing growth, providing a direct contrast to the alternative trend scenarios.

An additional scenario was developed using 'pipeline' planning applications as a guide to future housing development. These planning applications were pinpointed by postcode and each was given a 'build-out' rate of 5 years. Given that pipeline planning applications have only a limited time horizon; this scenario had only a short-term, nine-year forecast period.

Edge Analytics have been providing household forecasts for the Essex Planning Offices Association (EPOA) and neighbouring districts. Given their close work with the authorities they were best placed to obtain data available for each local authority.

Step 6: Prepare small area population and household estimates / Step 7: Compile a set of trend and local plan based population and household projections at small area

Population estimates and projections were converted to OA equivalents with an assignment of age-sex district trends to the age-sex structure of each OA. This approach avoided the issue of large variations in historical OA growth and decline affecting future trends but ensured that important age-sex differentials were reflected in the small area projections.

Population not-in-households (by age and sex) was derived from the 2001 Census for each OA. These data were scaled to ensure that estimates for each year of the projection period were consistent with the LAUA total taken from the CLG household projection model.

The derived OA population (by age and sex) was converted to a household estimate and projection using CLG's LAUA-level household formation rate assumptions.

To convert from households to dwellings, a vacancy rate was applied to each OA (taken from the 2001 Census). The vacancy rate measures the relationship between occupied household spaces and total dwellings.

A final step and one which ensured an important 'baseline' accuracy of the forecasts, involved rescaling the base year property number to those provided from NWL's billing database. This ensured that all property numbers were accurate for each OA in the base period.

Step 8: Using the postcode best fit approach to assign estimates and projections to your required geography
All OA estimates and forecasts were aggregated to produce totals by DMA and Drainage Area. Data for these geographies was apportioned from output areas based upon the proportional distribution of properties.

Edge Analytics
July 2013

Population Growth

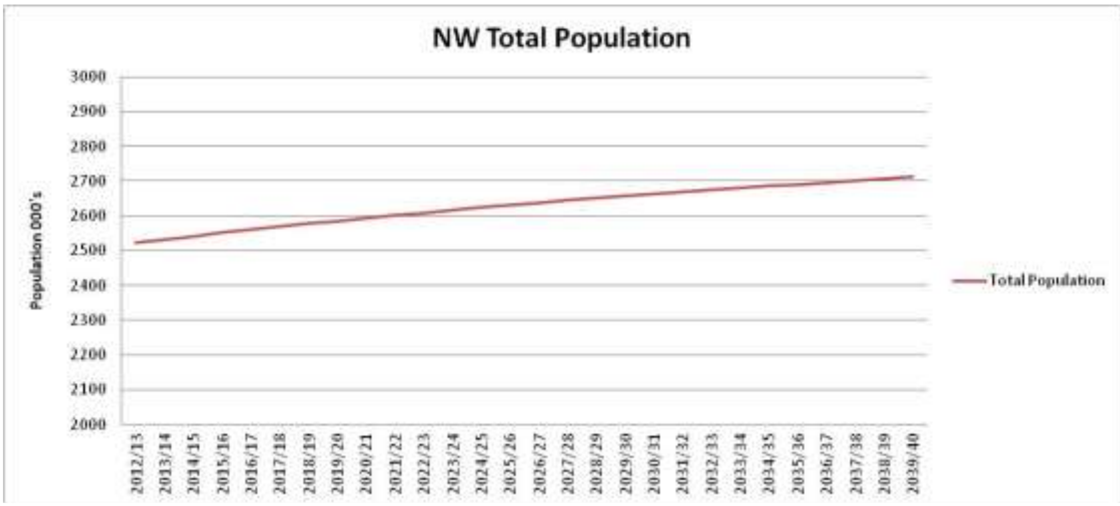
In the case of NW supply areas, the population forecasts for PR14 shows a steady growth in population over the planning horizon. For NW this has resulted in a 7.5% increase over 25 years.

The forecast overall occupancy reduces from 2.34 to 2.19.

The detailed methodology used to determine population growth is provided in detail: Appendix F of this plan.

Population Growth:

	2012/13	2039/40	Increase	% Increase
Northumbrian	2,523.46	2712.26	188.8	7.5%



4.4 Occupancy

The overall occupancy comes from the Edge Analytics domestic population figure plus the short term migrant / illegal immigrant population from Demographic Decisions. This total population is divided by the total number of billed households for the year to give an overall occupancy rate. However, whilst a total population figure is essential in our demand forecasts, an overall occupancy figure is at too high a level to be useful in the demand forecast directly. This is because the different housing categories of our customers have different average occupancies. For example unmeasured customers have a higher occupancy than that of the optant meter customers. This is due to low occupied properties where the customer gains financially by paying a measured charge whereas a high occupied property, if electing for a meter, would pay more for their water and sewage than if they remained unmeasured. It is therefore necessary to have a specific occupancy for different classes of customer.

The occupancies are set by various sources of information available to the Company, ranging from specific occupancy surveys sent to a random selection of customers, occupancy taken from meter optant applications, and professional judgement based on past occupancy and future forecasts of changes in the customer base.

Sources of Information

Customer Type	North Survey's combined 2012
Unmeasured	2.00
Existing	1.63
New	2.17
Optant	1.43
Measured	1.63

The most recent survey data has come from the Micro-component Survey and the Occupancy Survey used to determine the ownership and frequency of use of water using appliances in the home. These surveys were carried out in 2012 to populate the model for looking at future changes in per capita consumption. For Northumbrian Water a total of 11,833 responses were received from the micro-component and occupancy survey. More information on these surveys is available in section 4.6.4. Both in the appliance survey and the occupancy survey customers where asked to indicate the total number of people in the household and the breakdown of occupants for seven different age groups. See Figure 1.

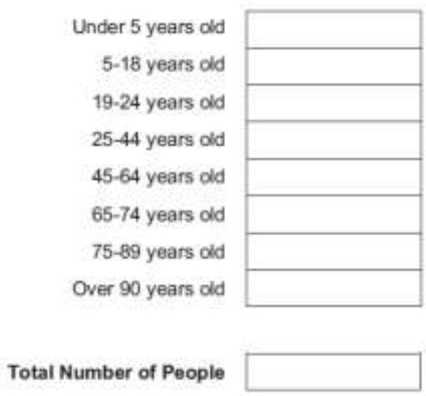

Under 5 years old
5-18 years old
19-24 years old
25-44 years old
45-64 years old
65-74 years old
75-89 years old
Over 90 years old
Total Number of People

Figure 1: Occupancy question answer

Some customers left the 'total' box blank and entered the number of occupants within each age group. Where this was the case, the numbers were totalled to give an overall occupancy. On the contrary, several customers did the opposite, stating the total number of occupants but not stating the breakdown. In these cases, the breakdown could not be established and were therefore left blank. Average occupancy for each household group is shown in Table 1 with total occupancy and the breakdown between age groups given.

Table 1: Average occupancy supplied by the appliance survey

North Unmeasured		North Existing	
Under 5	2%	Under 5	4%
5-18	12%	5-18	10%
19-25	9%	19-25	5%
26-44	17%	26-44	24%
45-64	70%	45-64	39%
65-74	46%	65-74	37%
75-89	36%	75-89	37%
Over 90	2%	Over 90	3%
Person / household	2.00	Person / household	1.63

Table 2: The occupancy results from the 2012 Micro-component survey and Occupancy survey.

Customer Type	Occupancy
Unmeasured	2.00
Existing measured	1.63
New homes	2.17
Optants	1.43

From all of the above data the following base year occupancy and future forecast occupancies were derived and used in the WRMP.

New homes

The occupancy for new homes have been lowered to 2.18 to reflect the overall lower occupancy, the results from the micro-component survey and the fact that in the recent few years there has been a significant increase in the number of single bedroom apartments being built. The occupancy is forecast to increase gradually through to the end of the planning horizon in line with an increase in overall occupancy.

Year	2011/12	2015/16	2020/21	2025/26	2030/31	2035/36	2039/40
Occupancy	2.18	2.20	2.22	2.24	2.26	2.28	2.30

New Optants

The optant occupancy has been slightly raised to 1.60 from the previously forecast 1.55. The Company forecast a modest increase in optant occupancy through to 2039/40 (1.88) as there will always be changes to family occupancy that will result in the remaining occupier opting for a meter.

Year	2011/12	2015/16	2020/21	2025/26	2030/31	2035/36	2039/40
Occupancy	1.60	1.64	1.68	1.74	1.79	1.84	1.88

Selective (change of occupier)

Selective metering will not now be introduced until 2025/26. The occupancy remains at 2.00 through-out the forecast.

Year	2011/12	2015/16	2020/21	2025/26	2030/31	2035/36	2039/40
Occupancy	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Existing metered

The base year for what becomes the existing measured is all the measured groups used in the reported outturn year, rebased to take account of changes in overall population and information from occupancy surveys. The figure of 1.77 has been used in the rebased numbers to account for the overall drop in total population. This figure then increases steadily over the whole of the planning horizon to 2.21 in 2039/40. In reality this occupancy is reset every five years when the new Water Resource Management Plan is produced.

Measured properties

The occupancy of the measured property group is calculated from all of the different metered components using their assigned occupancy and weighted by their forecast property numbers. Changes in this occupancy in the forecasts are influenced by the occupancy of the groups that dominate in future years e.g. new homes, optants or change of occupier selectives.

Year	2011/12	2015/16	2020/21	2025/26	2030/31	2035/36	2039/40
Occupancy	1.77	1.83	1.89	1.95	2.01	2.06	2.09

Unmeasured properties

The unmeasured occupancy is calculated by subtracting the population assigned to all of the measured groups from the total household population and dividing this by the remaining number of billed unmeasured properties. This would be expected to be the highest occupancy class but over time the overall measured occupancy and unmeasured occupancy will tend to converge towards each other.

Year	2011/12	2015/16	2020/21	2025/26	2030/31	2035/36	2039/40
Occupancy	2.52	2.54	2.54	2.54	2.50	2.45	2.40

4.5 Properties

Base year property figures are taken from the company billing database. The growth property figures for each of the forecasted years are provided by Edge Analytics.

In 2011, Edge Analytics delivered a series of scenario forecasts for the NWL DMAs and DAs. These scenarios included the following:

- SNPP - ONS 2008-based sub-national population projection (SNPP)
- Migration-led – 2010-based population projection
- CR 6 Yr – Dwelling growth based upon housing completion from the last 6 years
- Short- term – Growth trajectory based upon pipeline planning applications

The 'Migration-led' scenario was included to ensure the very latest demographic evidence was being used for comparison with the 'official' 2008-based SNPP.

During 2012, a variety of new demographic evidence has become available for local authority areas, including the following:

- Revised 2010 mid-year population estimates
- ONS 2010-based sub-national population projections
- Census 2011 populations & communal establishment populations

On the advice from the Environment Agency the NWL data was updated using the revised 2010 mid-year estimations.

The base year Edge Analytics property number is reconciled to the Total Domestic Premises numbers on our customer billing database 2011. NW has chosen the SNPP - ONS 2010-based sub-national population projection (SNPP) for both population and property forecasts.

All property changes from new homes and the metering programme are converted to "mid-year" changes for the purpose of demand forecasting.

All new properties, whether household or non-household have measured supplies.

Edge Analytics have provided new housing growth numbers from 2011. No account is taken of the current economic climate (2013), especially the lower availability of mortgages and the subsequent slow down in house building.

The numbers have been altered, as detailed below, to try and account for, and predict the effects of, the prevailing conditions:-
8000 properties over 6 years from 2013/14 have been removed from the new housing forecast (21% of forecasted properties). In 2012 only 64% of households forecasted were actually built.

The detailed methodology used to determine property growth is provided in detail: Appendix F of this plan.

Edge Analytics Forecasting Methodology

Step 1 - Build DMA to OA lookup

Step 2 - Estimate base year population at OA level

Step 3 - Derive projected population at LADUA level

Step 4 - Derive projected population at OA level

Step 5 - Derive projected population not in households at OA level

Step 6 -Derive household projections using headship rates

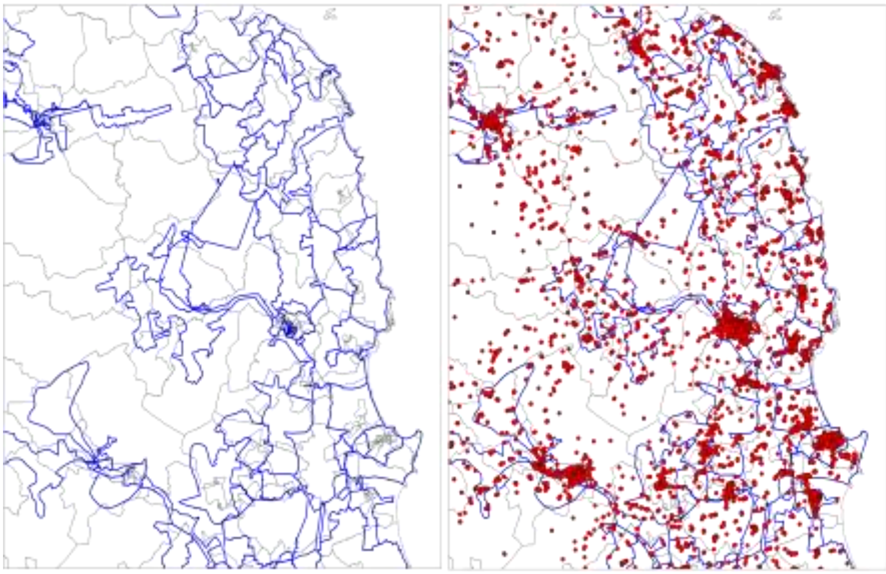
Step 7 – Derive dwelling projections using household to dwelling conversion

Step 8 - Derive DMA level projections using DMA to OA lookup

Step 9 - Rescale projections using property database counts

Step 1 – Build DMA to OA lookup

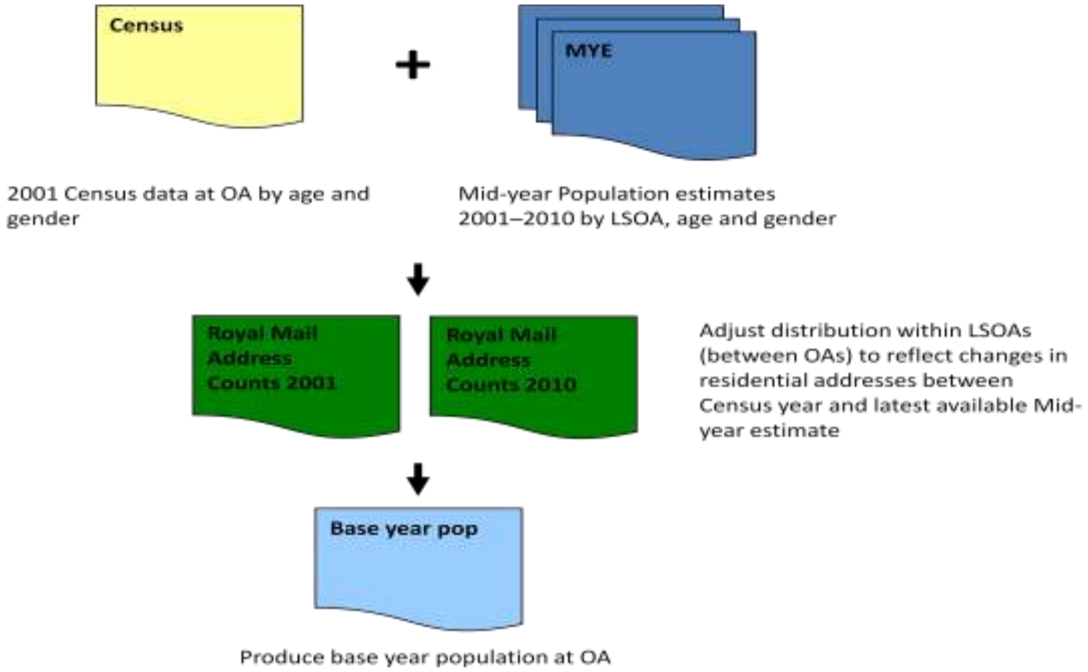
Overlay properties



Create proportions table

OA Code	DMA	Properties in DMA and OA	Total Properties in OA	Proportion
00CHFA0001	DST011	122	122	1.00
00CHFA0002	ST015	141	141	1.00
00CHFA0003	DST011	63	104	0.61
00CHFA0003	ST020	41	104	0.39
00CHFA0004	DST011	139	139	1.00
00CHFA0005	DST011	103	103	1.00
00CHFA0006	ST004	136	136	1.00
00CHFA0007	DST009	125	147	0.85
00CHFA0007	ST004	22	147	0.15
00CHFA0008	DST014	152	152	1.00
00CHFA0009	DST011	108	132	0.82
00CHFA0009	ST004	24	132	0.18
00CHFA0010	ST004	95	95	1.00
00CHFA0011	DST014	279	521	0.54
00CHFA0011	ST022	242	521	0.46
00CHFA0012	DST014	152	152	1.00
00CHFA0013	DST014	96	96	1.00
00CHFA0014	DST014	168	168	1.00
00CHFA0015	DST014	160	160	1.00
00CHFA0016	DST008	133	133	1.00
00CHFA0017	DST008	513	514	1.00
00CHFA0017	DST011	1	514	0.00
00CHFA0018	DST014	112	112	1.00
00CHFA0019	DST008	39	123	0.32
00CHFA0019	DST011	84	123	0.68
00CHFA0020	DST008	138	138	1.00

Step 2 – Estimate base year population at OA

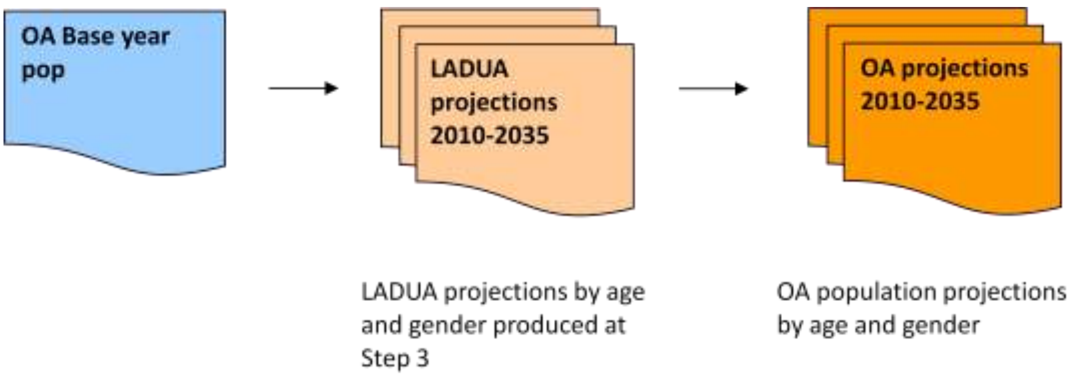


Step 3 – Project population at LADUA level

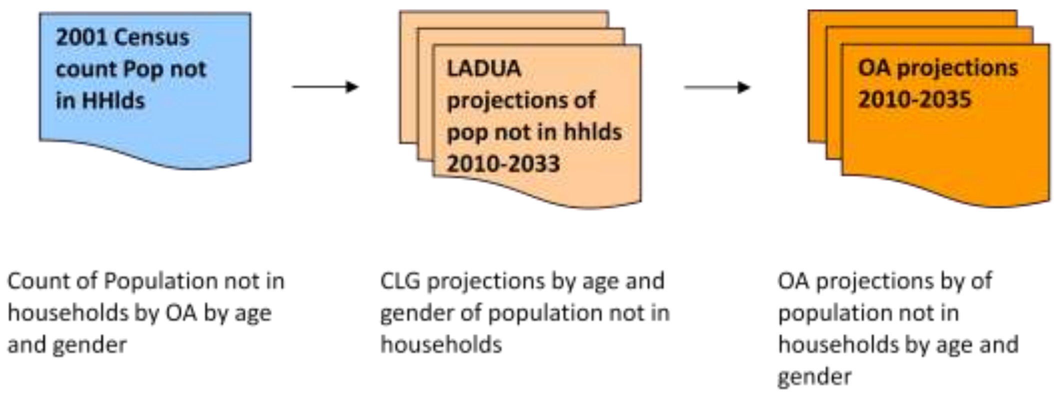
- 3 main scenarios
  - ONS 2008-based projection
  - Housing Completion Rates (average per year, last 6 years)
  - Migration-led (revised trend projection, 2010-based)
- Derived using a standard Cohort Component methodology

$$Pop_t = Pop_{t-1} + Births_{t-1,t} - Deaths_{t-1,t} + Net\ Mig_{t-1,t}$$

Step 4 – Derive projected population at OA



Step 5 – Derive projected not-in-hhld pop at OA



Step 6 – Derive household projections using headship rates

- Calculate an OA 'at-risk' population using:
  - OA Projected population (Step 4) minus
  - OA Population not in households (Step 5)
- Use LADUA Headship rates derived from CLG 2008 based household projections in conjunction with OA population at risk
- Headship rate model is:
  Households = (Population – Population Not in HHlds) * Headship Rate

Step 7 – Derive dwelling projections using conversion

- Derive a Household to Dwelling conversion or Vacancy Rate at OA level
- Vacancy Rate = Occupied Household Spaces / Total Dwellings
- Use this to calculate OA Dwellings:
  OA Dwellings = OA Households (Step 6) / Vacancy Rate

Step 8 – Derive DMA/Drainage area projections

- Apportion OA projections using proportional splits

Proportions table (Step 1)

OA Code	DMA	Properties in DMA and OA	Total Properties in OA	Proportion
00CHFA0001	DST011	122	122	1.00
00CHFA0002	ST015	141	141	1.00
00CHFA0003	DST011	63	104	0.61
00CHFA0003	ST020	41	104	0.39
00CHFA0004	DST011	139	139	1.00
00CHFA0005	DST011	103	103	1.00
00CHFA0006	ST004	136	136	1.00
00CHFA0007	DST009	125	147	0.85
00CHFA0007	ST004	22	147	0.15
00CHFA0008	DST014	152	152	1.00
00CHFA0009	DST011	108	132	0.82
00CHFA0009	ST004	24	132	0.18
00CHFA0010	ST004	95	95	1.00
00CHFA0011	DST014	279	521	0.54
00CHFA0011	ST022	242	521	0.46
00CHFA0012	DST014	152	152	1.00
00CHFA0013	DST014	96	96	1.00
00CHFA0014	DST014	168	168	1.00
00CHFA0015	DST014	160	160	1.00
00CHFA0016	DST008	133	133	1.00
00CHFA0017	DST008	513	514	1.00
00CHFA0017	DST011	1	514	0.00
00CHFA0018	DST014	112	112	1.00
00CHFA0019	DST008	39	123	0.32
00CHFA0019	DST011	84	123	0.68
00CHFA0020	DST008	138	138	1.00

Projections (Steps 4, 6 and 7)

OA	2008	2009	2010		2033	2034	2035
00CHFA0001	221.26761	222.4505	223.85002	.....	245.24046	246.4754	247.55057
00CHFA0002	371.51408	374.13062	376.4979	.....	371.16233	370.18531	369.16746
00CHFA0003	221.4183	222.67479	224.03683	.....	239.77636	240.28591	240.55898
00CHFA0004	243.88046	245.48845	247.10793	.....	251.06528	251.03008	250.91078
00CHFA0005	234.45277	235.66613	236.90121	.....	238.76497	238.6335	238.28485
00CHFA0006	270.41929	271.52521	272.52521	.....	276.94181	276.74231	276.33794
00CHFA0007	347.10448	348.99092	350.82073	.....	348.6293	348.77694	348.62483
00CHFA0008	194.65518	196.64029	198.41644	.....	196.36127	196.26555	196.22139
00CHFA0009	300.26766	302.14067	303.98166	.....	307.77001	307.70787	307.43652
00CHFA0010	218.54406	219.51236	220.39294	.....	217.24663	217.04585	216.71605

Step 9 – Rescale projections using property counts

- Use NWL property counts to rescale DMA/Drainage area dwelling projections
- Align base year with current domestic properties – rescale subsequent years in line with trend
- Produce an equivalent rescaled household projection – using dwelling to household conversion
- Population projections remain as the un-scaled version

Data sources:

- Census 2001
- ONS sub-national, mid-year population estimates, 2002-2010
- ONS sub-national population projections, 2008-based
- CLG household projections, 2008-based
- Output Area digital boundary data
- NWL digital DMA/DA boundaries
- NWL geocoded property database
- Glenigan's Planning Application database

4.6 Baseline Household Demand Forecasts

The household demand forecast has been developed by considering the population in 5 groups as follows:

1. Unmeasured
2. Meter Optants
3. New Homes
4. Existing
5. Selective (change of occupier)

These groups have been chosen because we believe their consumption characteristics are noticeably different. However, households already metered cannot sensibly be maintained assigned to the separate metered groups, as the consumption of this group is known, so it makes sense to regroup the metered customer base into a single category, which we call “Existing Metered” every 5 years.

For the unmeasured, new homes and existing metered groups we have forecast PCCs using a new improved micro-component model, which has been populated for the base year using data collected from an appliance survey.

4.6.1 Meter Optants and Selective (COO) PCC

For the meter optant and selective groups NW has determined their future PCCs as a percentage reduction relative to the unmeasured PCC, maintaining our previously accepted and agreed assumptions. For the unmeasured, and existing metered groups PCCs have been forecast using a micro-component model, which has been populated for the base year using data collected from an appliance survey.

Savings from the water efficiency target have been included in the baseline and Final PCC forecasts. Further details of these savings are provided in Section 5 of the Water Resource Management Plan.

4.6.2 New Homes PCC

All New homes across the forecasted years have a PCC of 125 l/h/d as a result of the introduction of water efficiency standards into Part G of the Building Regulations. The changes which came into force in April 2010 require that the estimated average water use of new homes is no more than 125 ml/d.

4.6.3 Appliance Survey 2012

To insure sufficient valuable data was obtained for the micro-component aspect of demand forecasting, a survey was created to collect occupancy, household appliance and water use information from Northumbrian Water customers.

A random sample of customer data was selected by meter status type from the customer billing system which was then cleaned to primarily ensure non-domestic and business customers were not targeted.

A total of 11,833 domestic customers located in Northumbrian Water received the first appliance survey mailing in January 2012[1]. This consisted of a letter, questionnaire and a pre-paid reply envelope (see Appendix C and D for copy). The letter aimed to give a brief explanation for the conduction of the survey and emphasise the importance of the survey both to customers and the company to ensure a good response rate.

The survey consisted of 27 detailed questions which began with household type, age and occupancy questions, followed by household water using appliance ownership, frequency and duration of use questions, and finishing with questions on garden watering and external water use (see Appendix D for an example of the questionnaire). The survey was marked with a unique code to categorise customers by their meter status. It enabled the identification as to whether the customer was firstly an unmeasured or measured customer, secondly if they were located in a rural or urban area and thirdly the acorn type associated with the property. Examples of the created codes can be found in Appendix D. Descriptions of the meter categories are given in the table 1 below.

Table 1: Meter Categories

Meter Category	Description
Unmeasured	Refers to customers paying for their water by the rateable value of the property.
Existing (metered)	Refers to all households that were metered before 2003.
Optant (metered)	Refers to households whose occupier opted to have a meter fitted after 2003.
New (metered)	Refers to new houses built after 2003 that had a meter fitted when they were built.

[1] The Anton Group printed and mailed out the appliance surveys and inputted responses using double data entry to reduce error. (Anton Group Limited, Christy Way, Laindon, SS15 6TR www.AntonGroup.co.uk)

A sum of 1,651 responses were received for this phase one appliance survey mailing, generating a 13% uptake rate overall. It was therefore decided upon completion of the phase one data collection, a phase two mailing should begin in order to increase the sample size. A total of 10,093 different customers were mailed for the phase two mailing in May 2012, which included exactly the same appliance survey as phase one. Phase two mailing gave a respectable 27% response rate, with 2,820 surveys returned. See table 1 for total mailings and response rate amounts.

Survey answers were inputted[2] and then split out into the micro-component sections of WC flushing, personal washing, clothes washing, dishwashing, outdoor use and general use for analysis.

Table 2: Appliance survey phase one and two mailing and response rates.

Phase	Total Mailed	Number of Responses	Response rate
Appliance Phase 1	11,833	1,651	13%
Appliance Phase 2	10,093	2,820	27%
Appliance Survey Totals	21,926	4,471	20%
Occupancy Survey	10,077	1,881	19%
Total	**32,003**	**6,352**	**20%**

4.6.4 Occupancy Survey

Occupancy questions were incorporated in the appliance surveys, however the sum of collected replies was considered insufficient to provide significant data concerning household occupancy. For this reason it was decided to conduct a separate survey focusing on household occupancy in Northumbrian Water.

The occupancy survey was mailed to 10,077 domestic customers in properties located in Northumbrian Water during May 2012. The survey consisted of one question asking the occupancy of the household and, if the resident was willing, the age categories that the occupants fitted into as well. An example of this survey can be found in Appendix C A total of 1,881 responses were received, giving a 19% return rate (Table 2).

[2] The Anton Group printed and mailed out the appliance surveys and inputted responses using double data entry to reduce error. (Anton Group Limited, Christy Way, Laindon, SS15 6TR www.AntonGroup.co.uk)

The occupancy survey was also marked with a unique identifier code in order to distinguish between measured or unmeasured, rural or urban, and acorn type households.

Collectively the appliance and occupancy surveys gave a mass total of 6,352 responses (average 20% response rate). This is believed to provide a significant quantity to effectively determine domestic water use.

4.7 Micro-component Model

The model used for PR09 has been updated and the base year is now 2011/12 which projects forward annually to the end of the demand planning horizon. The micro-components are split into the sections of WC flushing, personal washing, clothes washing, dishwashing, outdoor use and general use. These sections are subsequently split into sub-components to analyse ownership, frequency and duration of use in detail. This level of analysis aligns well with the Environment Agency's suggested categories. Wherever possible company specific data has been utilised and then reviewed alongside previous surveys and other available data sources to ensure that spurious results from small samples are indentified and treated with caution.

For all micro-components the start position and rate of change is defined and applied to the duration of the planning horizon. For those components involving white goods, a range of models and their associated average volumes per use have been identified. Along with this are stated the assumed model lifespan and the dates when lower-volume technologies are expected to be introduced.

In this section the results and analysis for each of the micro-component sections will be explained. The calculations, evidence and assumptions behind the results will be shown including the sources of data. The unique code printed on the survey enabled the results to be analysed by meter category to give results for North Unmeasured and North Existing.

4.7.1 Toilet Flushing

Toilet flushing was split into five separate groups to reflect the varying flush volumes. These include:

Dual flush pre 2001	9.25 litres
Full flush pre 2001	8.25 litres
Full flush post 2001	6 litres
Dual flush post 2001	4.7 litres

All households have at least one WC; therefore the ownership for all four types of WC's was proportioned to equal 100%. Please refer to table 3 for a summary of the toilet flushing base year and forecasting results.

4.7.1.1 Dual flush pre 2001

(Please refer to appliance survey Q7 and Q8)

The ownership for dual flush pre 2001 installed WC's was calculated from household's that had answered 'no' to fitting the WC since 2001 and answered their house was not built after 2001, but had answered that they had a dual flush. The total number of these dual flushes where divided by the total number of household's in the meter category (e.g. North Unmeasured) to give the ownership. Due to a WC lifespan of 15 years[3] and an increase in the ownership of WC's which increases the replacement rate[4], ownership is forecast to decrease over the planning horizon.

The frequency of toilet flushing per person per day is 5[5] and the frequency of flushing for existing properties is thought to be 4.71[6]. Based on the extrapolation of Herrington (1996), frequency is set to increase at a rate of 0.0504 flushes per week per year in both unmeasured and existing households.

First generation dual flush systems are assumed either to be set up incorrectly or to have double flushing on a lower flush volume so that the average flush volume is 9.25 litres.[7] This remains constant over the forecast horizon.

4.7.1.2 Full flush pre 2001

(Refer to appliance survey Q7 and Q8)

The household's that answered in the appliance survey 'no' to fitting the WC since 2001 and answered their house was not built after 2001, but had answered that they had a full flush WC was applied to give the ownership, whereby the total number of full flush pre 2001 WC's was divided by the total number of household's in the category (e.g. North Existing). Ownership is forecast to decrease over the planning horizon due to the same reasons as dual flush pre 2001, in that pre 2001 WC's will be replaced with post 2001 type WC's as WC lifespan finishes and replacement rate increases.

The frequency of flushes per person per day is 4.71[8]. The frequency is set to increase at a rate of 0.0504 flushes per week per year based on the extrapolation of Herrington (1996).

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[3] Defra (March 2011) MTP BNWAT01 WCs: market projections and product details version 1, pp7
[4] Defra (March 2011) MTP BNWAT01 WCs: market projections and product details version 1, pp7
[5] Based on average number of flushes per person per day from Waterwise.
[6] Defra (March 2011) MTP BNWAT01 WCs: market projections and product details. "Frequency of use if 4.71 flushes per person per day. Based on frequency data provided by water companies. Frequency ranges from 4.1-6.5 per person per day, influenced by the presence of a meter and single / dual flush systems." Pp7.
[7] Thames Water and BSRIA (January 2002) Information on WC's for Clare Ridgewell.
[8] Defra (March 2011) MTP BNWAT01 WCs: market projections and product details. "Frequency of use if 4.71 flushes per person per day. Based on frequency data provided by water companies. Frequency ranges from 4.1-6.5 per person per day, influenced by the presence of a meter and single / dual flush systems." Pp7.

A full flush pre 2001 toilet could include flush volumes of both 9 litres and 7.5 litres WC's and therefore the central value of 8.25 litres has been chosen to represent this. This value remains constant over the forecast horizon.

4.7.1.3 Full flush post 2001

(Refer to appliance survey Q2, Q7 and Q8)

The ownership for full flush post 2001 installed WC's was calculated using a number of different answers to questions from the appliance survey. Firstly if a household had answered 'yes' to installing a toilet since 2001 and the toilets stated would certainly be full flush WC, as shown by the answers to the questions, these would be counted. Secondly if the property was built 2001 onwards, as answered in question two of the appliance survey, then all full flush toilets stated are assumed to be post 2001 WC's. The total number of full flush post 2001 WC's are then divided by the total number of household's in the category (e.g. North Unmeasured). Ownership is forecast to grow by 30% of the decreasing rate of the pre 2001 two types of toilet combined for the planning horizon.

The frequency of flushes per person per day is 4.71[9]. The frequency is set to increase at a rate of 0.0504 flushes per week per year based on the extrapolation of Herrington (1996).

From 2001 onwards the majority of full flush WC's have a 6 litre flush volume[10] which is the maximum full flush permitted under the Water Supply Regulations[11], therefore throughout the forecasting period this volume remains constant.

4.7.1.4 Dual flush post 2001

(Refer to appliance survey Q2, Q7 and Q8)

The ownership of a dual flush WC installed since 2001 was calculated using a number of different answers to questions from the appliance survey. Firstly if the property was built 2001 onwards, as answered in question two of the appliance survey, then all dual flush toilets stated are assumed to be post 2001 dual flush WC's.

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[9] Defra (March 2011) MTP BNWAT01 WCs: market projections and product details. "Frequency of use if 4.71 flushes per person per day. Based on frequency data provided by water companies. Frequency ranges from 4.1-6.5 per person per day, influenced by the presence of a meter and single / dual flush systems." Pp7.

[10] Thames Water and BSRIA (January 2002) Information on WC's for Clare Ridgewell.
Defra (March 2011) MTP BNWAT01WCs "cisterns available on the market include a limited number of 4 litres cisterns, and a larger number of 4.5 and 6 litre available" pp28.

[11] WRAS (2000) Water Regulations Guide. Schedule 2 section 9, paragraph 25 WCs, flushing devices and urinals

Secondly if a household has answered 'yes' to installing a toilet since 2001, and the toilets stated would certainly be dual flush WC's as shown by the answers to the questions, these would be counted. The sum of the dual flush WC's is then divided by the number of households in the category (e.g. North Existing). Ownership is forecast to grow by 70% of the decreasing rate of the pre 2001 two types of toilet combined for the planning horizon because new WC sales are currently dominated by dual flush types[12].

The frequency of flushes per person per day is 4.71[13] in existing and 5[14] in unmeasured. The frequency is set to increase at a rate of 0.0504 flushes per week per year based on the extrapolation of Herrington (1996).

The average effective flush volume[15] calculated from the presently available dual flush volumes 6/4 litres, 6/3 litres and 4/2.6 litres[16] gave a result of 4.3 litres. This was increased to 4.7 to account for the 6/4 litre dual flush WC's that dominate the existing household stock and new sales[17].

Table 3: Summary of toilet flushing base year and forecasting

Dual flush pre 2001	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
North Unmeasured	11.57	-1% p.a. until 2020, -2% p.a. 2020-40	5.00	0.0504/7 p.a.	9.25
North Existing	12.62		4.71		
Full flush pre 2001	**Ownership %**		**Frequency (/h/day)**		**Volume (l)**
	Base Year	**Replacement Rate**	**Base Year**	**Growth Rate**	
North Unmeasured	59.81	-1% p.a. until 2020, -0.5% p.a. 2020-40	4.71	0.0504/7 p.a.	8.25
North Existing	53.98				

[12] Defra (March 2011) MTP BNWAT01 WCs, pp 27.
[13] Defra (March 2011)MTP BNWAT01 WCs, pp 7
[14] Based on average frequency of flushes from Waterwise
[15] Effective flush volume = average flush volume Defra (March 2011) MTP BNWAT01 pp29.
[16] Defra (March 2011) MTP BNWAT01 WCs, pp 27.
[17] Defra (March 2011) MTP BNWAT01 WCs, pp 35.

Full flush post 2001	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
North Unmeasured	12.59	+30% of the decreasing rate of dual flush pre 2001 and +30% of decreasing rate of full flush pre 2001.	4.71	0.0504/7 p.a.	6
North Existing	14.32				

Dual flush post 2001	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
North Unmeasured	16.03	+70% of the decreasing rate of the dual flush pre 2001 and +70% of the decreasing rate of full flush pre 2001	5.00	0.0504/7 p.a.	4.7
North Existing	19.09		4.71		

4.7.2 Personal Washing

The personal washing micro-component section has been split into bathing, showering, hand washing / teeth cleaning and bidet use.

4.7.2.1 Bath

(Refer to appliance survey Q7 and Q12)

Ownership levels have been taken from the appliance survey, where the total number properties with at least one bath for each category (e.g. North Unmeasured) have been divided by the total number of households in that category. Ownership of baths is forecast to decrease by 0.38 per annum in unmeasured households and 0.37 per annum in measured households, to account for the increase in showers replacing baths particularly in smaller households[18]. Ownership remains level from 2030 onwards due to uncertainty in the changes in bath ownership from this time.

The appliance survey asked how many baths where run in the household each week. These results are converted into a daily value and the average of this gave the bath frequency. The frequency of baths is forecast to decrease by 0.5% per annum. Decreasing frequency of baths is primarily due to the shift from bathing to showering[19].

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[18] Defra (March 2011) MTP BNWAT08 Modelling projections of water using products, pp11.
[19] Defra (March 2011) MTP BNWAT08 Modelling projections of water using products, pp11.

The volume of 84 litres was used for the unmeasured groups and 80 litres for existing groups. These values are based upon the Waterwise average volume figure of 80 litres[20] and evidence from the Market Transformation Programme (MTP)[21]. These remain constant for the forecasting horizon.

Table 4: Summary of bath base year and forecasting

Bath	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
North Unmeasured	85.12	-0.38 p.a. until 2030	0.41	-0.5% p.a. until 2020	84.0
North Existing	83.6	-0.37 p.a. until 2030	0.380	-0.5% p.a. until 2030	80.0

4.7.2.2 Showers

(Refer to appliance survey Q7 and Q13)

Showers are split into three types, handheld shower attachment, shower (including high pressure mixer and electric) and power shower. The count of the number of showers for each shower type was divided by the total number of households in the group (e.g. North existing) to give an ownership for each shower type. These ownerships were then proportioned to equal the total ownership for households with at least one shower. Ownership of handheld showers is forecast to increase over the planning horizon with existing power shower ownership increasing at a faster rate as it is assumed a higher take-up rate will occur in existing properties.

The frequency of use is assumed to be the same for all types of showers. An average figure for the total number of showers taken per person was provided rather than splitting this between each shower type. The base year figure for frequency is 0.54. Forecasted frequencies for each shower in unmeasured and existing are shown in Table 5.

To determine the base year shower volumes per use a shower duration time of 5.36 mins was calculated from evidence reports.[22] The flow rates of 8 litres / minute for handheld showers and 6 litres / min for showers (including electric and mixer) were applied to give the base year volumes.
Showers with flow rates greater than 10 litres / minute are classed as power showers and in the forecast it is assumed that the flow rate of a power shower

[20] Waterwise (November 2011) Showers vs Baths: facts, figures and misconceptions "average bath's 80 litres" *http://www.waterwise.org.uk/news.php/11/showers-vs.-baths-facts-figures-and-misconceptions*
[21] Defra (March 2011) MTP BNWAT03 Baths -reference scenario average pp 9 and highest % of sales in 2010 were for medium sized baths pp10.
[22] Defra (2007)- found in Waterwise report- mean shower time of 7.1 mins and MTP BNWAT02 reports mean shower time of 5.32 mins.

is 11 litres / minute. Shower volume increases as it is assumed that shower duration time will continue to increase.

Table 5: Summary of showers base year and forecasting

Handheld shower attachment	Ownership % Base Year	Replacement Rate	Frequency (/h/day) Base Year	Growth Rate	Volume (l)
North Unmeasured	20.28	+0.1% p.a. until 2040	0.54	+0.6% p.a. until 2030	42.88
North Existing	22.21	+0.1% p.a. until 2040	0.54	+0.005 p.a. until 2040	42.88
Shower (includes Electric and Mixer)	**Ownership % Base Year**	**Replacement Rate**	**Frequency (/h/day) Base Year**	**Growth Rate**	**Volume (l)**
North Unmeasured	58.52	+0.2% p.a. until 2040	0.54	+0.6% p.a. until 2030	32.16
North Existing	58.27	+0.2% p.a. until 2040	0.54	+0.05 p.a. until 2030	32.16
Power Shower (>10l/min)	**Ownership % Base Year**	**Replacement Rate**	**Frequency (/h/day) Base Year**	**Growth Rate**	**Volume (l)**
North Unmeasured	10.45	+0.2% p.a. until 2030	0.54	+0.6% until 2040	78.10
North Existing	11.71	+0.5% p.a. until 2030	0.54	+0.005 until 2022	77.00

4.7.2.3 Hand Washing / Teeth Cleaning

The ownership is set at 100% and remains constant. Frequency of use is set at 8 times a day and decreases constantly across the planning horizon[23]. The volume remains constant over the forecasting period at 2.32 litres per use, representing a 30 second flow duration using an average flow rate of 4.64 litres / min for washbasin taps[24].

[23] Across all household groups frequency decreases by taking the difference in frequency between the base year and 2040 and dividing this by the total number of years in the planning horizon. Then the previous year frequency is added to this value.
[24] Waterwise '6 litres / min' and Defra (March 2011) MTP BNWAT04 'washbasin tap flow rates range between 3.54-1.68', pp7.

Table 6: Summary of hand washing / teeth cleaning base year and forecasting.

Hand washing / teeth cleaning	Ownership %	Replacement Rate	Frequency (/h/day)	Growth Rate	Volume (l)
	Base Year		Base Year		
North Unmeasured	100	Remains constant	8	((2040 freq – base year freq) / 27) + yr before frequency	2.32
North Existing					

4.7.2.4 Bidet

(Refer to appliance survey question 7)

Household ownership of a bidet has been taken from the appliance survey results. In most cases, bidet use is considered too small to be included, therefore in our forecast frequency is assumed to remain at one use per day for the forecasting period. Volume per use also remains constant over the forecasting period at 1.2 litres in both measured and unmeasured properties[25].

4.7.3 Clothes Washing

The sections within the clothes washing micro-component are washing machine, washer-drier drying part only and washing clothes by hand.

4.7.3.1 Washing Machine

(Refer to appliance survey questions 7, 9, 10 and 11)

All washing machines have been split into four model groups with each model assigned an average volume used per load based upon the models currently available to customers.[26] Please see Table 7. It is assumed customers will buy from the most water efficient model on the market. Replacement rates of these models applied in the forecast are also shown in Table 7 varying around the assumed mean of 12.59 years[27].

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[25] Novita USA (Oct 2012) *http://www.novitausa.com/about/why-do-you-have-to-use-a-bidet-answer-2/* "1.2 litres / min and max for 1 min".

[26] Which? Notes on water and washing machines stating the best models have an average of 33 litres per load and worst models have an average of 80 litres per load. These higher consumption models are still available in most retailers.

[27] Defra (March 2011) MTP BNWO01 Combined Laundry 'washing machines and washer drier lifespan is assumed to be 12.59 years', pp13. Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, 'on average a clothes washing machine is replaced once every 12 years', pp 9.

As the ownership of washing machines increases and old washing machines are replaced by new more water efficient models, the percentage ownership of model 1 decreases and models 2, 3 and 4 are proportionally increased. Due to this, model 1 is assumed to be phased out by 2026 in unmeasured properties and 2025 in measured properties, and model 2 is phased out by 2029 in unmeasured properties and 2026 in measured properties.

Table 7: Washing machine models and assigned volumes

		Replacement Rates (years)	
Model	**Average volume per load**	**North Unmeasured**	**North Existing**
Model 1	72 litres	15	15
Model 2	55 litres	18	15
Model 3	45 litres	30	30
Model 4	39 litres		

From the appliance survey the total percentage ownership of all washing machines is calculated and includes washer driers. The growth rate of washing machines is 0.32 per annum[28] with total ownership capped at 99%. This allows for the total number of washing machines to be calculated based upon the total number of properties in the forecasting year.

The frequency of use for washing machines is taken from the appliance survey except for the unmeasured figure which has been taken from the unmeasured consumption monitor results[29] as these were believed to be more precise. The frequency of use grows by 0.05 per annum in unmeasured until 2025/26 where it stabilises. For existing properties the frequency grows by 0.025 per annum until the end of the forecasting horizon. The volume for each year is based upon the percentage of each model owned multiplied by the total litres per use.

Table 8: Summary of washing machine base year ownership and frequency

	Base Year Ownership	Base Year Frequency of Use (households / week)
North Unmeasured	95.18	4.87
North Existing	97.34	2.99

[28] From the Experian model.
[29] Study of Water Use (ESW) questionnaire results.

4.7.3.2 Washer Driers – drying part only

(Refer to appliance survey questions 7, 9, 10 and 11)

Washer driers use similar amounts of water in the washing phase as washing machines; however the drying phase also uses significant amounts of water as most operate by a process of condensation that removes humidity but consumes water[30].

The ownership of washer driers for each customer group is taken from the appliance survey results. Ownership is forecast to increase by 1% of the base year ownership through to 2040. Penetration of washer-driers is thought to increase as single-occupancy households and confined living spaces make washer driers more practical than separate washers and driers[31].

The base year frequency of use is the same as washing machines but increases by 1% per annum until 2040. The volume per use is calculated by taking the average total volume of 90 litres[32] that a washer drier uses in both the washing and drying phase minus the washing machine volume per use leaving the drying phase water volume only.

Table 9: Summary of washer drier base year ownership and model ownerships.

	Ownership % Base Year					Base Year Frequency of Use (Hsehlds/wk)
	Overall	% Model 1	% Model 2	% Model 3	% Model 4	
North Unmeasured	7.030	12	36	51	1	4.87
North Existing	11.06	4	30	52	10	2.99

4.7.3.3 Washing clothes by hand

The ownership values determined for washing clothes by hand for unmeasured households is 10% based on assumptions from Herrington (1996). Unmeasured household ownership remains constant at 10% throughout the forecasting horizon, whereas measured households decrease by 0.2% per annum over the horizon.

The frequency of use is 1.8 times per household per week and remains constant over the forecasting time[33]. The base year volume of 20 litres has been used unmeasured properties and 14 litres for measured properties[34].

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[30] Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 21.
[31] Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 21.
[32] Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, 'most using over 90 litres', pp 21.
[33] Frequency from Herrington (1996) and assumed to stay constant.

4.7.4 Dishwashing

The dishwashing micro-component has been split into four sections; dishwasher, washing up, waste disposal and recycling.

4.7.4.1 Dishwashers

(Refer to appliance survey questions 7, 9, 10 and 11)

The forecast model for dishwashers is based on the same approach as that used for washing machines. All dishwashers have been split into three models with each of these models assigned an average volume per load based upon the models currently available to customers[35]. Please see Table 8. It is assumed customers will buy from the most water efficient model on the market. Replacement rates of these models applied in the forecast are also shown in Table 10 varying around the assumed mean of 14.5 years[36]. As the ownership of dishwashers increases old dishwashers are replaced by new more water efficient models. As the percentage ownership of model 1 decreases, models 2 and 3 proportionally increased.

Table 10: Dishwasher models and assigned volumes

Model	Average volume per load	Replacement Rates (years)	
		North Unmeasured	North Existing
Model 1	17+ litres	8	6
Model 2	10-17 litres	18	12
Model 3	<10 litres	15	12

The ownership of dishwashers is taken from results from the appliance survey and forecast to increase over the planning horizon. Total ownership is capped at 99% (although none of the three models reach 99% by the end of the forecasting period). This allows the total number of dishwashers to be calculated based on the total number of properties.

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[34] Across all household groups frequency decreases by taking the difference in frequency between the base year and 2040 and dividing this by the total number of years in the planning horizon. Then the previous year frequency is added to this value.

[35] Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 10.

Which? (September 2012) *http://www.which.co.uk/energy/creating-an-energy-saving-home/reviews-ns/water-saving-products/water-efficient-dishwashers/*.

[36] Defra (March 2011) MTP BNDW01,'13 years', pp11. Waterwise report prepared for Defra (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, '16 years' pp 10. Mean of both these values is 14.5 years lifespan.

The frequency value assigned to dishwashers in measured properties has been taken from the appliance survey and unmeasured properties have been taken from the unmeasured consumption monitor results[37] as this is deemed a more appropriate figure. The forecast of the frequency of use is related to the number of people living in a property, so as the average occupancy increases over the forecast the dishwasher frequency increases at the same rate. The volume for each year is based upon the percentage of each model's ownership multiplied by the total litres per use.

Table 11: Summary of dishwasher base year ownership and frequency

	Ownership % Base Year				Base Year Frequency of Use (Hsehlds/week)
	Overall	% Model 1	% Model 2	% Model 3	
North Unmeasured	28.62	8	47	45	3.800
North Existing	32.82	8	47	45	1.72

4.7.4.2 Washing Up

(Refer to appliance survey question 7)

It is assumed that all homes that do not own a dishwasher will wash up. It is also assumed that 60% of households with a dishwasher will also do some washing up as well. Therefore the total percentage of customers who wash up is dependant upon the growth rate of dishwashers.

The frequency consists of a two part calculation based upon the assumption that people without a dishwasher wash up more times than people with a dishwasher. It is presumed that for properties without a dishwasher they wash up 18 times a week. Unmeasured properties with a dishwasher are assumed to wash up 3.8 times a week. Measured properties with a dishwasher are assumed to wash up 1.9 times a week.

A constant volume of 10 litres per wash load has been given to unmeasured properties. For measured properties it is reduced to 7 litres. These all remain consistent over the forecasting period.

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[37] Study of Water Use (South) questionnaire results.

4.7.4.3 Waste Disposal Units

(Refer to appliance survey question 7)

The ownership of waste disposal units is taken from the appliance survey and remains constant over the forecast. The 2007 appliance survey supplied us with a frequency value of 6.33 times per week (0.9 times a day)[38]. From Waterwise's components of demand figures (Sep 2008)[39] the volume of 9 litres per use has been assumed for unmeasured properties and 6 litres per use for measured properties. Both the frequency of use and the volume per use remain constant over the forecast horizon.

4.7.4.4 Recycling

For each household group a constant consumption has been assumed in the forecast. The 2007 appliance survey showed that 70% of customers recycle at home. The following consumptions have been determined based upon the water use in rinsing recyclable materials (Table 12).

Table 12: Recycling assumed consumptions

	Consumption (l/hd/d)
North Unmeasured	2.8
North Existing	1.0

4.7.5 Outdoor Use

The micro-component section outdoor use has been split into the following sections:

- pressure washer
- lawn sprinkling
- hose for watering garden
- watering can
- bucket for car wash and rinse
- hose for car rinse
- paddling pool
- large paddling pool (12-15ft +/or temp swimming pool)
- pond filling
- and swimming pool filling

[38] Frequency of waste disposal not asked in 2012 survey, but was asked in 2007 survey and considered not to have changed so remained the same.

[39] Waterwise (Sep 2008) Water consumption of components of domestic demand 'waste disposal unit (used with running water) 9 litres per min, can range between 6-25 litres / min'.

4.7.5.1 Pressure washer

(Refer to appliance survey question 7, 21, 26)

The ownership for pressure washer (power washers) is taken from the appliance survey results. Ownership is expected to continue to increase over the next few years before stabilising.

The frequency of use remains constant from the base year across the planning horizon. Figures for the existing group are based upon the results from the appliance survey. Unmeasured properties are set higher at 0.1 as they are not paying by a metered tariff.

A typical pressure washer volume ranges between 350-500 litres per hour with Waterwise stating the average is 400 litres / hour[40] and half an hour is the assumed length of time per use.

Table 13: Summary of pressure washer base year and forecast

Pressure Washer	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	13.35	+0.05 p.a. until 2021, +0.1p.a. until 2030	0.10	Remains constant	200
North Existing	13.32	+0.025 p.a. until 2020	0.075	Remains constant	150

4.7.5.2 Lawn sprinkling

(Refer to appliance survey questions 15, 16, 17, 18, 21 and 22)

As part of the appliance survey customer's where asked through a series of questions as to whether they sprinkled their lawn. These answers determined the ownership for this micro-component category. Existing properties are forecast to decrease by 0.1 per annum for the whole of the forecasting horizon whereas unmeasured properties remain more stable over the forecast.

The frequency of lawn sprinkling has been determined from the appliance survey answers to questions 16, 17, 18 and 21. Across all the property areas the average time sprinklers were used during the summer was less than 1 hour / week[41]. This has been increased for unmeasured properties. All frequencies remain constant over the forecasting period.

[40] Argos products available (September 2012) range from between 350-500 litres per hour, Waterwise estimate average is 400 litres / hour.

[41] This would give an average of 6 hours over the entire summer months (1x12 weeks (3 months) of 30 mins).

A volume of 1000 litres per use[42] has been used for all groups and remains constant over the forecasting horizon, with the exception of the unmeasured property group which decreases by 2% per annum from 2021 onwards.

Table 14: Summary of base year and forecast for lawn sprinkling

Lawn Sprinkling	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	3.98	Remains constant until 2030 where -5% p.a. until 2040.	7.5	Remains constant until 2030 where -5% p.a. until 2040.	1000
North Existing	4.24	-0.1 p.a. until 2040	3	Remain constant	1000

4.7.5.3 Hose for watering garden

(Refer to appliance survey questions 15, 17, 18, 19, 20, 21 and 22)

The percentage of people who water their garden using a hose is taken from the appliance survey answers. Unmeasured properties are assumed to increase over the forecasting period and existing properties are assumed to decrease over the forecasting period.

The frequency of use is based around an assumed average of 17.48 hrs per year and 1 hour per use. For unmeasured properties this has been increased to 20 hours per year and for existing properties lowered to 6 hours per year to reflect the assumed lower consumption of metered customers. These frequencies are forecast to remain constant over the forecasting period.

It is assumed that the volume of a hose used to water the garden will be 1000 litres / hour and if a trigger hose gun is attached 600 litres / hour. It is also assumed to be used for 30 minutes each use. From the appliance survey an average of 11% of unmeasured properties and 9% of measured properties did use a trigger hose gun therefore these properties will use 300l per use. The remainder percentage of properties will use 500l per use which gives an average of 477 litres per use for unmeasured properties and 482 litres per use for measured properties.

[42] Defra (March 2011) MTP BNWAT06 Domestic water use in new and existing buildings, ‘Sprinklers typically use 540-1000 litres per hour (9-16 litres per minute)’, pp 9.

Table 15: Summary of base year and forecast for hose used for garden watering

Hose used for watering garden	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	34.76	+0.1% p.a. until 2021, +0.2% p.a. until 2040	20	Remain constant	477.24
North Existing	28.71	-0.1% p.a. until 2040	6	Remain constant	482.48

4.7.5.4 Watering Can

(Refer to appliance survey questions 15, 16, 17, 18, and 21)

The appliance survey provided the percentage ownership for customers who use a watering can to water their garden. The base year figures are used for the forecast.

The frequency of using a watering can is based upon the BSL figure of 4.86 times a week and the estimation that it will be used for 12 weeks of the year[43]. This gives a frequency of 58.32 times a year which has been lowered for existing properties to reflect the assumption that these customers will be more water conserving. This remains constant through-out the forecast.

The volume used is 60 litres per use in existing properties and 30 litres per use in unmeasured properties and remains level through-out the forecast[44].

Table 16: Summary of base year and forecast for watering cans

Watering can	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	59.84	Remain constant	58.32	Remain constant	30
North Existing	60.54	Remain constant	20	Remain constant	60

[43] 12 weeks = 3 months =3 months of the summer (June, July and August).
[44] Defra (March 2011) MTP BNWAT06 Domestic water use in existing buildings, 'Watering cans come in a variety of volumes typically between 7-13 litres', pp 9. Therefore 6 fills of a 10 litre can per use = 60 litres in total per use.

4.7.5.5 Car Washing

Car washing has been split into three activities:

- using a bucket for both washing and rinsing
- using a bucket for washing
- using a hose for rinsing only

The ownership of using a bucket for both washing and rinsing and using a hose came from the appliance survey. The ownership for using a bucket for just washing equals the same as using a hose for rinsing as they are assumed to correspond with each other. These remain constant through-out the planning period.

The frequency for each car washing activity remains constant for the forecasting period. Frequency is based on answers from the appliance survey.[45]

The volume for a bucket used for car washing is based on an assumption of 2 buckets / wash and 6 buckets / rinse, with the volume of 1 bucket equalling 7 litres[46]. Therefore the total volume used for a wash only is 14 litres. For a wash and rinse it is 56 litres per use. This has been raised slightly for unmeasured properties to 60 litres[47]. The volume per use of 90 litres is used for a hose for rinsing[48]. These remain constant over the forecasting horizon.

Table 17: Summary of base year and frequency for car washing

	Bucket for both washing and rinsing			Bucket just for washing litres			Hose for rinsing only litres		
	Vol (l)	Ownership (%)	Frequency (H/wk)	Vol (l)	Ownership (%)	Frequency (H/wk)	Vol (l)	Ownership (%)	Frequency (H/wk)
North Unmeasured	60	33.81	15.81	14	10.98	20.36	90	10.98	20.36
North Existing	56	30.60	14.68	14	8.89	14.68	90	8.89	14.68

[45] The frequency of just over 1 x a month over the year. The average frequency is 1.35 x a month across Northumbrian Water.
[46] Most buckets on sale in B&Q (Sep 2012) average at 10 litres, assumed not to be filled to full capacity so a volume of 7 litres has been assigned. (*http://search.diy.com/search#w=bucket&asug=)*
[47] This assumes unmeasured properties use slightly more water due to not having as much of a water conserving behaviour as metered properties.
[48] Defra (March 2011) MTP BNWAT06 Domestic water use in existing buildings, 'Hoses can use upwards of 540 litres of water per hour depending on the pressure and hose size', pp9. Therefore assuming 540 litres / hour which gives 9 litres / min flow rate for 10 minutes to give 90 litres per use.

4.7.5.6 Paddling Pool

(Refer to appliance survey question 5)

Ownership of paddling pool is based on the assumption that 80% of household's with children under 5 will have a paddling pool. The percentage of children under 5 for each household group has been taken from the appliance survey[49]. This remains constant through the forecast. Households are assumed to use their paddling pools 11 times a year or 0.03 times per household per day. Measured customers are expected not to fill up their pools as much and this is reflected in the allocated volumes.

The range of advertised products currently available provides the bases for paddling pool volume. The volume used for unmeasured properties is 400 litres per use and for existing properties it is 200 litres per use[50]. Ownership, frequency and volume remain constant over the forecasting period.

Table 18: Summary of base year and forecast for paddling pools

Paddling Pool	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	5.00	Remain Constant	0.03	Remain Constant	400
North Existing	3.98				200

4.7.5.7 Large paddling pool, 12-15ft + / temporary swimming pool

(Refer to appliance survey question 25)

Large paddling pools / temporary swimming pools are now widely available on the market so these have been accounted for in the micro-component forecast. Appliance survey swimming pool ownership has been used as the ownership for large paddling pools. The frequency of use has been set at 0.01 times per day[51]. The volume per use assigned to large paddling pools is based on the availability of pools in the current market to customers. The median value between the largest pool volume available and the smallest has been used for unmeasured properties (7463.5 litres)[52].

[49] Percentage of children under 5 for each household category is multiplied by 0.8 (80%) to give the ownership of paddling pools, as it is assumed 80% of families with children under 5 will own a paddling pool.

[50] Argos catalogue (August 2012), smallest paddling pool was 110 litres and largest 8ft paddling pool was 2,300 litres. A suitable pool for under 5's has sizes between 110 litres and 700 litres which is an average of ~400 litres. This is halved for existing properties to account for water conserving behaviour.

[51] Equals 3.65 times a year.

[52] Argos catalogue (August 2012) Largest pool is 12,627 litres (15ft size) and 8ft pools are 2,300litres therefore a median value of 7463.5. (*http://www.argos.co.uk)*

Metered properties will be more conscious of how much water they use and so will fill up the pool less. Therefore half of the unmeasured value is used for measured properties (3731.75 litres). All assumptions made in the base year are carried forward at a constant rate across the forecast.

Table 19: Summary of base year and forecast for large paddling pools

Large Paddling Pool	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	0.16	Remain Constant	0.01	Remain Constant	7463.5
North Existing	0.32				3731.75

4.7.5.8 Pond filling

(Refer to appliance survey question 25)

The percentage of customers who own a pond has been taken for each customer group from the appliance survey. The frequency of pond filling is set at 0.01 per day for all customer groups[53]. Unmeasured customers will fill their ponds more than measured customers and this is shown in the volume differences. Unmeasured customers have a volume of 800 litres per use and measured customers have a volume of 500 litres per use. Ownership, frequency and volume remain constant over the forecasting horizon.

Table 20: Summary of base year and forecast for pond filling

Pond filling	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	3.27	Remain Constant	0.01	Remain Constant	800
North Existing	3.12				500

4.7.5.9 Swimming pool filling

(Refer to appliance survey question 25)

The ownership of swimming pools for each household group has been identified from the appliance survey. Frequency of pool filling for unmeasured properties has been set at the same value as pond filling of 0.01 as they are thought to be the alike. Measured properties frequency has been lowered to reflect the water conserving awareness of these customers.

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[53] 0.01 x 365 = 3.65 times a year

The daily water use of swimming pool filling has been taken from the Market Transformation Programme report evidence. The total daily water usage of a swimming pool is given as 271 litres for all households[54]. Ownership, frequency and volume remain constant over the forecasting horizon.

Table 21: Summary of base year and forecast for swimming pool filling

Swimming Pool filling	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
North Unmeasured	0.16	Remain Constant	0.01	Remain Constant	271
North Existing	0.32	Remain Constant	0.01	Decrease to 0.004 by 2014 and remain constant	271

4.7.6 General Use

The general use category takes into account all other areas of water use within the home and garden. For each household group a constant figure has been used over the planning horizon. General use has been split into the following areas of water use:

- Plumbing losses
- Other internal use (DIY, children's play, steam irons, house plants, washing paint brushes etc)
- Animals (Water used for drinking, washing and cleaning cages etc)
- Cleaning
- Drinking (Including filling kettles)
- Food prep / cooking
- Running tap (Running tap till hot/cold)
- Hot tubs + softeners

For each component the assumptions have been built up from ownership, frequency of use and volume assumptions. The resulting figures are shown in Table 22. In determining these figures we took account of the normalised base year total PCC's to achieve a balance. No additional allowance has been made for new appliances or for activities not mentioned above. It is assumed that these are accommodated within the uncertainty of the above assumptions.

[54] Defra (March 2011) MTP BNWAT06 Domestic water use in new and existing buildings pp9-10. BSPF response to Defra's consultation on proposed changes to powers to restrict non-essential uses of water.

Table 22: Summary of base year and forecast for general use

	Unmeasured North l/hd/d	Existing North l/hd/d
Plumbing losses	1.3	0.8
Other internal use	1.8	1.0
Animals	0.3	0.2
Cleaning	3.0	1.8
Drinking	2.6	2.0
Food preparation and cooking	3.0	1.7
Running taps	0.5	0.5
Hot tubs and water softeners	0.04	0.02
Total	12.5	8.03

4.7.7 Overall Household Demand

The resulting PCC forecasts show an overall household PCC, for the normal year, reducing steadily over the planning horizon from 144.93 l/h/d in 2012/13 to 136.67 l/h/d in 2039/40.

4.8 Non-Household Demand Forecasts

This section sets out our non-household demand forecasts for 2011/12 to 2039/40. These forecasts show actual volumes up to 2011/12, use year to date information for 2012/13 (as at the date of publishing 10 out of 12 months data was available) and use our non-household demand forecast methodology for 2013/14 and beyond.

We set out the methodology we have used for forecasting our non-household demand and then discuss the forecast results.

Non-potable demand is forecast using the same methodology as potable demand, and we also discuss the forecast demand for this type of water use.

4.8.1 Methodology

We have developed our own methodology forecast for non-household demand for the 2015 Water Resource Management Plan and for use in Ofwat's PR14 price control process. This methodology uses trend data based on past actual use by customers to predict a profile of future demand.

4.8.2 Approach

Our demand forecast methodology is based on a number of assumptions and a formula built on three elements.

We have split our customer base into two groups;

- identified customers who use more than 10,000 cubic metres of water per year and for whom an individual forecast has been generated for each customer;
- non-identified customers who use less than 10,000 cubic metres per year for whom an average volume per property is forecast, and their total demand is calculated by multiplying this average by the forecast number of properties.

The key assumptions that we have made are:

- no new identified customers will open during the forecast period, and no closures will be forecast, unless robust, public domain information is available. Any new customers will fall into the non-identified group of customers;
- in general demand for individual customers remains relatively stable unless there is a expansion or reduction on the customers site, or if they fundamentally change how they use water. These events cannot be predicted, as so we cannot make assumptions that these events will happen unless they are already in progress;
- Demand will trend to a flat line over time if there are no changes to water use on site. Recent past data may show a decreasing trend due, for example to water efficiency measures. However forecasting that reduction to continue at the same rate for 25 years is unrealistic. Therefore we have use a forecast calculation that trends demand to a flat line over time;
- It is extremely difficult to robustly forecast the economic climate 25 years in advance. Therefore we have not modified our forecast for the behaviour of the economy;

Taking into account these key assumptions we have developed a formula that uses a logarithmic trend to forecast demand. This forecast is based on three sections:

- Trend data
- Step change adjustment
- Economic adjustment

Demand components used in the calculation of household demand are all weighted average demand.

4.8.2.1 Trend forecast

The past 10 years of actual demand is used to develop a profile of demand based on a logarithmic trend. Using trend data provides a more average look at demand over time, and should provide a central forecast of demand out to the future. Any abnormal demand, such as a single year of high demand caused by leakage, or abnormally low demand as caused by a partial closure, will be smoothed out and will not overly influence the forecasts.

4.8.2.2 Step change adjustment

Over the past 10 years, some customers may have made a step change in their demand, which means that demand in recent years should have more influence over demand than the demand from 10 years ago. A pure trend analysis will not take full account of this step change, and therefore we have included a calculation that looks at the difference between demand early in the series of data and demand in the most recent years. The forecast based on the trend is adjusted by this difference, which we have called the "step change adjustment", to bring the forecast into line with actual demand experienced in the recent past.

4.8.2.3 Economic adjustment

This is a percentage multiplier to be factored on to the trend forecast, which is an assumption that allows us to say whether future demand will be more or less positive than experienced in the past.

We have currently not applied an adjustment to this element of the formula because we do not believe there is sufficiently robust data available to forecast the economy out into the future. At the most it may be possible to indicate that the next few years may show lower demand than past trend data may indicate, however it is difficult to say by how much. In addition the various forecasts of the economy, for example from HM Treasury, change on a regular basis. We also believe that it is difficult to tie demand for water use to the strength of the economy. Implementation of water efficiency can offset any growth, and the opening or closure of one large customer can throw any forecast out of line with expectations. Therefore we prefer to make no adjustment on this basis at this time. We may review our position on this adjustment.

Example

The graph below illustrates how this demand methodology would predict demand for a customer.

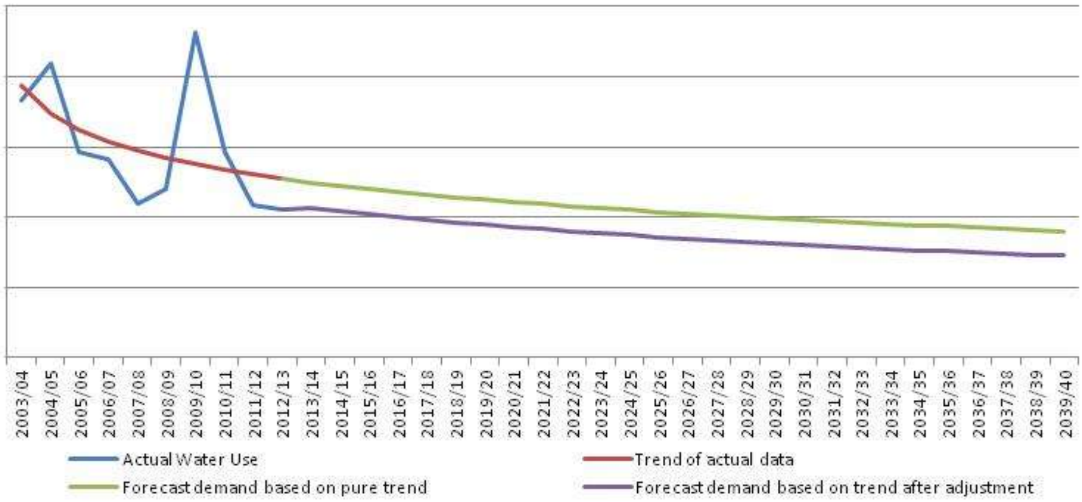


Figure 1: Example of demand forecast (purple line would be used in our forecast)

This customer clearly had some abnormal demand in 2009/10. This influences the trend and so purely using the trend forecast would over forecast (for this particular customer). The most recent demand has been lower than the trend would indicate, and so the step change adjustment modifies the forecast downwards for this example customer, although not to the lowest ever demand, but to a position in line with recent demand. The "step change adjustment" would adjust upwards, should recent demand be higher than the trend data indicates.

4.8.2.4 Application of the methodology

Our demand forecast applied an individual trend line for each of our identified customers. For all of the remaining non-identified customers we have derived an average demand per property and have applied the same trend approach to the average demand per property. The forecast average per property is then multiplied by the forecast number of non-identified properties to general a total forecast demand for the non-identified customers.

4.8.3 Non-Household Forecasting

4.8.3.1 Uncertainty

NW can never predict with certainty what will happen in the future, as has been demonstrated with the change to the economic climate over the past five years. Customers can close at a moments notice, and as there are no contracts with water customers, they can increase or decrease demand at any time.

While good contact with customers can keep track of general changes, frequently significant changes are commercially sensitive, and are not communicated in advance within the company at question, let alone with external suppliers, such as water companies.

The methodology we have chosen to use for our non-household demand forecast uses the real data we have available, and combines this with an overall view to result in a reasonable looking forecast. If we have experienced decreasing demand in recent years, and the economic climate seems to remain generally pessimistic, it seems reasonable to forecast decreasing demand in the next few years. It is unlikely that demand may suddenly surge, unless there is major growth in industry, but it is possible that a slight increase could occur, should the economy recover. On the other hand demand could collapse should current trends continue into the long term. Using a flat trend gives a forecast that arrives somewhere between these two scenarios. In reality, some customers will increase their demand and other will decrease, which in many cases will offset one another.

4.8.3.2 Sensitivity

Different ways of forecasting will produce different forecast volumes. We tested our demand forecast based on individual trend forecasts for individual customers against what the forecast would look like in trends based on sector or size were used instead.

These forecasts do not pick up step changes in single customer behaviour, they tend to be smooth. They also incorporate data for properties that have closed, therefore a sector or size trend tends to be lower than one based on individual trends. Such a trend could be viewed as valid, however it is counter to our starting assumption that all existing identified non-household customers will remain open, unless otherwise publicised.

Our overall demand forecast is most sensitive to assumptions in demand of the largest contributors to demand. These are the assumptions applied to the group of non-identified customers, and the demand profiles of our largest customers. The forecasts for our largest non-household have been reviewed individually to ensure that they take account of the latest information we have about them, and that their forecast consumption is based on a centrally reasonable estimate. The following graph shows how demand for a large customer can be volatile year on year. Using our trend based approach ensures that the forecast demand is not based on the peak or lowest demand. In this case our recent demand is slightly higher than the trend would indicate so the forecast used is adjusted slightly upwards to by the “step change adjustment” as previously described.

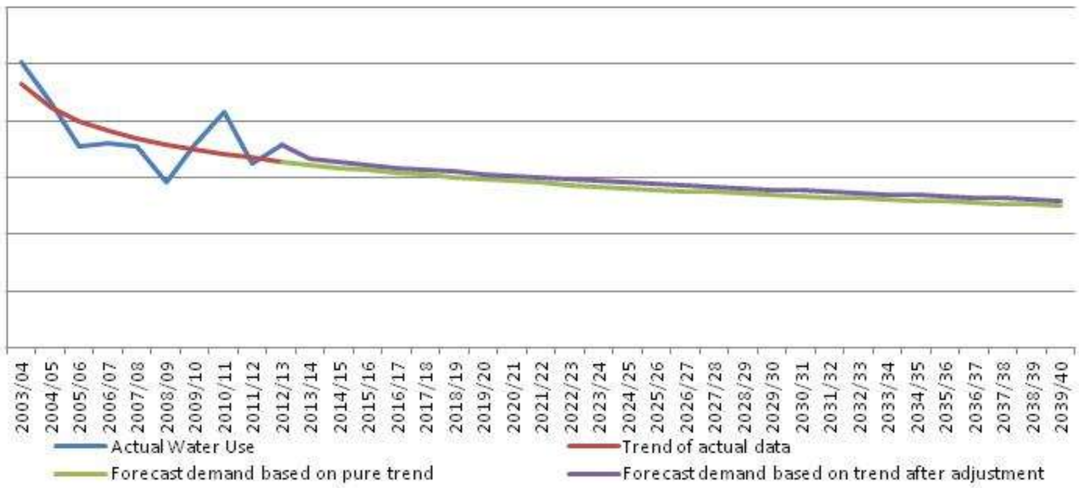


Figure 2: Example demand forecast for variable demand at anonymous larger customer

Our forecast would be sensitive to demand for this customer if we used either the 2010/11 peak demand or the lower demand of 2008/09. The trend gives us a clear way to make a decision on where to pitch demand, that can be consistently applied across all customers.

Should we hear that this particular customer is making a step change to their demand, for example by a partial closure in the next year, or maybe that they intend increasing their production line which will increase their demand, we can then build this information into our forecast, by either reducing demand in the year stated for the partial closure, or by increasing demand by overwriting the “step change adjustment” to reflect the expected increase.

Having tested our forecast methodology in several ways, we feel confident that it provides a reasonably central forecast that that is based on sensible assumptions.

4.8.4 Forecasts 2013-2040

General comments

This section discusses our non-household demand. It considers demand by sector and Water Resource Zone.

4.8.4.1 Non-Household Potable Water Demand by Sector

At this stage we have not analysed demand by Standard Industrial Classification (SIC). This is because our methodology of looking at smaller customers as a group means we do not need to look at different types of smaller customers. Small customer demand is discussed in more detail below.

Each of our larger customers have been allocated to one of ten broad sectors, which have been aimed at grouping their demand into a small set of groups for which drivers of demand should be fairly similar.

	Title	Description	Examples
Small customers	Non-Identified Customers	All customers who use less than 10,000 cubic meters of water per year.	
Large customers	Heavy Industry		Mining, oil refinery, car manufacturers
	General Manufacturing	All industry that produces something physical	
	Food & Drink	Food and drink manufacturers	
	Utility	All utilities	Power stations, water services, water and sewerage companies.
	Public Sector	Organisations which are mostly funded by government and will be affected by the public finances.	Hospitals, schools, councils, prisons, police, fire services etc.
	Retail	Anything that sells to the general public.	Shopping centres and supermarkets.
	Leisure	All customers who are part of providing leisure and holiday activities to the general public.	Hotels, holiday parks, sports clubs
	Agriculture		Farms, Dairies, etc
	Services	General service industries	Finance, insurance etc.
	Teesside	A small group of large industrial customers on Teesside in the North East.	

Figure 3 – Defined industrial sectors

The graphs below illustrate the proportion of demand in each region from each of the sectors defined above. Small customers who use less than 10,000 cubic meters per year make up approximately 50% of all demand.

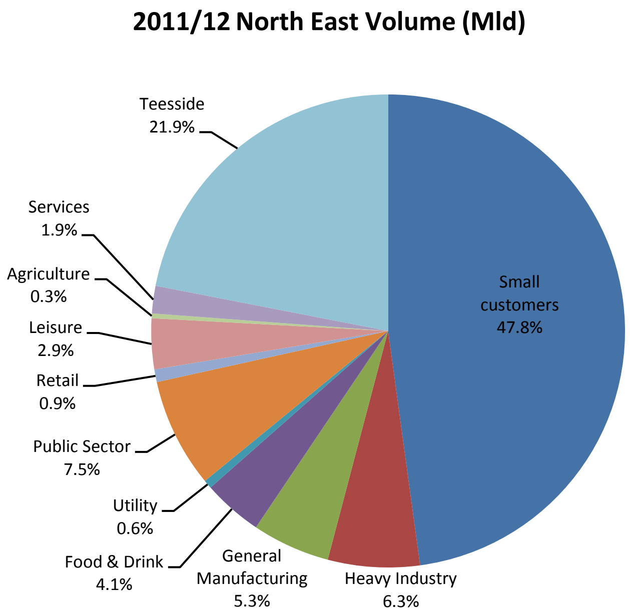


Figure 4 – Make up of non-household demand in the North East in 2011/12

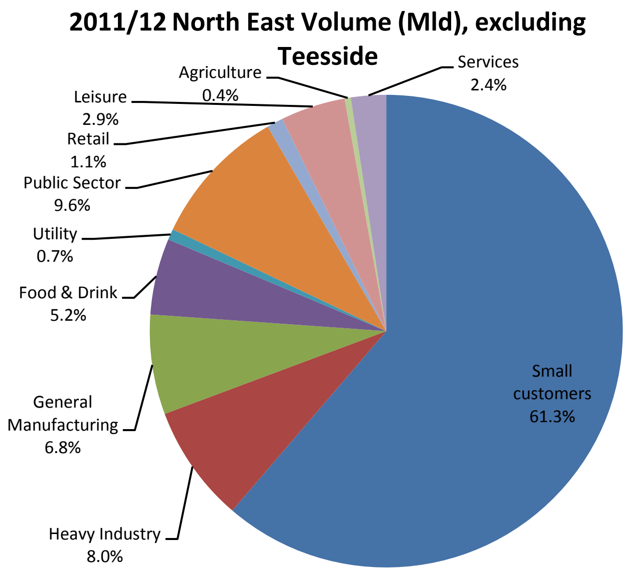


Figure 5 – Make up of non-household demand in the North East in 2011/12, excluding Teesside

In the North East we have identified a sector of customers as “Teesside”. This is a group of very large industrial customers based in a small area of Teesside, some of whom are dependent on one another to survive, and who have a significant impact on the overall demand in the North East, at about 20%.

4.8.5 Demand by Water Resource Zone (WRZ)

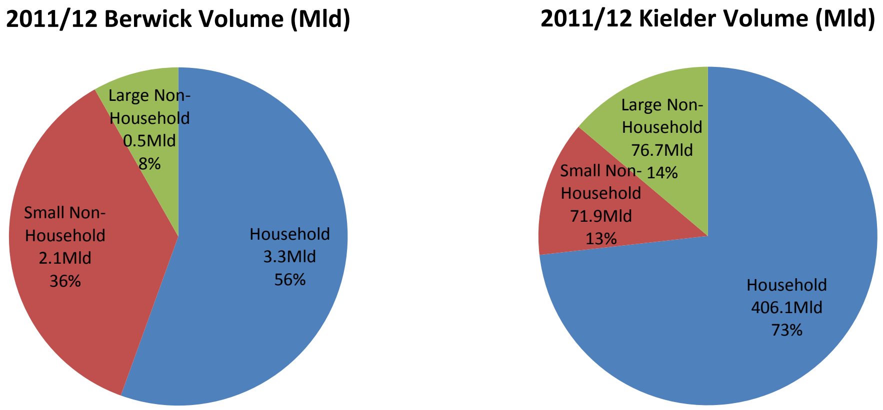


Figure 6 – Breakdown of demand in North East Water Resource Zones for 2011/12

Comparing the two WRZ shows that small non-household demand is a large proportion of the Berwick zone demand, whereas household demand dominates the Kielder zone.

4.8.5.1 Large Customer Historical Demand

Historically non-household demand has been quite stable, other than for closures of properties as illustrated in Figure 7. Only demand from Heavy industry has been reducing, which is due to a mixture of customer closures and reducing usage.

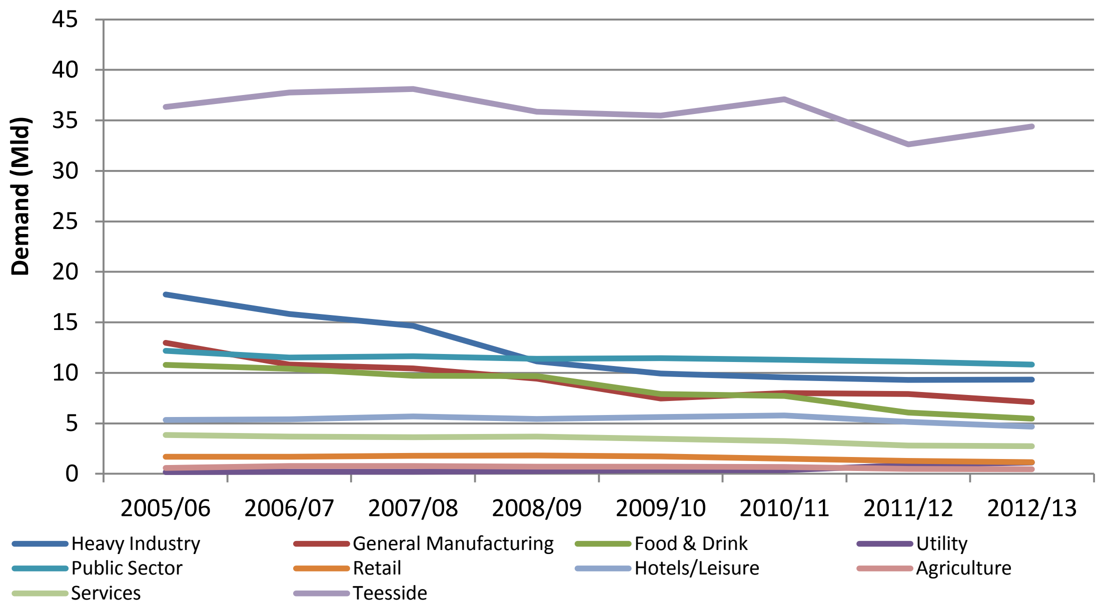


Figure 7 – Large non-household demand 2003/04-2012/13 – change in volumes

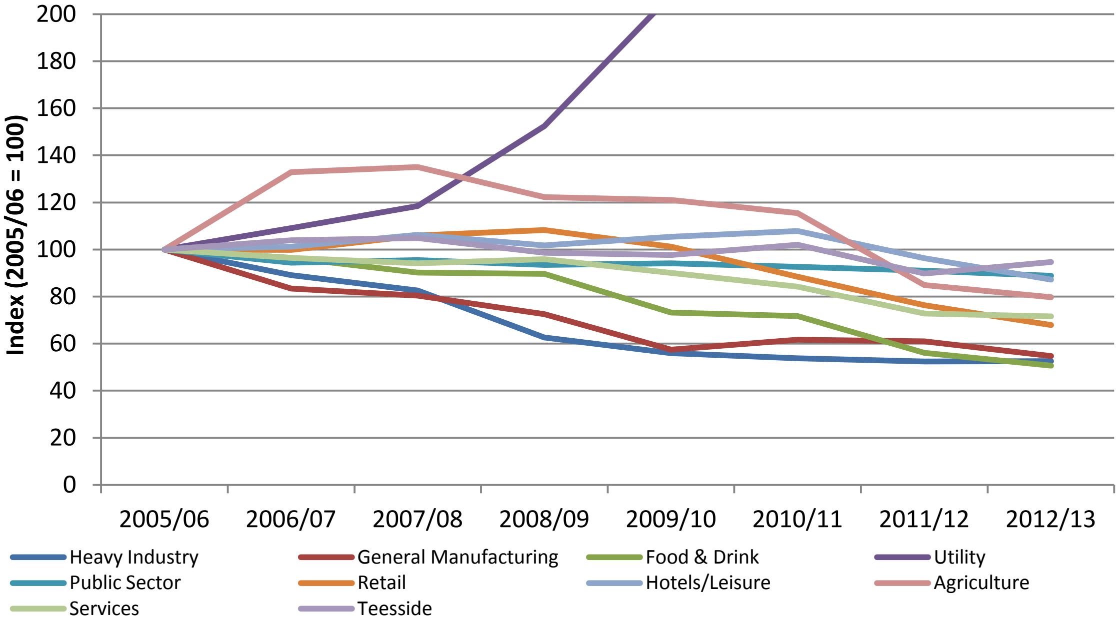


Figure 8 – Large non-household demand 2003/04-2012/13 – proportional change since 2005/06

Demand in all sectors is now lower than it was in 2005/06, other than the utility sector. The significant growth in this sector is due to a single large customer who has opened since 2005 and proportionately uses most of the water in the utility sector. The largest proportional reductions in demand can be seen in the more industrial sectors, which is partly due to customer closures, either partial or permanent, until 2010/11.

4.8.5.2 Small customer historic demand

In 2011/12 and 2012/13 there has been a clear reduction in demand from smaller non-household customer, which we believe will be permanent.

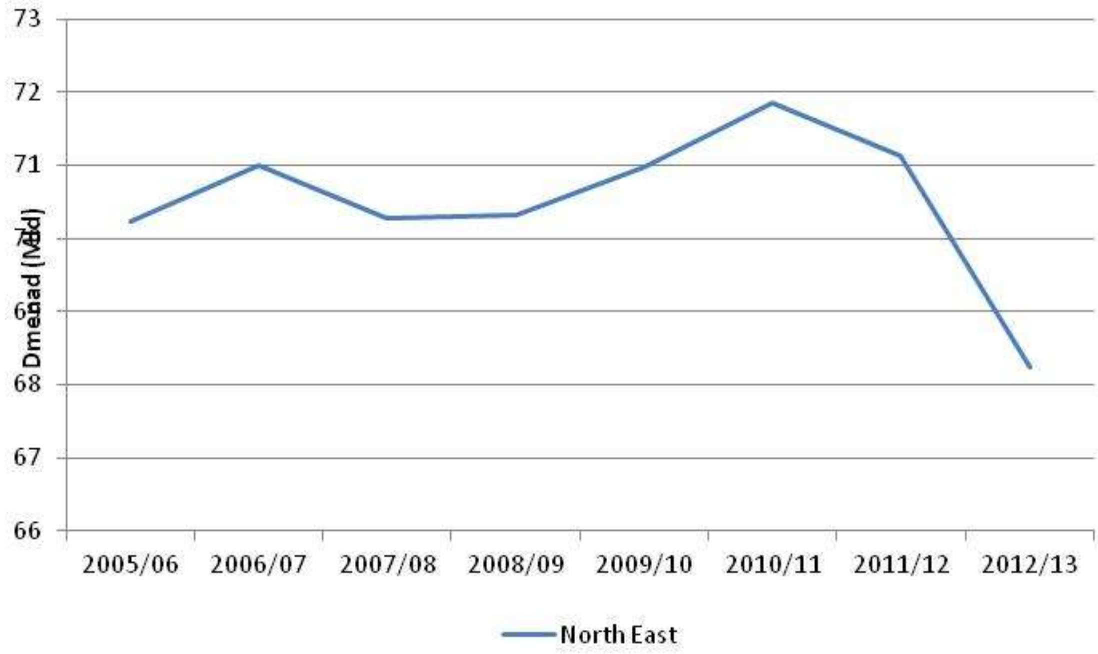
Figure 9 – Historic small non-household demand


Figure 9 – Historic small non-household demand

This stability in demand is also reflected in the average demand per property, which is illustrated in Figure 10. The most significant change can be seen in the past two years, where demand has fallen.

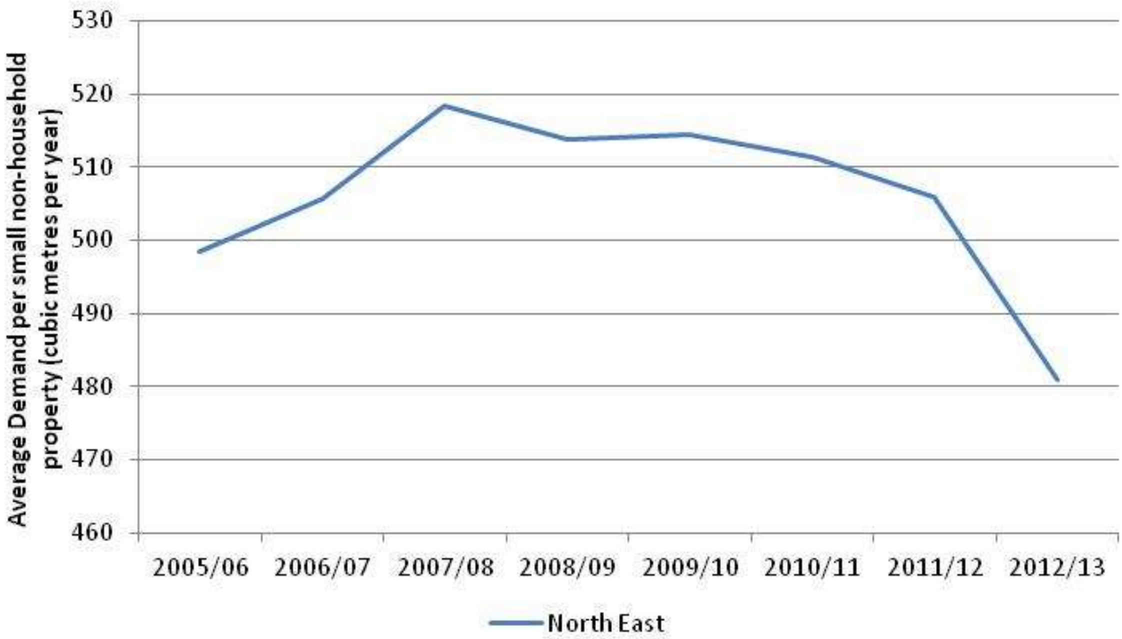


Figure 10 – Historic small non-household demand average per property

It is not possible to exactly determine the cause of the change from stable demand to reducing demand, however given that it has occurred a couple of years after the economic climate changed in 2008 and after the harsh winter of 2010, we would suggest that this reduction is a combination of customers finding and repairing leaks, and more attention being paid to water usage.

As such we would expect the lower demand average demand per property to continue into the future.

While the reduction in average demand per property seems relatively small, accumulated over all small non-household properties this can add up to a significant change in total demand.

4.8.5.3 Forecast Demand

Overall measured non-household forecast demand to 2040 is relatively flat. This is due to the assumption built into our forecast that individual customer demand will trend to a flat line over time. In the short term the forecast shows reducing demand compared to recent years, and there is some question about when this is likely to flatten out. Given the current views of government and HM Treasury, that the UK economy is likely to continue as it is for the next 3 to 5 years, the flattening of demand within this timescale seems reasonable.

We do not believe that demand is likely to suddenly begin increasing again, unless new large water users open. Our forecasts do not assume that this will happen because assuming new demand is uncertain until the new site actually starts operation.

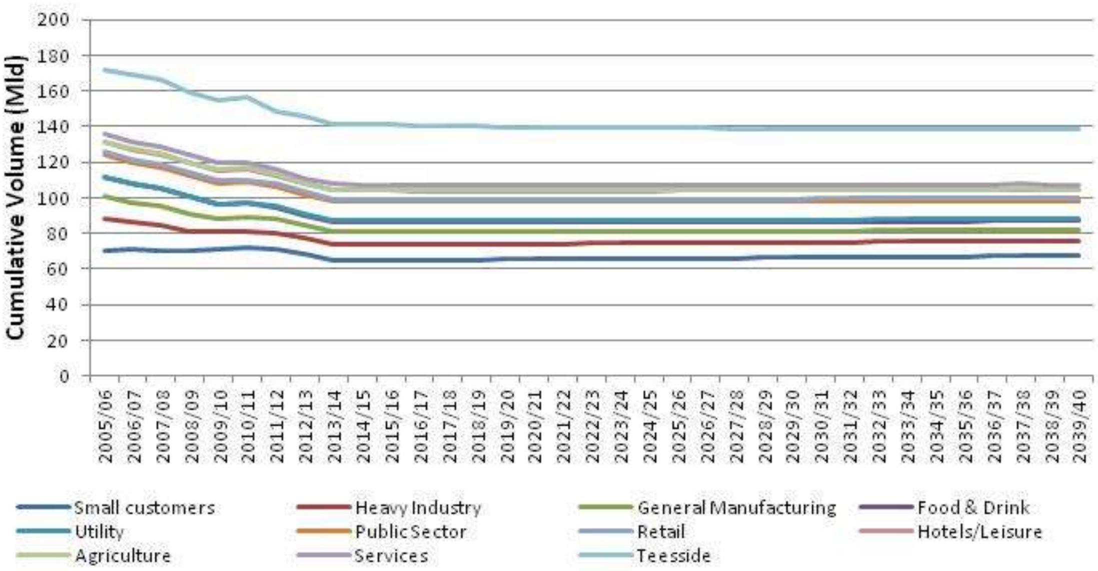


Figure 11 – Forecast demand in the North East by sector – volumes are cumulative, so the gap between each line is the size of each sector

Sector	Demand (Mld)		Change (Mld)	% Change	Notes
	2011/12	2039/40			
Small customers	71.1	67.3	-3.8	-5.4%	
Heavy Industry	9.3	8.5	-0.8	-8.4%	
General Manufacturing	7.9	6.1	-1.8	-23.0%	Large reduction due to closure of several customers
Food & Drink	6.0	5.0	-1.0	-17.1%	
Utility	0.9	1.1	0.3	31.6%	Increase due to a new customer who was not fully on line in 11/12
Public Sector	11.1	10.4	-0.7	-5.9%	
Retail	1.3	1.2	-0.1	-4.9%	
Hotels/Leisure	5.1	4.8	-0.4	-7.5%	
Agriculture	0.5	0.3	-0.1	-28.2%	Underlying trend of all customers is downwards, resulting in large percentage decrease.
Services	2.8	2.7	-0.1	-3.8%	
Teesside	32.6	30.6	-2.0	-6.1%	
Total	148.7	138.2	-10.5	-7.1%	

Figure 12 – Change in measured non-household demand by sector between 2011/12 and 2039/40

The largest areas of change in forecast demand are due to known closures of specific larger customers early in the forecast period. Other changes in the forecast demand is a result of the trends of each individual customer, and where the sector trend is decreasing this will be because more individual customer demands have decreasing trends, than increasing, and vice versa.

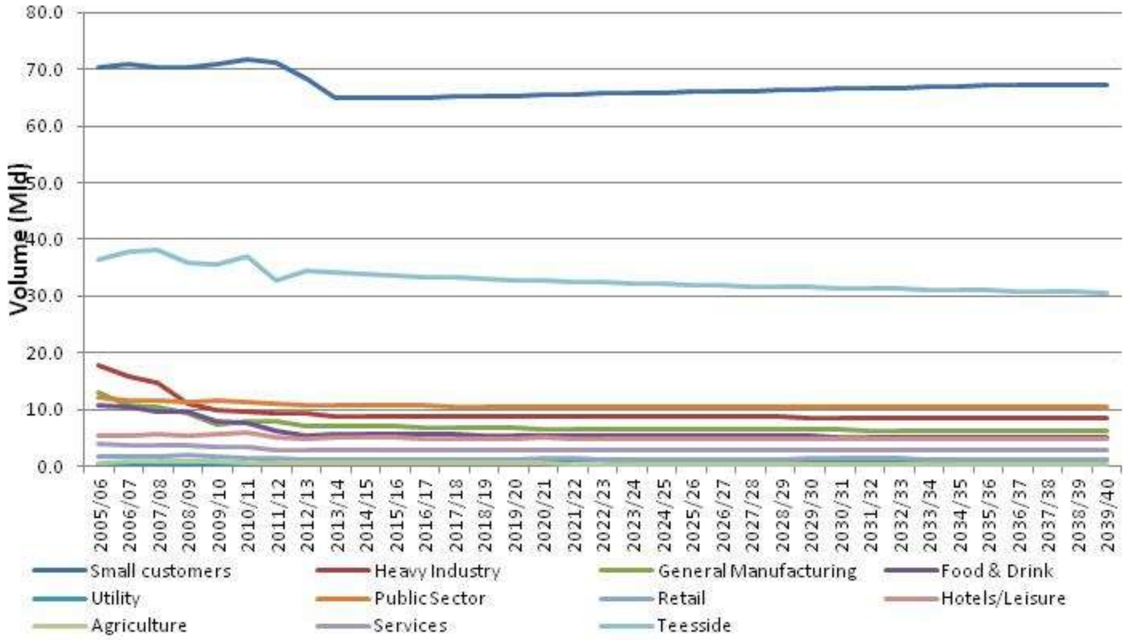


Figure 13 – Forecast demand in the North East – by sector

4.8.5.4 Non-potable demand

In the north east we supply a significant volume of non-potable water to a small group of customers on Teesside. To forecast demand for this non-potable water we have applied exactly the same methodology as applied for the potable water. A trend, based on non-potable demand, has been generated for each of these customers, and used to forecast demand into the future. As each of these customers are large, changes from any one customer can significantly affect the forecast. Nevertheless we have used the same principles as the potable forecast, and have only forecast a change to a customer's demand where it is based on robust, public domain information.

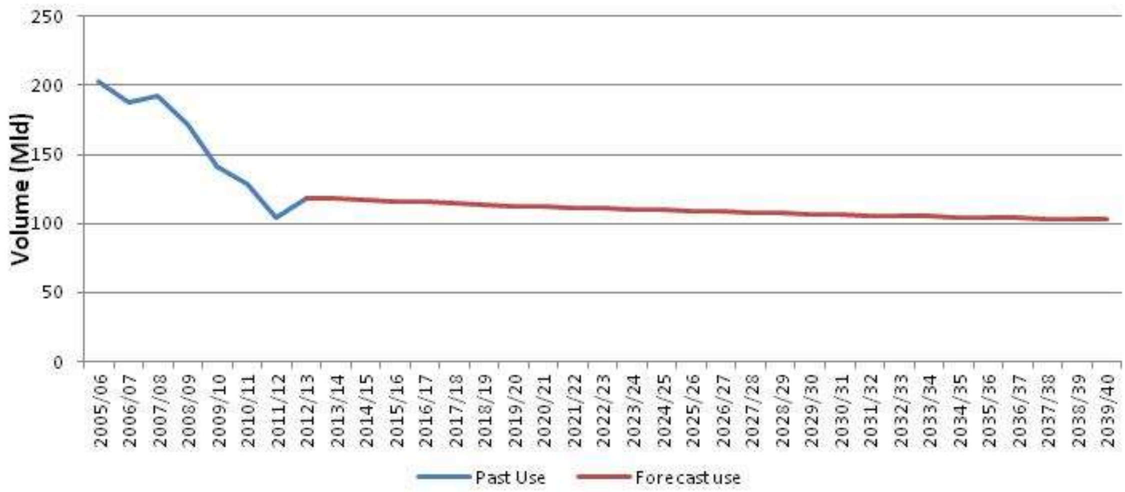


Figure 14 – Non-potable demand forecast for the Teesside Raw Water system

There has been a significant downward trend in non-potable demand over the past five years. This is mainly due to closures of customers as well as reduction in use. The increase in demand in 2011/12 was due to the reopening of a customer who had closed.

The forecast shows a much more gradual downward trend than we have experienced in recent years. This is because, in line with our potable forecast assumptions, we have assumed that no customers will close, unless publicly announced. Therefore the forecast is based on the underlying trends from existing customers. As there are a very few large customers in this group, demand is extremely sensitive to single customer behaviour.

4.9 Total Normal Year Baseline Demand Forecasts

The total baseline demand forecast is comprised of the elements described in the preceding sections and the demand management described in section 5.

4.10 Defining Dry Year Factors

The historic record of weather versus demand has been examined to identify conditions of a dry year and the weighted average number of dry years expected has been calculated for Northumbrian Water.

4.10.1 Background Information

A dry year definition is required when a company decision is to be made for the June Return submission to OFWAT stating that the weather experienced during the period of the return has been a dry year or not. Simple criteria will be selected based on average maximum temperature and total rainfall for the return year. The supply and demand should be forecast under a dry year scenario reassuring people and organisations that the actions they will take under a dry year scenario will meet their expected level of service.

Guidelines from the EA, OFWAT and NERA state that a dry year should be the basis of the demand planning process, however there appears to be no distinct, precise definition of the characteristics of a dry year. This definition is problematic to apply as the introduction of demand restrictions is more commonly linked to water resource availability resulting from weather conditions over a prolonged period, usually a previous year.

A weighted average demand forecast is required as the basis of the companies revenue forecast[55]. In the planning horizon not all years will turn out to be 'dry'. Typically the demand a company is most likely to be faced with will be a combination of demand from 'normal' years, 'dry' years or 'wet' years[1]. The frequency of each type of year in the planning horizon and the demand associated with these types of years will be reflected in the weighted average forecast.

4.10.2 Objectives

- To review the dry year definitions available.
- To examine the relationship between weather and demand and identify years of specific interest due to unusual weather and demand patterns with the peak summer period (June-September) being examined in greater detail.
- To compare rainfall with the 10 and 30 year long-term averages and maximum temperature compared to the 10 year and 30 year long-term means for the identified years of specific interest.
- To identify the dry years that have occurred in the Northumbria Water supply regions in the past 25 years as determined by the annual number of days greater than 25^{o}C and yearly cumulative rainfall.
- To determine the weighted average number of dry years which may occur in a 10 year period for Essex and Suffolk areas.

4.10.3 Dry Year Definitions

Environment Agency

The Environment Agency state the definition of a dry year (household) is "A period of low rainfall and unconstrained demand" (EA, 2007a). In the EA report 'A scenario approach to demand forecasting' (EA, 2001), 1995 is assumed to represent a dry year.

The Water Resources Planning Guideline (EA, Ofwat, Defra, Welsh Government, 2012) states a water company should analyse historical supply and climate data to set out the dry year demand as a continuous profile over a year at monthly or weekly intervals. The term 'dry year' is defined as a period of unconstrained demand and low rainfall.

Ofwat

Ofwat stated in their Business Plan Guidelines (Ofwat, 1998) that "Companies should describe in the commentary of their Business Plan the relationship between expected demand in a year with normal weather and expected demand in a dry year.

[55] Water Resource Planning Guideline, (2012), EA, Ofwat, Defra, welsh government.

Where a company has provided the Environment Agency with a demand and supply forecast based on its critical period (assumed to be peak week unless otherwise stated), they should focus on key milestone planning years e.g. 2002-2003 and 2007-2008." (Part D, D8, Business Plan Guidelines).

NERA

NERA (UKWIR/Environment Agency, 2002) state "There is no universally accepted standard specifying the increase and decreases in demand associated with dry and wet conditions. In the absence of a standard, forecasts of weather related variations in demand should have an empirical justification, for example, they might be based on an historical analysis of demand and relevant weather variables, or demand given weather conditions that occur '1 in x' years."

Guidelines state "The characterisation of supply e.g. during a wet/dry/normal year, is a simplification of reality. The distribution of supply is not necessarily such that a dry year implies the lowest deployable output. Instead, there could be effects that carry over from one year to a next, so that deployable output in a normal year could be low as a result of the preceding year being dry, or it could be reduced in an extremely wet year due to turbidity disabling sources."

NERA (UKWIR/Environment Agency, 2002) also state "Any given year could be categorised as wet, normal or dry, although there is an infinite number of possibilities ranging from the very wettest to the very driest years possible. For any given 'type' of year, say a dry year, there is a distribution of possible yields around the expected value. Thus, it would be possible to say that dry year yield is 120Ml/d with 95% confidence, but only 110Ml/d with 98% confidence, for example. Furthermore, for each 'type' of year, normal, wet or dry, there is a distribution of possible demand outcomes around the expected value, with this distribution driven by stochastic processes. In addition, over a number of years climate change will also influence demand."

Stage 1 of the NERA guidelines suggests that "Planners collect supply and demand detail for a range of weather conditions and for a number of critical periods. Critical periods are when there is the greatest stress on the ability of the water supply system to meet demands. Critical periods may be driven by peaks in demand, by troughs in deployable output, or by a combination of the two."

4.10.4 Methodology and limitations

Weather data for Northumbrian Water was acquired from the Met Office for the Durham, Esh Village and Copley weather stations. Northumbrian Water operates over a large area and as such the use of a mixed source of data would be the main limitation for this information as this may not deliver a correct and sufficient level of detail.

However it must be assumed that these measurements are representative of the region as a whole although there will be small regional differences.

Demand information, in the form of daily distribution input for Northumbrian Water was obtained and imported into spreadsheets for analysis.

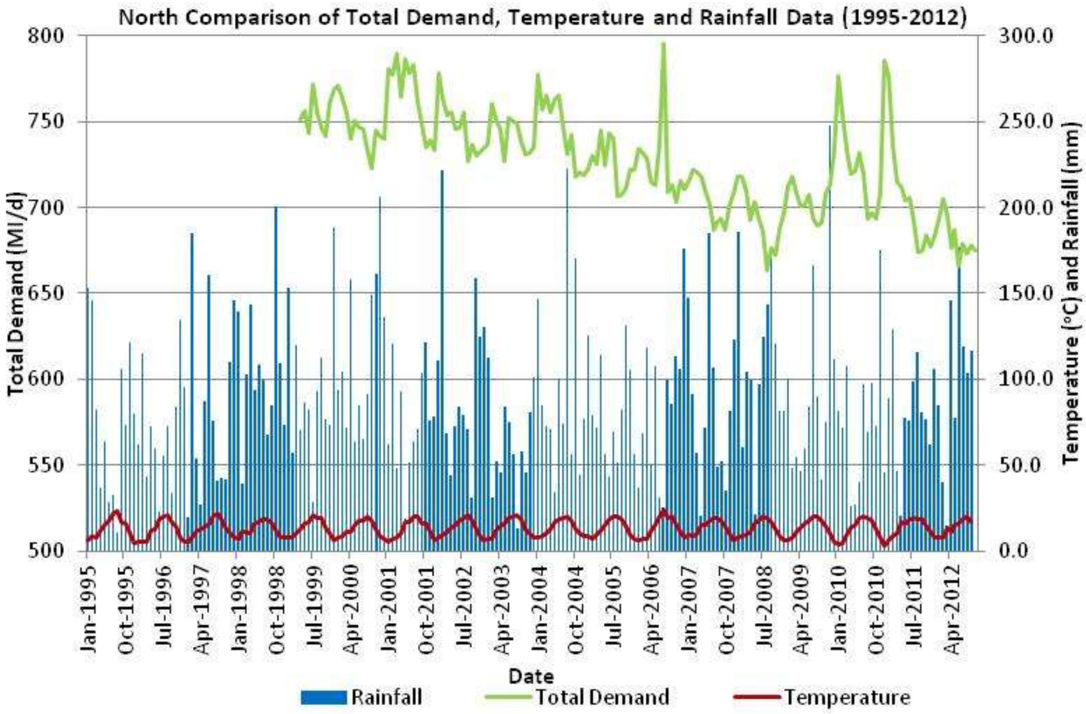
The period of analysis chosen was 1995-2012. This period would be affected by changes in conditions that have occurred over the last 10 years, such as increases in metering and improved leakage controls and provides an analysis period of 17 years. Key years of interest that comprise of dry year conditions were identified from analysis of weather data. The summaries of weather data for these years of specific interest were collated and a number of graphs were prepared as a basis for identifying patterns in demand and weather.

- Weather summaries for the specific years of interest.
- Peak period monthly average demand compared with daily maximum temperature and daily rainfall.
- Average monthly Distribution Input (DI) compared to the 10 year average DI (2001-2010).
- Average, maximum monthly temperature compared with 10 year and 30 year long term averages.
- Cumulative monthly rainfall compared with cumulative 10-year and 30 year average monthly rainfall.

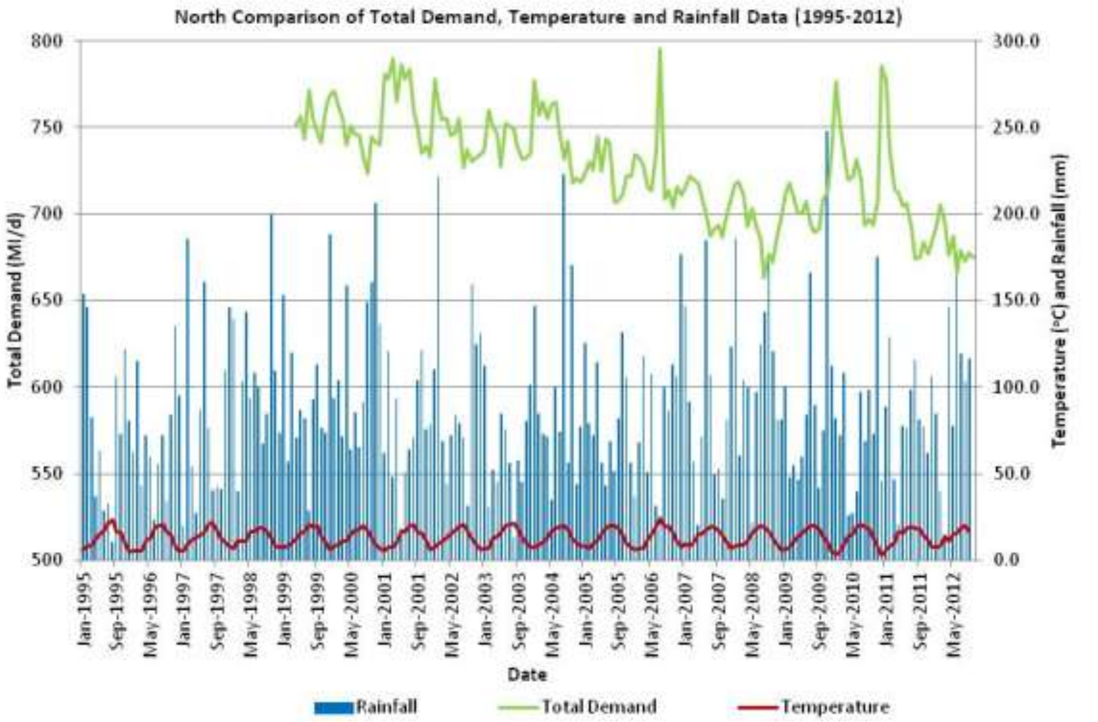
To determine the weighted average number of dry years that occur in a 10 year period, the count of the annual number of days greater than 25^{o}C and the yearly cumulative rainfall were combined to give the ‘dry years’ within the last 25 years. These were then averaged over 10 years to generate the weighted average.

Specific Years of Interest

The weather and demand data for the period 1995-2012 was carefully studied and a number of years identified for further comparisons. The weather summaries for these years are shown below as taken from the Met Office yearly summaries.



North Comparison of Total Demand, Temperature and Rainfall Data (1995-2012)
Total Demand (Ml/d)
Temperature (°C) and Rainfall (mm)
800
750
700
650
600
550
500
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Jan-1995
Oct-1995
Jul-1996
Apr-1997
Jan-1998
Oct-1998
Jul-1999
Apr-2000
Jan-2001
Oct-2001
Jul-2002
Apr-2003
Jan-2004
Oct-2004
Jul-2005
Apr-2006
Jan-2007
Oct-2007
Jul-2008
Apr-2009
Jan-2010
Oct-2010
Jul-2011
Apr-2012
Date
Rainfall
Total Demand
Temperature



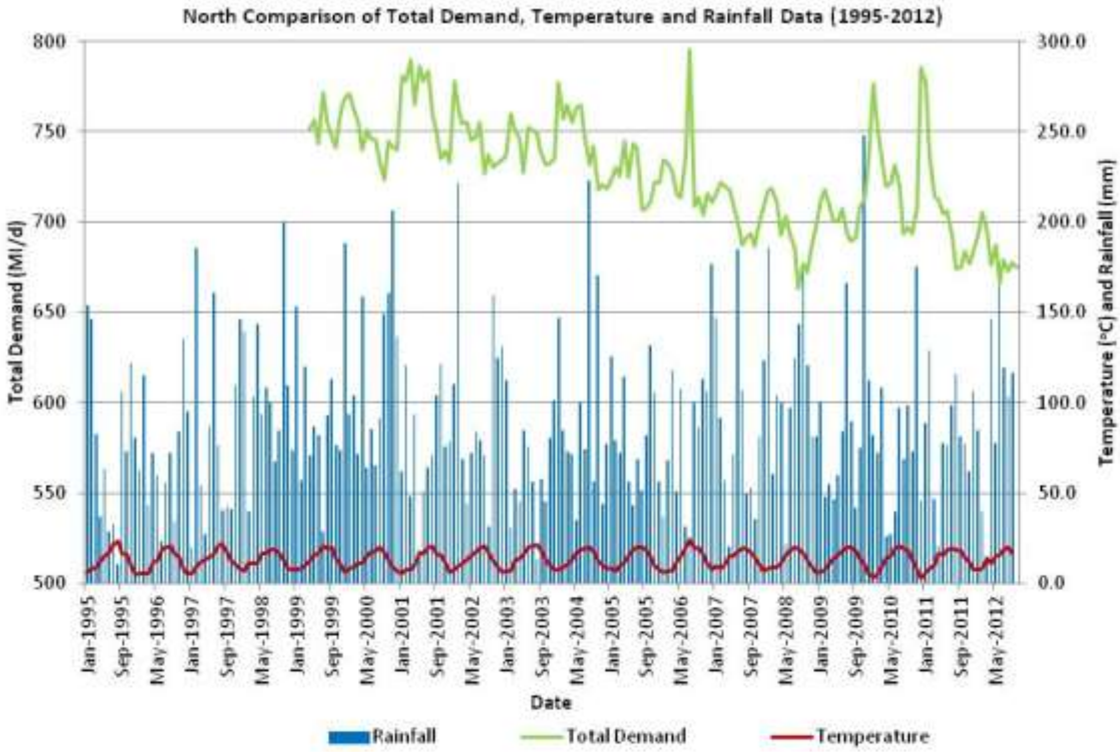


Figure **15** compares the daily total demand, maximum temperature and rainfall totals for the years 1995-2012, and highlights the years of interest within this period as determined by a combined high demand, high temperature and low rainfall.

Weather Summaries

1990: A very warm and dry year. Rainfall totals from the period since early March being one third of the average. The first four days in August saw a degree of high temperatures that exceeded any other hot spell in C20th with 3rd seeing the hottest temperatures on record.

1995: The hottest summer since 1976, one of the warmest years on record and one of the driest years since 1976.

1996: The driest year on record since records began in 1943.

2003: Very warm year with a mean maximum air temperature was 12.53^{o}C, 0.43^{o}C above the 1995-2012 average.

2005: Warm and very dry year. This year was at the midpoint of the dry-year spell of 2004-06 where from November 2004 to July 2006.

2006: A warm and dry year with July 2006 as the warmest month on record and 10% less rainfall than the 30 year mean and an exceptionally sunny year in the North East of England as well.

2010: The driest year since 2003. The period between January and June was particularly dry generally the driest period since 1953. However rainfall deficits were reduced by a very wet July and August in the North.

2011: A very warm April and October with record temperatures widely exceeding 25^{o}C during the heatwave in October.

Figures 2-14 summarise the relationships between demand and weather for three of the key specific years of interest.

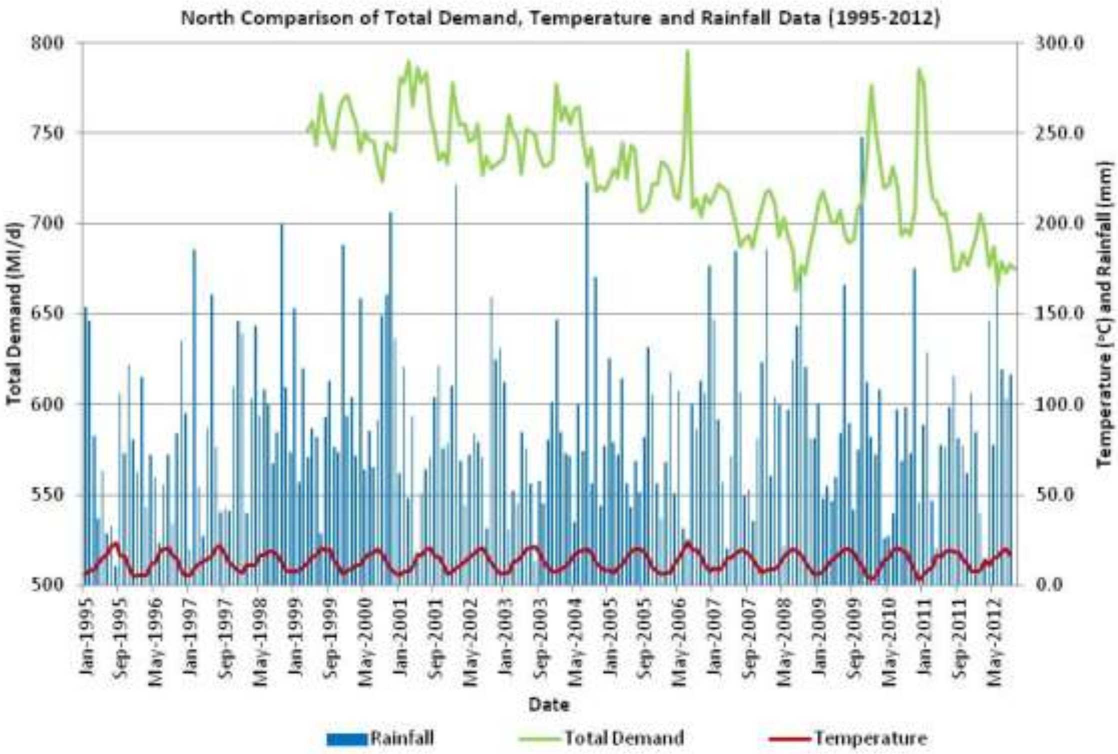


Figure 15: A comparison of daily total demand (green), daily maximum temperature (red) and daily total rainfall (blue) from 1995 until June 2012 for the Northern supply area. The identified periods of interest as determined by a high total demand and maximum temperature combined with a low total rainfall were 1995, 1996, 2003, 2005, 2006, 2010 and 2011.

1995:

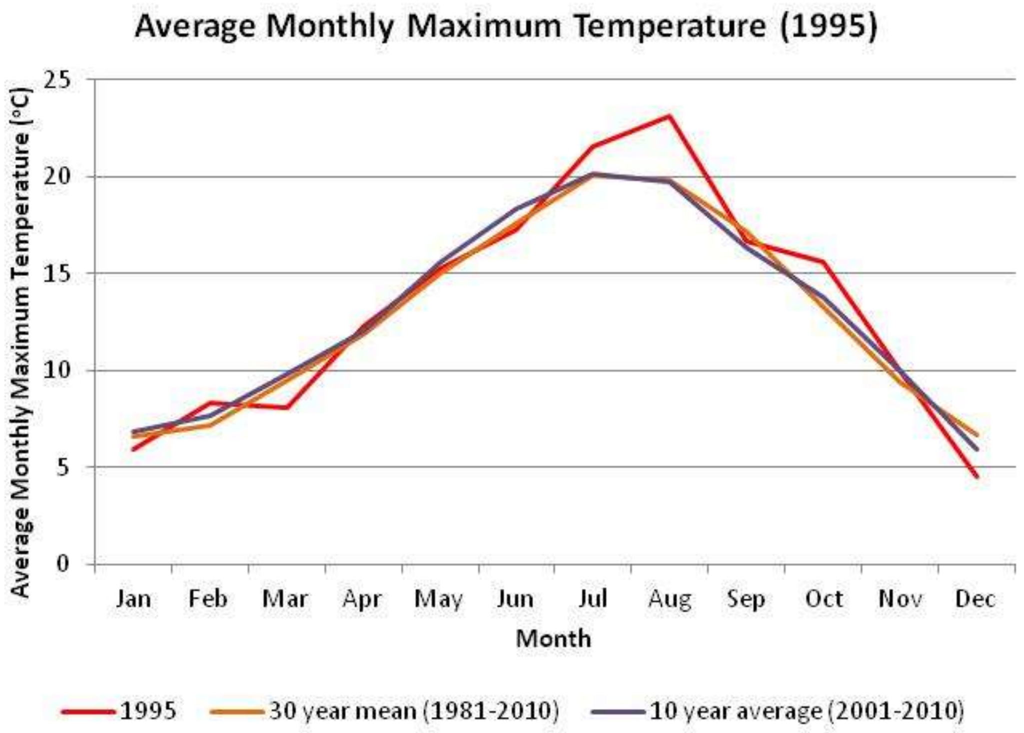


Figure 2: The average monthly temperature for 1995 compared to the 30 year and 10 year means. It shows 1995 temperatures where higher than average for the summer peak period.

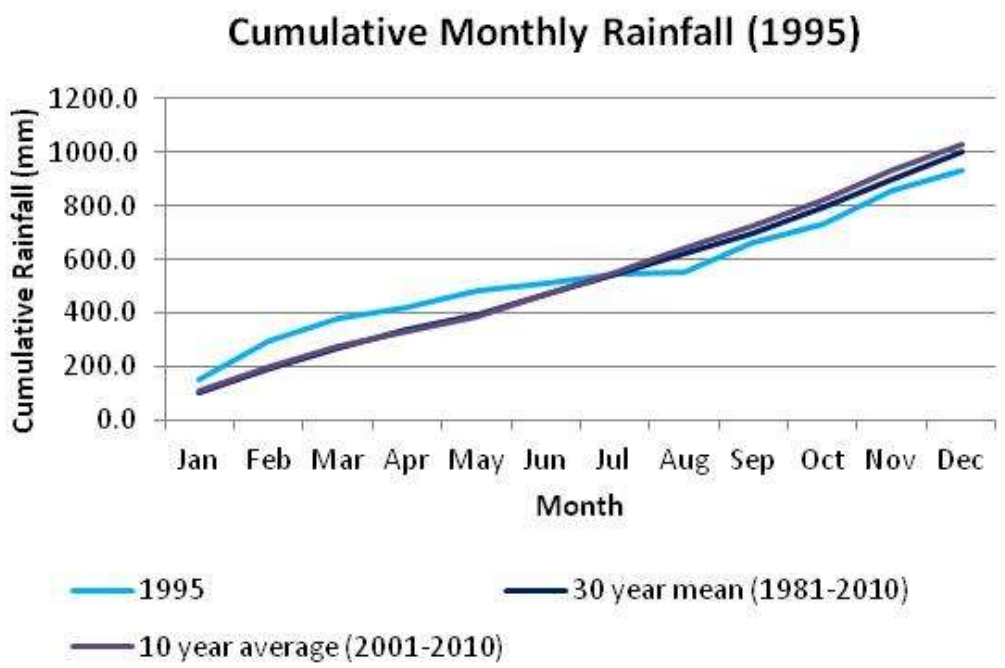


Figure 3: The cumulative monthly rainfall for 1995 compared to the 30 year and 10 year means. The graph demonstrates that the rainfall for 1995 is greater than the mean at the beginning of the year and close to the average monthly rainfall for the remainder of the year.

2003:

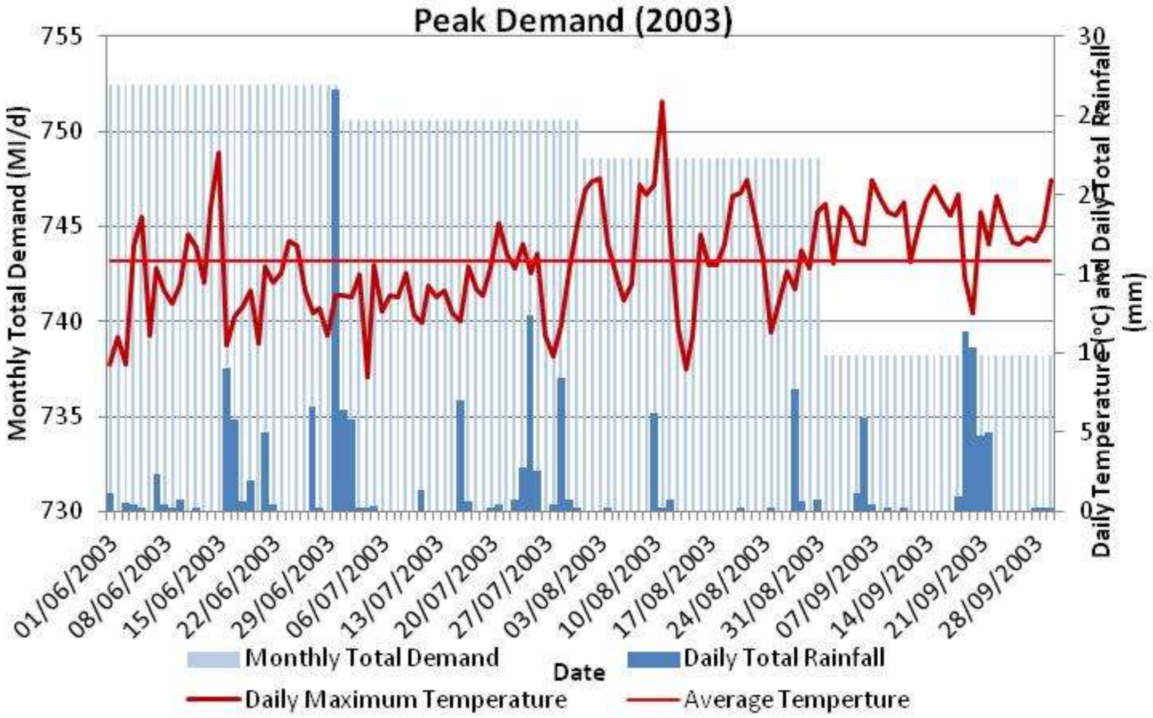


Figure 4: Peak period demand compared to maximum daily temperature and total daily rainfall for 2003.

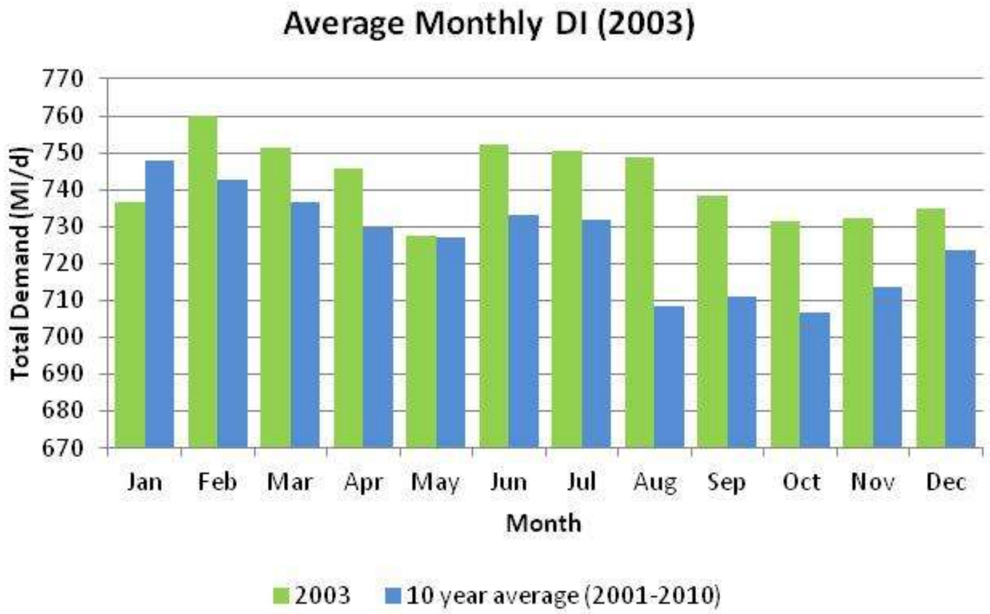


Figure 5: 2003 total demand compared to the 10 year average. For 10 months of the year the 2003 demand is higher than the 10 year average.

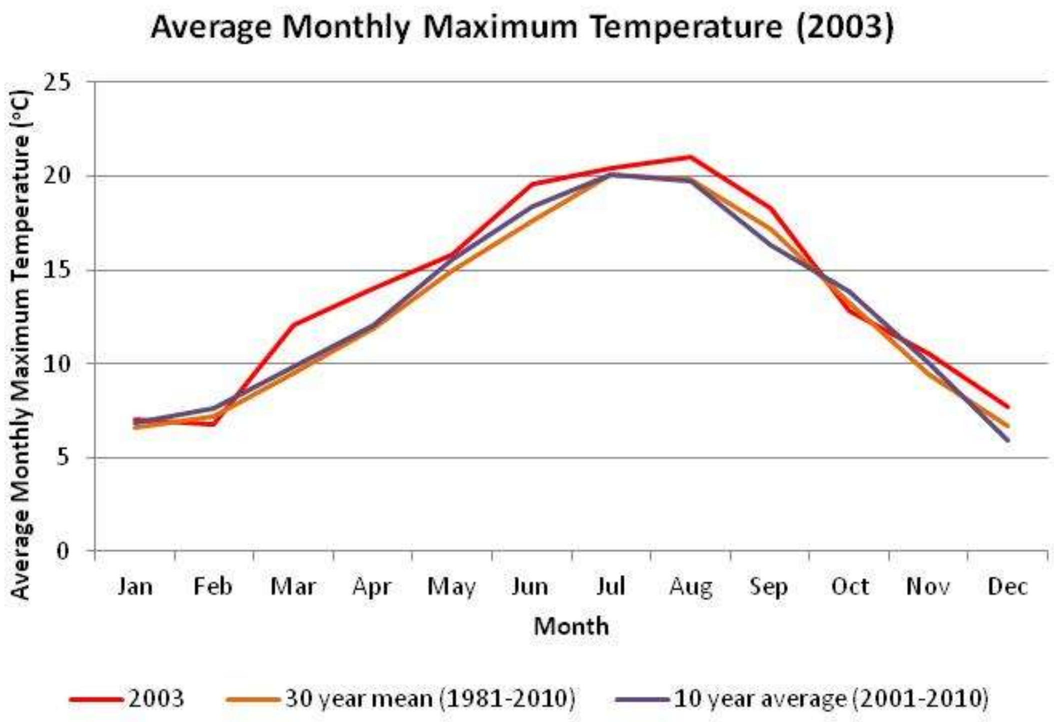


Figure 6: The average monthly temperature for 2003 compared to the 30 year and 10 year means. It shows 2003 temperatures where higher than the 30 year and 10 year means over the peak summer period.

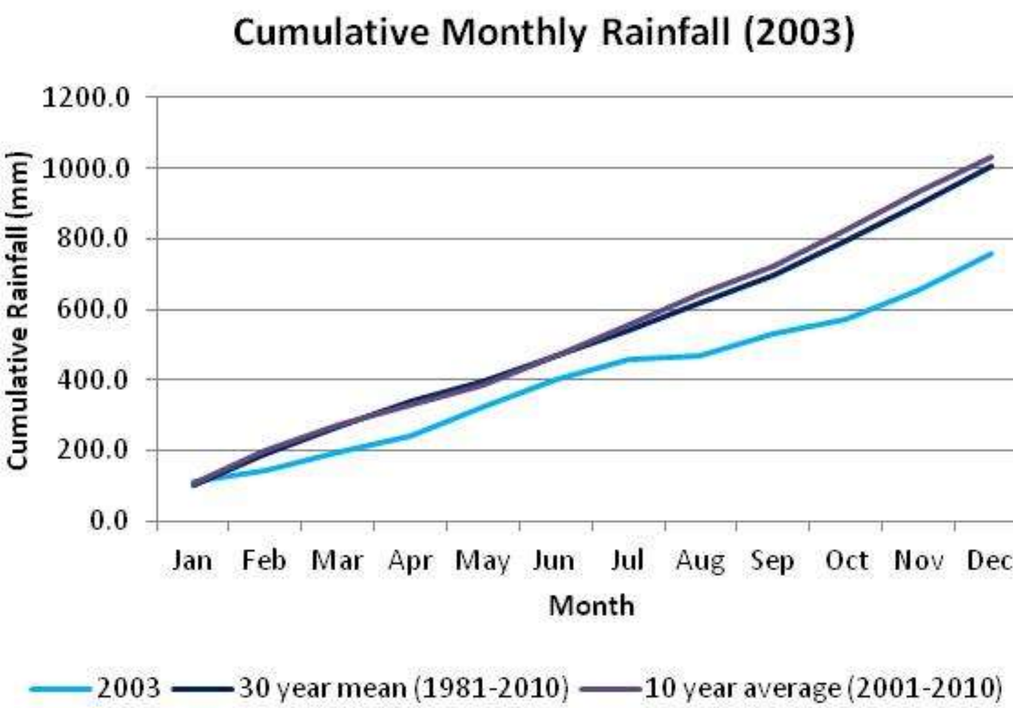


Figure 7: The cumulative monthly rainfall for 2003 compared to the 30 year and 10 year means. The graph shows clearly that rainfall for this year was much lower than the average.

2006:

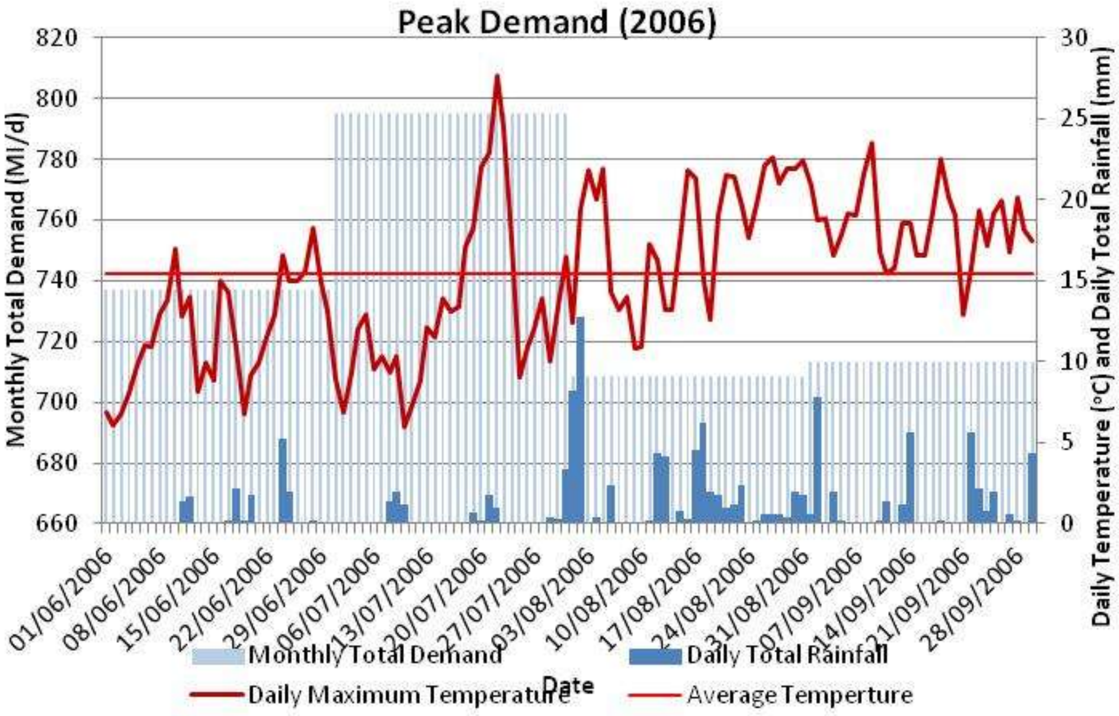


Figure 8: Peak period demand compared to maximum daily temperature and total daily rainfall for 2006.

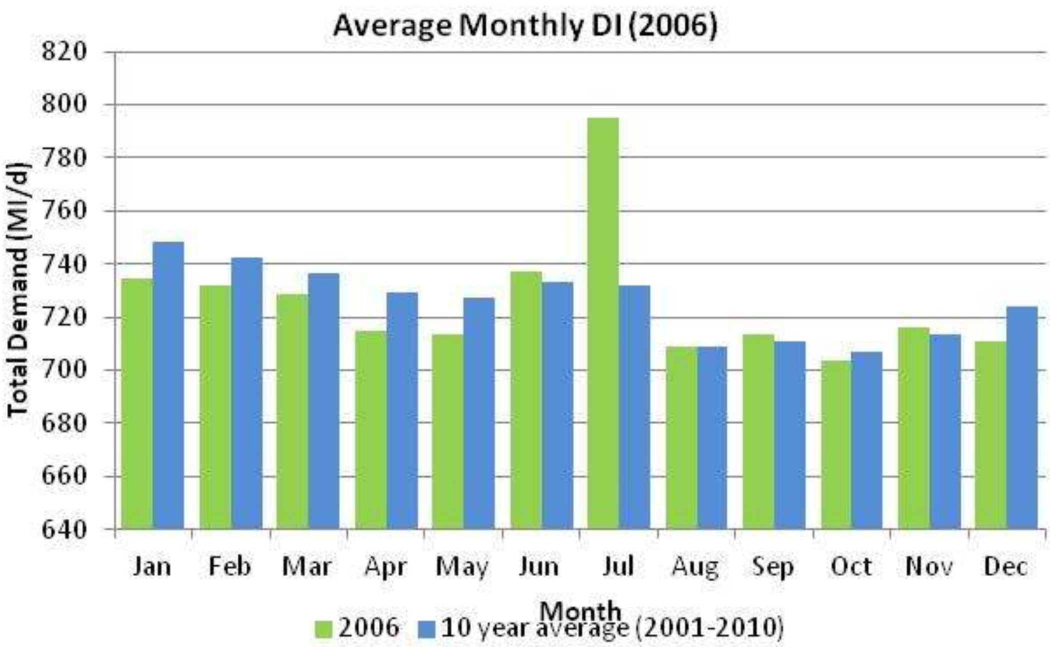


Figure 9: 2006 total demand compared to the 10 year average whereby 2006 demand tends to be slightly lower than the 10 year average demand apart from the month of July where demand is much higher.

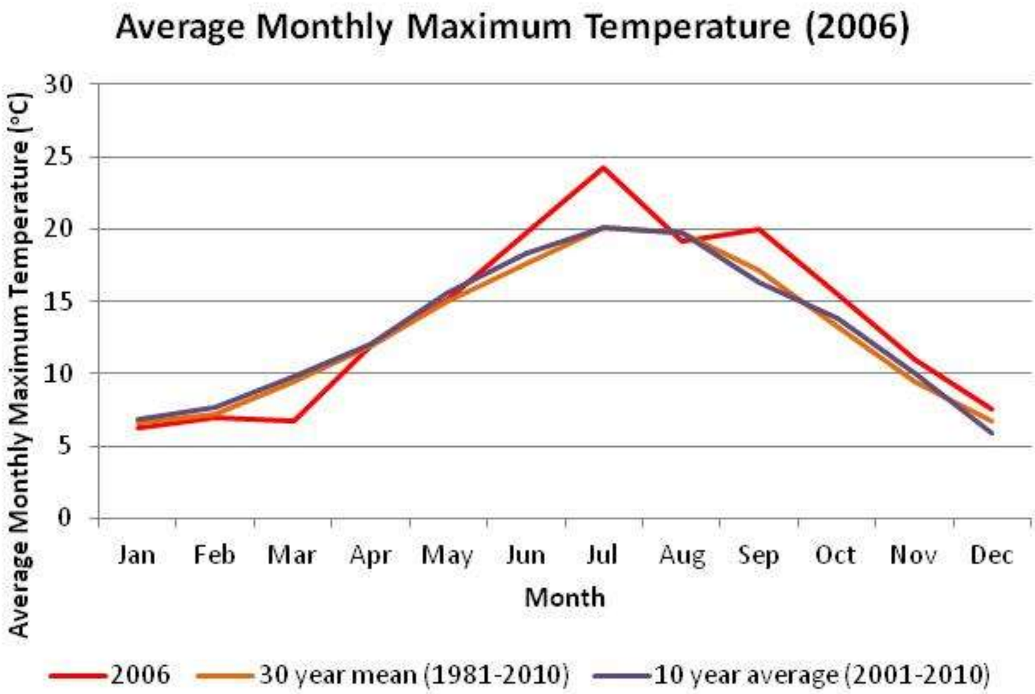


Figure 10: The average monthly temperature for 2006 compared to the 30 year and 10 year means. Average monthly temperature increases considerably in the months of June and July and stays above the 30 year mean for the rest of the year.

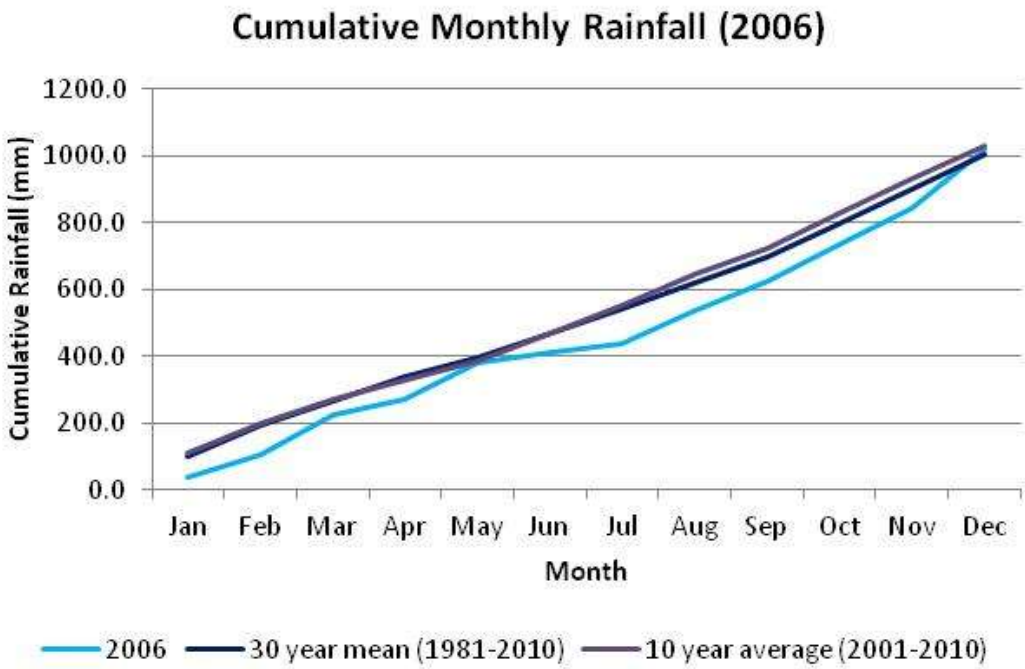


Figure 11: The cumulative monthly rainfall for 2006 compared to the 30 year and 10 year means. For eight months of the year cumulative rainfall stays below both 30 year and 10 year means.

4.10.5 Data Results

By undertaking analysis of the patterns in weather and demand data for the specific years of interest in Northumbrian Water, the following summary of the results for each these years are given.

1995: Across the country 1995 was classed as one of the warmest and driest years since 1976. Low rainfall and high temperatures occurred over the summer peak period. Summer temperatures were on average 1.03^{o}C higher than the 10 year mean (2001-2010) and cumulative rainfall for 1995 was 96mm less than the 10 year cumulative average.

1996: Cumulative rainfall was 153mm lower than the 30 year cumulative mean (1981-2010). Out of the eight specific years of interest, 1996 is classed as the second driest. Temperatures for this year were close to the 10 and 30 year means.

2003: The annual cumulative rainfall is the lowest recorded from the specific years of interest at 755.6mm, 73% of the 10 year average (2001-2010). Temperatures were seen to be above average for most of the year. The highest temperature of 30^{o}C was experienced on the 16th September. For ten months of the year the average monthly total demand is higher than the 10 year average.

2005: This year was at the mid-point of the dry-year spell of 2004-06 where from November 2004 to July 2006. Total demand is variable for 2005 with the months April, June and July showing the highest demand. Both temperature and rainfall matched closely to the 10 and 30 year averages.

2006: July 2006 was the warmest month on record with the average maximum temperature reaching 24.2^{o}C for the month, 4.1^{o}C higher than the 30 year mean (1981-2010). Average total demand peaked this month for the year and was 8% higher than the 10 year average (2001-2010). However the rest of the peak demand period saw an average total demand that was less than the 10 year average. Cumulative monthly rainfall was below the 10 and 30 year averages for the year.

2010: For most of the year rainfall was less than the 10 year and 30 year average however rainfall deficits were reduced by a very wet August. Temperatures remained closed to the 10 and 30 year averages with small peaks in April and June. Total demand was found to be below average to most months, except the winter months of January, February and December where demand was significantly higher than the 10 year average.

2011: Temperatures in 2011 were above the mean in the spring and autumn with the average maximum temperature in April 39% higher than the 30 year mean. 2011 total demand was below average for most of the year with the exception of January which was 3.9% higher than the 10 year average for that month. Rainfall for the year matched very closely to the 10 and 30 year means.

4.10.6 Data Analysis

In developing a dry year definition it is important that the approach should combine the summer demands with the all year round weather conditions. A simple approach was decided upon where the number of days in a year where the temperature rose above 25^{o}C was compared to the cumulative rainfall for that year.

Table 1 indicates the number of days where the maximum daily temperature exceeds 25^{o}C and the annual cumulative rainfall for the years 1987-2012 in Northumbrian Water.

The axes of the quadrant are drawn to include the dry years experienced in the 25 year historic record. Once constructed to account for the dry years, the days of temperature above 25 C and rainfall allow the other year's to fall into the appropriate section of the quadrant. Whilst the choice of number of days over 25 C and rainfall below 1025mm is pragmatically selected, use of these criteria does then aid in making the selection of dry, wet or normal year's far more objective than the previous subjective judgements that were made.

Graphic representation of this data shows that the position of the year in a specific quadrant defines the year as either a wet, normal or dry year. Please refer to figure 15. The quadrants for the graph were drawn where the number of days greater than 25^{o}C equalled 19 as this is regarded as a significantly higher than average number of warm days, and secondly that cumulative rainfall equalled 1025mm, as rainfall less than 1025mm would be considered as on the dry side of the average year in the Northumbrian Water supply region. Thus the 'dry' quadrant would be where the number of days greater than 25^{o}C exceeded 19 and the cumulative rainfall was below 1025mm and years placed within this quadrant would be defined as 'dry years'.

The results from this graphic representation approach show that the two years defined as dry years are 1995 and 2006.

Table 1: The number of days greater than 25°C and the annual cumulative rainfall for the years 1987-2012 in Northumbrian Water supply area. Cells highlighted in red indicate where the annual number of days greater than 25°C exceed 19 and cells shaded in blue signify yearly cumulative rainfall less than 1025mm.

Year	No. of days > 25oC	Cumulative Rainfall Jan-Dec (mm)
1987	2	1136.26
1988	1	1077.23
1989	11	745.79
1990	9	1057.59
1991	4	992.18
1992	4	939.39
1993	1	1071.07
1994	3	1046.26
1995	20	935.91
1996	5	851.16
1997	8	989.40
1998	2	1261.89
1999	5	1141.09
2000	3	1385.90
2001	2	906.68
2002	2	1196.59
2003	6	755.57
2004	2	1154.75
2005	8	985.07
2006	20	1018.75
2007	1	1021.17
2008	2	1295.08
2009	2	1125.71
2010	2	912.21
2011	3	978.68
2012	1	1278.3

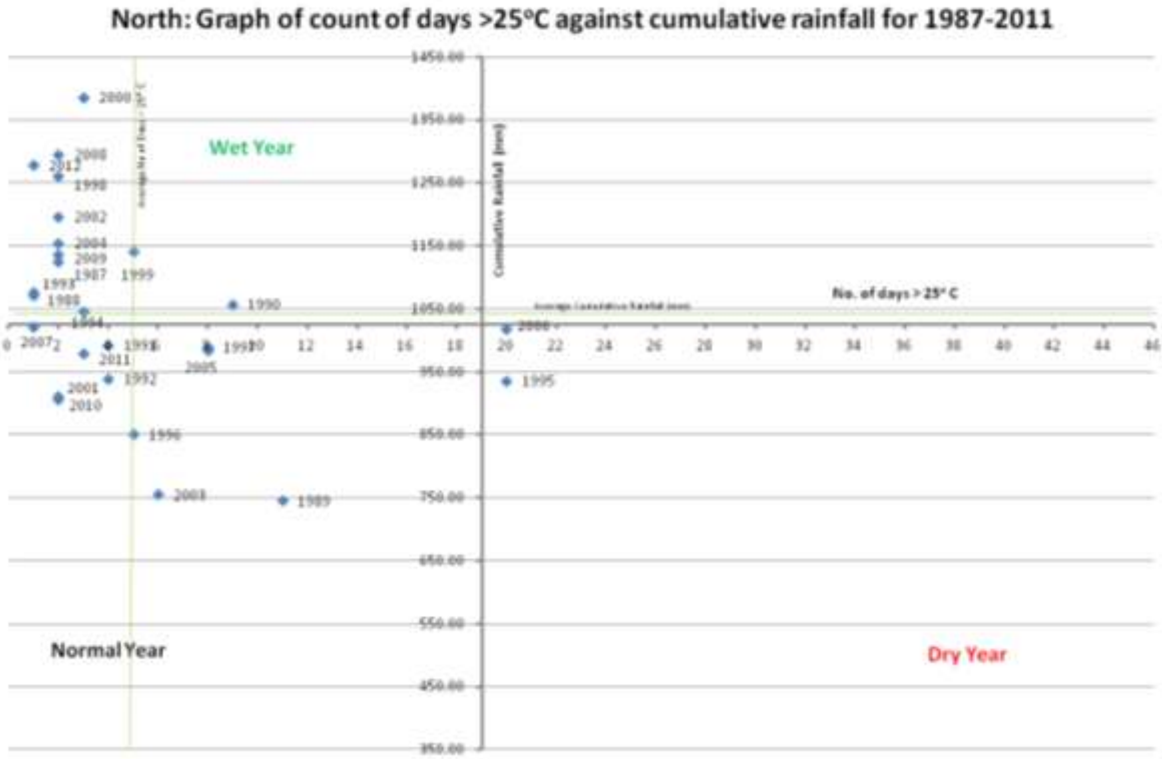


Figure 12: The annual number of days greater than 25°C and the annual cumulative rainfall for the years 1987-2012 in the Northumbrian region. The green lines indicate the average temperature and cumulative rainfall for the period 1987-2012 in Northumbria. The axes indicate the split in quadrants which are named either ‘wet’, ‘normal’ or ‘dry’ according to the likely conditions experienced. The graph shows that the years 1995 and 2006 are classed as dry years under this approach.

4.10.7 Weighted Average Dry Years

To determine the weighted average number of dry years that occur in a 10 year period the count of the annual number of days greater than 25^{o}C and the yearly cumulative rainfall were combined to give the ‘dry years’ within the last 25 years. As shown by figure 15 the years defined as dry years using this approach are 1995 and 2006. The numbers of dry years are averaged over 10 years to generate the weighted average. Table 2 shows the weighted average results.

Table 2: The weighted average dry year results for Northumbrian Water.

Region	Number of dry years from 1987-2012 (25 years)	Average number of dry years over 10 years	Weighted average: ‘dry’ years to ‘normal’ years
Northumbrian Water	2	0.8	0.8 : 9.2 8 % Dry : 92% Normal

4.10.8 Summary

Various statistical analyses are available to apply to weather data to clearly define the weather conditions for a particular year or seasons of that year but there seems to be no universally accepted method to employ.

The decision to take into account the two variables of cumulative rainfall and number of days with maximum temperatures greater than 25^{o}C offers a very simplistic but effective approach for the definition of a dry year. By using weighted average dry years it allows the forecast of the most likely frequency of dry years to normal years and thus the demand associated with them.

4.11 Dry Year Baseline Forecasts

The increases (from Normal Year to Dry Year) assumed for a Dry Year were applied to unmeasured and measured per capita consumptions, plus an increase for non-household consumption and leakage. These increases were reviewed in 2008 and it is now considered that only household demand is likely to increase in a Dry Year,

The household increases were based on analysis of the demands in 1995/96 and were modified for PR09 to take account of the changes to the base demands arising from metering.

The previous additional PCC has been applied to the 2006/7 populations to provide an estimate of the 1995/96 based Dry Year forecast for 2006/7. It is expected that as metering has increased, the current and future Dry Year impact on unmeasured households will have increased and the impact on measured households will have decreased.

This is because the measured households are increasingly composed on meter optants, who are low users of water and selectively metered customers who will be seeking to restrain their bills. The remaining unmeasured households will have a strong element of customers who have deliberately chosen not to opt for a meter, and are high users.

The increases have been calculated as follows:

Previous increase in meas PCC x 2006/7 meas population = 95/96 based additional Dry Year Meas Consumption for 2006/7

Previous increase in unmeas PCC x 2006/7 unmeas population = 95/96 based additional Dry Year Unmeas Consumption for 2006/7

Sum the above to give Total 95/96 based additional Dry Year Consumption for 2006/7.

Unmeas. Population x Revised PCC increase = 2006/7 rebased Dry Year Unmeas Consumption

2006/7 rebased Dry Year Unmeas Consumption - Total 95/96 based additional Dry Year Consumption for 2006/7, divided by Meas population gives 2006/7 rebased Dry Year Meas Consumption

The increases are as follows:

	Unmeas PCC l/hd/d	Meas PCC l/hd/d
NW	3.1	1.24

5.0 BASELINE WATER EFFICIENCY, METERING & LEAKAGE CONTROL

5.1 Water Efficiency Overview

Northumbrian Water (NWL) has continues to develop and refine its water efficiency programme to ensure that it delivers initiatives that are both cost effective and achieve genuine water savings. One of our key developments in AMP5 has been the introduction of our home audit programme for domestic customers. These initiatives are based on the methods developed by our southern operating company, Essex and Suffolk Water (ESW), to reduce water consumption, develop analysis techniques, improve the industry's understanding of water use behaviour and evaluate the approach.

Through the implementation of these techniques, NWL is beginning to develop its evidence base for water efficiency. This evidence together with evidence based on quantifiable and measured water savings collected by ESW, has been included in our baseline demand forecast. NWL will continue improve its evidence by monitoring results of our projects to determine actual savings, assess their sustainability and carry out customer surveys to gauge the effectiveness of our approach.

5.2 Progress in AMP5 and Current Strategy

5.2.1 Water Efficiency Targets

The Ofwat target for water efficiency, as introduced in April 2010, was to save one litre per property day for each of the five years in AMP5 (2010/11 – 2014/15). For NWL this target equates to 1.12 Ml/d. Through a combination of domestic retrofit audit projects and offering of water saving kits upon request, NWL has exceeded Ofwat's annual water efficiency target each year since its introduction, as shown in table 5.2.1.1

Measure	2010-11	2011-12	2012-13
Base level target (Ml/d)	1.12	1.12	1.12
Performance (Ml/d)	1.71	1.16	1.13*
Cumulative assumed savings (Ml/d)	1.71	2.87	3.90*
Carried forward (Ml/d)	0.59	0.63	0.64
Target met	Yes	Yes	Yes

Table 5.2.1-1: Northumbrian Water's performance against the Ofwat water efficiency target. * Note: 2012/13 figures based on estimated performance against target.

5.2.2 Retrofit audit projects

NWL began to offer home water audits to our domestic customers in 2010 based on the methodology developed by ESW. These projects involve a plumber attending an appointment at a customer's property to fit and/or deliver water-saving products that will improve the efficiency of the home. To promote behaviour change, the customer is engaged in conversation by the plumber and encouraged to spend time with them while the products are fitted. This allows the plumber to explain how the products work, but also ensures that behaviour change messages are conveyed effectively.

The table below summarises the retrofit audit projects carried out in since 2010. More information about each of these projects is described in the sections that follow.

Project	Area	Year	No. audits	Average water saving (l/prop/d)
Water Saving Project	North Tyneside	2010/11	2012	29.10
ecoFIT trial	Durham	2011/12	386	55.0
ecoFIT	Hougton Le Spring, Wearside	2012/13	2003	74.9

Table 5.2.2: Key results of retrofit projects carried out since 2010. * Based on assumed savings.

5.2.2.1 Water Saving Project

In 2010/11 NWL carried out the first water efficiency retrofit project in the northeast of England. 20,000 customers across North Tyneside and Whitley Bay were invited to take part in the project with an introductory letter and project leaflet. It explained that a qualified plumber would attend their property to fit water efficient devices free of charge. The project was carried out by contractors Mouchel Ltd.

In total 2012 customers had water efficiency audits at their homes and water saving devices fitted. As well as fitting the products for the customers, the plumbers also took the customers around their homes to show them where they could save water by using it more wisely.

The table below summarises the number of devices that were fitted during the project.

Product	Quantity Fitted
ecoBETA	221
Save-a-Flush	891
Aerated Shower head	981
Eco-Flow Tap Spray	228
Dripping Tap Repairs	75
Hose gun	1554
Water butt	1443

Table 5.2.2.1-1: List of products and services fitted and/or delivered.

The total project saving, based on the Ofwat assumptions, was 58,576.40 l/day which equates to 29.10 l/prop/day.
5.2.2.2 EcoFIt Trial – Are you EcoFit?

Following success of this initiative in our southern operating area, NWL trailed, ecoFIT, a new type of home water audit. ecoFIT is a successful retrofit programme that aims to maximise water savings at minimum cost by offering customers the most water efficient devices. The project is centred on the conversion of a single flush siphon toilet into a dual flush toilet by installing an ecoBETA dual flush retrofit device. Only customers with toilet suitable for an ecoBETA to be installed qualified for a full retrofit audit. Those who did not were encouraged to request water saving devices from the NWL website.

Customers that were invited to take part in the project received an invitation pack, explanatory factsheet and reply envelope. The factsheet contained information about the products on offer including the potential to save water, money and carbon. It also described the limitations of the products to help screen those customers that would not be eligible to take part. The products that were offered to customers as part of this initiative are listed in the table below.

Products to be fitted	Products to be delivered
ecoBETA dual flush device	Shower timer
Save-a-Flush	Water storing crystals
Tap inserts	Water stick
Eco-Flow Tap Spray	Trigger hose gun
Aerated shower head	Water butt
Re-washering dripping taps	

Table 5.2.2-1: List of products and services fitted and/or delivered though the ecoFIT trail.

Just over 380 domestic customers in Durham agreed to take part in the trial in 2011/12. Each property saved on average 55 l/prop/day, based on Ofwat assumptions, or 21,172 litres/day in total. The table below summarises the number of products that were fitted during the project.

Product	Quantity Fitted
ecoBETA	285
Save-a-Flush	10
Aerated Shower head	129
Eco-Flow Tap Spray	180
Tap Inserts	77

Table 5.2.2-2: Summary of products fitted and/or delivered though the ecoFIT trail.

5.2.2.2 EcoFIT Wearside – Are you EcoFIT?

Based on the success of the trial, NWL wrote to 15,000 customers in Houghton Le Spring, Wearside in autumn 2012 offering them the opportunity to have a qualified plumber attend their property to convert their existing single flush toilet to a dual flush toilet.

Mouchel was appointed to deliver the ecoFIT programme in Houghton Le Spring, Wearside. They were responsible for recruiting customers, delivering and installing water saving products and collecting consumption data. The flow diagram below shows the process that NWL follow throughout home audit.

Figure 5.2.2.3-1: Process flow demonstrating the ecoFIT methodology.

During the appointment with the customer, the plumber offered to install other water saving devices for the home and garden (listed in table 5.2.2.3.2). As in previous projects, the customer was encouraged to accompany the plumber during the audit so that the plumber could provide advice and literature on how to save water as well as fully explaining the purpose of any device and its mode of savings.

Initially, uptake by customers was slow (less than a 1000 audits) until NWL worked in partnership with a registered social landlord. NWL and the landlord wrote a joint letter to provide further information about the project and encourage them to take part. The project was also promoted by local housing officers. This resulted in 2,003 customers participating in the project with over 15,000 products being delivered and/or installed. This represents a 13.3% project take-up by customers. Of those customers audited, 93% had at least one ecoBETA fitted.

Despite its success, relatively few complete sets of meter reads were obtained due to bad weather and problems on 'thunder Thursday' hampering attempts by the plumbers to obtain meter read. The table below summarises the key results from the project:

Key Results	
Total customers invited to participate	15,134
Applications received	2,006
Audits completed	2,003
Product	**Quantity Fitted**
ecoBETA	2163
Save-a-Flush	214
Aerated Shower head	577
Shower inline regulator	72
Tap inserts	2927
Eco-Flow Tap Spray	870
Shower timer	1705
Hose gun	1936
Water storing crystals	1810
Water butt (190l)	1438
Water butt (100l)	143

Table 5.2.3-3: Summary results from ecoFIT retrofit project.

Working in partnership with registered social landlords proved to be a highly successful. In total the project saved over 150,000 litres/day with each property achieving an assumed saving of 75 litre per property per day. NWL plan to adopt this approach in the remainder of AMP5 and throughout AMP6 to maximise water savings, but at least cost.

5.2.3 Water Saving Kits

In 2010 NWL began to offer domestic customers a free water saving kit to provide them with ‘easy-to-install’ products and information about saving water in and around the home. The kit has proved a highly effective tool to educate customers about how they can improve their and make them more water efficient. The water saving kit includes a five-minute shower timer, Save-a-Flush, in-line shower regulator, twin-pack of tap inserts, universal plug and an information leaflet/questionnaire.

Distribution of water saving kits has made a significant contribution to our achievement of our water efficiency targets in AMP5. Since 2010, 46,796 have been distributed to customers, upon request broken down as follows:

Year	No. water saving kits requested
2010/11	16,079
2011/12	18,074
2012/13	12,643

Table 5.2.5-1: Number of water saving kits distributed annually to customers upon request. * Note that 2012/13 figures represent the number of water saving kits distributed up to and including 13th March 2013.

NWL also offer customers the opportunity to request a selection of products for their home and garden in the form of a bespoke kit. When requesting water-saving products from the NWL website, customers have the option of requesting a ‘standard’ water saving kit or a ‘selection of products’.

NWL has exploited a wide range of advertising routes in order to ensure the water saving kits have been made available to all customers. A key initiatives included offering water saving kits at meter optant surveys or at appointments attended by our distribution technicians. Our most successful method of distributing the water saving kit is at public events. Recent examples include events to promote sustainability with the NHS, Nestle and Sunderland University climate change week.. NWL has also used other advertising routes to promote water saving kits such as radio, articles in newspapers and magazines, internal staff campaigns or promotions via the NWL website.

5.2.4 Behavioural change

Behaviour change underpins all of our water efficiency projects. Influencing customer behaviour, through informing customers how much water they use, how they use water and challenging the habitual nature in which they use water, in turn delivers quantifiable and sustainable water savings.

5.2.4.1 Little Green Riding Hood

NWL recognise the importance of stopping bad habits from developing at an early age and that working with younger generations is key to affecting sustained behaviour change.

In 2010 a theatre company called Fame Factory Spotlight approached NWL to sponsor (with other companies) a ‘green’ themed pantomime for schools. NWL took the opportunity to fully sponsor the pantomime and therefore influence the script writing to include lots of water saving messages.

The Little Green Riding Hood programme visits schools and alongside a brilliantly fun and interactive pantomime about water efficiency, the pupils also have a workshop about good and bad water habits which reinforces the water saving messages.

To date, over 50,000 primary school pupils have taken part in the initiative across the north east of England. Based on Ofwat’s guidance for calculating the water savings achieved through behaviour change initiatives, the total water saving achieved through the Little Green Riding Hood educational programme is 0.86 Ml/day.

5.2.5 Non-Household Customers

5.2.5.1 Schools Audit

26 schools in the Gateshead, Newcastle and Sunderland Council areas were audited in February 2011 as part of a pilot schools project. These schools were chosen by their respective councils to take part in the project and all received water saving products as a result of their audits. Contractors, Aqualogic WC Ltd. carried out this work. Water saving products on offer included tap inserts, Save-a-flushes, ecoBETAs, and urinal controls. Meter readings were taken 3 weeks prior to the audit, on the date of audit and 3 weeks after audit. The total reported water saving for the project is 14,464.06 l/day which equates to 556.31 l/school/day.

5.2.6 Information and Events

5.2.6.1 Source Magazine and Billing Leaflets

The billing leaflet and NWL's annual Source Magazine (distributed to every customer) provide an ideal means of advertising water saving kits, providing advice and information and also advertising specific water-saving promotions.

5.2.6.2 Water Efficiency Evidence Base

NWL contributes to the Water Efficiency Evidence Base Collaborative Fund; a fund that aims to expand the water efficiency evidence base through collaborative projects.

5.2.7 Education Strategy

The key focus of our education policy continues to be to educate young people and develop a more water aware generation of customers for the future.

Water in the school website

Launched in January 2002 this was a joint venture between 13 water companies, Water UK and WaterAid. Located at www.waterintheschool.co.uk, the website provides everything needed to set up and run a water conservation project in school.

The Water in the Schools website has been very well received. and we have built on this success by part sponsoring and being actively involved in the development of a new educational website looking at Water in the Home (and garden). The site (www.waterfamily.co.uk) has a completely different look and feel to Water in the School, which was mainly designed as a resource for the teacher.

The new site is very much child orientated (who influence their parents) and is very interactive and a lot of fun. It was officially launched on 15th April 2005. We also have copies of the game on CD-ROM and have been distributing these free of charge on request by schools.

Fact sheets
A series of fact sheets have been developed focusing on the following topics; water resources, Water for Health, the water cycle, water safety, reservoirs and treatment. The fact sheets are offered to schools and customers upon request and as part of school talks.

The H_2O gang
The H_2O Gang was developed by NWL to help primary school children learn about the importance of water. The H_20 Gang - Karl, Kelly, Jermaine, Bethany and Splash, battle with the evil foes of wasting water, to fight dehydration and to explain why water is so important. Their arch enemies are Dr Dry and his side kick Drip whose sole desire is to rule the world by stealing or wasting water. The H_2O gang visit schools to act a cartoon story to the children.

5.2.8 Water Efficiency Strategy for Remainder of AMP5

NWL will continue to deliver projects and initiatives similar to those documented in the preceding sections for the remainder of AMP5. Home audit retrofit projects will be carried on an annual basis but in partnership with other organisations to increase promotion and uptake by customers. The scale of these projects will be subject to adequate funding being available. NWL will also begin to pilot the non-household retrofit projects with local authorities and other commercial customers.

NWL will also continue other initiatives such as Little Green Riding Hood and distribution of our water saving kits at public events and via the website. Further information on the pilot projects that are planned is described in the section that follow.

5.2.8.1 Water Efficiency for Business – Pilot project with WRAP

NWL has partnered with WRAP, leading experts in resource efficiency, to offer a free water efficiency support package to non household customers in Berwick upon Tweed. The Rippleffect provides business with a straightforward and structured approach to help: understand how much water business uses, identify simple ways to start saving water and money, measure the water and cost savings that you have made, and learn about 'quick win' water saving devices.

5.2.8.2 Water efficiency audits for the Elderly Persons Sheltered Housing

Before the end of AMP5, NWL plans to embark on a partnership project with Riverside ECHG to audit 190 sheltered housing units and communal areas across the north east of England. Working together with Riverside ECHG, NWL will use different approaches to engage with the residents to encourage participating. Initially, NWL and Riverside ECHG will write to residents to invite them to take part and receive a free home water audit, but will also engage with residents through the use of small focus groups to help them understand their water use and how they can make simple changes to save water. It is estimated this project will achieve 0.001 Ml/d assuming that each property saves on average 50 litre per property per day.

5.2.8.3 Pilot partnership project with local authorities

Before the end of AMP5, NWL plans to work in partnership with two or three local authorities to audit and install water efficiency devices on four types of building: an office, residential care home, a school, leisure facility or public toilet. This is a two year pilot that will not only seek to audit and retrofit buildings owned by local authorities, but will also train maintenance staff on how to install water efficiency devices. The aim of this project is to help identify a long-term, cost effective approach for working with local authorities to reduce consumption of their buildings. It is estimated this project will achieve 0.045 Ml/d saving assuming per local authority based on savings achieved by ESW for piloting non-household retrofit with local authorities.

5.2.8.4 Schools Audit

NWL plans to continue to audit 20 schools across Northumberland and North Tyneside. Schools will be chosen by their respective councils to take part in the project and all received water saving products as a result of their audits. NWL will appoint a contractor to deliver this project in summer 2013. It is estimated this project will achieve 0.011 Ml/d saving.

5.3 Water Efficiency Strategy for AMP6

NWL has considered the Governments proposed water efficiency policies together with Defra's Water White paper. NWL plans to continue to deliver a range of initiatives that are described above and continue its strategy of carrying out initiatives with a strong focus on customer engagement to promote behaviour change, but also, achieve genuine water savings through the installation and delivery of water saving devices. NWL intends to carry out the following initiatives between 2015/16 and 2019/20:

Home Audit Programme

NWL plans to continue to offer home audits for domestic customers based on the approach developed for ecoFIT, but it plans to deliver these projects in partnership with local authorities, registered social housing providers and local groups involved in community engagement. Assuming 2,000 ecoFIT retrofit audits are completed annually, it is assumed that each property will achieve a minimum of 44 litres per property per day or 0.066 Ml/d.

Water saving kits

NWL will continue to offer customers the opportunity to request water saving products either as a standard or bespoke water saving kit. The products and devices will remain similar to those offered at present (shower timer, in-line shower regulator, Save-a-Flush, tap inserts, trigger hose gun, water saving crystals, water stick and information leaflet). It is forecast that 12,000 water saving kits will be delivered each year based on 2012/13 figures resulting in in a water saving of approximately 0.184 Ml/d.

Schools Water Audit

NWL plans to continue to offer schools across the north east of England free water audits. It assumes that it will audit 20 schools per annum achieving an approximate savings of 0.011 Ml/d.

Non household retrofit with local authorities

Assuming that the outcome of the pilot project with local authorities is successful, NWL plans to continue to develop partnerships with local authorities to audit and install water efficiency devices on four types of building: an office, residential care home, a school, leisure facility or public toilet. It is estimated this project will achieve 0.045 Ml/d saving assuming per local authority based on savings achieved by ESW for piloting non-household retrofit with local authorities.

Little Green Riding Hood

Due to the success of the educational play and workshop, the company intends to continue offering the programme to approximately 100 schools per annum in AMP6. This will be possible by engaging with schools that have yet to have been offered the programme as well as approaching those schools that have taken part in the past but now have a new intake of pupils. It is estimated that the water savings of 0.045 Ml/d will be achieved per annum.

Partnership working

NWL is exploring the scope to work with organizations such as Warm Zone and Go Warm to install water efficiency devices when these organizations visit a customer to install energy efficiency devices. This would include the ecobeta, water efficient showerhead, tap inserts, ecoflow tap adaptor and possibly, the combisave devise. Discussions are ongoing, but it is hoped that a pilot could take place in AMP6.

NWL estimate that implementation of the above demand management initiatives will result in water savings of 0.32 Ml/day. 0.295 Ml/d will be achieved through the delivery of water efficiency activity with households and 0.25 Ml/d will be saved from activity with non-household customers. The estimated water savings are based on evidence from NWL and EWS projects. The water efficiency savings have been factored into the company's baseline demand forecasts and applied cumulatively from 2011/12 to the end of the planning horizon.

5.4 Metering

5.4.1 Background

The Northumbrian Water area has a large surplus of supply over demand for water in its Kielder WRZ. The area is classed as not seriously water stressed, therefore compulsory metering cannot be considered. In the much smaller Berwick WRZ there is a large uncertainty as to the sustainable volume of water available to the company. During this coming AMP period studies will be undertaken to more fully understand the water resource situation of the area. As such the metering strategy which will currently be taken forward applies to the whole of Northumbrian water. Dependant on the outcome of the studies into water availability in the Berwick WRZ, a different meter strategy may be required for this area at PR19, (2020 onwards).

NW started the year 2000 with a very low level of meter penetration. Up until this time, when the Water Act then required a water company to provide a meter free of charge to any domestic customer who requested one (and it was not unduly expensive for the company to meter the property), a customer wanting a meter had to pay the full installation cost. This led to very few requests to have a meter installed. Only new properties built after 1989 were metered as there were no longer new rateable values being set and no way of charging new homes apart from by measured volume. However, once free optant meters became available, there was a pent up demand for them with high numbers of requests for a free meter between 2000 and 2010. By the start of 2010 (AMP5) over 20% of domestic properties were metered.

For the AMP5 period (2010 – 2015) we had forecast new optant meter installations of 14,000 per annum. This is looking to be close to the actual numbers installed of 70,000 over the 5 years. This will give a meter penetration of approximately 30% by the end of 2014/15.

5.4.2 Customer opinion on metering

Customer attitudes towards metering appear to be mixed to favourable. Quantitative research conducted in 2011 gives an inconclusive picture with 53% of NW customers stating they felt positive towards metering as a means of charging. A more positive attitude is apparent across three programs of qualitative research conducted for PR09 and PR14. Favourability towards metering primarily seems to be concerned with three factors.

- On a personal level some respondents believe that the installation of a water meter would bring their water bill down; *"I want to get a meter because I think my bill is too much"* (NW customer in 2012).
- Secondly, on a societal level respondents have suggested that metering is the fairest method of charging for water consumption across customers.
- A third factor cited in support of metering is that metered systems make customers more aware of how much water they use, and so encourage water saving behaviour.

This is supported by qualitative evidence that metered customers seem more aware of their bill amount than non metered customers.

Despite this positivity towards metering there is evidence that customers are against enforced metering. Quantitative work conducted in 2011 showed that 82% of NW customers were against enforced metering. Qualitative research conducted in 2012 indicates why this is the case. The respondents were against enforced metering on two grounds;

- Firstly that it restricts consumer choice, which is considered to be unacceptable.
- Secondly concerns were expressed that bills would increase following the installation of a meter either instantaneously or as a result of unanticipated increases to the household size; *"They would cost more money when you have children" (View of NW customer in 2011)).*

This is supported by two programs of recent qualitative research in May 2012 and December 2012 for NW which suggests s a customer requirement for education around metering and potential bill savings.

Whilst customers expressed these views they were probably envisaging a compulsory metering programme. We rarely receive inquires about removing a meter from a metered property that a customer moves into, either a new build or where the previous owner had opted for a meter.

Removal of a meter (apart from within 1 year of someone opting for a meter) will not be considered. Under current legislation we cannot seek powers to compulsorily meter any of NW customer's.

What we can do under existing powers is selectively meter customers either because they are big water users or when the occupant of a previously unmeasured property changes. It is the later that we would propose introducing after 2025 as the metering of large water users already occurs.

Our experience in our Southern operating area and the experience of a number of other companies that have introduced selective metering on change of occupant, shows this method of metering is accepted by customers. Moving to a property that already has a meter, either because it is post 1989, a previous owner has opted for a meter or because we install one prior to any water bill being received, rarely results in customer complaint. By 2025 over 45% of properties will be metered anyway therefore customers moving to a different property will already have an almost 50% chance of going into a metered property.

5.4.3 Purpose of metering properties

A number of diverse reasons drive the move from an unmeasured water supply, where the occupant is charged according to the rateable value of the property, to a metered supply. In new properties they are metered as the only way of charging for water and sewage. Customer's who live in low occupancy premises with a high rateable value, opt to have a meter to lower their water and sewage bills. Other customers who opt perceive themselves to be low water users and again would financially benefit from paying by meter. Environmentally meters are seen to be beneficial by lowering the demand for water. This uses the principle that if you pay for what you use, you are more likely to use less, thus leaving more water in the environment. Less energy, hence less carbon dioxide emissions, is used to pump and treat the water and less energy is needed to pump and treat the waste water.

There is also the question of equity. As more customers become metered, although the cost of the remaining unmeasured customers increases more than the measured, profligate unmeasured users are having the cost of their water subsidised by the metered customers.

5.4.4 Selective metering of large domestic water users

All water companies in England and Wales have powers to meter domestic properties that are deemed large water users. This does not refer to occupancy of a property but is mainly associated with customers who want to use a garden sprinkler, or similar non-handheld watering device or properties where potable water is used to fill a swimming pool or pond greater than 10,000 litres capacity.

There are a few other uses that could be selectively metered but these tend to be internal uses of water such as certain power showers and water softeners that we rarely would have knowledge of. We inform our customers that if they wish to use a garden sprinkler, or install a swimming pool or pond above the stated capacity they will need to have a meter installed.

The majority are then classed as optants. If we discover an unmetered property using a sprinkler or having a swimming pool/large pond, in the first instance, we advise them of the need to have a meter. Most comply and are counted as optants. The few that do not, we selectively meter.

We believe the vast majority of our customers who are large users of water are, after over 20 years of the rules being in place, now metered.

In the last 3 years (2010/11 -2012/13) we have only selectively metered 18 customers because of their high use of water. These were all associated with swimming pools therefore the effect of metering was to collect fair revenue from the customer rather than in controlling their water demand. Any demand savings would only come from them being more careful with their other water use and in total is negligible. We do not expect the number of selectively metered large water using customers to differ in AMP6 from the last three years average. We therefore forecast 6 selective high water use meters per annum to be fitted over the planning horizon with a demand saving of zero.
The cost of these 6 meters will depend on whether a meter chamber is already installed at the property or whether we need to install a chamber. The costs are the same as for optant metering ie. £126.83 for a drop in (chamber already exists) or £381.19 if a new installation is required.

Selective high water users per AMP

Period	AMP6	AMP7	AMP8	AMP9	AMP10
Number Meters	30	30	30	30	30
Water saved l/p/d	0	0	0	0	0

5.4.5 Savings in water use from metering

We assume an average saving from a customer having a meter installed of 5% of the unmeasured consumption from an optant and 8% from a selectively metered on change of occupier customer. These savings are based on our experience in Essex, with the optant saving borne out from the NW programme.

The rationale for the difference is that those who tend to opt for a meter are often lower than average users of water to begin with. This is often why they opt so as to gain a financial benefit for their careful water using behaviour. Therefore after a meter is installed they have less opportunity to make further water savings to lower their bill. The average selective / new home metered customer may not have been so careful with their water use whilst in an unmeasured property therefore their opportunity to save water is greater.

The water savings, based on the forecast average unmeasured household consumption for 2015 /16 of 380litres and the unmeasured occupancy of 2.59, optant occupancy 1.64, water saving of 5%, is calculated as:

(380 x 0.05 / 2.59) x 1.64 = 12.03l/p/d (litres/property/day)

Installing 15,500 optants per annum = 186,465 litres water per day saved.
If we assume the daily consumptions and occupancies remain constant over the AMP6 period (a reasonable estimation) then the daily volume of water saved by the metering programme at the end of 2019/20 will be **0.93Ml/d.**

5.4.6 Implementation of the meter programme

The provision of free water meters to customers of unmeasured properties is a requirement of the Water Act on companies. The billing literature and our website inform customers of their right to a free meter and which customers are likely to benefit. It also informs them of their right to revert to an unmeasured supply within 1 year of the meter installation. Customers can apply for a meter online, by phone or by submitting a form. The company go out to survey the property to determine the location of the meter and if metering is going to be possible. When an application is made we aim to fit 95% within 60 days and 100% within 90 days.

Selective metering of high water users is opportunistic and arises when the company attends a property, either at the request of the customer or because of operational reasons, and our personnel see a swimming pool at the property. When a pool is discovered at an unmeasured property we serve notice that we will install a meter over the next 14 days using our powers under the Water Industry Act. These unmeasured properties with pools tend to be historic installations and only 6 on average per annum are detected.

5.4.7 Proposed metering strategy going forward

Given the current rate of meter installation from the AMP5 optant programme, and the views of customers, optant only metering will continue for AMP6 and AMP7 at the forecast rate of 14,000 properties per annum. In addition a further 1,500 optant meters will be installed as part of the company's plan for dealing with households struggling to pay their water bills. Low income eligible households will be offered the Watersure tariff if they agree to opt for a meter to be installed. This will give a total number of optants of 15,500 per annum for each year of AMP6.

Achieving these numbers will see the company reaching a meter penetration of 39.29% by the end of AMP6.

AMP6 Costs

The cost of installing an optant meter varies according to where on the property we can fit the meter. There are four possible locations with four different costs, with the intention of always choosing to install in the cheapest practical location. These locations are:-

- Drop in (to an empty existing meter chamber)
- Internal
- External private (new chamber installation in customers ground)
- External public (new chamber installation in public footpath /road)

The respective costs for these are (2012/13 prices):-

- Drop in £126.83
- Internal £278.64
- External private £339.11
- External public £381.19

The forecast location split for AMP6, derived from location splits outturned in AMP5 and the company's meter location policy is:-

- Drop in 20.3%
- Internal 9.6%
- External Private 9.8%
- External public 60.3%

(Nb. Internal meters are not favoured due to access problems to read and maintain. Also opportunities to install a meter chamber in private land is limited due to the high cost of re-instating expensive garden paths and driveways.)

Therefore the 77,500 forecast meters for AMP6 break down to the following costs;-

Drop in 15,733 meters @ £126.83 = £1.995m
Internal 7,440 meters @ £278.64 = £2.073m
Private 7,595 meters @ £339.11 = £2.576m
Public 46,732 meters @ £381.19 = £17.814m

Total cost of optant metering for AMP6 = **£24.458m**
Total water saved from optants in AMP6 = **0.93Ml/d**
Cost per Ml of water saved **= £26.3m per Ml**

This form of metering is very expensive compared to developing new water resources but it is a legal requirement upon the company.

The split of meter installations between the Kielder WRZ and Berwick WRZ is forecast to be proportional to their populations. It is forecast that of the 77,500 meters installed the numbers per WRZ are:-

- Berwick – 127 meters per annum, 635 in AMP6
- Kielder – 15,373 meters per annum, 76,865 in AMP6

Proposed metering in AMP7 (2020 – 2025)

The actual metering proposal for AMP7 will form part of the PR19 WRMP but currently we are assuming that we can continue to meter 14,000 properties per annum on an optant basis. We have reasonable confidence that we can achieve this number of optants for this five year period by more directly stimulating people to opt for a meter. Mailing customers, outside of the water billing period, to remind them of their right to opt for a meter and the possible financial benefit to them has been shown to increase the optant numbers in our Essex area. Installing 14,000 meters in this period will take the meter penetration at the end of 2024/25 to 47%. We do not at this stage propose including 1,500 extra meters per annum for those low income households that require being metered to move to the Watersure tariff. There should be sufficient headroom in the proposed numbers to allow for these customers.

AMP8 (2025 – 2030) and beyond.

After 2025, with almost 50% of the properties now metered the number of those likely to opt for a free meter drops considerably. We therefore forecast the following number of optant meters to be installed in these periods.

	AMP7	AMP8	AMP9	AMP10
Optant	70,000	27,500	25,000	25,000
End of AMP Metered %	47	52	55	57

Total cost of NW metering strategy per AMP

Period	AMP6	AMP7	AMP8	AMP9	AMP10
£m	24.46*	22.09	8.68	7.90	7.90

*Note This number also contains the 7,500 Watersure meters

5.5 Leakage Forecast

5.5.1 Background

The Sustainable Economic Level of Leakage

The ‘sustainable economic level of leakage’ (SELL) is defined as the point at which the marginal cost of active leakage control is equal to the marginal cost of water lost through leakage. Both sets of costs should include the external costs, i.e. the environmental, social and carbon costs.
This is in accordance with the following statement made by Ofwat:

“It is generally accepted that expenditure on leakage control should be increased to the point where the incremental costs involved are in balance with the incremental costs of alternatives for balancing supply and demand, for example resource development or demand management (such as metering)”.

The level of leakage control activity should be increased or reduced to the point where the marginal cost of finding an additional unit of water equals the marginal benefit derived from the water saved.

Although often presented as applying solely to leakage, the marginal benefit of water saved from leakage control is a function of the marginal cost of water provided by all of the other options, such as new water resources schemes or additional metering. This emphasises the integrated nature of the assessment and the importance of optimising across the full range of water supply and demand options.

5.5.2 SELL Review

In the course of preparing our WRMP, we have considered in detail all of the recommendations of the recent DEFRA/EA/Ofwat Review of SELL report. We have taken these into account as follows:

We have included all categories of external costs in the SELL modelling. These were calculated using the methodologies presented in the 2008 Ofwat guidance document on “The Inclusion of Externalities in the SELL Calculation”. Although the SELL Review report provides optional default values for some of these values, all the values used were derived from company-specific data, as described in our WRMP document.

Our calculation methods for leakage and the SELL are entirely consistent, as both are bottom-up methodologies built up from the same DMA-level leakage data.

We did evaluate in detail the costs and benefits of operating at a leakage level below the SELL, as recommended in the SELL review. This showed that the additional net cost of operating marginally below the SELL is relatively small. This analysis was used as the basis of the leakage options which were presented to our Customer Forum (Customer Challenge Group) for our willingness to pay investigations. However we did not receive a mandate from our customers for operating below the SELL, and therefore it is proposed that the target should be set at the SELL.

The SELL Review report recommended that companies should consider the economics of customer-side leakage separately from company-side leakage. The unique cost/benefit balance of customer-side leakage management is not well understood in the UK, and therefore we have not been able to do this. However Northumbrian Water is taking the lead in formulating, promoting and managing an UKWIR project specifically to examine this aspect of the SELL analysis. This project will begin in November 2013 and will be completed in late 2014.

5.5.2.1 The Northumbrian Water SELL Model

In 2007 NWL introduced a new SELL model to replace the earlier LIMES model. The model is based on the natural rates of rise of leakage, with the economics of active leakage control being optimised at DMA level. It was conceived and designed in 2007 by in-house experts but has been completely rebuilt for the PR14 submissions. It is fully compliant with the recommendations of the Tripartite Report of 2003, and therefore conforms to best practice.

The SELLs are calculated at DMA level, and these are then simply summed to give the overall ELL at company level. The model is applicable to a system in steady state.

Principles of the model

A water undertaker has a choice of two operational options in response to increasing levels of leakage:

(i). Increase the volume of water put into supply
(ii). Increase the level of effort on active leakage control (ALC).

Figure 1 illustrates the trade-off between the two options. Increasing the volume of water put into supply results in increased production costs (i.e. cost of water), which follows a linear relationship. The cost of increasing effort on active leakage control (ALC) is non-linear and shows diminishing returns. The total cost curve is the sum of the marginal supply cost curve (the cost of water lost) and the manpower cost curve (the manpower costs incurred in undertaking ALC). It is at a minimum when the gradients of the two component curves are equal and opposite.

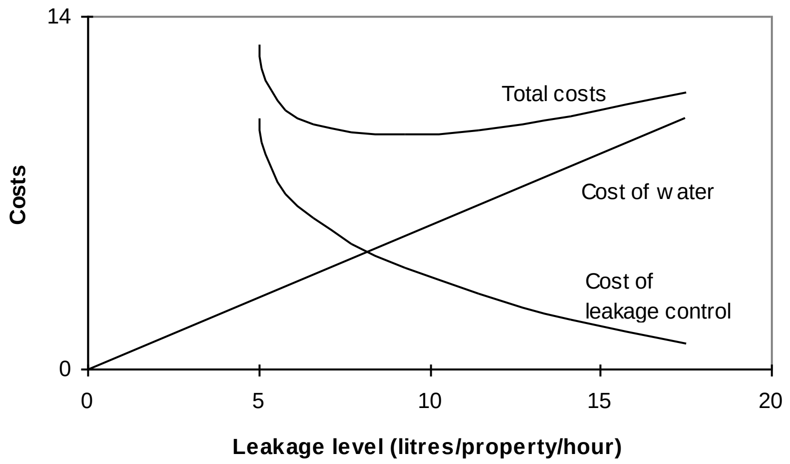


Figure 1. Leakage cost curves

Figure 2 represents the hypothetical behaviour of leakage in a DMA

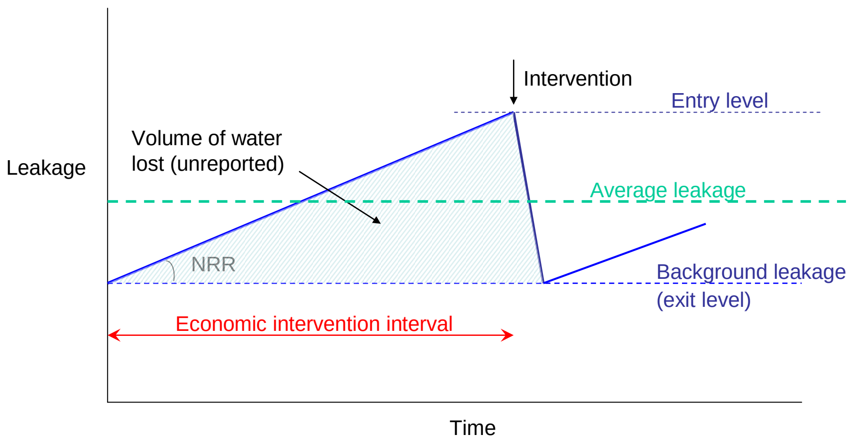


Figure 2 Hypothetical profile of leakage in a DMA

At time zero on Fig 2, an intensive leak detection and repair campaign has just been completed, and leakage has been reduced to the background level. Thereafter leakage rises at a gradient equal to the natural rate of rise. Eventually another leakage reduction campaign is undertaken, and leakage is again brought down to the background level. The shaded triangle represents the volume of water lost above the background level between interventions, i.e. water lost due to unreported burst leakage. It can be shown that the total cost to the company is a minimum when the value of the water lost between interventions is equal to the cost of the intervention. The intervention frequency will then be the economically optimum intervention frequency.

The average leakage level in the medium or long term is at half the height of the triangle as shown, and this is the economic level of leakage for the DMA. The ELL for the company is then calculated by summing the ELLs for the DMAs.

5.5.2.2 Previous submissions and current positions

The most recent submissions on the SELL analyses and leakage targets were made as part of the Strategic Business Plans and Water Resources Management Plan for PR09. It was demonstrated at that time that the SELL was 141.2 Ml/d.

The leakage target for 2009/10, the final year of AMP4, was 153.0 Ml/d. For AMP5 therefore, the agreed targets followed a non-linear glide path to reach the new ELL of 141.2 Ml/d in 2013/14, as follows.

Annual Reporting Period	Leakage Target (Ml/d)
2010/11	150.0
2011/12	146.1
2012/13	142.2
2013/14	141.2
2014/15	141.2

5.5.2.3 Data sources for current submission

The data used in the models are 100% company-specific; no use is made of industry default values.

Background leakage levels and ICFs

Background leakage levels were estimated for each DMA from the physical characteristics of the DMAs. The relationships used were those presented in the UKWIR report "Factors Affecting background Leakage Levels", published in 2013. This work was carried out by the same consultants who were responsible for the UKWIR study.

These estimated background levels were then expressed as a proportion of the reference background leakage levels calculated from the relationships defined in "Managing Leakage 2010". This ratio is termed the "Infrastructure Condition Factor" (ICF). For the North-eastern area the average Infrastructure Condition Factor is 0.61, which is reasonable considering the age of the network and the soil conditions.

Natural rates of rise of leakage

For ELL modelling, the Natural Rate of Rise (NRR) for a DMA is defined as the rate at which leakage will rise due to unreported bursts if no active leakage control takes place. A separate study was commissioned to derive NRR values for all DMAs in the Northern area. The method used followed exactly the recommendations of the UKWIR report on calculation of NRR, published in 2005.

The method involves analysis of time-sequences of minimum night flow data, and calculation of regression relationships for periods between consecutive unreported leak repairs. Short periods below a minimum duration are discarded, and the final NRR calculation is the average of the results from each regression period, weighted by the duration of each.

The overall NRR for the whole of the Northern operating area is 65.3 Ml per day per year.

Burst frequencies

The average annual numbers of reported bursts on distribution mains, service pipes and supply pipes in each DMA were calculated from Netbase, using data from 2007 to 2011. Netbase automatically imports this data weekly from “Engarde”, the company’s work management system.

Property counts

Property numbers have been derived for each DMA from Netbase. Netbase uses a composite analysis of customer information imported from the corporate ICIS customer database and geographic information on customer locations and DMA boundaries from the APIC GIS database. All of this data is updated in Netbase, using an automated import routine on a monthly schedule.

Mains lengths

Mains lengths are derived for each DMA from Netbase. Netbase holds the APIC GIS database information and analyses the lengths of each material type and diameter within each of the DMA polygons.

Average zonal night pressure

Average zonal night pressures in each DMA are calculated within Netbase, utilising the pressure data collected by telemetry. Each DMA has a designated pressure monitor and the ground levels within the DMA are derived from the APIC GIS information.

The average AZNP for the North-east is 46.4 metres.

Hour-day factors

The hour-day factor is a conversion factor applied to the night leakage value to derive a daily leakage value. The conversion factor is derived using recorded diurnal pressure profiles from each DMA, together with an appropriate leakage-pressure relationship. Analyses are carried out for several different times of year. Hour-day factors for the North East vary from 17.8 hours to 26.7 hours, with an average of 22.8 hours.

Unit costs of leak detection staff

For direct labour staff the unit costs include the direct costs of all leak detection technicians, both direct labour and contractors. The rates also include costs of supervision and support of these staff, as well as the equipment and vehicles required to carry out the work. However no on-costs are added.

For contract staff the unit rates from the framework contracts were used.

DMA leakage survey costs

The model requires a predicted cost for a full leak detection survey in each DMA. These were calculated using detection cost modelling analysis. Historical costs were compiled for recent surveys using several different survey procedures. Regression analyses were then performed to relate the number of man-hours required to the numbers of properties and length of mains within each DMA. The analysis was carried out for two different survey processes:

(i) Noise logging in areas of non-plastic mains, followed by sounding of areas of interest identified, together with intensive sounding in plastic areas.

(ii) Intensive sounding of the whole DMA

The analyses made an allowance for a proportion of the DMAs requiring second and third pass surveys in order to reduce leakage to the exit level.

Reported leakage

The reported leakage component of the SELL is calculated from reported burst frequencies, reported burst flow rates and awareness, location and repair times.

Burst flow rates were derived as part of the calibration process for the natural rate of rise study. The numbers of each type of reported burst with appropriate burst flow rates are calibrated against the overall natural rate of rise (i.e. for reported and unreported bursts).

Awareness and location times are based on the company's processes for management of reported bursts. The repair times for reported bursts were calculated by analysis of data from Engarde, the company's works management system.

Marginal costs of water

The short run marginal cost of water for each DMA comprises the marginal operating costs for electricity, treatment chemicals and sludge disposal. Electricity costs are based on average flows for the past three years, together with the 2012/13 electricity tariffs. The costs cover both raw water and treated water pumping costs, including all boosting and pumping costs within the network. Marginal treatment costs used for SELL analysis relate to the most expensive source within each zone, as this is where any leakage saving would be realised. The resulting marginal operating costs were calculated separately for each DMA, and varied from £59 / Ml to £312 / Ml.

The company has always been in resource surplus since the construction of Kielder Reservoir. Therefore the SELL for this area is a short-run economic level, and the marginal cost of water used is simply the marginal operating cost.

There has been no need to carry out a least cost planning analysis incorporating capital options for leakage management. However pressure management has been considered separately (see later).

5.5.2.4 External costs of leakage

The environmental, social and carbon costs of leakage have been assessed using the document "Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation", published by OFWAT in September 2008. The methodology covers four separate strands:

1. Environmental costs of leakage
2. Carbon costs of leakage
3. Social costs of leakage management
4. Carbon costs of leakage management

Environmental costs of leakage

For the North East, the environmental value of leakage relates to its impact on Kielder Reservoir. The reserves stored in Kielder are so large, that the environmental cost can be assumed to be negligible.

Carbon costs of leakage

In Northumbrian Water, the carbon costs of leakage relate to the carbon emissions associated with electricity used for pumping, and with disposal of sludge either to landfill or by recycling. These were assessed using an emissions factor of 0.44 Kg of CO_2 per KWh and the 2012 non-traded cost of carbon of £14 per ton of CO_2. The resulting cost was 0.26 p/cu.m.:

External costs of leakage management
The external costs of leakage management consist of the social and carbon costs associated with leak detection activities and with the repair of leaks.

There is a strong consensus amongst the leakage experts of the UK that the rate at which leaks break out is unaffected by the intensity of active leakage control (ALC). There is some anecdotal evidence that the repair of one leak may in some cases cause another leak to break out, but the evidence is limited and the effect cannot be quantified. Therefore it must be assumed that the only activities that can affect the leak breakout rate are pressure management and infrastructure renewal. This has been the basis of the BABE theories and all ELL models since the early 90's.

If the intensity of ALC is increased, a lower overall leakage level is achieved by reducing the average run time. As a company moves from one leakage level to a lower one, there will be a short term increase in the repair rate during the transition. However once leakage is in equilibrium at the new lower level, the repair rate will be the same as before. The number of repairs per year which must be carried out in a given DMA to overcome the natural rate of rise and hold leakage steady is equal to the number of leaks that break out per year.

Thus the number of leaks repaired per year is the same at all leakage levels, and the external costs of repairs do not affect the SELL. For the same reason, NWL does not include the direct cost of repairs in the SELL calculation. Therefore, in keeping with the OFWAT Guidance document, we have not taken the external costs of leak repairs into account in the SELL calculation.

For leak detection activities, the social costs are nil and the carbon costs are insignificant (total carbon costs are about £4,000 in the Northeastern area).

Therefore, the external costs used in the SELL analysis can be summarised as follows:

Environmental costs of leakage	0.00 p/cm
Carbon costs of leakage	0.26 p/cm
Social costs of leakage management	Nil
Carbon costs of leakage management	Negligible
Total external costs	0.26 p/cm

5.5.2.5 Results of ALC modelling

The resulting leakage-cost curves for active leakage control are shown in Figure 3.

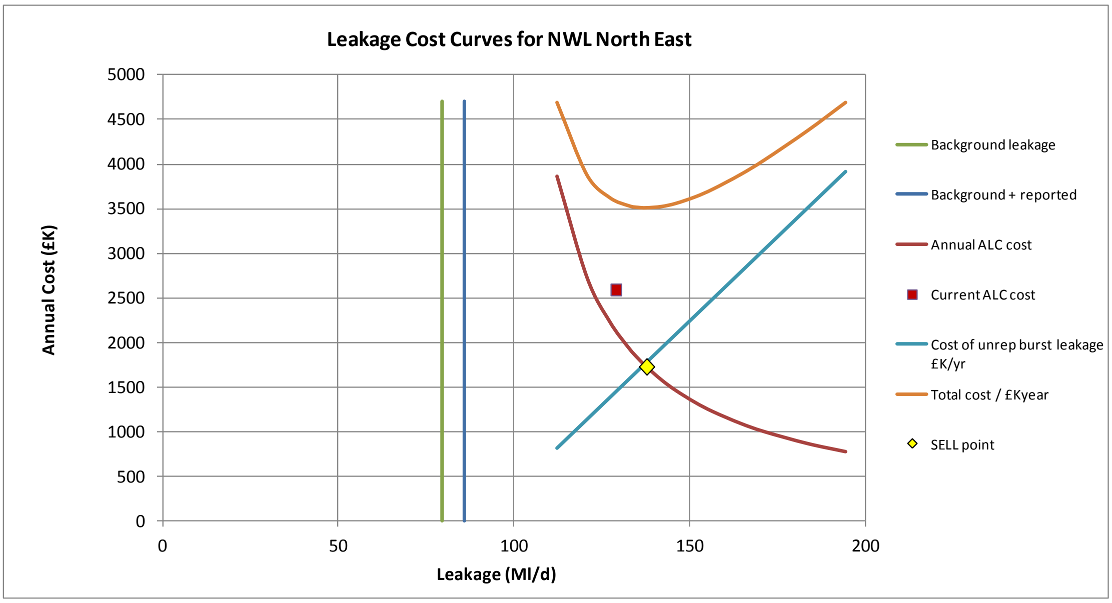


Figure 3. ALC cost curve for the North East

Figure 3 shows that the current SELL is 138 Ml/d.

In Figure 3 the point representing the current position, i.e. the current leakage level and the current annual expenditure, lies above the ALC curve. This is because the leak detection resources were increased at the beginning of 2011/12 following two successive failures against the target. The expenditure and leakage levels used are the averages for 2011/12 and 2012/13.

5.5.2.6 Other options for leakage management

As there is no resource deficit in the Northeastern area, capital leakage options are not considered in the context of balancing supply and demand. However, where these are economically self-justifying, the Company has considered the following additional options for leakage management, in addition to active operational leakage control:

- Increasing DMA coverage
- Pressure management
- Leakage-driven mains renewal

The current DMA coverage in the Northeast is 86%, and the company has set a target to reach 95%. A budget of £800,000 has currently been allocated to fund the following work:

- Design of 90 new DMAs which will be sufficient to reach the target of 95% coverage.
- The first stage of installation, which will increase the coverage to 89%.

The remaining installation work will be carried out in the AMP6 period.

A small number of new pressure control schemes will be implemented where these can provide a payback of less than five years.

As mains renewal is not an economic way to reduce leakage, this has not been included in the plan for AMP6.

5.5.2.7 Consistency with bottom-up leakage calculation

MLE adjustments

The bottom-up leakage calculation of actual leakage is based on analysis of the company's records of minimum night flows in DMAs. However, in the MLE process, the final values of actual leakage as reported are adjusted, normally upwards. For NWL North, the value of this adjustment in recent years has been about 5.0 Ml/d. It is implied by this process that the final post-MLE reported values are the best estimates of "true leakage", and that the bottom-up process underestimates true leakage by these amounts.

The key parameters in the SELL model are the background leakage levels and the natural rates of rise. Both of these are derived from analysis of the same records of minimum night flows in DMAs, as the SELL model is basically a bottom-up process. Therefore it should be assumed that these parameters have been underestimated by the same amounts as the MLE adjustments. Thus, in order to ensure that the SELL calculation is consistent with the bottom-up calculation of actual leakage, as required by the Tripartite Report, the same adjustment is added to the SELL value from the ALC model.

Trunk main leakage

As all trunk mains are contained either in DMAs or in dummy DMAs, it is assumed that trunk main leakage is already included in the bottom-up calculation of actual leakage. The same assumption is made in the SELL assessment, so no separate allowance has been added to the SELL for trunk main leakage.

Service reservoir leakage

As service reservoirs are outside of the DMAs and dummy DMAs, leakage from this source was considered separately in the bottom-up analysis. For the North East, this was assessed at 1.7 Ml/d, all added to the Kielder zone as the Berwick zone is insignificant, and this has been added to the modelled SELL.

5.5.3 Final sustainable economic levels of leakage

The results of the processes described above, and the final value of the economic level of leakage for NWL's Northern area, is shown in the following table.

SELL from ALC modelling (Ml/d)	132.7
MLE adjustment (Ml/d)	5.0
Final Sustainable Economic Level of Leakage (Ml/d)	137.7

This value is slightly lower than the SELL reported at PR09, which was 141.2 Ml/d.

5.5.4 Future Leakage Targets

On the basis of the analysis described above, it is proposed that leakage targets through AMP6 for NWL Northeast should be set at 141Ml/d for 2015/16 then reduce to 137Ml/d in 2016/17 and continue at this level throughout the planning period. This has been assumed in the water resource plan tables.

Our methodology for the calculation of the total volume for USPL describes the assumption to be 35% of distribution losses excluding trunk mains and service reservoir losses. Externally metered households are allocated half the volume of unmeasured or internally metered households.
The calculation within the water balance is particularly sensitive in the Berwick area and is influenced by the different structure in the area's demands as described in the WRMP.
The USPL calculation is only calculated as part of the annual water balance and does not impact on the targeting of leakage in Berwick or Kielder WRZ.

5.5.5 Further information on leakage as required by Defra

5.5.6 SELL Review

In the course of preparing our WRMP, we have considered in detail all of the recommendations of the recent DEFRA/EA/Ofwat Review of SELL report. We have taken these into account as follows:

We have included all categories of external costs in the SELL modelling. These were calculated using the methodologies presented in the 2008 Ofwat guidance document on "The Inclusion of Externalities in the SELL Calculation". Although the SELL Review report provides optional default values for some of these values, all the values used were derived from company-specific data, as described in our WRMP document.

Our calculation methods for leakage and the SELL are entirely consistent, as both are bottom-up methodologies built up from the same DMA-level leakage data.

We did evaluate in detail the costs and benefits of operating at a leakage level below the SELL, as recommended in the SELL review. This showed that the additional net cost of operating marginally below the SELL is relatively small.

This analysis was used as the basis of the leakage options which were presented to our Customer Forum (Customer Challenge Group) for our willingness to pay investigations. However we did not receive a mandate from our customers for operating below the SELL, and therefore it is proposed that the target should be set at the SELL.

The SELL Review report recommended that companies should consider the economics of customer-side leakage separately from company-side leakage. The unique cost/benefit balance of customer-side leakage management is not well understood in the UK, and therefore we have not been able to do this. However Northumbrian Water is taking the lead in formulating, promoting and managing an UKWIR project specifically to examine this aspect of the SELL analysis. This project will begin in November 2013 and will be completed in late 2014.

The components of the SELL / ELL calculation are described and the latest costs used and detailed where appropriate eg marginal cost of water £59 - £321 / ML, carbon cost of leakage based on 2012 non-traded cost of carbon of £14 tonne / CO2 = 0.26p/m3.

The overall effect of incorporating the Review's recommendations, and using 2012 figures, is the SELL has reduced from the PR09 figure of 141.2Ml/d to 138Ml/d.

The EA, and NE, wanted detail around the statement on Environmental Costs of Leakage:-

The environmental, social and carbon costs of leakage have been assessed using the document "Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation", published by OFWAT in September 2008. The methodology covers four separate strands:

1. *Environmental costs of leakage*
2. *Carbon costs of leakage*
3. *Social costs of leakage management*
4. *Carbon costs of leakage management*

Environmental costs of leakage
For the North East, the environmental value of leakage relates to its impact on Kielder Reservoir. The reserves stored in Kielder are so large, that the environmental cost can be assumed to be negligible.

The SELL is calculated at the Company level, which in the case of NW is in reality the Kielder WRZ as this comprises 99% of it's customer base. Within this WRZ the main sources of water are from reservoirs or rivers, most with compensation discharges and Minimum Maintained Flows ie predominantly artificial flow regimes.

The reservoirs that control the river flows are themselves controlled by Control Curves. Should the reservoir levels begin to drop to action limits within their control curves the Kielder reservoir water can be transferred to replace the reservoir waters needed to meet the water demand, either directly or by substitution. The sheer volume stored in Kielder means even under drought conditions it still has a fairly short draw down range. This could easily accommodate a much greater draw down, should it ever be required, and still have no negative impact. This huge storage and substitution of water allows the company to conclude there is no environmental benefit from reducing leakage further. This conclusion is further validated by our agreement under the WFD Heavily Modified Water Bodies improvement towards Good Ecological Potential to reduce compensation discharges in the summer and increase them in winter to more closely mimic a natural river.

Although the SELL is set on the Kielder WRZ we do recognize that Berwick may have an environmental cost from leakage. Whilst Berwick does not get calculated separately we have decided to reduce the leakage target for this WRZ from the draft WRMP target of 2.0Ml/d to 1.6Ml/d (a 20% reduction). This far exceeds the average range of the environmental cost of leakage around the water industry of between 0% and 3%.

6.0 CLIMATE CHANGE

6.1 Introduction

6.1.1 Vulnerability Assessment

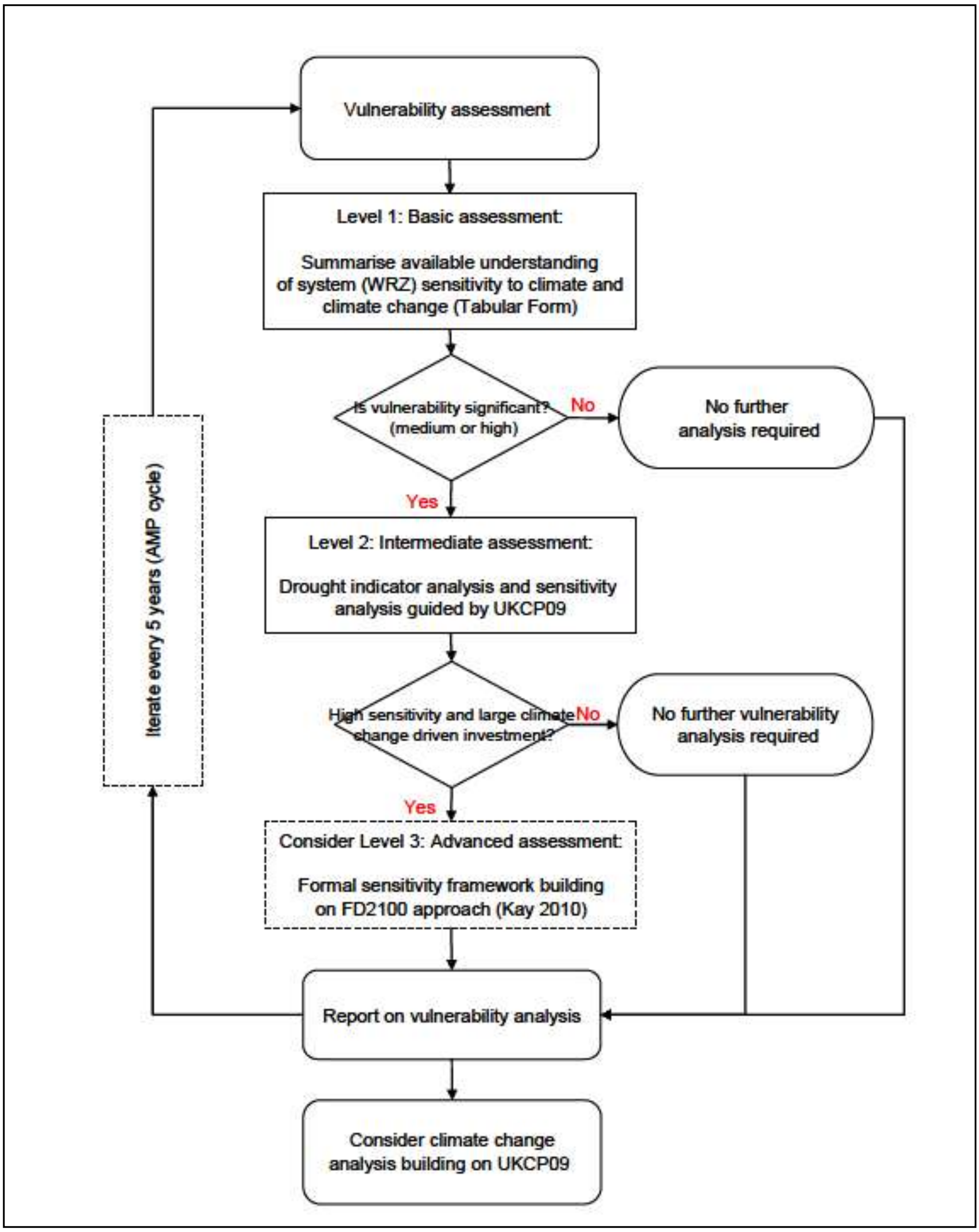
NWL's Vulnerability Assessment was carried out in line with Section 3 of the 'Water Resource Planning Guideline' (WRPG).

In line with Section 3 'Climate change approaches in water resources planning – Overview of new methods'. The following information is provided for each WRZ.

- A magnitude versus sensitivity plot of deployable output change from previous climate change assessments.

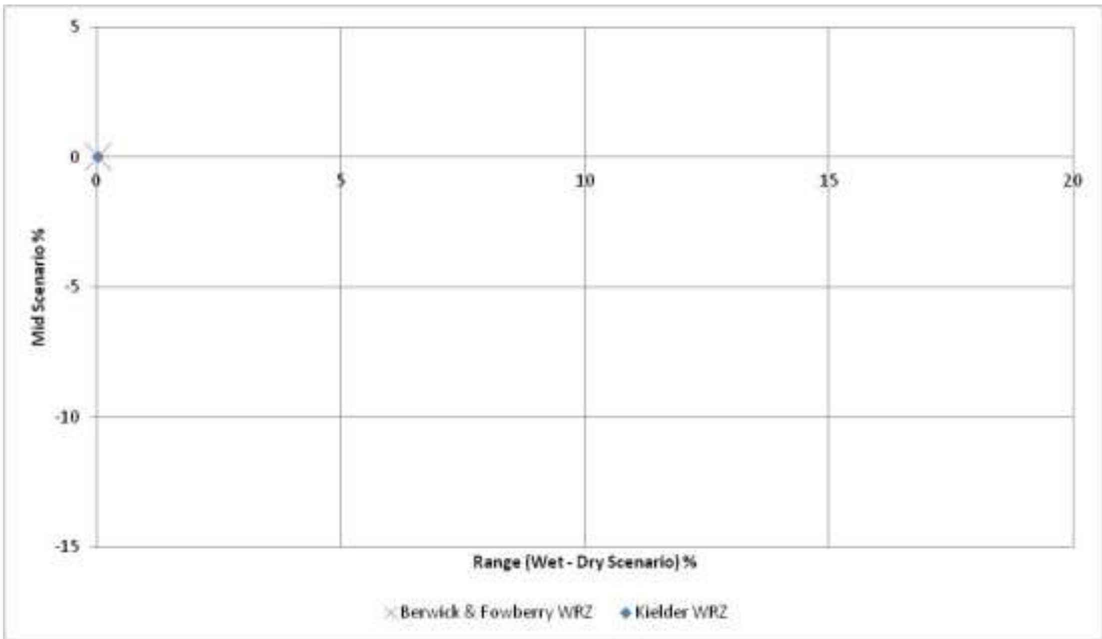
- A table summarising information which will be used to determine the final vulnerability of a resource zone to climate change.
- A justification for the derivation of the vulnerability assessment from the above sources of information.

As detailed in Figure 3.1 of 'Climate change approaches in water resources planning – Overview of new methods' (see below), the Level 1, Basic assessment, was carried out for each WRZ and both WRZs were considered to be of low vulnerability to climate change. To further justify this decision some of the Level 2, Intermediate assessment, was also undertaken.



Magnitude vs. Sensitivity Plot

The magnitude vs. sensitivity plot below is based on the results of the climate change analysis carried out for the previous WRMP.



Berwick & Fowberry – In the three scenarios tested for the previous WRMP, only the 'dry' scenario resulted in a reduction in the available yield. However when this reduction in yield was applied to the base yield available, it still left an abstraction volume available that is greater than the DO for the area, therefore this earlier climate change assessment showed no drop in the DO of the Berwick & Fowberry WRZ.

Kielder WRZ – Again only the 'dry' scenario result in a reduction of the availability of water with only Fontburn and Wear Valley WTWs having a reduction in their DOs. As with the Berwick and Fowberry WRZ the volume of water available for abstraction at the Sunderland GWS was reduced, although once again this reduction still left a large enough abstraction volume to not impact on the DO of the GWS. The overall effect was a reduction of 0.01% of DO in the Kielder WRZ.

6.2 Effect of Climate Change on Supply

6.2.1 Kielder WRZ

The table below is a summary of NWLs knowledge of the Kielder WRZ and likely impact of climate change on the availability of water in the zone.

Description	Source	Data	Comment
Critical drought years (top three)	Drought Plan	1929, 1959, 1995/96	These are the years identified as critical in the Drought Plan, for both ground water and surface water.
Types of sources	WRMP / Drought Plan	19 Upland reservoirs, 4 River Intakes and 14 Groundwater sources.	In the majority of cases the deployable output is due to the limit of treatment capacity rather than any restriction in resource availability.
Period used for analysis	Drought Plan	1926 – 1996 for surface water.	Surface water resource model covers this period of time.
Supply-demand balance	WRMP	DO of 969.39Mld, surplus of 208.72Mld.	WRZ has a surplus of approximately 200Mld throughout the planning period (2007 – 2035). NWLs stated Level of Service is to have to no restrictions to use.
Critical climate variables	UKCP09 High Emission scenario.	Reduction of summer rainfall.	High Emission scenario used as NWL sought to carry out the sensitivity analysis on the 'worst case' scenario.
Climate change DOs	June Return / Drought Plan / WRMP	2011/12 demand of 676.18Mld Dry Year DO of 939.39Mld	Drought plan demonstrated the ability to supply a demand of 845.58Mld, under drought conditions. This demand is 25% greater than the 2011/12 demand experienced. 0% change in DO from normal to dry years.
Adaptive capacity	Drought Plan		Kielder reservoir enables a DO to be maintained that is in excess of demand levels, headroom available in the region of 200Mld.
Sensitivity	**LOW**	Treatment capacity is the key constraint on DO rather than the availability of water resource. The Drought Plan has demonstrated that NWL can support an extreme demand whilst experiencing drought conditions. See the sensitivity analysis carried out for further justification.	

Sensitivity Analysis

The UK Climate Projections (UKCP09) website provides projections of future rainfall and temperature data based on the current understanding of the climate system.

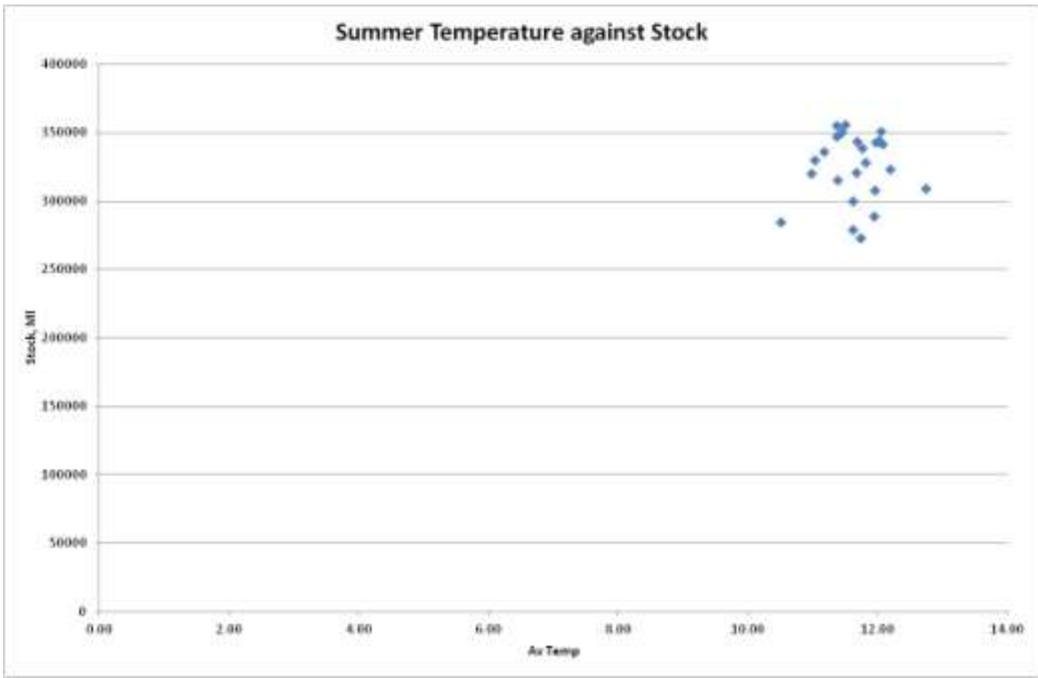
The sensitivity investigation was based on the high emissions scenario this was used to ensure that the absolute worst case of climate change had been taken into account. The UKCP09 website summarises the change in temperature and precipitation in the North East (Kielder and Berwick & Fowberry WRZs) for the 2050's (2040 – 2069) as;

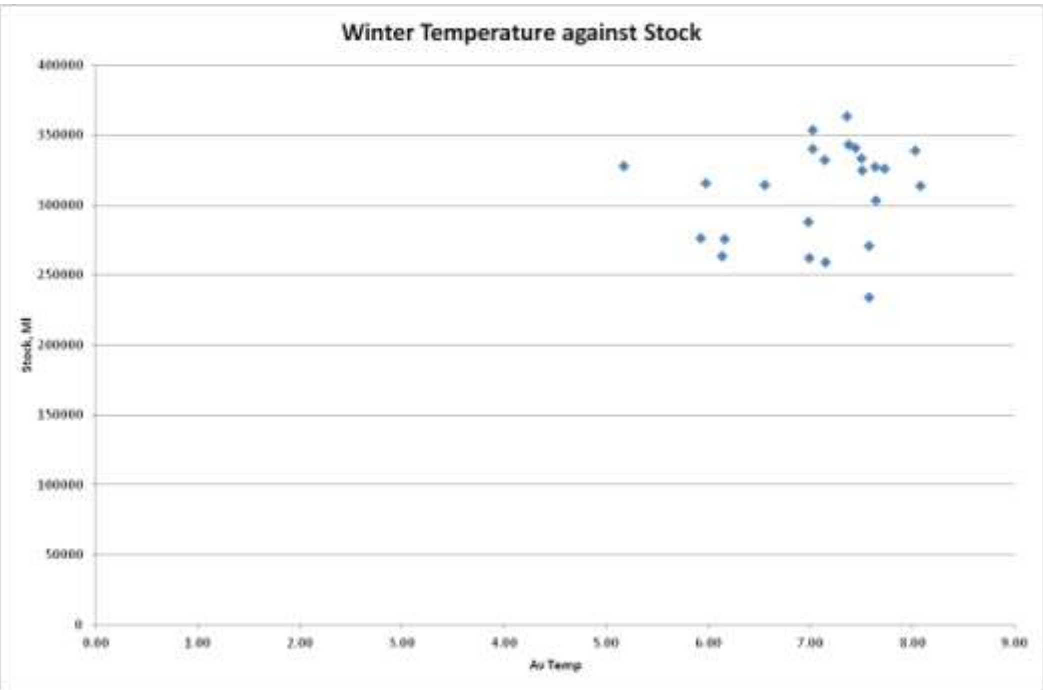
2050's Projections	Central Estimate	Likely Range
Winter mean temperate	+2.2^{o}C	> +1.2^{o}C, < +3.4^{o}C
Summer mean temperature	+2.9^{o}C	> +1.4^{o}C, < +4.7^{o}C
Annual mean precipitation	0%	> -5% , < +5%
Winter mean precipitation	+12%	> +1% , < +26%
Summer mean precipitation	-15%	> -31% , < +2%

Table 6.2.1

As the majority of the resource in the Kielder WRZ is surface water historical data for reservoir storage, rainfall and temperature was collated and analysed to determine any correlation between them.

Temperature – The average summer/winter temperature was plotted against the average reservoir stock for the WRZ, for the corresponding period to determine if there is any relationship between the two variables.

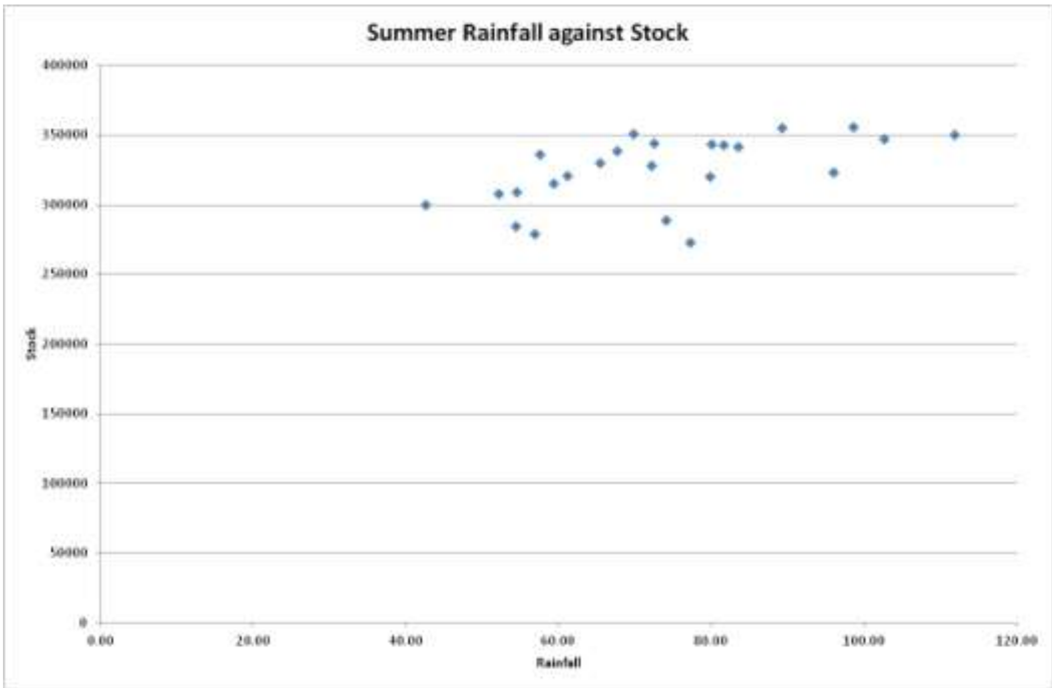


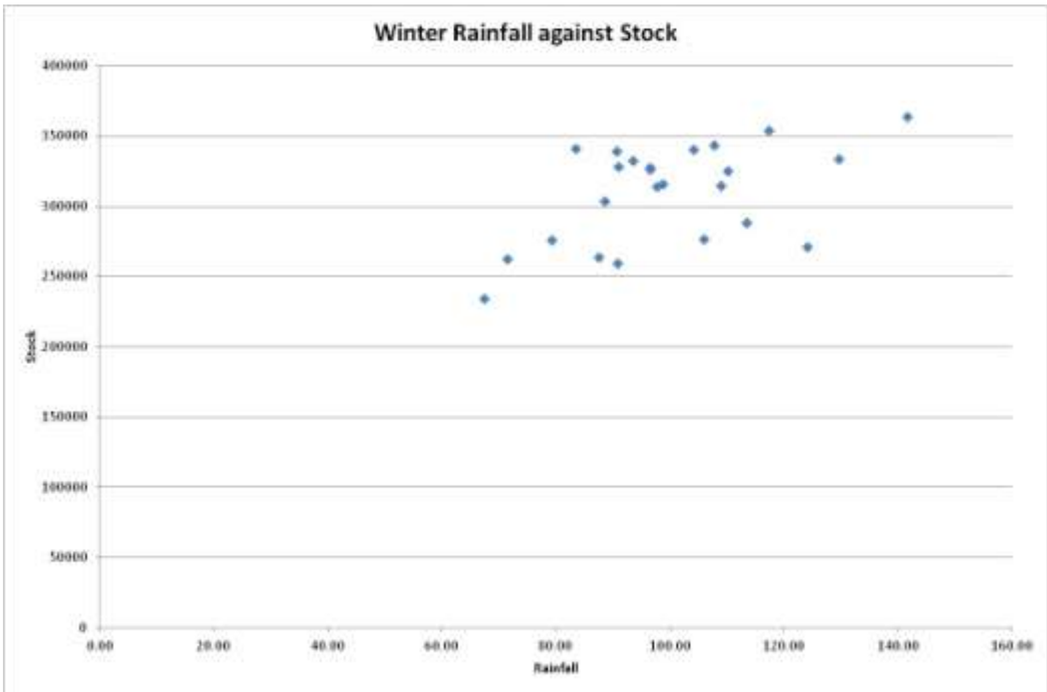


As can be seen in the two plots above there is very little correlation, to further substantiate this regression analysis* was also carried out, the R^2 values for the summer and winter periods were 0.003 and 0.03 respectfully indicating an insignificant relationship between temperature and stock levels. Therefore any increase in temperature due to climate change was deemed to have a negligible effect on the availability of surface water.

** Regression analysis is a statistical technique for estimating the relationship, if any, between a dependent variable (Reservoir Stock) and an independent variable (Temperature or Rainfall).*
R^2 is the coefficient of determination, it is used to describe how well a regression line fits a set of data. An R^2 value near 1 indicates that a regression line fits the data well, while an R^2 closer to 0 indicates a regression line does not fit the data.

Rainfall - The average summer/winter rainfall was plotted against the average reservoir stock for the WRZ, for the corresponding period to determine if there is any correlation between the two variables.

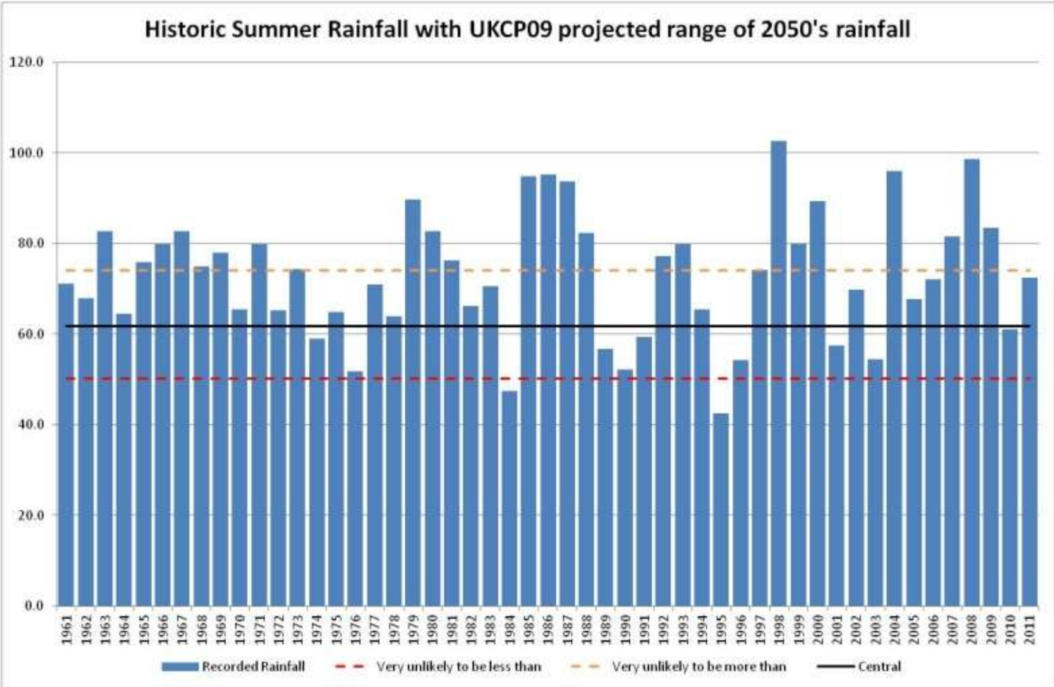


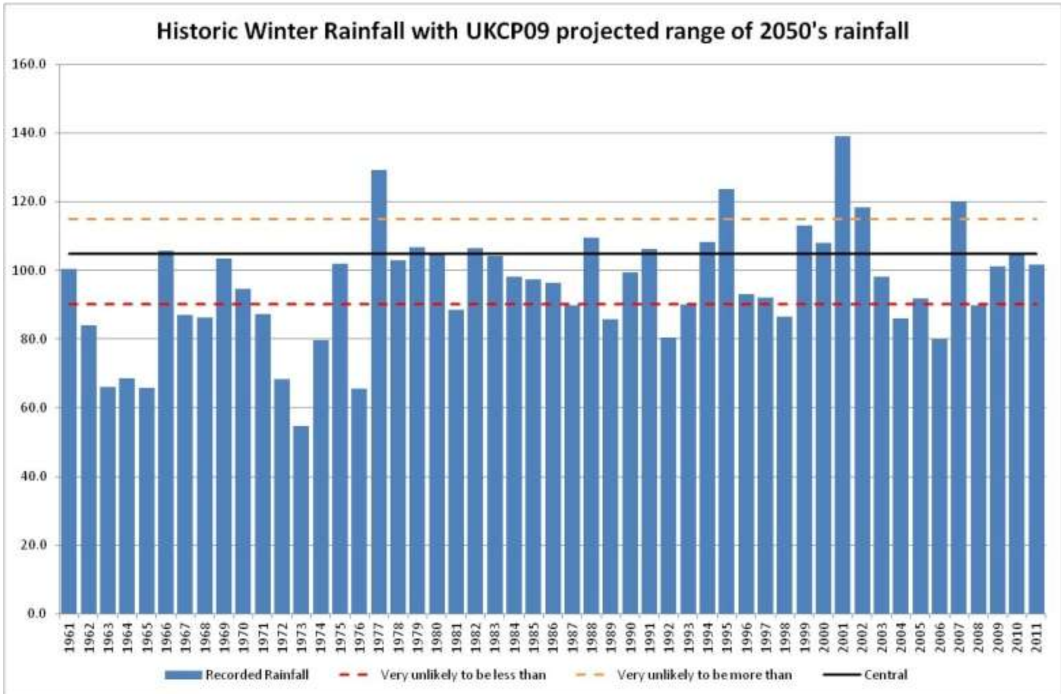


As can be seen in the two plots above there appears to be a relationship between rainfall and stock levels, as would be expected. As with the temperature data, regression analysis was also carried out and the R^2 values for the summer and winter periods were 0.34 and 0.26 respectfully.

These R^2 values indicate a weak correlation between rainfall and stock levels, it was decided that due the results of the regression analysis only the influence of rainfall on stock levels would be subjected to the sensitivity testing using the UKCP09 projections.

Climate Change assessment – The UKCP09 high emission projections (as detailed in table 6.2.1) were applied to the historic data for 1961 – 1990, as this is the base period used for the UKCP09. This range (along with the central estimate) of projected rainfall was then compared against the 1961-2011 historic data to evaluate what, if any, effect the projected change in rainfall would have on future reservoir stock (2012 was excluded as an anomaly due to the extreme rainfall experienced).

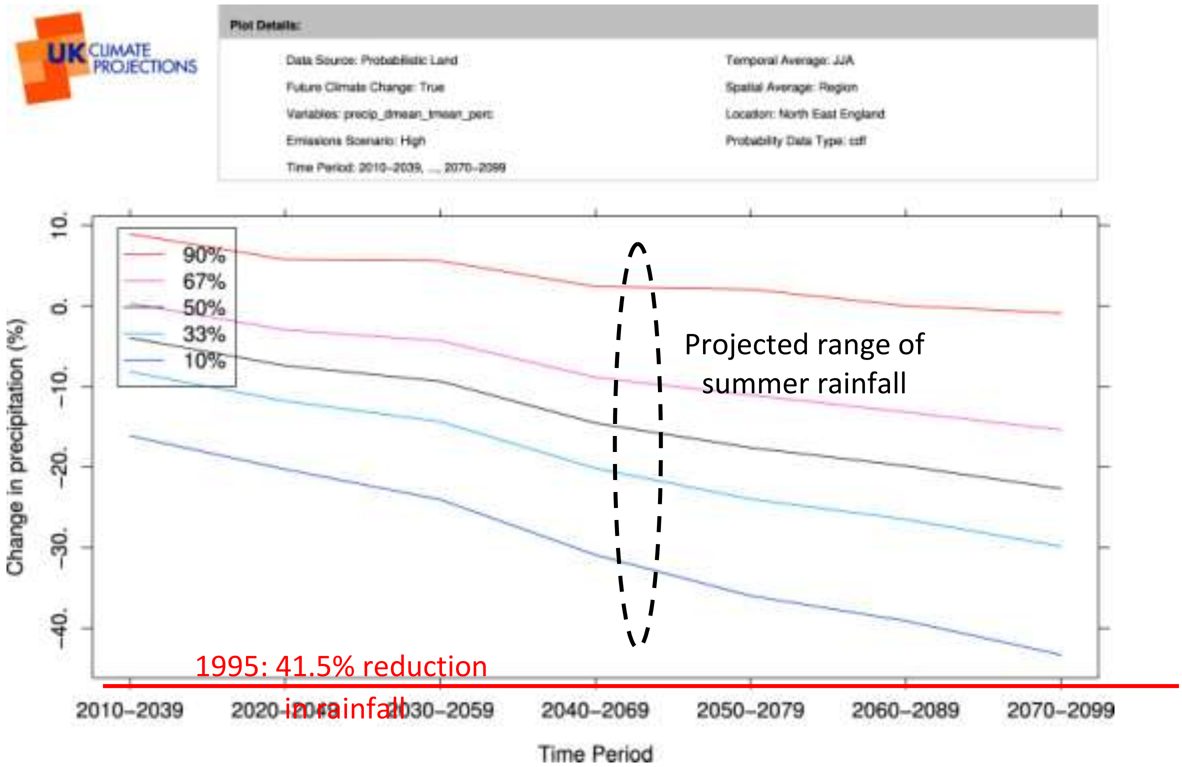




As can be seen in the graphs above, the reduction of summer rainfall (central estimate of -15%), would not be outside the historic summer rainfall that the region has experienced. The increase in winter rainfall (central estimate of +12%) would be at the higher end of the amount of rainfall experienced in winter, as most of NWLs WTWs are supported from reservoirs the net effect would be that the summer drawdown could potentially be lower than normally experienced. However the increase in winter precipitation would allow the reservoirs to refill prior to the next drawdown, as can be seen in table 6.2.1 the overall projected change in annual rainfall is 0%.

The Kielder WRZ also has several groundwater stations (GWS) in the Sunderland area. As can be seen in the graph of 'Historic Summer Rainfall' above,, the summer of 1995 was the driest experienced recently, this corresponds to 58.5% of the 1961-1990 summer rainfall data.

To establish the effect of a change in rainfall on the Sunderland GWS the rainfall experienced in the summer of 1995 (i.e. 41.5% reduction in rainfall from the base period of 1961-1990) was plotted against the UKCP09 projections.



As can be seen the conditions experienced in 1995 were well below the 10% projected change (worst case) in summer rainfall due to climate change. Therefore the groundwater stations have been subjected to far more extreme events than what is projected to become the norm due to climate change, without any detrimental effect on their ability to supply water.

As previously mentioned the projected increase in winter rainfall will mean that the net change in annual rainfall is 0% allowing a recharge of the aquifers during the winter months, and possibly meaning that the aquifer level is actually higher in the winter, therefore the summer reductions in level would not be as low as experienced in 1995.

Summary - The UKCP09 projects indicate that summers are going to get both drier and warmer, with the winters getting wetter. As detailed above the increase in temperature will have negligible effect on the water available within the WRZ. The potential decrease in summer rainfall is within the range of historic rainfall for the area and as such is not going to affect the quantity of surface or groundwater water available.

Therefore, along with the result of the magnitude vs. sensitivity plot, the Kielder WRZ's vulnerability to climate change would be **LOW**.

6.2.2 Berwick WRZ

The table below is a summary of NW's knowledge of the Berwick WRZ and likely impact of climate change on the availability of water in the zone.

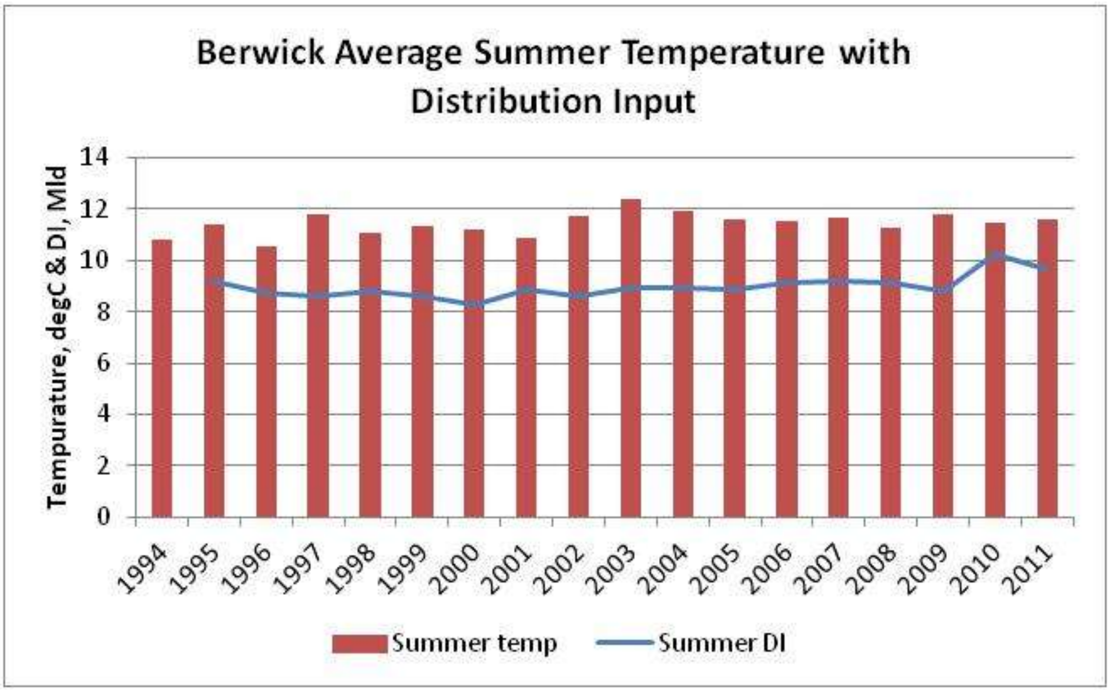
Description	Source	Data	Comment
Critical years	Recorded Data	2003, 2006	2003 a dry year, 2006 a peak in demand.
Types of sources	WRMP	All groundwater sources, a total of 10 ground water sources.	DO of 12.29Mld
Period used for analysis	Recorded Data	Rainfall 2000 – 2011 Temperature Data 1995 -2011	Rainfall data from Berwick area, the temperature data is an average between the Durham and Leuchars stations.
Supply-demand balance	June Return	Demand of 8.20Mld	No significant increase in demand in a warmer period.
Critical climate variables	UKCP09 High Emission scenario.	Annual temperature & summer rainfall.	High Emission scenario used as NWL sought to carry out the sensitivity analysis on the 'worst case' scenario.
Climate change DOs	WRMP	0% change in DO from normal to dry years.	Previous WRMP demonstrated that climate change had no effect of the DO of the WRZ.

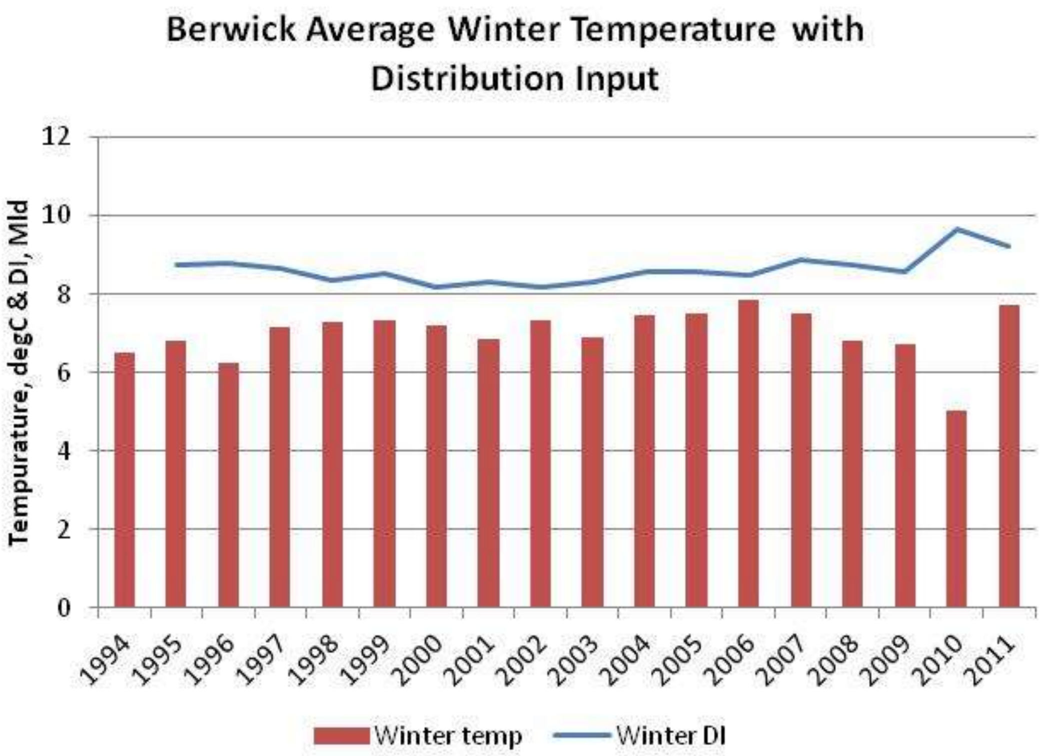
Adaptive capacity		Historically no issue being able to meet demand.	Although there are issues with the DO available due to turbidity issues, climate change will not impact on this and it is subject to a separate study.
Sensitivity		**LOW**	

Sensitivity Analysis

As with the Kielder WRZ, the sensitivity investigation was based on the high emissions scenario this was used to ensure that the absolute worst case of climate change had been taken into account. There is only limited data available for the local Berwick area so data was taken from the Durham and Leuchars weather stations and averaged. A similar approach to the sensitivity analysis carried out on the Sunderland GW Stations was used for the Berwick & Fowberry WRZ.

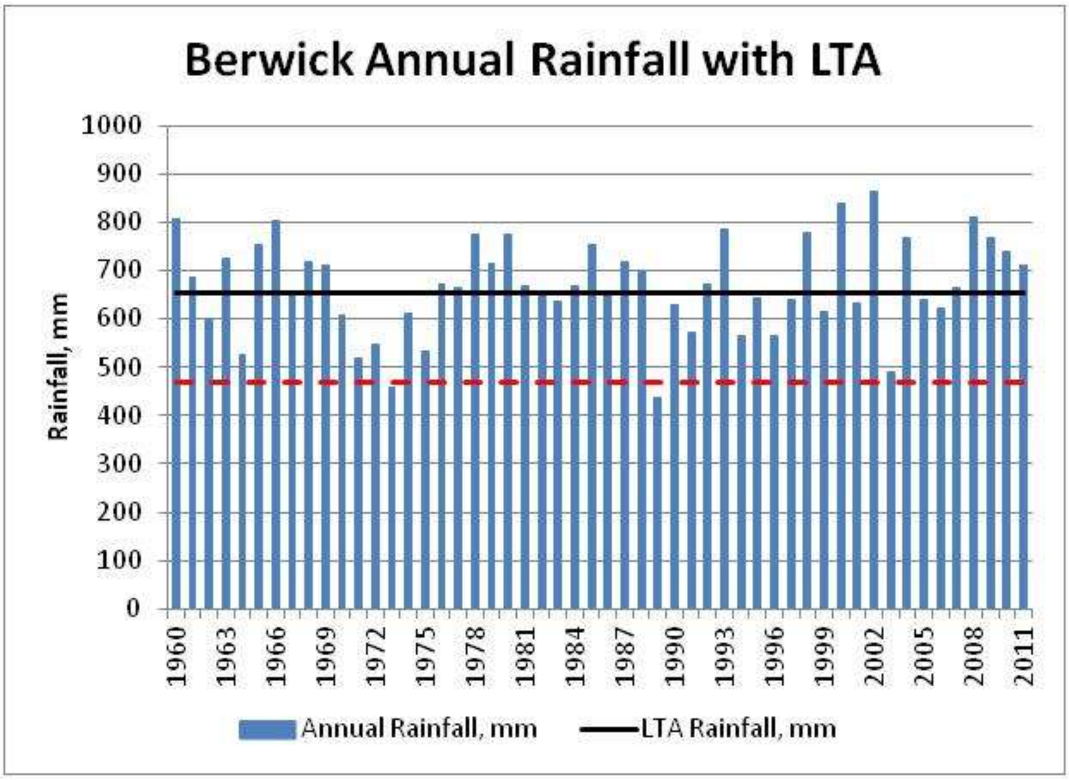
Temperature Change: The average summer and winter temperatures from 1994 – 2011 were plotted along with the corresponding average DI. This limited period of data is used as DI data is only available from 1995 onwards.



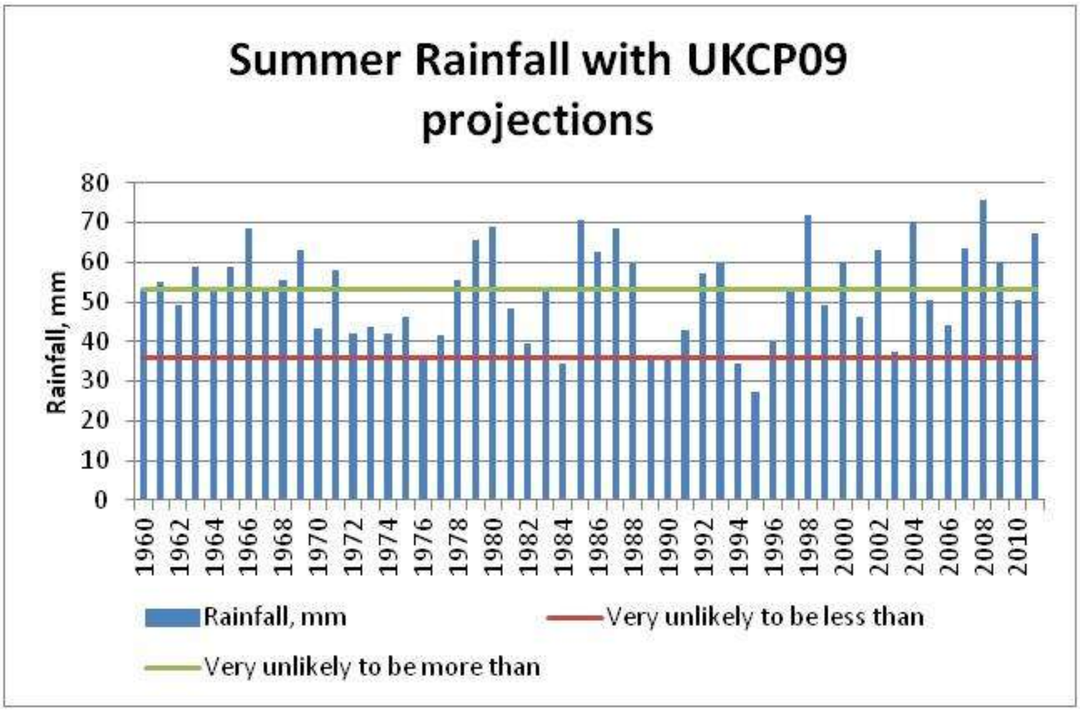


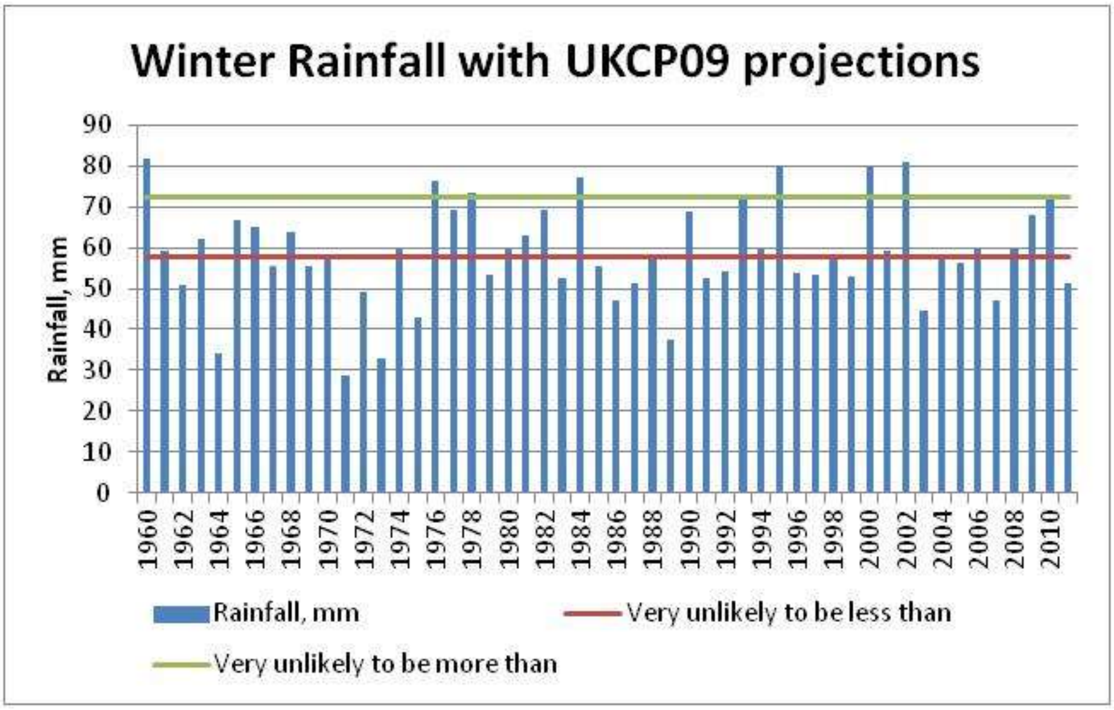
As can be seen the 2003 summer temperature was the highest summer temperature and did not result in any significant rise in demand for water in the WRZ. The increase in demand in 2010 was due the bad winter of 2009/10 resulting in an increase in leakage in the area. As temperature does not have any significant impact on the amount of water required in the zone, it is not considered a factor going forward.

Rainfall Change: Below is a plot of annual rainfall along with the 1961 – 1990 long term average (LTA).



As can be seen typical rainfall in a dry year is approximately 470mm (red dashed line), this historic data was compared to the UKCP09 summer and winter projections for the north east region.





As can be seen the projected rainfall conditions in the 2050's is within the historical range that the WRZ is subjected to, and this currently has no impact on the ability to supply water within the WRZ. Hence the impact of climate change on rainfall is unlikely to have an effect on our ability to supply water, and the WRZ's vulnerability to climate change would be low.

Summary - The UKCP09 projects indicate that summers are going to get both drier and warmer, with the winters getting wetter. As detailed above the increase in temperature will have negligible effect on the water available within the WRZ. The potential decrease in summer rainfall is within the range of historic rainfall for the area and as such is not going to affect the quantity of groundwater water available.
Therefore, along with the result of the magnitude vs. sensitivity plot, the Berwick WRZ's vulnerability to climate change would be **LOW**.

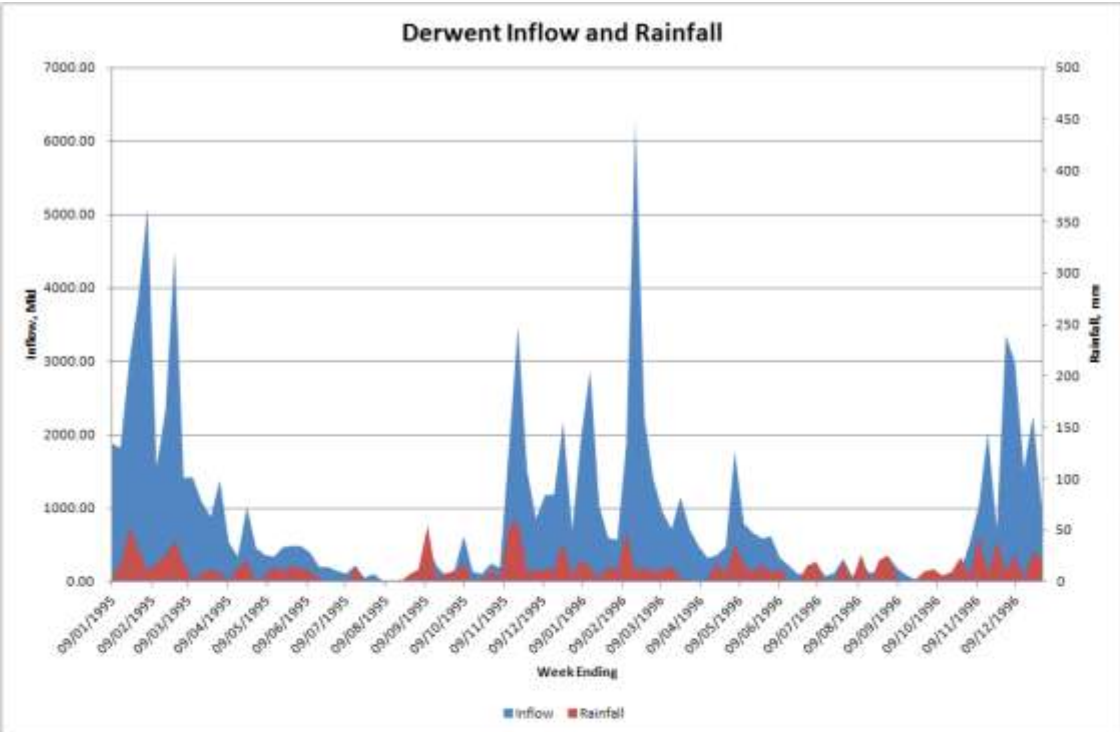
6.2.3 Climate Change Effects on Supply – Results

Kielder WRZ

Surface Water Analysis - Currently NW utilises a modelling package called i-Think, this is set up to reflect the operation of the raw water network, including abstraction limits along with the rule curves set out in the Kielder Operating Agreement. It also encompasses modelled inflow data from 1926 – 1998. NW is in the process of moving the Kielder WRZ system model from the current i-Think model to the more widely used Aquator model. Discussion have taken place between the company's modelling consultant and the Regional EA water resource planners to ensure the data to be input into the model satisfies the EA's requirements for a system model.

Agreement has been reached that the data in i-Think is suitable for transfer up until 1998 but the post 1998 data needs re-evaluating. The post 1998 "reservoir inflow" data has been put out to a consultant to derive and it was hoped that it would be available for inclusion in the current i-Think model for the draft WRMP. This has not been possible as the timescale proved to be too tight. The updated reservoir inflow data will be available for the construction of the Aquator model, and have been utilised in the final WRMP. NW are confident that the addition of modelling 1998 – 2011 will not have adversely affect the DO calculations as there are more extreme climate events pre 1998 that have more of an impact on the WRZ's DO.

The Kielder WRZ is comprised mainly of surface water resource, the vulnerability of the zone was assessed to be low, and as per the WRMP Guidelines modelling for 20 scenarios using the monthly UKCP09 flow factors from the UKWIR study was carried out. The UKCP09 flow factors for precipitation were used to perturb the inflow data used in the i-Think models, a 10% decrease in rainfall was assumed to be a 10% decrease in reservoir inflow. This assumption is based on analysis carried out on Derwent Reservoir using rainfall data and calculated inflows for 1995-1996 provided by the EA. As can be seen in the graph below, there is a good correlation between the recorded rainfall and the calculated inflow to the reservoir.



The following points describe how the scenario modelling was undertaken to assess the effects of climate change on resource supply availability.

- A separate model was created for each of the 20 climate change scenarios, with the reservoir catchment flows and river flows transformed based on the UKCP09 flow factors for precipitation.

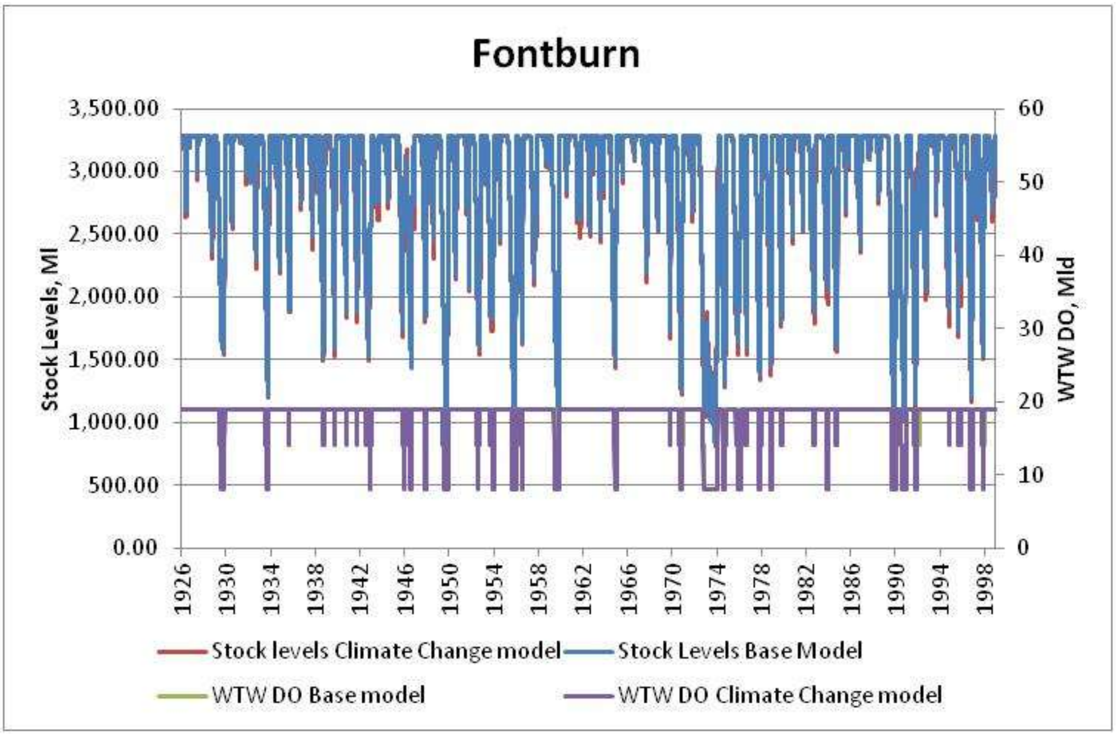
- The resulting DO's for each scenario was then totalled for each year from 1926 – 1998.

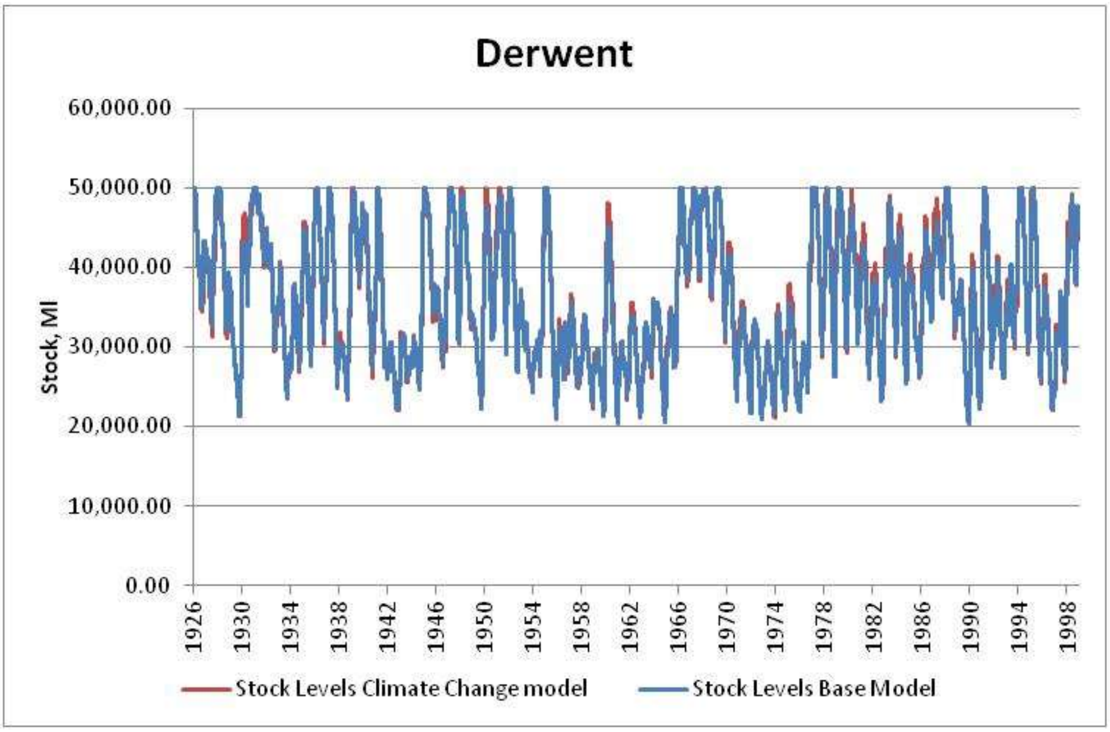
- The average DO for each year across the scenarios was determined so that, yearly surface water DOs under an average climate change scenario was developed.

- The yearly DO data was then separated into Dry and Normal years. Dry years were defined as years where the annual cumulative rainfall was less than 1025mm (inline with the dry year definition in Section 4), normal years where the remaining years with annual rainfall greater than 1025mm.

The results of this modelling showed that there would be a potential temporary reduction in DO at Lartington, Wear Valley, Honey Hill and Fontburn WTWs. Although the amount of water sent to treatment during low inflow periods may need to be reduced at these WTWs, there wouldn't be any need to change the operation of the surface water resources system drastically due to the bamount of headroom available.
The reduction in DO from these WTWs is inline with the rules set out in the Kielder Operating Agreement, and the flow from these works is regularly altered under current operations due to the impounding reservoirs level.

The graphs below are examples of the results obtained from the surface water modelling, as can be seen there is no significant difference in the reservoir levels or operation of the WTW in the climate change model from the base model.





<u>Groundwater Sources</u> – A coupled recharge and groundwater model exists for the Magnesian Limestone, namely NW's Sunderland Groundwater Model. AMEC were commissioned to carry out the climate change analysis for the Magnesian Limestone aquifer and followed the A1 (Low to Medium vulnerability) approach as detailed in the WRMP Guidelines.

The following text is an extract from the AMEC Groundwater Climate Change Assessment Report.

The Sunderland Groundwater Model comprises the following two main components:

- *A recharge and runoff model that provides input data to the uppermost boundary of the groundwater flow model. This model uses AMEC's Rainfall, Runoff and Recharge Routing (4R) code (Heathcote et al., 2004; Entec, 2006) to process soil moisture balance, interflow, runoff and recharge data on a daily time step; and*

- *A one layer groundwater flow model that simulates flow in the Magnesian Limestone aquifer. The model is implemented using MODFLOW 96, a well established and tested version of the United States Geological Survey (USGS) MODFLOW code.*

The model runs from January 1961 to December 2009, and the first ten years of the model simulation period is required for the simulation to "stabilise". The model calibration consequently focuses on the period 1975 to 2009.

The 4R model has a daily time step, and the MODFLOW model has a monthly time step.

The 4R and MODFLOW models have a common 200 m x 200 m fixed mesh grid, which comprises 120 columns and 190 rows of grid cells. The Sunderland Groundwater Model comprises one layer, which represents the Magnesian Limestone Formation and the underlying Yellow Sands as a single aquifer. The drift geology is not specifically represented, but has been taken into account in the 4R calculations, and influences the amount of recharge simulated for the Magnesian Limestone aquifer.

The baseline model that has been used for the climate change assessment runs is based on the historical Sunderland Groundwater Model, which contains groundwater abstractions, surface water abstractions and surface water discharges at their historical rates.

The historical model discussed in AMEC (2012) contains two rates for the Magnesian Limestone/Yellow Sands leakage into the underlying Coal Measures. These two rates are based on assumed pre- and post-1996 leakage conditions, and the full details of the justification and implementation of these two leakage rates are given in the 2012 report. However, in summary, the conceptual model assumes that prior to 1996 the Coal Measures are being actively dewatered, inducing enhanced leakage from the Magnesian Limestone. Post-1996 water levels in the Coal Measures are higher as they are not being actively dewatered, so the amount of leakage is reduced in the model. As the climate change predictions concerns potential future climate, the baseline model used in this assessment only contains the post-1996 Magnesian Limestone–Coal Measures leakage condition.

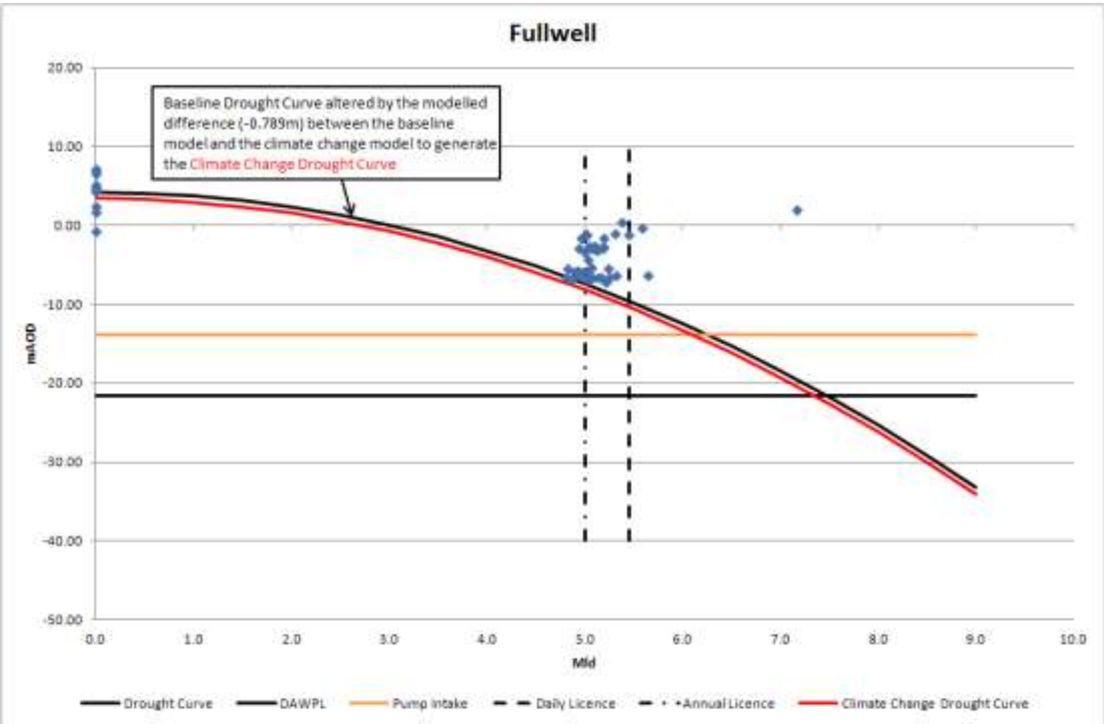
For the Magnesian Limestone, the change in annual average recharge in the climate change scenarios varies between a minimum of 73% of the baseline long term average recharge amount in the "driest" scenario to 109% for the "wettest" scenario. For the modelled heads, the output for both the regional observation boreholes and the Northumbrian Water abstraction wells has been considered. For the regional observation boreholes, the biggest difference between the baseline and the "driest" recharge scenario is seen at High Fallowfield (5.41 m), and the smallest difference is seen at West Hall Farm (0.33m).

For the Northumbrian Water abstraction locations, two of the abstractions (Stonygate and New Winning) dry out in the model during the drier model runs. The difference between drought water levels between in the baseline ranges from about 2m at some locations (e.g. -1.55m at Mill Hill) to 10s of cm at others, for example -0.26m at Ryhope.

The change in water from the baseline for each of the Sunderland GWS is detailed in the table below.

Abstraction location	Baseline (Sund78)	Driest, Rank 20 Sund105		Medium Dry, Rank 17 Sund111		Median, Rank 10, Sund098		Medium Wet, Rank 5 Sund104	
		Absolute	Difference from baseline	Absolute	Difference from baseline	Absolute	Difference from baseline	Absolute	Difference from baseline
Stonygate	14.889	Dry Cell	N/A due to dry cell	Dry Cell	N/A due to dry cell	11.884	-3.005	15.315	0.426
Fulwell	-7.457	-8.246	-0.789	-7.862	-0.405	-7.753	-0.296	-7.458	-0.001
Seaton	20.961	18.419	-2.542	19.455	-1.506	20.031	-0.930	21.039	0.078
North Dalton	0.244	-0.696	-0.940	-0.323	-0.568	-0.156	-0.400	0.313	0.068
Thorpe	2.378	1.822	-0.556	2.160	-0.218	2.145	-0.233	2.434	0.056
Dalton	0.649	-0.282	-0.930	0.111	-0.538	0.272	-0.377	0.719	0.070
Ryhope	4.123	3.859	-0.264	3.838	-0.285	3.791	-0.332	4.181	0.058
Peterlee	-0.914	-1.076	-0.162	-0.340	0.574	-1.484	-0.570	-0.778	0.136
Hawthorn	3.443	2.608	-0.835	3.036	-0.408	3.115	-0.328	3.514	0.071
New Winning	24.667	Dry Cell	N/A due to dry cell	Dry Cell	N/A due to dry cell	22.548	-2.119	25.015	0.348
Mill Hill	15.044	13.492	-1.553	14.488	-0.556	14.295	-0.749	15.192	0.148
Burdon	14.964	18.206	3.242	16.124	1.160	13.491	-1.473	15.188	0.224

To asses the impact of climate change on the Sunderland GWS DO the head differences between the baseline run and the driest climate change run (the worst case scenario) has been used to amend the Drought Bound Curve for the relevant site. The water level data was obtained from manual dips taken on site and the corresponding pump flow rate also recorded. Below is an example of the graphs produced for each of the GWS.



As can be seen in this example the base yield and the climate change yield, that is where the drought curves intersect the Deepest Available Water

Pumping Level (DAWPL), are both greater than the Daily Abstraction Licensed volume so there is no impact on the DO at Fullwell GWS due to climate change. The Groundwater Performance Graphs for each of the GWS's are included in Appendix G.

As stated in the AMEC report New Winning and Stoneygate run dry in the driest climate change run, therefore for the purpose of climate change analysis it is assumed that these sources are not available for abstraction.

The DO for each of the GWS was calculated as the minimum of either the climate change yield, licence constraint or the treatment capacity. The table below shows the DO for each GWS.

	Climate Change Yield, Mld	Daily Licence Limit, Mld	Historic Max Output, Mld	Deployable Output, Mld
New Winning	0.0	10.6	8.2	0.0
Hawthorn	3.4	6.2	4.8	3.4
Stoneygate	0.0	5.3	9.0	0.0
Peterlee	3.2	4.6	3.4	3.2
North Dalton	17.3	13.8	12.4	12.4
Dalton	8.3	11.8	7.9	7.9
Fullwell	6.1	5.5	7.1	5.5
Thorpe	5.7	5.6	5.0	5.0
Total	44.5	64.5	57.8	37.4

The current DO of the Sunderland GWS is 44Mld, therefore climate change potentially reduces the DO by 6.6Mld.

The following table is a summary of the effects of climate change on the Kielder WRZ.

Current DO	969.39Mld
Reduction in Surface Water DO (Dry year)	8.5Mld
Reduction to Sunderland GWS DO (driest model run)	6.6Mld
Potential DO due to climate change	954.29Mld (-1.6%)

The overall reduction to DO in the Kielder WRZ of 1.6% due to projected climate change is negligible as the Water Resource Zone has a surplus in the order of 180Mld.

Berwick & Fowberry WRZ

The Berwick & Fowberry WRZ gets it water solely from the Fell Sandstone aquifer.

AMEC have previously produced a comprehensive conceptual model report of the Fell Sandstone in Northumberland on behalf of the EA and NWL. This model divided the area into 4 distinct water balance domains, namely Berwick Local; Berwick to Wooler; Alnwick to Rothbury; and Catcleugh to Kielder. Quantitative water balances based on spreadsheet models were presented for each of these water balance areas, and these water balances included recharge calculations and groundwater budget components. Output from the Fell Sandstone Water Balance Spreadsheets included estimations of recharge and also groundwater level change.
The climate change assessment only considers the Berwick Local and Berwick to Wooler Water Balance Areas.

The following text is an extract from the AMEC Groundwater Climate Change Assessment Report.

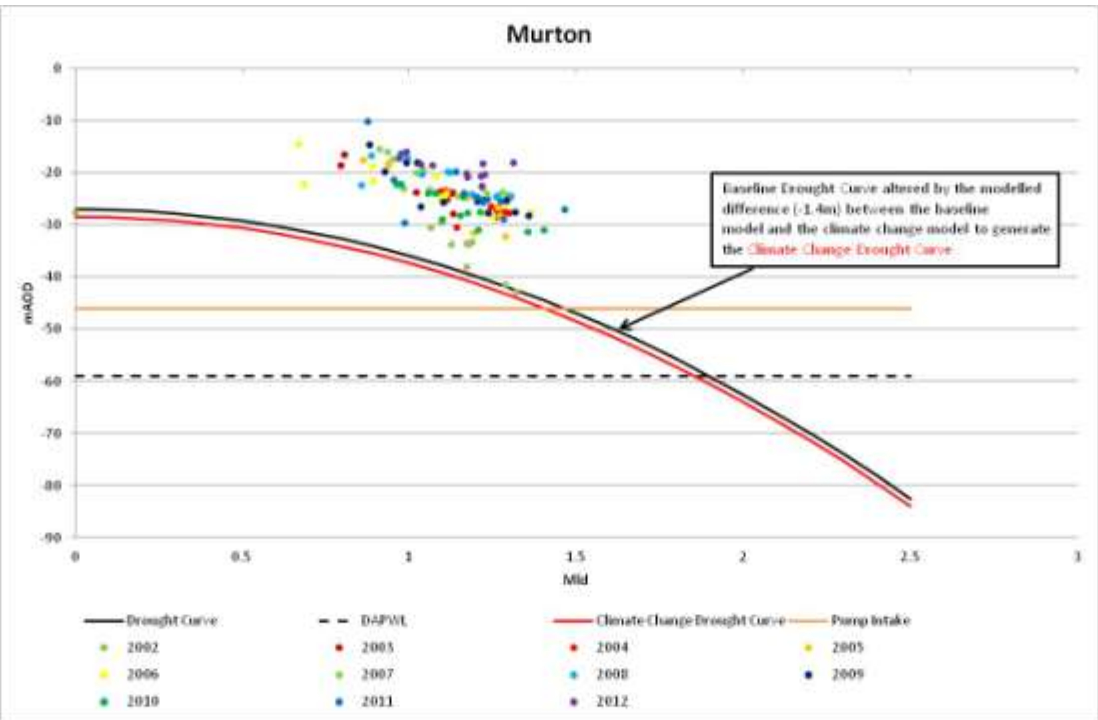
The UKCP09 Rapid Assessment Report contained 20 sets of UKCP09 climate change factors. These were used to produce 20 assessments of potential climate change impact on modelled groundwater levels. The models were run on a daily time step from Jan 1980 to December 2010. The recharge calculations were undertaken on a daily time step, and the groundwater budget calculations were undertaken on a monthly time step. The spreadsheets used a loamy sand soil type.
Baseline rainfall and PET meteorological data were used, and these data were perturbed by the climate change factors. This resulted in 20 meteorological input series that were feed into the Water Balance Spreadsheets to produce 20 sets of modelled groundwater heads and flows.

AMEC found that –

Modelled groundwater levels calculated by the Water Balance Spreadsheets show that the difference between the baseline and the "driest" scenario varies through the duration of the water balance period. It reaches a maximum of between 1.4 mAOD for the Berwick Local Water Balance Area and 1.0 mAOD for the Berwick to Wooler Water Balance Area.

To asses the impact of climate change on the Berwick & Fowberry WRZ DO, as with the Sunderland GWS the head differences between the baseline run and the driest climate change run was used to amend the Drought Bound Curve for the relevant site. For the Berwick boreholes the head difference of 1.4m (from the Berwick Local Water Balance Area) was used, and for the Fowberry sites the head difference of 1m (from the Berwick to Wooler Water Balance Area) was used.

There is no dip meter data available for the Berwick and Fowberry boreholes, so the telemetry data had to be used to construct the Groundwater Performance Graphs. The graphs were constructed using the monthly average abstraction from each borehole and the minimum monthly water level recorded. As a result of this the data has to be analysed with care, a project to collect manually dipped water levels for the Berwick and Fowberry boreholes is due to start shortly. An example of one the Groundwater Performance Graphs is shown below, the graphs for the other sites can be seen in Appendix G.



For each borehole the base yield and the climate change yield were calculated as the intersect of the relevant drought curve and either the DAWPL or the pump intake level. As some of the boreholes at Berwick do not have individual Abstraction Licences the yields for those sites were combined and then assessed against the licence constraint.

The table below shows the DO calculations for the Berwick boreholes.

<table>
<tr><th></th><th>Base Yield, Mld</th><th>Climate Change Yield, Mld</th><th>Daily Licence Limit, Mld</th><th>Historic Max Output, Mld</th><th>Climate Change DO, Mld</th></tr>
<tr><td>Bleakridge</td><td>1.6</td><td>1.5</td><td>3.0</td><td>2.3</td><td>1.5</td></tr>
<tr><td>Felkington</td><td>1.9</td><td>1.9</td><td>2.9</td><td>1.2</td><td>1.2</td></tr>
<tr><td>Murton</td><td>1.5</td><td>1.4</td><td rowspan="2">6.8</td><td>1.8</td><td rowspan="2">2.6</td></tr>
<tr><td>Thornton Mains</td><td>1.3</td><td>1.2</td><td>1.5</td></tr>
<tr><td>Thornton Bog 1</td><td>1.5</td><td>1.5</td><td rowspan="2">4.6</td><td>1.2</td><td rowspan="2">3.3</td></tr>
<tr><td>Thornton Bog 2</td><td>2.5</td><td>2.5</td><td>2.1</td></tr>
<tr><td>Total</td><td>10.3</td><td>10.0</td><td>17.3</td><td>10.0</td><td>8.7</td></tr>
</table>

As can be seen although the projected climate change reduces the yield of the boreholes by 0.3Mld this is still above the declared DO of 8.64Mld for the area, hence climate change would not reduce the DO available.

The same process was followed for the Fowberry boreholes and a summary of the data is in the table below. The Groundwater Performance Graphs for the Fowberry sites can be seen in Appendix G.

	Base Yield, Mld	Climate Change Yield, Mld	Daily Licence Limit, Mld	Historic Max Output, Mld	Climate Change DO, Mld
Fowberry Mains A	1.00	0.97	3.64	1.5	0.97
Fowberry Mains B	1.25	1.21		1.2	1.20
Fowberry Tower	1.44	1.38		1.6	1.38
Total	3.68	3.56	3.64	4.28	3.55

Again the projected climate change reduces the yield of the Fowberry boreholes by 0.12Mld, however in this instance it would reduce the DO of the sites by 0.09Mld.

For the Berwick & Fowberry WRZ the projected climate change would reduce the DO of the zone by 0.09Mld to 12.2Mld a reduction of less than 1%.

6.3 Effect of Climate Change on Demand

Background:

The impact of climate change on demand has been considered in terms of:

(1) The explicit effect on distribution input. This has been defined for two scenarios; the most-likely and least likely (maximum) scenarios. The most-likely scenario has been chosen as the central scenario to be included within the deployable output in the supply demand balance.

(2) The uncertainty on the effect on distribution input as described in target headroom (using triangular distributions defined by zero, best estimate and maximum scenarios)

The above assessment can also enable definition of an envelope of climate change. Such an envelope can be defined for each weather scenario considered in demand forecasts (principally dry and normal).

The above information has been used to illustrate the effect of climate change on demand in each resource zone both in tabular and graphical format. The following sections give a brief synopsis as to how climate change has been considered followed by this summary information of the results.

Methodology:

The UKWIR Impact of climate change on demand project (UKWIR, 2013) results have been used to calculate forecasts of climate change impacts on household water demand for this WRMP. The report associated with this project has been used as an updated reference source that quantifies the impact of climate change on demand.

In summary, this UKWIR project used statistical analysis on five case studies looking at household and micro-component water consumption and non-household water consumption. The weather- demand relationships developed from the case studies have been used in combinations with UKCP09 climate projections to derive algorithms for calculating estimates of the impact of climate change of household water demand for each UK region in the format of look-up tables (UKWIR, 2013). These look-up tables present the estimated future impacts of climate change on household demand for any river basin between the years 2012-2040 and for a range of percentiles to reflect the uncertainty of the UKCP09 climate projections (UKWIR, 2013). Please refer to the report for a complete description on the methodology in creating the look-up tables' used (UKWIR, 2013).

A look-up table is provided for each UKCP09 river basin areas and the associated area. Within each area look-up table demand factors, describing the percentage change in household demand, are for two case study relationships (Thames Water and Severn Trent Water) and three demand criteria (annual average, minimum deployable output and critical period). The changes in household demand are provided for the 10th, 25th, 50th, 75th and 90th percentile to reflect the uncertainty in UKCP09 climate projections.

Due to the planning scenario selected for our Company the annual average demand criterion is the only one that applies to us, therefore this is the only set of rows that have been employed.

The table below shows the river basin area and case study relationship chosen for each area.

Area	River Basin look-up table selected	Case Study relationship selected
North	Northumbria	Severn Trent

The Severn Trent case study relationship was selected for the North as the Severn Trent area is more rural than Thames and provides a better representation of the North.

Different percentiles have been selected to give the most-likely and least likely (maximum) effects of climate change on demand across the planning horizon.

For the most-likely effects of climate change the 50^{th} percentile has been chosen (a one in two chance of occurrence). To determine the least likely (maximum) effect of climate change of demand the 90^{th} percentile was selected (a one in ten chance of occurrence). This approach allows the different probabilities of climate change occurring to be examined over the next 25 years.

The look-up table values give the percentage change in demand which has been applied to the total micro-component consumption to give the most-likely and least likely (maximum) forecasts of climate change impact. The report has advised that the same percentage change in demand can be assumed for both measured and unmeasured properties (UKWIR, 2013). Therefore within the micro-component model the total PCCs have been adjusted by the overall percentage change in demand as found in the look-up tables. It has been assumed that household demand is the only component of demand affected by climate change. Non-household demand is not expected to be effected by climate change. The report also stated that where necessary to allocate the effects of climate change across components of household demand, it would be reasonable to assume that all additional water consumption in hotter or drier weather is for external water uses (UKWIR, 2013).

6.3.1 Impact on Supply Demand Balance

Climate change has no significant impact on the company's supply demand balance. There remains a very significant actual headroom at the end of the planning horizon when climate change is fully accounted for. There is no requirement to develop any new water resources over the 25 years and no investment is driven by climate change.

7.0 TARGET HEADROOM

7.1 Background

The target headroom is defined by UKWIR as:

'The minimum buffer that a prudent water company should allow between supply and demand to cater for specified uncertainties (except those due to outages) in the overall supply demand balance'.

The methodology applied to generate the target headroom figure was that contained in UKWIR document 'A Practical Method for Converting Uncertainty into Headroom' 1998. This methodology is appropriate since no resource investment is proposed in either zone and the headroom is greater than 25% of demand, for the base year of 2011/12.

The methodology is based upon the identification of the principal uncertainties in the supply/demand balance assessment and assigning scores to each of these categories of uncertainty. The total score for the Resource Zone is then converted into a Target Headroom value.

Eleven categories of uncertainty have been identified, eight of which are supply related and three are demand related.

Supply Related

- Vulnerable Surface Water Licences
- Vulnerable Ground Water Licences
- Time Limited Licences
- Bulk Transfers
- Gradual Pollution Causing a Reduction in Abstraction
- Accuracy of Supply Side Data
- Single Source Dominance and Critical Periods
- Uncertainty of Climate Change upon Yield

Demand Related

- Accuracy of Sub-Component Data
- Demand Forecast Variation
- Uncertainty of Climate Change upon Demand

This document provides a series of Pro–forma's that need to be completed in order to derive the Target Headroom figure for the Resource Zone under investigation.

7.2 Kielder WRZ

Target headroom for the Kielder zone (approximately 99% of the Company's potable distribution input) has been developed for the 30-year horizon. The calculated range is from 1.5% of WAFU in the base year to 3.7% of WAFU in 2039/40 as uncertainty increases into the future. A summary of the main contributing factors as listed in the methodology is as follows:

- Vulnerable surface water licences – none identified at present
- Vulnerable ground water licences – none identified at present
- Time limited licences – none identified as assumption of renewal.
- Bulk transfers- none of significance. Small rural transfers made at the water company boundary.
- Gradual pollution causing a reduction in abstraction- none identified at present
- Accuracy of supply side data – the overall assessment is good with records extending over 86 years for surface water and 48 years for the ground water with good accuracy.
- Single source dominance – the dominant source of Kielder reservoir has been considered with no critical period.
- Uncertainty of Climate Change on Yield – a case 1 best estimate.
- Accuracy of sub-component data – overall data reliability mostly class A, reconciliation item from initial water balance – good.

- Demand forecast variation – Demand is currently falling, case 1 with a spread of WAFU less than 15%.
- Impact of Climate Change on demand – negligible.

The resultant calculated target headroom is 13.1Mld from the present day, rising to 32.4Mld at the end of the planning period. As can be seen in the WRP tables the target headroom is comfortably met, with available headroom in the order of 190Mld and no resource schemes are required.

7.3 Berwick WRZ

Target headroom for the Berwick zone (<1% of the Company's potable distribution input) has been developed for the 30-year horizon. The calculated range is from 6.5% of WAFU in the base year to 9% of WAFU in 2039/40 as uncertainty increases into the future. A summary of the main contributing factors as listed in the methodology is as follows:

- Vulnerable surface water licences – none identified at present
- Vulnerable ground water licences – potential sustainability reduction
- Time limited licences – none identified as assumption of renewal.
- Bulk transfers- none.
- Gradual pollution causing a reduction in abstraction- none identified at present
- Accuracy of supply side data – the overall assessment is good with records extending over 30 years with good naturalisation and good accuracy.
- Single source dominance – the dominant source of the single aquifer has been considered with a critical period of more than a season.
- Uncertainty of Climate Change on Yield – a case 1 best estimate.
- Accuracy of sub-component data – overall data reliability mostly class A, reconciliation item from initial water balance – good.
- Demand forecast variation – Demand is currently falling, case 1 with a spread of WAFU less than 15%.
- Impact of Climate Change on demand – negligible.

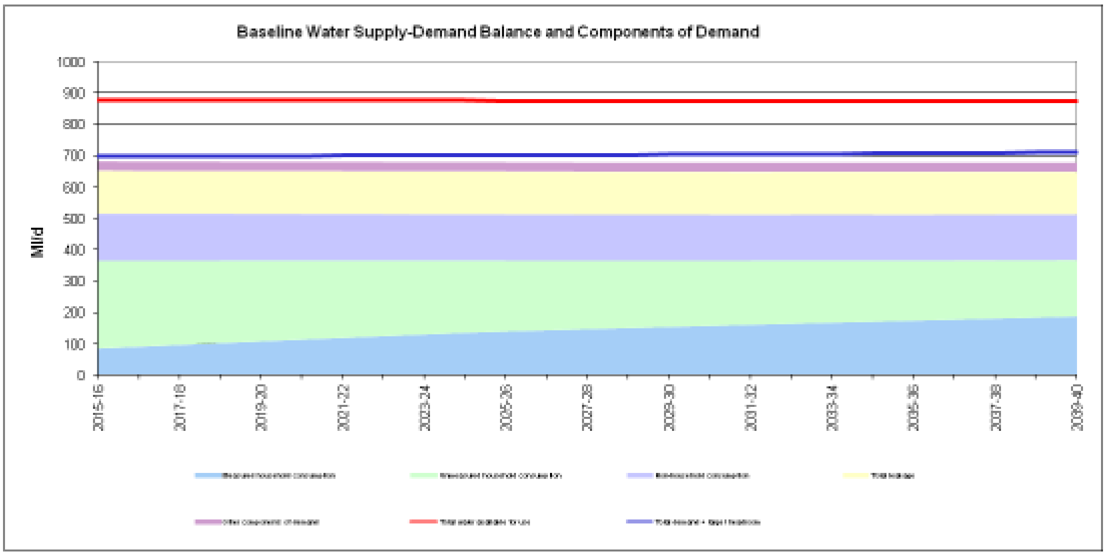
The resultant calculated target headroom is 0.72Mld from the present day, rising to 0.75Mld at the end of the planning period. As can be seen in the WRP tables the target headroom is met, with available headroom in the order of 0.83Mld in 2039/40.

8.0 BASELINE SUPPLY DEMAND BALANCE

8.1 Kielder Water Resource Zone

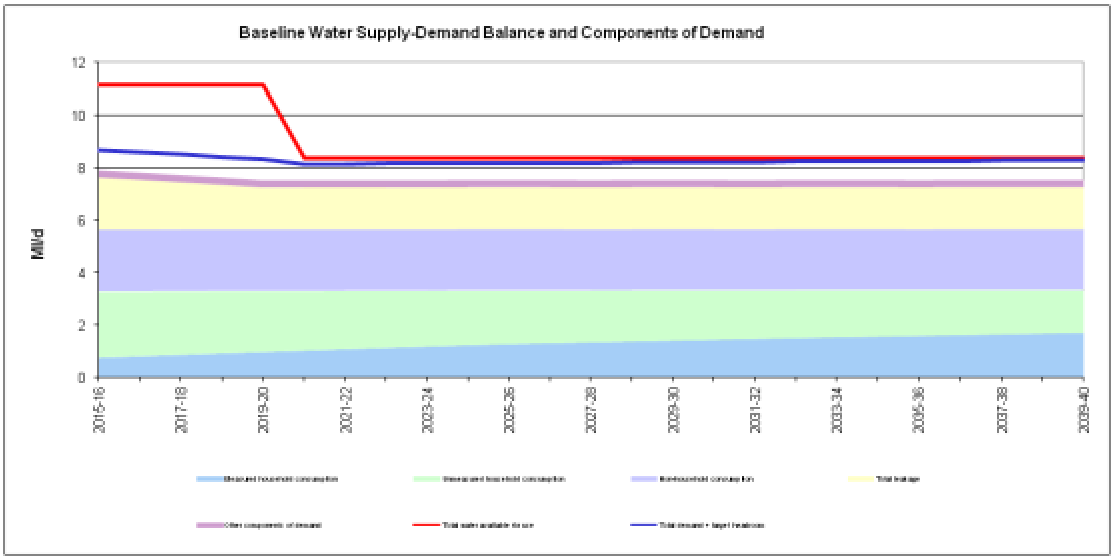
The baseline supply demand balance for this water resource zone is also the final plan as the zone remains in surplus of supply to the forecast demands over the whole of the planning horizon.

At the base year the surplus is around 180 Ml/day and by 2039/40 the zone still remains with an excess of supply to demand of over 150Ml/d.



8.2 Berwick and Fowberry Resource Zone

The Berwick WRZ remains in surplus over the whole of the planning horizon. The base year surplus is around 3.5 Ml/day however as a result of the potential sustainability reductions this falls over the planning period and by 2039/40 this surplus falls to 0.45 Ml/day.



8.3 Impact of Climate Change on the Overall Supply Demand Balance

8.3.1 Kielder Water Resource Zone

As explained in the Climate Change section above the impact of on the Kielder Zone is minimal with an estimated reduction in DO of 1.1%. This would still leave the zone with a healthy surplus.

8.3.2 Berwick and Fowberry Resource Zone

The assessment of the vulnerability within the Berwick and Fowberry zone to climate change is low. Current information does not allow a detailed analysis of the effect of this on the performance of the aquifer, however working with the EA we will produce an assessment for the final plan. Based on the evidence of climate change on the remainder of our area of supply and the level of surplus in the zone we would not expect that climate change would affect the ability to supply water in the zone.

8.4 Sensitivity to Climate Change on the Baseline Supply Demand Balance

8.4.1 Kielder Water Resource Zone

There is no significant difference in the supply demand balance between the scenarios with or without climate change.

8.4.2 Berwick and Fowberry Resource Zones

There is no significant difference in the supply demand balance between the scenarios with or without climate change.

8.5 Sensitivity to Indicative Sustainability Reductions

As explained earlier NEP investigations showed no issues with our abstractions on the Coquet for Warkworth treatment works and modelling has shown that our abstractions from the Magnesian Limestone aquifer had no detrimental effect and therefore there were no sustainability reduction issues with these sources.

The proposed amendments to compensation flows will similarly have no effect on the DO of the majority works supplied by the reservoirs from which the water will be released and with an overall surplus in the zone of around 180 Ml/day indicative sustainability reductions will not cause a change in our overall water resources strategy.

We are in discussion with the EA regarding a pragmatic reduction in our total abstraction licenced within the Berwick and Fowberry Zone. This is the subject of continued investigations over the next 5 years however in our overall tables we have assumed a value to this reduction coming into force in 2020/21 and with this reduction the area is still in surplus at the end of the planning period.

9.0 OPTIONS APPRAISAL

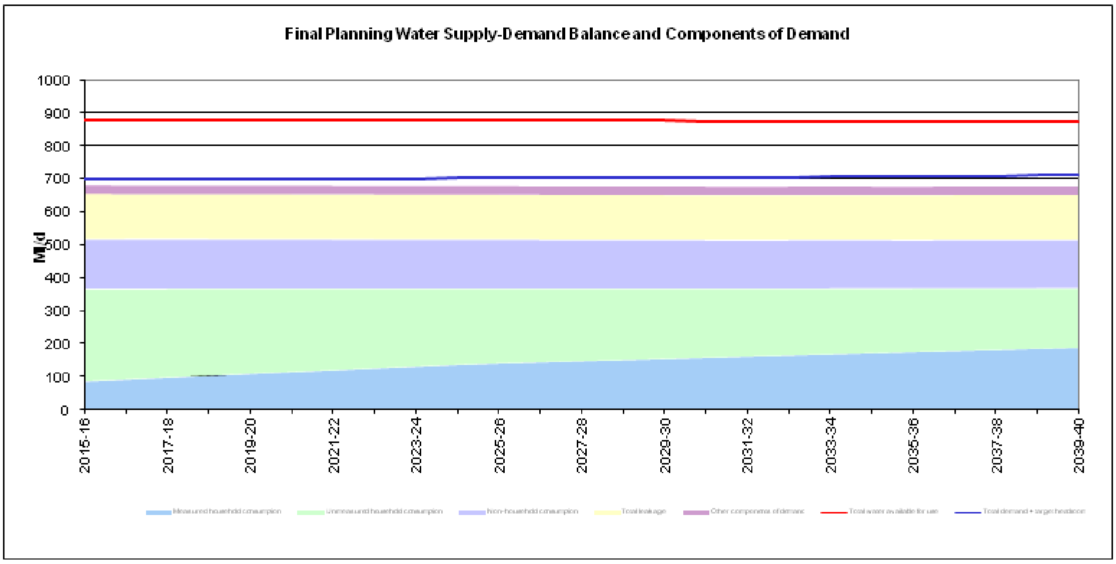
The supply demand balance demonstrates a surplus of supply for both Water Resource Zones over the planning horizon through to 2039/40. As such there are no plans to develop new water resources and therefore there are no resource schemes to appraise and no demand actions beyond those included in the base line

10.0 FINAL WATER RESOURCES STRATEGY

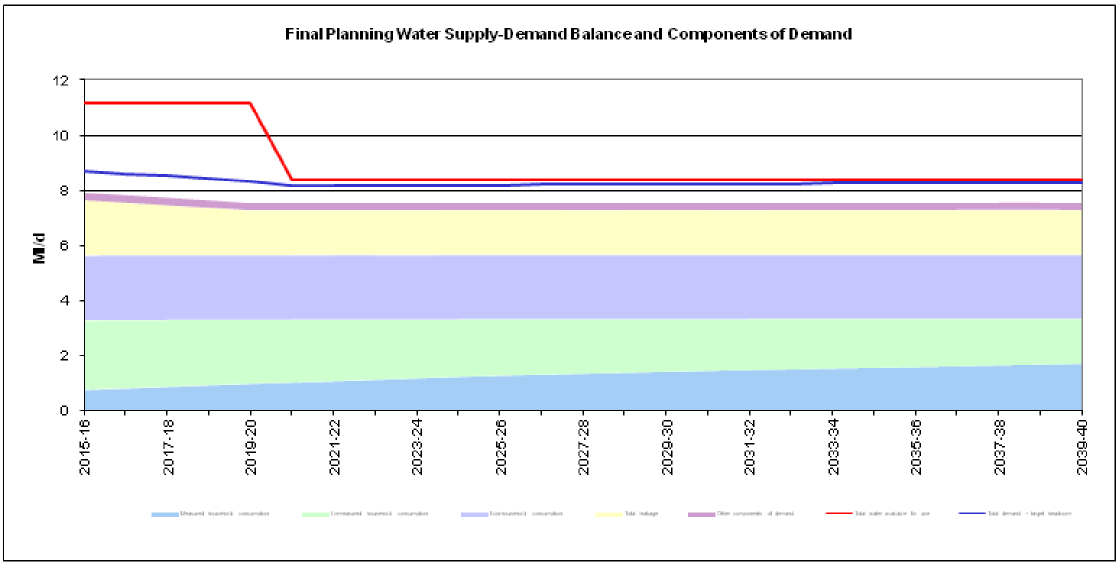
10.1 Final Planning Supply-Demand Balance

The final Plan is the same as the baseline plan as no additional supply or demand schemes are proposed beyond those in the baseline.

Kielder WRZ



Berwick WRZ



10.2 Summary of Overall Water Resources Strategy

The company will continue with its water efficiency and optant metering strategy. We will also begin the AMP6 period with our new Sustainable Economic Level of Leakage (SELL) of 138Ml/d. This SELL will be maintained over the whole planning horizon. No new water resource schemes are required although during AMP6 studies will be undertaken to get a fuller understanding of the sustainability of our abstractions from the Fell sandstones. This may result in options being considered for PR19.

11.0 WATER RESOURCES PLANNING TABLES

The tables are available on request by emailing waterresources@nwl.co.uk.

12.0 SECURITY INFORMATION

Appendix A has been excluded on the grounds that the information could be contrary to the interests of National Security. No other part of the Plan has been redacted.

APPENDICES

APPENDIX A: WATER RESOURCE ZONE INTEGRITY REPORT

This Appendix has been excluded from the draft Plan on advice from our Security Advisor on the grounds that the information would be contrary to the interests of National Security.

APPENDIX B: SEA SCREENING REPORT

DOCUMENT CONTROL SHEET

Report Title	Water Resources Management Plan SEA Screening		
Release Date	20th February 2013	**Report Status**	Draft Final
Authors	John Gray		
Reviewed by	Martin Lunn		
Previous Issue	None		
Distribution List	**Internal :** Applicable Management & Affected Depts **External :** Alison McAleer, Natural England		

Document History

Version	Approved	Date
Final	 Martin Lunn	20th February 2013

Northumbrian Water is a trading division of Northumbrian Water Limited which is a group company of Northumbrian Water Group

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CONTENTS

INTRODUCTION

Background

Northumbrian Water (NW) is currently preparing its draft PR14 Water Resources Management Plan (WRMP). This forecasts customer demand and water available for use (WAFU) and states how customer demand will be met between 2015 to 2040.

Central to the WRMP is the production of a "supply demand balance" which identifies surplus or deficits of water within individual Water Resource Zones (WRZ). NW has two WRZs, one for the Berwick and Fowberry supply area and one covering the area with the potential to be supported from Kielder reservoir.

NW has prepared a draft supply demand balance for each of its WRZs, all of which will have a surplus of water over the 25 year planning horizon.

PR09 WRMP Strategic Environment Assessment (SEA)

Directive 2001/42/EC of the European Parliament and of the Council on the Assessment of the Effects of Certain Plans and Programmes on the Environment (the Strategic Environmental Assessment Directive) was transposed into English law by the Environmental Assessment of Plans and Programmes Regulations 2004 (Statutory Instrument 2004 No.1633).

Subject to meeting defined conditions (confirmed through screening), plans and programmes require a Strategic Environmental Assessment (SEA) to be undertaken and an environmental report to be produced.

Purpose of this Report

The purpose of this report is to identify and document whether NW is required to undertake an SEA of its draft WRMP. This assessment will be based on the following guidance:

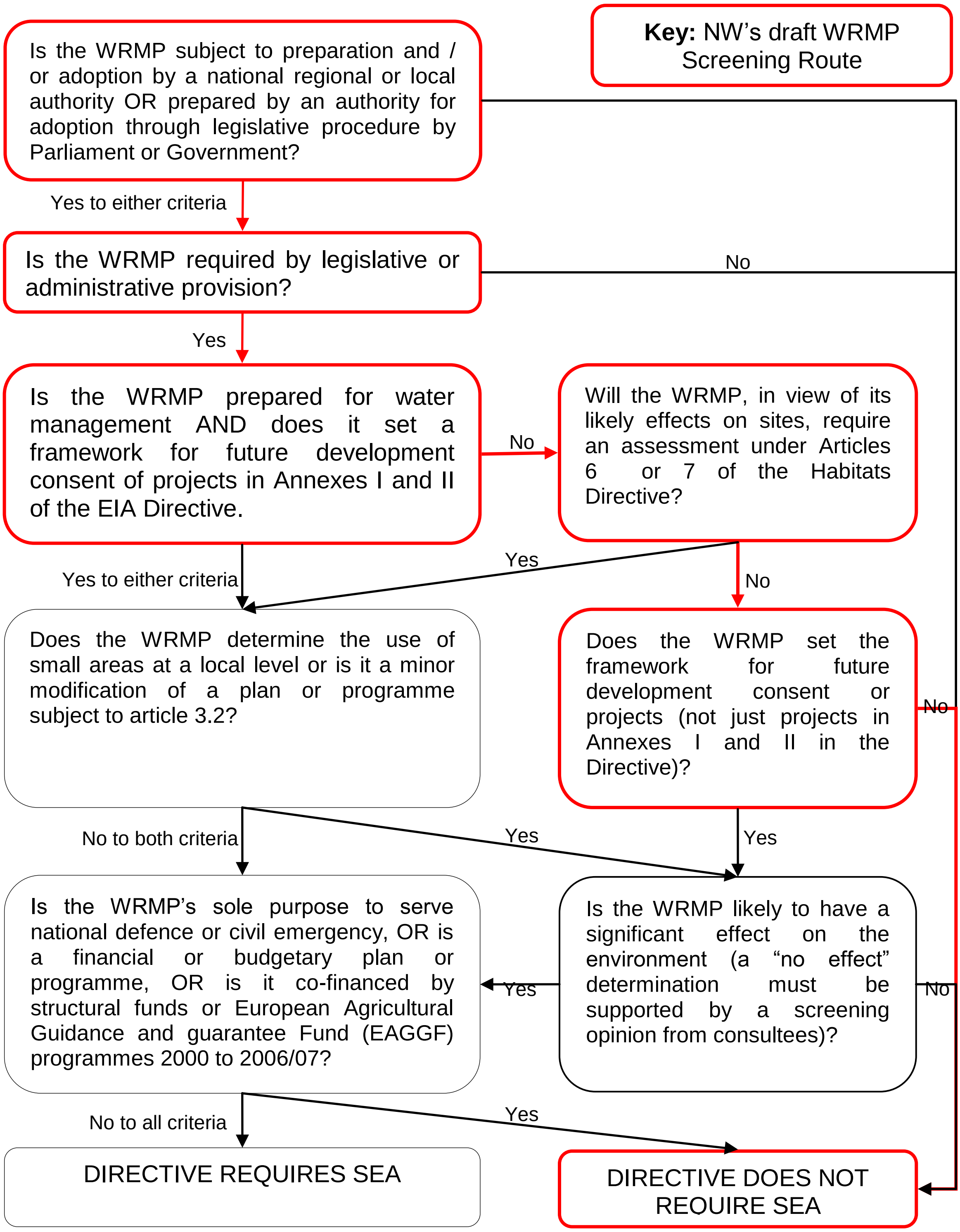
UKWIR (2007) Guidance for Water Resources Mgt Plans & Drought Plans

Environment Agency (February 2013) Strategic Environmental Assessment for Water Resources Management Plans – assessment of transfer options and consideration of cumulative effects

SEA Screening

Figure 1 below illustrates the key stages and the results of NW's SEA screening exercise using the 2007 UKWIR methodology.

Figure 1: Key Stages of Screening



Source: UKWIR (2007) Guidance for Water Resources Mgt Plans & Drought Plans

The results of the screening exercise are as follows:

i. The WRMP will be prepared and adopted by NW who, under the EIA Directive, is considered an "authority";
ii. The WRMP is required by legislative provision, being a statutory document under the Water Act 2003 amending the Water Industry Act 1991;
iii. The WRMP will be prepared for water management although based on the current draft supply demand balance calculations, it will not contain any supply schemes;
iv. The WRMP will not be seeking permission for any schemes which will require an assessment under Article 6 or 7 of the Habitats Directive;
v. The WRMP does not set the framework for future development consent or projects (not just projects in Annexes I and II in the Directive).

Based on the above assessment using the 2007 UKWIR methodology, NW concludes that its draft WRMP does not fall within the remit of the SEA Directive and therefore it is not required to undertake an SEA or prepare an SEA Environmental Report.

The Environment Agency has recently prepared a guidance note entitled, *"Strategic Environmental Assessment for Water Resources Management Plans – assessment of transfer options and consideration of cumulative effects"* (February 2013).

The note provides guidance on the assessment of proposed transfer options. It states that,

"The donor company should consider the potential environmental impacts of the transfer through its SEA where appropriate. The assessment a donor company may need to carry out will depend on the circumstances of the transfer. For example:

a. Where there is a definite dependency between a proposed transfer and a new resource(s), i.e. where the transfer is dependent on a new source(s) being developed by the donor company, the environmental impact of the new resource(s) should be assessed, alongside other options, within the SEA of the donor company's WRMP.

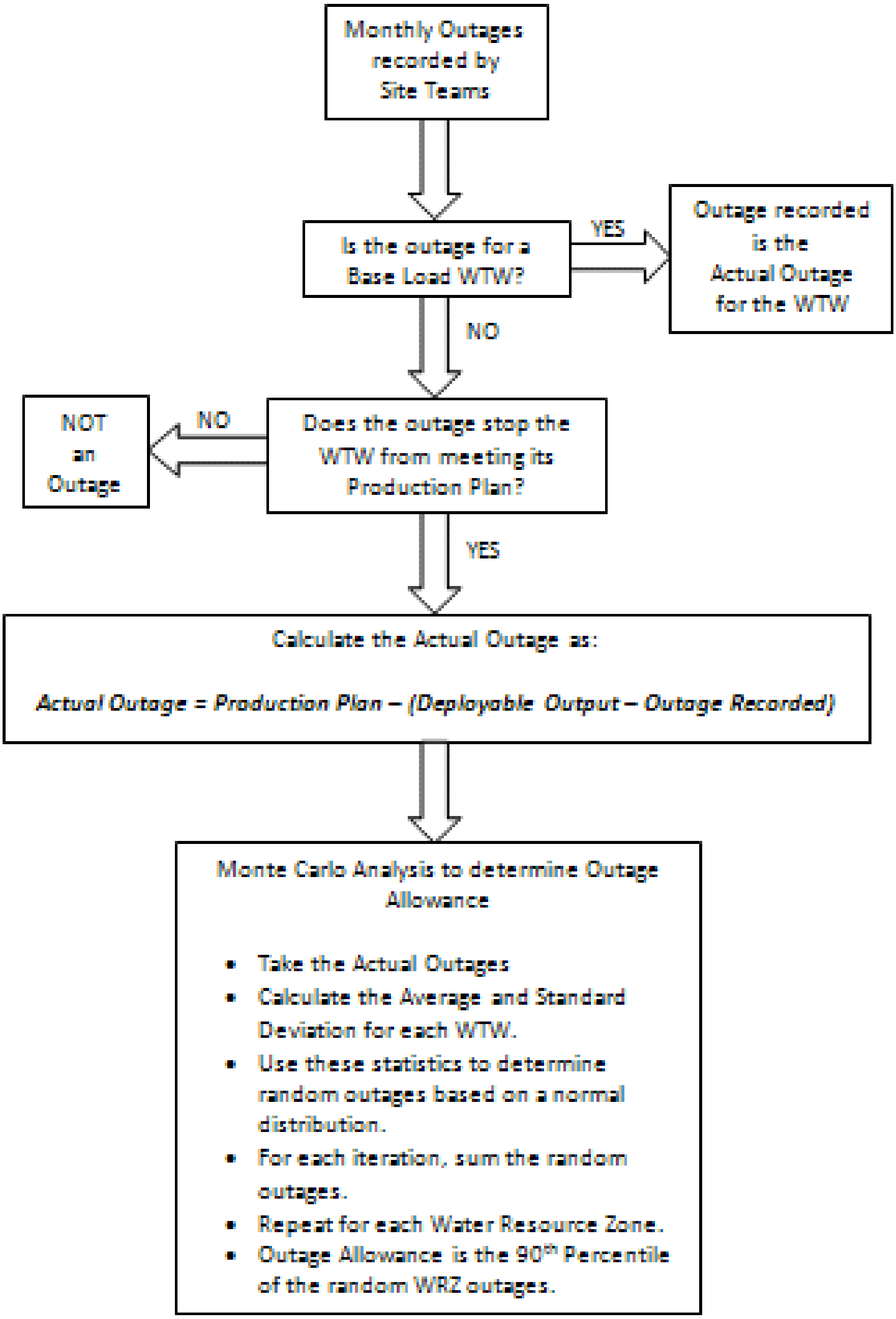
b. Where there is a surplus in the donor company's water resource zone, and the proposed transfer would operate within existing abstraction licence conditions, the donor company should consider if it is appropriate to assess the environmental impacts of the export within the SEA of its WRMP. For example, using an unused existing licensed source may have an environmental impact.

NW has an indicative supply surplus in its Kielder WRZ. If this surplus is traded with another water company, the WRZ will remain in surplus and will not have a supply demand deficit.

In a dry year, the trade could result in more frequent use of the Tyne-Tees Transfer System than otherwise would be the case. However, these transfers would be made within licence conditions.

Having considered the revised SEA guidance, NW still concludes that its draft WRMP does not fall within the remit of the SEA Directive and therefore it is not required to undertake an SEA or prepare an SEA Environmental Report.
In the event that a trade of NW's surplus is agreed, NW will provide the recipient water company with the necessary information that it would need to undertake an SEA should it be required to do so.

APPENDIX C: OUTAGE ALLOWANCE METHODOLOGY



Monte Carlo Outage Analysis results

Kielder WRZ

Percentile	Outage, Mld	Return Period
0	0.00	
10	10.66	
20	14.47	
30	17.55	
40	20.44	
50	23.19	1:2 Years
60	26.19	
70	29.22	
75	30.80	
80	32.92	1:5 Years
85	35.60	
90	38.64	1:10 Years
95	43.49	1:20 Years
100	68.69	

Berwick & Fowberry WRZ

Percentile	Outage, Mld	Return Period
0	0.24	
10	0.47	
20	0.53	
30	0.57	
40	0.61	
50	0.65	1:2 Years
60	0.69	
70	0.74	
75	0.77	
80	0.80	1:5 Years
85	0.84	
90	0.89	1:10 Years
95	0.97	1:20 Years
100	1.32	

APPENDIX D: MICROCOMPONENT AND OCCUPANCY SURVEY

Micro-component Letter

Abbey Road, Pity Me, Durham, DH1 5FJ
Telephone: +44 (0) 845 604 7468
Fax: +44 (0) 191 301 6202
Website: www.nwl.co.uk

NF
1 0000001 11
99900 00001

Property Number:

May 2012

Dear

Water Use Survey
"Help us to Help You"

At Northumbrian Water we are committed to providing **sufficient water supplies** to meet the needs of our customers in the long term. To do this we need to gain an understanding of how water is being used across our region. This enables us to evaluate how the **demand for water** is likely to change over a period of time.

In order to help us with this study, we are presently asking a number of households to fill in and return the enclosed **questionnaire**. The questionnaire asks a series of questions about how you use water and the appliances you currently own.

You have been randomly selected to take part in this survey and so we would greatly appreciate it if you could take just a couple of minutes to fill in the questionnaire and return it in the pre-paid envelope provided by XXDATEXX. We would like to emphasise that the answers you provide will only be used for the purposes of this study and that the results will be collated to a company-wide level.

Thank you very much for your co-operation and interest in taking part in this survey. For further information, please contact me on 01268 664013.

Yours sincerely,

T Wagstaff

Tim Wagstaff
Project Manager

01 0000001

NWGLH07

Northumbrian Water Limited
Registered in England and Wales No 2366703
Registered office: Northumbria House,
Abbey Road, Pity Me, Durham, DH1 5FJ

Micro-component Questionnaire

Water Use Questionnaire

ESSEX & SUFFOLK WATER

To help Essex & Suffolk Water understand water use in homes, please answer the questions below, by **CROSSING ☒ the relevant boxes in blue/black ink**. The confidentiality of this information is guaranteed through the Data Protection Act. This questionnaire will be read electronically so please write in a clear format and keep within the boxes. Thank you.

HOUSEHOLD

Q1. Is your property:

A house or bungalow that is: ☐ *Detached* ☐ *Semi-Detached*

☐ *Terraced (including end of terrace)*

Or a flat, maisonette or apartment that is: ☐ *Purpose built block*

☐ *Part of a converted or shared house*

☐ *In a commercial building e.g. (over shop, hotel, or office block)*

Q2. When was your property built?

☐ *pre 1900* ☐ *1900-1950* ☐ *1951-1988*

☐ *1989- 2000* ☐ *2001 onwards*

Q3. Property Ownership:

☐ *Owner Occupied* ☐ *Part Owned*

☐ *Rented from Private Landlord* ☐ *Housing association/ Local authority*

Q4. Is the property your: ☐ Main Residence ☐ Second Home

Q5. How many people are there in the following age groups? *Include only those people resident for more than 6 months of the year. Please answer* ***numerically (e.g. 2)***

Under 5 years old	
5-18 years old	
19-24 years old	
25-44 years old	
45-64 years old	
65-74 years old	
75-89 years old	
Over 90 years old	
Total Number of People	

Q6. How many adults are normally at home during the day (9am-5pm) from Monday to Friday? ☐

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APPLIANCES

Q7. Do you have any of the following? Please **cross** ☒ the number of each

	1	2	3	4	5
Sink					
Washbasin					
WC with single flush					
WC with dual flush					
Bidet					
Bath					
Shower attachment (to bath or basin taps)					
Power shower (pump attached to increase pressure)					
Shower					
Waste Disposal Unit					
Outside Tap					
Water Softener (plumbed in)					
Power Washer (patio cleaner)					
Washing Machine					
Combined Washer/Drier					
Dishwasher					
Cold Water Tank (in roof supplying cold water)					
Jacuzzi/ Hot Tub					

Other water using fittings/appliances, please state: ....

Q8. Have you fitted a WC since January 2001? ☐ *Yes* ☐ *No*

If Yes, how many? ☐

Q9. In a typical **week** how many loads do you wash? Please answer **numerically (e.g. 2)**.

Washing Machine Loads ☐ Per week
Dishwasher Loads ☐ Per week

Q10. Do you **most often** use a full load / half load?

	Full Load	*Half Load*
Washing Machine / Combined wash drier	☐	☐
Dishwasher	☐	☐

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Q11. Do you run your washing machine or dishwasher at night?

Washing Machine ☐ *Yes* ☐ *No*

Dishwasher ☐ *Yes* ☐ *No*

Q12. What is the total number of baths run (by all persons) each week? Please answer **numerically (e.g. 2).** ☐

How many of these are re-used (e.g. children sharing the bath)? ☐

Q13. What is the total number of showers taken (by all persons) each week? ☐

Q14. How many people leave the tap running while cleaning their teeth, if any? ☐

GARDEN

Q15. Does your property have a garden? ☐ *Yes* ☐ *No (If No please skip to Question 26)*

Q16. Does your garden have: (cross all that apply)

☐ *Lawn* ☐ *Flower Beds* ☐ *Patio Tubs/Pots*

☐ *Hanging Baskets* ☐ *Vegetable Bed* ☐ *Greenhouse*

Q17. Which of these do you water? (cross all that apply):

☐ *Lawn* ☐ *Flower Beds* ☐ *Patio Tubs/Pots*

☐ *Hanging Baskets* ☐ *Vegetable Bed* ☐ *Greenhouse*

Q18. How do you water the garden during the summer months (April-Sept)? (cross all that apply)

☐ *Hose* ☐ *Watering Can* ☐ *Irrigation system (rain collected)*

☐ *Sprinkler* ☐ *Mains Fed Irrigation system* ☐ *Do not water during the summer*

Q19. If you use a hose do you attach it to: ☐ *An inside tap* ☐ *An outside tap*

Q20. Does the hose have a trigger gun (allows flow to be turned off)? ☐ *Yes* ☐ *No*

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Q21. How many hours during hot weather do you water your garden in the week?

☐ *Less than 1 hour* ☐ *1-2 hours* ☐ *2-3 hours*

☐ *3-4 hours* ☐ *More than 4 Hours* ☐ *Never*

Q22. At what time of day do you most often water the garden?

☐ *9am-1pm* ☐ *1pm-6pm* ☐ *6pm-9pm* ☐ *9pm-9am*

Q23. Do you use bath/dish water to water the garden? ☐ *Yes* ☐ *No*

Q24. Do you own a water butt? ☐ *Yes* ☐ *No*

If yes, how many? ☐1 ☐2 ☐3 ☐4+

How many are connected to your guttering? ☐1 ☐2 ☐3 ☐4+

Q25. Do you have a:

	Yes	*No*
Swimming Pool	☐	☐
Jacuzzi/Hot Tub	☐	☐
Pond (which is mains water filled)	☐	☐

Q.26 How many cars do you own? ☐1 ☐2 ☐3 ☐4+

Q26. Which do you most often use to wash the car(s) at home?

☐ *Hose* ☐ *Power Washer* ☐ *External Car Wash* ☐ *Bucket*

Q27. Total No. of carwashes for all cars per month EXCLUDING visits to the car wash (give total for all cars)

☐0 ☐*1* ☐*2* ☐*3* ☐*4* ☐ *more than 4*

Thank you very much for taking part in this questionnaire. Please **return** in the pre-paid envelope **by XXDATEXX.**

Questionnaire WU May 2012 E M R 0 374469

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Codes for Questionnaires

	Northern
N M 1	NorthMeasuredAcorn < 13
N M 13	NorthMeasuredAcorn 13-23
N M 24	NorthMeasuredAcorn 24-36
N M 37	NorthMeasuredAcorn 37-43
N M 44	NorthMeasuredAcorn 44+
N U 13	NorthUnmeasuredAcorn 13-23
N U 24	NorthUnmeasuredAcorn 24-36
N U 37	NorthUnmeasuredAcorn 37-43
N U 44	NorthUnmeasuredAcorn 44+
N U RP	NorthUnmeasuredRandom
N M OP	NorthMeasuredOptant
N M EX	NorthMeasuredExisting

Occupancy Survey

Q. How many people are there in the following age groups in your household?

Include only those people resident for more than 6 months of the year. Please answer numerically (e.g. 2). If you do not feel happy disclosing ages please just fill in the total number of people at the bottom.

Under 5 years old	
5-18 years old	
19-24 years old	
25-44 years old	
45-64 years old	
65-74 years old	
75-89 years old	
Over 90 years old	

Total Number of People	

APPENDIX E: EA WRMP TABLES

Water Resource Management Plan Tables (WRMP)

Amendments have been made to some of the calculations within the WRMP tables where errors have been identified or basic demand components have not been accounted for. These issues and agreed work-a-rounds to the tables have been raised and agreed with the regional Environment Agency.

Details of these changes and explanations can be found below:

Measured household consumption (row 29 BL/FP)

29 BL	Measured Household PCC
29.1BL	Measured toilet flushing
29.2BL	Measured personal washing
29.3BL	Measured clothes washing
29.4BL	Measured dish washing
29.5BL	Measured miscellaneous internal use
29.6BL	Measured external use

The calculated row in 29BL/FP is the average PCC for all measured properties this includes New, Optants, Selectives and Existing metered customers. These metered categories have individual PCC's within the demand forecasting process. The measured separate microcomponent rows are based on the Existing customer group. The small difference between the sum of the microcomponents and row 29 is the difference when you average all measured groups. Row 29 also includes under registration in the calculation which is not included as part of the microcomponent process, as this should be customer consumption.

Unmeasured household consumption (row 26BL/FP)

30BL	Unmeasured Household - PCC
30.1BL	Unmeasured toilet flushing
30.2BL	Unmeasured personal washing
30.3BL	Unmeasured clothes washing
30.4BL	Unmeasured dish washing
30.5BL	Unmeasured miscellaneous internal use
30.6BL	Unmeasured external use

The calculated row in 30BL/FP is taken from unmeasured consumption which includes any water efficiency savings and used to calculate water delivered. The very small differences between 30 and sum of 30.1-30.6 is these do not include water efficiency targets. Water efficiency is included as part of total consumption.

APPENDIX F: POPULATION AND PROPERTY METHODOLOGY

Northumbrian Water Ltd

Population, Household and Property forecasts

August 2012

edge analytics

www.edgeanalytics.co.uk

Contact details:

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Edge Analytics Ltd

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Web: www.edgeanalytics.co.uk

1.0 Summary

1.1 Introduction

Each Water Company has a statutory requirement to produce a 25-year, Water Resources Management Plan (WRMP) which identifies a long-term and sustainable supply and demand balance for its Supply Area. The WRMP must take account of likely demographic change and must consider the implications of climate change upon water availability and use. Furthermore, with general concerns over the environmental sustainability of our lifestyles and the costs of water abstraction and use, Water Companies are required to consider how measures which introduce more 'efficient' water use might reduce per capita consumption (PCC).

The latest forecasts of demographic change in the UK suggest that population growth and household growth will be a ubiquitous characteristic of local communities over the next 25 years. Ageing population profiles and a reducing average household size are key considerations for planners and policy makers. More people living in more households will require more water; with the existing geographical disparities between the supply and demand for water projected to become significantly more acute. At the same time climate change is expected to increase water use and impact resource availability, with projections of rising temperatures, wetter winters, drier summers and increased climate variability.

In the face of this uncertainty, the Water Industry, comprising the individual Water Companies and the regulatory bodies, continues to evaluate the data and methodology it employs to produce estimates and forecasts of water demand. Northumbrian Water Limited (NWL) has requested an update to its household estimates and forecasts for District Meter Areas (DMA) within each of the Essex, Suffolk and its Northern area. Additional forecasts were requested for Drainage Areas (DA) in the Northern area.

The current economic situation and stagnation in the housing market makes forecasting a challenging proposition, with considerable uncertainty with regard to future demographic growth in local areas. Local authorities in Essex, Suffolk and the Northern area continue to develop their revised housing development policies and plans following the revocation of the previous RSS. These plans will evolve through local consultation over the next 6-12 months.

1.2 Previous Scenarios

During the latter part of 2011, Edge Analytics delivered a series of scenario forecasts for the NWL DMAs and DAs. These scenarios included the following:

1. SNPP - ONS 2008-based sub-national population projection (SNPP)
2. Migration-led – 2010-based population projection
3. CR 6 Yr – Dwelling growth based upon housing completion from the last 6 years
4. Short- term – Growth trajectory based upon pipeline planning applications

The 'Migration-led' scenario was included to ensure the very latest demographic evidence was being used for comparison with the 'official' 2008-based SNPP.

1.2 Updated Scenarios

During 2012, a variety of new demographic evidence has become available for local authority areas, including the following:

- Revised 2010 mid-year population estimates
- ONS 2010-based sub-national population projections
- Census 2011 populations & communal establishment populations

Given the new evidence, NWL has requested a revised set of forecasts for its DMA and DA geographies. Given there is now consistency between the 'official' SNPP projections and the latest mid-year population estimates, the 'Migration-led' scenario is not required as an alternative.

Two key scenarios have been derived:

- SNPP - ONS 2010-based sub-national population projection (SNPP)
- CR 6 Yr – Dwelling growth based upon housing completion from the last 6 years

Forecasts for each DMA and DA have been produced with a 2011-2040 time horizon, with the new 2011 base year consistent with the very latest 2011 Census data released in July 2012.

Each of these two forecasts encompasses the following components:

- Total population
- Population not-in-households
- Households
- Dwellings (properties)

In addition (in Essex and Suffolk only, as no data was available for the Northern area) an estimate of the 'Hidden & Transient' population has been apportioned to each DMA/DA based on a prior, 2008-based estimate.

A final 'short-term' scenario has been developed:

- Short- term – Growth trajectory based upon pipeline planning applications

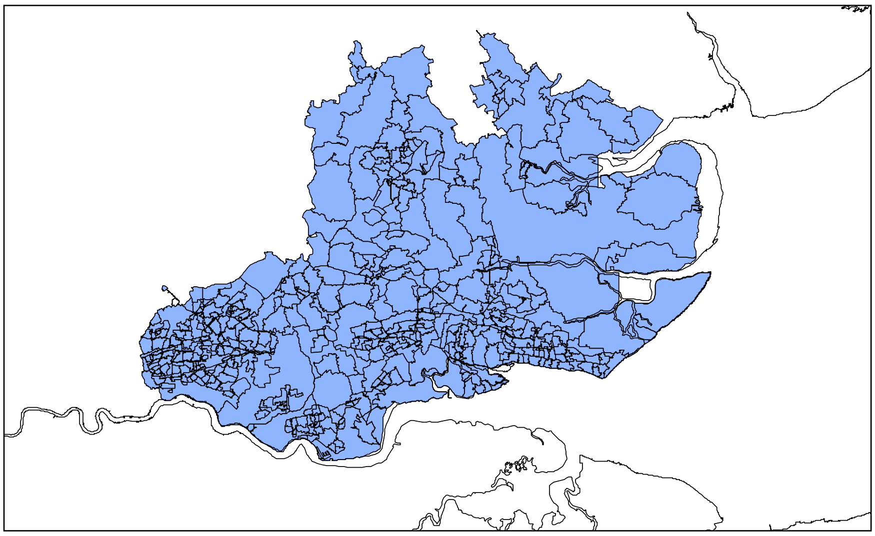
This illustrates the most likely property and household growth trajectory based upon pipeline planning applications for the development of residential units.

All scenarios are presented in a MS Excel workbook which allows NWL to access all data by individual DMA (or DA) or for the respective areas in total.

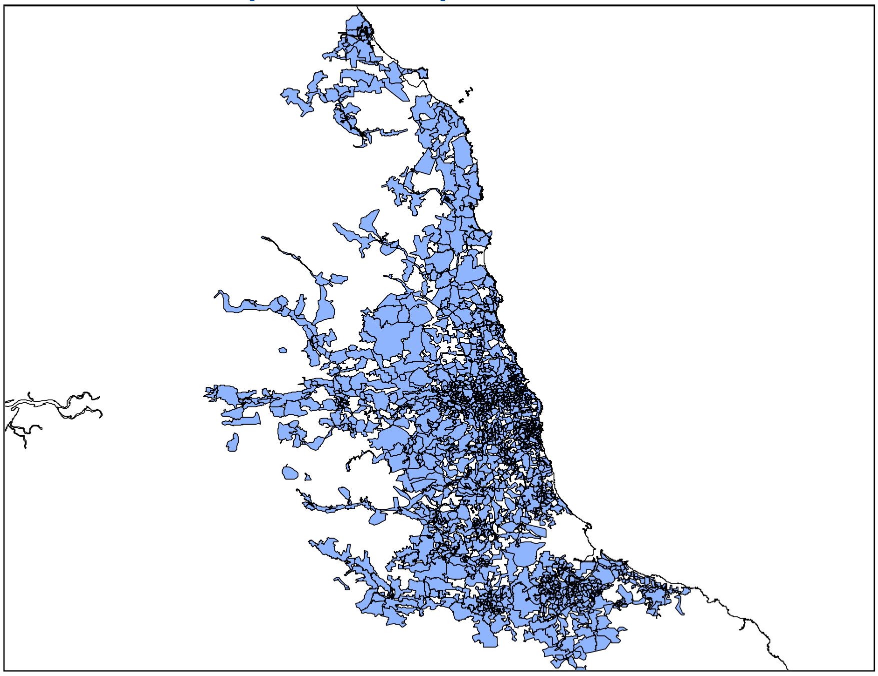
Area Definitions

The three areas of Essex, Suffolk and Northern were treated as separate areas and forecasts produced for each in turn. For each area, the 'total' was defined as the sum of the individual DMAs (or DAs). The definition of the DMAs by area is as follows:

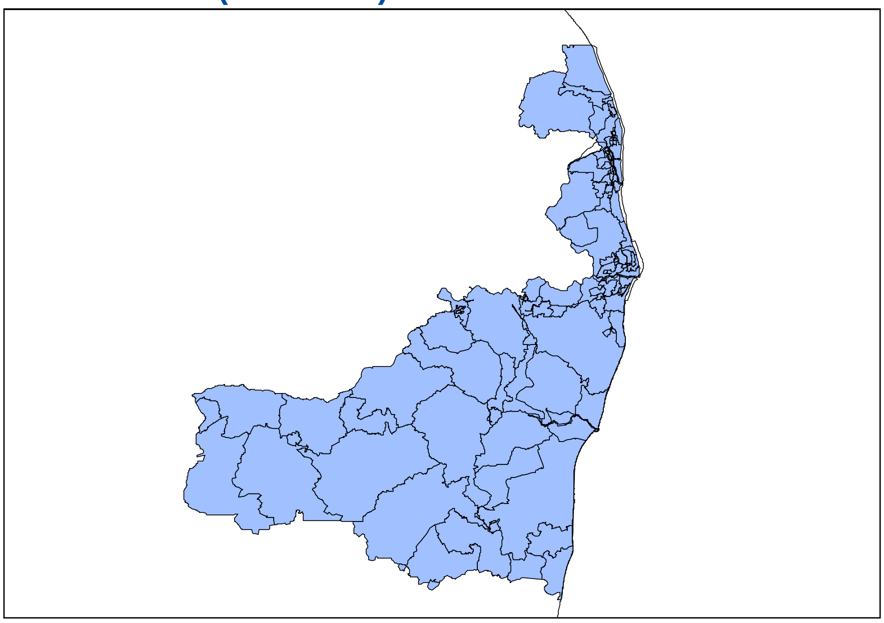
Essex DMAs (437 in total)



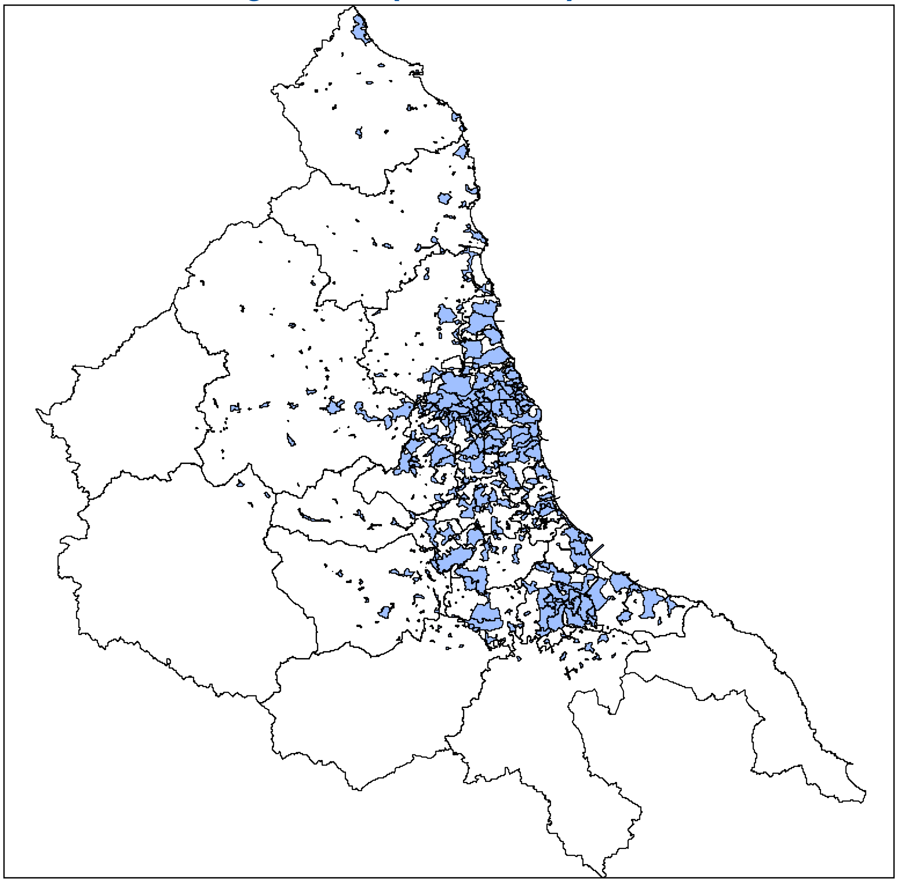
Northern DMAs (1381 in total)



Suffolk DMAs (85 in total)



Northern Drainage Areas (477 in total)



3.0 Data sources & scenario forecast definition

3.1 Data Sources

The following principal data sources have been used to derive the DMA estimates and projections.

- Census 2001
- ONS sub-national, mid-year population estimates, 2002-2010
- Census 2011 populations & communal establishment populations
- ONS sub-national population projections, 2010-based
- CLG household projections, 2008-based
- Output Area digital boundary data
- NWL digital DMA/DA boundaries
- NWL geocoded property database
- Glenigan's Planning Application database

3.2 Scenario forecast definition

Three alternative scenario forecasts have been developed for the NWL DMA/DA geographies. Each has been run with a 2040 forecast horizon. The definition of these alternative scenarios is as follows:

SNPP
The SNPP scenario is the benchmark against which other scenarios are compared. The scenario replicates the 2010-based sub-national projection from ONS; the latest set of 'official' projections for local authority districts in England. However, the projection is scaled to ensure consistency with the very latest 2011 Census data, with the SNPP trend continuing from 2012 onwards, after scaling has been achieved.

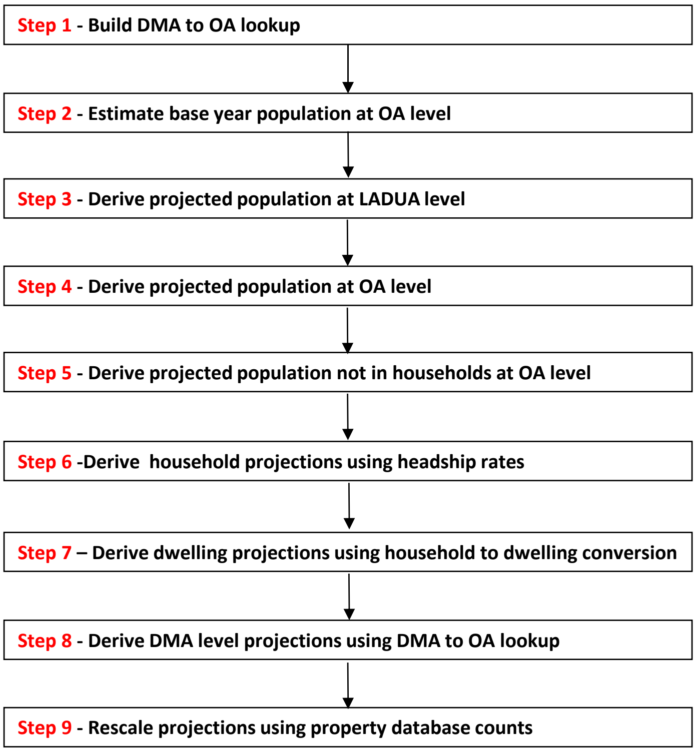
CR 6 Yr
The second scenario uses evidence on recent housing completions (average from the last six years) to derive a 'dwelling-constrained' forecast. Dwelling growth, based on the six-year-average of completion rates, acts as a 'constraint' on population and household growth, with 'migration' used to balance the population and households required to achieve the dwelling target. The projection again is scaled to ensure consistency with 2011 Census data. Dwelling constraints are applied from 2012 onwards.

Short-term
A final scenario illustrates the most likely property and household growth trajectory based upon pipeline planning applications for the development of residential units. This is a 'short-term' view as it takes into account only those developments that are in the planning pipeline, applying an average build-out of five years to all proposed developments.

4.0 Forecast Methodology

4.1 Long-term forecast methodology

The methodology that has been applied to the development of the forecasts is summarised as a series of distinct steps, as follows:



Step 1. Creation of a DMA to OA Lookup

Output Area (OA) and DMA digital boundaries have been used in conjunction with the NWL property database to build a lookup of OAs to DMAs. The property data is used to facilitate an accurate proportional assignment of an OA to its linked DMA. Where property data is not provided (for parts of OAs which lie outside any DMA) Royal Mail property information has been substituted.

Step 2. Estimation of a base year population at OA level

Mid-year population estimates are readily available for each year since the 2001 Census up until 2010. These data are available by age and gender for areas known as Lower Super Output Areas (LSOA) (aggregations of Output Areas). These data have been used in conjunction with OA level data from the 2001 Census to produce a base year (2011) estimate of population at Output Area level. An adjustment to the spatial distribution of population within each LSOA has been made to account for local area change between census year (2001) and the projection base year (2011). This adjustment is made using changes in Royal Mail address counts between these two years.

Step 3. Derivation of projected population at LADUA level

Alternative population forecasts for local authority district and unitary authorities (LADUA) within each of the three areas have been derived using the POPGROUP suite of demographic models. POPGROUP technology is used extensively by planners across the public sector. The software is owned by the Local Government Association (LGA) and is maintained, developed and distributed by Edge Analytics.

Population projections delivered using POPGROUP use a standard cohort component methodology (the methodology used by the UK statistical agencies). The household projections use a standard household headship rate as employed Communities and Local Government (CLG) for its household projection statistics. POPGROUP can also produce labour force projections using a standard economic activity rate methodology. A more detailed description of the population and household projection methodologies is available from the User Guide and Reference Manual on the POPGROUP website.

www.ccsr.ac.uk/popgroup/about/manuals.html.

Appendix 4.2 provides a summary illustration of the operation of the population and household projection methodologies.

For the NWL forecasts, one ‘trend’ scenario has been run using POPGROUP. The SNPP scenario replicates the latest ONS, 2010-based projections. A second ‘dwelling-constrained’ scenario (CR 6 Yr) has been run which projects recent annual average housing completions and controls population and household numbers to these housing totals.

Each scenario has been constrained to ensure that the ‘base’ year population, i.e. 2011 is constrained to match the 2011 Census total population.

The output from each of these scenarios provides the basis for which the OA and DMA/DA forecasts are produced.

Step 4. Derivation of projected population at OA level

The OA distribution of population by age group and gender (determined in Step 2) has been used to disaggregate the projected population at LADUA level derived in Step 3. This has provided a projected population by age group and gender at OA level for the 2011/12 – 2039/40 projection period.

Step 5. Derive projected population not-in-households at OA level

A count of population not-in-households by age group is provided at OA level in the 2001 Census. A projection of population not-in-households, also by age group, is provided at LADUA level in the CLG 2008 based household projections. This is provided as percentages for age groups over 75 and as counts for younger age groups. The OA level data has been re-scaled for each projection year so that it is consistent at LADUA level with the population not-in-households totals from the 2011 Census.

Step 6. Derive household projections using headship rates

An 'at risk' population has been calculated at OA level using the projected population by age and the population-not-in-households by age derived in Step 5. This population-at-risk has been used in conjunction with headship rates derived from the CLG 2008-based household projections. These headship rates have been scaled to account for the small area variation that exists between district and OA household formation, observed in the 2001 Census. The application of OA headship rates to OA populations by age and sex results in a household projection at OA level. Headship rates have been fixed beyond 2033, the latest year for which CLG information has been made available.

Step 7. Derive dwelling projections using household to dwelling conversion

Household projections at OA level have been used to derive a comparable dwelling (property) projection at OA level, using an OA-specific household-to-dwelling conversion ratio, again derived from the 2001 Census.

Step 8. Derive DMA level projections using DMA to OA lookup

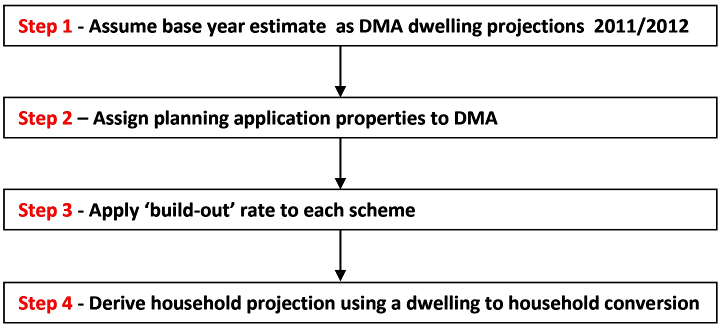
Using the DMA to OA lookup derived in Step 1, OA-based projections for population, households and dwellings have been apportioned to derive DMA-based projections.

Step 9. Re-scale DMA projections using property database counts

NWL property counts have been used to produce a re-scaled version of the DMA dwelling projections – aligning the base year with the number of domestic properties on the database. An equivalent re-scaled household projection has also been derived using an appropriate dwelling to household conversion factor. Population projections remain as in the un-scaled version.

4.2 Short-term forecast methodology

A final scenario has been developed which constrains future growth based on known (pipeline) planning application taken from the Glenigan's local authority database. The steps involved in the development of this scenario are as follows:



Step 1. Assume base year estimate as DMA dwelling projections 2011

The base year projection is taken to be the base year from the long term projections – see above.

Step 2. Assign planning application properties to DMAs

Planning application data – with a count of proposed properties (units of residential development) by postcode or postcode sector is provided by Glenigan's database. Proposed properties are assigned to DMAs based upon a lookup between postcodes and DMAs.

Step 3. Apply 'build out' rate to each scheme

A 'build-out' rate is applied to each proposed scheme. Given the uncertainty over the speed of future development, a prudent, five year build-out rate is applied to all planned developments, regardless of size. Each planned development is effectively spread over a five year period from its proposed start-date and aggregated to DMA level.

Step 4. Derive household projections using a dwelling to household conversion

The short-term dwelling projection is used to provide an equivalent short-term household projection using the appropriate dwelling to household conversion rate.

4.2 Hidden & Transient populations

NWL requested that an estimate of the Hidden & Transient population was added to the forecasts. No data is available for the Northern region but for Essex and Suffolk the Hidden & Transient total was taken from the 2008 report produced for NWL by the University of Leeds. The Hidden & Transient total is apportioned to individual DMA/DA based upon population size and is kept constant throughout the projection period.

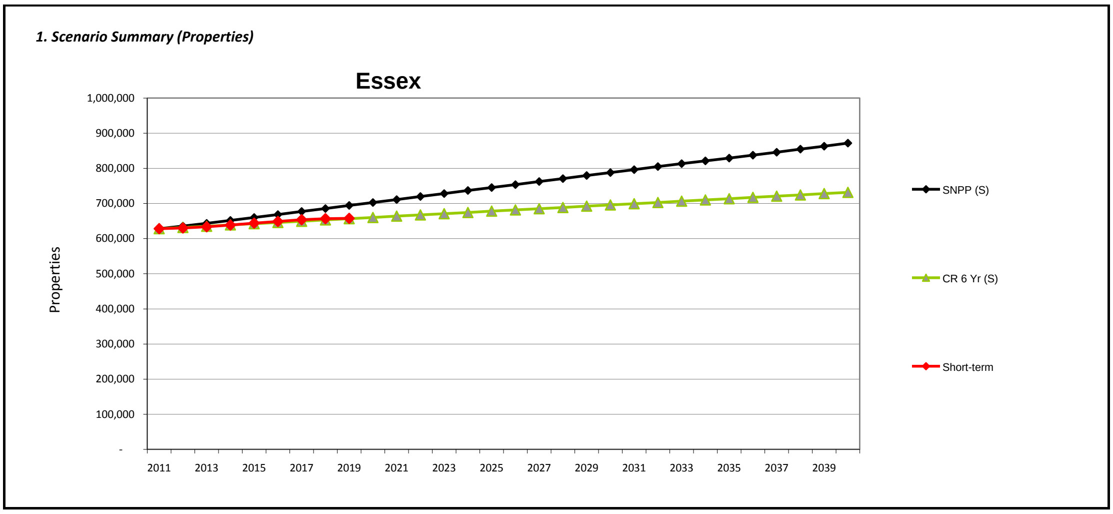
Results

Scenario results have been delivered within a MS Excel workbook. This workbook provides 'summary' information for each DMA/DA plus all the detail that sits behind these summaries. The table below is included in the workbook and provides guidance on the composition of each of the worksheets that has been provided.

Category	Sheet Name	Description
DMA Summaries	1. DMA Summary - Essex	Summary for each DMA in Essex
	2. DMA Summary - Suffolk	Summary for each DMA in Suffolk
	3. DMA Summary - Northern	Summary for each DMA in Northern area
WRZ Summaries	1a. Essex	Fixed summary with PR09 data included
	2a. Suffolk	Fixed summary with PR09 data included
	2b. Suffolk Blyth WRZ	Fixed summary with PR09 data included
	2c. Suffolk Hartismere WRZ	Fixed summary with PR09 data included
	2d. Suffolk N Cent WRZ	Fixed summary with PR09 data included
	3a. Northern	Fixed summary with PR09 data included
	3b. Kielder WRZ	Fixed summary with PR09 data included
	3c. Berwick WRZ	Fixed summary with PR09 data included
Properties (Rescaled)	4. SNPP Properties	Dwelling forecast for ONS 2010-based SNPP scenario, scaled to NWL billing data
	5. CR 6 Yr Properties	Dwelling forecast for 6-year completion-rate scenario, scaled to NWL billing data
	6. DMAShortTerm - Prop	Dwelling forecast for short-term based on pipeline planning applications
Households (Rescaled)	7. SNPP HHlds	Household forecast for ONS 2010-based SNPP scenario, scaled to NWL billing data
	8. CR 6 Yr HHlds	Household forecast for 6-year completion-rate scenario, scaled to NWL billing data
	9. DMAShortTerm - HHld	Dwelling forecast for short-term based on pipeline planning applications
Population	10. Pop_SNPP	Population forecast for ONS 2010-based sub-national population projection (SNPP)
	11. Pop_CR 6 Yr	Population forecast based on continuation of housing completion rates from the last six years
Population not in households	12. PopNotInHhlds_SNPP	Population not-in-households for ONS 2010-based sub-national population projection (SNPP)
	13. PopNotInHhlds_CR 6 Yr	Population not-in-households for 6-year completion-rate scenario
	14. Measured & Occ	Property type and void status taken from NWL billing data

Scenario forecasts: worksheet content (DMA Version)

For each DMA/DA a summary illustration of the scenario growth trajectories in terms of property numbers is provided. Users may choose from a 'drop-down' list of areas for each of Essex, Suffolk and the Northern area.



Scenario Summary

Within each summary, an indication of the type of properties present within an area is provided, taken directly from NWL's billing database.

2. Billing Data Summary (July 2011)

Occupied	606,998	Unmeasured	353,045
Void	66,998	Metered	320,951
Total	673,996	Total	673,996
Void %	10%	Metered %	48%

Property Summary

The detail associated with each forecast is presented, illustrating property, household, population, population-not-in-household, hidden & transient and population/property statistics.

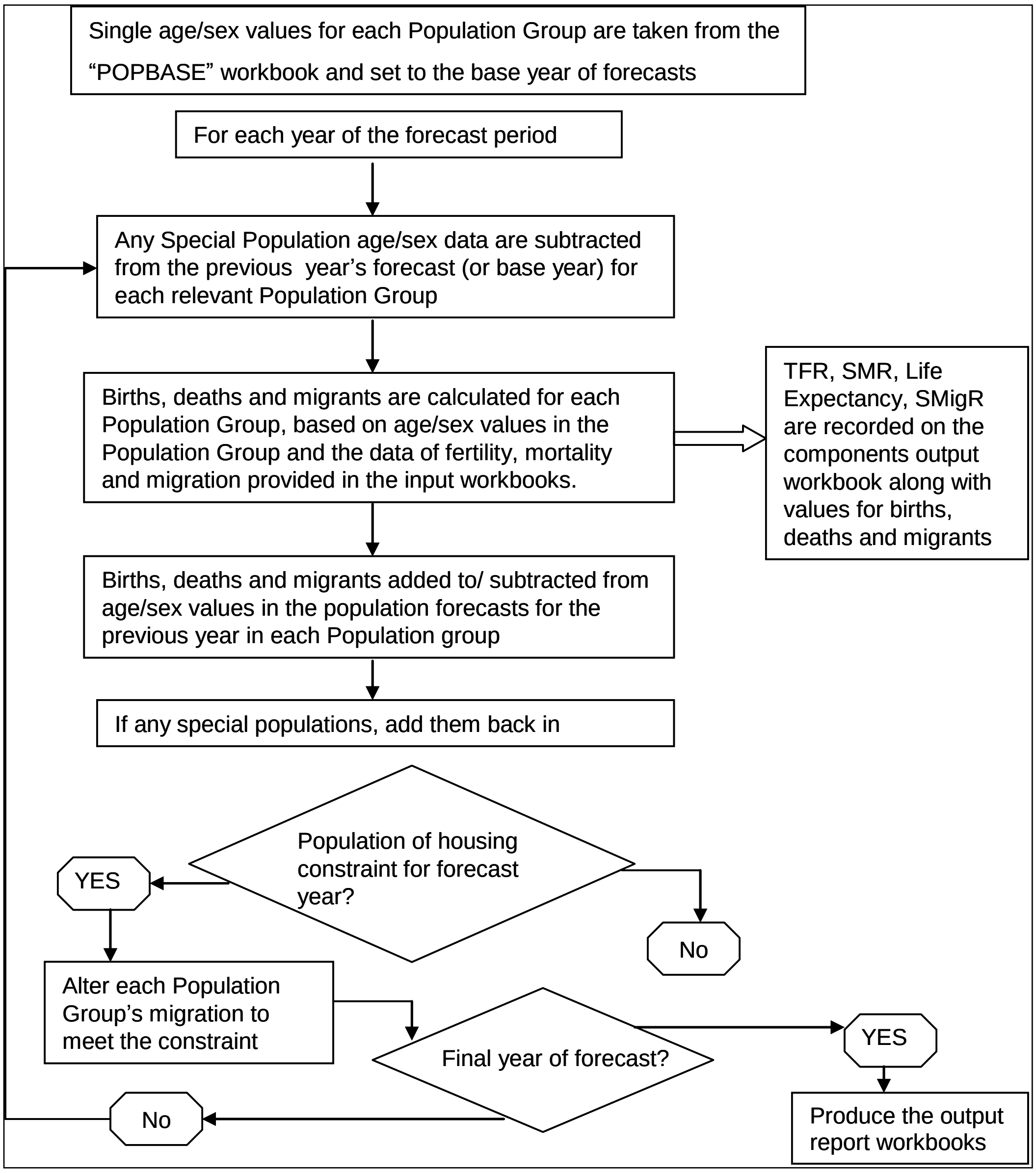
SNPP (S)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Properties	627,966	635,545	643,322	651,432	659,893	668,499	676,995	685,520	694,195	702,675	711,112	719,773	728,225	736,776	745,178	753,538	762,145	770,804	779,417	787,936
Households	612,948	620,351	627,945	635,867	644,131	652,536	660,837	669,166	677,642	685,928	694,174	702,636	710,894	719,248	727,461	735,632	744,043	752,505	760,921	769,243
Total Population (excl H&T)	1,552,436	1,569,470	1,587,186	1,605,392	1,623,702	1,641,996	1,660,218	1,678,402	1,696,712	1,715,061	1,733,213	1,751,049	1,768,501	1,785,614	1,802,395	1,818,834	1,834,903	1,850,802	1,866,579	1,882,129
Total Population (incl H&T)	1,575,401	1,592,435	1,610,151	1,628,357	1,646,667	1,664,961	1,683,183	1,701,367	1,719,677	1,738,026	1,756,178	1,774,014	1,791,466	1,808,579	1,825,360	1,841,799	1,857,868	1,873,767	1,889,544	1,905,094
Household Population (excl H&T)	1,540,355	1,557,250	1,574,842	1,592,918	1,611,062	1,629,204	1,647,250	1,665,247	1,683,377	1,701,512	1,719,445	1,736,977	1,754,114	1,770,959	1,787,473	1,803,689	1,819,435	1,834,977	1,850,416	1,865,649
Population not in hhld	12,081	12,221	12,343	12,473	12,641	12,791	12,968	13,156	13,335	13,549	13,768	14,072	14,387	14,655	14,922	15,145	15,468	15,825	16,162	16,480
H&T estimate	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965
Population / property	2.49	2.49	2.48	2.48	2.48	2.47	2.47	2.46	2.46	2.45	2.45	2.45	2.44	2.43	2.43	2.42	2.42	2.41	2.40	2.40

CR 6 Yr (S)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Properties	627,966	631,541	635,119	638,693	642,269	645,846	649,420	652,985	656,542	660,099	663,659	667,224	670,778	674,327	677,874	681,409	684,955	688,508	692,065	695,632
Households	612,947	616,439	619,934	623,428	626,924	630,420	633,914	637,400	640,879	644,358	647,839	651,324	654,798	658,266	661,735	665,193	668,660	672,132	675,607	679,091
Total Population (excl H&T)	1,552,477	1,557,837	1,563,482	1,568,573	1,573,255	1,577,315	1,581,824	1,586,730	1,591,165	1,596,248	1,601,240	1,605,225	1,609,364	1,612,817	1,616,781	1,620,595	1,623,549	1,626,333	1,629,155	1,632,271
Total Population (incl H&T)	1,575,442	1,580,802	1,586,447	1,591,538	1,596,220	1,600,280	1,604,789	1,609,695	1,614,130	1,619,213	1,624,205	1,628,190	1,632,329	1,635,782	1,639,746	1,643,560	1,646,514	1,649,298	1,652,120	1,655,236
Household Population (excl H&T)	1,540,451	1,545,697	1,551,244	1,556,235	1,560,776	1,564,715	1,569,072	1,573,812	1,578,094	1,582,986	1,587,780	1,591,488	1,595,337	1,598,548	1,602,270	1,605,889	1,608,548	1,611,004	1,613,514	1,616,339
Population not in hhld	12,026	12,140	12,237	12,338	12,479	12,600	12,752	12,917	13,071	13,262	13,460	13,737	14,027	14,268	14,512	14,706	15,002	15,329	15,641	15,932
H&T estimate	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965	22,965
Population / property	2.49	2.48	2.48	2.47	2.47	2.46	2.45	2.45	2.44	2.43	2.43	2.42	2.41	2.40	2.40	2.39	2.38	2.37	2.36	2.36

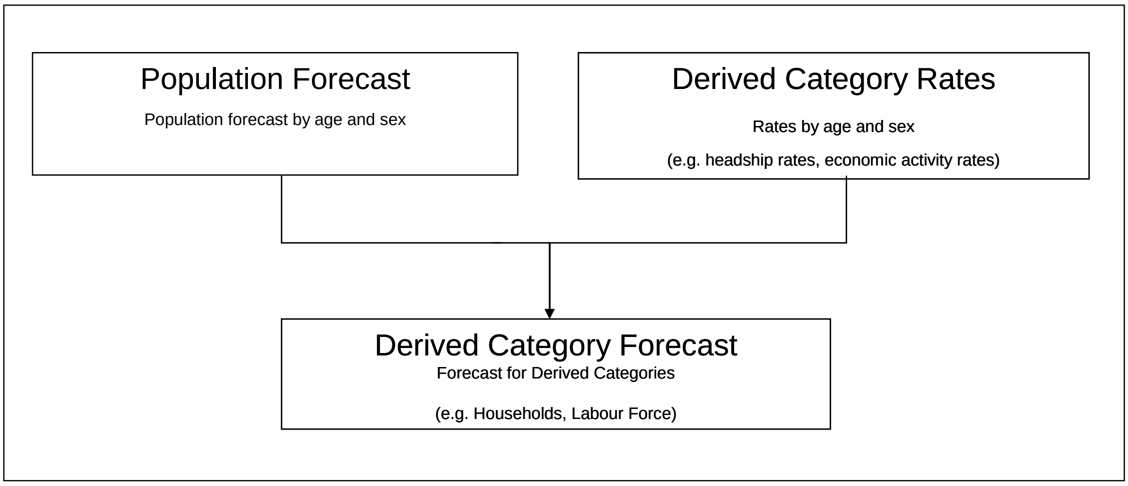
Short-term	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Properties	627,966	630,101	633,653	638,613	643,574	648,535	653,496	656,322	657,731											
Households	612,948	615,042	618,521	623,375	628,229	633,083	637,936	640,696	642,070											

Scenario Detail (scaled to 2011 billing data totals)

Appendix Edge 2



POPGROUP population projection methodology



Algebraically the model is defined as follows:

$$\mathbf{D}_{a,s,u,y,d,g} = \mathbf{P}_{a,s,u,y,g} * \mathbf{R}_{a,s,u,y,d,g} / 100$$

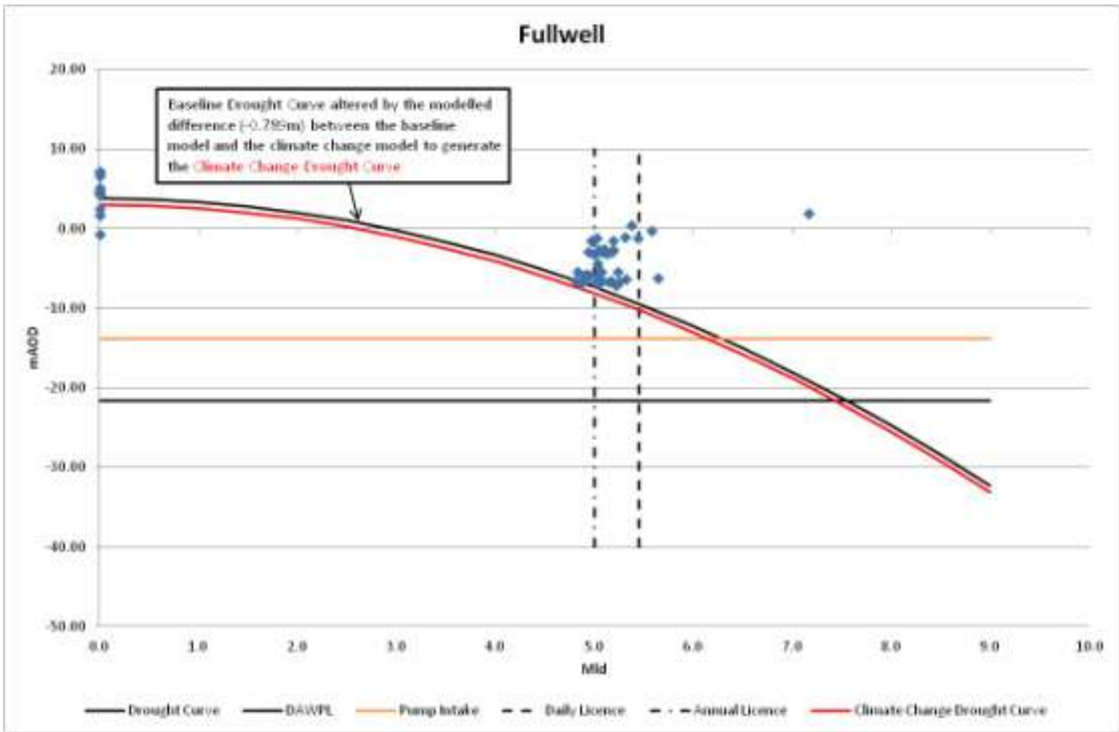
Where:

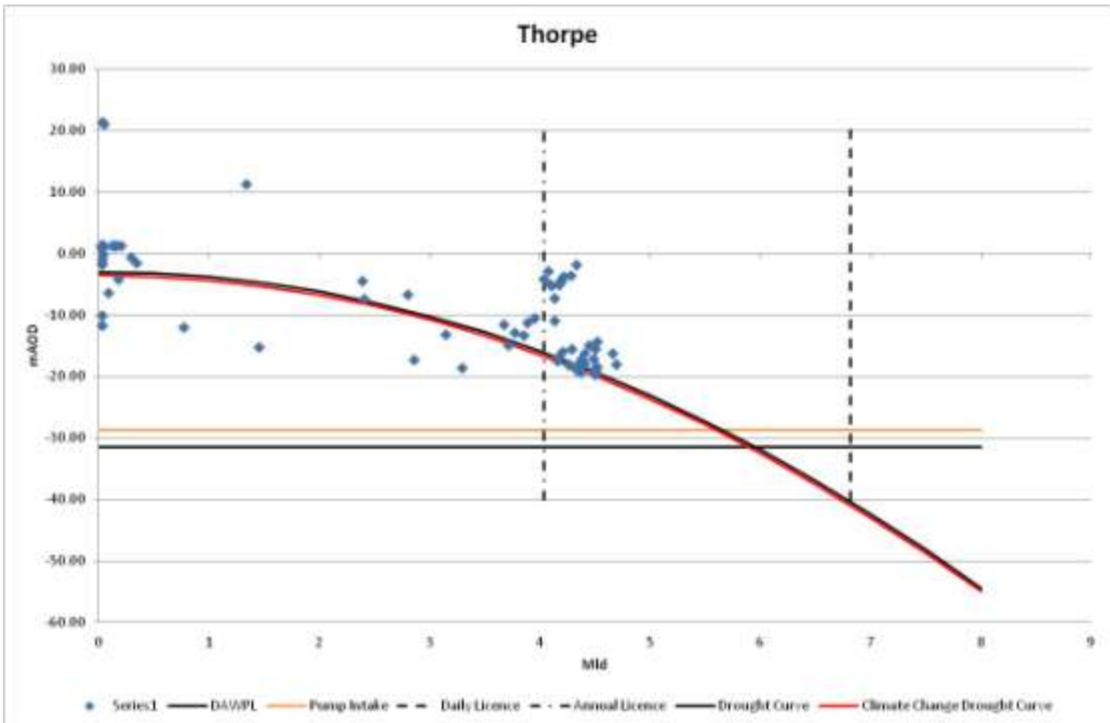
D = Derived Category Forecast
P = Population 'at risk' Forecast
R = Derived Category Rates

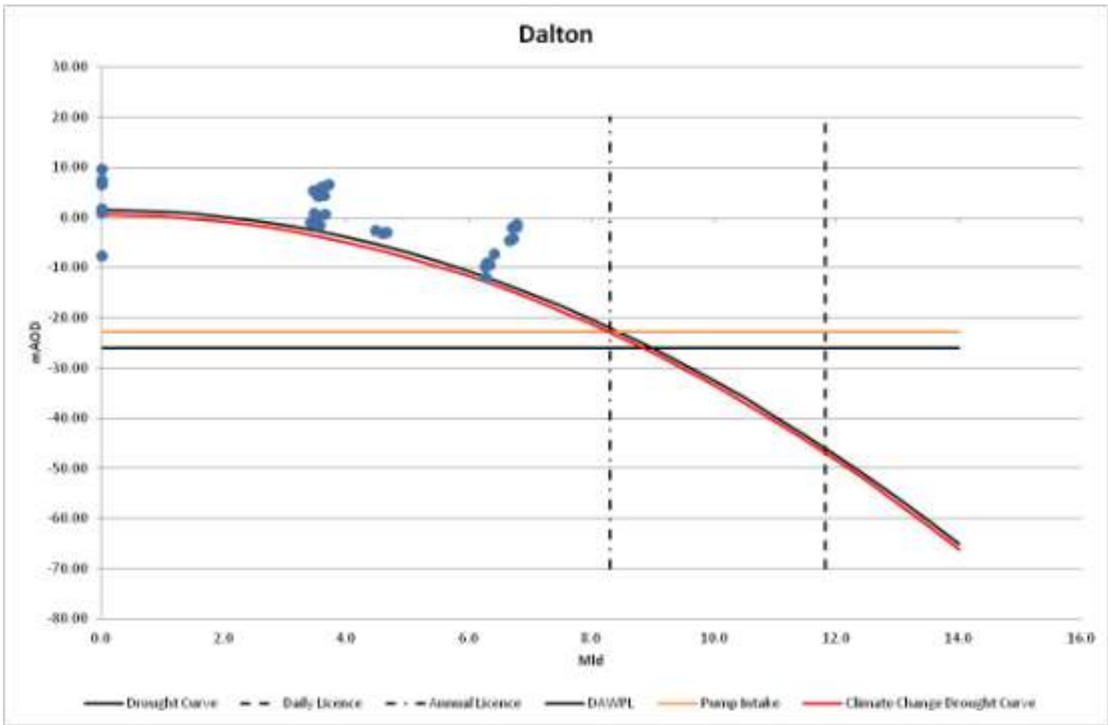
and
a = age-group
s = sex
u = Sub-population
y = year
d = derived category
g = group (usually an area, but can be an ethnic group or social group)

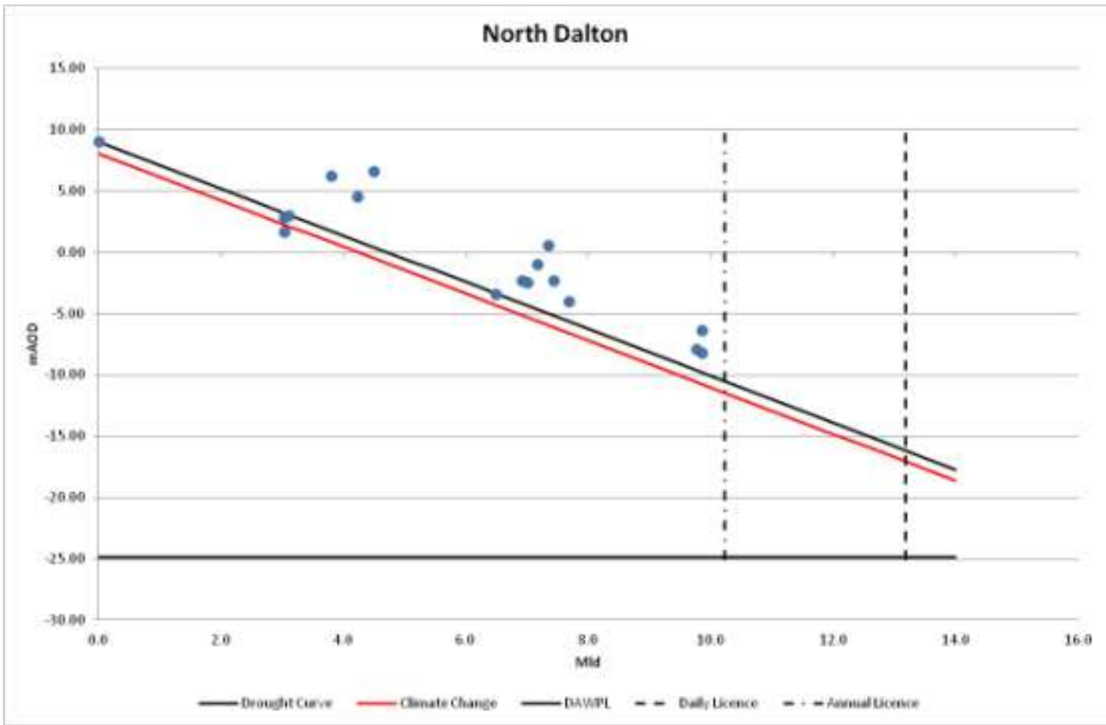
Derived Forecast Model: household projection methodology

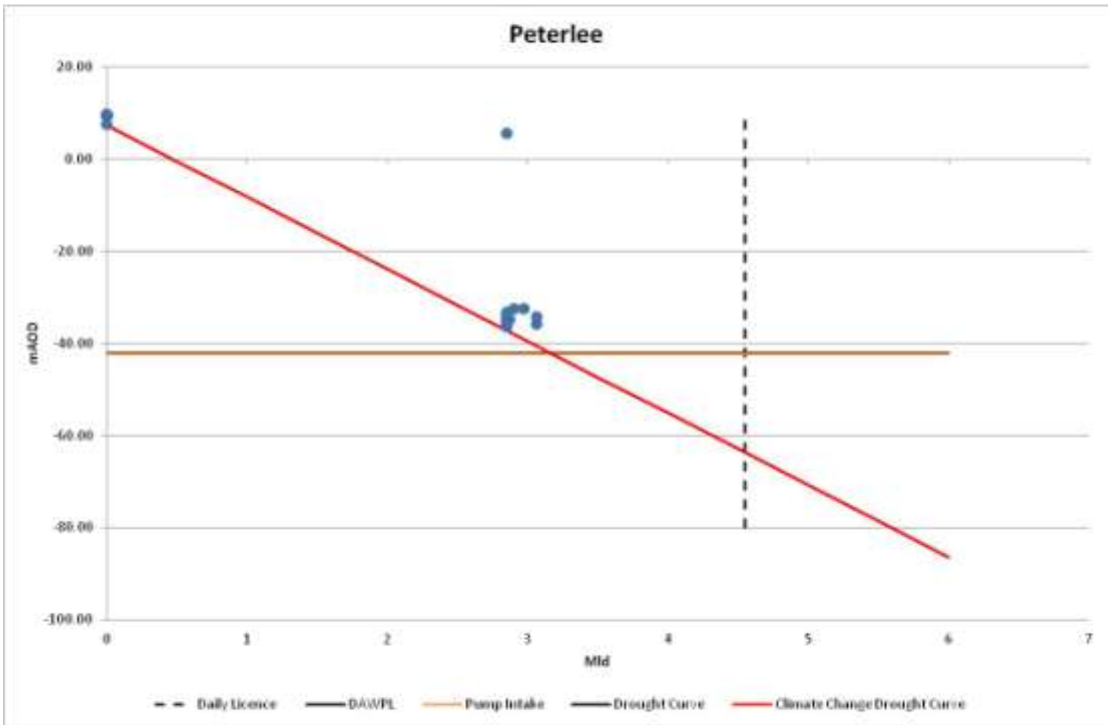
APPENDIX G: GROUNDWATER DROUGHT CURVES

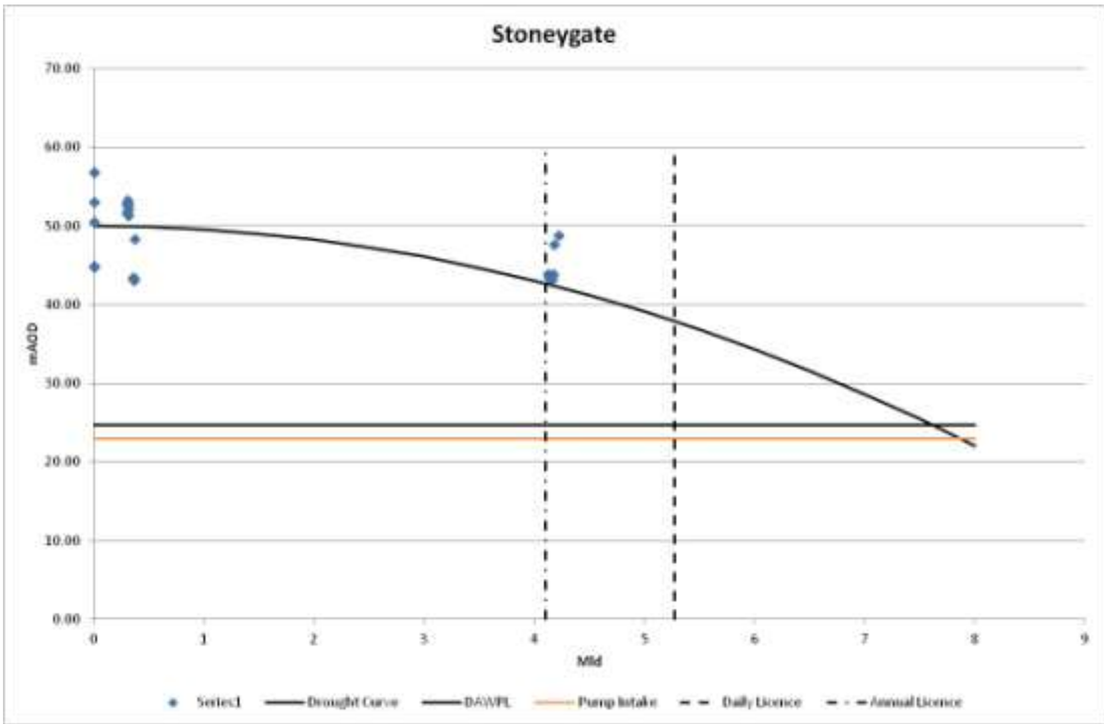

Fullwell
Baseline Drought Curve altered by the modelled difference (-0.789m) between the baseline model and the climate change model to generate the Climate Change Drought Curve
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
mAOD
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Mld
Drought Curve
DAWPL
Pump Intake
Daily Licence
Annual Licence
Climate Change Drought Curve

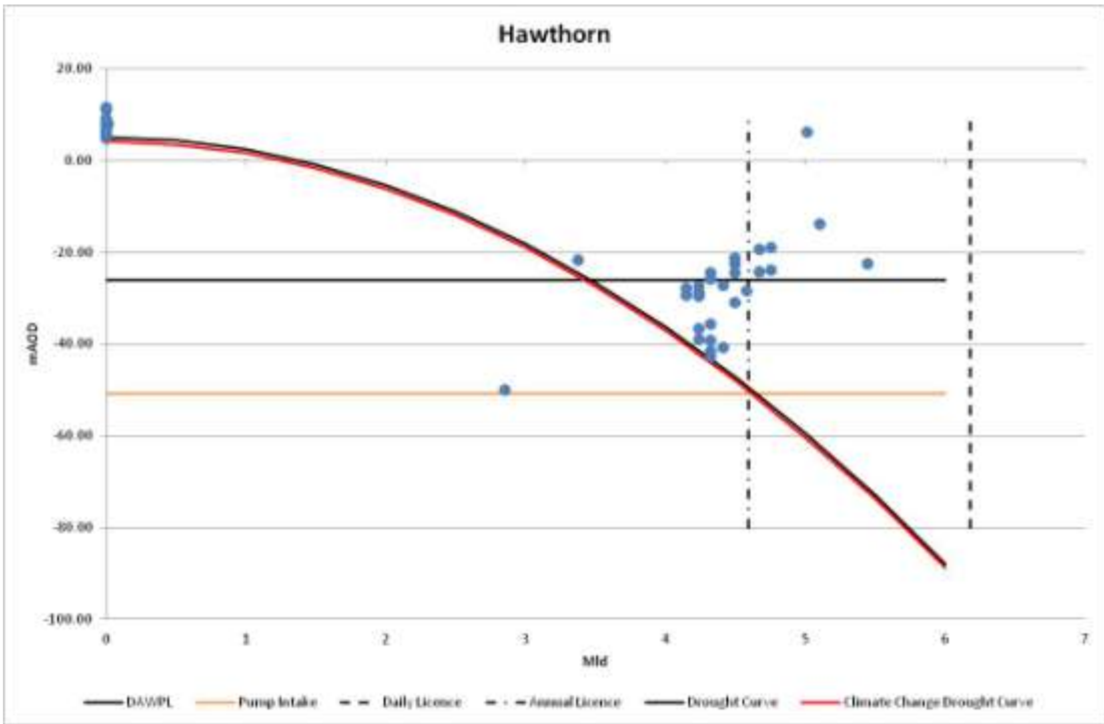

Thorpe
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
mAOD
0
1
2
3
4
5
6
7
8
9
Mld
Series1
DAWPL
Pump Intake
Daily Licence
Annual Licence
Drought Curve
Climate Change Drought Curve

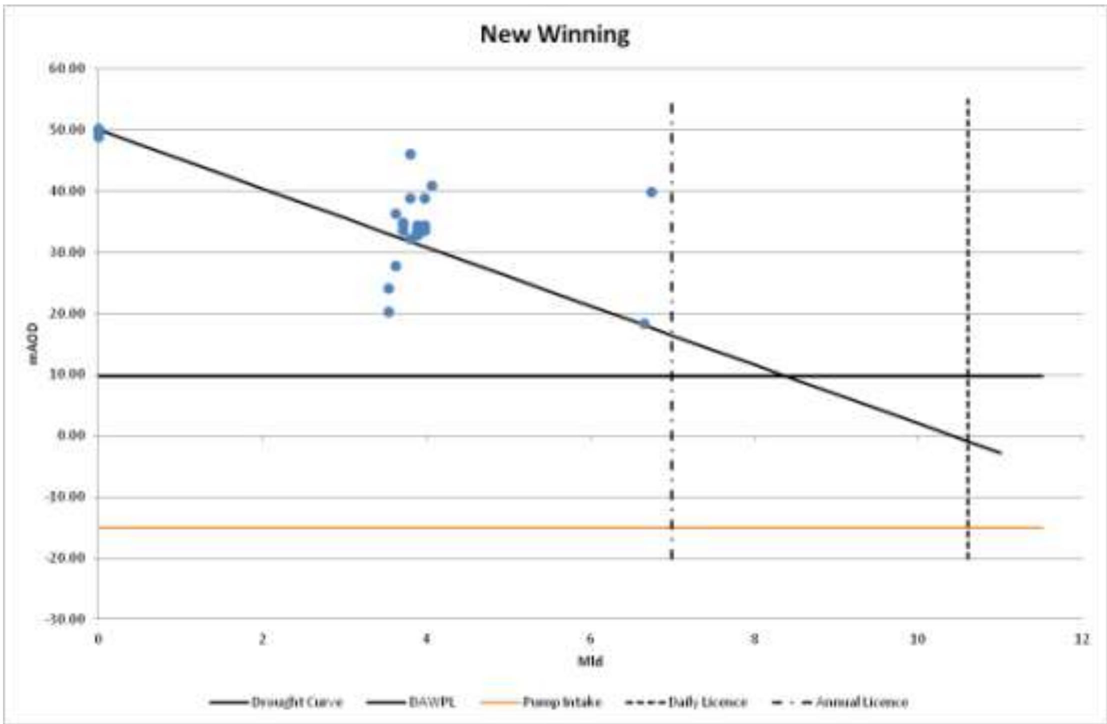

Dalton
mAOD
Mld
Drought Curve
Daily Licence
Annual Licence
DAWPL
Pump Intake
Climate Change Drought Curve

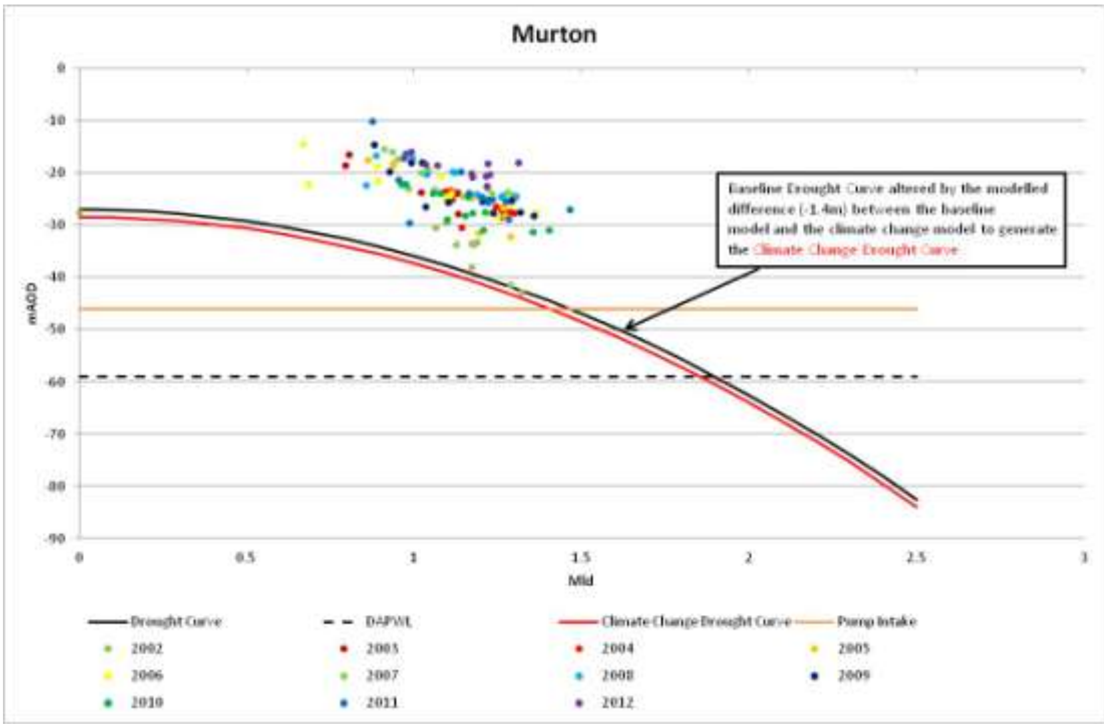

North Dalton
mAOD
Mld
Drought Curve
Climate Change
DAWPL
Daily Licence
Annual Licence

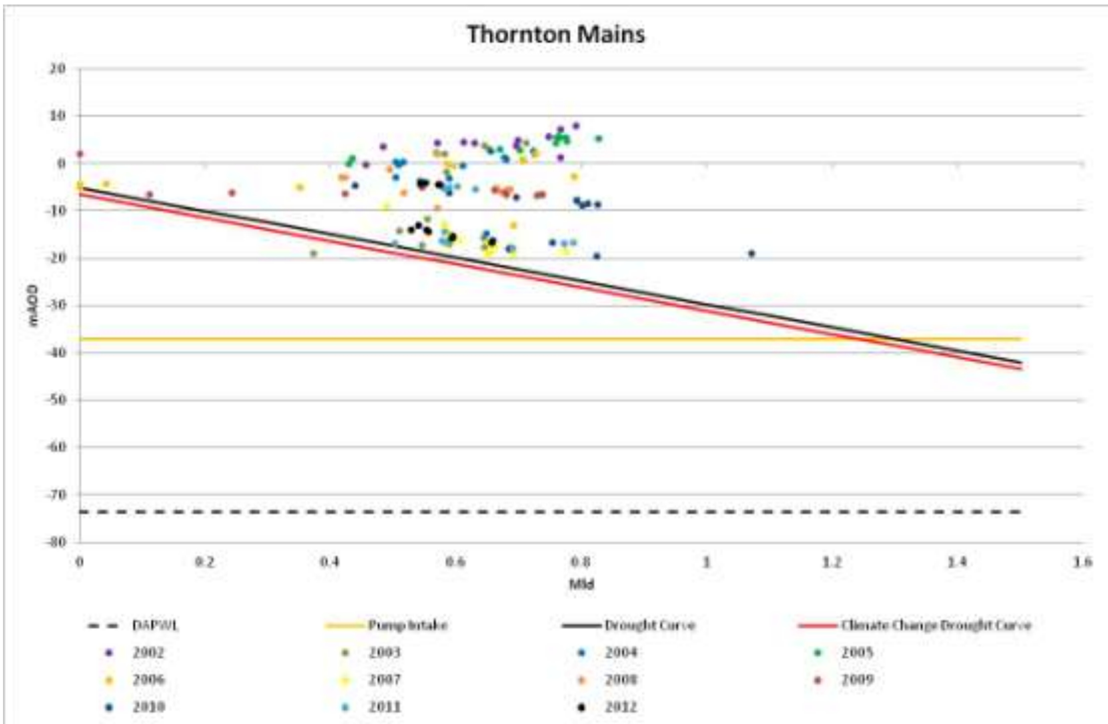

Peterlee
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
mAOD
0
1
2
3
4
5
6
7
Mld
Daily Licence
DAWPL
Pump Intake
Drought Curve
Climate Change Drought Curve

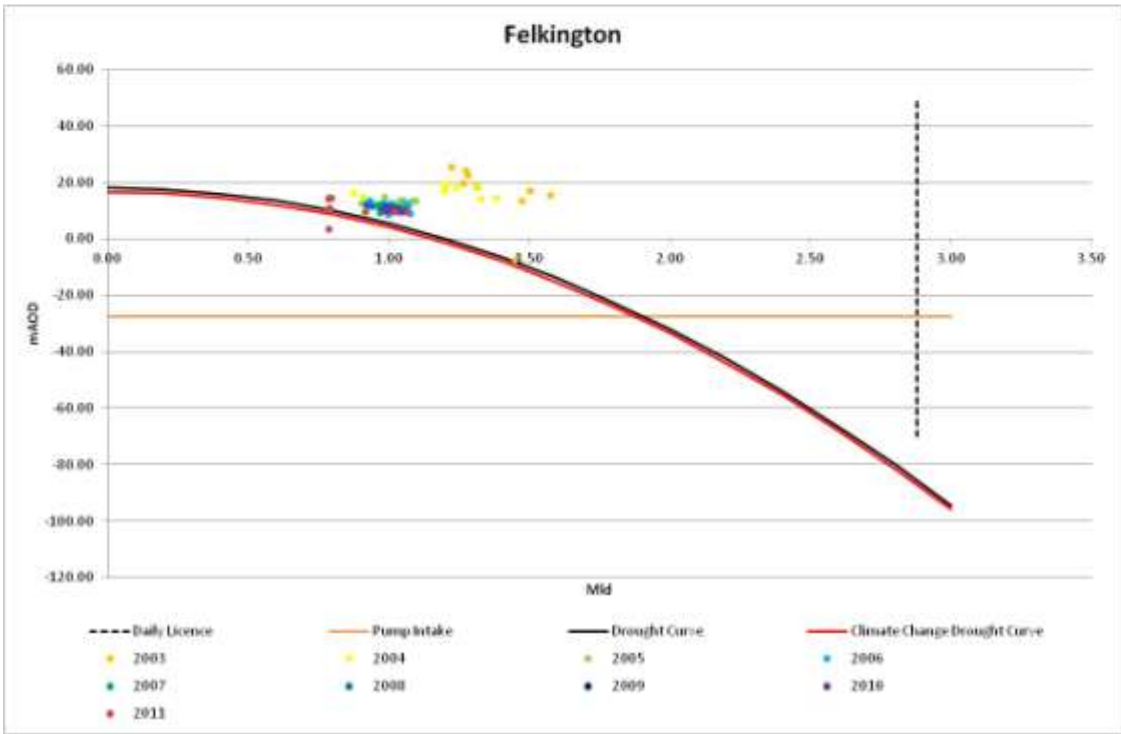

Stoneygate
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mAOD
0
1
2
3
4
5
6
7
8
9
Mld
Series1
Drought Curve
DAWPL
Pump Intake
Daily Licence
Annual Licence

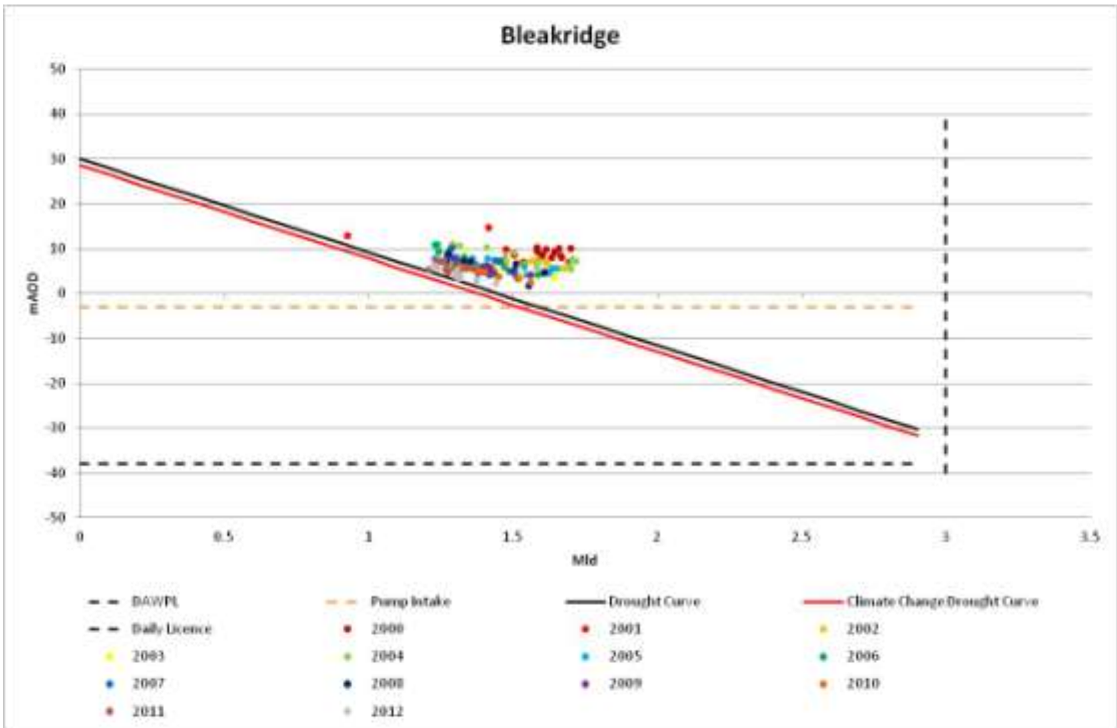

Hawthorn
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
mAOD
0
1
2
3
4
5
6
7
Mld
DAWPL
Pump Intake
Daily Licence
Annual Licence
Drought Curve
Climate Change Drought Curve

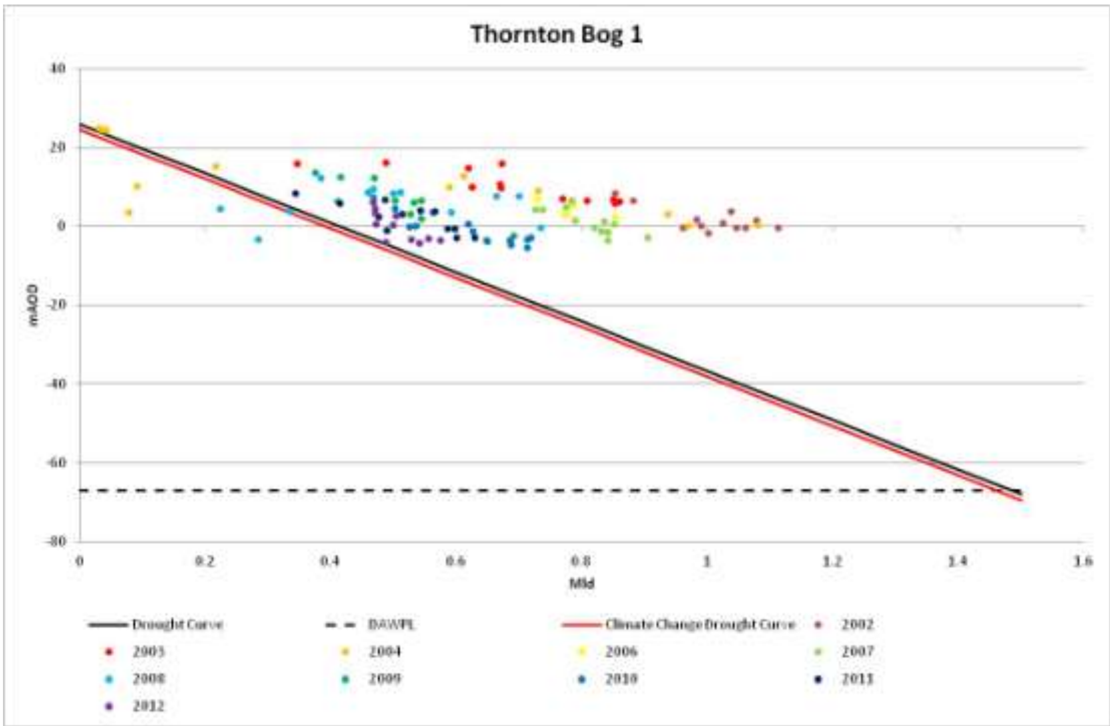

New Winning
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
mAOD
0
2
4
6
8
10
12
Mld
Drought Curve
DAWPL
Pump Intake
Daily Licence
Annual Licence

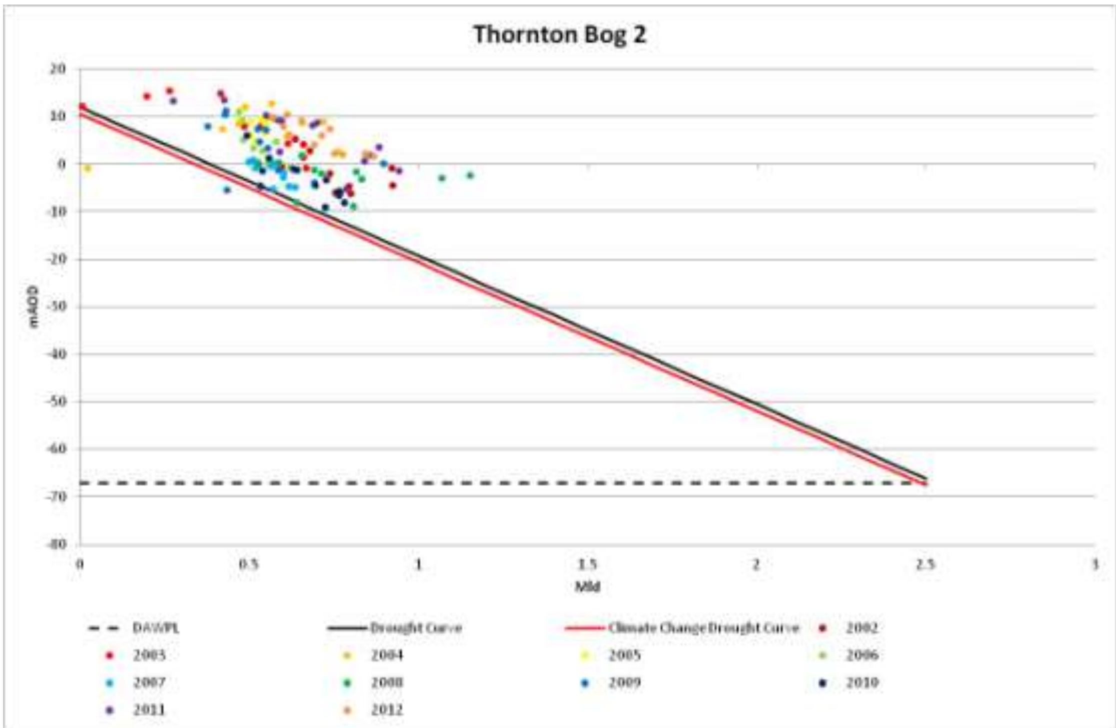

Murton
Baseline Drought Curve altered by the modelled difference (-1.4m) between the baseline model and the climate change model to generate the Climate Change Drought Curve
mAOD
Mld
Drought Curve
DAPWL
Climate Change Drought Curve
Pump Intake
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Thornton Mains
mAOD
Mld
DAPWL
Pump Intake
Drought Curve
Climate Change Drought Curve
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Felkington
mAOD
Mld
Daily Licence
Pump Intake
Drought Curve
Climate Change Drought Curve
2003
2004
2005
2006
2007
2008
2009
2010
2011


Bleakridge
mAOD
Mld
DAWPL
Pump Intake
Drought Curve
Climate Change Drought Curve
Daily Licence
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Thornton Bog 1
mAOD
Mld
Drought Curve
DAWPL
Climate Change Drought Curve
2002
2003
2004
2006
2007
2008
2009
2010
2011
2012


Thornton Bog 2
mAOD
Mld
DAWPL
Drought Curve
Climate Change Drought Curve
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012