northern ireland water

Delivering what matters

Water Resource And Supply Resilience Plan

31st March 2020

Contents

Glossary of Acronyms

Term	Description
AIC	Average incremental cost
AIR AIR09	Annual information return Annual information return 2009
AISC	Average incremental social cost
ALC	Active leakage control
AONB	Area of Outstanding Natural Beauty
Aquator	Water resource modelling application
ASSI	Area of Special Scientific Interest
BAP	Biodiversity Action Plan
BAG	Benefits assessment guideline
BFIHOST	Baseflow index
BH	Borehole
CAPEX	Capital expenditure
CC	Climate change
CERF	Continuous Estimation of River Flows
CEH-GEAR	Centre for Ecology & Hydrology – Gridded Estimates of Areal Rainfall
CCNI	Consumer Council for Northern Ireland
CWT	Clear Water Tank
DAERA	Department of Agriculture, Environment and Rural Affairs
DAF	Dissolved air filtration
DC(s)	Demand centre(s)
Defra	"Climate Change and the Demand for Water" (Defra, 2003)
DI	Distribution Input
DMA(s)	District Meter Area(s)
DN	Diameter Nominal
DO(s)	Deployable output(s)
DfI	Department for Infrastructure
DRD	Department for Regional Development
DYAA	Dry year annual average
DYCP	Dry Year Critical Period
EA	Environment Agency (England and Wales)
EBSD	Economics of balancing supply and demand
ELL	Economic level of leakage
E&S	Environmental & Social
GIS	Geographical information system
GVA	Gross Value Added
HH(s)	Household(s)
HRA	Habitats Regulation Assessment

IR	Impounded Reservoir
l/h/d	Litres per head per day – unit of per capita consumption
LFE	Low Flows Enterprise software
LoS	Levels of Service
LTA	Long term average
mHH	Measured household
mNHH	Measured Non-household
Ml/d	Mega litres per day
MLE	Maximum likelihood estimation
NHH	Non-household
NIAUR	Northern Ireland Authority for Utility Regulation
NIEA	Northern Ireland Environment Agency
NISRA	Northern Ireland Statistics and Research Agency
NI Water	Northern Ireland Water
NPC	Net present Cost
NPV	Net present value
NYAA	Normal year annual average
OPEX	Operational expenditure
PC15	Price Control 2015
PCC	Per capita consumption
PE	Potential evaporation
PET	Potential evapotranspiration
Planning Period	WR&SR Planning Period from 2015 to 2042
PPP	Public Private Partnership
ROI	Republic of Ireland
SAC	Special Areas of Conservation
SDB	Supply Demand Balance
SEA	Strategic Environmental Assessment
SELL	Sustainable Economic Level of Leakage
SPL	Supply pipe leakage
SR	Service Reservoir
TH	Target Headroom
TUBS	Temporary Use Bans
TMM(s)	Trunk mains model(s)
UCDB	Unit Cost Data Base
UKCP09	Climate Programme 2009
UKWIR	UK Water Industry Research Ltd
umHH	Unmeasured household
umNHH	Unmeasured Non-household
UR	Utility Regulator
WAFU	Water available for use

WCP	Winter Critical Period
WDMS	Water Demand Management Strategy
WFD	Water Framework Directive
WRMP	Water Resources Management Plan
WRPG	Water Resources Planning Guideline (England and Wales)
WRS 2002	Water Resources Strategy 2002–2030, published in January 2003
WR&SR	Water Resources and Supply Resilience
WRZ(s)	Water resource zone(s)
WSZ	Water Supply Zone
2006 Order	Water and Sewerage Services (Northern Ireland) Order 2006 (2006 No.3336 (N.I.21)),
WTW(s)	Water treatment work(s)
The Plan	Water Resource and Supply Resilience Plan

Executive Summary

Introduction

Northern Ireland Water (NI Water) has a legislative requirement to produce a Water Resource Management Plan (WRMP) and a Drought Plan as part of its forward planning process. The Water & Sewerage Services Act (Northern Ireland) 2016 permits NI Water to combine these two plans into the Water Resource and Supply Resilience Plan (WR&SR Plan). The WR&SR Plan sets out how NI Water intends to maintain the balance between supply and demand for water for all its customers over the long-term and the operational and management options and activities available to respond to short-term critical events such as drought and freeze-thaw. A key strategic aim of this plan is to improve the resilience of Northern Ireland's water supply system.

NI Water's most recent WRMP was published in 2012 (WRMP 2012) with an outlook up to 2035. The WR&SR Plan takes 2014/15 as its base year and has a planning horizon up to 2042/43 for the Water Resource Management element.

The Drought Plan element is the first plan of its kind to be published by NI Water.

Changes since the last Plan

There has been a significant decrease in the dry weather average demand from WRMP 2012 dropping from 677 Ml/d in 2008/09 to 570 Ml/d in 2014/15. This reduction of 107 Ml/d results from a combination of improved dry year uplift assessment (38 Ml/d), reduced household and non-household demand (55 Ml/d) and reduced leakage (14 Ml/d) achieved through continued high levels of active leakage detection and sustained investment in water mains. These high levels of active leakage detection and sustained investment will continue to maintain the Economic Level of Leakage (ELL) into the future.

NI Water has also invested in upgrading its water mains infrastructure, which allows it to transfer drinking water between towns and cities throughout Northern Ireland. In the WRMP 2012 the Carland to Cookstown Intervention was identified and this has since been implemented.

The following major capital projects, not recommendations of the 2012 WRMP, have also brought about significant improvements in its overall water mains infrastructure:

- Castor Bay to Belfast;
- Ballydougan to Newry;
- Castor Bay to Dungannon.

The result of the changes is that the security of supply for most of Northern Ireland's customers has significantly improved since the last plan. Tables A and B below illustrate the positive benefits across the Province between the 2012 Plan and the present in terms of the two main planning scenarios.

Table A - 2012 Water Resources Management Plan (Deficits for Normal and Dry Year Annual Average)

Water Resource Zone	Normal Year Annual Average (NYAA)	Dry Year Annual Average (DYAA)
South	None	**-20 Ml/d**
East	None	**-18 Ml/d**
North	None	None
Central	None	**-4 Ml/d**
West	None	None

Table B - Water Resource & Supply Resilience Plan (Deficits for Normal and Dry Year Annual Average)

Water Resource Zone	Normal Year Annual Average (NYAA)	Dry Year Annual Average (DYAA)
North	None	None
North East	None	None
East	None	None
South	None	None
South West	None	None
West	None	None
Central	None	None

Water Resource Zones (WRZs)

WRMP 2012 separated Northern Ireland into 5 WRZs based on the ability to transfer water around the supply system. The WR&SR Plan reviewed these boundaries and identified 7 WRZs to more accurately represent the system's connectivity. These WRZs are North, North East, East, South, South West, West and Central.

Levels of Service (LoS) and Drought Plan

The WR&SR Plan has taken the target LoS as providing customer reliability of 97.5%, equivalent to accepting a water supply failure for one year in forty. This is in line with the LoS adopted by several other UK water companies, including both Welsh Water and Scottish Water. To maintain customer supplies in drought events more severe than this, actions detailed in the Drought Plan are applied. The Drought Plan reflects the current infrastructure so some actions are currently required more frequently than the target LoS.

The Drought Plan incorporates Department for Infrastructure (DfI) guidelines on applying for a Drought Order and the process for consultation on the Order. The Drought Plan sets out the actions NI Water envisage would be required to maintain supplies with the minimum impact on customers and the environment. These measures include the consideration of hosepipe bans and non-essential use restrictions, and applications to the DfI for permission to reduce compensation flows.

Supply Demand Balance (SDB)

The supply assessment builds on the WRMP 2012 modelling through extension of flow sequences back over a longer period. There have also been discussions with Northern Ireland Environment Agency (NIEA) to better define constraints on some key water abstraction licences. The impact of climate change on Northern Ireland's water resources has been considered. The supply assessment has not significantly changed the water available for use. It has identified that the worst historical droughts impacting Northern Ireland's water resources in the over 100 year record occurred after 1975. The water available for use for the target LoS is approximately 765Ml/d.

The demand assessment has shown that there has been a significant decrease in demand compared to the WRMP 2012 which used 2008-09 as its base year for analysis. The dry weather average demand has dropped from 677Ml/d in 2008/09 to 570 Ml/d in 2014/15 (dry year demand). The forecast demand over the planning horizon shows a reduction to 556 Ml/d by 2021 as further leakage reduction takes place. This is followed by a very marginal increase to 575 Ml/d by 2042, driven by an increase in population.

The figures above represent the whole of Northern Ireland. However, a SDB assessment has been undertaken for each of the seven Water Resource Zones. Three planning scenarios have been assessed for each WRZ:

- Dry Year Annual Average (DYAA) based on a 1:40 drought;
- Dry Year Critical Period (DYCP) based on a summer critical peak demand;
- Winter Critical Period (WCP) based on the 2009/10 freeze thaw event.

The two Critical Period planning scenarios were not considered in the 2012 plan, and have been included to improve the robustness of the investment decision making process.

It should be noted that the Winter Critical Period is not based on the more severe 2010/11 event. The 2010/11 event is deemed such an unusually severe event that the WR&SR Plan does not plan for that scenario. Instead the 2009/10 event, which was a significant event, is used as the basis for the Winter Critical Period.

The SDB assessment shows that under the DYAA scenario all 7 zones have a surplus of water throughout the planning period. This is a significant improvement in resilience from the previous plan, which identified deficits in 3 of the 5 zones.

The new critical period scenarios have identified deficits at the end of the 2042 planning horizon in the South, Central and West zones. In the South WRZ there is a deficit of approximately 13 Ml/d in the DYCP only. In the Central WRZ there is a deficit of approximately 2 Ml/d in both the DYCP and WCP. In the West WRZ there is a deficit of approximately 3 Ml/d in the DYCP and a very small defecit of 0.1 Ml/d in the WCP. The remaining 4 zones have a surplus in all scenarios.

Options Appraisal

In order to address the deficits, a set of preferred options have been identified. These were derived following a comprehensive options development process. Firstly, a set of 'unconstrained' options were identified and screened on the basis of environmental, technical, water availability and promotability factors. The screening produced a 'constrained' list of feasible options that have been assessed in more detail based on a number of monetary and non-monetary factors. Combinations of the constrained options were tested and compared through a Least Cost Modelling exercise and Multi-Criteria Assessment undertaken in parallel with the Strategic Environmental Assessment.

On the basis of the options appraisal, a recommended plan has been developed which is strongly focussed on improving the resilience of the supply system and therefore the security of supply to NI Water's customers.

NI Water Resource Plan Recommendations

Demand Management activities are recommended throughout Northern Ireland. The activities to be implemented include; targeted non-household (NHH) water audits, schools water audit and retrofit, hotel and hospitals water audit and retrofit and farm audits. These are actions beyond the current water efficiency measures NI Water already promotes. NI Water Communications team will continue to work on initiatives promoting the water efficiency message.

In order to meet a 3Ml/day SDB deficit in the West WRZ, a trunk main from Carmoney Water Treatment Works (WTW) to Strabane is recommended to transfer water from the North Zone. However, taking into account overall resilience in the west of the country, a 17 Ml/d main is recommended. This is intended to provide additional security of supply in the West WRZ from a resilience perspective as it will enable the West WRZ to use the available headroom in the North WRZ in the event of an outage at the Derg WTW or any other WTW in that WRZ. This scheme is included in PC15 as a nominated output and was funded by the UR in the final determination pending clarification of abstraction licence conditions and risk. NI Water will continue to consider the priority of this and other schemes within its overall PC15 funding allocation taking into account other emerging priorities identified in the period. Any proposed changes would be requested through the formal change control process.

The abstraction licence at the River Faughan which supplies Carmoney WTW is currently being reviewed by NIEA. A Habitat Regulation Assessment has recently been carried out and no issues have been identified and therefore the risk is considered to be very low that the approved abstraction would be reduced below the current Carmoney WTW output. It is hoped that this review will be resolved in the coming months so that NI Water can proceed with the scheme.

The deficits in the South WRZ are to be addressed through the implementation of a 20 Ml/d pump station and trunk main to transfer water from Castor Bay WTW to Ballydougan Service Reservoir (SR). This will facilitate the transfers needed to cover the deficit in the South and Central WRZs and provides a further 4Ml/d of resilience for more extreme events. This WRZ currently shows a small deficit under the dry year critical period planning scenario and so the scheme will be promoted for implementation as early as funding provisions permit in order to meet this and the emerging deficit.

In order to meet a 2 Ml/d SDB deficit in Central WRZ, booster pumps will be required on the recently constructed transfer pipeline from Carland to Cookstown, to increase the transfer capacity from 2.4 Ml/d to 5.0 Ml/d.

A summary table of the areas showing deficits during all scenarios, including the critical periods, is shown in Table C & D below.

Table C – Summary of Supply/ Demand in Water Resource & Supply Resilience Plan

(Deficits for Normal and Dry Year Scenarios)

Water Resource Zone	Normal Year Annual Average (NYAA)	Dry Year Annual Average (DYAA)
North	None	None
North East	None	None
East	None	None
South	None	None
South West	None	None
West	None	None
Central	None	None

Table D – Summary of Supply/ Demand in Water Resource & Supply Resilience Plan

(Deficits for Critical Scenarios)

Water Resource Zone	Critical Period Scenarios	
	Dry Year Critical Period (DYCP)	Winter Critical Period (WCP)
North	None	None
North East	None	None
East	None	None
South	**-12.9 Ml/d**	None
South West	None	None
West	**-3.3 Ml/d**	**-0.1 Ml/d**
Central	**-1.9 Ml/d**	**-2.4 Ml/d**

Figure A below illustrates the Water Resource recommendations proposed.

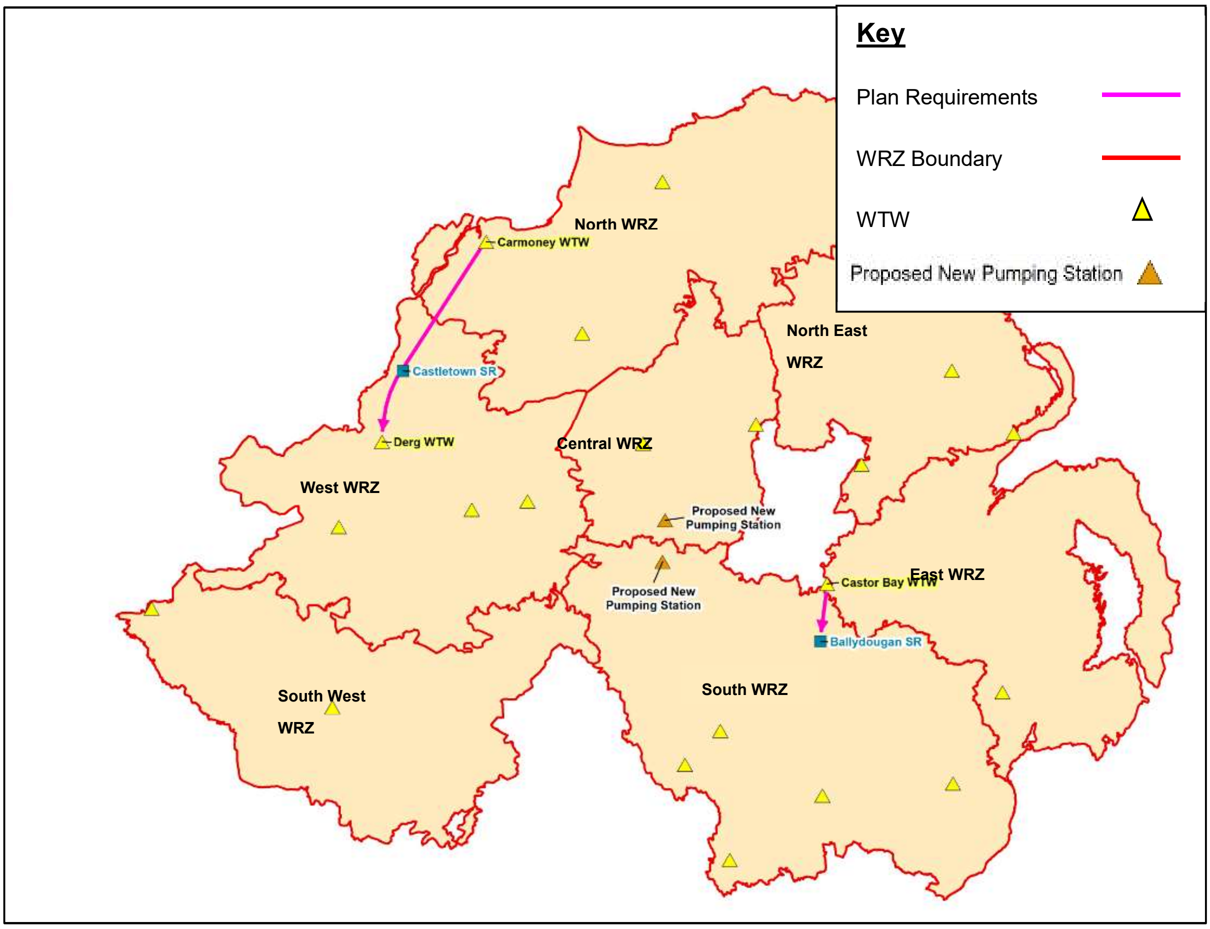


Figure A: Water Resource Recommendations

NI Water Supply Resilience Plan Recommendations

A number of potential resilience issues throughout the country were identified for consideration during the WR&SR Plan development. Several of these were discounted following further investigation for reasons including operational considerations, lack of benefit or lack of demonstrable need. It is recommended that the following remaining schemes are considered further during the early stages of the WR&SR Plan period to determine their scope, whether they are necessary and whether they would prove cost beneficial for improving the resilience provided to NI Water's customers.

- Lough Fea WTW & Moyola WTW Resilience;
- Upgrade Killyhevlin WTW;
- Seagahan to Clay Lake Trunk Main;
- West WRZ Resilience, Trunk Main Upgrades and Links;
- Ballinrees Resilience.

Figure B below illustrates the range of potential Resilience Recommendations to be investigated further.

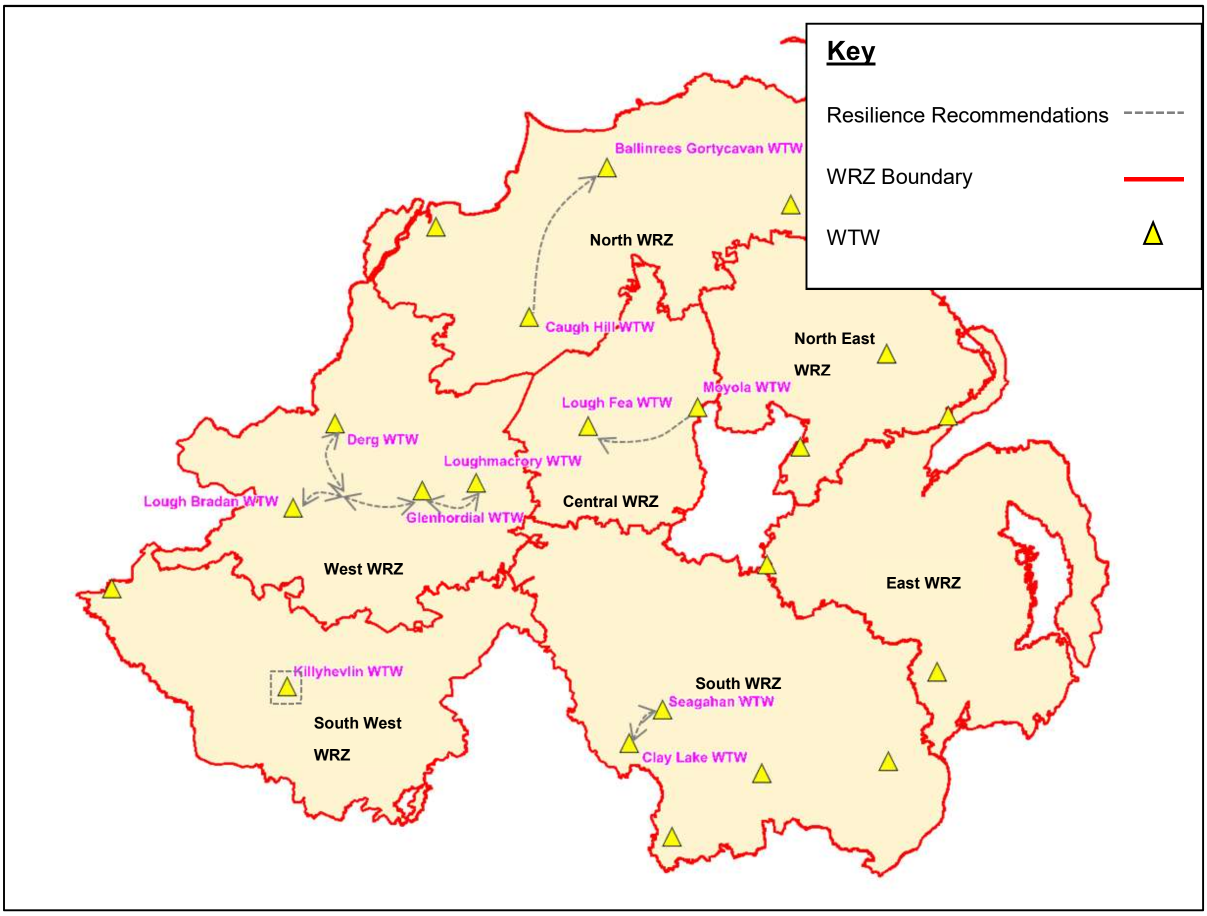


Figure B: Potential Resilience Recommendations

High Water Demand Event (Summer 2018)

Towards the end of June 2018 Northern Ireland, the Republic of Ireland and other parts of the UK experienced unusually high temperatures and dry soils. In Northern Ireland, this increase in temperature coincided with schools breaking up for the summer holidays and the water network had to cope with an unprecedented peak in summer demands.

This peak in demand was higher than the Dry Year Critical Peak (DYCP) values modelled as a planning scenario in this report. All Water Resource Zones (WRZs) showed an increase in peak demand. In most WRZs, the increases were minimal, between 1-2%, but the increases in the East WRZ and the South WRZ were significant.

In order to accommodate intensive peaks in demand such as experienced in summer 2018;

- The Castor Bay WTW to Ballydougan SR Trunk Main Upgrade should be increased from 16 Ml/d (as previously planned) to 20 Ml/d.
- A demand monitoring and communication strategy is currently being developed to prevent demand from exceeding planned levels of distribution input.

1. Introduction and Strategic Context

1.1 Introduction

This is Northern Ireland Water's (NI Water) Water Resource and Supply Resilience (WR&SR) Plan for the period 2014/15 to 2042/43. NI Water has consulted with key stakeholders through the development of this plan on how it proposes to manage its water resources into the future.

The WR&SR Plan sets out how NI Water intends to maintain the balance between supply and demand for water over the long-term, and the operational and management options and activities available to respond to short-term critical events. The Plan draws on the technical guidance for the WR&SR Plan issued by the then Department for Regional Development (DRD) together with UK Water Resources Planning and Drought Planning guidelines. These guidelines were produced by the UK Environment Agency (EA) in collaboration with Department for Environment, Food & Rural Affairs (Defra), the Welsh Government and Ofwat; along with other water industry best practice guidance and documentation.

NI Water published the last Water Resource Management Plan in 2012 (WRMP 2012) and later in 2012 made provision in the PC13 Business Plan submission to produce a Drought Plan in the PC13 period. The then DRD and the Northern Ireland Authority for Utility Regulation (NIAUR) agreed, in discussion with NI Water, to change the legislation and combine the WRMPs and Drought Plans into a single document. Producing this on a rolling 6 yearly programme would have significant advantages for NI Water and better align to the Price Control periods. This decision was formalised in the Water & Sewerage Services Act (Northern Ireland) 2016.

These following activities are undertaken in development of the plan:

- Assess the availability of water available from NI Water's resources;
- Assess the forecast demand on these resources from customers and other sources of demand;
- Identify areas where there are current/forecasted deficits during normal, drought and freeze-thaw conditions;
- Identify, develop and assess options that provide resilient solutions to meet these deficits;
- Assess the supply resilience of the water resource system and identify solutions to improve this resilience;
- Develop a Drought Plan identifying actions to be taken before and during drought events;
- Strategic Environmental Assessment on the plan; and
- Public Consultation on the plan.

1.2 Objectives and Government Policy

The average volume of water required for NI Water has reduced by 24% from around 735 mega litres per day (Ml/d) in 2001/02 to 570 Ml/d in 2014/15. This has been achieved through sustained investment in water mains to reduce leakage along with reduced demand.

NI Water needs to assess the vulnerability of its services to climatic and other risks and, where appropriate and cost beneficial, increase the resilience of its water assets. The WR&SR Plan has adopted a risk-based approach to estimating and forecasting components of supply and demand, and in estimating the uncertainty surrounding those forecasts.

The WR&SR Plan will ensure that water resources are used in an efficient and sustainable manner over the long-term, giving due consideration to short-term operational issues that may occur. Where a shortfall of supply to meet potential demand for water is identified, a set of options has been identified to restore the balance between supply and water demand. The SDB underpinning the plan takes due account of:

- The aims and objectives of the Water Framework Directive (WFD) in promoting the sustainable and efficient use of water resources;
- Future pressures on water resources from the effects of climate change (CC) on available resources and water use;
- The cost of providing water; and
- Environmental considerations and constraints.

DfI published *Sustainable Water - A Long Term Water Strategy for Northern Ireland (2015-2040)* in March 2016. The strategy sets out a number of key policy priorities for the Government that are relevant to the WR&SR Plan. A key theme of the strategy is sustainable water management: managing and investing in water and sewerage assets and infrastructure to improve services and protect the environment without compromising future service provision. In line with policy on sustainable environmental regulation in the above mentioned document, this will entail a *'move away from traditional high energy solutions towards natural approaches where quality issues can be addressed at source'.*

Sustainability and Climate Change form a key component of the key strategic investment themes in the Ministerial Social and Environmental Guidance for PC15 and are therefore a key focus in the WR&SR Plan. The plan considers the following government objectives and aspirations:

- Sustainable catchment management – improving drinking water quality by managing diffuse pollution within an integrated catchment plan rather than through energy-intensive "end of pipe" treatment processes;
- Water demand management – reducing leakage and introducing demand management measures that reduce waste, rather than by increasing water abstraction, treatment and transfer which all have an associated energy demand; and
- Energy efficiency and reduced carbon emissions – managing and maintaining the existing asset base to improve energy efficiency and minimise emissions.

1.3 Legislative Context

The Water and Sewerage Services (Northern Ireland) Order 2006 (2006 No.3336 (N.I. 21)), known as the '2006 Order', sets out the requirements for the production of both the Water Resources Management Plan (WRMP) (Articles 70 to 72) and the Drought Plan (Article 73). It also details the processes related to Drought Orders (Articles 137 to 144) and temporary hosepipe bans (Article 116).

NI Water was previously required to produce a WRMP on a 5 yearly basis (Article 70) and a Drought Plan on a 3 yearly basis (Article 73). The current WRMP sets out NI Water's strategy for maintaining drinking water supplies over the period 2010 to 2035.

The Water & Sewerage Services Act (Northern Ireland) 2016 provided amendments to the 2006 Order which permitted the combination of WRMPs and Drought Plans into a single document. The document would be produced on a rolling 6-8 yearly programme, ideally to coincide with Price Control periods. This is being implemented by the preparation of this overarching WR&SR Plan, which will cover the current Price Control period (PC15) and beyond to 2042. The next WR&SR Plan will be produced in 2023/2024 during the PC21 Price Control period.

A WR&SR Plan must address each of the following to be compliant with the 2006 Order:

1) The estimate of the quantities of water required to meet its obligations;

2) The measures which the water undertaker intends to take or continue for the purpose of planning to manage and develop water resources so as to be able to meet its obligations;

3) The likely sequence and timing for implementing the measures; and

4) Such other matters as directed by DfI.

While a Drought Plan must address:

5) The measures the water undertaker might need to take to restrain demand for water;

6) The measures the water undertaker might need to take to obtain extra water from other sources;

7) How the water undertaker will monitor the effects of the drought and of the measures taken under the Drought Plan; and

8) Such other matters as directed by DfI.

1.4 Changes since the last Plan

The previous WRMP was published in 2012. Prior to that was the Water Resource Strategy produced in 2002 (WRS 2002) which was updated in 2007. NI Water has made significant progress in delivering a more resilient water infrastructure following the outputs from the previous plans. There has been a significant decrease in demand from the WRMP 2012. The base year for WRMP 2012 was 2008/09 and the demand figure was 677Ml/d. The base year for the current plan is 2014/15 and the demand figure is 570Ml/d, a reduction of 107Ml/d. This reduction has been achieved through continued high levels of active leakage detection and sustained investment in water mains to reduce leakage, along with reduced household and non-household demand.

NI Water has also invested in upgrading its water mains infrastructure which allows it to transfer drinking water between towns and cities throughout Northern Ireland. In the WRMP 2012 the Carland to Cookstown Intervention was identified and this has since been implemented.

The following major capital projects, have also brought about improvements in its overall water mains infrastructure:

- Castor Bay – Belfast;
- Ballydougan – Newry;
- Castor Bay – Dungannon.

The result of this investment is that the deficits identified in three of the five Water Resource Zones (WRZs) in 2012 no longer exist for the planned Level of Service (LoS). Based on the scenario tested in 2012 all of Northern Ireland has sufficient quantities of safe, secure drinking water. However, the 2012 plan did not fully assess critical period events where there are significant peaks in demand such as a freeze thaw. The WR&SR

Plan will test these scenarios further with a view to ensuring an enhanced security of supply for NI Water's customers.

1.5 Integrated Water Resource, Drought Management and Critical Period Plans

In general, a WRMP sets out how a water company intends to maintain the balance between water supplies available and the demand for water over a long-term planning horizon of 25 years. The WRMP will ensure that supply meets demand during the most critical conditions where supplies are low due to dry conditions, and demand is correspondingly high without any demand restrictions in place (such as hose pipe bans).

Under years where the climatic conditions experienced may be classified as being either relatively “wet” on average, or “normal”, water companies would generally have plenty of spare water resource capacity to meet customer water demands. This is because the amount of rainfall in these years results in higher river levels (and groundwater levels) and reservoirs can be kept at near full capacity. Subsequently, plenty of water is available to be abstracted, treated and supplied to customers to meet their water demands. At the same time, customer demand will tend to be relatively low, on average over the year, as there are likely to be relatively limited periods of prolonged hot and dry weather.

In contrast, in “dry” years, the water supply system is likely to be under greater stress as river flows tend to be lower, with corresponding reduced reservoir capacity. Water demand is likely to be higher due to increased periods of prolonged hot and dry weather.

Where there is a sustained period of dry weather, the resulting water resource situation could develop into a drought event. A drought can be defined as occurring “when a period of low rainfall creates a shortage of water for people, the environment, agriculture, or industry”. When a drought occurs management action will be required. This could include measures to reduce demand, such as hosepipe bans. Drought Action Plans define reactive measures to be implemented during a drought and therefore do not affect the long-term water supply infrastructure.

There may also be periods which are particularly critical in terms of the stress they impose on water resources. The summer months are often considered as a critical period, due to the higher likelihood of prolonged periods of hot, dry weather culminating in higher demands for water. This corresponds with potentially lower rainfall and subsequent supply-side stresses, even outside of drought events, imparting significant stress on the system.

Other critical periods particularly relevant to Northern Ireland are “freeze-thaw” events, which occur during winter. Major events of this type are typically caused by short-term increases in leakage as a result of prolonged periods of temperatures well below freezing, followed by relatively rapid warming. The short-term increase in pipe bursts, which occur in customer pipes as well as on the company's infrastructure, places a high “demand” for water on the supply system. This may challenge the company's capacity to treat and supply water in some areas.

The WR&SR Plan considers the critical periods in the context of water resource planning and considers various permanent interventions to address any shortfalls resulting in the SDB. Section 5 of the plan specifically considers the operational interventions required to manage drought events in the short-term.

1.6 Future Water Resource and Supply Resilience (WR&SR) Plans

Future WR&SR Plans will take account of any changes in best practice methodologies for water resource planning developed by the UK water industry, changes in Government policy, customer behaviour and the introduction of sustainability reductions to meet the requirements of the WFD.

The main changes to future WR&SR plans are therefore likely to include:

- The assessment of raw water intakes for surface water sources requires further investigation to gain a fuller understanding of constraints at NI Water's drinking water sources particularly at sources such as Lough Fea and Lough Bradan;
- Changes in technology that may lead to more cost effective delivery of leakage reduction;
- Changes to UK Water industry best practice methodologies for water resource planning and regulatory guidance which is likely to cover, the definition of Water Resource Zones (WRZs), the treatment of uncertainty and risk in the SDB and investment decisions, environmental and customer LoS, consideration of extreme events, and the treatment of Climate Change on both supplies and demands;
- Changes to the cost of carbon; and
- Changes in customer behaviour that is reflected in observed water consumption, as reported in the Annual Information Returns (AIR).

2. Water Resource Zones (WRZs)

Northern Ireland was previously divided into 5 WRZs for the purposes of the 2012 Water Resource Management Plan. The number of zones has now been increased to 7 WRZs to better represent the interconnectivity of the supply system. The old West WRZ has been split in to the South West WRZ and the new West WRZ to reflect the poor connectivity between Fermanagh and the Omagh area. In the east of the country the old East and South WRZs have been split into 3 WRZs – North East, East and South to better reflect the interconnectivity that exists.

2.1 The 2012 WRZs

The 2012 WRMP split Northern Ireland into 5 WRZs as shown in Figure 2.1. As part of the WR&SR Plan these WRZs have been reviewed to determine if they are robust.

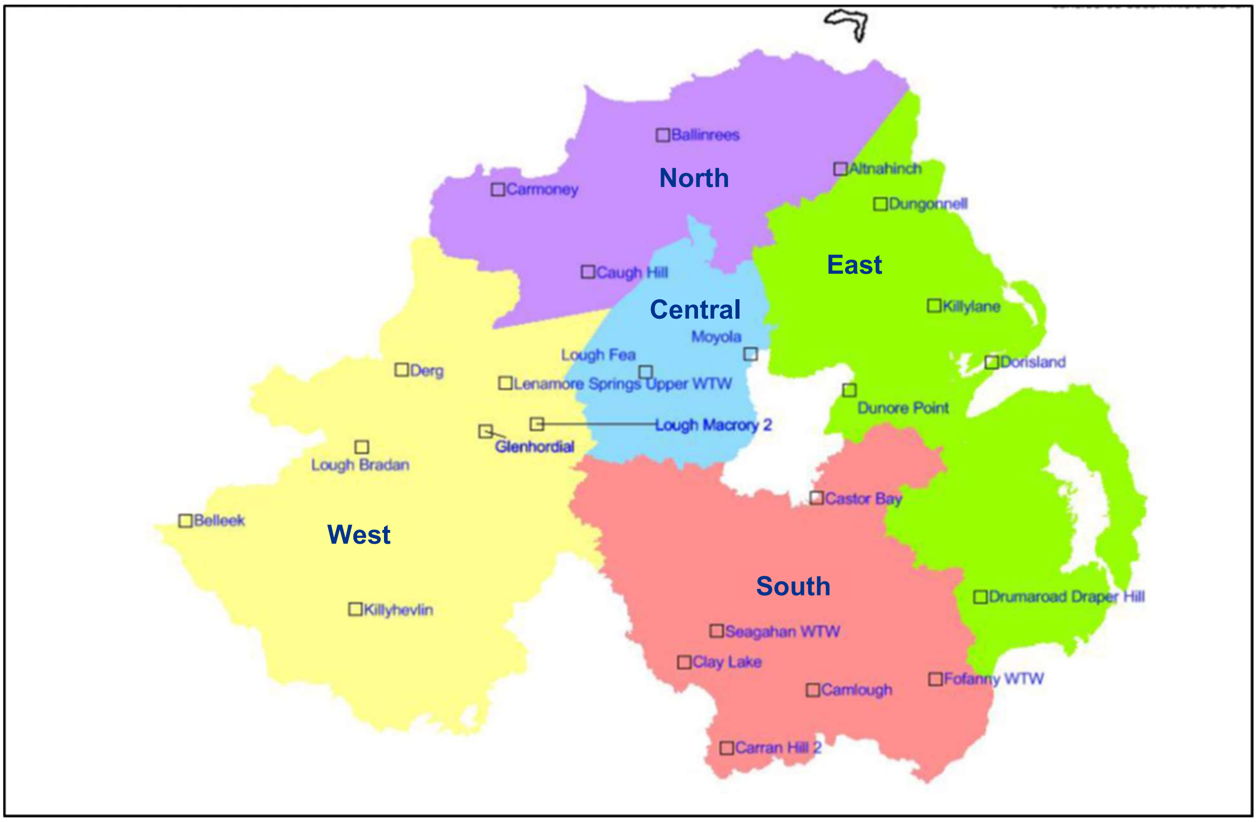


Figure 2.1: NI Water WRMP 2012 WRZs

2.2 WRZ Review Process

In line with the United Kingdom Water Industry Research Ltd (UKWIR) definition for a WRZ the following key criteria were tested as part of the WRZ Integrity Check:

- WRZs must be based on a sound and robust supply area within which the bulk transfer of water can be achieved;
- All significant Demand Centres (DC) must be suitably linked within the WRZ;
- Any network constraints must be such that they do not restrict the effective sharing of resources within the WRZ;

- All customers with the WRZ should experience the same risk of supply failure from a resource shortfall; and

- Controls must be sufficient so as not to significantly adversely affect the bulk distribution of water throughout the zone.

2.3 Issues with Existing WRZs

Since 2012 there has been some concern expressed about the West WRZ. The south of the zone has a stable source of water in the form of Lough Erne and is therefore hydrologically secure. The north of the zone relies primarily on local rivers which are susceptible to flow variation caused by changing weather, and is therefore hydrologically constrained. Operational experience has indicated that there is poor connectivity between the hydrologically secure south and the hydrologically constrained north of the WRZ. This has been demonstrated historically by some water stress issues around Omagh and Strabane that were not experienced in Fermanagh. Therefore, the entire zone does not share the same level of risk. As a result this WRZ was a particular focus for the review.

Another area of focus is on the south and east of the country and in particular the supply to Belfast. The WRMP 2012 split the supply to Belfast into separate WRZs. With so much interconnectivity in and around Belfast, it is considered that it would be more appropriate to have the major demand centre (DC) for Northern Ireland contained in the same Resource Zone.

There are other issues that have also been considered further in consideration of WRZ boundaries in this plan. These include: how best to deal with Rathlin; whether some of the more remote sources like Clay Lake and Belleek should have their own WRZ, and whether some of the WRZs notably Central and West require improved resilience.

2.4 WRZs

Following the review process 7 No. WRZs have been recommended for the WR&SR Plan. These are shown in Figure 2.2.

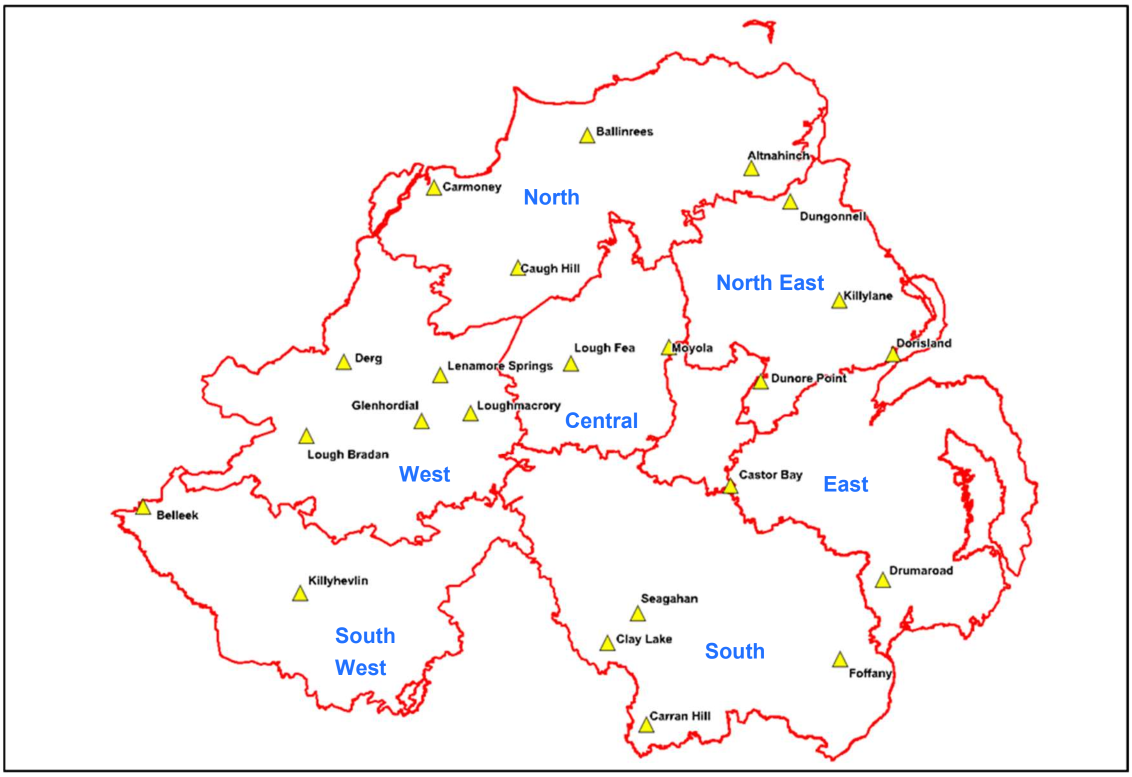


Figure 2.2: WRZs included in WR&SR Plan

The changes between the 2012 WRZs and the WR&SR Plan WRZs are as follows:

1) The 2012 West WRZ has been split into 2 zones, the West WRZ and the South West WRZ. The reason for this split is the lack of connectivity across the new WRZ boundary resulting in differing levels of risk between the zones.

2) The 2012 South and East WRZs have been split into 3 zones (South, East and North East) which better reflect the operation of the supply system.

- Supply to Belfast has been combined into the new East WRZ as there is extensive interconnectivity in this area.

- The selection of the North East/East resource zone boundary is based on the limited connectivity between the Water Supply Zones (WSZs) along this boundary. The exception is the bulk transfer from Dunore Point WTW to Hydepark Service Reservoir (SR). However, as this provides a distinct and measured boundary point this was considered an appropriate border.

- The selection of the South/East boundary is based on the lack of interconnectivity between the WSZs along this line. While both zones are supplied from Castor Bay WTW, they both have their own dedicated trunk mains direct from the WTW.

3) Rathlin has been included in the North WRZ as in the event of a water shortage on Rathlin, water from the North WRZ is tankered in to meet the shortfall.

3. Planning Scenarios

In order to produce a plan that can meet the range of hydrological conditions that can be expected over the 25 year planning horizon and beyond, a set of planning scenarios have been derived so as to test the plan to ensure it can meet NI Water's declared level of service and associated design critical conditions. For this purpose the following planning scenarios have been derived:

- NYAA – Normal Year Annual Average, representing conditions in a normal year;
- DYAA – Dry Year Annual Average, representing conditions in a typical dry year;
- DYCP – Dry Year Critical Period, representing summer peak conditions in a critical dry year;
- WCP – Winter Critical Period, representing winter critical conditions during a freeze/thaw event.

A range of durations have been determined for each planning scenario, representing the likelihood of occurrence of each condition over the life of the plan, in order to evaluate the net economic benefit of each development option to be investigated. In addition, a 1 in 40 year level of service (LoS) has been selected that can meet the peak summer demand during a critical dry year, at an acceptable return period, in line with those adopted by other UK water companies.

3.1 Introduction

The base year for the WR&SR Plan is 2014/15 and the planning period for forecasting is 25 years, covering the period 2018/19 to 2042/43. A number of Planning Scenarios have been considered and the plan aims to meet the demands of these scenarios for the required Level of Service (LoS) in all WRZs. This section describes the criteria for the required LoS and outlines the four Planning Scenarios being considered. Drought Planning Scenarios are considered in the Drought Plan in Section 5 of this report.

3.2 Review of UK Water Companies LoS

A review of typical Levels of Service (LoS) and drought triggers for water companies in the rest of the UK has been carried out and are presented in Table 3.1 below:

Table 3.1: UK Water Company Levels of Service

Water Company	Temporary Use Bans	Drought Orders	Drought Permits
Anglian Water	1 in 10yrs (90%)	1 in 40yrs (97.5%)	1 in 40yrs (97.5%)
Welsh Water	1 in 20yrs (95%)	1 in 40yrs (97.5%)	1 in 40yrs (97.5%)
Severn Trent Water	3 in 100yrs (97%)	3 in 100yrs (97%)	3 in 100yrs (97%)
South West Water	1 in 10yrs (90%)	1 in 20yrs (95%)	1 in 20yrs (95%)
Southern Water	1 in 10yrs (90%)	1 in 20yrs (95%)	1 in 20yrs (95%)
Thames Water	1 in 10yrs (90%)	1 in 20yrs (95%)	1 in 20yrs (95%)
United Utilities	1 in 20yrs (90%)	1 in 35yrs (97%)	1 in 35yrs (97%)
Wessex Water	1 in 30yrs (96.7%)	1 in 30yrs (96.7%)	1 in 30yrs (96.7%)
Yorkshire Water	1 in 25yrs (96%)	1 in 80yrs (98.8%)	1 in 80yrs (98.8%)
Scottish Water	Not stated – tied to DO application	1 in 40yrs (97.5%)	1 in 40yrs (97.5%)

Table 3.1 above shows the anticipated frequency that drought triggers are expected to be applied with the associated Level of Service (LoS) expressed as a probability (%). These figures show that generally, temporary use bans have an anticipated frequency range of between 1 in 10 years and 1 in 20 years, indicating an unrestricted Level of Service (LoS) of between 90% and 95%; and that Drought Orders and drought permits have an anticipated frequency range of between 1 in 20 years and 1 in 80 years, indicating a restricted Level of Service (LoS) of between 95% and 98%. The application of emergency Drought Orders (to implement water cuts and/or standpipes) is rarely envisaged and certainly never more than 1 in 100 years (99%).

From the above it can be seen that most companies plan to apply temporary use bans (TUBS) approximately 1 in 10 years (on average) thus indicating that normal supplies can be maintained for 90% of all years. Also it can be seen that Drought Orders and drought permits are planned to be applied in a range with an average approaching 1 in 40 years thus indicating a dry year supply reliability of about 97%, above which drought measures would need to be introduced.

3.3 NI Water Level of Service (LoS)

The LoS is the target reliability of supply that the water resources plan is designed to meet without causing water shortages within the NI Water water supply system.

For the purposes of this WR&SR Plan, the target LoS has been taken as providing the level of investment that allows water supply failures for one year in forty; equivalent to a supply reliability of 97.5%. This LoS compares favourably to the average for other UK water companies (as shown above). The Deployable Outputs (DOs) of existing and future water sources (described in Section 4) have been based on this target LoS. Sensitivity analyses showing the effect of different LoS assumptions (DO and Demand) on the final WR&SR Plan are described in Section 13.

The actions of the Drought Plan aim to maintain customer supplies in drought events beyond the LoS. The Drought Plan reflects the current infrastructure and therefore the current LoS rather than the Target LoS stated above. Therefore, some actions are currently required more frequently than the target LoS. Provided the recommendations of this plan are implemented then the supply system will meet the target LoS of 97.5% and drought actions will only be required during the most extreme events.

For extreme drought events beyond the stated LoS it is assumed that various drought measures, such as temporary use bans (TUBS), Drought Orders and/or drought permits would be applied for return periods beyond 97.5%. These issues are addressed more fully in the Drought Plan (Section 5).

There is further discussion on the target LoS in Section 9 where it is discussed in conjunction with the SDB.

3.4 The Normal Year

The normal year scenario describes the demand and supplies available to the company in a typically average weather year. Demands are expressed in terms of the average daily demand that would typically be experienced in an average weather year without any forms of demand restrictions in place, and are measured in Ml/d. This scenario is therefore often referred to as the Normal Year Annual Average (NYAA) scenario.

For the purposes of water resources planning NYAA is not a critical scenario, as the other scenarios below are more severe. However, NYAA is used to demonstrate how the company might operate its sources in most years and is therefore important for whole life costing.

For carrying out the economic analyses in the Plan, it is necessary to assess the expected duration of normal years and dry years throughout the planning period. It is standard international practice in arid countries (with a predominance for irrigation) to adopt a definition of a dry year as one year in five (i.e. 20% duration) and thus the definition of a normal year as four years in five (i.e. 80% duration).

However, it is customary practice in the UK for water supply utilities (where the desired supply reliability is higher) to define a dry year (not a drought year) as occurring only one year in ten (i.e. 10% duration) on average. Therefore, the definition of NYAA is that which is likely to occur in nine years out of ten (i.e. 90% duration). These durations are utilised for the whole life costing in the Plan.

3.5 The Dry Year

The dry year scenario, also known as the Dry Year Annual Average (DYAA) scenario, is when there is low rainfall but no constraints on demand (i.e. no demand restrictions such as hosepipe bans). Demands are based on the average daily demands experienced over the year under “dry” year weather conditions. Demand would be higher than in normal years, but no restrictions on water demand (e.g. non-essential use bans) would be required.

Supplies available during the DYAA scenario are based on the DO of sources under dry and drought conditions for the defined LoS. The DO from each source may be affected by hydrological conditions, as well as infrastructure, treatment capacity and abstraction licences. As previously described, the defined LoS is the target reliability of supply that the water resources plan is designed to meet. NI Water has defined a target reliability of 97.5%.

3.6 Critical Period Scenarios

These scenarios are particular critical periods where there are potential SDB issues, which consequently act as a driver for investment in infrastructure and water resources. There can be many causes of critical periods but a typical example is when demand is sufficiently high and/or DO is sufficiently low so that the DYAA scenario is exceeded. For the purposes of this plan, the scenarios tested below are deemed to be reasonable to cover any foreseeable critical period event within the defined LoS. The 2010/11 extreme freeze-thaw event is not covered in the critical period scenarios as it is considered to be an event so extreme that it is beyond the defined LoS.

3.6.1 The Dry Year Critical Period (DYCP)

The DYCP generally occurs during the summer where demands during dry years can be significantly higher than the annual average. The critical demands for this plan are deemed to occur over a period of a number of weeks.

The DYCP is generally defined to occur for about one week in fifty over the planning period, which is equivalent to a duration of 2%.

It should be noted the DYCP scenario is separate to high water demand events as experienced in summer 2018. The Summer 2018 High Water Demand Event Review is covered within Section 14.7 of the report.

3.6.2 The Winter Critical Period (WCP)

The WCP generally occurs as a result of freeze-thaw incidents as has been evidenced in Northern Ireland in the winters of 2009-10 and 2010-11. High demands during these periods are driven by an increase in leakage from pipe bursts. The constraining supply factor is the capacity of WTW or the maximum volume of water that can be supplied to the distribution network.

The freeze-thaw of 2010-11 was an extremely rare event which had significant consequences on NI Water's delivery system. It was such an extreme event that it is well outside the defined LoS. The investment required in infrastructure improvements to plan for such an event would be prohibitively expensive. Therefore, it is not deemed practical for the WR&SR Plan to recommend investment to meet this extreme event. Through discussions with stakeholders it was agreed that the scenario that will be used to define the WCP will be the less severe but still significant freeze thaw event of 2009-10. This is discussed further later in the report.

The duration of the WCP is more difficult to estimate. For the purposes of these analyses, it has been taken as having a duration of approximately 2 days per year over the planning period.

4. Supply

This chapter covers the assessment of the existing supply side water resource yields that are currently available in each water resource zone (WRZ) to meet the water demand forecasts as described in the Section 6. The water resources available in each WRZ are assessed by determining the Deployable Output (DO) of each source which is defined as the exploitable yield as constrained by the relevant abstraction licences. Having established the deployable output for each source, allowances for water treatment process losses and treatment works outages have then been deducted to produce the net Water Available for Use (WAFU) for each WRZ that are used later to derive Supply/Demand Balance (SDB) over the 25 year planning horizon.

The Deployable Output (DO) for each WRZ has been determined using a water resources yield model (AQUATOR) that can simulate all the existing sources within each WRZ, taking account of current supply network constraints such as water intake, conveyance pipeline and WTW capacity constraints. The AQUATOR water resource model has thus been used to determine the DO, by zone, for each planning scenario as follows:

- Normal Year Annual Average (NYAA) – DO available for 90% of the time;
- Dry Year Annual Average (DYAA) – DO available for 97.5% of the time (design LoS);
- Dry Year Critical Period (DYCP) – increased DO available during the summer peak-week;
- Winter Critical Period (WCP) – WTW capacity available during freeze/thaw events.

This DO assessment has been carried out twice, for each planning scenario, firstly for current (2014) conditions and secondly for future (2042) conditions, taking account of climate change, as described in Section 7. The overall DO for Northern Ireland is 805Ml/d.

Outage is a temporary loss in DO usually associated with either a planned or unplanned shutdown. In order to establish the Water Available for Use (WAFU) an allowance of 5% has been determined. This results in a WAFU for Northern Ireland of 765 Ml/d.

4.1 Introduction

The Deployable Output (DO) assessment is the main supply-side component of the NI Water WR&SR Plan. The DO value represents the output of a source (or group of sources) that can be achieved under specific design conditions, generally determined by the most severe drought on record. The UKWIR WR27 Water Resources Planning Tools (2012) report defines DO as:

The output for specified conditions and demands of a commissioned source, group of sources or water resources system as constrained by: hydrological yield; licenced quantities, environment (represented by licence constraints); pumping plant and/or aquifer properties; raw water mains and/or aqueducts; transfer and/or output main; treatment; water quality and LoS.

This section outlines the methodology and presents the results from the DO Assessment. The methodology builds on the modelling work undertaken in WRMP 2012 and improves upon its robustness through the following modifications/additions:

- Development of long time series of river flows to extend flow sequences over a longer period;
- Additional information on the physical constraints within the system, particularly in the catchments and improved understanding of the operation of the system;
- Revised licence constraints for the Derg/Strule system;
- Improved data on Process Losses;

- Consideration of DO in the DYCP and WCP.

The assessment has been undertaken for the 7 No. WRZs detailed in Section 2 rather than the 5 WRZs from the WRMP 2012. This should provide improved granularity particularly in the West WRZ.

There remain many limitations to the models which could be improved on by further data collection and assessment, as mentioned in the recommendations section.

4.2 Abstraction Licences

The collection and application of the current abstraction licence conditions in Northern Ireland is a central component of the water supply assessment for the NI Water WR&SR Plan. NI Water's abstraction licences are issued by NIEA. The limits in the abstraction licences have been used to set the maximum daily volumes of raw water that can be abstracted for each of the licensed intake sources. NIEA plan to review all their abstraction licences over the coming years. However, as the timeline for this is unknown and it could take well over 10 years before all assessments are complete the current licences have been used in the production of the Plan.

During the development of the Plan the licence for the River Derg and Strule regime has been updated and the changes incorporated into the DO assessment. Historically, River Derg has been used as the only abstraction source for supplying raw water to Derg WTW. The 2007 Derg abstraction licence (AIL/2007/0037) stated that NI Water could abstract a daily limit of 15 Ml/d from River Derg and no environmental flow conditions were imposed. At that stage the River Derg was the only source for the Derg WTW.

The implementation of an additional abstraction from the River Strule to supplement the River Derg supply, particularly during times of low flow, was completed in 2015. This required the revision and reissue of the abstraction licence conditions for the River Derg and Strule source group. A new abstraction licence issued in draft in 2010 stated that up to 26.6 Ml/d can be abstracted from either the River Derg or from the new River Strule intake. However, the combined group volume taken from both rivers cannot exceed 26.6 Ml/d. The interpretation of the environmental flow conditions in the 2010 draft licence was clarified in a revised licence (AIL/2008/0178 v3), which was issued in March 2018. The abstraction volumes are unchanged; however this clarification has resulted in a net increase in the DO from Derg WTW.

The River Faughan currently has a licence to abstract considerably more than the 35 Ml/d capacity at Carmoney WTW where the water is treated. An abstraction of up to 55 Ml/d using the existing intake has been modelled and reviewed, with preliminary outputs indicating that this would not have a detrimental effect on the ecology currently supported by the river. This will be confirmed through a formal application to NIEA. The Faughan source is an important source for NI Water as it supplies large quantities of water to Londonderry/Derry in the North WRZ. The source is also important to this plan as using the available headroom in the North and transferring water from Carmoney to Strabane is a viable option for meeting deficits in the West WRZ as discussed later in the report.

The remainder of the source assessments have been undertaken using the existing abstraction licences. There is a long term plan for NIEA to review these licences and therefore there are risks to those sources also. However it is envisaged that this review will take place over an extended period and, other than the Faughan, NI Water are not aware of the timing of particular licence reviews. It is recommended that the status of the abstraction licences is reviewed again in the next Water Resource and Supply Resilience Plan when more specific information may be available.

4.3 Water Treatment Works (WTW) Design Capacities

NI Water Operations have provided details on WTW design capacities. The design capacity is the maximum output that the plant can provide over a sustained period of time and does not include the plants ability to increase output for short periods of time in an emergency or other situation. These design outputs are provided in Table 4.1 and are used in the Aquator Model.

Table 4.1: WTW Design Capacities and Abstraction Licence Quantities

WRZ	WTW	WTW Design Capacity (Ml/d)	Abstraction licence quantity (Ml/d)
North	Altnahinch	10.3	14.5
	Ballinrees (PPP)	50	50
	Carmoney	35	55
	Caugh Hill	34	40
South	Castor Bay (PPP)	147	183
	Seagahan	13.6	20
	Clay Lake	5	10
	Carran Hill	6.8	9.5
	Fofanny	44	52
East	Dorisland	46	50
	Drumaroad	124	155
Central	Lough Fea	13.5	17
	Moyola (PPP)	19	21.1
North East	Dungonnell	12.5	14.5
	Killylane	12.5	16.1
	Dunore Point (PPP)	180	200
South West	Belleek	2	2.6
	Killyhevlin	36	44
West	Derg	25	26.6
	Lough Bradan	8.3	14.5
	Lough Macrory	12	18.5
	Lough Glenhordial	6	8

4.4 Deployable Output (DO)

A DO assessment can be performed for a single or a group of sources. However, the UKWIR WR27 report advocates the use of modelling techniques to examine the conjunctive use of sources within a WRZ, this is considered best practice in the UK. The DO calculations are based on the behavioural modelling analysis of the WRZs, using the longest flow time series available for the most robust assessment results. The water resource modelling application (Aquator) has been selected to calculate the DO at WRZ level, therefore, building upon the approach of the WRMP 2012.

4.4.1 Hydrological analysis

The WRMP 2012 DO assessments were undertaken using the same modelling technique as this Plan. However, the 2012 Plan was limited by the length of hydrological record (1975-2009) and the availability of rainfall data to produce the rainfall-runoff models. UK water industry best practice requires the use of long time series of river flows to determine DO. Therefore, a key aim within the WR&SR Plan supply-side assessment was the extension of flow sequences to be applied within the Aquator DO modelling. With relatively short gauged records available in Northern Ireland, the extension of sequences using rainfall-runoff modelling was deemed appropriate.

Following on from work undertaken between NI Water and stakeholders following the WRMP 2012, the Continuous Estimation of River Flows (CERF) tool was selected for use. These were based on gridded rainfall data from the recently developed Centre for Ecology & Hydrology – Gridded Estimates of Areal Rainfall (CEH-GEAR) product with data available from 1890-2012 at the start of the project. The calibration of the CERF model was based on gauges throughout Northern Ireland. This extension of modelling inflow sequences should produce a more robust DO assessment as there is a greater chance of encompassing historical drought conditions within the design period.

4.4.1.1 Centre for Ecology & Hydrology – Gridded Estimates of Areal Rainfall (CEH-GEAR) rainfall data

As part of the rainfall-runoff modelling for the selected group of NI Water source catchments, rainfall datasets from the CEH-GEAR product have been used to generate a series of catchment daily average rainfall values for the long-term period of 1890-2012. The CEH-GEAR datasets contain reliable 1 km gridded estimates of daily and monthly rainfall for Great Britain and Northern Ireland and approximately 3000 km2 of catchment in the Republic of Ireland, from 1890-2012. The primary function of these datasets is to support hydrological modelling.

The rainfall estimates are derived from the Met Office national database of historical rain gauge observations. Neither these station records nor the gridded data were available at the time of the last plan. The estimated rainfall on a given day refers to the amount of precipitation in 24 hours between 09.00 on that day until 09.00 GMT on the next day. See Keller et al. (2014)1 for a detailed description of the CEH-GEAR product.

4.4.1.2 Continuous Estimation of River Flows (CERF) generated flow sequences

Applying the CEH-GEAR gridded rainfall data for 1890-2012, the CERF regionalised rainfall-runoff model2 was used to derive extended flow sequences for Northern Ireland. The CERF rainfall-runoff model is a deterministic model, developed by CEH-Wallingford and the EA. The inputs into the model are time-series of precipitation and potential evaporation (PE) demand, and the output is a time-series of daily simulated river flows. The input rainfall data used for this study is supplied from the CEH-GEAR product in the form of daily mean catchment average rainfall for the period 1890-2012, as described above. The PE time series were estimated using a temperature based model reviewed and applied across many hydro-climatic regions3.

Wallingford Hydro Solutions (WHS) have developed a report, entitled "Application of the CERF model for the NI Water Resource Resilience Plan", which presents a general overview of the CERF model and its application for the derivation of flow sequences for NI Water.

4.4.1.3 Grouping of catchments for flow derivation purposes

NI Water has abstractions from 78 catchments across the region. As part of the WR&SR Plan hydrological analysis approach, a subset of 28 NI Water source catchments were chosen for CEH-GEAR rainfall data and CERF flow sequence derivation. These 28 donor catchments have been determined to represent the 78 NI water source catchments through a catchment pooling process based on key parameters representing the hydrological characteristics. These were taken from the Flood Estimation Handbook (FEH) catchment descriptors, notably:

- Area;
- SAAR (61-90);

[1] Keller, V.D.J., Tanguy, M., Prosdocimi, I., Terry, J.A., Cole, S.J., Fry, M., Morris, D.G., Dixon, H. (2014). CEH-GEAR: 1 km resolution daily and monthly areal rainfall estimates for the UK for hydrological use.
[2] Griffiths, J., Keller, B., Morris, D., Young, A.R. (2007). CERF – Project Summary. EA Science Report W6 – 101.
[3] Ludovic Oudin, L., Hervieua F., Michela C., Perrin C., Andreassian V., Anctil F. & Loumagne C. (2005), Which potential evapotranspiration (PET) input for a lumped rainfall–runoff model? Part 2—Towards a simple and efficient PET model for rainfall–runoff modelling. Journal of Hydrology, Vol 303, 290–306

- BFIHOST;
- SPRHOST;
- FARL.

Catchments were grouped on the key descriptors and then representative catchments were selected from each pooling group to form the subset for CEH-Wallingford. The long-term flow sequences derived for the 28 donor catchments could then be transposed to the rest of the target catchments through the process of scaling the flow sequences by catchment area. This catchment grouping and transposition of flow sequences approach served to help make the derivation of numerous flow sequences a more efficient process.

4.4.2 Water resource modelling

4.4.2.1 Use of Aquator

Computer software applications are not necessarily required for calculating the output of an individual source, but are essential when analysing the DO of conjunctive water resources. Aquator has been selected as the most suitable software package as it is a reliable and robust tool for high level strategic water resource planning. Its benefits are based on its intuitive and flexible platform that enables the user to best represent the current water supply system at the WRZ level whilst also being able to make modifications to the model environment to simulate future conditions and scenarios with relative ease. Aquator was selected for the previous plan (WRMP 2012), and in order to build upon this modelling approach Aquator will again be utilised for the DO assessment of the WR&SR Plan.

4.4.2.2 DO and LoS

The main function of the Aquator application in relation to the WR&SR Plan is its ability to assess DO at the WRZ level. Within the Aquator platform there are two different approaches for calculating DO: the Scottish DO Method; or the English & Welsh DO Method. The WRMP 2012 applied the English & Welsh method which involved setting a minimum and maximum overall demand in a WRZ and incrementally increasing the demand until there is a failure to meet the demand. Through this method, the DO is defined as the demand that is one increment below the demand causing a failure. However, the WRMP 2012 did not explicitly set out customer LoS within their DO analysis, as previously NI Water had no stated policy on LoS relating to customer restrictions as part of its operational and management response to drought conditions.

LoS had not been considered within the previous NI Water resource planning strategy because the supply system was not considered to experience large seasonal variations in demand. Similarly, planning on meeting peak demands was also not fully considered. However, the 2014 Technical Guidance[4] from the DfI requires NI Water to develop LoS. Following discussion with Stakeholders, which included consultation with the Consumer Council for Northern Ireland (CCNI), a LoS of 1 in 40 years has been adopted in the WR&SR Plan (Sections 3 and 9 discuss this in more detail). This is in line with the LoS adopted by several other UK water companies, including both Welsh Water and Scottish Water (refer to Table 3.1: UK Water Company Levels of Service).

In order to adhere to the LoS requirements, the Scottish DO Method has been applied within Aquator. This method assesses the capability of the WRZ system to support increasing levels of demand through multiple iterations, and counts the number of failure years for each demand value. A failure year is registered when demand or an environmental flow condition is not met. By plotting the number of failures against the length of record a return can be assigned. If this is repeated for a range of demands, a system DO curve can be derived, providing a yield for a given return period e.g. the LoS requirement of 1 in 40 years. Thus, by employing the Scottish Method tool to analyse DO, it has been possible to establish the reliable yield (DO), that each WRZ can deliver, to meet this target LoS.

[4] Technical Guidance – Water Resource & Supply Resilience Plan, DfI, November 2014.

4.4.2.3 WRZ model build

The 7 No. Aquator WRZ models developed for the WR&SR Plan build upon the models built in the WRMP 2012. However, a key difference is that while the previous plan had Northern Ireland split into five WRZs, these zones have been further separated out into seven zones with an additional two WRZs (South West and North East) to better represent the current system (see Section 2).

For estimating DO at the WRZ scale, the systems can be represented at a relatively high-level. Therefore, the supply distribution network is simplified to focus on the representation of the transfer of water from the NI Water licenced sources to the WTWs, and from the WTWs to the DCs. The Aquator model schematics for each WRZ were developed using all relevant information, mapping and other data sources made available from NI Water including:

- WRMP 2012 Aquator models;
- WRMP 2012 Trunk Mains Models (TMMs);
- NI Water Raw Water System Infrastructure schematics;
- Geographical Information System (GIS) mapping layers (reservoirs, river intakes, WTWs, mains etc.);
- NI Water Abstraction Licences; and
- DfI Reservoir Inspection Reports.

As part of the WR&SR Plan supply-side assessment approach, within each WRZ model all NI Water abstraction sources are linked to supplying a single centralised WRZ DC. This is a modification of the WRMP 2012 model build, which constrained the zones by using several different DCs per WRZ. This single WRZ DC approach is based upon the refreshed review of the WRZ boundaries (See section 2), and serves to provide a more useful indication of the total DO potential of the WRZ as supply is focused on meeting a single total WRZ demand value. With a single DC there is improved ‘connectivity’ as the zone is unconstrained from the issue of sub-DCs ‘silo’ groups functioning independently. This streamlining of the high-level supply network acts to promote the rationalisation of water supply and the increased conjunctive use of reservoir/lough and river sources across the zone. This model build strategy is also consistent in approach with the selection of the Scottish Method DO analysis tool for testing the maximum WRZ output achievable. However, it must be noted that this assumes the sources and WTWs operate effectively to allow proper connectivity between them.

The Aquator models consist of all abstraction sources confirmed by NI Water as licenced for public water supply and currently in-use at the time of the WR&SR Plan. The model abstraction sources are a combination of reservoir (impounding reservoirs (IR) and natural loughs) and river sources. Any assets identified as out of service, abandoned or decommissioned have been removed from the process and are therefore not in the Aquator models. This includes Camlough WTW which was decommissioned in 2016. Furthermore, all groundwater sources (with the exception of Rathlin Island Boreholes) are assumed to be out of service and therefore are also not included in the DO assessment. Within the models, several WTWs are titled with ‘PPP’ to notify that these assets were run under the PPP (Public Private Partnership) scheme that Dalriada (Kelda Water Services) had operated on the behalf of NI Water since 2008, including:

- Dunore Point WTW;
- Ballinrees WTW;
- Castor Bay WTW;
- Moyola WTW.

Note that in a strategic move which brings all clean water production in Northern Ireland back into public ownership, the company has announced the acquisition of Kelda Water Services' holdings in the four treatment plants that provide almost half of the treated water in the province. This move followed the decision by the Kelda Group to put the non-regulated businesses of Kelda Water Services (KWS) up for sale. This included the Project Alpha Public Private Partnership (PPP) contract operated by KWS. The PPP contract remains in place and continues to govern how NI Water and its newly acquired subsidiaries (Dalriada Water and NI Water Alpha Ltd) engage in a PPP project that continues to have outstanding bank debt commitments. Howeveras under the same ownership NIW's ability to instigate change in assets and services provided under the PPP contract is greatly enhanced.

As mentioned, the zones are developed at a high-level of representation. Therefore, they do not incorporate smaller scale distribution and operational conditions involved at the District Meter Area (DMA) level. It is also important to note that the link components within Aquator do not aim to represent a particular type, scale or quantity (individual or collective) of pipeline – they serve to simply illustrate the general conveyance of water (raw or treated) across an area. A number of cross boundary transfers are not represented explicitly in the Aquator models, if they operate on a constant basis. The demand on the zone providing the transfer and the benefit to the recipient zone is accounted for in the Supply Demand Balance tables (Section 9)

Several individual NI Water abstraction sources which were grouped together in the 2012 plan have been disaggregated so that the models include every individual source intake supplying the WRZ. This disaggregation process enables a much finer detail of representation of the NI Water supply system, as all licensed intake sources have been attached individual flow sequences, conditions and constraints. This allows for a more effective simulation of the conjunctive use of all the sources supplying each WRZ, and therefore a more robust assessment of the DO which can be achieved for each zone. Whilst there are gaps in asset data the model provides a better framework for ongoing improvement, and is more directly transferable to drought planning scenarios, where asset interaction with low flows is key.

4.4.2.4 Model component input data

The Aquator model has the capability of incorporating an extensive range of input data and information into its different components. A fundamental aspect of the model build stage was the gathering of key physical asset data and operational information from NI Water in order to accurately represent the water supply network within the Aquator models. Alternative sources of information were also used for data collection, as well as the reliance of making suitable assumptions and estimations, in order to gather the minimum input data required for Aquator to function.

The following list represents the critical information that has been collated to use as the input data for the baseline Aquator models:

- IR and Loughs
    - Storage capacity;
    - Inflow record – mean daily flow time series determined using the CERF model;
    - Observed storage records (limited years and not available for all reservoir/lough sources);
    - Compensation releases.
- Abstraction licences
    - Daily and annual quantities;
    - Minimum and environmental flow conditions.
- Infrastructure

  - WTW capacities and process losses – both minimum and maximum flow limits were applied

- River and stream catchment inflow record
  - Mean daily flow time series determined using the CERF model

- DCs
  - Daily demand quantities using Northern Ireland Distribution Input (DI) values for the period 01/04/2010 – 31/03/2015, showing the recorded daily demand met at each WTW in the NI Water system. Therefore, a suitable up-to-date 5-year average DI demand value can be calculated for each WRZ.
  - Daily demand factors profile for calculating DO for the DYCP demand scenario.

It is important to note that not all of the required information could be obtained e.g. operational rules and storage control curves for IR, exact intake arrangement details etc. Further investigation is recommended before the next WR&SR Plan to collect this data and thus further improve upon the robustness of the DO assessments.

It should also be noted that the failure mechanisms of each system are dependent on the operational rules set. These operational rules are often based on how the system behaved in the past, however, such behaviour is often the result of an event that the modellers would not have had sight of. Furthermore, the operational actions may be different for future events, as this is dependent on many factors. Therefore, this is a significant limitation on the model output. In particular the source identified as failing first may not be the source that fails first, if the operational rules on site are later changed.

4.4.2.5 Recommendations

It is important to note that not all of the required asset and operational information could be obtained for the Aquator model build stage and the DO assessment approach has made best use of the available data and techniques. The Aquator models can be updated as and when improved asset and operational information becomes apparent in the future. Further investigation is recommended before the next WR&SR Plan to collect this data and thus further improve upon the robustness of the DO assessments. Additional information on the reservoir and river supply sources which would be highly beneficial to the accuracy of yield assessments would include details on the reservoir storage control curves, reservoir spillway arrangements operational practices and rules, exact abstraction intake arrangements etc.

4.4.3 Planning Scenarios

After developing the models to best represent the current NI Water supply network, baseline DO estimates have been calculated for each of the seven WRZ models. DO estimates for three different scenarios are assessed which are aimed at providing a sufficient supply to meet different demand scenarios:

- NYAA demand – the DO that can be sustained for 1 in 10 years, when applying a constant normal year annual average demand across the whole year during the DO analysis;

- DYAA demand – the DO that can be sustained for 1 in 40 years when applying a constant dry year annual average demand across the whole year (selected as the most suitable LoS for the WR&SR Plan); and,

- DYCP demand – the DO that can be sustained for 1 in 40 years, when applying a variable dry year demand profile across the year, comprising the dry year critical period (DYCP) demand to reflect the critical peak-week demand in summer, together with the normal year annual average (NYAA) demand in winter, with the average over the year equalling the dry year annual average (DYAA) demand.

A different profile of daily demand factors has been calculated for each of the DC components of the seven WRZ models within Aquator. The peak demand factor for each WRZ is taken from the annual peak week, when demand has been determined to be greatest in the summer. When calculating the DO estimate for the DYCP demand scenario, the 1 in 40 years return period value was then multiplied by the WRZ peak demand factor to give the appropriate DO estimate for DYCP. A typical dry year demand profile is shown in Figure 4.1 below.

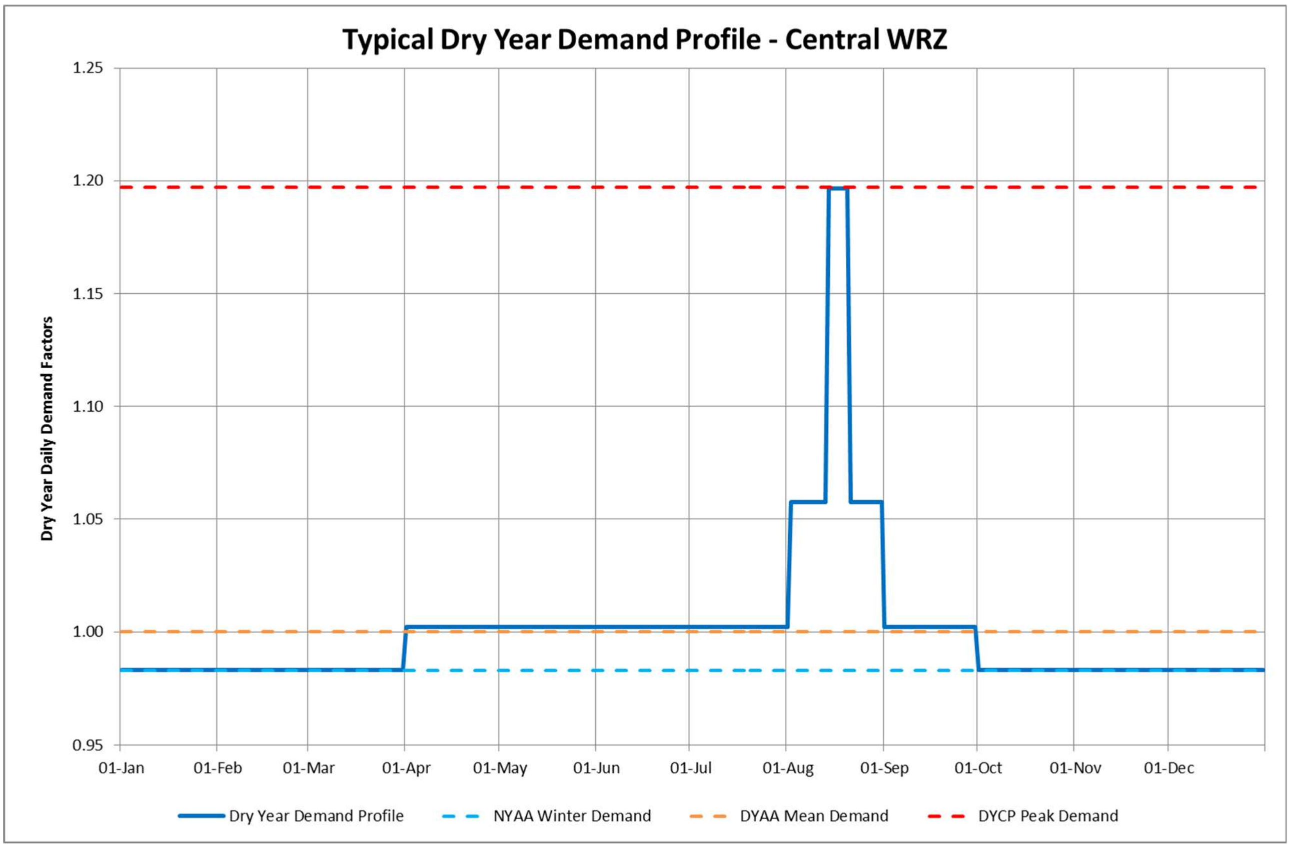


Figure 4.1: Typical Dry Year Demand Profile – Central Zone

The WCP demand scenario is tested against the system in winter when there are no hydrological limits on the system. In this case, for all WRZs, the limiting factor is the WTW capacity. Thus the DO for WCP scenario is taken as the total WTW capacity for each WRZ.

It should be noted that the DYCP DO will always be higher than, or at least equal to, the DYAA DO as this is the condition to meet the summer peak-week demand in a dry year. This should be greater than the average demand in a dry year. Also, as the DYCP scenario uses a variable demand profile, its winter demand should be less than the DYAA demand and its summer demand should be higher than the DYAA demand (including a marked increase in August to reflect the peak-week demand). This means that although the system may not fail during average (DYAA) conditions, it may nevertheless fail during DYCP conditions if there is insufficient storage available to meet the peak summer demand. It was observed in the modelling, that while DYCP was found to be the critical dry year supply condition, system failures did not always occur during the peak-week itself in August but often a few weeks later in September. This was due to the dynamics of reservoir storage in the system.

4.4.4 Baseline DO estimates

Table 4.2 shows the results from the Baseline DO assessment. The combined WTW capacity for each WRZ (i.e. the sum of the maximum outputs of all WTWs within the zone) is shown to give a reference to what the zone could deliver as a DO if there were no hydrological constraints limiting the WTWs from meeting their design capacities on a daily basis.

It is important to note that the Baseline DO estimates have included WTW process losses within their assessments and these production losses are incorporated within the Aquator modelling setup (section 4.4). Hence, the Baseline DO estimates do not require process losses to be further applied. However, they do require the addition of designated 'Outage' values (section 4.7) in order to calculate Water Available for Use (WAFU) for the SDB.

Using the daily DI values supplied by NI Water for each WTW for the period 01/04/2010 – 31/03/2015, the average DI 5-year figure can be calculated for each WRZ by combining the average daily DI values for the WTWs in operation in those zones. This average demand value can provide a useful comparison to the Baseline DO estimates calculated from the Aquator modelling to see how the modelled DO performs against the average demand that has been met over that period.

Table 4.2: Baseline DO Estimates for each WRZ (excluding imports/exports) and Northern Ireland Total

WRZ	WTW Capacity (Ml/d)	DI 5yr avg. 2010-15 (Ml/d)	DO (Ml/d)			
			NYAA	DYAA	DYCP	WCP
North	129.3	71.9	126	113	124	129
South	216.4	137.0	216	215	216	216
East[5]	170.0	132.3	169	161	170	170
Central	32.5	26.4	32.5	32.5	32.5	32.5
North East[6]	205.0	198.7	205	205	205	205
South West	38.0	26.2	38	38	38	38
West	51.3	36.7	43	41	42	51
NI Total	**842.5**	**629.1**	**829**	**805.5**	**827.0**	**842.5**

Note: These figures do not include transfers between WRZs (see section 4.5).

The overall Baseline DO for Northern Ireland for the DYAA scenario (for the selected 1:40 LoS for the WR&SR Plan) has been calculated as 805.5 Ml/d. This is equivalent to around 1.3 times the 2010-2015 DI average value (i.e. the DO is 1.3 times higher than the average demand met in those years).

4.4.4.1 North WRZ

For the North WRZ model, the calculated DO for the DYAA demand scenario is 113 Ml/d, which is equivalent to 1.6 times the 2010-2015 DI. When all WTWs within the zone are fully performing at their design capacity then the combined WTW capacity for the zone is 129.3 Ml/d. Ballinrees WTW and Altnahinch WTW can consistently deliver their capacities for the given LoS under the operational rules used. However, when the WRZ demand is incrementally increased to a certain point then Carmoney WTW and Caugh Hill WTW cause the model to fail because of their inability to continue to deliver at their maximum output due to hydrological constraints affecting the sources supplying these two WTWs.

Carmoney WTW has a capacity of 35 Ml/d which it regularly delivers through the abstraction from the River Faughan watercourse. However, within drier periods of certain years, low flows cause the plant to drop its output and therefore result in the model failing to meet this capacity. Similarly, Caugh Hill WTW has a capacity of 34 Ml/d which it fails to deliver when WRZ demand has been increased to a certain level, because of the emptying of the Altnaheglish IR source which supplies the plant.

[5] Based on Drumaroad WTW (works cap. = 124 Ml/d) and Dorisland WTW (works cap. = 46 Ml/d) only. Not including cross-zonal bulk transfer from Dunore Point WTW (PPP) from North East WRZ which is supplied from Lough Neagh – an infinite inflow source
[6] Based on 180 Ml/d from Dunore Point WTW (PPP) which is supplied from Lough Neagh – an infinite inflow source

4.4.4.2 South WRZ

The DO for the South WRZ has been calculated as 215 Ml/d for the DYAA, which is equivalent to 1.6 times the 2010-15 DI value. The combined WTW capacity for the zone is 216.4 Ml/d when all WTWs are delivering their respective design capacities. Fofanny WTW appears to be the critical WTW responsible for causing the model to fail when demand has been incrementally increased to a certain level.

The zone is mainly supplied by Castor Bay WTW (PPP), which can deliver its design capacity of 147 Ml/d on a daily basis, as the plant abstracts from Lough Neagh; an infinite inflow source. However, there is limit of 95 Ml/d in the quantity that Castor Bay WTW can transfer within the South WRZ. This is addressed in the SDB. The plants at Seagahan WTW (works cap. = 13.6 Ml/d), Clay Lake (works cap. = 5 Ml/d), and Carran Hill (works cap. = 6.8 Ml/d) can all consistently deliver their works design capacities for the given LoS under the operational rules used. However, at Fofanny WTW (works cap. = 36 Ml/d), the sources of Fofanny IR and Spelga IR that supply the plant can empty during certain drier years when the South WRZ demand has been increased, causing the model to fail.

The analysis does not include for exports from the system from Castor Bay WTW to the East and Central WRZs. These are discussed further in section 4.5.

4.4.4.3 East WRZ

The calculated DO for the East WRZ is 161 Ml/d, which is equivalent to nearly 1.2times the 2010-15 DI value. This assessment does not include the cross-zonal bulk transfers from Dunore Point WTW (PPP) in the North East WRZ and Castor Bay WTW (PPP) in the South WRZ. The combined WTW capacity of the zone is 170 Ml/d: Dorisland WTW can output a maximum of 46 Ml/d, and Drumaroad WTW can deliver 124 Ml/d.

The Dorisland WTW can consistently provide this capacity as it is supplied by a series of reservoirs so encounters no hydrological constraints. Comparably, at Drumaroad WTW, the large IRs at Silent Valley IR and Ben Crom IR, along with the River Annalong source, provide sufficient water for the plant to deliver its design output without risk of emptying the reservoir sources. Therefore, for the given LoS, the East WRZ model is constrained only by WTW capacities, not by hydrological conditions, and therefore has a DO identical to the zone WTW capacity.

4.4.4.4 Central WRZ

Similarly, the DO for the Central WRZ is also constrained by WTW capacity and not by hydrological conditions in the zone for the given LoS. The calculated DO is 32.5 Ml/d, which is equivalent to 1.2 times the 2010-2015 DI value. This DO is identical to the combined WTW capacity for the zone, which is based on both Moyola WTW (PPP) (works cap. = 19 Ml/d) and Lough Fea WTW (works cap. = 13.5 Ml/d) able to consistently deliver their design capacities.

Lough Fea WTW can meet its works capacity as it has sufficient supply from Lough Fea as well as river abstractions which feed into the lough source. Moyola WTW (PPP) has a deemed ‘infinite’ inflow supply from Lough Neagh to also deliver its works design capacity regularly without causing the model to fail to meet demand.

4.4.4.5 North East WRZ

For the North East WRZ, the DO has been calculated as 205 Ml/d, which is also identical to the combined WTW capacity of the zone. This is based on Dunore Point WTW (PPP) supplying its works capacity amount of 180 Ml/d, which is not under any hydrological constraints as the plant is fed by Lough Neagh. Dungonnell WTW (works cap. = 12.5 Ml/d) and Killylane WTW (works cap. = 12.5 Ml/d) are similar systems as they both have reservoirs which are fed by river abstraction intakes, which can supply the works to meet design capacity output without risk of emptying for the given LoS. Hence, the North East WRZ model is also only constrained by the combined WTW capacity limits in the zone, and not by hydrological conditions.

The analysis does not include for exports from the system from Dunore Point to the East WRZ. This is discussed further in section 4.5.

4.4.4.6 South West WRZ

The DO for South West WRZ has been calculated as 38 Ml/d, which is equivalent to 1.4 times the 2010-15 DI. This DO estimate is also identical to the combined WTW capacity of the zone, as both Belleek WTW (works cap. = 2 Ml/d) and Killyhevlin WTW (works cap. = 36 Ml/d) are supplied raw water from the Lough Erne source, and therefore have no issues in consistently delivering their maximum output levels. Therefore, the South West WRZ model is constrained by WTW capacity, and not by hydrological conditions, when assessing DO.

4.4.4.7 West WRZ

The West WRZ has a calculated DO of 41 Ml/d, which is equivalent to around 1.1 times the 2010-2015 DI value. The combined WTW capacity of the zone is 51.3 Ml/d but the model is unable to achieve a DO of this because of hydrological constraints limiting the output of certain critical WTWs during the simulation.

The Lough Macrory WTW (works cap. 12 Ml/d) is fed by a series of loughs as well as upland stream intakes; it can meet its design capacity for the given LoS based on the operational rules used. Lough Glenhordial WTW (works cap. = 6 Ml/d) can also deliver its relatively small works design capacity requirements. The hydrological constraints that limit the overall WRZ DO are shown to be experienced at the Lough Bradan WTW (works cap. = 8.3 Ml/d) and Derg WTW (works cap. = 25 Ml/d) abstraction groups. When WRZ demand has been incrementally increased to a certain demand, the moderately sized Lough Bradan source empties during low flow periods of certain dry years, meaning the WTW output drops and the model fails in meeting demand.

The Derg WTW is supplied by two different river sources which are an abstraction from River Derg, and a relatively newly installed river intake at Strule River. Despite the additional intake and revisions to the Derg/Strule abstraction licencing conditions to allow for more water to be treated at the plant, the works still suffers reduced output during times of low flows in certain dry years.

4.5 Raw and potable water transfers and bulk supplies

There are 3 bulk transfers of water not included in the Aquator Modelling that need to be accounted for in the SDB. These are:

- Dunore Point WTW (PPP) in the North East WRZ transfers up to 160 Ml/d to the East WRZ;
- Castor Bay WTW (PPP) in the South WRZ transfers up to 77.5 Ml/d to the East WRZ; and
- Castor Bay WTW (PPP) in the South WRZ transfers up to 2.4 Ml/d to the Central WRZ.

4.6 Distribution operational use and treatment works losses

During the data gathering stage, operational information on the process losses of each WTW is collected and this is presented in Table 4.3. This assessment of Process Losses is an improvement on the WRMP 2012 which used the same assumption for the majority of the WTWs.

For many treatment works, the process water is returned back upstream to the source or to the head of the works. This means that the WTW can still output its works design capacity as long as it can abstract the additional raw water to include the additional amount needed for process water. However, it is important to note that for WTWs with process losses that have abstraction licences identical to WTW capacity, then the output that can actually be delivered may be reduced because the works cannot abstract enough to compensate for production losses.

For the WTWs within the ‘PPP’ scheme, the WRMP 2012 used estimated abstraction and measured delivery volume data provided by Dalriada to calculate typical losses of 5% for the works. This process loss estimation was confirmed to still be accurate by NI Water for the WR&SR Plan.

Table 4.3: WTW Process Losses

WRZ	WTW	Process loss	Net Process loss	Notes
North	Altnahinch	5.0%	0.0%	5% but returns to source and abstraction is greater than WTW capacity so no net loss
	Ballinrees (PPP)	5.0%	5.0%	PPP scheme WTW estimated process losses
	Carmoney	4.0%	0.0%	Depending on Water quality 3 - 5% is lost to river but abstraction is greater than WTW capacity so no net loss
	Caugh Hill	8.0%	0.0%	8% but returns to source and abstraction is greater than WTW capacity so no net loss
South	Castor Bay (PPP)	5.0%	0.0%	Returns to Lough Neagh and abstraction is greater than WTW capacity so no net loss
	Seagahan	10.0%	0.0%	Approximately 10% but returns to head of the works so no net loss
	Clay Lake	12.0%	0.0%	Approximately 12% but returns to head of the works so no net loss
	Carran Hill	10.0%	0.0%	Approximately 10% but returns to head of works so no net loss
	Fofanny	0.0%	0.0%	All returned to head of works
East	Dorisland	0.0%	0.0%	All returned to head of works
	Drumaroad	0.0%	0.0%	All returned to head of works
Central	Lough Fea	3.5%	0.0%	3-4% but returns to source and abstraction is greater than WTW capacity so no net loss
	Moyola (PPP)	5.0%	0.0%	Returns to Lough Neagh and abstraction is greater than WTW capacity so no net loss
North East	Dungonnell	5.0%	0.0%	5% but returns to source and abstraction is greater than WTW capacity so no net loss
	Killylane	0.0%	0.0%	All returned to head of works
	Dunore Point (PPP)	5.0%	0.0%	Returns to Lough Neagh and abstraction is greater than WTW capacity so no net loss
South West	Belleek	5.0%	0.0%	Nothing is returned but abstraction greater than WTW capacity so no net loss
	Killyhevlin	13.0%	0.0%	Returns to Lough Erne and abstraction is greater than WTW capacity so no net loss
West	Derg	9.0%	9.0%	Nothing is returned to the head of the works
	Lough Bradan	8.5%	0.0%	Nothing is returned but abstraction greater than WTW capacity so no net loss
	Lough Macrory	3.5%	0.0%	3-4% but returns to source and abstraction is greater than WTW capacity so no net loss
	Glenhordial	2.5%	0.0%	2-3% but returns to source and abstraction is greater than WTW capacity so no net loss

Temporary or short-term reductions in DO are considered under outage allowances (see section 4.8.). An element of long-term losses to DO includes the calculation of target headroom (TH) which acts as the buffer that NI Water must provide between its supply and demand balances to take into account the impact of various uncertainties involved in supply and demand forecasting.

Primarily, long-term losses to DO are concerned with sustainability reductions. This encompass the changes to DO which could stem from modifications to the amount of volume NI Water is authorised to abstract for public supply as well as any amendments in the requirements for environmental conditions. At the time of the development of the WR&SR Plan, there is no knowledge of any current or upcoming sustainability reductions for NI Water. The recent revisions of abstraction licences for the rivers Derg and Strule have all been reviewed and re-issued by NIEA and suitably incorporated within the supply assessment of this plan. There will be additional revisions of abstraction licences in the future which will require the DO to be reassessed. As previously mentioned, there still remains a level of ongoing uncertainty regarding the potential reduction to the available River Faughan abstraction. However, for the purposes of the plan no further assessment on sustainability reductions has been made.

4.7 Comparison with previous DO

Table 4.4 shows the comparison of the WR&SR Plan Baseline DO estimates with the results from the WRMP 2012. Overall, the total DO for Northern Ireland appears to have had little change from the previous assessment. The WR&SR Plan Baseline DO estimate (using DYAA LoS) for Northern Ireland has been calculated as 814.5 Ml/d, which is around a 25 Ml/d increase from the 789.2 Ml/d overall DO from the previous plan assessment. In order to facilitate the comparison between the two assessments, the WRZs have been based on the WRMP 2012 WRZ boundaries approach which split Northern Ireland into five zones. Therefore, the South, East and North East WRZs DO estimates have been combined to compare to the WRMP 2012 East and South WRZ DO estimates. The DO results from West WRZ and South West WRZ have also been combined in order to compare to the West WRZ estimates of the WRMP 2012.

Table 4.4: Comparison of WR&SR Plan and 2012 WRMP Baseline DO Estimates

WRZ (based on WRMP 2012 WRZs)	WRMP 2012 DO (Ml/d)	WR&SR Plan DO (DYAA) (Ml/d)	Comments
North	115.6	113	
South and East	553.4	590	Camlough WTW has been decommissioned. Differences in constraints including Drumaroad WTW capacity Lough Island Reavy modelled as a permanent source for Fofanny WTW Hydrological differences due to length of record and revised inflow sequences
Central	31.1	32.5	Slight increase in Lough Fea output.
West	89.1	79	The differences are likely mostly due to different assumptions made on the licence restrictions at the Derg/Strule.
NI Total	**789.2**	**814.5**	

It is important to note that although the WRZ boundaries have been aligned to facilitate the comparison of the DO results for the two assessments, it is not possible to make a fully like-for-like direct comparison between the two sets of DO calculations because of other major differences in the DO approaches.

Firstly, the two assessments use different Aquator methods for calculating the DO. The WRMP 2012 used the English & Welsh method which defined DO as the demand that is one increment below the demand causing a failure. The WR&SR Plan uses the Scottish method to identify a DO that meets a 1 in 40 years LoS (i.e. DYAA demand scenario). This difference in approach could be a factor for the WR&SR Plan overall DO being higher because the Scottish method does not necessarily use the lowest DO before model demand failure which the English & Welsh method always does.

Secondly, the WRMP 2012 and the WR&SR Plan have used different hydrological analysis methods to derive the inflow sequences for the Aquator sources. In addition the length of records available has improved considerably. The WRMP 2012 was limited to using flow records from 1975-2009 as long-term rainfall data was not readily available for the whole region. Recently digitised rainfall data has allowed a rainfall runoff model to be developed to produce estimated flows from 1890-2012. A review of these modelled long-term flow sequences has shown that the most severe drought events have all occurred in the last 40 years and within the period assessed in the WRMP 2012. As the assessment has been conducted using a longer period of record it should be considered more robust, although there may be uncertainties about the accuracy of rainfall measurements in the early part of the record. As the WRMP 2012 assessment also considered the worst years on record there is no notable reduction in DO from the previous plan. There are actually small increases in Deployable Output as failures between 1975 and 2009 are now considered to have a higher return period when compared against a longer period of record.

Furthermore, alongside the review of the WRZ boundaries, the WR&SR Plan has made many changes to the network layout and operational conditions of the various assets in the Aquator models in order to better represent the NI Water system.

4.8 Outage

Outage is a temporary loss in DO usually associated with either a planned or unplanned shutdown.

A review of the UK water companies shows that outage ranges from 2% to 8% with an average of 5% of DO. The WRMP 2012 assumed an allowance of 2% of DO for unplanned outages and no allowance for planned outages.

There is little historic outage data for unplanned outages and none at all for planned outages. The 2008/09 data shows that there were unplanned outages approximately 12 days in the year; approximately 3% of the time. This is a small sample it is expected that the long-term average (LTA) would likely be higher than this and thus a figure of about 4% for unplanned outages may be more realistic, particularly as there is such little historic outage data available.

It is accepted that the risk of outage during any planned maintenance activity would likely be significantly less than that for unplanned outages. This is because the maintenance activity will be more controlled with staff on hand to cope with any outage that could occur. However, this risk can never be eliminated entirely and thus some minimum allowance needs to be included to cover for this risk. In view of the fact that there is no data to corroborate that this risk is zero, it is considered that a minimum planned outage allowance of 1% is assumed. Taking these two figures together gives a total outage allowance for the NI Water WR&SR Plan of 5% which is in line with average assessed figures for UK water companies.

While the existing data and assumptions support the use of the UK water company average the data is limited. Therefore, it is recommended that further outage data is collected in advance of the next plan.

4.9 Water Available for Use (WAFU)

Applying the Outage figures to the DO provides the WAFU for each WRZ. The WAFU estimates for each WRZ are provided in Table 4.5 below for various Planning Scenarios.

Table 4.5: WAFU estimates (Ml/d) for each WRZ for Various Planning Scenarios

WRZ	Scenario			
	NYAA	DYAA	DYCP	WCP
North	119.70	107.35	117.61	122.84
South	205.58	204.25	205.58	205.58
East	161.50	161.50	161.50	161.50
Central	30.88	30.88	30.88	30.88
North East	194.75	194.75	194.66	194.75
South West	36.10	36.10	36.10	36.10
West	40.85	38.95	39.71	48.74
NI Total	**789.4**	**773.8**	**786.0**	**800.4**

It must be noted that these do not include any transfers between WRZs.

5. Drought Plan

This section covers the drought management procedures that are to be implemented during periods of drought. This differs from the Water Resources Plan that identifies what supply side and demand side measures need to be implemented to maintain the water supply Level of Service (LoS) at the target supply reliability of 97.5% (with water shortages permitted for 1 year in 40 on average). The Drought Plan determines the procedures to be implemented either to temporarily reduce demand or increase supply during droughts with a return period in excess of the target LoS.

The drought procedures thus set out the actions to be carried out not only once a drought has occurred, but also during the period that a drought may be developing. The Drought Plan thus provides for the following three key steps:

- Drought monitoring;
- Drought triggers;
- Management actions.

Drought monitoring comprises the monitoring of river flows and reservoir storage levels to give advance warning of an impending drought, while drought triggers determine when particular management actions need to be undertaken. Drought triggers comprise control curves for a particular group of reservoirs and the associated management actions comprise measures to reduce demand such as Hosepipe ban and Drought Orders or measures to temporarily increase abstractions such as drought permits.

5.1 Drought Management Process

Droughts are a naturally occurring phenomenon which occur when lower than average rainfall causes a shortage of water. This shortage affects both the natural environment and sectors such as agriculture and water supply. The duration, timing and intensity of a drought can vary considerably, and these factors will combine to affect different sectors in different ways. NI Water has set out how it seeks to provide water to customers with a level of service of 97.5% (equivalent to allowing water supply failures for one year in forty) and identifies the actions required to do this over the next 25 years. This Drought Plan sets out the actions required to maintain water supplies to customers for the very rare events that are more severe than the level of service. The plan is based on the assets available to the company at the current time, but the Drought Plan needs to be updated as and when changes to the infrastructure occur.

5.1.1 Outline of Drought Management Process

Droughts can impact from a local to national extent, and can present impacts from mild to severe, making it difficult to develop a definitive plan of actions which will apply to all situations. The drought management process is designed to accommodate this escalating from routine monitoring activities to the inception of a drought incident team, who will shape the actions needed to respond to the event as it develops. The Drought Plan allows a flexible approach based on the precise circumstances of the time. It depends on timely routine data collection and monitoring, clearly defined responsibilities and active communications, within NI Water and with stakeholders and customers.

The drought management process relies upon the routine monitoring of water resources and production data against trigger levels or control curves developed for each source or resource zone. An example of a control curve is illustrated in Figure 5.1. As the current position of storage and time of year is plotted on these curves, this directly indicates the risk to supply in four categories as detailed in Table 5.1. The curves are determined for a group of sources that behave in a similar manner, or can be managed in a group. The typical progression is illustrated in Figure 5.2

Where a drought develops and the supply risk escalates through each control curve, a range of actions need to be considered. These actions are designed to reduce demand or increase the supply available to a zone or source.

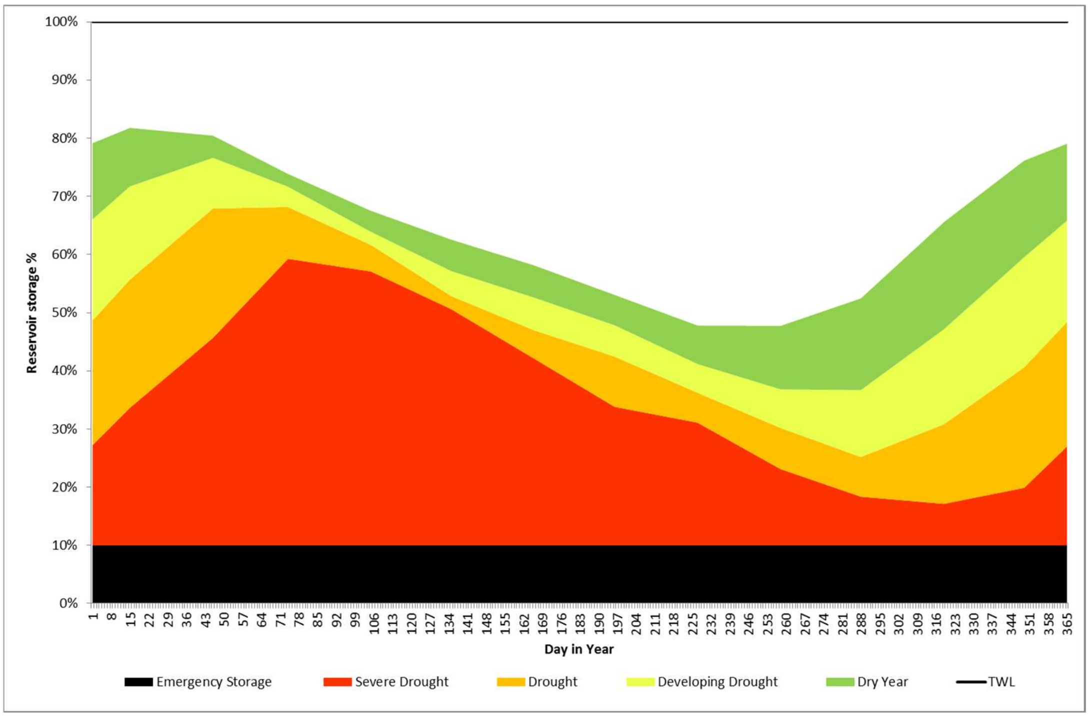


Figure 5.1: Drought Curves Developed for a Reservoir Group

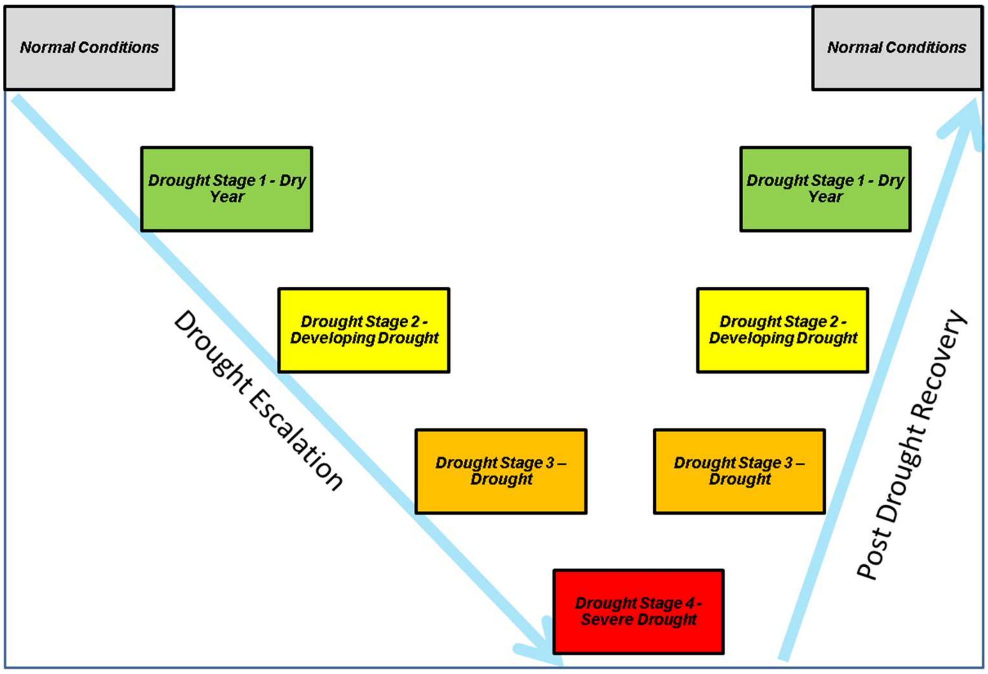


Figure 5.2: Typical Drought Progression

Table 5.1: Categorised Risk to Supply

Drought Stage		Drought Actions		
		Monitoring	Triggers	Management Actions
0	***'Normal' conditions***	Routine monitoring of reservoir group level/storage	Use individual drought control curve to compare current reservoir storage against Stage 1 trigger	Normal operation
1	***Dry Year***	Routine monitoring of reservoir group level/storage	Use individual drought control curve to compare current reservoir storage against Stage 2 trigger	Implement specific actions (demand/supply measures) for Stage 1 trigger
2	***Developing Drought***	Increased monitoring of reservoir group level/storage	Use individual drought control curve to compare current reservoir storage against Stage 3 trigger	Implement specific actions (demand/supply measures) for Stage 2 trigger Increase customer engagement Initiate planning for Drought Order
3	***Drought***	Increased monitoring of reservoir group level/storage	Use individual drought control curve to compare current reservoir storage against Stage 4 trigger	Implement specific actions (demand/supply measures) for Stage 3 trigger Apply for Drought Orders Introduction of hosepipe bans Increased communications Enhanced leakage reductions
4	***Severe Drought***	Increased monitoring of reservoir group level/storage	Use individual drought control curve to compare current reservoir storage against Emergency Storage trigger	Implement specific actions (demand/supply measures) for Stage 4 trigger Determine and implement Drought Orders Introduction of other customer restrictions for non-essential use

5.1.2 Levels of Service (LoS)

The LoS is the target reliability of supply that the water resources plan is designed to meet without causing water shortages within the NI Water water supply system.

For the purposes of this WR&SR Plan, a target LoS was chosen, in consultation with the statutory stakeholders, based on a review of the range of LoS adopted in England, Wales and Scotland. The chosen LoS has been taken as providing the level of investment that allows water supply failures for one year in forty; equivalent to a supply reliability of 97.5%. This LoS compares favourably to the average for other UK water companies.

This Drought Plan reflects the current asset base operated by NI Water, and where these levels of service are currently not met, measures are identified through the WR&SR Plan. This Drought Plan will be updated in line with substantial changes to the asset base.

5.1.3 Summary of Legislation that facilitates drought management

The management of NI Water's operations and its interaction with the environment is governed by the following key legislation:

- The Water and Sewerage Services (Northern Ireland) Order 2006 (2006 No.3336 (N.I. 21)), known as the "2006 Order";

- The Water Framework Directive;
- The Habitats Directive;
- The Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995;
- The Water (Northern Ireland) Order 1999;
- The Fisheries Act (Northern Ireland) 1966.
- Water Abstraction and Impoundment (Licensing) Regulations (Northern Ireland) 2006

The “2006 Order” is the central piece of legislation that details what measures NI Water can take to facilitate drought management. Article 116 enables NI Water to apply temporary hosepipe bans. Articles 137-144 and Schedule 5 provide a means for NI Water to apply to DfI for a Drought Order.

5.1.4 Drought Order process for NI Water

The following is a high level summary of the steps in the process of applying for a Drought Order:

1. Routine monitoring suggests potential for deficiencies in water supplies due to exceptional shortage of rain.
2. Commence liaison with stakeholders and regulators and agree to monitor the situation whilst mobilising a drought management group.
3. If the situation continues to develop, update draft Drought Order application documents and submit to DAERA (NIEA) for comment prior to making a formal application to DfI and advertising the application.
4. DfI considers the application and any associated objections made within a 7 day objection period. An independent hearing by the Water Appeals Commission may be required. Determination of the Drought Order follows this.
5. If the order is granted NI Water can undertake enabling works and operations in line with the Order. An Order can last for up to six months, extendable by application for another three months.

A Drought Order can:

a) Allow any person (such as NI Water) to abstract water from a specified source (subject to conditions).

b) Give NI Water permission to prohibit or limit certain activities of water use. DfI must give a Direction if this provision is sought (Article 138(1)(b)).

c) Allow NI Water to discharge water to a specified place (subject to conditions).

d) Authorise NIEA to prohibit or limit abstraction from a specified source by parties other than NI Water if it is satisfied that such abstraction is seriously limiting NI Water’s supply.

e) Suspend or modify any restrictions or obligations on NI Water or any other person (subject to conditions) regarding:

   i) abstraction;

   ii) discharging;

iii) supplying;

iv) filtration or other treatment of water.

f) Authorise NIEA to suspend or vary any specified consent regarding effluent discharge in water (by NI Water or anyone else). Any suspension or variation will need to be assessed by NIEA.

In developing this Plan NI Water has considered the range of powers available. The company has decided not to consider actions that would affect the quality of water supplied to customers to the extent that the company's obligations would be compromised.

5.2 Developing the Drought Plan

The Drought Plan has been developed through a process which assesses the issues within each WRZ and identifies the options to mitigate against drought risks. This has been assessed against each functional group of sources, defined where a single set of drought control triggers or curves can represent a collection of sources. This may be at finer detail than WRZ level. Solutions have been developed locally for each functional group of sources and then cross checked for consistency and to ensure measures such as enhanced transfers are achievable in drought conditions.

The summary of the stages in developing the Drought Plan is as follows:

- Characterise the sources and drought response;
- Review history of drought issues within the zone;
- Identify options for drought management actions;
- Develop control curves utilising the drought management actions;
- Identify monitoring requirements for production, water resource and environmental indicators.

Each of these steps is summarised below.

5.2.1 Characterise the sources and drought response

In each WRZ the zone schematics and operational performance have been reviewed to characterise the areas which pose the greatest risk within the zone. NI Water operates river and reservoir abstractions that respond in differing ways, and the size of the abstractions in relation to the catchments can also impact the response patterns. The sources have been grouped according to their similarity of response to drought and connectivity through the supply system. Each group will have assigned a single set of drought control curves and a range of specific drought management actions (supply and demand measures) which are triggered when each drought stage is encountered.

5.2.2 Review history of drought issues within the zone

Past performance of sources in a resource zone are likely to be a key indicator of future performance, although changes in demand and network configuration may impact on how a source would respond now. The water resource models have been analysed to look at the failures in the historic record under current demands. Recent operational experience has been collected to validate the model runs. With some time since the last significant drought, it is inevitable that some history from drought events may have been lost. Reservoir levels are available for a number of sources, but the asset base has changed considerably since serious drought events were last experienced with the introduction of the PPP Schemes. Therefore, a direct comparison is not possible. The scale and nature of the failures have been used to guide the selection of appropriate mitigation measures.

5.2.3 Identify options for drought management actions

The Drought Plan identifies a range of options available for managing the drought situation. These encompass both supply side measures and demand side actions. Not all options are included in control curve development. The decision to include measures is made on the basis of practicality and cost. As a drought becomes more severe, the yardstick for what is practical or acceptable in cost or environmental terms will change so some options will only become tenable in a very severe event.

5.2.3.1 Demand side measures

Demand side measures have been developed in line with NI Water’s levels of service and policy statement. There is very little data on the effectiveness of demand management measures in Northern Ireland, although the positive response of consumers to requests to reduce consumption during the period of high demand in summer 2018 does indicate that consumer receptiveness and response could be influenced by the effectiveness of NI Water’s engagement and communication plans . There are a number of reports examining the effectiveness of drought measures from events in England from 2005/6 and 2012, but it is difficult to quantify the effectiveness of single measures from an overall observed total. It is likely that many of the savings occurred as a result of press coverage rather than the specific measures, as demand savings were also observed in areas where there were no restrictions in place, but bordered areas with restrictions. The areas affected are also more used to experiencing droughts and are generally in receipt of stronger water saving messages. The receptiveness to appeals for savings may generally be more positive than in Northern Ireland where public perception is significantly different. The assumptions surrounding the effectiveness of water saving measures have been treated similarly until an evidence base in Northern Ireland is established.

There are four main themes:

- Customer savings from voluntary actions;
- Large water users;
- Additional Leakage Reduction;
- Mandated customer restrictions.

Customer savings from voluntary actions

It is normal for companies to commence their engagement with customers at an early stage of the drought, commonly with an increase in the effort in the water efficiency campaign. Generally, this is easier in areas where customers are used to receiving water saving messages. In Northern Ireland, the general perception of the climate, drought risk, leakage levels and freeze thaw issues, may make convincing people to take action difficult. However, changes in customer behaviour have the potential to deliver far greater savings than the reductions directly arising from hosepipe bans or other restrictions. Actions undertaken by companies in the past include:

- Radio and cinema adverts;
- Street stalls;
- Local paper and bus advertising;
- Operational vehicle vinyl wraps;
- Issue of Hippo bags / shower timers /Water saving tap fittings;
- Mass, discounted water butt offers.

NI Water has developed a separate Communications Plan which sits alongside the Drought Plan, but recognises the planning stages used within the Drought Plan. It has also identified the opportunities for supportive messaging from regulators and local authorities to deliver a complementary effort to reduce customer water use.

The main objectives of the communications plan are:-

- To provide clear, consistent, accurate and timely information to all stakeholders and members of the public about the changing situation on an ongoing basis
- To increase awareness and understanding of the preventative actions that can be taken and the reasons / need for any measures being introduced
- To ensure an effective process for handling media enquiries and web based customer interaction i.e. website and social media
- To foster support amongst keys stakeholders and business bodies
- To increase awareness that the responsibility of water conservation/ efficiency is a collective responsibility, driven by NI Water.

Large water users

Efforts will be made with large water users to try to establish what efficiencies can be made, if alternative supplies can be offered. There would be a particular emphasis on the lack of value sometimes placed on water, resulting in a high degree of waste when simple actions can remedy this. Water audits can be used to engage with customers to lower use and the effort surrounding these can be intensified in times of drought.

Additional leakage reduction

As part of any response an increase in leak detection work will be needed which may go well beyond the ELL and should give a high priority to visible leaks, although this may not achieve a large water saving. Communications around activities to repair leaks are also essential to ensure customers report leaks when observed and understand that sometimes leaks can appear to take some time to fix because of the complexities involved in any repair.

As part of this Plan it is difficult to assign an expected volume saved, but this should be assessed at the outset of any drought event, based on current leakage performance at the time of the drought. If the drought event occurred in five years' time substantial leakage reductions may have been achieved and the understanding of what was additionally available may be quite different.

Hosepipe Bans

NI Water has the ability to impose some restrictions of water use directly, and can apply for additional powers through the Drought Order process. The estimates of the benefits of these restrictions comes from studies based on England and Wales's experience, generally in more water stressed areas.

Article 116 of the 2006 Order allows for a hosepipe ban. This is implemented via formal advertisements in local press, and a communications campaign delivered by the company.

Drought Orders affecting the use of water

The Drought Order powers can be used to restrict certain activities of water use, as set out in Article 138 of the 2006 Order. The measures that may be used need to be set out in a Direction by DfI. DfI has advised that this would happen as a drought develops, as part of the Drought Order process. NI Water has based the plan on potential measures that could be introduced, as detailed below.

NI Water has reviewed the available information including the UKWIR best practice guidance, and arranged the restrictions into tiers, reflecting their likely implementation. Timescales in securing restrictions can vary and there area wide range of actions which can be applied. The implementation of the restrictions will be staggered by advertisement.

Table 5.2 below sets out a proposed phasing, plus estimated benefits drawn from previous experience. The experience in England has shown that it can be difficult to communicate different levels of customer restrictions in neighbouring geographical areas. NI Water therefore proposes that the same set of restrictions are applied uniformly in all areas where they are required. Appendix F of the UKWIR document ‘Managing Through Drought: Code Of Practice And Guidance For Water Companies On Water Use Restrictions – 2013’ provides more detail on each measure.

Table 5.2: Suggested Demand Restriction Hierarchy and Benefit.

Suggested NI Water implementation phase	Demand Restriction	Drought Phase	Estimated Demand reduction
HPB (art 116)	Watering a 'garden' using a hosepipe	Drought	3%
HPB (art 116)	Cleaning a private motor vehicle using a hosepipe	Drought	
DO tier 1	Watering plants on domestic or other non-commercial premises using a hosepipe	Drought / Severe Drought	5% in total
DO tier 1	Cleaning a private leisure boat using a hosepipe		
DO tier 1	Filling or maintaining a domestic swimming or paddling pool		
DO tier 1	Drawing water, using a hosepipe, for domestic recreational use		
DO tier 1	Filling or maintaining a domestic pond using a hosepipe		
DO tier 1	Filling or maintaining an ornamental fountain		
DO tier 1	Cleaning walls, or windows, of domestic premises using a hosepipe		
DO tier 1	Cleaning paths or patios using a hosepipe		
DO tier 1	Cleaning other artificial outdoor surfaces using a hosepipe		
DO tier 2	Watering outdoor plants on commercial premises	Severe Drought	5% in total
DO tier 2	Filling or maintaining a non-domestic swimming or paddling pool		
DO tier 2	Filling or maintaining a domestic pond using a hosepipe (Drought Order)		
DO tier 2	Operating a mechanical vehicle-washer		
DO tier 2	Cleaning any vehicle, boat, aircraft or railway rolling stock		
DO tier 2	Cleaning non-domestic premises		

DO tier 2	Cleaning a window of a non-domestic building		
DO tier 2	Cleaning industrial plant		
DO tier 2	Suppressing dust		
DO tier 2	Operating cisterns in unoccupied/closed buildings		

5.2.3.2 Supply side options

Supply side options have been developed to a level of detail that permits realistic estimates of timings and yields to be made. This has included identifying the proposed outline solution, risks and constraints. The level of detail is sufficient to commence more detailed design if required as a drought develops, bearing in mind that this may be some time in the future.

Rezoning

The Drought Plan addresses the management steps within a source grouping in the first instance, and in some places the steps include the rezoning of supplies from more resilient sources. Consideration has been given to the likelihood of these sources being impacted by the same drought event and what water may be available under these circumstances.

Discussions with Operations have taken place to identify restrictions in the existing system which could be removed by quickly implemented engineering works. Where appropriate these options have been identified as potential actions. For these actions estimates of water savings have been calculated using District Meter Area (DMA) meter data or population based calculations.

Recommissioning disused sources

The development of the control curves against historic data has not identified the need to reintroduce any disused sources. The steps below have been undertaken to identify actions that might be required in a situation worse than the historic record.

Examination has been made of existing water sources in Northern Ireland which have been mothballed or decommissioned in recent years. The reasons for closure, likely asset condition and the status of legal permissions to operate the sites all have a bearing on their viability. Those sources that were closed due to issues with maintaining yield are unlikely to be worth pursuing further. However, those closed for efficiency reasons could be reintroduced to make some contribution to the drought situation. Those sites that have suffered water quality problems may be viable if temporary package treatment plants can be added to the site. Any historic performance data has been reviewed to identify possible yields that could be achieved to factor into control curve development.

The legal status of sources will dictate how they can be reintroduced. Those without abstraction licences will require a Drought Order to permit abstraction, which may become the critical path on the development of the control curve. Prior to the application for a Drought Order, significant design and construction work may be required to make the source operational. This may have a longer duration than the Drought Order application process. The desk study of the option should try to assess if work could continue on the basis of local agreement with landowners or if legal powers would be required to gain access to land.

Viable sites for new sources need not be restricted to old NI Water sites. There may be legacy industrial sites for river or groundwater abstractions which could be utilised, although significant temporary works are likely to be required.

Drought Orders for existing sources

Drought Order options for existing sources are generally a preferable option for additional supplies although environmental impacts may be greater than moving to new sources. They are also likely to have some history of drought operation which may be used to assess the impacts of future operation. Option identification at this stage has evaluated the broad engineering requirements to enable the Drought Order to be utilised, the possible downstream impacts and the network capacity to utilise the water if a Drought Order was granted. Environmental risks have been considered in the same way as for new sources.

Drought Orders should also be considered for modifications to discharges, where relaxing dilution constraints on sewage treatment works' would allow additional abstraction to be made upstream.

Environmental impacts of drought measures

Some supply side drought measures have the potential to affect the environment, either through the associated construction activity or as a consequence of the additional water taken. In some areas it may not be possible to deliver a drought response that does not include a temporary environmental impact, and the acceptability of that impact must be judged against:

- the degree of risk to supplies;
- the potential recovery post-drought;
- the possible impacts in the drought situation without interventions.

Key factors in identifying environmental risk include the potential to impact on:

- Biodiversity Action plan (BAP) habitat and species;
- ASSI and NNR designated areas;
- SPA, SAC and RAMSAR sites – these pose an additional risk due to the possibility of an Appropriate Assessment being required.

Mitigation measures may be possible on a temporary basis which could limit the nature of impact or aid recovery post drought. The mitigation will be site and time specific and will be developed in consultation with stakeholders.

5.2.4 Develop control curves utilising the drought management actions

The development of the control curves (example in Figure 5.1) has been carried out in close consultation with NI Water asset and operations staff. The process has been undertaken in parallel with the development of the Drought Plan. The drought curves are first developed for the baseline condition, assuming no drought measures are implemented. They are developed from the bottom up, with the red 'Severe Drought' curve representing the storage required to meet demand and water releases to the environment during the most severe drought in the analysis. This value is calculated for each day of the year, sampling the total number of years available for analysis.

For the purposes of the analysis reconstructed river flows from 1900 – 2012 (113 years) have been used, using the same data and rainfall runoff models discussed in Section 4. This includes a number of severe droughts, including 1976, 1984 and 1995. In some cases the storage required is close to or in excess of the total reservoir capacity. In these cases the measures identified in the drought stages prior to entering 'Severe Drought' have the effect of reducing the total demand on the reservoir and hence lower the severe drought curve. The time periods set for the curves above the severe drought curve are based on expected implementation times for the actions triggered within that curve and can be adjusted according to identified engineering or legislative constraints.

5.2.5 Identify monitoring requirements for production, water resource and environmental indicators

Linked to the implementation of the control curves, a series of monitoring activities are required to develop a comprehensive picture of a developing drought. These will need to be capable of providing rapid information and move from a routine frequency in normal conditions to more intensive actions in time of drought. The indicators will include measurements of reservoir stocks, river flows and groundwater levels, as well as measures of demand to allow the understanding of the current supply demand balance. Associated with certain options may be additional environmental monitoring requirements to protect key features.

6. Demand Forecasts

Water demand or Distribution Input (DI) forecasts have been derived for each WRZ, over the 25 year planning horizon, comprising primarily the following elements in line with standard UK practice:

- Household unmeasured water demand;
- Non-household measured water demand;
- Unbilled water taken;
- Distribution system operational use;
- Network leakage losses.

Just as for the deployable output forecasts, water demand forecasts have been derived for each planning scenario (NYAA, DYAA, DYCP & WCP), for determining the supply/demand balance (SDB), by WRZ, for each planning year.

Initially the normal year (NYAA) demand forecasts were determined using current water production figures, projected forward for later years, using population projections, projected per-capita consumption estimates and other economic indicators. Demand forecasts for a typical dry year (DYAA) were then derived using appropriate dry year uplift factors, with the dry year critical period (DYCP) demand estimated using summer peaking factors based on typical peak-week demands.

The ‘baseline’ water demand forecasts also include any current on-going demand management or leakage reduction measures, but excluding any future demand management or leakage reduction options that may be implemented in the final plan. The full demand forecasting methodology is set out below.

This Plan assesses the demand as 570 Ml/d which is a reduction of over 100 Ml/d in the last 6 years. The reduction is thought to have been achieved through continued levels of active leakage detection, sustained investment in watermains to reduce leakage and a reduction in NHH demand.

There is very little change in demand projected over the planning horizon with the 2042 demand estimated to be 572 Ml/d. This is considerably less than the 732 Ml/d forecast in the 2012 plan.

6.1 Introduction

This Section describes the methodology, assumptions and data used in the detailed studies that have been undertaken to calculate “baseline” water demand forecasts for the WR&SR Plan. It also presents the forecast water demands for each WRZ throughout the planning period to 2042/43.

“Baseline” demand forecasts include current demand management policies, such as leakage reduction and water efficiency programmes planned to 2020/21. They exclude the effects of any additional demand management measures that will be identified by the options appraisal to determine the best value approach to resolving any supply-demand deficits or resilience requirements. The effects of such measures will be included in the final planning demand forecasts (when developed).

Demand forecasting has been undertaken for each of the standard water demand components:

- Unmeasured household (umHH) consumption;
- Measured household (mHH) consumption – does not apply in Northern Ireland;
- Measured non-household (mNHH) consumption;
- Unmeasured non-household (umNHH) consumption;
- Water taken unbilled (WTU);

- Distribution operational use (DSOU);
- Total leakage – including distribution losses from NI Water system and underground supply pipe leakage (SPL) from customer pipes.

The values for these seven components should sum to equal the total water put into supply from NI Water WTWs, known as DI. As explained in the following sections, each component has been estimated for the base year (2014/15) and forecast for each future year for the WR&SR Plan.

Total water put into supply from NI Water's WTW (i.e. DI) in 2014/15 was 564 Ml/d. Figure 6.1 presents a summary breakdown of the demand components, consistent with the 2015 AIR. It shows for example that water consumption by households (HHs) represents nearly half of total water supply.

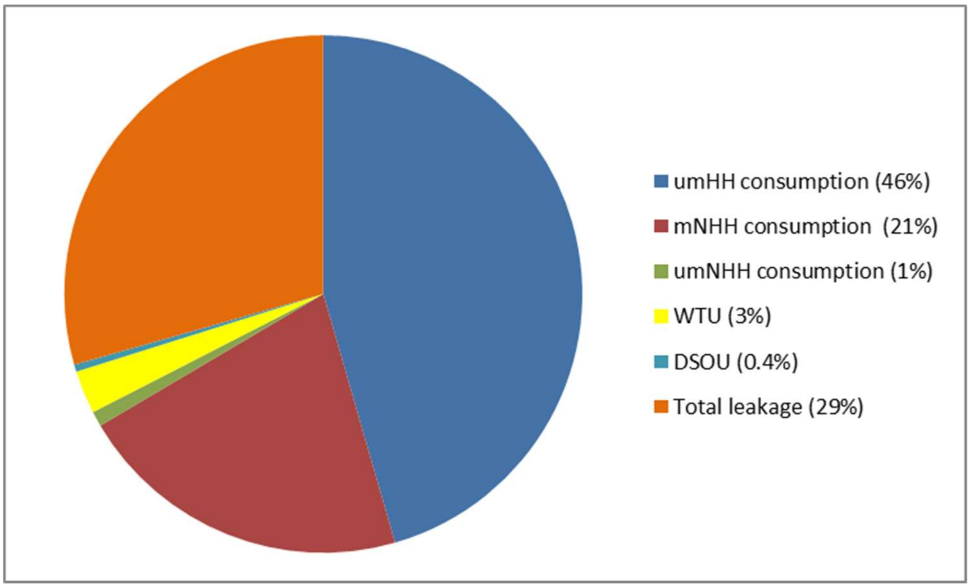


Figure 6.1: Summary of Demand Components for Northern Ireland 2014/15

6.2 Planning Scenarios

Rainfall and temperature can have a strong influence on customer demand, and in particular domestic consumption. In general, during the summer months, periods of wet weather mean that there is less need for domestic customers to use water outside the home, so consumption may be similar to winter levels. In contrast, dry conditions accompanied by sustained periods of high temperature can increase customer consumption, particularly through discretionary water use such as garden watering and other outside use. This has been observed by many studies including UKWIR (2013). Winter periods of sub-zero temperatures can result in increased demand because of increased numbers of pipe bursts.

6.2.1 Weather Characteristics

It is important to understand the weather characteristics of 2014/15, in particular the summer period, relative to a normal or dry year. This enables calculation of forecast normal year and dry year demands relative to 2014/15 actual demands.

Data from the Meteorological Office for the Armagh weather station was used to analyse the summer weather for the years 1961 to 2014 in comparison with the average summer weather for this period. The results are summarised in Figure 6.2, which shows the average temperature and total rainfall over the summer months of April to September for each year.

Figure 6.2 shows four quadrants labelled “Hot, dry”, “Hot, wet”, “Cold, wet” and “Cold, dry”. The summer of 1995 stands out as being very dry and also hotter than nearly all other years. The base year for this WR&SR Plan, 2014/15, experienced much higher summer temperatures than average but was only slightly drier than average.

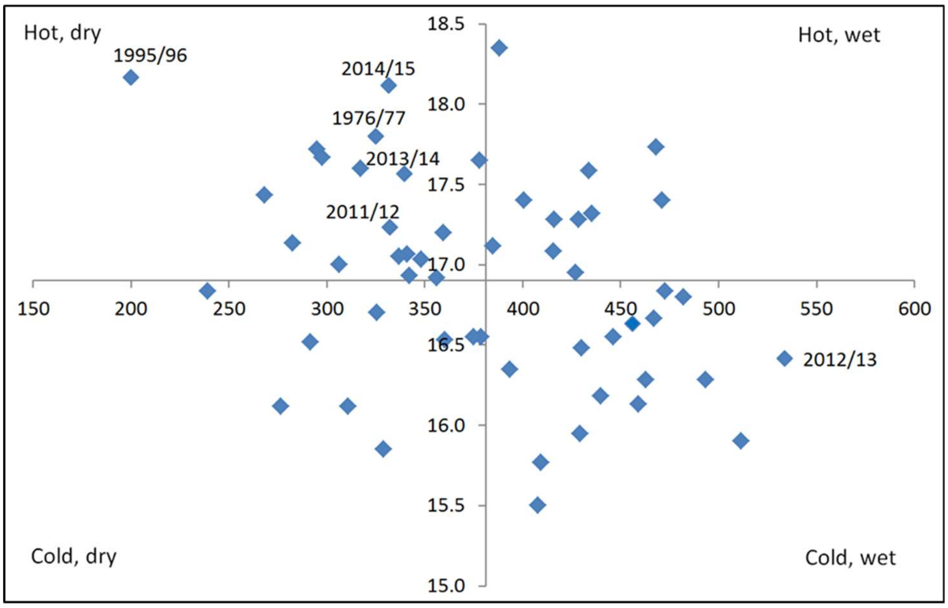


Figure 6.2: Scatter Plot of Summer Average Temperature (ºC) and Total Summer Rainfall (mm) for 1961 to 2014

It is concluded that 1995/96 was a dry year and that 2014/15 was part way between a normal year and a dry year. This has been taken into account in the analysis of the dry year uplift factor described below.

6.2.2 Dry Year Uplift Factor

The term “dry year uplift factor” refers to the % uplift (or the ratio) that should be applied to average demand (Ml/d) in a normal weather year to estimate the average demand (Ml/d) in a dry weather year. The current UKWIR/EA project “WRMP19 Methods: HH Consumption Forecasting” (report in preparation) contains a review of methods to estimate dry year uplift factor. It concluded that there are several potential methods that can be used, depending on the data availability and the complexity of analysis.

The findings of this UKWIR project have been used to undertake three approaches for estimating the dry year uplift factor. The three approaches are:

i. Increased summer demand – this compared average summer (April to September) DI for Northern Ireland with the average base demand for recent years since 2008/09.

ii. Increased summer per capita consumption (PCC) – this compared average summer (April to September) PCC for Northern Ireland with the winter average demand in the last three years for which consistent PCC data was available.

iii. Monthly weather-demand modelling – a statistical regression model was developed to produce a relationship between monthly DI and weather parameters for the period April 2008 to March 2015 for which monthly regional demand data was available.

Table 6.1 summarises the estimated uplift factors for 1995/96, the driest and nearly hottest summer between 1961 and 2014, and for some recent years that were drier and warmer than average. (Note: summer 2012/13 was wetter than average – see Figure 6.1).

Table 6.1: Comparison of Estimates of % Uplift Factors

Year	Approach 1 (summer demand)	Approach 2 (summer PCC)	Approach 3 (monthly model)	Value chosen
1995/96 (dry year)	n.a.	n.a.	1.70	1.70
2011/12	1.27	n.a.	0.3	-
2013/14	1.02	0.96	0.85	-
2014/15 (WRMP base year)	0.25	0.68	0.65	0.65

The different approaches measure uplift effects in different ways and so it is not surprising that a range of values has been found. It is helpful to use a variety of methods to test the robustness of whatever value is chosen.

The results for Approaches 1 and 2 are based on actual demand variations. They show for example, that demand elevations in the summers of 2011/12 and 2013/14 were surprisingly higher than in 2014/15 although, as Figure 6.2 illustrates, 2014/15 was generally warmer and drier. Approach 3 is based on how weather conditions can be expected to affect demand. It records uplift factors relative to normal weather year conditions, and provides assessments across a much wider range of years. The weather-demand model includes a squared effect of temperatures above 18 deg C, and so the particularly high temperatures in parts of summer 2013 have resulted in a higher estimated uplift factor for 2013/14 than for 2014/15.

The value chosen for the dry year uplift factor is 1.70% obtained from applying the monthly demand-weather model to the dry weather year 1995/96. This estimates that average DI would be 1.70% higher in a dry year (like 1995/96) than in a normal weather year.

The corresponding uplift factor chosen to be applied to 2014/15 is 0.65%. It has also been calculated from the weather-demand model and so is consistent with the approach used for the dry year assessment. This suggests that the average DI in 2014/15 would be expected to be 0.65% higher than if it had been a normal weather year.

Hence, it is concluded that:

- Dry year (DYAA) up-lift factor relative to normal year (NYAA) is 1.70%;
- Normal year (NYAA) demand factor relative to 2014/15 demand is -0.65%;
- Dry year (DYAA) demand factor relative to 2014/15 demand is 1.05%.

The chosen dry year factor is equivalent to HH and agricultural demand being 3.4% higher in a dry year than in a normal year, assuming that other components of DI are not significantly affected by dry weather.

The 1.7% value derived for Northern Ireland lies well in the range of dry year uplift factors from 0.9% to 3.9% calculated by water companies in Northern Britain in their latest WRMPs (Northumbrian Water = 0.9%, Yorkshire Water = 1.2%, Severn-Trent = 2.3%, United Utilities = 3.3%, Welsh Water = 3.9%, Scottish Water – no reported value).

6.2.3 Summer Peak Factors

Summer peak demands have been analysed in line with the UKWIR (2006) "Peak Demand Forecasting Methodology". Peak week factors have been calculated as the ratio of maximum weekly average demand and typical "base" demand (i.e. employing "normalisation" as recommended in the UKWIR report).

The summer peak week factors for each WRZ were estimated using 2 methods:

i. Calculated as maximum weekly DI in the summer divided by average DI during the year.

ii. Calculated as maximum weekly DI in the summer divided by median DI during the year. The peak week factors are similar to the values in i, but are slightly higher as the median DI values are not "inflated" by the high peaks in summer demand or winter leakage in the way that the annual average values are.

The use of median values was preferred instead of the annual averages or winter averages, in order to prevent high peaks in summer demand or winter leakage having a distorting effect on the estimate of "base" demand level and peaking factor for the year. Hence, the estimates for peak week factor % uplift for each WRZ are based on the maximum values and are presented in Table 6.2.

Table 6.2: Chosen Summer Peak Week Factors by WRZ

	Central WRZ	East WRZ	North WRZ	North East WRZ	South WRZ	South West WRZ	West WRZ	Region
Summer Peak Week factor	21.7%	13.0%	18.8%	24.8%	19.7%	26.6%	14.8%	15.5%

The timing of the maximum peak week value during the 2009-15 period varied between WRZs. However, for 4 WRZs, and the Northern Ireland region, the maximum peak week demand compared with base demand, occurred in the 7 days ending 23 July 2013. This was a very hot and dry week with no rain and a maximum daily temperature of 29.5^{O}C on 19th July. At this time, high peak PCCs were observed by the HH consumption monitor. It was noted that many people in Northern Ireland are away on holiday in July and so even higher peaking factors may have occurred if this very hot, dry period had been in June or August instead of July. However, no statistically significant difference of the weather effect on different summer months was found in the data. It is possible that the weather effect on demand peaking is higher in June or August than in July but no evidence was found to support this in the available data.

These peaks are applied to the estimated Dry Year Annual Average (DYAA) demand to derive the Dry Year Critical Period Demand (DYCP).

6.2.4 Winter Peak Factors

Severe freeze-thaw events occurred in winters 2009/10 and 2010/11, which resulted in very high leakage and DI values and consequential difficulties in maintaining water supplies. These events are illustrated in Figure 6.3 which presents a time series plot of regional DI. Significant elevation in DI occurred in all WRZs in the 2009/10 and 2010/11 winters.

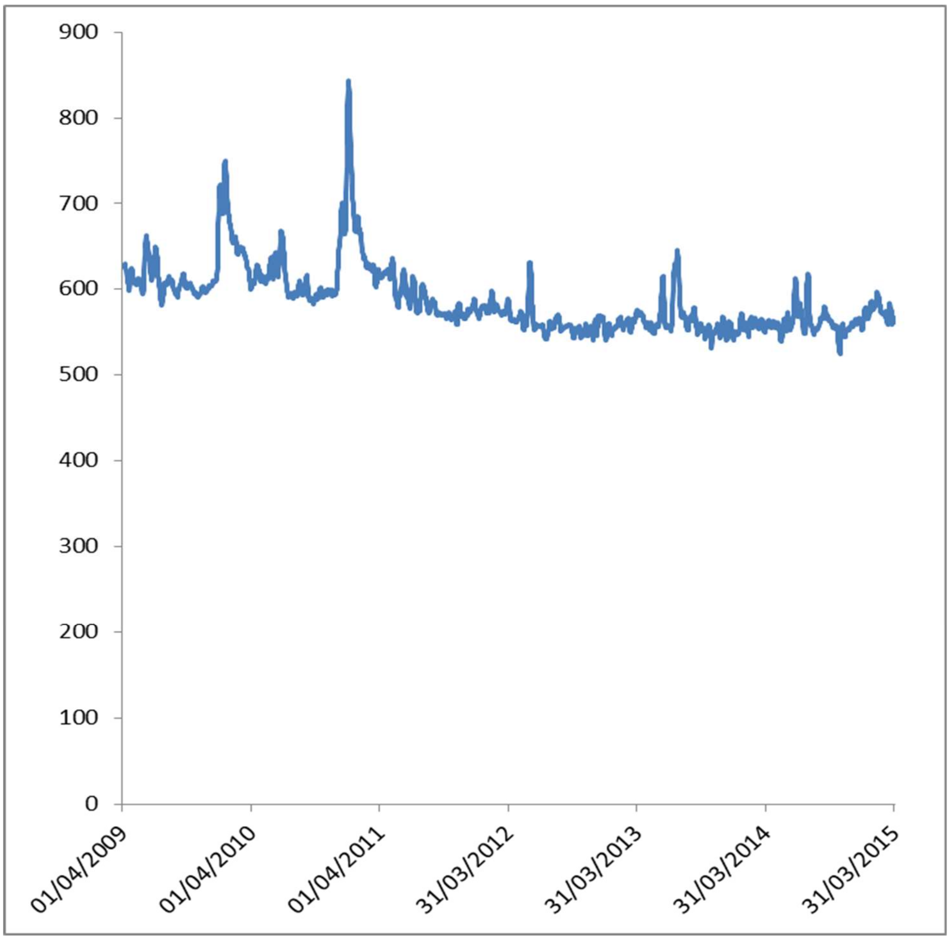


Figure 6.3: Northern Ireland DI April 2009 to March 2015 (Rolling 7-day Average Values) (Ml/d)

The freeze-thaw event of winter 2010/11 was more severe than in 2009/10. Very large demand increases occurred after a sustained period of extremely low (sub-zero) temperatures before and during Christmas, due to bursting of customer supply pipes and water company mains. Widespread difficulties in maintaining water supplies resulted. The Utility Regulator undertook a detailed investigation of the problems that occurred, and reported (Utility Regulator, 2011) that:

- Similarly severe cold weather events have not occurred in Northern Ireland in the last 100 years.
- Water demand rose significantly on 26 December 2010 as the thaw began. SR levels began to fall and were unable to meet demand, and so the DI data does not fully represent demands during the peak period.
- Water demand peaked on 27 December as the thaw developed and plumbing repairs began in HHs and non-domestic premises. The Utility Regulator estimated the peak demand on 27 December to be of the order of 1050 Ml/d, which is about 20% greater than the maximum quantity of water the company was able to produce.
- The overall imbalance between supply and demand from 27 December was exacerbated by local hydraulic constraints. At this point the introduction of widespread rotation of supplies became inevitable.

As stated in 3.5.2, the freeze thaw event of 2010/11 is deemed as such a severe event that to plan for it would be cost prohibitive. While it is difficult to provide a return period for a freeze thaw event the 2010/11 event was estimated by NIAUR as likely being in excess of a 1 in 100. Therefore, in consultation with stakeholders it has been agreed that the 2009/10 freeze thaw event is a more realistic event to base the winter critical period analysis on. This event has been considered in estimates to be between 1 in 20 and 1 in 40.

The increases in demands in each WRZ during the 2009/10 freeze thaw have been used to derive peaking factors that have been applied to the Normal Weather Annual Average (NYAA) demand to produce the Winter Critical Period demand for each WRZ.

Table 6.3: Chosen winter peak week factors by WRZ

	Central WRZ	East WRZ	North WRZ	North East WRZ	South WRZ	South West WRZ	West WRZ	Region
Winter Peak Week factor	28.5%	25.9%	32.5%	29.2%	12.4%	38.8%	35.1%	22.5%

6.2.5 Restricted demands during drought events

In the event of water use restrictions being imposed on customers during a drought period, it can be expected that customer demand would reduce. A hosepipe ban was introduced in response to the High Water Demand Event experienced during summer 2018. Although this was a period of high temperatures and low rainfall, it did not constitute a drought and so further work is required to assess whether any conclusions drawn from this event can be applied in different circumstances. This will be considered when preparing the next WR&SR plan. As it is otherwise many years since water use restrictions have been applied in Northern Ireland there is no other reliable data from Northern Ireland available to estimate the impact on demand. Therefore, experiences across the UK were reviewed and determined that the values experienced in the north of the UK are lower than the South East. Lower values have been adopted as a precautionary approach in the current absence of more robust local data.

Therefore, it is intended to use a value of 4% in the water source modelling of drought events. This is comparable with a 5% impact that has often been assumed by other UK water companies.

6.2.6 Summary of weather effects on demand

The effects of variations in weather on water demand have been analysed to derive factors for calculation of dry weather year and dry weather peak week demands. In addition, the effect of past severe winter conditions on leakage has been analysed and calculated for each WRZ.

It was found that:

- Summer 2014 was warmer than average and its weather was part way between a normal year summer weather and a dry year summer weather. It is estimated that average DI in 2014/15 would have been 1.05% higher than actually occurred if 2014/15 had been a dry weather year.
- The average regional DI in a dry weather year is 1.7% higher than in a normal weather year. This is equivalent to HH and agricultural demand being 3.4% higher in a dry year than in a normal year, assuming that other components of DI are not significantly affected by dry weather.
- Summer peak week regional DI is about 15.5% higher than annual average demand. The peaking varies across WRZs with estimated zonal values ranging between 13.0% (East WRZ) and 26.5% (South West WRZ).

- Elevated DI occurred in all WRZs in winter 2010/11, during a period of extremely low ground temperatures. The peak week total regional DI was 22.5% higher than annual average.

6.3 WRZ Water Balances for 2014/15

6.3.1 Methodology

The methodology for calculating the 2014/15 water balance for each WRZ is as follows:

- The 2015 AIR report provides numbers of properties and population for the total Northern Ireland supply area (Table 7 of AIR); volume of water delivered; and component data (Table 10 of AIR). Equivalent data component values have been derived for each of the 7 WRZs, based on best available zonal data.

- Where there is an imbalance between DI and the sum of components in the 2014/15 values, a water balance reconciliation is undertaken to calculate reconciled 2014/15 water balances for each WRZ.

- The reconciliation of each WRZ's water balance has been undertaken using a similar approach as for the overall water balance reported in AIR 2015, by which maximum likelihood estimation (MLE) was applied in accordance with national good practice, as set out originally in "Demand Forecasting Methodology" (UKWIR/NRA, 1995).

6.3.2 Collation of WRZ Data

The following data was obtained for each WRZ to derive initial water balances before reconciliation (as summarised in Table 6.4):

- DI into each WRZ in 2014/15 was calculated from the recorded daily volumes of water put into supply in each of NI Water's 17 water supply flow monitoring zones.

- Population and property numbers in each WRZ were based on population and HH data published by Northern Ireland Statistics and Research Agency (NISRA) and NI Water estimates of property numbers in each WRZ in 2014/15. This is described in Section 4.

- The umHH PCC for the whole NI Water supply area is 148.42 l/hd/d, as reported in AIR 2015. The 2014/15 results from NI Water's uMHH consumption monitor show that there is a relationship between PCC and occupancy. This relationship was used to derive an estimated average PCC value for each WRZ according to its average HH occupancy.

- mNHH consumption in each WRZ was based on 2014/15 metered volumes for each customer sector in each WRZ obtained from NI Water's billing system data.

- umNHH water delivered per property of 606.98 l/prop/d (as reported in AIR 2015) was used for each WRZ.

- Distribution system operational use and water taken unbilled in each WRZ were estimated from the AIR 2015 values in proportion to the total number of properties in each WRZ.

- Total leakage was allocated between WRZs in accordance with data on leakage levels in 2014/15 in each DMA.

In accordance with the application of the MLE approach for the overall water balance reported in the AIR 2015, error estimates have then been applied to apportion WRZ imbalances to the water demand components.

6.3.3 Reconciled Water balance for each WRZ

The resulting reconciled water balances are shown in Table 6. There are no imbalances between the sum of demand components and DI for each WRZ. Also, the WRZ values sum in each case to the Northern Ireland total reported in the 2015 AIR.

Table 6.4: Water Balance for each WRZ 2014/15, AFTER Reconciliation

	Central WRZ	East WRZ	North WRZ	North East WRZ	South WRZ	South West WRZ	West WRZ	Total
	Water balance for each WRZ (Ml/d)							
umHH water delivered	12.18	133.55	38.68	25.98	56.25	9.83	15.89	**292.36**
mNHH water delivered	6.57	39.77	17.57	12.33	30.26	6.21	7.46	**120.17**
umNHH water delivered	0.27	2.68	0.73	0.47	1.17	0.26	0.24	**5.82**
WTU (incl. SPL)	0.74	7.91	2.31	1.57	3.34	0.69	0.97	**17.53**
DSOU	0.11	1.13	0.33	0.23	0.48	0.10	0.14	**2.51**
Distribution losses	6.76	39.41	13.00	10.77	37.19	7.03	11.93	**126.08**
DI (Ml/d)	**26.62**	**224.45**	**72.62**	**51.34**	**128.68**	**24.12**	**36.63**	**564.47**
	Key supplementary data							
HH population ('000)	78.11	771.37	233.00	161.55	332.95	62.97	91.69	**1,731.65**
PCC (l/hd/d)	138.04	151.63	145.94	140.39	149.77	136.72	153.80	**148.42**
Total leakage (Ml/d)	8.41	57.69	18.28	14.42	44.61	8.55	14.03	**165.99**

6.4 Population and HH Properties

The NISRA population and HH projections for each local authority have been aligned to WRZs, in accordance with the UKWIR good practice methodology for forecasting population and HH properties (2015, in preparation). This involved:

- Using NI Water's billing system to calculate the number of HH customers in each local authority and each WRZ, consistent with NI Water's 2015 AIR.
- Using the HH counts to apportion the NISRA population projection values of each local authority to the WRZs.

Application of these proportions to the HH and population values for 2014/15 and 2042/43, for example, results in the values presented in Table 6.5.

The WRZ population forecasts for each year to 2042/43 are shown in Figure 6.4.

Table 6.5: Estimated Total HHs and Total Population by WRZ in 2014/15 and 2042/43 ('000)

	Central WRZ	East WRZ	North WRZ	North East WRZ	South WRZ	South West WRZ	West WRZ	Total
	2014/15							
Total HHs	29.02	344.08	97.63	67.37	133.75	25.81	37.30	734.98
Occupied HHs	27.47	326.14	91.99	64.86	125.44	23.96	35.07	694.93
Total population	83.03	819.88	247.65	171.71	353.89	66.93	97.45	1840.54
HH population	78.11	771.37	233.00	161.55	332.95	62.97	91.69	1731.65
HH occupancy	2.84	2.37	2.53	2.49	2.65	2.63	2.61	2.49
	2042/43							
Total HHs	34.48	393.50	110.40	78.07	162.41	30.29	42.92	852.08
Occupied HHs	32.93	375.56	104.76	75.56	154.09	28.44	40.69	812.04
Total population	93.71	887.09	260.53	187.22	410.80	74.44	103.72	2017.50
HH population	88.80	838.59	245.88	177.06	389.86	70.48	97.95	1908.61
HH occupancy	2.70	2.23	2.35	2.34	2.53	2.48	2.41	2.35

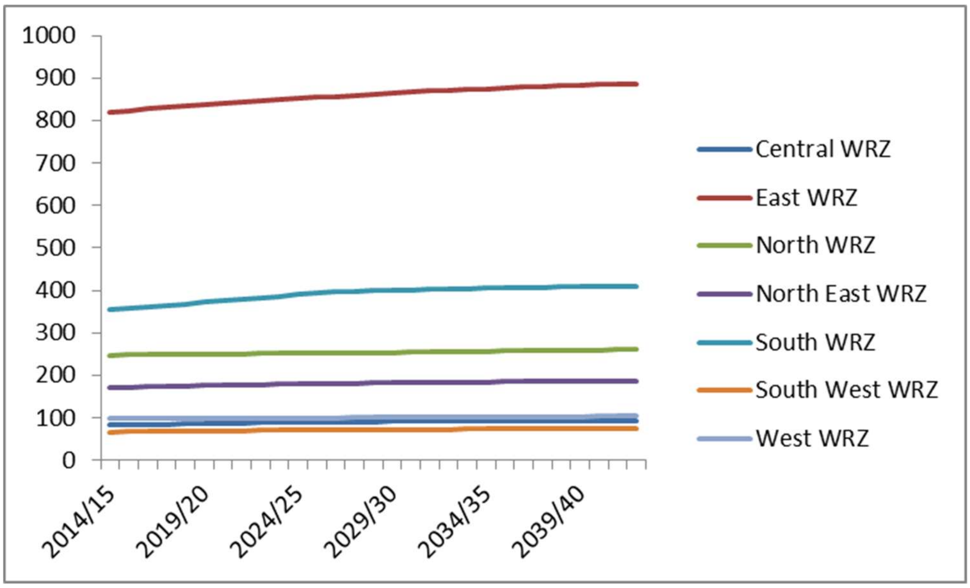


Figure 6.4: WRZ Total Population Forecasts ('000)

The forecast of population and HHs served by NI Water are summarised in Table 6.6 and this provides good consistency with the NISRA data. As expected, the NISRA values are slightly higher than the AIR values because the NISRA definitions of HHs and population are different to those used by NI Water. In particular NISRA include people and properties that do not receive their water supply from NI Water, and NISRA's HHs include some properties that NI Water class as non-households (NHHs).

Table 6.6: Summary of HH and Population Forecasts ('000)

HHs ('000)	2014/15	2026/27	2042/43	Increase 2014/15 to 2026/27
NISRA HH projection	718.43	774.10	n.a.	55.67
Forecast occupied HHs served by NI Water	694.93	750.60	812.04	55.67
Population ('000)	**2014/15**	**2026/27**	**2042/43**	**Increase 2014/15 to 2042/43**
NISRA population projection	1844.3	1951.6	2021.3	177.0
Forecast total population served by NI Water	1840.5	1947.8	2017.5	177.0
Forecast HH population served by NI Water	1731.7	1838.9	1908.6	177.0

NISRA publish projections of population and HHs for each local authority to 2027, and so 2026/27 is the latest financial year for which forecasts can be made based directly on NISRA data for local authorities. NISRA also publish nation population projections to 2062, which have been used in the estimation of WRZ population and HH forecasts from 2027/28 to 2042/43.

In summary:

- The total population served by NI Water is forecast to increase by 9.6% from 1.84 million in 2014/15 to 2.02 million in 2042/43. The WRZ forecasts are illustrated in Figure 6.4.
- Over the same period the number of occupied HHs served by NI Water is forecast to increase by 16.8% from 0.69 million to 0.81 million.

6.5 HH Consumption

6.5.1 Methodology

There are no HHs in Northern Ireland that are charged on a metered basis, and so all HHs are classed as unmeasured. The calculation and forecasting of umHH consumption has been undertaken in accordance with good practice (e.g. UKWIR/EA 2015, in preparation).

For each WRZ, the HH consumption has been estimated, for each year, by multiplying the forecast WRZ population by the estimated PCC value. The derivation of HH population forecasts is described in Section 4, and this section explains the derivation of PCC forecasts.

NI Water operate a HH consumption monitor, which continuously monitors the consumption of approximately 4900 HHs in 103 metered small areas. The measured volume data from each of the 103 areas is analysed to produce a robust estimate of average PCC, for reporting in each year's AIR. The PCC value reported for 2014/15 was 148.42 l/hd/d.

Micro-component analysis has been widely used by UK water companies for forecasting future PCC levels, in accordance with the "Water Resources Planning Guideline" (EA et al, 2012). A micro component approach, based on the analysis carried out for NI Water's WRMP 2012, has therefore been used to derive future PCC values for Northern Ireland.

6.5.2 Reported PCC values

The PCC values reported for NI Water for each year since 2002/03 show that the values have fluctuated from year to year. The step change in PCC values around 2008/09 was due in part to a revised method for estimating PCCs from the consumption monitor. There were high values in 2009/10 and 2010/11 result from the extreme cold weather winter events that caused some bursts in customer water tanks or pipes. The fluctuations in the data and the limited period of fully consistent PCC values make it difficult to identify a clear trend.

Reported PCC values for other UK water companies show that PCC values have fluctuated but there is no clear upward or downward trend.

6.5.3 WRZ PCC values for 2014/15

The 2014/15 results from NI Water's HH consumption monitor were used to compare the PCC values for each small area with the average occupancy values, as illustrated in Figure 6.5 below. A linear relationship was obtained which was weakly statistically significant (at the 90% level).

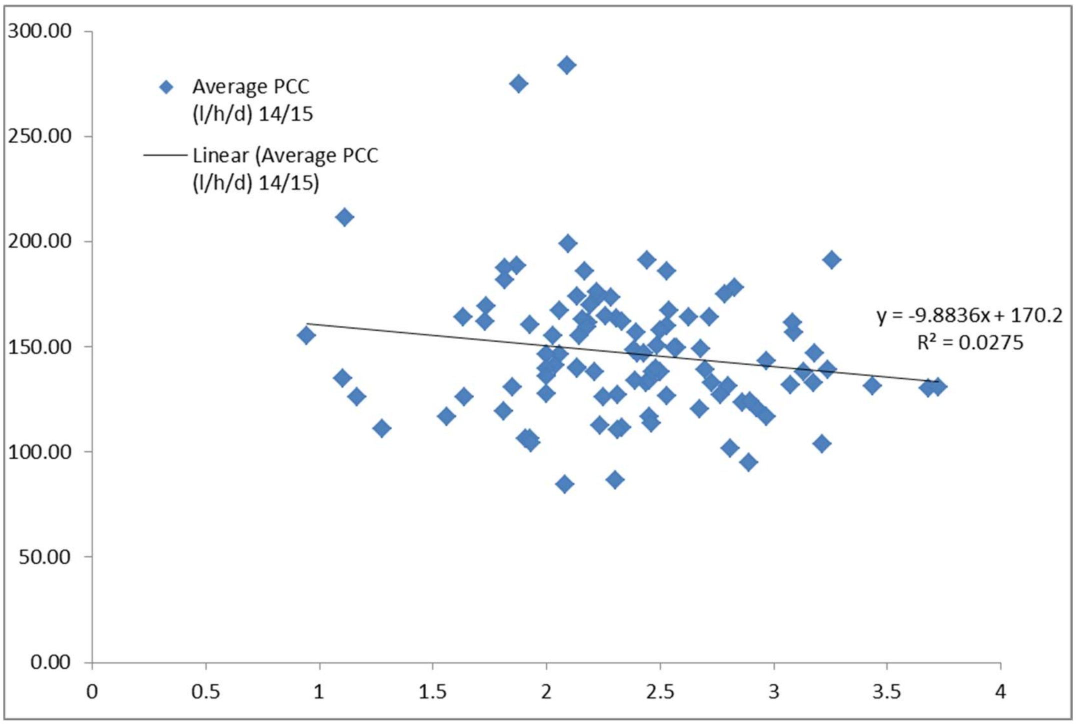


Figure 6.5: Scatter Plot of PCC (l/hd/d) and Average Occupancy 2014/15

This relationship was used to estimate the average PCC for 2014/15 in each WRZ as shown in Table 6.7, which also shows the effect of applying the 1.05% uplift factor derived in Section 5.2 to estimate dry weather year PCC values.

Table 6.7: PCC Values for each WRZ (l/hd/d) in 2014/15

	Central WRZ	East WRZ	North WRZ	North East WRZ	South WRZ	South West WRZ	West WRZ	Total
Estimated actual PCC (l/hd/d)	138.04	151.63	145.94	140.39	149.77	136.72	153.80	148.42
DI uplift to dry year*	1.05%	1.05%	1.05%	1.05%	1.05%	1.05%	1.05%	1.05%
PCC uplift to dry year**	2.03%	1.91%	2.04%	2.12%	2.26%	2.09%	2.14%	2.04%
Dry year PCC (l/hd-d)	**140.84**	**154.52**	**148.91**	**143.37**	**153.17**	**139.58**	**157.09**	**151.45**

* The distribution input (DI) uplift to dry year for 2014/15 has been estimated as 1.05%, calculated as the uplift factor of 1.70% for 1995/96 (i.e. dry year) minus the uplift factor of 0.65% for 2014/15, as described in Section 6.2.2.

** The PCC uplift to dry year due to the DI uplift for each water resource zone has been calculated as 1.05% * DI in WRZ in 2014/15 / (Household demand + Agricultural demand in WRZ in 2014/15). This assumes that the DI uplift in dry weather can be attributed to household and agricultural demands, with any effects on other demand components being negligible.

6.5.4 HH PCC Forecasts

The micro component approach seeks to quantify baseline ownership and usage of HH water using appliances and assesses how these factors may change in the future. This analysis is reliant on extensive customer surveys to understand how customers use water. NI Water does not have such data and it would be costly and time consuming to obtain data from their customers. Atkins undertook such an approach for NI Water's WRMP 2012, based on data collected from customers elsewhere in the UK. It concluded that whilst some uses will increase others will reduce and the overall effect was of negligible change in the long-term PCC level.

In discussion with NI Water, it was decided that the findings from the Atkins study are a valid base for assuming that PCC levels will remain at the 2014/15 level through the planning period to 2042/43. The data used by Atkins concerning the future trends in each component water usage were based on respected UK data sources, in particular forecasts in appliance ownership and usage identified by Waterwise and Defra's Market Transformation Programme. The assumption that PCCs will remain at current levels is compatible with the forecasts by UK water companies.

It has therefore been assumed that the PCC for each WRZ will remain at the 2014/15 level over the planning horizon. The resulting HH consumption demand forecasts for the region are summarised in Table 6.8 below.

Table 6.8: Forecast umHH Consumption for Northern Ireland (Ml/d)

	2014/15	2026/27	2042/43
Dry year PCC (l/hd/d)	151.45	151.45	151.45
HH population ('000)	1731.7	1839.9	1908.6
Dry year consumption (Ml/d)	262.3	278.5	289.1

6.6 Non-Household (NHH) Properties

6.6.1 Methodology and Assumptions

The forecasts of umNHH and mNHH property numbers have been calculated using assumptions about future changes. The assumptions (see below) have been derived through review of past data from recent AIRs (summarised in Table 6.9) and NI Water estimates that about 2500 umNHHs will be metered over the next 5 years. After completion of the metering programme, most of the remaining umNHHs will be impractical to meter, for example due to shared supply pipework.

Table 6.9: Summary of NHH Property Numbers from Recent AIRs ('000)

	2011-12	2012-13	2013-14	2014-15
NHH properties connected during the year	0.329	0.195	0.204	0.260
umNHH properties	11.943	10.896	10.271	9.589
mNHH properties	68.674	69.158	69.567	69.645

The provisional assumptions about future changes in NHH property numbers have been taken as follows:

- Future conversions to metering : 2500 over next 5 years
- Closures of umNHHs : 1% each year
- Closures of mNHHs : 1% each year
- New NHH connections (measured) : 247 per year

6.6.2 NHH Property Forecasts

Figure 6.6 summarises the property forecasts obtained through these assumptions; this shows:

- The number of mNHHs has increased recently (average of 324 per year over last 3 years), largely as a result of conversion to metering programme, but is forecast to reduce in the future;
- The reduction in umNHH property numbers is less than in previous years (average 784 per year over last 3 years; average 580 per year over next 5 years); and
- Void HHs are forecast to remain at the 2014/15 level.

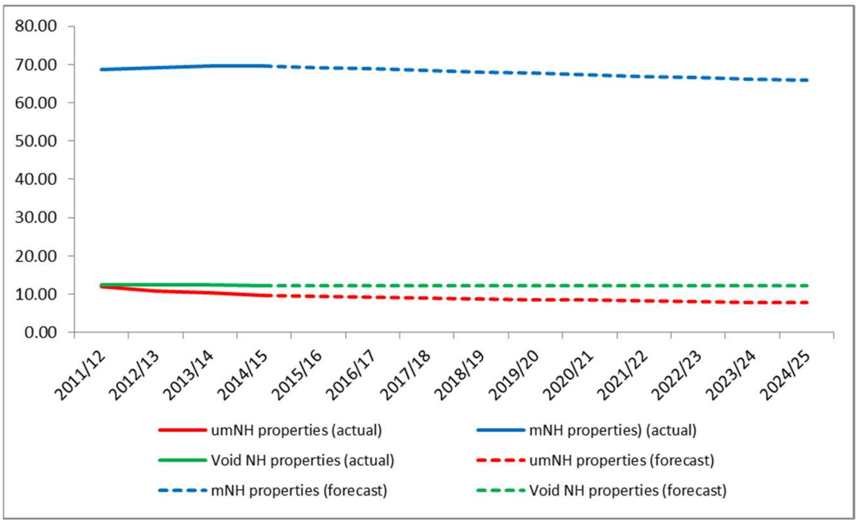


Figure 6.6: NHH Property Forecasts for NI Water Supply Area ('000)

6.7 Measured Non-Household (mNHH) Demand

6.7.1 Methodology

Econometric analysis of past NHH demand has been undertaken, in line with current UK good practice (UKWIR/EA, 1997) and the requirements of DfI NI's Technical Guideline. This type of analysis seeks to find relationships between sectoral demand and economic and other factors.

In line with the approach used by several UK water companies and suggested in the UKWIR/EA methodology the econometric analysis was carried out on broad NHH sectors. The broad sectors that were chosen for investigation were: agriculture, service sector and non-service sector.

6.7.2 Data

Two sets of measured NHH demand data have been obtained from NI Water:

- Sectoral NHH metered volumes from NI Water's billing system for 2009/10 to 2014/15;
- Total NHH demand, as reported in AIRs, for 2002/03 to 2014/15.

Economic data was obtained from Oxford Economics for each year from 1991 to 2032 for each of 19 industrial/commercial sectors:

- Economic output of Northern Ireland, measured as Gross Value Added (GVA), i.e. the value of goods and services produced in an area, industry or sector of an economy
- Total employment in Northern Ireland

mNHH volumes from NI Water's billing system for 2014/15 are given in Table 6.10 below.

Table 6.10: mNHH Demand by WRZ and Sector for 2014/15 (Ml/d)

	Central	East	North	North East	South	South West	West	All WRZs
Agriculture	3.09	6.47	3.49	2.76	9.95	3.59	3.98	33.32
Services	1.75	26.62	6.82	5.24	10.09	1.96	2.25	54.73
Non-service	1.73	6.68	7.26	4.33	10.23	0.66	1.23	32.12
All sectors	6.57	39.77	17.57	12.33	30.26	6.21	7.46	120.17

6.7.3 Analysis of sectoral NHH demand

The measured volume of water delivered to each NHH customer type, as recorded by meter readings, for each year from 2009/10 to 2014/15 was analysed. The customers were grouped into three broad sectors: agriculture, service sector and non-service sector. Figure 6.7 shows that the water demand by each sector has fluctuated from year to year with a general slight downward trend since 2009/10. Attempts were made to derive relationships for each sector between demand and economic output or economic growth rate or employment level in Northern Ireland, but no statistically significant relationships were found.

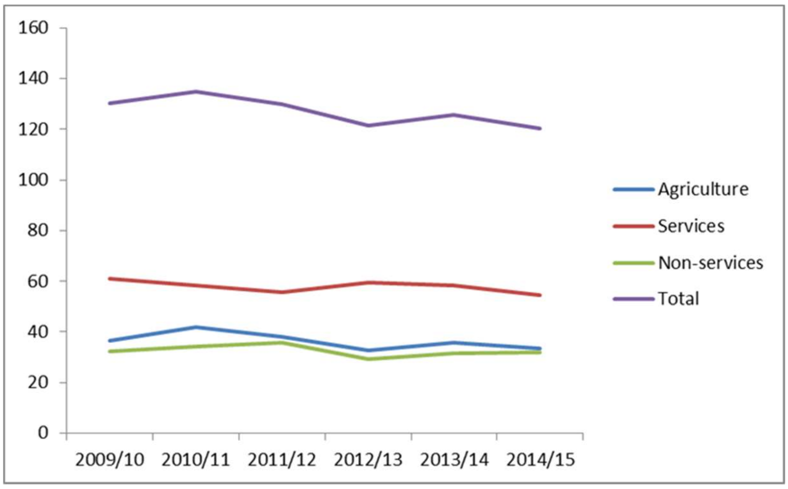


Figure 6.7: mNHH demand by broad sector (Ml/d)

6.7.4 Analysis of total NHH demand

The water delivered to mNHHs in each year from 2002/03 to 2014/15, as reported in AIRs, was collated. There has been steady long-term reduction in demand, amounting to a 41% reduction over the 12 year period. This was due to a combination of water efficiency measures by NHHs and business closures; although the rate of decline seems to be lower in more recent years.

Attempts were made to derive relationships between total NHH demand and economic output or economic growth rate or employment in Northern Ireland. No statistically significant relationship was found. But there was a strongly significant downward trend in demand over time. Various forms of time trend relationship were tested. A quadratic relationship between NHH demand and time, with a correlation coefficient of 94%, was chosen. It has been used to forecast a reduction of 8% in demand over the next 5 years, and then assumes no further reduction in demand thereafter, as shown in Figure 6.8.

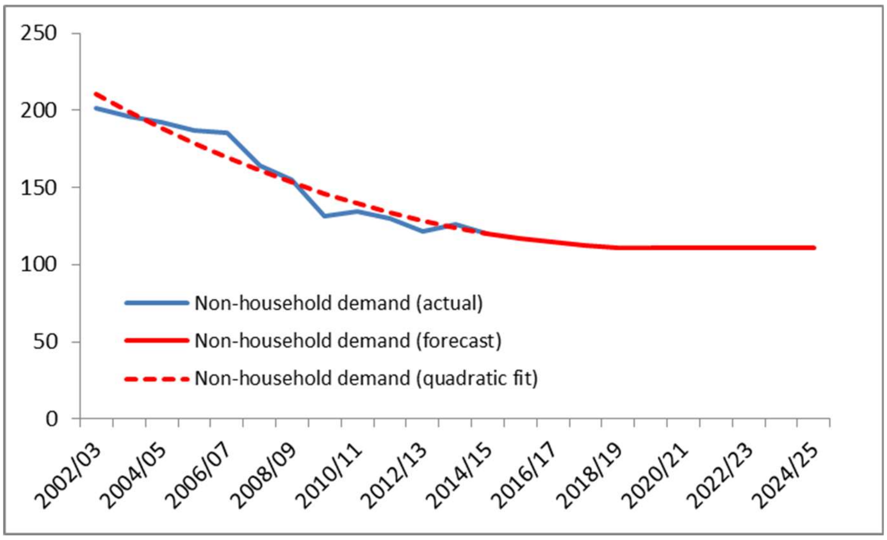


Figure 6.8: Past and forecast NHH Demand (Ml/d)

This is in contrast to the WRMP 2012 which forecast that mNHH demand would increase. For example, the WRMP 2012 forecast that mNHH demand would grow by between 0.5% and 1.0% each year, whereas it has reduced by 22% between 2008/09 and 2014/15, with particularly large reductions to 2012/13 during and following the economic recession. This suggests that the WRMP 2012 overestimated the forecasts.

6.8 Minor Components of Demand

6.8.1 umNHH demand

umNHH demand is a small component of total water demand. It has been calculated for each WRZ as the product of:

- Number of billed umNHH customers, which is expected to continue to reduce, and
- Average water demand per property by umNHHs, which has been assumed to remain at the 2014/15 level.

Water demand by umNHHs is forecast to reduce by 30% over the next 5 years, as a result of the forecast 30% reduction in number of such properties. Therefore, umNHH demand is expected to reduce from 5.82 Ml/d (or 5.33 Ml/d excluding SPL) in 2014/15 to 4.05 Ml/d (3.71 Ml/d) in 2019/20. Demand by umNHHs will continue to reduce slowly thereafter, as the number of properties continues to reduce.

6.8.2 Distribution system operational use

Distribution system operational use refers to the volume of potable water used by NI Water in carrying out its operations, in particular flushing of pipework or other assets after repair or refurbishment work. The volume of water involved is assumed to remain in the future at the 2014/15 level of 2.51 Ml/d, as reported in the 2015 AIR.

6.8.3 Water taken unbilled

Water taken unbilled refers to water used by people or companies, either legally or illegally, that is not billed. Such water uses can include fire-fighting or fire service training, road and gully flushing by local authorities, use at NI Water sites, illegal connections or SPL at void properties. The volume of water involved in these uses is assumed to remain in the future at the 2014/15 level of 17.53 Ml/d (or 15.23 Ml/d excluding SPL), as reported in the 2015 AIR.

6.8.4 Minor Components Summary

The forecasts for the minor components is summarised in Table 6.11

Table 6.11: Summary of Minor Component Demand Forecasts (Ml/d)

	2014/15	2019/20	2042/43
umNHH consumption (excluding SPL)	5.33	3.71	2.94
umNH water delivered (including SPL)	5.82	4.05	3.21
Distribution system operational use	2.51	2.51	2.51
Water taken unbilled consumption (excluding SPL)	15.23	15.23	15.23
Water taken unbilled (total) (including SPL)	17.53	17.53	17.53

6.9 Leakage Forecasts

6.9.1 Methodology

It is good practice in the UK to maintain total leakage at, or below, the sustainable economic level of leakage (SELL) calculated in accordance with the national guidance (Ofwat, 2007, 2012).

NI Water will continue with their current leakage reduction investment to maintain the ELL. As a result baseline total leakage for NI Water is forecast to reduce from 165.99 Ml/d in 2014/15 to 153 Ml/d by 2020/21, based on the findings of the 2014 SELL assessment by RPS Consultants for NI Water. The 153 Ml/d value takes account of a change made, since the 2014 SELL report, in the hour-day-factor used in the calculation of leakage levels. This figure of 153 Ml/d is 6 Ml/d below the SELL figure of 159Ml/d.

6.9.2 Forecast leakage levels in each WRZ

Initial estimates of the leakage level in each WRZ in 2014/15 were calculated from the weekly leakage levels recorded by each of NI Water's 1100 DMAs. These were revised by the water balance reconciliation as described in Section 3 to produce WRZ leakage levels consistent with the total NI Water volume in 2014/15 of 165.99 Ml/d as recorded in the 2015 AIR.

The forecast leakage levels in each WRZ have been derived from the SELL leakage reductions in each flow monitoring zone recorded in the 2014 SELL report, and are shown in Table 6.12 and Figure 6.9. It has been assumed that baseline leakage levels will remain at the 2020/21 levels thereafter.

Table 6.12: Baseline SELL Forecasts by WRZ (Ml/d)

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2042/43
Central WRZ	8.41	8.26	8.10	7.98	7.86	7.73	7.61	7.61
East WRZ	57.69	56.70	55.72	54.93	54.14	53.35	52.56	52.56
North WRZ	18.28	17.82	17.35	16.97	16.60	16.22	15.84	15.84
North East WRZ	14.42	14.34	14.27	14.21	14.14	14.08	14.02	14.02
South WRZ	44.61	44.12	43.62	43.23	42.83	42.44	42.04	42.04
South West WRZ	8.55	8.52	8.49	8.47	8.44	8.42	8.39	8.39
West WRZ	14.03	13.74	13.46	13.23	13.00	12.77	12.54	12.54
Northern Ireland total	**165.99**	**163.50**	**161.00**	**159.00**	**157.00**	**155.00**	**153.00**	**153.00**

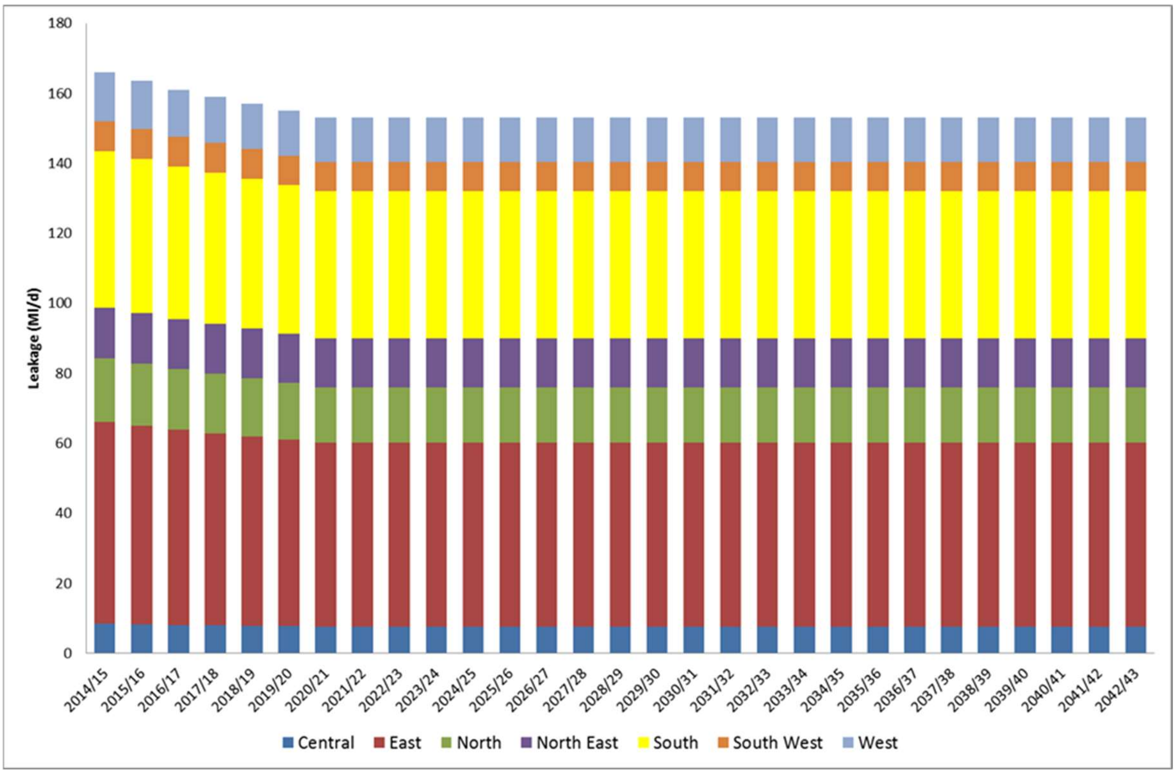


Figure 6.9: Baseline SELL Forecasts by WRZ (Ml/d)

The options appraisal for the WRMP 2012 identified that leakage reductions were required as part of the preferred solution to maintain supply-demand balances in each WRZ. This would result in total leakage being reduced to 135 Ml/d by 2035. A fresh analysis of the leakage reduction requirements is being undertaken in accordance with Technical Guidance. The WRZ leakage levels reported above are baseline levels which include reductions agreed to 2020/21. Potential further reductions to these will be considered as part of the new option appraisal for WRZs where future supply-demand deficits exist, and incorporated into final planning leakage levels.

6.10 Climate Change (CC) Impacts

6.10.1 Methodology

Use has been made of the findings in the most recent UK studies of how CC may impact water demand:

- "Impact of Climate Change on Demand "(UKWIR, 2013) which used the UK Climate Impact Projections 2009 (UKCIP09) to calculate estimated effects on HH water demand for each WFD River Basin. It found limited evidence of any significant effects on NHH demand, except for agriculture in South East England.
- "Climate Change and the Demand for Water" (Defra, 2003) which preceded the development of the UKCIP09 climate projections, but used previous climate projections to calculate estimated CC impacts on each sector.
- Page 16 of the UK Climate Change Risk Assessment (Northern Ireland Supplement). This includes in In9: "*Risks to public water supplies from drought and low river flows*" and estimates that the action status for this for N.Ireland is to "*Sustain Current Actions*" while the action for this for England and Wales is "*More Action Needed*". Further information on this is included in: https://www.theccc.org.uk/uk-

climate-change-risk-assessment-2017/national-summaries/northern-ireland-2/ (Table NI3. Urgency scores for infrastructure Page 29-30).

The UKWIR work has been used as the basis for the assumed impacts on HH demand in Northern Ireland, using the factors derived for river basins in Northern Ireland. The Defra study has been used as the best available estimate for the effect on agricultural demand in Northern Ireland.

6.10.2 Estimated effects

The estimated effects of CC on water demand are modest:

- The effect on HH demand is estimated to increase gradually over a 25 year period to 0.67% (average, ranging from 0.59% for West WRZ to 0.68% for East WRZ).
- The effect on agricultural demand is estimated to increase gradually over a 25 year period to 2.3 % (single value applied across Northern Ireland).

6.11 WRZ Demand Forecasts

6.11.1 DYAA forecasts

Figures 6.10 to 6.17 summarise the DYAA demand forecast for Northern Ireland and each WRZ. They each show a similar pattern with a small reduction in total demand in the early years due to reductions in leakage and mNHH demand, and a small increase in the longer term as a result of steadily increasing population and HH consumption. Overall, future total demand in 2042/43 is expected to be similar to the 2014/15 total demand level.

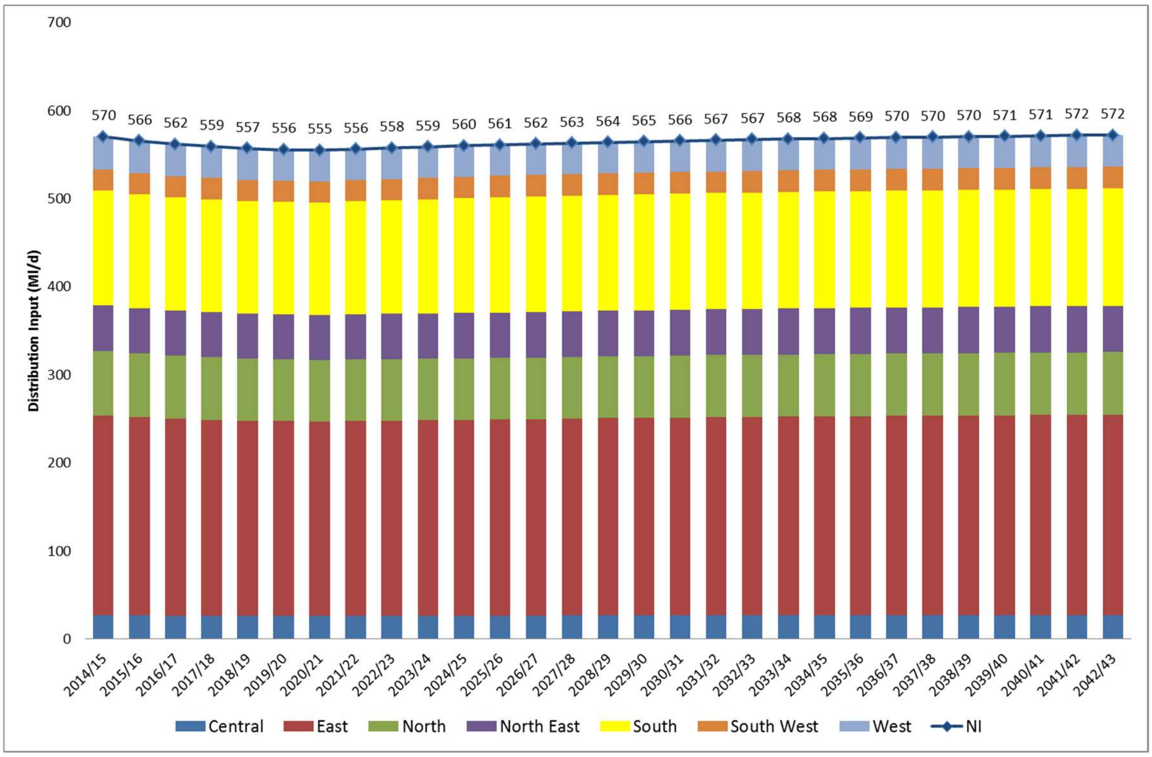


Figure 6.10: Northern Ireland DYAA Demand Forecast (Ml/d)

Figure 6.11: Central WRZ DYAA Demand Forecast (Ml/d)

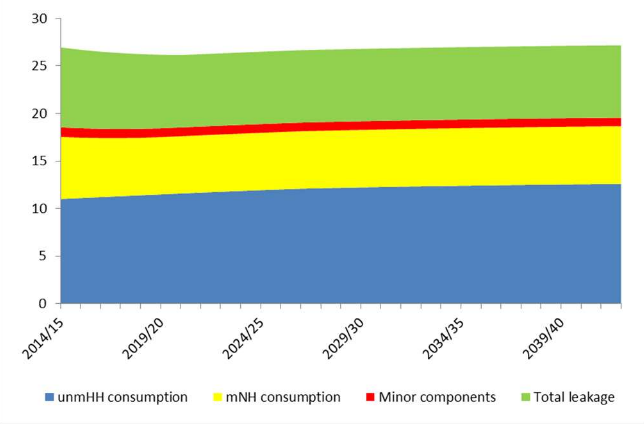


Figure 6.12: East WRZ DYAA Demand Forecast (Ml/d)

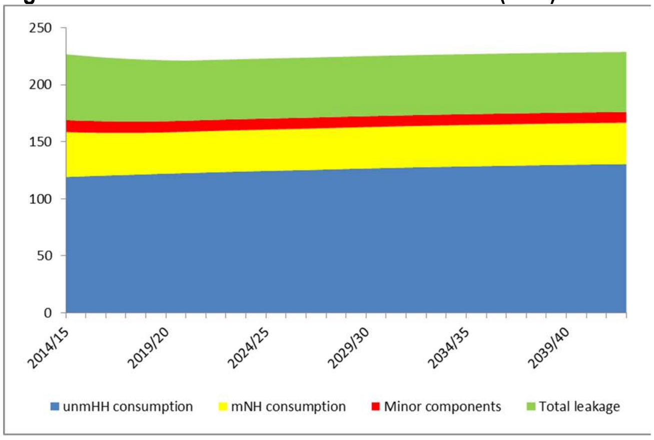


Figure 6.13: North WRZ DYAA Demand Forecast (Ml/d)

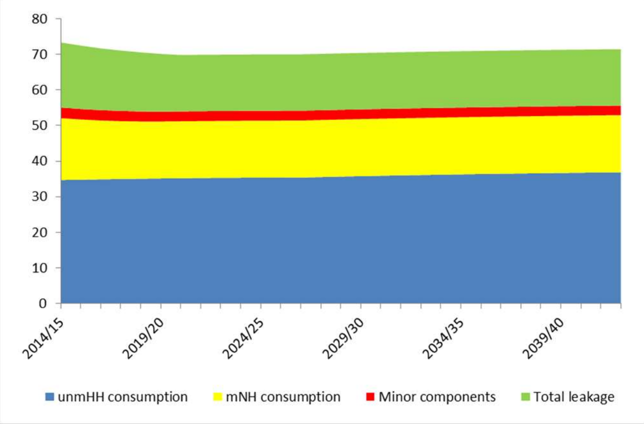


Figure 6.14: North East WRZ DYAA Demand Forecast (Ml/d)

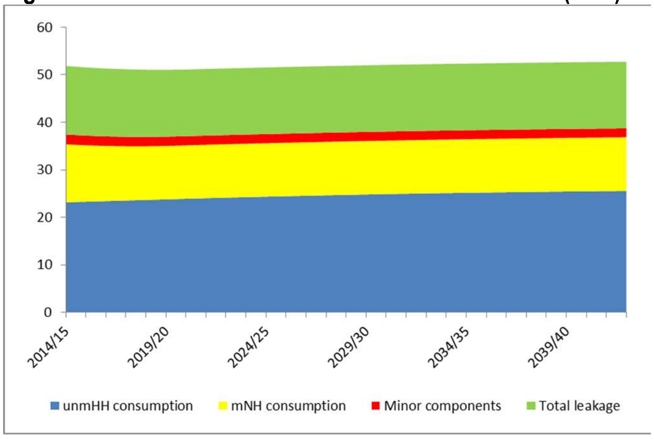


Figure 6.15: South WRZ DYAA Demand Forecast (Ml/d)

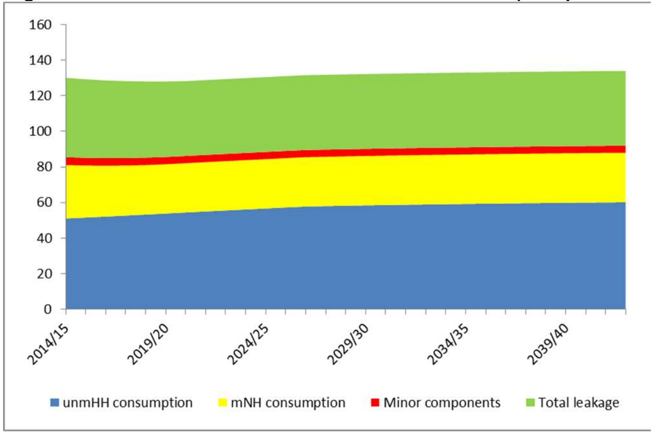


Figure 6.16: South West WRZ DYAA Demand Forecast (Ml/d)

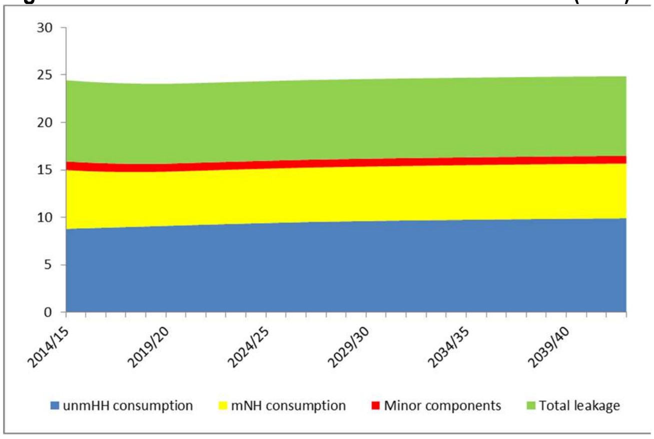
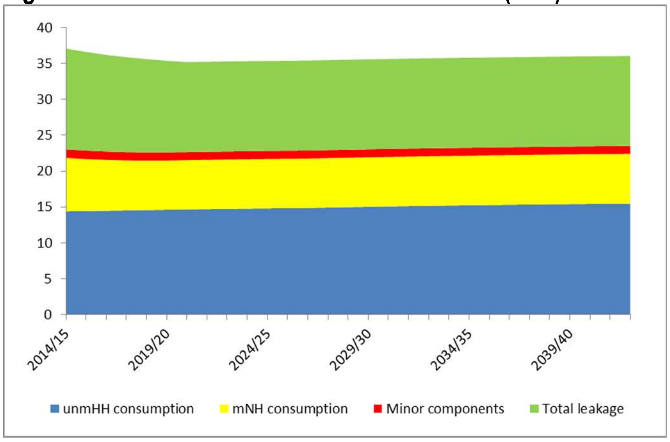


Figure 6.17: West WRZ DYAA Demand Forecast (Ml/d)



6.12 Comparison with previous Demand Forecast

This plan assesses the demand as 570 Ml/d. The base year (2008/09) demand for the 2012 plan was 677 Ml/d. Therefore, demand has reduced by over 100 Ml/d in the last 6 years. The reduction is thought to have been achieved through continued levels of active leakage detection and sustained investment in watermains to reduce leakage and a reduction in NHH demand.

There is very little change in demand projected over the planning horizon with the 2042 demand estimated to be 572 Ml/d. This is considerably less than the 732 Ml/d forecast in the 2012 plan.

7. Climate Change (CC)

In line with standard UK Environment Agency practice, an assessment has made of the likely climate change impact on the DOs for each WRZ. An initial vulnerability assessment was made of the NI Water's catchments which showed that they exhibited a low vulnerability to climate change and hence a simplified flow factor approach has been adopted. Climate change factors based on the 2020's emissions scenario (centred around 2025) have thus been utilised and extrapolated to 2042 to represent conditions at the end of the planning period.

These flow factors were thus applied to the AQUATOR water resources model and the deployable outputs reassessed for 2042, with DO's interpolated between 2014 and 2042.

7.1 Introduction

The assessment of the impact of projected CC within the WR&SR plan broadly follows the EA guidance set out within their Water Resources Planning Guideline (WRPG) 2013 document, although some adaptations were necessary reflecting the limited availability of CC data in Northern Ireland.

In the plan the flow sequences are derived from CERF rainfall-runoff model outputs (Section 4.2), using CEH-GEAR gridded rainfall data. Whilst this represents a significant change to the determination of the hydrology from the previous 2012 assessment[7], the available projections of CC on flows have not changed. Elsewhere in the UK the Future Flows programme (CEH, 2012)[8] has produced new estimates of impact based on Climate programme 2009 (UKCP09) CC understanding, but that project did not extend to Northern Ireland. Consequently, the work reported here uses the flow factors provided in the UKWIR Report No. 09/CL/04/11[9].

It is noted that a new set of CC projections (to be known as UKCP18) are due in 2018. It is recommended that the results presented here be revisited in light of their release which should provide an improved understanding of future hydrological conditions.

7.1.1 Vulnerability assessment

To set the context of the CC assessment an indicative WRZ vulnerability assessment was undertaken following the guidance given in the EA (2013) "Water Resources Planning guide"[10]. This calls upon the latest pre-existing understanding of the CC performance of the zones to be used. The predicted percentage change to DO is obtained by comparing the mid-scenario DO to that of the current baseline DO. This is mapped against the sensitivity of the DO projections to the range of CC projections (obtained from the difference between the DO estimates for the wet and dry scenarios). This is presented graphically in Figure 7.1.

[7] Atkins, 2012. WRMP 2012 – Main Report. Report for NI Water Limited. Doc No 5079991/70/DG/115

[8] CEH Wallingford (2012) - https://data.gov.uk/dataset/future-flows-climate-data

[9] HR Wallingford (2010). Assessment of the significance to WRMPs of the UK Climate Projections 2009. UKWIR Report Ref. No. 09/CL/04/11

[10] EA, Natural Resources Wales, Ofwat, Defra and the Welsh Government (2013), Water resources planning guideline: The technical methods and instructions.

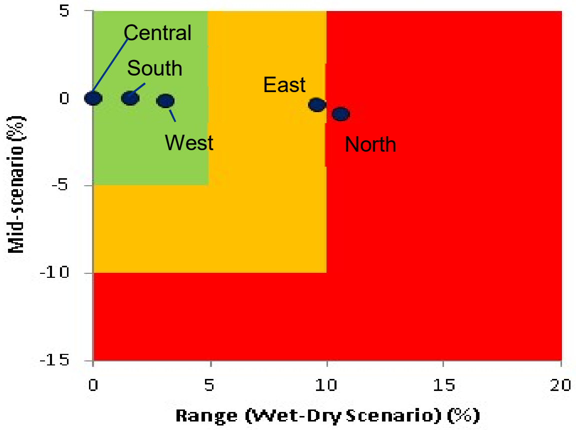


Figure 7.1: CC Mid Scenario % Change in DO vs Uncertainty Range (DO change %) for the 5 Northern Irish WRZs Considered in the WRMP 2012

The vulnerability assessment suggests that none of the WRZs' DOs are likely to significantly change if the central (mid) CC projection were to happen, but that there are two zones (North, East) where there is relatively higher uncertainty. This is due to the DO predictions exhibiting greater sensitivity across the range of the plausible CC projections. The EA guidance points to these two zones potentially warranting more detailed investigation in subsequent studies than the others. In the WRMP 2012 the Northern Irish system was assessed as only 5 separate WRZs, whereas in the current study this has been revised and further broken down into seven WRZs. This coupled with the limited amount of CC data available for Northern Ireland, has led the current study to assess afresh the influence of CC in an approach that deploys the same level of detail to all the WRZs. It does nevertheless indicate that a higher level of risk is presented by CC to those two zones. If this is found to be the case in the revised representation of the WRZs, then recognition of this greater risk should be incorporated into any approach taking these particular zones forward.

7.2 Methodology

The baseline DO for each of the WRZs was first established using the Aquator models. CC flow factors were then applied to the model inflows and the revised DO calculated.

The flow factors used were for the 2020s Medium Emissions scenario which provided the projected change with respect to a 1961-1990 baseline period. The 2020s time horizon covers the 30-year period 2011-2040 centred upon the year 2025. Given that the baseline understanding will be developed from the period that mainly spans the 20th century, the application of the flow factors for the 2020s with respect to the 1961-1990 baseline was judged to be appropriate. The results (centred upon 2025) were then linearly extrapolated to 2042 (the end of the planning horizon) with the baseline taken to be centred on the year 1975. [Linear scaling factor of 1.34 was applied to the change in DO predicted by the 2020s to estimate the 2042 value].

The UKWIR flow factors come in the form of monthly factors that sample the range of possible projected outcomes. The supplied factors are for the 5th, 25th, 50th, 75th and 95th percentile projections. The 50th percentile factors represent the central estimates (median) whilst the others sample the uncertainty in the projections with the 5th and 95th percentile values sampling the outer extremes of what is projected to be plausible.

UKWIR (2010) only supplies CC flow factors for a total of five example catchments within Northern Ireland (Figure 7.2; Table 7.1). It is understood that these were selected to geographically sample the conditions across Northern Ireland.

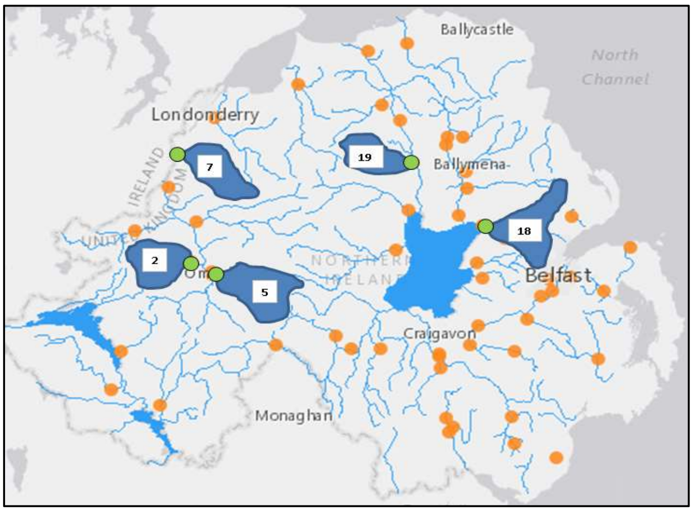


Figure 7.2: The Five Northern Irish Catchments with UKWIR 2010 CC Factors

Table 7.1: Northern Irish Catchments with UKWIR (2010) CC Factors

Label Number	Station Number	Station name	Catchment area (km2)
2	201002	Fairywater @ Dudgeon Bridge	161
5	201005	Camowen @ Camowen Terrace	276
7	201007	Burndennet @ Burndennet Bridge	147
18	203018	Six Mile Water @ Antrim	278
19	203019	Claudy @ Glenone Bridge	126

Examination of the monthly flow factors suggests relatively little difference between the catchments. For example Figure 7.3 compares the central (50^{th} percentile) flow factors of the five catchments together with their average.

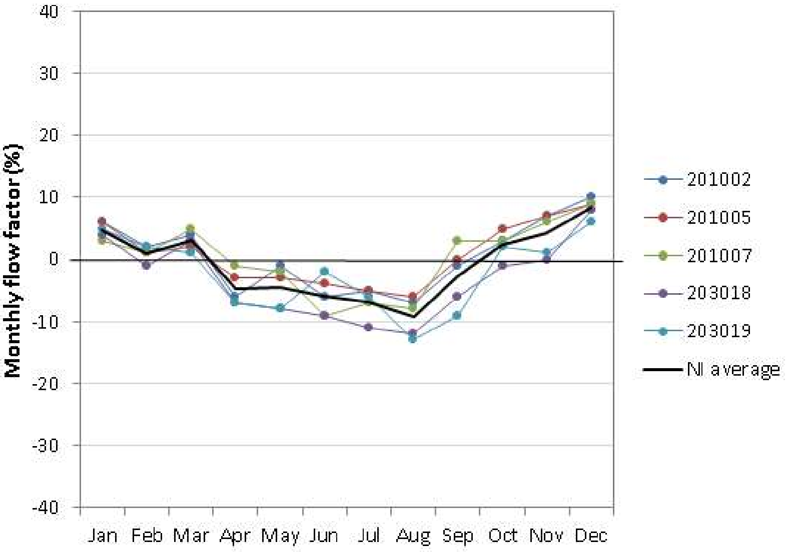


Figure 7.3: UKWIR (2010) Central Flow Factors (50th percentile projection) for the 2020s Time Horizon Relative to the 1961-1990 Baseline Period

The flow factors from the five CC catchments were used to adjust the long-term daily inflow series of the NI water source catchments. The criteria for assigning the donor catchment flow factors to the target CERF catchments was based upon judging catchment similarities in: Baseflow Index (BFIHOST), annual rainfall (SAAR 61-90), and proximity. This method builds upon similar donor allocation techniques used in the low flows work undertaken by CEH Wallingford in the development in of their LF2000 and Low Flows Enterprise software (LFE) procedures. This process applied the five sets of flow factors to the 28 CERF flow sequences, which are in turn associated to the 78 discrete catchments modelled in the Aquator models.

The DO for each WRZ with the CC adjustments to the hydrology could then be determined following the methodology described in Section 4. The models were subject to three CC scenario runs: 5th %ile CC, 50th %ile CC, and 95th %ile CC. The results can then be compared to the output from the Baseline DO runs to gain an indicative understanding of the implications of CC across the plausible range of projected CC conditions.

Three of the WRZs (North East, South West, and Central) could however be treated more simply because of the presence of very large waterbodies amongst their sources for which the availability of water is simulated as infinite. The two waterbodies are Lough Erne (supplying water in the South West WRZ), and Lough Neagh (supplying water to both the North East and the Central WRZs). Due to these waterbodies these zones have hydrological yields considerably in excess of the total WTW capacities. (i.e. within the Aquator model the DC demand is consistently met with every increment in demand until the demand is set beyond the combined output capacities of all the WTWs within the zone. Consequently, the DO for these zones is simply assumed to be the combined WTW capacity of that zone). The other sources in those WRZs will be affected, however, given the assumption that there is unconstrained ability to transfer water across the WRZ, the deficits at smaller sources are simulated as always being met from the large waterbodies and no recourse to assessing the impact of CC is needed.

7.3 Results

Figures 7.4 – 7.5 present the predicted demand failure to return period relationships[11] for WRZs North, South, East and West, as predicted for the 2020s CC scenarios.

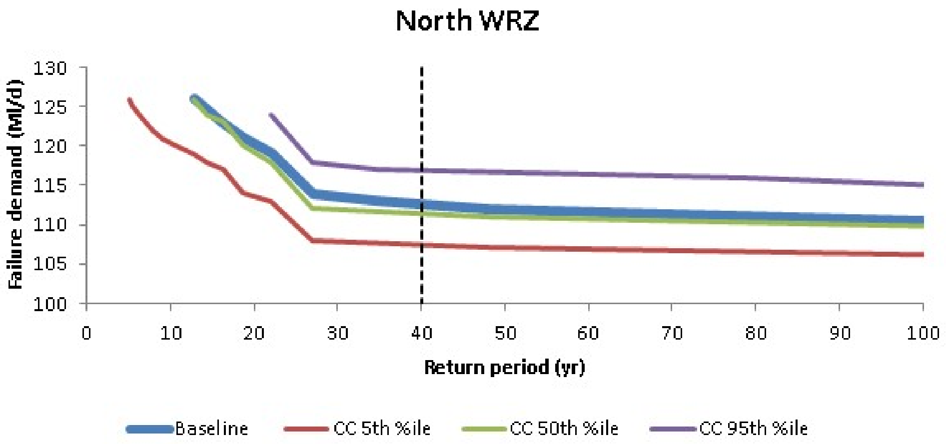


Figure 7.4: Projected DO Plot as a Function of Return Period, North WRZ

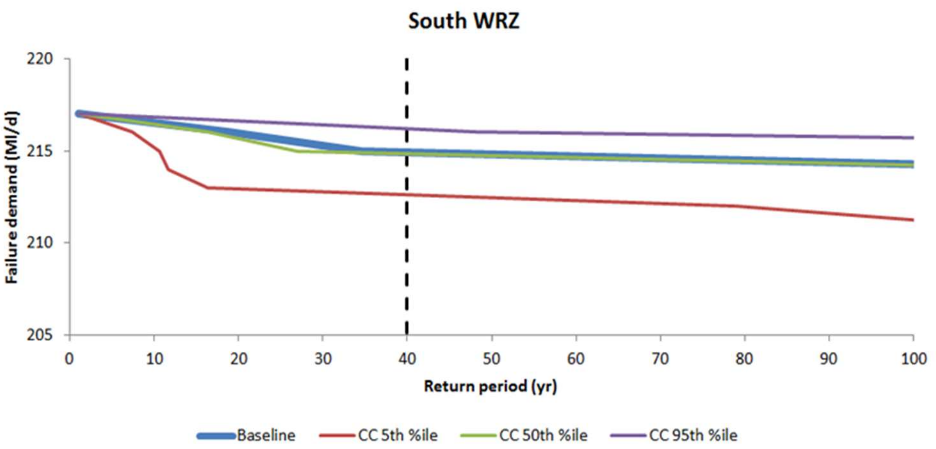


Figure 7.5: Projected DO plot as a Function of Return Period, South WRZ

[11] These results are based on the DYAA demand scenario of a flat demand throughout the year.

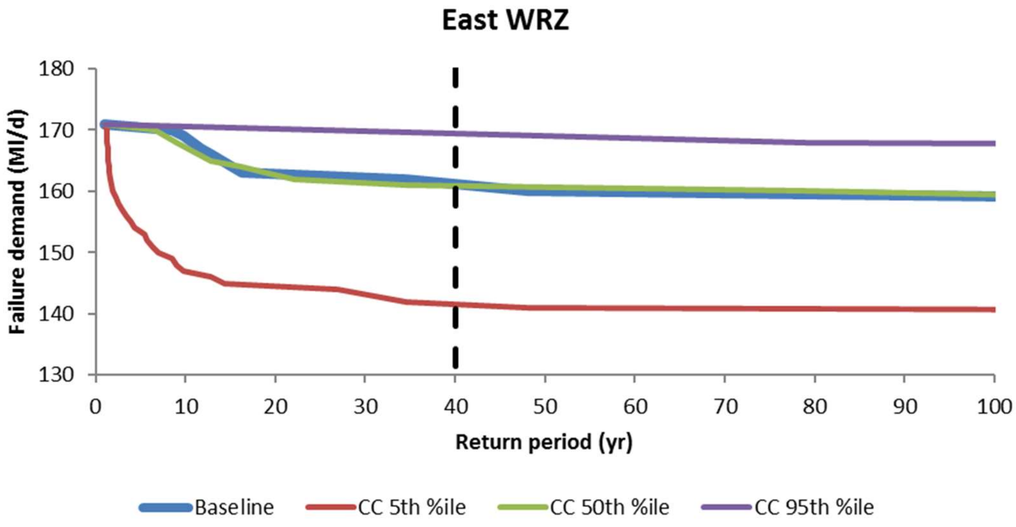


Figure 7.6: Projected DO Plot as a Function of Return Period, East WRZ

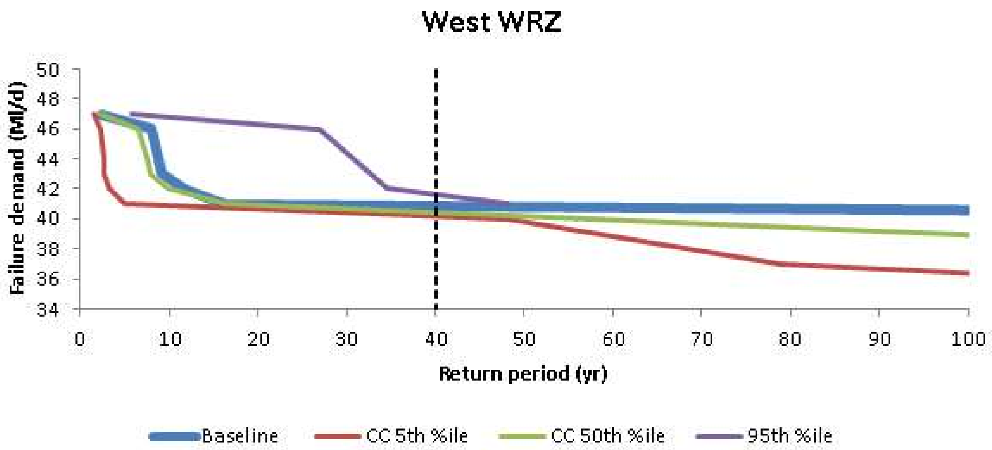


Figure 7.7: Projected DO Plot as a Function of Return Period, West WRZ

Differing sensitivities to CC are suggested; reflecting the differing composition of sources. For the East WRZ the straight line plots of the 50%-ile CC and 95%-ile CC on top of the same straight line for the baseline scenario indicates that the sources are able to provide sufficient water to meet the total WTW capacity of the zone for these return periods whilst the slightly lower amounts of water associated with the 5%-ile CC scenario triggers the zone to no longer operate in this state.

The other three zones (North East, South West, and Central), by virtue of the presence of very large waterbodies, are not considered to be sensitive to CC and their DO has been set to be equal to the combined WTWs capacities within each zone.

Table 7.2 presents the estimated DO for each zone projected to the target 2042 time horizon. Table 7.3 gives the projected future DOs as a percentage of the current Baseline DO.

Table 7.2: Projected Impact of CC on WRZ DO, by the year 2042.

WRZ	Total WTW capacity[a] (Ml/d)	Baseline DO[b] (Ml/d)	2042 CC Scenario DO (Ml/d)		
			5th percentile	50th percentile	95th percentile
North	129	113	105	110	118
South	216	215	211	215	216
East	170	161	136	161	170
Central	32.5	32.5	32.5	32.5	32.5
North East	205	205	205	205	205
South West	38	38	38	38	38
West	51	41	40	40	42
NI Total	**842.5**	**805.5**	**767**	**802**	**823**

[a] including process losses, [b] DYAA demand scenario

Table 7.3: CC - Projected Change in DO as a Percentage of the Current Baseline DO

WRZ	2042 CC Scenario DO as a percentage of Baseline DO		
	5th percentile	50th percentile	95th percentile
North	93%	98%	105%
South	98%	100%	101%
East	84%	100%	106%
Central	100%	100%	100%
North East	100%	100%	100%
South West	100%	100%	100%
West	97%	98%	103%
NI Total	**96%**	**99%**	**101%**

CC is not predicted to affect many of the WRZs, however, several do show some sensitivity. These are the North, East and West WRZs and recognition of this greater risk should be incorporated in any approach taking these particular zones forward.

These figures have inputted into the overall Headroom Assessment in Section 8.

8. Target Headroom

Target headroom is an allowance for uncertainty in estimating the forecast supply/demand balance (SDB) for each water resources zone (WRZ). This headroom allowance covers both supply side and demand side components of uncertainty, which have been combined using a probabilistic 'Monte Carlo' model to produce an overall measure of SDB uncertainty.

A total of 9 supply side components and 4 demand side components have been considered and evaluated using 15,000 simulations, with the 90% probability percentile selected to represent the headroom uncertainty allowance. The target headroom methodology is described further below.

The Target figures for Northern Ireland vary between 3% and 9% through the planning period. The headroom calculated is added to the demand forecasts for each WRZ.

8.1 Introduction

Target Headroom (TH) is the buffer that water companies generally provide between its supply and demand balances to take into account the impact of various uncertainties in supply and demand forecasting. There are many sources of uncertainties that arise when supply and demand is forecasted over a planning period. These can be supply related uncertainties or demand related uncertainties. Making an allowance for TH ensures that LoS is maintained and the water companies have flexibility in managing the uncertainties arising on account of assumptions made about future growth, variations in available data, impact of CC and its effect on supply sources etc.

8.2 General Methodology

TH assessment is based on UKWIR Improved Methodology for Assessing Headroom (2002). This methodology details the process to assess the level of uncertainty in the SDB. It helps to quantify the uncertainties through a risk analysis. The quantified uncertainties can be added to the demand balances as an allowance. The risk analysis is done using a Monte Carlo model.

The general methodology followed in calculating TH for NI Water is as follows:

- A review of the models produced for NI Water for the WRMP 2012 was undertaken.
- Detailed analysis of supply side uncertainties and demand side uncertainties was carried out.
- The models are updated with new supply demand data based on the new planning period.
- Assumptions were made based on existing resource zone conditions relevant to NI Water's WRZs.
- Supply side uncertainties and demand side uncertainties were quantified.
- Probability distribution based on the guidance provided in UKWIR methodology was applied.
- This probability distribution was used to populate the Monte Carlo model.

8.3 Headroom Uncertainties

Assessment of TH enables water companies to see which components of their SDB are the major sources of uncertainties. By understanding the uncertainties in its supply demand projections, NI Water can make appropriate investment decisions so as to maintain the LoS to its customers.

The 2002 UKWIR methodology suggests that there are eight sources of uncertainty in the supply side data and four in the demand side. These are listed below:

Supply side uncertainties are listed from S1 to S9 as below:

- S1 Vulnerable surface water licenses
- S2 Vulnerable groundwater licenses
- S3 Time-limited licenses
- S4 Bulk imports
- S5 Gradual pollution of sources causing a reduction in abstraction
- S6 Accuracy of supply-side data
    - S6–1 - Infrastructure uncertainty
    - S6–2 - Meter uncertainty
    - S6–3 - Uncertainty for aquifer constrained sources
    - S6–4 - Uncertainty for hydrology constrained sources
- S8 Uncertainty of impact of CC on source yields
- S9 Uncertain output from new resource developments

Demand side uncertainties are listed from D1 to D4 as below:

- D1 Accuracy of sub-component data;
- D2 Demand forecast variation;
- D3 Uncertainty of impact of CC on demand; and
- D4 Uncertain outcome from demand management measures.

Table 8.1 below identifies the uncertainties that are not applicable to NI Water's supply system or deemed to be zero and hence have not been modelled.

Table 8.1: Headroom Uncertainties Not Applicable to NI Water.

Uncertainty	Reason for zero headroom
S2 Vulnerable groundwater licenses	No groundwater sources in the NI Water supply system.
S3 Time-limited licenses	There are no licenses that would be time limited within the period of this plan (see 8.4)
S4 Bulk imports	There no imports from other water companies.
S5 Gradual pollution of sources causing a reduction in abstraction	An assessment has identified that no abstractions are at risk from gradual pollution.
S6–3 - Uncertainty for aquifer constrained sources	There no aquifer constrained sources in NI Water.
S9 Uncertain output from new resource developments	There are no new or extended sources recommended which would have an uncertain output.

8.4 Key Assumptions

Key assumptions that have been made in this study are:

- 2017 has been considered as the Base year for the headroom modelling;
- 2017 data has been projected from 2014 data;
- A planning period of 25 years has been considered from 2017 for this modelling;
- Camlough has been discontinued as a supply source. Therefore, the NI Water supply system now has 22 DO sources.

Key assumptions made on NI Water's supply side uncertainties are as follows:

- To account for the risk of meter uncertainty, an unbiased ±2.1% has been applied to all sources following UKWIR guidelines;
- To account for the risk of infrastructure uncertainty, an unbiased ±5% (consistent with AIR15) normal distribution has been applied to 11 of the 22 sources;
- To account for the risk of hydrological uncertainty, an unbiased ±10%,normal distribution has been applied to 11 NI Water sources based on professional judgement;
- No correlations were calculated between any supply side components;
- A correlation of +0.6 has been adopted between S8 and D3 CC components.
- A key assumption that has been made on NI Water's demand side uncertainties is that demand-side components are identified as being independent of each other. Thus, no correlations have been calculated between these different uncertainties.

8.5 Modelling Results

All uncertainties are quantified in the headroom model. They are represented by probability distributions. These probability distributions are used to populate a Monte Carlo risk analysis model which models the overall risk to any WRZ. The model is simulated to run for 15,000 iterations. It sums all the distributions and uses the Monte Carlo risk analysis method to produce a final probability distribution for each WRZ. A planning period of 25 years is considered at 5 year intervals from the base year. A value is selected from the output of the analysis and this is the chosen probability distribution for headroom uncertainty for the WRZ.

The results from this model for the 90th percentile are presented in Table 8.2 and Figure 8.1 and all values are in Ml/d.

Table 8.2: Target Headroom

WRZ	2014	2017	2022	2027	2032	2037	2042
Eastern	3.97	5.36	8.06	11.28	14.75	18.24	21.68
Northern	2.31	2.46	2.86	3.38	3.92	4.78	5.57
Central	0.85	0.91	1.06	1.24	1.41	1.67	1.91
Western	1.13	1.11	1.16	1.26	1.39	1.54	1.70
Southern	4.31	4.65	5.54	6.44	7.61	8.71	10.14
NorthEast	4.43	4.48	4.69	4.92	5.22	5.54	5.93
SouthWest	1.18	1.26	1.33	1.43	1.54	1.65	1.80
Total	18.18	20.24	24.71	29.94	35.84	42.13	48.74

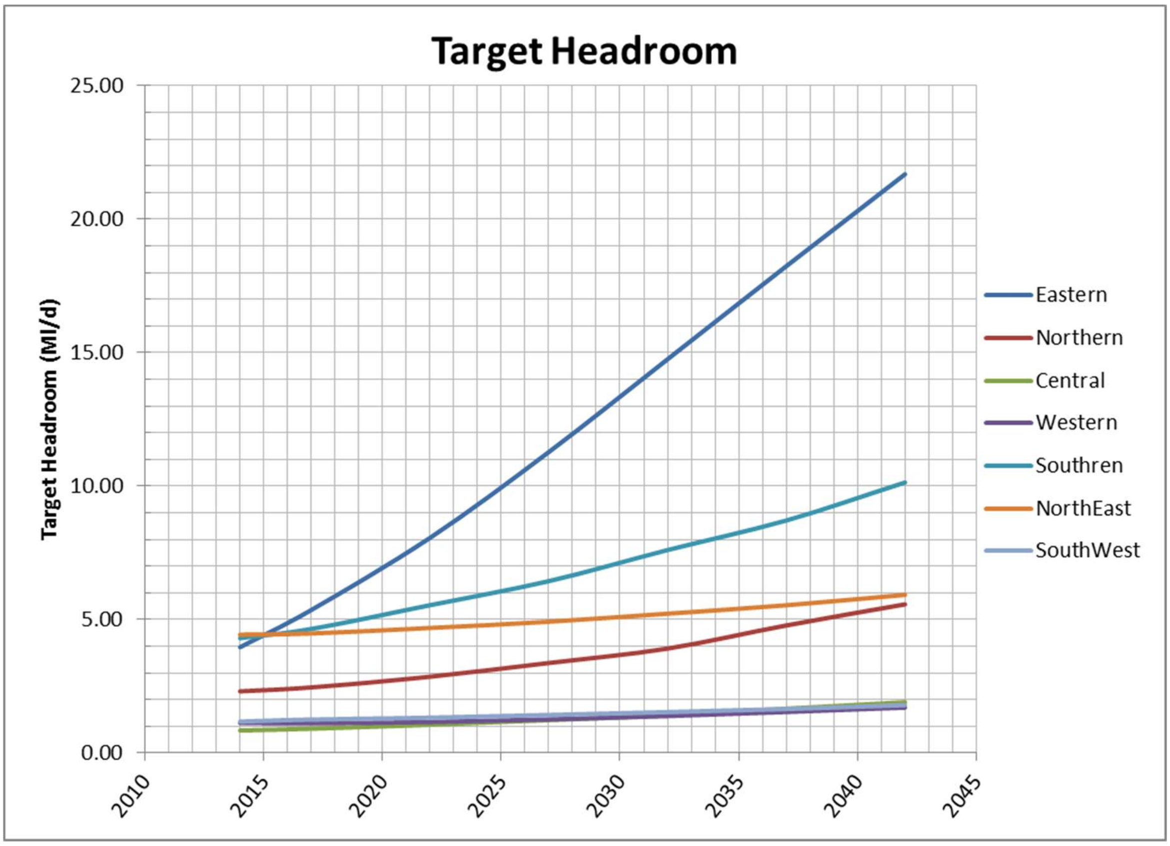


Figure 8.1: Profiles of TH for each WRZ

The Headroom Modelling for the 7 WRZs shows that:

- The East WRZ has the largest values of TH ranging from 6 Ml/d at the base year of the modelling to 25 Ml/d at the end of the planning period.
- The South, North East and North WRZs have TH values ranging from 2 to 8 Ml/d.
- The Central, South West and West WRZ have TH values that remain fairly constant with a range of 1 to 2 Ml/d over the 25 year planning period.

The headroom analysis identified the following:

- The differences in headroom volume in each WRZ are primarily due to the differences in supply and demand in each WRZ.
- The elements contributing the largest headroom are the Accuracy of supply-side data (S6) and Demand forecast variation (D2).
- The increase in headroom due to Uncertainty of the impact of climate change on source yields (S8) is more significant in the east of the country than the west. This is the main reason why the East WRZ headroom has such a significant increase through the planning period.

8.6 Headroom Assessment for Critical Periods

The above analysis has been undertaken for the DYAA planning scenario. Consideration was also given to assessing headroom for the DYCP and WCP scenarios. However, as the DYCP scenario is essentially a subset of the DYAA scenario, any difference would be insignificant and well within the modelling error. Likewise the WCP is a subset of the NYAA scenario, which is less severe than the DYAA scenario.

Therefore, the conservative DYAA headroom assessment has been applied to all planning scenarios.

9. Baseline Supply Demand Balance (SDB)

Water modelling software has been used to establish the quantity of water available from the water supply system during the various planning scenarios. Similarly, water demand projections have also been established with an allowance for headroom added. These figures are compared to show the balance of water that can be supplied against that which is demanded for the various scenarios. This is known as the Supply Demand Balance.

For the dry year annual average (DYAA) scenario all 7 WRZs have a surplus of water. However, when analysis is undertaken for critical periods i.e. during summer (DYCP) and winter peaks (WCP) there are deficits in the South and West zones.

9.1 Introduction

The SDB for each WRZ has been assessed to compile baseline SDB forecasts for each WRZ over the 28 year planning period. The components of the SDB comprise the following:

- DO;
- WTW process losses;
- System outage allowance;
- WAFU;
- Water transfers between zones;
- DI;
- TH;
- WRZ SDB.

This provides the projected supply/demand balance by year, including the impact of CC, for each WRZ based on the agreed Target LoS of allowing water supply failures for one year in forty; equivalent to a supply reliability of 97.5%. Failures in the system beyond the LoS are addressed in Section 5: Drought Plan.

Supply/Demand Balance forecasts have been prepared for each of the following SDB scenarios:

- NYAA;
- DYAA;
- DYCP;
- WCP.

From these SDB forecasts it is thus possible to identify anticipated water supply deficits for each of the above scenarios, in each WRZ. These deficits will need to be met either by water transfers from neighbouring zones or from potential water resource or demand management options that could be developed within each zone.

9.2 Deployable Output (DO)

The DO for each WRZ has been evaluated utilising the AQUATOR water resources model, described in Section 4. The resulting DOs (both excluding and including WTW process losses) for the current base year 2014/15 and future predicted CC year 2042/43 are presented below:

Table 9.1: Base Year DO - 2014/15

Gross Source DO - 2015 (excluding process losses)

DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	129.90	214.00	170.00	224.40	42.70	33.90	46.10	861.0
DYAA	116.90	214.00	170.00	223.00	42.70	33.90	44.10	844.6
DYCP	127.70	213.90	170.00	224.40	42.70	33.90	44.90	857.5
WCP	133.20	214.00	170.00	224.40	42.70	33.90	54.40	872.6

WTW Process Losses

	WRZ							Ml/d
WTW	North	North East	East	South	South West	Central	West	TOTAL
Process Losses	3.90	9.00	0.00	8.00	4.70	1.40	3.10	30.1

Net DO from AQUATOR Model - 2015 (including process losses)

DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	126.00	205.00	170.00	216.40	38.00	32.50	43.00	830.9
DYAA	113.00	205.00	170.00	215.00	38.00	32.50	41.00	814.5
DYCP	123.80	204.90	170.00	216.40	38.00	32.50	41.80	827.4
WCP	129.30	205.00	170.00	216.40	38.00	32.50	51.30	842.5

Table 9.2: CC DO - 2042/43

Gross Source DO - Climate Change 2042 (excluding process losses)

DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	129.90	214.00	170.00	224.40	42.70	33.90	44.80	859.7
DYAA	114.20	214.00	170.00	223.00	42.70	33.90	44.10	841.9
DYCP	127.70	213.90	170.00	224.40	42.70	33.90	44.90	857.5
WCP	133.20	214.00	170.00	224.40	42.70	33.90	54.40	872.6

WTW Process Losses

	WRZ							Ml/d
WTW	North	North East	East	South	South West	Central	West	TOTAL
Process Losses	3.90	9.00	0.00	8.00	4.70	1.40	3.10	30.1

Net DO from AQUATOR Model - Climate Change 2042 (including process losses)

DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	126.00	205.00	170.00	216.40	38.00	32.50	41.70	829.6
DYAA	110.30	205.00	170.00	215.00	38.00	32.50	41.00	811.8
DYCP	123.80	204.90	170.00	216.40	38.00	32.50	41.80	827.4
WCP	129.30	205.00	170.00	216.40	38.00	32.50	51.30	842.5

9.3 WAFU

The WAFU is defined as the DO less WTW process losses and an allowance for outage for each WRZ. The resulting WAFU for the current base year 2014/15 and future predicted Climate Change year 2042/43 are presented below. In addition the assumed water transfers between each WRZ are also presented.

Table 9.3: Base Year WAFU - 2014/15

WTW Outage	5%							
DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	6.30	10.25	8.50	10.82	1.90	1.63	2.15	41.5
DYAA	5.65	10.25	8.50	10.75	1.90	1.63	2.05	40.7
DYCP	6.19	10.25	8.50	10.82	1.90	1.63	2.09	41.4
WCP	6.47	10.25	8.50	10.82	1.90	1.63	2.57	42.1
Baseline WAFU Reductions (due to network constraints)								
WCP	0.00	0.00	0.00	14.70	0.00	0.00	0.00	14.7
Gross WAFU - 2015 (including process losses and outage)								
WAFU	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	119.70	194.75	161.50	190.88	36.10	30.88	40.85	774.7
DYAA	107.35	194.75	161.50	189.55	36.10	30.88	38.95	759.1
DYCP	117.61	194.66	161.50	190.88	36.10	30.88	39.71	771.3
WCP	122.84	194.75	161.50	190.88	36.10	30.88	48.74	785.7
Inter-Zonal Water Transfers - 2015			Transfer to East:	30.00				
Water Transfer	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	NET
NYAA/DYAA	0.00	-110.00	140.00	-31.80	0.00	1.80	0.00	0.0
DYCP/WCP	0.00	-110.00	140.00	-32.40	0.00	2.40	0.00	0.0
Net WAFU - 2015 (including water transfers)								
WAFU	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	119.70	84.75	301.50	159.08	36.10	32.68	40.85	774.7
DYAA	107.35	84.75	301.50	157.75	36.10	32.68	38.95	759.1
DYCP	117.61	84.66	301.50	158.48	36.10	33.28	39.71	771.3
WCP	122.84	84.75	301.50	158.48	36.10	33.28	48.74	785.7

Table 9.4: Climate Change WAFU - 2042/43

WTW Outage	5%							
DO	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	6.30	10.25	8.50	10.82	1.90	1.63	2.09	41.5
DYAA	5.52	10.25	8.50	10.75	1.90	1.63	2.05	40.6
DYCP	6.19	10.25	8.50	10.82	1.90	1.63	2.09	41.4
WCP	6.47	10.25	8.50	10.82	1.90	1.63	2.57	42.1

Baseline WAFU Reductions (due to network constraints)

WCP	0.00	0.00	0.00	14.70	0.00	0.00	0.00	14.7

Gross WAFU - Climate Change 2042 (including process losses and outage)

WAFU	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	119.70	194.75	161.50	190.88	36.10	30.88	39.62	773.4
DYAA	104.79	194.75	161.50	189.55	36.10	30.88	38.95	756.5
DYCP	117.61	194.66	161.50	190.88	36.10	30.88	39.71	771.3
WCP	122.84	194.75	161.50	190.88	36.10	30.88	48.74	785.7

Inter-Zonal Water Transfers - 2042

Water Transfer	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	NET
NYAA/DYAA	0.00	-110.00	140.00	-31.80	0.00	1.80	0.00	0.0
DYCP/WCP	0.00	-110.00	140.00	-32.40	0.00	2.40	0.00	0.0

Net WAFU - 2042 (including water transfers)

WAFU	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	119.70	84.75	301.50	159.08	36.10	32.68	39.62	773.4
DYAA	104.79	84.75	301.50	157.75	36.10	32.68	38.95	756.5
DYCP	117.61	84.66	301.50	158.48	36.10	33.28	39.71	771.3
WCP	122.84	84.75	301.50	158.48	36.10	33.28	48.74	785.7

9.4 Distribution Input (DI)

The water demand projections for each WRZ, expressed as the DI, for demand years 2014/15 to 2042/43 are fully described in Section 6 and the results are summarised below:

Table 9.5: Distribution Input

Distribution Input - Years 2014/15 to 2042/43

Distribution Input - 2014/15

DI	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	72.11	50.98	222.88	127.87	24.03	26.49	36.44	560.8
DYAA	73.34	51.85	226.69	130.06	24.44	26.95	37.07	570.4
DYCP	86.23	64.04	253.50	154.06	30.62	32.45	42.11	663.0
WCP	96.17	66.30	282.44	144.66	33.58	34.26	49.56	707.0

Distribution Input - 2024/25

DI	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	68.73	50.64	218.97	128.09	23.93	26.02	34.72	551.1
DYAA	69.98	51.54	222.93	130.45	24.35	26.49	35.34	561.1
DYCP	83.00	64.19	250.77	156.39	30.71	32.28	40.42	657.8
WCP	89.65	65.55	273.42	144.03	33.30	33.08	46.46	685.5

Distribution Input - 2034/35

DI	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	69.61	51.42	222.69	130.55	24.27	26.48	35.15	560.2
DYAA	70.89	52.35	226.78	133.01	24.71	26.97	35.79	570.5
DYCP	84.23	65.39	255.47	159.98	31.25	32.94	41.00	670.3
WCP	90.54	66.34	277.19	146.53	33.65	33.54	46.90	694.7

Distribution Input - 2042/43

DI	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	70.14	51.79	224.57	131.43	24.42	26.67	35.38	564.4
DYAA	71.44	52.74	228.71	133.93	24.87	27.16	36.04	574.9
DYCP	84.98	65.97	257.84	161.28	31.49	33.22	41.31	676.1
WCP	91.08	66.72	279.09	147.43	33.81	33.74	47.14	699.0

9.5 Target Headroom (TH)

The methodology for deriving the TH for each WRZ is described fully in Section 7. TH is an additional demand allowance to account for uncertainty in both the supply side and demand side components of the SDB. This is used by the Economics of Balancing Supply and Demand (EBSD) model (described in Section 12) to ensure that sufficient options are provided for in the water resources plan to meet the forecast SDB. This includes an allowance for uncertainty in the forecasts.

The assessed TH for demand years 2014/15, 2024/25, 2034/35 and 2042/43 are presented below:

Table 9.6: Target Headroom

Target Headroom - 2014/42								
TH	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
2014/15	2.31	4.43	3.97	4.31	1.18	0.85	1.13	18.18
2024/25	3.07	4.78	9.35	5.90	1.37	1.13	1.20	26.80
2034/35	4.26	5.35	16.15	8.05	1.58	1.51	1.45	38.35
2042/43	5.57	5.93	21.68	10.14	1.80	1.91	1.70	48.74

9.6 Supply Demand Balance (SDB)

The baseline SDB for each WRZ is defined as the difference between the WAFU, plus water transfers, and the DI plus TH. The resulting SDB for demand years 2014/15, 2024/25, 2034/35 and 2042/43, for each of the SDB scenarios, are presented below:

Table 9.7: Supply Demand Balance

Supply/Demand Balance - 2014/15

SDB	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	45.28	29.33	74.66	26.91	10.89	5.34	3.28	195.7
DYAA	31.69	28.46	70.84	23.39	10.47	4.88	0.75	170.5
DYCP	29.07	16.18	44.04	0.11	4.29	-0.02	-3.53	90.1
WCP	24.35	14.02	15.10	9.51	1.34	-1.84	-1.95	60.5

Supply/Demand Balance - 2024/25

SDB	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	47.90	29.33	73.18	25.09	10.81	5.52	4.49	196.3
DYAA	33.39	28.43	69.22	21.40	10.38	5.05	2.40	170.3
DYCP	31.54	15.68	41.38	-3.81	4.03	-0.13	-1.91	86.8
WCP	30.12	14.42	18.73	8.55	1.43	-0.94	1.07	73.4

Supply/Demand Balance - 2034/35

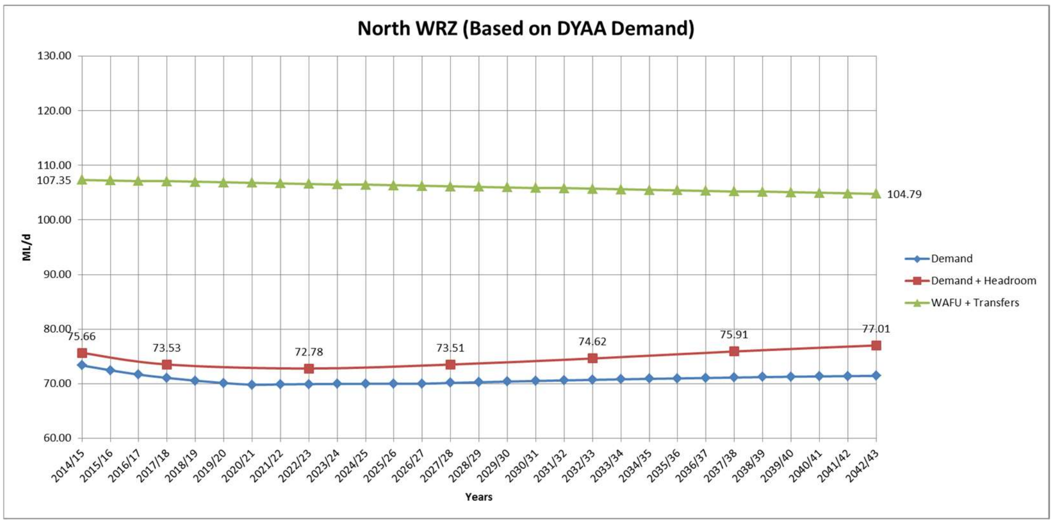
SDB	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	45.83	27.98	62.66	20.48	10.24	4.68	3.37	175.3
DYAA	30.37	27.05	58.58	16.69	9.81	4.19	1.71	148.4
DYCP	29.12	13.91	29.89	-9.15	3.27	-1.58	-2.74	62.7
WCP	28.03	13.06	8.16	3.90	0.87	-1.78	0.39	52.6

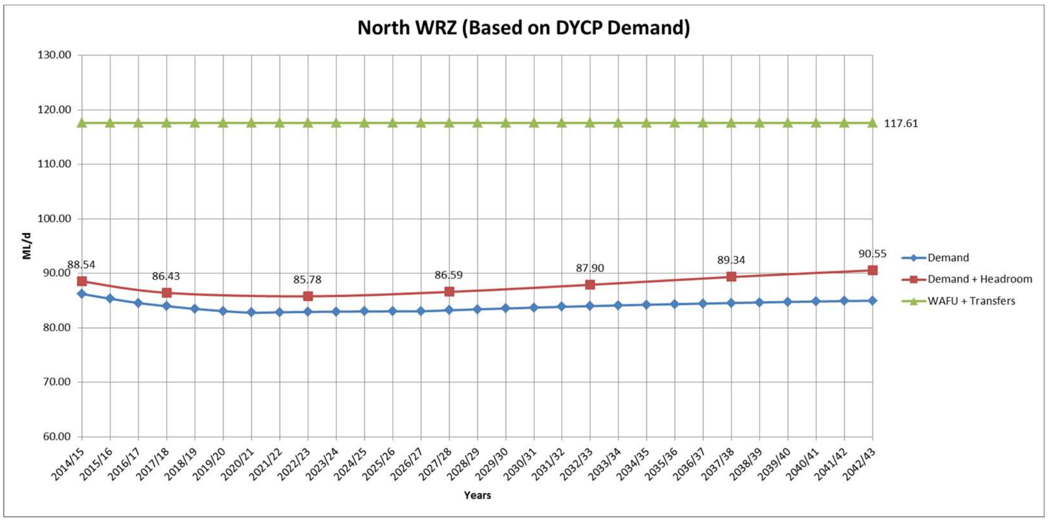
Supply/Demand Balance - 2042/43

SDB	WRZ							Ml/d
Scenario	North	North East	East	South	South West	Central	West	TOTAL
NYAA	43.98	27.03	55.25	17.51	9.88	4.10	2.53	160.3
DYAA	27.77	26.08	51.10	13.68	9.44	3.60	1.21	132.9
DYCP	27.06	12.75	21.97	-12.94	2.81	-1.85	-3.30	46.5
WCP	26.18	12.10	0.73	0.92	0.50	-2.37	-0.11	37.9

Note that those zones identified to have a baseline SDB deficit in any given year are highlighted in red. Graphs showing the SDB for the DYAA, DYCP and WCP scenarios from 2014/15 to 2042/43, for each WRZ, are presented overleaf.

9.6.1 North WRZ SDB





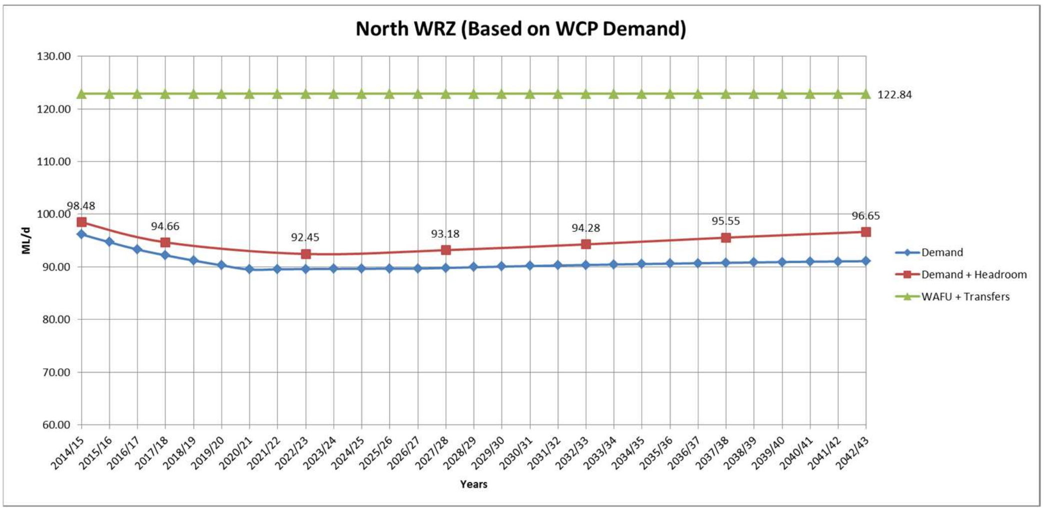


Figure 9.1 – North WRZ SDB

9.6.2 North East WRZ SDB

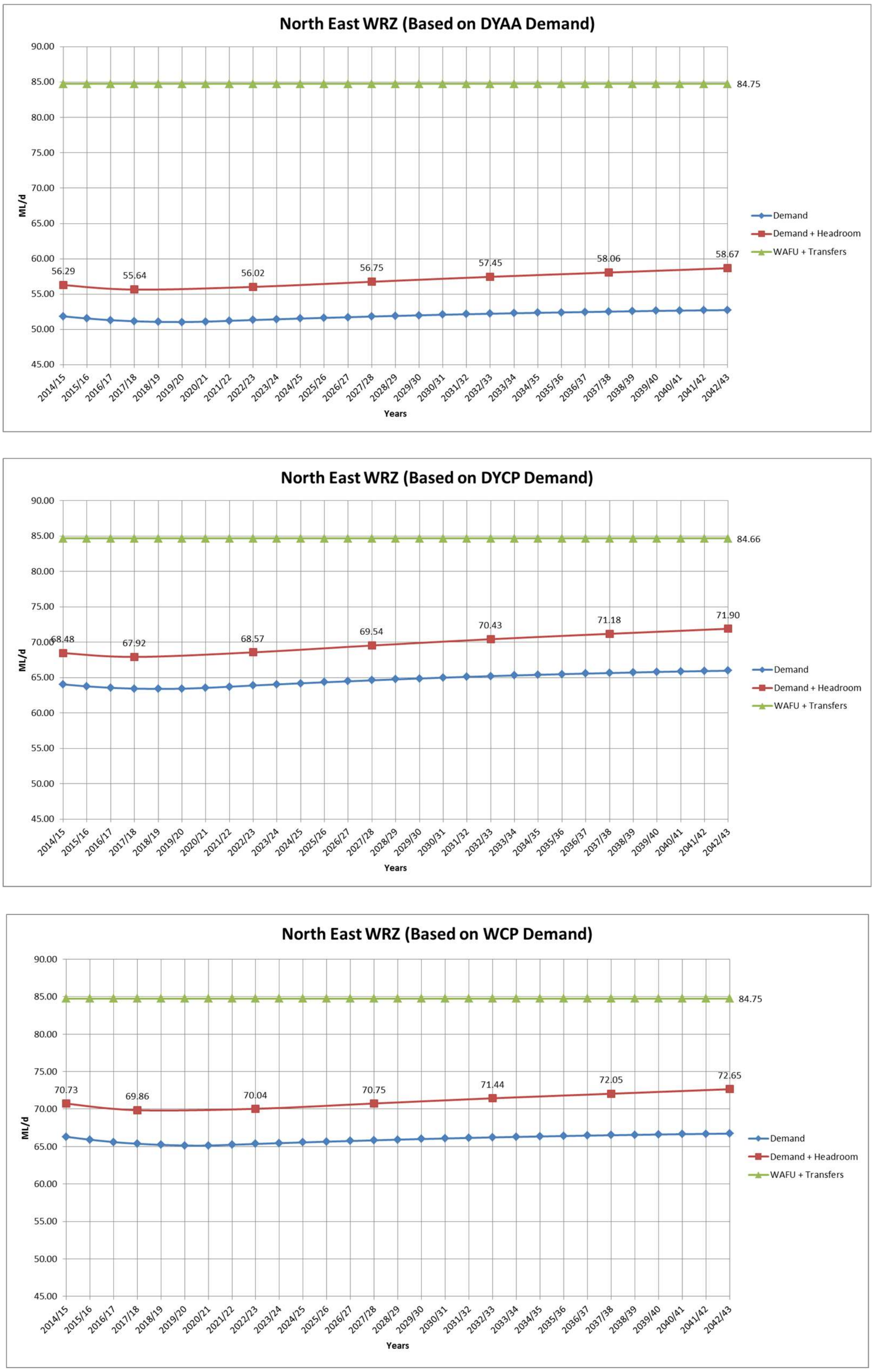
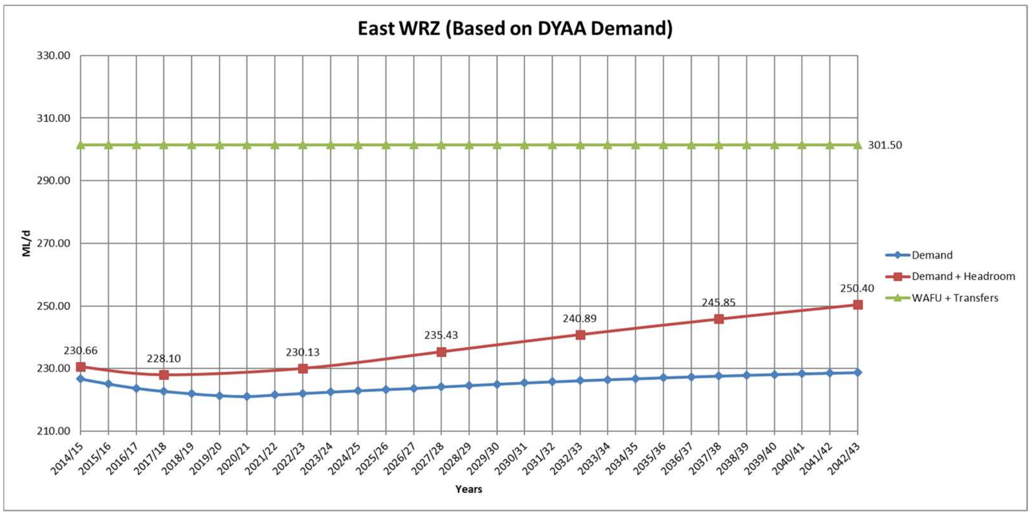
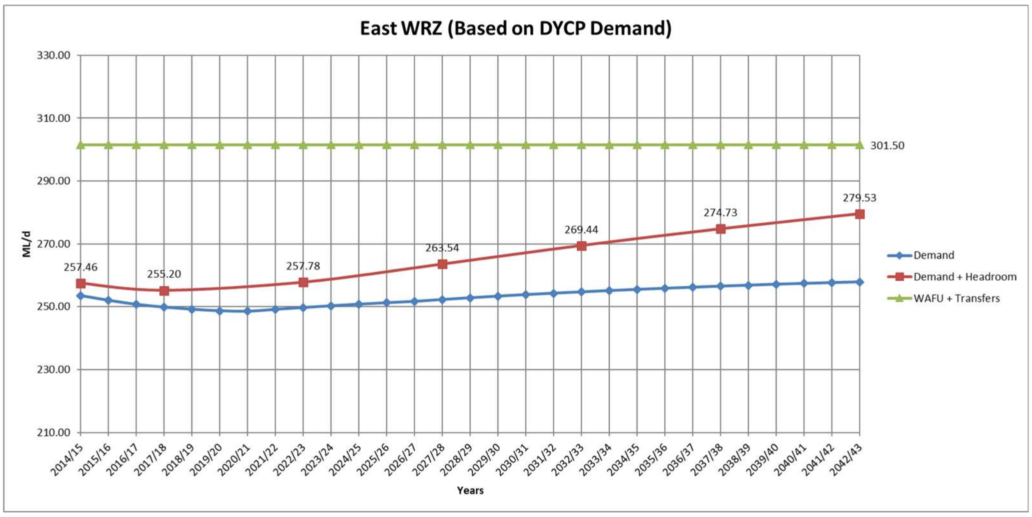


Figure 9.2 – North East WRZ SDB

9.6.3 East WRZ SDB





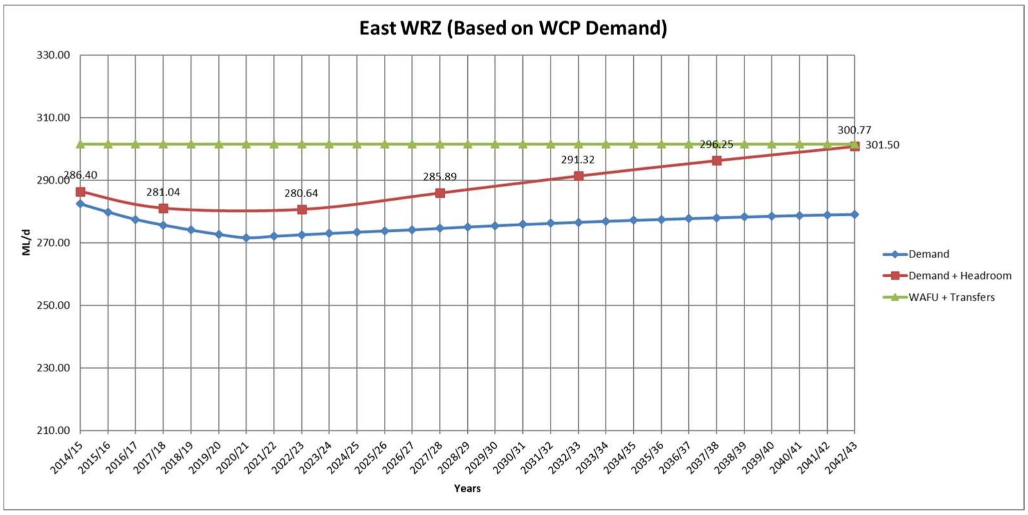


Figure 9.3 – East WRZ SDB

9.6.4 South WRZ SDB

Figure 9.4 – South WRZ SDB

9.6.5 South West WRZ SDB

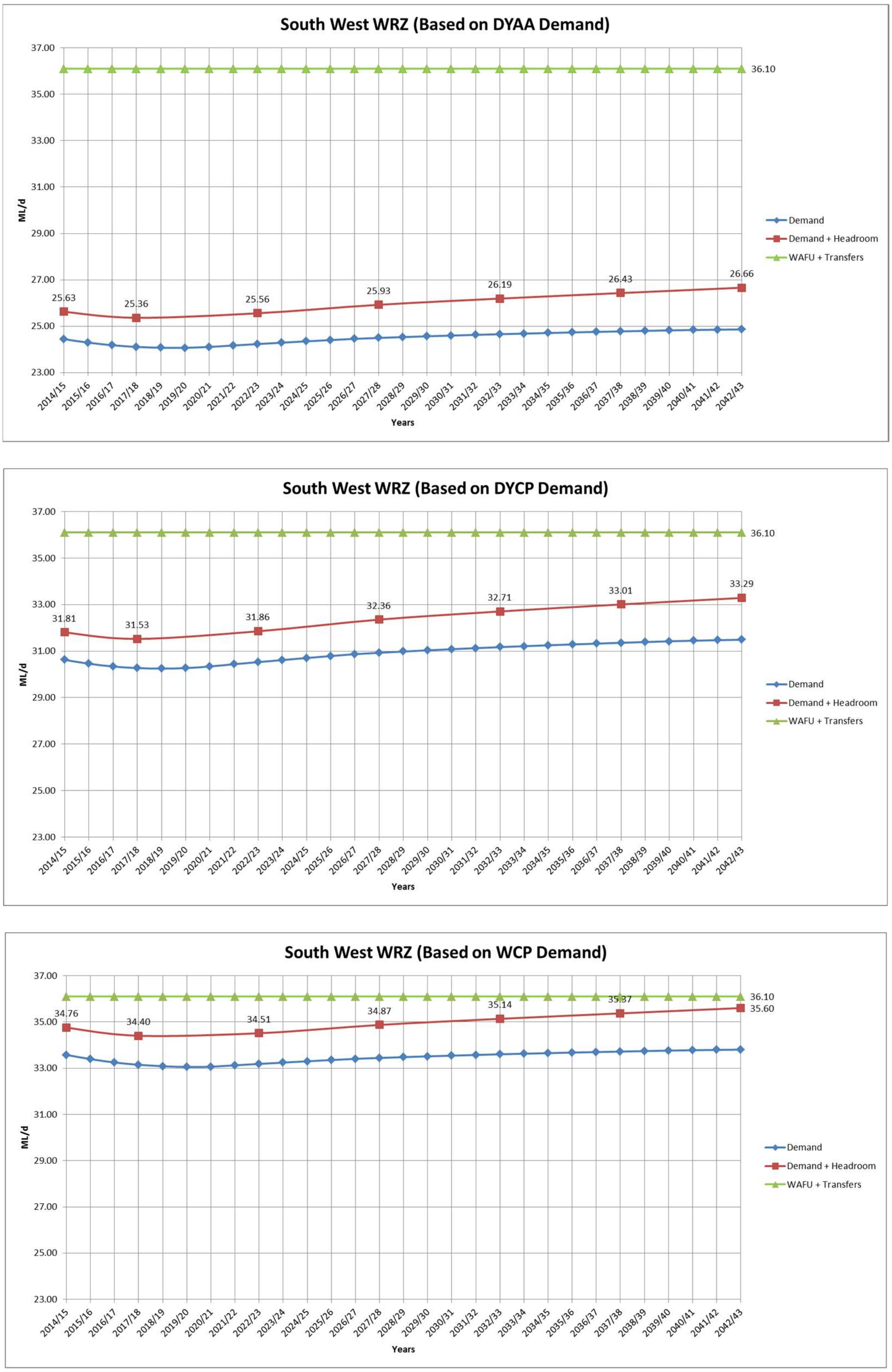
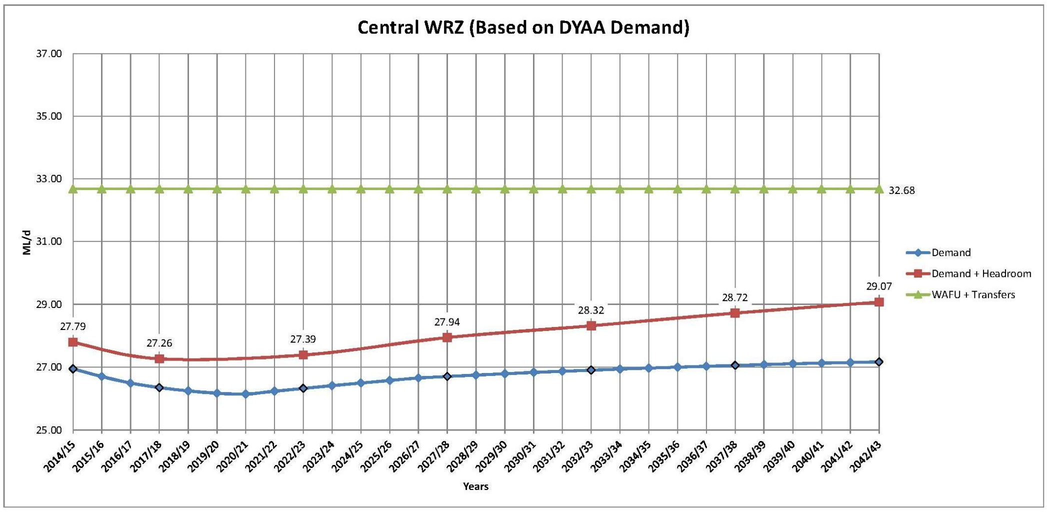
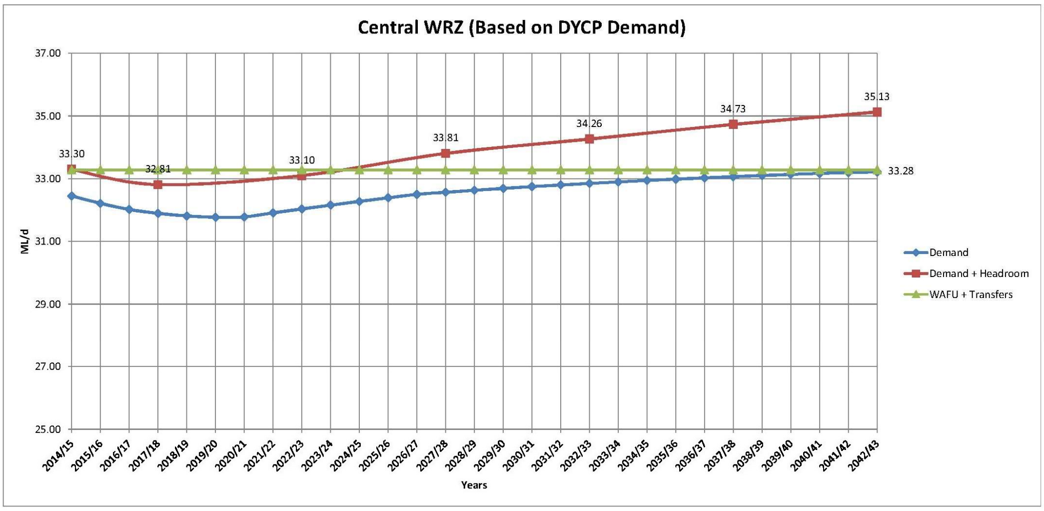


Figure 9.5 – South West WRZ SDB

9.6.6 Central WRZ SDB





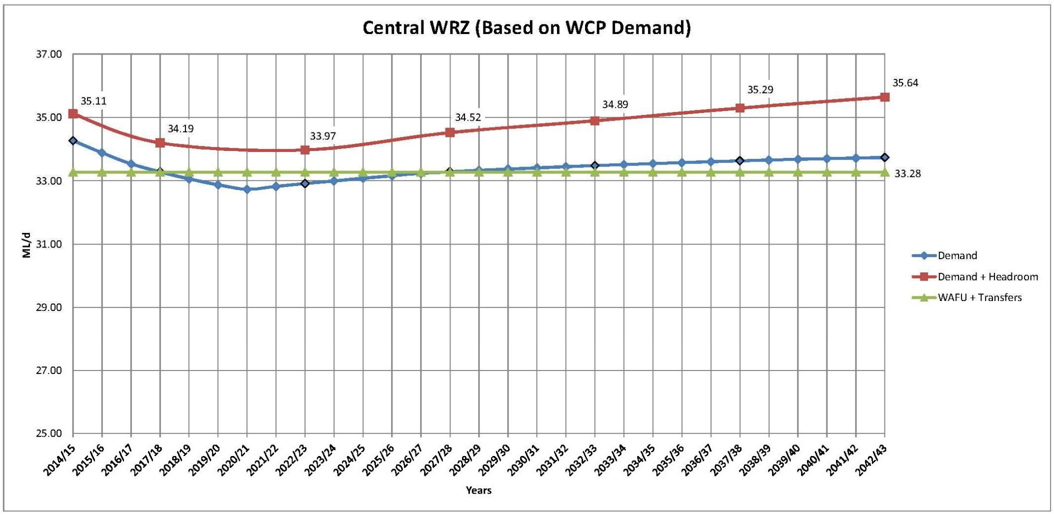
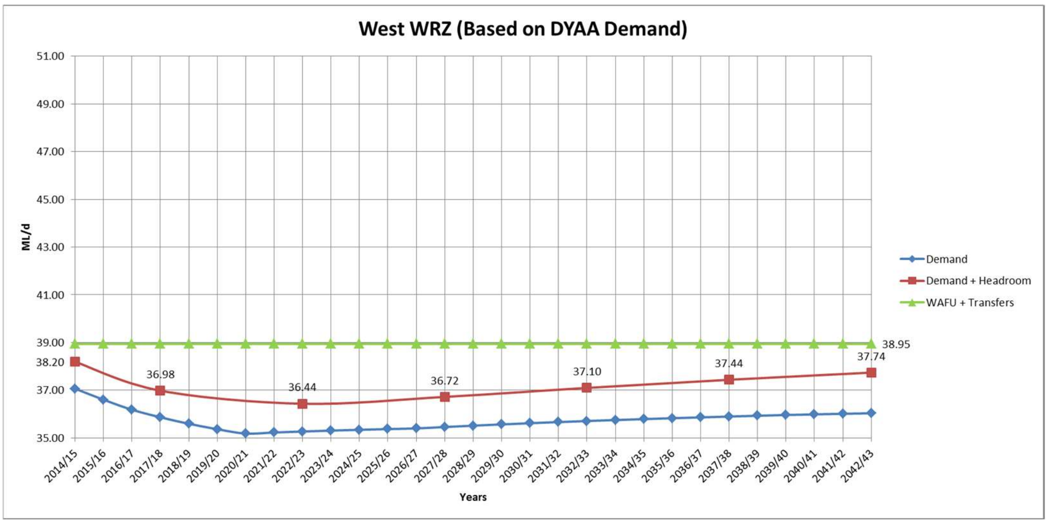
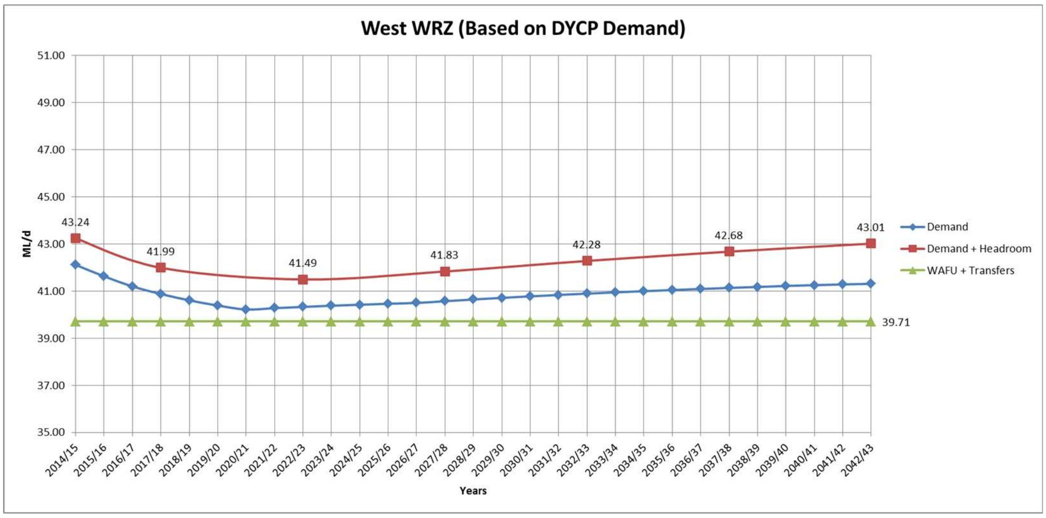


Figure 9.6 – Central WRZ SDB

9.6.7 West WRZ SDB





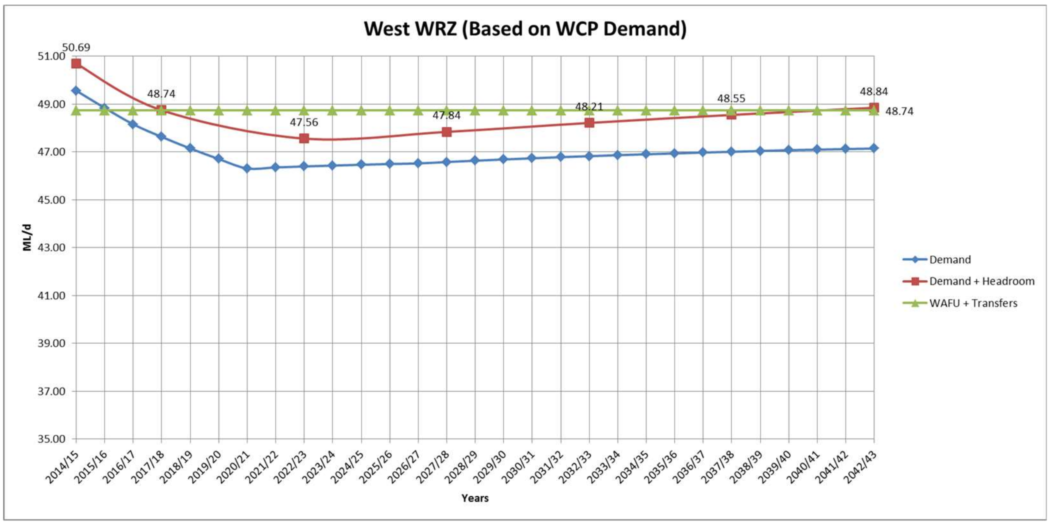
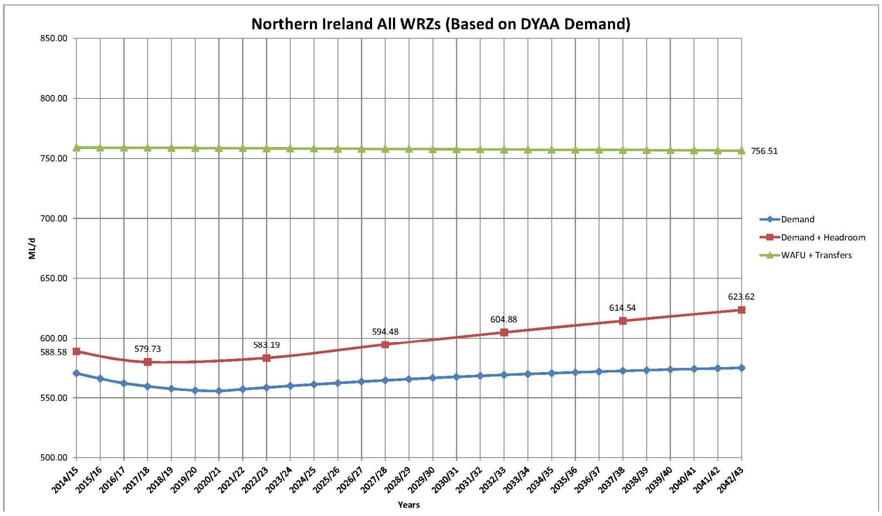
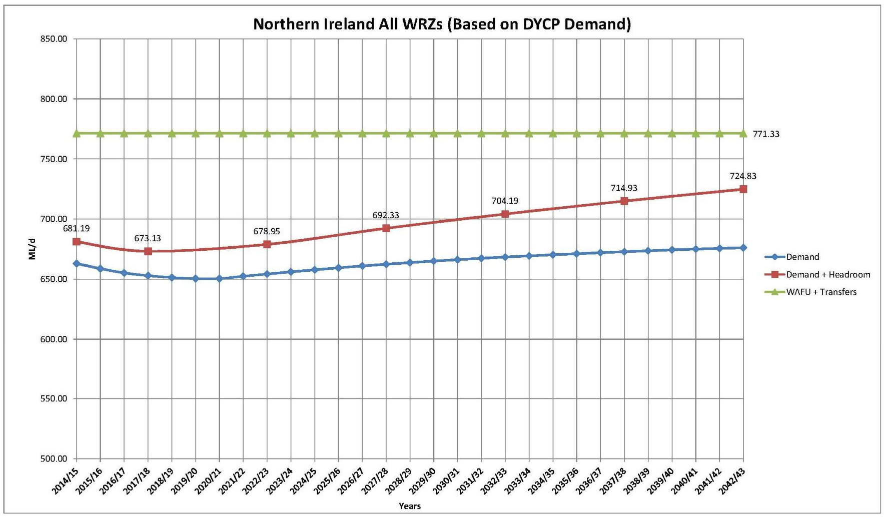


Figure 9.7 – West WRZ SDB

9.6.8 Northern Ireland SDB





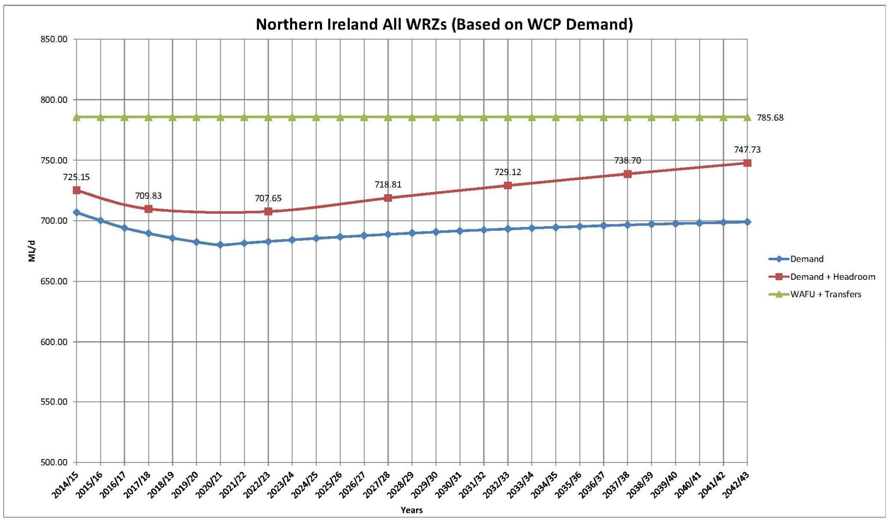


Figure 9.8 – Northern Ireland SDB

9.7 SDB Commentary

The SDB assessment shows that under the DYAA scenario all 7 zones have a surplus of water throughout the planning period for the Target LoS. This is an improvement in resilience from the previous plan which identified deficits in 3 of the 5 zones. The improvement is primarily due to reductions in leakage and reductions in NHH Demand.

The Critical Period assessments, which were not modelled in the previous plan, show that there are forecast supply/demand deficits, over the planning period, in the following WRZs:

- South Zone – 12.9 Ml/d deficit for the DYCP scenario by 2042;
- West Zone – 3.3 Ml/d deficit for the DYCP scenario and 0.1 for the WCP scenario by 2042.
- Central Zone – 1.9 Ml/d deficit for the DYCP scenario and 2.4 for the WCP scenario by 2042.

These deficits are based on the original baseline demand forecasts prepared in 2016/17.

9.7.1 South WRZ

The WAFU before transfers in the South WRZ is higher than the critical period demands. This is because Castor Bay is a South WRZ source with an output that if deployed solely in the South WRZ would mean deficits are easily met. Castor Bay has a deployable output of 147 Ml/d, but transfers up to 30 Ml/d to the East WRZ which, after allowing for outages, results in the remaining WAFU available for the South WRZ reducing to only about 110 Ml/d. However, there is a limitation of 95 Ml/d on the quantity of water that can be transferred from Castor Bay WTW to Ballydougan SR , which means that approximately 15 Ml/d of Castor Bay's capacity cannot currently be utilised. Finally, there is a newly installed transfer from Carland to Cookstown which can transfer up to 2.4 Ml/d to the Central WRZ, which would also need to be supplied from Castor Bay.

Therefore, once transfers to the East WRZ and Central WRZ and the Castor Bay to Ballydougan constraint are applied, there would be a 12.9 Ml/d deficit in the South WRZ for the DYCP scenario at the end of the WR&SR planning period (2042). However, if the Carland to Cookstown main were to be upgraded to a achieve a 5 Ml/d flow, the deficit in the South WRZ will increase further by 2.6 Ml/d to a total of 15.5 Ml/d. A review of the High Water Demand Event (Summer 2018) demands (section 14.7) showed that during more intensive dry periods, the deficit could increase by another further 4.2 Ml/d, giving for a total deficit of 19.7 Ml/d by 2042. Measures to address the current and emerging deficits will thus be required.

9.7.2 Central WRZ

There are deficits in the Central WRZ by 2042 due to the current capacity of the Carland to Cookstown transfer being limited to 2.4 Ml/d. This limitation is not related to the size of the pipe, but due to the lack of head at Carland service reservoir and other pressure related issues. Increasing this transfer capacity to 5Ml/d would remove the DYCP and WCP deficits.Furthermore, there is some uncertainty as to the hydraulic capacity of the intake at Lough Fea. It is possible that the hydraulic capacity of this pipe could be higher than assumed currently which would potentially increase the DO of this WRZ further improving the SDB, however it is understood from operations staff that, due to the configuration of the intake, this may be difficult to achieve.

9.7.3 West WRZ

A deficit of 3.3 Ml/d during the DYCP scenario has been identified by 2042. There is currently (2017) a deficit in this scenario of around 3.5 Ml/d, but this is forecast to reduce to 1.6 Ml/d by 2020. The analysis shows that there is a deficit during the WCP scenario in only the early years of the plan but that with leakage reduction this deficit disappears. There is a very small deficit in the WCP at the end of the planning period but any measures implemented to address the DYCP deficit will benefit the SDB for the WCP scenario. There are no forecast deficits for the DYAA scenario.

10. Options Assessment

Having established the baseline supply/demand balance for each water resources zone, this identified SDB deficits in the South, Central and West WRZs under critical period planning scenarios. In order to address these identified SDB deficits, an initial wide range of 'unconstrained' development options was identified. An option screening process was then carried out to produce a reduced set of 'constrained' development options for further design and costing. The following cost components were considered:

- CAPEX costs;
- OPEX costs;
- Environmental & Social costs;
- Carbon costs.

These fully costed options were then carried forward for economic evaluation using the EBSD model to produce a range of plans, ranked in terms of overall NPV cost, for further programme appraisal and consultation to arrive at a preferred water resources plan, as described in Section 13.

10.1 Assessment Overview

This Section sets out the process for identification and assessment of options to meet the supply demand deficits over the 25 year planning period. The options consider key issues including sustainable catchment management, efficient use of the resources, flexibility, resilience, WFD and CC constraints. Sustainable water requirements are also considered, based on the March 2016 document 'Sustainable Water – A Long-Term Water Strategy for Northern Ireland 2015-2040'

The options considered are designed to meet the deficits identified in Section 9. While addressing deficits is the primary aim of these options it is preferable that they also provide added resilience. There are 2 types of SDB Options which are:

Water Resource Options – Options which provide additional water resource to a WRZ to increase the WAFU in that WRZ and help address the deficit. These include new sources and new transfers from one WRZ to another.

Demand Side – Options which reduce the demand in a WRZ and therefore reduce the deficit. These include options such as leakage reduction or water efficiency measures. These options are additional to the work already being undertaken by the NI Water Communications team in promoting the water efficiency message which will continue throughout the life of the WR&SR Plan.

The first stage in the options assessment was the development of an unconstrained options list, via a series of workshops. The unconstrained list includes 53 options that could reduce the vulnerability of the water supply system and increase the resilience of the water assets but before considering the practical and technical feasibility, cost or environmental constraints.

Following identification of the unconstrained options, an exercise was conducted to screen out unfeasible options and enable suitable options to be taken forward for consideration within a constrained options list. The following four criteria were used in this screening:

- Environmental Impact;
- Technical Suitability;
- Water Availability/Resilience;
- Promotability.

A Red, Amber, Green (RAG) scoring methodology, based on the four criteria above and described in Table 10.1 below, was used to assess each of the options. On the basis of this assessment options were screened out where constraints deemed that option to clearly not be feasible. Those options that were not screened out make up the 'Constrained Options'.

Table 10.1 – Criteria Scoring

Colour	Description
Red	Significant issues or sensitivities that affect the ability to implement this option. This could include options in areas where there is no further water available or where the option may have a significant detrimental impact on a designated site.
Amber	Some issues or sensitivities identified, which may not be showstoppers but which could result in risks or complicated design and implementation strategies. For example, this could be an option located within an Area of Outstanding Natural Beauty, where the option may need to be designed in a more sensitive way to gain approval. These options are not preferred but would be drawn on if additional options are required.
Green	No major issues or sensitivities identified at the strategy stage for this option. These will form the preferred list of options which are screened in to the constrained list.

The constrained options have been taken forward for further appraisal. In this process each of the options is investigated in more detail including the following:

- High level concept design developed;
- Capital expenditure (CAPEX) costs are derived using the NI Water unit cost database;
- Operational Expenditure (OPEX) costs are considered for the SDB options using previous WTW unit cost data as well as pumping tariff information. These are used to derive an OPEX £/Ml for each option;
- Carbon and Environmental & Social (E&S) costing;
- Environmental assessments undertaken in line with the SEA process;
- Other constraints are identified such as Land and Planning;
- Additional resilience benefits provided;
- Period of Implementation.

With all the options assessed and dossiers complete the information above is used to develop a Least Cost Model and a Multi-Criteria Analysis to assess the options further. These are then used to determine the final water resources plan (see Section 13 and 15).

10.2 Unconstrained Options

The unconstrained options identified in the process outlined in Section 10.1 are listed in Table 10.2 below. The options which are not taken forward as constrained options are highlighted and the rationale for ruling out these options is outlined in section 10.2.1.

Table 10.2 – Unconstrained Options List

Option Category	Option Name	Target WRZ	Option Promoted to Constrained List?
New Reservoir Locations	New Glenedra Dam	West	No
	New Glenedra Bankside Storage	West	No
	New Glendergan Dam	West	No
	Derg Pumped Storage	West	No
	Derg Bankside Storage	West	Yes
New Surface Water Abstractions	Lough Neagh, New WTW and Trunk Main Transfer	West	Yes
	Rationalise small West WRZ sources and supply from increased Killyhevlin WTW	West	Yes
	New Abstraction from the Foyle	West	No
	Raw Water Transfer from New Kesh Source to Lough Bradan	West	No
	Enlarge Lough Bradan Impoundment	West	No
WTW Expansion	Increase Killyhevlin WTW Capacity	West	Yes
	Increase Castor Bay WTW Capacity to address deficit in the West	West/South West	No
Increase WTW Output	Increase output from Dunore Point	Central/West	No
WTW Refurbishment	Refurbish Belleek WTW	South West	No

Option Category	Option Name	Target WRZ	Option Promoted to Constrained List?
Groundwater Options	New Groundwater Sources in Fermanagh	West	Yes
	Recommission of former groundwater source	West	No
New Trunk Main Transfers	Carmoney WTW to Strabane Trunk Main	West	Yes
	Caugh Hill WTW to Strabane Trunk Main	West	Yes
	Killyhevlin to Lough Bradan Trunk Main	West	Yes
	Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade	South	Yes
	Booster upgrade on Carland to Cookstown Trunk Main	Central	Yes
Leakage Management Options	Further Leakage Reductions	All	Yes
	Supply Pipe Free Repairs	All	No
	Supply Pipe Replacement	All	No
Water Efficiency Options	HH Water audits	All	Yes
	Targeted NHH water audits (key accounts)	All	Yes
	Additional education talks at schools	All	No
	Retrofit dual/variable flush	All	No
	Cistern displacement devices - Reduce volume of a flush	All	No
	Water saver shower heads - reduce the flow rate of normal showers	All	No
	Tap aerators and flow restrictors - reduce the flow rate of taps	All	No
	Rainwater harvesting and water butts - Storage of rainwater for garden use	All	Yes

Option Category	Option Name	Target WRZ	Option Promoted to Constrained List?
	Greywater re-use - Wastewater collected and re-used	All	No
	Rainwater harvesting - internal and external daily use	All	No
	Incentives for new water saving appliances	All	Yes
	Incentives for new water saving fittings	All	Yes
	Promotion of water efficient white-goods and sanitary wear in new build houses	All	Yes
	Schools water audit and retrofit	All	Yes
	Free water saving devices	All	Yes
	Hospital and Hotel Audits & Retrofit programme	All	Yes
	Hotel efficiency packs	All	Yes
	Collaborated water & energy efficient retrofit programme delivered by third parties	All	Yes
	Retrofit dual or variable flush (non-household)	All	No
	NHH on-line account information	All	No
	Installing domestic showers where none present	All	No
	Social housing refurbishment	All	Yes
	Farm Audits	All	Yes
Other Options	Effluent Reuse	All	No
	Desalination	All	No
	Aquifer Storage	All	No

10.2.1 Screened Out Options

The following options are discarded as they have been deemed to be not feasible on the basis of one or more of the four screening criteria listed in 10.1.

10.2.1.1 New Glenedra Dam

This option involves the construction of a new impounding reservoir (IR) on the Glenedra River to supplement the supply to Caugh Hill WTW. This would then facilitate additional transfer to the West and Central Zones, addressing any identified deficits and increasing resilience. The option is discounted as there are major concerns over potential environmental impacts and restrictions in building a dam within an Area of Special Scientific Interest (ASSI) and Special Areas of Conservation (SAC) boundaries. A new reservoir scheme would involve the flooding of existing valleys with associated high impacts on the environment and local communities. The option would involve an unacceptably long lead-in time and would be unable to address deficits in the short to medium-term.

10.2.1.2 New Glenedra Bankside Storage

Similar to the previously described option, this proposes construction of a new raw water storage reservoir adjacent to the Glenedra River to supplement flow to Caugh Hill WTW. Although it is felt that the environmental implications are less than damming the river, there are still significant environmental concerns about constructing a new reservoir so close to environmental designations. Furthermore the lead-in time is once again deemed too long to address deficits in the short to medium-term.

10.2.1.3 New Glendergan Dam

This proposal is to develop a new IR on the Glendergan River to regulate the supply to the Derg WTW thus increasing its deployable output to meet deficits in the West WRZ. The proposed area for the impoundment is located in an ASSI and a SAC. Therefore, this option has significant adverse environmental impacts and would take many years to implement. The location of the scheme near to the Republic of Ireland (ROI) border would also lead to cross border catchment issues. All these issues have led to the scheme being screened out.

10.2.1.4 Derg Pumped Storage

This option considers the potential to pump raw water from the Derg or Strule rivers to new high-level storage locations at off-peak times or seasonally when water is available in the source rivers. This water would be stored and used to supplement the Derg WTW at times of low flow. This option would have a lead-in time well in excess of 5 years. It is similar to the Derg Bankside storage option but is more environmentally constrained and is predicted to require a much larger capital outlay but with no added benefits. The decision has therefore been taken to screen this option out and give further investigation to the Derg Bankside Storage Option.

10.2.1.5 New Abstraction from the River Foyle or Mourne River

The option to locate a new raw water abstraction and treatment works on the banks of either the River Foyle or Mourne River in the Strabane area has been considered. The new source would supply southwards into the West WRZ and address supply shortfalls. This option is screened out due to licence restrictions preventing further abstraction from the same catchment as the Derg and Strule rivers.

10.2.1.6 Raw Water Transfer from New Kesh Source to Lough Bradan

This involves the abstraction of additional raw water from Lough Erne near Kesh and transferring this water to Lough Bradan WTW in West WRZ. This option is screened out as the WFD restricts the transfer of raw water between catchments to ensure there is no cross contamination of invasive species. Zebra Mussels are known to be present in Lough Erne and are classified as an invasive species.

10.2.1.7 Enlargement of Lough Bradan Impoundment

This proposal is to restrict the natural outlet at Lough Bradan and raise the top water level to provide additional storage thus increasing the deployable output of the source. This option has been screened out due to the poor water quality of the catchment presenting difficulties in the treatment process. Therefore, it is felt that increasing a source of water that is difficult to treat would potentially reduce the resilience of the system.

10.2.1.8 Increase Castor Bay WTW Capacity to address deficits in the West WRZ

The option to increase Castor Bay to its full licence capacity to enable more widespread supply to many WRZs was considered. It was deemed inefficient to expand this works to regularly pump water a considerable distance west.

However, increasing Castor Bay WTW to provide additional resilience to the areas it already supplies is considered further as a resilience option in 9.3.3.11.

10.2.1.9 Increase Output from Dunore Point WTW

The option to increase the abstraction and WTW capacity at Dunore Point and transfer the additional water either directly or indirectly has been considered. However, the WRZs in deficits are a long way from Dunore Point and to make use of the additional water would require excessive pumping and lengths of pipeline. Therefore, this option is screened out.

10.2.1.10 Refurbish Belleek WTW

This option involves increasing the abstraction licence and WTW capacity at Belleek WTW to provide additional water in the South West WRZ to enable a transfer to the West WRZ. Due to the relatively remote location of Belleek the new transfer pipelines required would be very long. It is also felt that from a resilience point of view it does not make sense to increase the reliance on such a small and remote plant.

10.2.1.11 Recommission Groundwater Source

In the last 20 years NI Water has decommissioned a number of small boreholes (BH) and spring sources in the west of the country. Consideration has been given to recommissioning these sources such as Lenamore and Newtownstewart to provide additional water to the West WRZ. These sources were decommissioned because they were deemed to be vulnerable to pollution, costly to operate and provided relatively low volumes of water. All these issues would remain if the sources were recommissioned so the option is therefore screened out.

10.2.1.12 Effluent Reuse

Effluent reuse has been considered as it is being considered more frequently in the rest of the UK. This is because it is becoming more of a necessity in some water stressed areas of GB. However, it is screened out as an option as it is not a promotable solution to customers in Northern Ireland while other options are available. Furthermore the high cost of such schemes would be prohibitive.

10.2.1.13 Desalination

The option to treat seawater from Lough Foyle to produce potable water has been considered. As with the option for Effluent Reuse it is screened out as it is not a promotable solution to customers and is cost prohibitive. Furthermore, the concentrated brine discharge, which is a by-product of the process, has the potential to lead to localised adverse environmental impacts.

10.2.1.14 Aquifer Storage and Recovery

This involves the re-injection of potable water back into an existing aquifer for later recovery and use. This option would be of limited use in Northern Ireland as the technique is primarily used to reinject into existing groundwater sources in winter to avoid depletion during the summer months and NI Water does not operate any groundwater sources. There is also uncertainty over the availability of suitable sites and the option would be cost prohibitive. For these reasons the option is screened out.

10.2.1.15 Supply Pipe Repair

Options for free or subsidised supply pipe repair have been considered. The benefit of this is it reduces leakage time in these pipes and encourages customers to report leaks sooner. This action would demonstrate the company's commitment to water efficiency. However, it has been determined that in order to tackle supply pipe leakage the company operates a Leakage Notice Procedure. Under this procedure customers with a supply pipe leak identified receive a 28 day notice. The notice informs the customer that there is a leak and that it is the customer’s responsibility to arrange for its repair. If after 28 days the leak has not been repaired customers are issued with a letter informing them that NI Water will repair the leak at the customer’s expense. Under the current arrangement leaks are repaired reasonably quickly and any savings in water from subsidised repair would be very small. Therefore, this option is screened out.

10.2.1.16 Additional Education Talks at Schools

This involves visiting schools to give talks to school children and indirectly to parents promoting efficient water use. This does already occur in certain areas and so the option is more of a baseline water efficiency action than a water resource management option so is not considered further.

10.2.1.17 Retrofit Dual/Variable Flush (Domestic and Non-Domestic) & Cistern Displacement Devices - Reduce Volume of a Flush

This involves retrofitting a dual flush mechanism and cistern displacement devices on older toilets in customer properties. Although it is believed that these would lead to reduction in flush volumes it has been decided that the savings would be minimal particularly as there will be a natural replacement of these through time. The other significant issue is that NI Water cannot enter people’s houses to undertake work. Therefore, this option is screened out.

10.2.1.18 Water Saver Shower Heads/ Tap Aerators and Flow Restrictors - Reduce the Flow Rate of Normal Showers and Taps

The option of installing new flow controlling fittings in customer properties on taps and showers has been considered. While savings can be made experience from the UK has shown that achieving significant savings and customer take-up is unpredictable and therefore it is difficult to promote as a water resource option alone. Once again the restriction on entering customers’ property applies. Therefore, this option is screened out although NI Water should still promote the use of these more efficient fittings in their water saving messaging.

10.2.1.19 Greywater Re-Use - Wastewater Collected and Re-Used / Rainwater Harvesting - Internal and External Daily Use

The potential for fitting of greywater systems for toilet flushing or rainwater harvesting for internal use in new or refurbished domestic properties has been considered. Although it could provide reduction in HH water use, the very high cost of installation and high maintenance requirements would make them difficult for NI Water to fund as a water resource option when compared with other options. It is also felt that there would be difficulty in promoting this option to customers in an area that people do not perceive to be water stressed. Therefore, this option is screened out although NI Water should still promote the use of these more efficient fittings in their water saving messaging.

10.2.1.20 NHH on-line account information

The benefit of introducing widespread database with online access to consumption data/benchmarking was considered. The information could be used to help customers understand where they use most of their water to then help them focus reducing their consumption. However, there would be a high cost in implementing this and as customers are not currently charged for their water in Northern Ireland there is little incentive for them to use the information to reduce consumption. Therefore, this option is screened out.

10.2.1.21 Installing domestic showers where none present

It has been proposed that domestic showers are promoted for installation where none are present on the basis of research showing that this consumes less water than bath usage. It is considered that as a standalone scheme it would be unlikely to gain much uptake and had limited scope for savings and is therefore screened out.

10.3 Constrained Options

With the screening complete on the Unconstrained Options the remaining feasible options are carried through to the Constrained List for further assessment. The constrained list of options is set out in Table 10.3. Outline descriptions for each option are provided under sections 10.4.1 to 10.4.2.

Table 10.3 – Constrained Options List

Option Reference	Options Driver	Option Name	Target WRZ
1	SDB	Derg Bankside Storage	West
2	SDB	Lough Neagh, New WTW and Trunk Main Transfer	West
3	SDB	Rationalise small West WRZ sources and supply from increased Killyhevlin WTW	West & South West
4	SDB	New Groundwater Sources in Fermanagh	West
5	SDB	Killyhevlin WTW to Lough Bradan Trunk Main	West
6	SDB	Carmoney WTW to Strabane Trunk Main	West
7	SDB	Caugh Hill WTW to Strabane Trunk Main	West
8	SDB	Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade	South
9	SDB	Booster upgrade on Carland to Cookstown main	Central

Option Reference	Options Driver	Option Name	Target WRZ
10	Demand Management	Further Leakage Reductions	All
11	Demand Management	HH water audits	All
12	Demand Management	Targeted non-HH water audits (key accounts)	All
13	Demand Management	Rainwater harvesting - external daily use	All
14	Demand Management	Water efficient white goods discount vouchers	All
15	Demand Management	Incentives for bathroom retrofit	All
16	Demand Management	Improved specification of water fittings in new homes	All
17	Demand Management	Schools water audit and retrofit	All
18	Demand Management	Free water saving devices	All
19	Demand Management	Hotel & Hospitals water audit and retrofit	All
20	Demand Management	Hotel Water Audits and installation of water saving devices	All
21	Demand Management	Collaborated water & energy efficient retrofit programme delivered by third parties	All
22	Demand Management	Social housing refurbishment	All
23	Demand Management	Farm Audits	All

10.3.1 Constrained Options – SDB Options, Description and Assessment

10.3.1.1 Option 1 - Derg Bankside Storage

This option involves the construction of a new raw water bankside storage reservoir in land adjacent to the existing Derg WTW. Low flows and restrictions to abstraction from the Derg and Strule rivers reduce the DO of the Derg WTW and therefore the West WRZ. The proposed bankside storage reservoir will help smooth out periods of low flow in the rivers and therefore increase the DO from the Derg WTW to operate at near full capacity for the required LoS. It has the added resilience benefit of helping to address raw water quality issues experienced currently during low flows. The reservoir will have a capacity of 175ML and help maintain the maximum 26Ml/d output from the WTW. 175 ML has been assessed as the required volume that will provide the adequate retention to maintain 26 Ml/d at all times.

However it must be noted that it does not provide the same level of resilience that the trunk main options provide. Assuming that surplus water will be available the trunk main options provide resilience to the WRZ as whole and to WTW outages. The bankside storage does not protect the WRZ in the event of an outage at Derg WTW for example. Furthermore, improvements at Derg WTW will reduce the risk of outage there.

The existing inlets to the WTW will be utilised with additional pipework installed, transferring diverted flow to and from the reservoir.

This option would also be considered a Resilience Option as it addresses raw water quality issues with the Derg WTW.

10.3.1.2 Option 2 - Lough Neagh, New WTW and Trunk Main Transfer

This option involves the construction of a new 3Ml/d WTW on the shores of Lough Neagh. The new works will treat raw water taken directly from a new abstraction point on the lough. Treated water from the site is transferred to Loughmacrory WTW, via a new trunk main, and onwards into the West WRZ to meet deficits in this WRZ.

The new WTW has been scoped as a Dissolved Air Filtration (DAF) treatment process with standby generation and 24hr storage on site. The potable water is pumped to Loughmacrory via a 300mm Diameter Nominal (DN) pipe.

10.3.1.3 Option 3 - Rationalise small West WRZ sources and supply from increased Killyhevlin WTW

This option involves the construction of a new expanded WTW at Killyhevlin adjacent to the existing works to replace the existing Killyhevlin WTW. The new works is to have the capacity to supply the whole South West WRZ, including the Belleek Garrison WSZ, as well as supplying the WSZs from three existing WTWs in the West WRZ – Lough Bradan, Glenhordial and Loughmacrory WTWs. This would facilitate the decommissioning of all these WTWs. A new series of treated water trunk mains and pumping stations are required to transfer treated water to the West WRZ and to Belleek from Killyhevlin. The new WTWs and supply network will also have the capacity to meet the deficit predicted in the West WRZ.

A 3Ml/d 280mm DN pipe would be required to main out the works at Belleek. This would improve the interconnectivity of the whole South West WRZ.

A new 26Ml/d trunk main would transfer water to the West WRZ, supplying 12, 8 and 6Ml/d to Lough Bradan, Glenhordial and Loughmacrory WTWs respectively.

The option to transfer water from Killyhevlin WTW to Lough Bradan has previously been included in the WRMP 2012 as a Constrained Option.

This option would also be considered a Resilience Option as it addresses Killyhevlin WTW reliance on old technology as highlighted in 9.1.2.

10.3.1.4 Option 4 - New Groundwater Sources in Fermanagh

This comprises the installation of 12 No. new BH Wells east of Killyhevlin in County Fermanagh which has been identified by hydrogeologists as an area that could potentially provide reliable quantities of raw water. Raw water abstracted from these boreholes would be treated in a new purpose built WTW in an area central to the BH field and then pumped to Loughmacrory WTW in the West WRZ to meet the 3Ml/d SDB deficit.

A desk study carried out on the hydrogeology of the west and south west of the country identified the proposed location as the most likely to abstract from a reliable aquifer. It recommended the installation of 12 No 60m deep boreholes at 2km centres. Each BH would have the capacity to abstract 500 m^3/d.

The new WTW is proposed as a 3Ml/d treatment capacity using the DAF process but would require further ground water sampling and analysis to confirm process requirements. The transfer will be pumped to Loughmacrory via a 300mm DN pipe.

10.3.1.5 Option 5 - Killyhevlin to Lough Bradan Trunk Main

This comprises provision of a new treated water trunk main from Killyhevlin WTW to Lough Bradan WTW to utilise any excess headroom in the South West WRZ to meet the 3Ml/d SDB deficit in the West WRZ. The main is sized to have a flow capacity of 5Ml/d and is intended to address the 3Ml/d SDB deficit identified in the West WRZ.

The transfer is to be pumped from Killyhevlin to Lough Bradan via a 300mm DN trunk main.

This option has previously been included in the WRMP 2012 as a Constrained Option.

This option would also be considered a Resilience Option as it provides increased interconnectivity between 2 WRZs.

10.3.1.6 Option 6 - Carmoney WTW to Strabane Trunk Main

This includes provision of a new treated water trunk main between Carmoney WTW in the North WRZ to Strabane's Castletown SR in the West WRZ. This is to utilise excess headroom in the North WRZ to meet the 3Ml/d SDB deficit in the West WRZ.

This option was included in the WRMP 2012 and has since been the subject of further investigations and reports by NI Water including the recent 'JL715 – Caugh Hill, Carmoney to Strabane Strategic Link watermain Capital Investment Report 2013'.

Although the deficit in the WRZ is only 3 Ml/d this plan recognises the need to improve resilience in the West WRZ due to the potential for outages in the WRZ causing reductions to supply. Therefore, 17 Ml/d has been identified as the optimum size to improve the security of supply of the West WRZ for the following reasons:

- 17 Ml/d is the quantity that would maintain supply in the West WRZ in the NYAA in the event of an outage at Derg WTW or any other WTW in the zone.
- This volume utilises existing headroom in the North WRZ.
- Increasing the capacity above the 17 Ml/d to meet critical period scenarios during outages would require an additional 14.4km of main.

To facilitate this volume new pumps are required at Carmoney WTW to provide the additional supply to Avish Hill SR. New 500mm DN pipework is required in the network downstream of the reservoir to provide the required additional flow volume to Corrody SR. From here the additional 17Ml/d is to be pumped to Castletown SR. From this point the increased volume can be transferred to Derg WTW and further into the network.

This option assumes that the existing abstraction licence at the River Faughan will be maintained at least to the level required to maintain the 35 Ml/d output from Carmoney WTW. The abstraction licence at the River Faughan which supplies Carmoney WTW is currently being reviewed by NIEA. A Habitat Regulation Assessment has recently been carried out and no issues have been identified and therefore the risk is considered to be very low that the approved abstraction would be reduced below the current Carmoney WTW output. However, this option is subject to completion of this abstraction licence review.

10.3.1.7 Option 7 - Caugh Hill WTW to Strabane Trunk Main

This option is similar to that described in Option 6 with a new trunk main transfer to utilise excess headroom in the North WRZ to meet the 3Ml/d SDB deficit in the West WRZ. In this option, the additional supply is to be taken from Caugh Hill WTW and gravitated to Corrody SR via a 500mm DN trunk main. As with Option 6, the additional flow volume can be transferred to Castletown SR and onwards to the Derg WTW supply zone.

10.3.1.8 Option 8 – Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade

This option increases the capacity of the transfer between Castor Bay and Ballydougan by 20 Ml/d to 115 Ml/d to meet deficits in the South WRZ. There is already sufficient treated water capacity at Castor Bay to meet the required demands in the South WRZ but it cannot be transferred to the WRZ due to a limitation in the capacity of the transfer between Castor Bay and Ballydougan. The transfer includes additional pumps on the existing site at Castor Bay WTW to enable the 20 Ml/d transfer along with an additional 500mm DN trunk main between Castor Bay and Ballydougan Clear Water Tank (CWT).

10.3.1.9 Option 9 – Booster Upgrade on Carland to Cookstown Trunk Main

The existing pipeline from Carland to Cookstown has sufficient capacity to transfer 5 Ml/d to Central WRZ, which would remove the deficit here. Currently this transfer typically runs at around 2.4 Ml/d under gravity. The addition of booster pumps will enable the 5 Ml/d capacity to be realised.

10.3.2 Constrained Options – Demand Management, Description and Assessment

10.3.2.1 Option 10 - Further Leakage Reductions

This option considers further leakage reduction options beyond those already identified as required to enable NI Water to reach its target SELL by 2021 as detailed in Section 5. A 2014 report by RPS for NI Water titled “Update of the Sustainable Economic Level of Leakage (SELL) for PC15” (document no UUX0434) was used as basis for deriving leakage management options. RPS identified leakage reduction options based on the following:

a) Active leakage control (ALC) only and

b) ALC with a further optimisation to allow for asset renewal and pressure management, where it was economic to do so.

This assessment included a quantitative assessment of the full range of social, environmental and carbon costs and benefits associated with leakage management, and with the value of Water.

The cost-leakage relationships developed by RPS (see figure E2 in the above report), together with detailed data subsequently obtained from RPS for Flow Monitor Zones (FMZs) in deficit, were used to develop zone-specific cost curves of future leakage reduction. Both ALC, and optimised leakage management, as described in a) and b) above, were developed and used to model the costs and benefits of further leakage interventions.

10.3.2.2 Option 11 - HH water audits

This option involves organising appointments with customers to undertake audit of fittings and appliances with fault rectification. Where required, the retrofit of flow/volume reducing devices could be implemented if permissible. Advice on replacement can be imparted alongside water regulations advice. Work could be undertaken by a third party or NI Water trained inspectors.

The option would be available to all NI Water customers with optional take-up. The aim of the option is to achieve significant reductions in HH demand.

This option has previously been included in the WRMP 2012 as a Constrained Option.

10.3.2.3 Option 12 - Targeted NHH water audits (key accounts)

This option provides key account customers with a free water audit service, by inspector, combined with water regulations advice. The aim of the option is to achieve significant reductions in NHH demand.

The audit would provide recommendations for improvement with estimated payback time. Improvements could be urinal controls, water efficient devices, leakage reduction or process improvements. All improvements are selected and paid for by the customer on the basis of payback information provided in the report. It is assumed that implementation takes place one year after the audit.

This option has previously been included in the WRMP 2012 as a Constrained Option.

10.3.2.4 Option 13 - Rainwater harvesting - external daily use

This option would involve the provision of subsidised water butts for domestic customers upon request. The aim of this option is to encourage seasonal reduction in water usage and therefore reduce HH demand.

This option has now been removed as subsidising water butts is not permissible.

10.3.2.5 Option 14 - Water efficient white goods discount vouchers

This option encourages customers to buy best in class water efficient washing machines and dishwashers. Although this would be predicted to be a long-term and slow initiative with regards to uptake, with reduction in water use achieved gradually, it would require no need for in-house intervention by NI Water.

This option has now been removed as subsidising white goods is not permissible.

10.3.2.6 Option 15 - Incentives for bathroom retrofit

This option is similar to Option 14, but in this case recommendations for customers would be to buy best in class water efficient toilets, taps and showers to replace what they currently use. As with Option 14 the uptake would be predicted to be slow but both could lead to a gradual decrease in HH demand.

This option has now been removed as subsidising bathroom retrofits is not permissible.

10.3.2.7 Option 16 - Improved specification of water fittings in new homes

This option involves collaboration with new housing providers to influence more water efficient specification of new properties, the aim of which would be to reduce HH demand in the future.

The option would require no physical intervention by NI Water and would avoid the need for future retrofits.

10.3.2.8 Option 17 - Schools water audit and retrofit

This option includes an audit, advice on improvement and a range of efficiency devices fitted as required, including cistern displacement devices. It includes advice on retrofit of dual-flush systems, push-taps, aerating taps and improving urinal flow controls. Significant water use reductions are documented (over 70% in some cases). This could be done in collaboration with education/local authorities.

10.3.2.9 Option 18 - Free water saving devices

This option provides DIY water efficient device packs to customers upon request which would be fitted by the customer.

10.3.2.10 Option 19 - Hotel & Hospitals water audit and retrofit

This option requires a range of measures to be agreed between NI Water and hoteliers and hospitals with the highest consumption to implement water audits and a range of device retrofitting.

Hospital retrofitting would be based on the outcome of an initial audit provided free of charge by NI Water with recommendations, details of any subsidies and estimated payback for improvements. Devices could include water efficient devices but hospitals would fund the remaining cost of improvements.

Hotels would be invited to assess their water usage and request devices that reduce water use. Cistern displacement devices, aerated showerheads and tap inserts are provided free of charge on request. Additional water efficiency information cards are also provided for hotel guests to ensure correct use and water saving practices.

10.3.2.11 Option 20 - Hotel Water Audits and installation of water saving devices

This option will involve the same measures detailed in Option 19 but solely for hotel purposes.

10.3.2.12 Option 21 - Collaborated water & energy efficient retrofit programme delivered by third parties

This option offers water and energy audits and is advertised and available to all customers. Visits are to be arranged by appointment and will include an audit of fittings and appliances with simple fault rectification (i.e. adjustment of overflowing ball valve, new washers in dripping taps). Where required, flow/volume reducing devices will be retrofitted. Advice is provided on replacement as appropriate along with water regulations advice. Work could be undertaken by third party or NI Water trained inspectors.

The range of services/fittings is relatively wide to ensure that some savings can be made in most properties audited.

The energy aspect adds additional value to the customer and provides a financial dimension. Of all domestic initiatives, this one would likely have the highest take-up.

10.3.2.13 Option 22 - Social housing refurbishment

This option is similar in many aspects to Option 16 in that it relies on influencing third parties, in this case, social housing providers, to increase water efficiency of fittings in homes. It is predicted that the uptake would be slow but both could lead to a gradual decrease in HH demand.

The option involves collaboration with social housing providers to influence more efficient specification of properties that are due for refurbishment. Improvements are targeted at properties where planned refurbishment is due. Therefore, there would be little additional costs and no need for NI Water to undertake fittings.

10.3.2.14 Option 23 - Farm Audits

This option involves provision of a free water audit service by an inspector, offered to farms combined with water regulations advice. The audit would provide recommendations for reduction in water usage along with an estimated payback time. Improvements are farm-specific and audits are undertaken by specialist auditors who have knowledge of farming practices. Improvements are selected and paid for by the customer. This option could be undertaken in collaboration with Ulster Farmers Union and the aim would be to reduce farm water usage and costs for farmers.

The savings for this would be limited as there has already been a lot of work undertaken by organisations such as the Ulster Farmers Union and it is thought most farmers would already have undertaken some kind of review of their water usage. Therefore, while savings for this option can be high it is thought the take-up would be very low.

11. Consultation

11.1 Consultation Aim

NI Water was required to publish the Draft WR&SR Plan for consultation with its customers. This provided customers an opportunity to make representations on the options appraisal process and the company's preferred plan. In addition, legislation requires that the company undertake "pre-draft" consultation with regulators and the CCNI. This consultation allows the views of interested groups and affected parties to be taken into account in the development of the Plan.

Consultation was also required for the Strategic Environmental Assessment (SEA) process to meet the SEA regulations. This included consultation on the scope of the SEA during the pre-draft consultation period and public consultation on the SEA Environmental Report published alongside the Draft WR&SR Plan. It also includes publication of a post adoption statement with the Final WR&SR Plan on how SEA and consultation has influenced the Plan. A Habitats Regulations Assessment report has also been published with the Final WR&SR Plan.

11.2 Pre-Draft Consultation

Pre-draft consultation was undertaken with key stakeholders. At the outset of the project a Steering Group comprising regulator representatives and key stakeholders was established. This Steering Group included the following stakeholders:

- Drinking Water Inspectorate (DWI);
- Northern Ireland Utility Regulator (NIAUR);
- Department for Infrastructure (DfI);
- Department of Agriculture, Environment and Rural Affairs (DAERA), NIEA;
- CCNI.

The Steering Group met 10 times during the Pre-Draft phase where methodologies and preliminary results on multiple aspects of the plan's development were presented and discussed.

The first formal stage in the consultation process was undertaken on the SEA Scoping Report for the WR&SR Plan. The purpose of the SEA Scoping Report consultation was to inform the approach for undertaking the SEA on the Draft WR&SR Plan and how this would be presented in the SEA Environmental Report. The consultation ran for 5 weeks from 11 October 2016 to 16 November 2016. Comments received have been addressed and used to inform the SEA process and are detailed in the SEA Environment Report.

11.3 Draft Consultation

The final stage in the consultation process was undertaken on the Draft WR&SR Plan and SEA. This consultation ran for nine weeks from 26th July 2019 to 27th September 2019. Responses were received from 3 consultees and the comments have been reviewed and addressed as appropriate to inform the outputs of the final plan.

A summary of the consultation responses relevant to the WR & SR Plan can be seen in Appendix 1.

12. Environmental Assessment

12.1 Introduction

Environmental assessment has been integrated into the development of the WR&SR Plan through the options screening and appraisal process, through input to the options costings used in the economic supply and demand modelling and in selection and assessment of the preferred Plan. These inputs were undertaken through the following:

- Strategic Environmental Assessment (SEA) - a process for assessing potential significant effects on the environment, the identification of mitigation measures and monitoring requirements. The SEA is informed by specific assessments required to meet a range of other regulatory, government guidance and best practice requirements and are listed below:

  - Habitats Regulations Assessment (HRA) is required to assess likely significant effects on nature conservation sites designated as of European or international importance;

  - Water Framework Directive (WFD) Assessment is required to assess if the plan complies with the WFD and avoids potential to cause deterioration of waterbody status or to prevent objectives being achieved;

  - Valuation of environmental and social costs and benefits (including carbon) – an approach for costing the societal impacts and benefits and incorporating these into the economic balance of supply and demand (EBSD) modelling for the selection of options to meet predicted demand (EBSD modelling is explained in Section 12);

  - Equalities Impact Assessment – to determine that the plan meets statutory equal opportunity and non-discrimination requirements;

  - Regulatory Impact Assessment - to determine socio-economic costs and benefits of the plan are considered; and

  - Rural Proofing Assessment - to ensure that the needs of rural communities and economy are taken into account.

12.2 Strategic Environmental Assessment Requirements

SEA is required to be undertaken on the WR&SR Plan to comply with the SEA Directive (200142/EC) and the Environmental Assessment of Plans and Programme Regulations (S 163 2004) which implement the directive.

The objective of SEA is *'to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development'.* The aim is that the SEA process is fully integrated into the plan development from the earliest stages and is taken into account when selecting the preferred WR&SR Plan.

The SEA involves collecting information, defining alternatives, identifying environmental effects, developing mitigation measures and revising proposals in light of the predicted environmental effects. It includes reporting on how the WR&SR Plan is likely to impact on the environment and the measures required to mitigate and monitor significant environmental effects during implementation. The SEA Environmental Report is published with the WR&SR Plan and a brief overview is provided in this section.

12.2.1 Habitats Regulation Assessment

Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna provides the framework for the designation and protection of 'European sites' (Natura 200 sites), the protection of 'European protected species'. The Conservation of Habitats and Species Regulations (Northern Ireland) 2010 transposed the Directive into NI law. European sites designated for conservation include Special Areas of Conservation (SACs), and Special Protection Areas (SPAs). Ramsar sites are also included within the regulations.

Under the Regulations, NI Water as a competent authority has a general duty to have regard to the Habitats Directive and to undertake Habitats Regulations Assessment (HRA) of its WR&SR Plan. Any plan considered to have a potential impact on a Natura 2000 site must go through an appropriate assessment which will consider the potential implications for the Natura 2000 site. The competent authority is required to only agree to a plan after ascertaining that it will be not adversely affect the integrity of the site concerned. In some cases where a potential impact cannot be avoided, designed out or mitigated, there must be an imperative reason for overriding public interest (IROPI) to allow the plan to go ahead. In this instance the Habitats Directive recommends a hierarchy of; avoidance, mitigation and compensatory measures.

An HRA screening assessment has been undertaken for the plan to identify likely significant effect on HRA sites. This is available separately to the main report.

12.2.2 Water Framework Directive Assessment

Directive 2000/60/EC on Establishing a Framework for Community Action in the field of Water Policy ('The Water Framework Directive') requires any new development to ensure the fundaments of the Directive are not compromised. The Directive came into force in Northern Ireland in 2003 through the implementation of the Water Environment (Water Framework Directive) (Northern Ireland) Regulations 2003 and aims to achieve the following;

- Enhance the status of and prevent further deterioration to aquatic ecosystems and their dependant terrestrial ecosystems and wetlands;
- Promote sustainable water use based on the long-term protection of available water resources;
- Reduce discharges and emissions of water pollutants to surface and groundwater, especially by 'priority' and 'priority hazardous' substances;
- Mitigate the effects of flood and droughts and thereby providing a sufficient supply of good quality surface water and groundwater.

Water Framework Directive (WFD) assessment is required to be undertaken on individual schemes and plan level assessment is undertaken to help ensure compliance.

12.2.3 Equality Impact Assessment

Section 75 of the Northern Ireland Act (1998) places a statutory requirement on each public authority to have regard to the need to promote equality of opportunity between and have regard to promoting good relations between;

(a) Persons of different religious belief, political opinion, racial group, age, marital status or sexual orientation;
(b) Men and women generally;
(c) Persons between a disability and persons without; and
(d) Persons with dependants and persons without.

An Equal Opportunity Screening Analysis has been undertaken on the options and plan as a whole to consider the potential effect of the plan on vulnerable members of society.

12.2.4 Regulatory Impact Assessment

The Northern Ireland Better Regulation Strategy requires 'all government departments, arm's length bodies and other bodies' to consider Regulatory Impact Assessment as part of the development process of policies and plans. A Regulatory Impact Assessment has been undertaken for the plan to consider the potential significance of the economic costs and benefits of the plan, particularly in relation to business.

12.2.5 Rural Proofing

The Rural Needs Act (Northern Ireland) 2016 places a duty on public authorities to consider rural needs when developing, adopting, implementing or revising policies, strategies and plans and designing and delivering public services. A rural proofing assessment has been carried out for the Plan to consider whether there is a differential impact on rural areas, and to identify any requirements for adjustments to take account of particular rural circumstances.

12.3 Environmental Assessment Approach and Methodology

12.3.1 Qualitative SEA assessment

The general approach for integrating of the SEA and WR&SR process is illustrated in Figure 12.1 below.

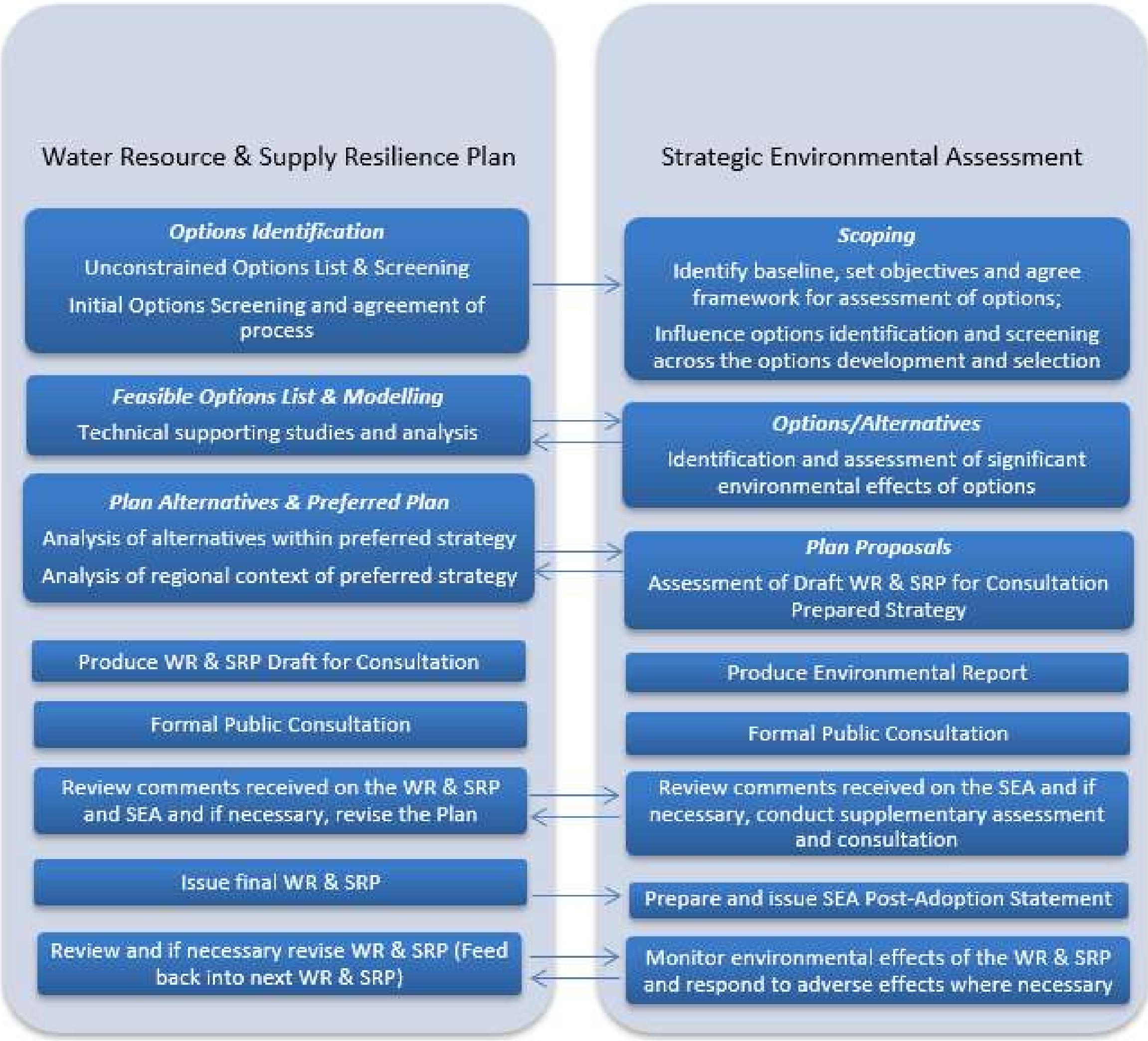


Figure 12.1 SEA and WR&SR Process

During the SEA scoping stage, the relevant policies and regulations were reviewed to understand the context for the plan and the current environmental baseline and key trends and pressures were identified. A set of SEA objectives were developed against each SEA topic or theme as a basis for the assessment (see table 12.2 below). These objectives, along with an outline of the proposed approach to the SEA, were consulted on through the SEA Scoping Report. Consultation comments received have been taken into account in the baseline information and the approach to the assessment of options and the Plan.

Table 12.1 SEA Objectives

SEA Theme	*Objectives*
Population, Economy and Human Health	• To protect public health and promote wellbeing and avoid disadvantaging any group or area. • To protect and enhance recreational amenity and public access. • To contribute to raising awareness of water conservation.
Tourism and Recreation	• To protect and enhance recreation and amenity facilities.
Material Assets/infrastructure	• To avoid conflict with strategic infrastructure, and support viable land use, businesses and sustainable resource use.
Biodiversity, Flora and Fauna	• To protect and enhance aquatic and terrestrial biodiversity including statutory and non-statutory sites, protected species, fisheries and priority habitats.
Landscape, Townscape and Visual Amenity	• To maintain and enhance valued landscape character and visual amenity.
Climate	• To minimise the carbon footprint of the Company. • To contribute to climate change adaptability of the environment to resilience of water supply.
Water Environment	• To protect and improve surface water and groundwater body status; including water quality and quantity. • Ensure sustainable levels of surface water and groundwater abstraction.
Cultural Heritage and Archaeology	• To conserve and enhance buildings, sites and features of archaeological and historic interest and their settings.
Geology and Soils	• To protect and enhance soil quality and avoid conflict with identified mineral resources and ASSI's.
Sustainability Issues	• To ensure environmental and supply resilience to natural events and extreme weather events such as droughts, flood events and freeze/ thaw.

The SEA assessment for the WR&SR Plan included input at the following stages:

- Unconstrained Options Screening - a high level assessment of potential environmental impacts informing the options screening process. This included taking into account potential conflicts with international and national designated sites and risk to WFD waterbody status. This led to a Constrained list of Supply Demand Balance Options; this screening process is reported in Section 10.

- Feasible Options - an assessment of each resource option against the SEA objectives based on desk study including GIS based information. The options definition, baseline information, potential impacts and mitigation requirements have been considered as part of this plan.

- Assessment of the Plan alternatives and sensitivity testing (see Section 13) and input to the MCA based on the SEA assessment of the feasible options and consideration in selection of the preferred Plan;

- Assessment of the preferred Plan in terms of potential significant environmental effects or risk and identification of mitigation;

- Resilience Options Screening – Screening of resilience options was carried out in tandem with the Plan development. These options were assessed under the same methodology as the Supply Demand Balance options and aided the selection of a small number of options to be proposed for further consideration throughout the WR&SR Plan period.

- HRA and WFD and other assessment conclusions for the preferred Plan; and

- Development of a draft monitoring plan for the implementation of the WR&SR Plan.

The feasible options assessment identified potential for significant impacts against each SEA topic and an overall option environment risk category based on residual impact taking into account expected mitigation.

12.3.2 Valuation of environmental and social (E&S) costs (including Carbon)

The environmental and social (E&S) costing allows wider societal costs to be considered as well as direct scheme costs and was based on the following guidelines and methodologies:

- Benefits Assessment Guidance (BAG), Environment Agency, 2004;

- Water Resource Planning Guideline – The technical methods and instructions. Joint development by the Environment Agency, Ofwat, Defra and the Welsh Government, June 2012;

- BAG User Guide, Economics for the Environment Consultancy Ltd (eftec), January 2012; and

- BAG Worked Example, eftec, February 2012.

The aim of the calculations was to capture and value significant residual impacts in relation to the categories examined. In addition to the calculations for each category, a qualitative assessment and/or notes relevant to calculations were recorded as required.

General impact categories examined for costing included:

- Biodiversity and ecology, including water quality, designated conservation areas and habitats;

- Landscape amenity;

- Construction impacts (congestion costs);

- Energy and climate change;

- Financial loss to public;

- Personal disturbance;

- Health impacts;

- Additional energy;

- Carbon saving;

- Waste generated;

- Public awareness; and

- Social inequality.

Carbon footprint and associated carbon costings including embodied and operational carbon are as follows:

- **Embodied carbon** - greenhouse gas (GHG) emissions associated with a manufactured product or built asset. This is often referred to as construction carbon. This includes the emissions generated from the extraction, transportation and processing of raw materials required to create them.

- **Operational carbon** - GHG emissions arising from performing operational activities made directly or indirectly by the company in the day-to-day business of delivering drinking water and removing wastewater.

Reporting for the GHG impact of the options under consideration is carried out using unit of mass of carbon dioxide equivalent (CO_2e) emissions, which allows for the emissions of the key GHG to be expressed in terms of their equivalent global warming potential in mass of CO_2.

The E&S and carbon footprint and costs for each option has been calculated. These costs were used to add to the average incremental costs (AIC) to generate the Average Incremental Social Cost (AISC) which were inputs to the Economic Balance of Supply and Demand (EBSD) modelling (see chapter 13).

12.4 Environmental Assessment for Options and Plan

12.4.1 Supply/Demand Deficit options

Environmental aspects were taken into account in the EBSD modelling through E&S and carbon cost input to the AISC.

Six core plan alternatives for meeting the supply demand deficit were compared. These plan alternatives comprise the following options components:

Package 1 Demand management selected by the model for all plan alternatives included the following options (the selection and packaging of these options is described in section 13.2.2):

- Targeted non-household water audits (key accounts);

- Schools water audit and retrofit;

- Hotel & Hospitals water audit and retrofit;

- Farm Audits.

These were all assessed as low risk and overall beneficial due to potential water and associated energy and carbon savings. They also providing potential for water conservation awareness raising.

For the South WRZ, only one option other than demand management was considered feasible, which is the Castor Bay WTW to Ballydougan transfer. This option was therefore common to all plan alternatives meeting the deficit over the plan period. The SEA and the HRA screening identified potential impacts for this on the Lough Neagh Ramsar site and nearby SPA/ASSI from pipeline construction, however, these are expected to be temporary short-term impacts with mitigation including potential limitations on construction timing.

Similarly, only one option other than demand management was considered feasible for the Central WRZ. This is a booster pump upgrade on the existing Carland to Cookstown transfer.

Alternative options for meeting the deficit were considered for the West WRZ. These alternatives were considered through a multi-criteria analysis including supply resilience, deliverability and climate change adaptability as well as meeting SEA objectives. This multi-criteria analysis is reported in Chapter 13 and the environmental considerations for each Plan Alternative are summarised in the tables below. Note that Option 3 was not taken through this process as the costs were exceptionally high in comparison to the other options.

Table 12.2 A1 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A1			SEA Environmental Social risk	E&S costing	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Water Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water , associated carbon savings and awareness raising benefits
West	2018/19	Option_6 Carmoney to Strabane TM	Low	£691,335	Mainly temporary construction impacts with routing and mitigation
		Overall	Low	£665,969	

Table 12.3 A2 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A2			SEA Environmental Social risk	E&S costing + carbon	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Water Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water & carbon savings and awareness raising benefits
West	2018/19	Option_1 Derg reservoir storage	Moderate	£1,862,553	Visual, property & habitat impact and construction risk to SAC river
		Overall	Moderate	£1,837,187	

Table 12.4 A3 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A3			SEA Environmental Social risk	E&S costing	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water & carbon savings and awareness raising benefits
West	2018/19	Option_5 Killyhevlin to Lough Bradan TM (5 Ml/d)	Low	£260,837	Mainly temporary construction impacts with routing and mitigation
		Overall	Low	£235,471	

Table 12.5 A4 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A4			SEA Environmental Social risk	E&S costing	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Water Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water , associated carbon savings and awareness raising benefits
West	2023/24	Option_2 Lough Neagh, New WTW and Trunk Main Transfer	Moderate	£2,449,186	Mainly temporary construction impacts with routing and mitigation
		Overall	Moderate	£2,423,820	

Table 12.6 A5 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A5			SEA Environmental Social risk	E&S costing	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Water Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water , associated carbon savings and awareness raising benefits
West	2022/23	Option_4 Fermanagh Groundwater Source	Moderate	£9,145,681	Mainly temporary construction impacts with routing and mitigation
		Overall	Moderate	£9,120,315	

Table 12.7 A6 Plan Alternative Summary Assessment

Supply Demand Plan Alternative A6			SEA Environmental Social risk	E&S costing	Comment
WRZ	**Start date**	**Option No. & Name**			
South	2017/18	Water Efficiency Package 1	Low	-£205,546	Water & carbon savings and awareness raising benefits
South	2022/23	Option_8 Castor Bay WTW to Ballydougan SR TM	Moderate	£247,142	Potential temporary pipeline construction impacts on Ramsar site
Central	2017/18	Water Efficiency Package 1	Low	-£48,647	Water & carbon savings and awareness raising benefits
Central	2018/19	Option_9 Booster Upgrade on Carland to Cookstown Tunk Main	Low	£31,979	Mainly temporary construction impacts
West	2017/18	Water Efficiency Package 1	Low	-£50,294	Water , associated carbon savings and awareness raising benefits
West	2020/21	Option_7 Caugh Hill to Strabane TM	Moderate	£1,176,405	Mainly temporary construction impacts with routing and mitigation
		Overall	Moderate	£1,151,039	

Following the multi criteria assessment, Plan Alternatives A1-A3 were taken forward for further appraisal. These are discussed in more detail in Section 13.6.5. As can be seen from the tables above, Plan Alternatives A1 and A3 were given a lower environmental risk. While the A1 and A3 Plan Alternatives were considered similar for environmental risk, A3 had a lower operational carbon footprint and cost but A1 was considered to provide greater supply resilience and as a combined set of options also greater potential for environmental climate change resilience and was therefore preferred overall. Plan Alternative A2 included the Derg Bankside storage option. This has a higher environmental risk compared to the pipeline options, which was associated with potentially greater deliverability, lead time and supply resilience risks as identified in Section 13.

Plan Alternatives A4-A6 were eliminated for the following reasons:

- A4 had the longest lead time due to the new source and water treatments works required at Lough Neagh.
- A5 was the most costly and included new groundwater sources in Fermanagh.
- A6, despite also being a pipeline option similar to Scenarios A1 and A3 has a higher environmental risk due to a higher carbon costs/footprint.

The rationale for eliminating these Plan Alternatives is discussed in more detail in Section 13.6.4.

12.4.2 Resilience options

A number of resilience options, which are discussed further in section 14, were assessed against SEA objectives similarly to the supply demand resource options and E&S valuation was undertaken but the costings were not used as part of economic balance of supply and demand modelling and were used to inform the SEA. The environmental impacts for these options were identified as either low or moderate risk, as illustrated in Table 12.9. The impacts could be managed through appropriate route selection, investigation and mitigation to minimise long-term impacts from pipeline construction.

Table 12.8 Resilience Options Environmental Summary

Option Name	Environmental Risk category
Resilience options	
Lough Fea WTW & Moyola WTW Resilience	Low
Killyhevlin to Belleek TM	Low
Seagahan to Clay Lake Trunk Main	Low
West WRZ WTWs Trunk Main Link	Moderate
Ballinrees Resilience	Low

12.5 Environmental Assessment conclusions and recommendations

The SEA identified the 'do nothing' or 'no plan scenario' as a high environmental risk scenario. This is because of increased likelihood of water use restrictions being applied with impacts on households and business. There is also the greater likelihood of drought measures including Drought Order actions with potential associated environmental effects on sensitive designated sites. Overall the preferred Plan as identified in Section 13 includes low to moderate risk options largely due to temporary construction. These options contribute to supply resilience and reduce the need to develop new resource options in the future.

12.6 Water Framework Directive Assessment

The Water Framework Directive assessment considered the potential risks to WFD waterbodies affected by the individual options and options combined. The main risk identified related to the pipeline river crossings and the need for appropriate investigation and mitigation including the use of trenchless technologies where appropriate. This would avoid potential long-term impacts on river geomorphology. Option costs have included this approach as an assumption. The overall WR&SR Plan is therefore considered to be compliant with the WFD requirements.

12.7 HRA assessment

The Stage 1 HRA screening assessment of the WR&SR Plan to identify potential for likely significant effects screened out all options in the preferred Plan as requiring Stage 2 Appropriate Assessment with the exception of the Castor Bay WTW expansion within the Lough Neagh Ramsar site. As part of the WR&SR Plan a high level Appropriate Assessment will be required. Where appropriate assessment identifies the potential for likely significant effects on the Ramsar site or SPA there would need to be a commitment to replace this option to avoid stage 3 and 4 HRA being required.

Many of the Plan options will require project level HRA to be undertaken to take account of detailed design and final route or site location.

The Drought Plan includes short-term actions with potential significant effects on HRA Natura 2000 and Ramsar sites. These are likely to require stage 2 Appropriate Assessment.

12.8 Other Assessments

The WR&SR Plan is assessed as in compliance with the equalities and rural proofing requirements and has no significant socio-economic or business impacts considered through the regulatory impact assessment.

While this Plan did not consider the UK Climate Change Risk Assessment 2017 (Northern Ireland Supplement) it is noted that this report recommends actions to take in managing the risks to public water supplies from drought and low river flows. This Committee on Climate Change report states the action status for Northern Ireland is to "sustain current actions" while the equivalent status for England and Wales is "more action needed".

12.9 Mitigation and Monitoring

The SEA identifies a range of mitigation measures to reduce impacts and enhance the benefits of the WR&SR Plan. These include good practice investigation, construction and reinstatement measures for pipelines and supportive measures such as identifying priorities for catchment management support to reduce water quality risks to existing abstractions. A range of monitoring measures are identified to provide feedback on the plan implementation to inform future plan development.

13. Final Water Resource Plan

This is the final part of the water resources planning process, where the Plan Alternatives, comprising sets of feasible 'constrained' options, are evaluated using the EBSD (Economics of Balancing Supply & Demand) model. This is used to produce a set of optimised development plans that are refined further under the programme appraisal stage. A preferred development plan is then produced for NI Water.

The process is thus divided into the following stages:

- EBSD modelling of plan alternatives;
- Presentation of total NPV cost and average incremental cost (AIC/AISC) of each plan alternative;
- Cost sensitivity analyses;
- Yield robustness analysis;
- Multi-criteria analysis (MCA) of plan alternatives;
- Programme appraisal to select the preferred plan alternative for the final plan.

This process resulted in the elimination of a number of options and the selection of the final recommended water resource options as detailed at the end of the section.

13.1 EBSD Methodology

The methodology utilised to optimise the NI Water final Water Resources Management Plan is based on the Economics of Balancing Supply and Demand (EBSD) methodology as currently adopted in the UK. This methodology comprises the following steps:

- Determination of AIC & AISC costs for each option;
- Least-cost EBSD modelling of plan alternatives;
- Programme appraisal.

For this analysis we have utilised an EBSD model used by other UK water companies for optimising their water resources plans. This model utilises a dynamic programming (DP) algorithm to evaluate a range of candidate options in order to arrive at an optimum solution, together with an audit trail that tracks how the optimum was arrived at. The EBSD model finds the optimum development plan comprising a range of least-cost options and development sequence over the 25 year planning period, in terms of the minimum overall NPV CAPEX, OPEX, environmental, social & carbon cost.

The EBSD model uses a dynamic programming (DP) algorithm to search for the optimum least-cost development programme for each water resource zone. The model works by treating the water resources plan as a sequence of staged developments, whereby each stage is optimized in sequence, until the sequence that has the least overall NPV cost is found.

The inputs used by the EBSD model include:

- Baseline supply/demand balance (SDB) over the planning period;
- Range of alternative water resource and demand management options;
- Option CAPEX, OPEX, environmental, social and carbon costs;
- Option deployable outputs;
- Plan start date (year);

- Economic discount rate (3.5%);
- Target Levels of Service (% duration) for NYAA, DYAA, DYCP and WCP periods;
- Antecedent options (defining which options are mutually inclusive, i.e. which need to be implemented in advance of other specified options);
- Alternative options (defining which options are mutually exclusive, i.e. a group of options from which only one option may be implemented);
- Priority options (defining which options need to be implemented as a priority).

13.2 Summary of Option CAPEX & OPEX Costs and Yields

13.2.1 Water Resource Options

A summary of the CAPEX & OPEX costs and deployable outputs for the set of constrained water resource options (Options 1 to 9), described in Chapter 10, is presented in Table 13.1.

Table 13.1 – Water Resource Option CAPEX & OPEX

Option	Option Name	TOTAL CAPEX & OPEX Costs			
		CAPEX cost (£k)	OPEX Variable (£/Ml)	OPEX Saving (£/Ml)	OPEX Fixed (£k/yr)
1	Derg Bankside Storage	£6,092	£109.56	£0.00	£0.00
2	Lough Neagh, New WTW and Trunk Main Transfer	£17,441	£294.80	£0.00	£1.17
3	Rationalise small West WRZ sources and supply from increased Killyhevlin	£84,290	£96.76	£110.00	£25.78
4	New Groundwater Sources in Fermanagh	£31,391	£237.17	£0.00	£1.17
5	Killyhevlin WTW to Lough Bradan Trunk Main	£11,302	£294.80	£0.00	£0.00
6	Carmoney WTW to Strabane Trunk Main	£13,787	£212.68	£0.00	£0.00
7	Caugh Hill WTW to Strabane Trunk Main	£20,473	£133.78	£0.00	£0.00
8	Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade	£6,244	£160.93	£0.00	£0.00
9	Booster Upgrade on Carland to Cookstown Tunk Main	£1,648	£155.33	£0.00	£0.00

13.2.2 Water Efficiency (Demand Management) Option Costs and Water Savings

For water efficiency options to be successful it is practical for a water company to target all its customers and not just those in the WRZs where there is a deficit. Even if there is no deficit in a particular WRZ there are still savings to the company through more efficient use of water in those zones. It is also difficult to promote water efficiency measures in one part of the country and not another. Therefore, based on this assumption that wider application of demand management and promoting good water conservation practice would be positive, while also being supportive of equality aspects and avoiding any public feeling that some areas are unfairly targeted, it is assumed that all water efficiency options recommended are implemented throughout the country.

Water efficiency options (Options 11 – 23) presented in Chapter 10 are all options with small reductions in demand. During a more detailed review of options it was identified that options 13-15 were no longer feasible as NI Water was unable to provide any financial incentive to customers. These options were therefore discarded at this stage.

In order to achieve savings in demand that will make any significant impact on the supply demand balance, the remaining options have been grouped into packages comprising a number of demand management options. The options in Package 1 have been selected on the basis that these provide the least cost (£) for every Ml saved. The second package then adds the next group of options in the ranking of £/Ml and finally package 3 includes all options. Table 13.2 details the options in each water efficiency package.

Table 13.2 – Water Efficiency Packages

Option Number	Option	Water Efficiency Package		
		1	2	3
12	Targeted non-household water audits (key accounts)	Yes	Yes	Yes
17	Schools water audit and retrofit			
19	Hotel & Hospitals water audit and retrofit			
23	Farm Audits			
16	Improved specification of water fittings in new homes		Yes	Yes
21	Collaborated water & energy efficient retrofit programme delivered by third parties			
22	Social housing refurbishment			
11	Household Water Audits			Yes
18	Free water saving devices			
20	Hotel Water Audits and installation of water saving devices			

A summary of the installation costs for the water efficiency option packages (5 year programme), described in Chapter 10, is presented in Table 13.3. The estimated water savings for the water efficiency option packages is presented in Table 13.4.

Table 13.3 Water Efficiency Package Installation Costs – Year 1 to 5 (commencing 2017)

Options	Option_Name	WRZ_Name	Units	Year_1	Year_2	Year_3	Year_4	Year_5
12, 17, 19, 23	Water Efficiency Package 1	Central	£000s	£3.7	£3.7	£3.7	£3.7	£3.8
		East	£000s	£22.3	£22.3	£22.4	£22.5	£22.6
		North	£000s	£8.2	£8.2	£8.2	£8.3	£8.3
		North East	£000s	£6.7	£6.7	£6.7	£6.7	£6.8
		South	£000s	£13.2	£13.3	£13.3	£13.4	£13.4
		South West	£000s	£3.6	£3.7	£3.7	£3.7	£3.7
		West	£000s	£4.0	£2.8	£2.8	£2.8	£2.8
		Total	**£000s**	**£61.8**	**£60.7**	**£60.9**	**£61.1**	**£61.2**
12, 17, 19, 23, 16, 21, 22	Water Efficiency Package 2	Central	£000s	£99.7	£100.4	£101.2	£102.0	£102.8
		East	£000s	£1,214.6	£1,219.9	£1,225.4	£1,230.8	£1,236.9
		North	£000s	£346.1	£347.4	£348.6	£349.8	£351.0
		North East	£000s	£237.8	£239.1	£240.4	£241.8	£243.2
		South	£000s	£438.0	£442.3	£446.8	£451.4	£456.2
		South West	£000s	£87.4	£87.9	£88.5	£89.1	£89.7
		West	£000s	£130.3	£131.1	£131.7	£132.4	£133.1
		Total	**£000s**	**£2,553.9**	**£2,568.1**	**£2,582.7**	**£2,597.4**	**£2,613.0**
12, 17, 19, 23, 16, 21, 22,11,18, 20	Water Efficiency Package 3	Central	£000s	£225.4	£226.0	£227.2	£229.1	£231.0
		East	£000s	£2,755.3	£2,766.4	£2,778.7	£2,791.4	£2,805.7
		North	£000s	£784.1	£785.9	£788.1	£790.9	£793.7
		North East	£000s	£538.1	£539.9	£542.2	£545.5	£548.9
		South	£000s	£1,011.2	£1,020.1	£1,030.0	£1,040.8	£1,052.0
		South West	£000s	£197.3	£197.5	£198.2	£199.5	£201.0
		West	£000s	£295.1	£295.7	£296.6	£298.2	£299.8
		Total	**£000s**	**£5,806.4**	**£5,831.6**	**£5,860.9**	**£5,895.4**	**£5,932.2**

Table 13.4 Water Efficiency Package Water Savings (commencing 2017)

Options	Option_Name	WRZ_Name	Units	Year_1	Year_5	Year_10	Year_15	Year_20	Year_25
12, 17, 19, 23	Water Efficiency Package 1	Central	Ml/d	0.010	0.086	0.095	0.095	0.076	0.072
		East	Ml/d	0.051	0.552	0.626	0.626	0.446	0.401
		North	Ml/d	0.020	0.281	0.327	0.327	0.273	0.260
		North East	Ml/d	0.014	0.198	0.230	0.230	0.192	0.183
		South	Ml/d	0.032	0.396	0.454	0.454	0.375	0.355
		South West	Ml/d	0.010	0.065	0.069	0.069	0.055	0.051
		West	Ml/d	0.010	0.064	0.072	0.072	0.072	0.072
		Total	**Ml/d**	**0.147**	**1.642**	**1.872**	**1.872**	**1.490**	**1.393**
12, 17, 19, 23, 16, 21, 22	Water Efficiency Package 2	Central	Ml/d	0.041	0.204	0.162	0.162	0.144	0.139
		East	Ml/d	0.399	1.928	1.426	1.426	1.246	1.201
		North	Ml/d	0.121	0.676	0.556	0.556	0.502	0.489
		North East	Ml/d	0.084	0.470	0.387	0.387	0.349	0.340
		South	Ml/d	0.153	0.883	0.719	0.719	0.640	0.619
		South West	Ml/d	0.036	0.165	0.126	0.126	0.112	0.108
		West	Ml/d	0.049	0.232	0.176	0.176	0.162	0.158
		Total	**Ml/d**	**0.882**	**4.559**	**3.552**	**3.552**	**3.155**	**3.055**
12, 17, 19, 23, 16, 21, 22,11,18, 20	Water Efficiency Package 3	Central	Ml/d	0.058	0.279	0.212	0.189	0.171	0.166
		East	Ml/d	0.604	2.822	2.038	1.762	1.583	1.537
		North	Ml/d	0.179	0.930	0.729	0.651	0.597	0.584
		North East	Ml/d	0.124	0.645	0.505	0.452	0.415	0.405
		South	Ml/d	0.233	1.226	0.949	0.845	0.766	0.746
		South West	Ml/d	0.050	0.229	0.169	0.150	0.136	0.132
		West	Ml/d	0.071	0.328	0.241	0.212	0.198	0.194
		Total	**Ml/d**	**1.320**	**6.459**	**4.843**	**4.261**	**3.865**	**3.764**

13.2.3 Leakage Reduction Option Costs and Water Savings

A summary of the installation costs and savings of Option 10 – Further Leakage Reduction, described in Chapter 10, is presented in Table 13.5 below for the West and Central WRZs.

Table 13.5 Leakage Reduction Option Installation Costs £k

Option	WRZ_Name	Total Savings Ml/d	Year 1-5 Cost (£k)	Year 6-10 Cost (£k)	Year 11-15 Cost (£k)	Year 16-20 Cost (£k)	Year 21-25 Cost (£k)
Leakage Reduction 1st Iteration	Central	0.86	£2,548	£2,788	£3,041	£3,317	£3,609
Leakage Reduction 2nd Iteration	Central	0.86	£3,717	£4,131	£4,516	£4,927	£5,361
Total	**Central**	**1.72**	**£6,265**	**£6,919**	**£7,557**	**£8,243**	**£8,970**
Leakage Reduction 1st Iteration	West	1.61	£4,669	£5,166	£5,618	£6,114	£6,640
Leakage Reduction 2nd Iteration	West	1.61	£6,368	£7,115	£7,751	£8,436	£9,162
Total	**West**	**3.22**	**£11,037**	**£12,281**	**£13,369**	**£14,551**	**£15,802**

13.3 Option AIC/AISC Costs

13.3.1 Introduction

An initial options appraisal, based on cost, can be carried out by calculating the average incremental cost (AIC) and/or the average incremental and social cost (AISC) for each option. In this way, a preliminary option ranking of the least-cost options available for each WRZ can be made.

The AIC for each option is defined as the NPV of the combined CAPEX and OPEX, at a given discount rate (3.5%), divided by the NPV of the achieved output for that option. The model calculates both a capacity-based AIC (assuming the full capacity is utilised) and utilisation-based AISC (assuming the actual utilisation is determined by the supply/demand balance over the planning period). The AISC for each option is defined in a similar way but with the estimated environmental, social and carbon costs added in.

13.3.2 Results

Table 13.6 summarises the NPV and AISC results for the options.

Table 13.6 NPV and AISC Option Costs

Option No	Option Name	DO Ml/d	WRZ	NPV TOTEX (k)	AISC £/Ml
1	Derg Bankside Storage	3.3	West	£5,270	15,420
2	Lough Neagh, New WTW and Trunk Main Transfer	3.3	West	£16,588	39,851
3	Rationalise small West WRZ sources and supply from increased Killyhevlin	3.3	West	£38,317	50,291
4	New Groundwater Sources in Fermanagh	3.3	West	£27,024	82,561
5	Killyhevlin WTW to Lough Bradan Trunk Main	3.3	West	£10,689	23,246
6	Carmoney WTW to Strabane Trunk Main	3.3	West	£13,428	27,729
7	Caugh Hill WTW to Strabane Trunk Main	3.3	West	£18,531	40,737
8	Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade	20.0	South	£33,936	£3,852
9	Booster Upgrade on Carland to Cookstown Tunk Main	5.0	Central	£5,884	£9,811
10	Further Leakage Reduction West	3.22	West	£42,822	289,033
See Table 13.4	Water Efficiency Package 1	0.07	West	£13.7	-7,147
See Table 13.4	Water Efficiency Package 2	0.16	West	£595	11,074
See Table 13.4	Water Efficiency Package 3	0.19	West	£1,341	21,854
See Table 13.4	Water Efficiency Package 1	0.36	South	£60	-6,409
See Table 13.4	Water Efficiency Package 2	0.62	South	£2,017	8,436

Option No	Option Name	DO Ml/d	WRZ	NPV TOTEX (k)	AISC £/Ml
See Table 13.4	Water Efficiency Package 3	0.75		£4,651	18,169
See Table 13.4	Water Efficiency Package 1	0.97	North, North East, East, Central & South West	£202	
See Table 13.4	Water Efficiency Package 2	2.28		£9,047	
See Table 13.4	Water Efficiency Package 3	2.83		£20,480	

It should be noted that the Water Efficiency options expire after 5 years and most of the savings in Ml/d are subsequently lost over time, although savings realised through options such as installation of water efficient devices can reasonably be sustained in the long term.

13.4 Plan Scenarios

The EBSD model is used to compare the different options and identify which options or combinations of options (plan alternatives) provide the optimum solution to meeting the deficits based on particular scenarios. There are four scenarios that have been selected for testing of the plan which are:

- Least Cost Plan;
- Low Carbon Plan;
- Best Environmental;
- Optimum Lead-in time.

The model was programmed to select the optimum solution for each scenario. The results inform us which plan alternative best meets each scenario and provide costs and timings for those scenarios. This information is then used to inform the decision on the preferred solution. The outcome of this is discussed further in 13.6.

The range of Plan Alternatives is listed below and evaluated in the subsequent sections. Water Efficiency Package 1, Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade and the Booster Upgrade on Carland to Cookstown Tunk Main are common to all scenarios. Also as option 3 has such excessively high costs in comparison to the other options (as discussed in 13.6.4.3) this is not considered further in the analysis.

Plan Alternatives A1 – A6 – Alternative water resource options

- A1 – Option 6 Carmoney to Strabane Trunk Main;
- A2 – Option 1 Derg Bankside Storage;
- A3 – Option 5 Killyhevlin to Lough Bradan Trunk Main;
- A4 – Option 2 Lough Neagh, New WTW and Trunk Main Transfer;
- A5 – Option 4 Fermanagh Groundwater Source;
- A6 – Option 7 Caugh Hill to Strabane Trunk Main.

13.5 Sensitivity analysis

A sensitivity analysis is undertaken on each of the group of options to determine how they would be impacted upon by changes in the input data that would affect the results of any analysis. Consideration has been given to what may impact the viability of particular options and the decision making process for selection of the preferred Plan. Sensitivity analysis has been carried out for the following criteria:

- Capital cost estimates (CAPEX);
- Supply Demand Balance (SDB).

13.5.1 CAPEX Cost Sensitivities

Sensitivity analyses have been carried to determine the effect of CAPEX increases on the total NPV cost of each scenario for the following range of CAPEX increases, to cover for further additional contingencies, including optimism bias:

- Base CAPEX;
- CAPEX +10%;
- CAPEX +20%;
- CAPEX +30%.

The results are presented in Table 13.7 and Figure 13.1 below.

Table 13.7 CAPEX Cost Sensitivity Analyses

Total NPV Cost	Base CAPEX	CAPEX +10%	CAPEX +20%	CAPEX +30%
Plan Alternative A1	£20,349,215	£22,384,137	£24,419,058	£26,453,980
Plan Alternative A2	£12,247,840	£13,472,624	£14,697,408	£15,922,192
Plan Alternative A3	£17,578,914	£19,336,806	£21,094,697	£22,852,588
Plan Alternative A4	£21,465,811	£23,612,392	£25,758,974	£27,905,555
Plan Alternative A5	£33,922,524	£37,314,777	£40,707,029	£44,099,281
Plan Alternative A6	£25,494,899	£28,044,389	£30,593,879	£33,143,369

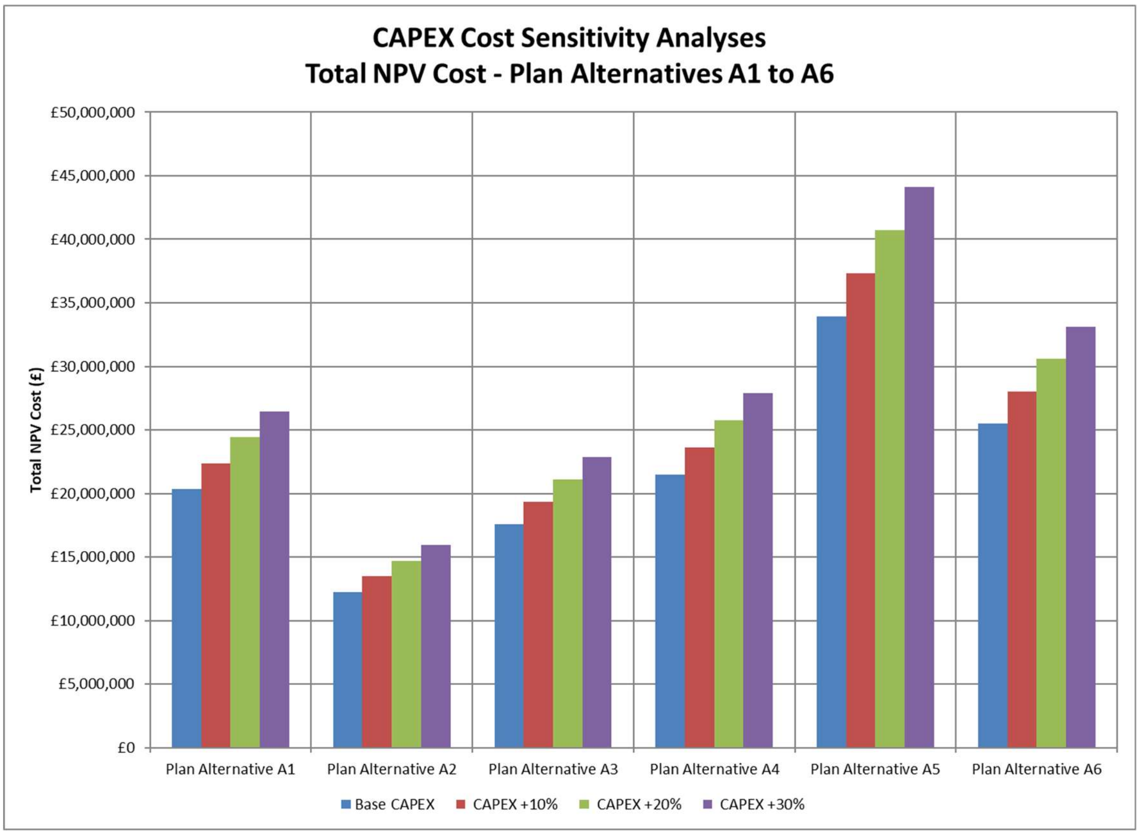


Figure 13.1 CAPEX Cost Sensitivity Analyses

The analysis shows that changes in CAPEX make little difference to the NPV option comparison. Therefore, it can be concluded that changes in CAPEX would have no significant bearing on the option selection.

13.5.2 Supply Demand Balance Sensitivity Analyses

Sensitivity analyses have also been carried to determine the effect of increases in Distribution Input (DI) on the ability of each option to meet increases in water demand as follows:

- Base Distribution Input (DI);
- Increases in DI from 5% to 10%.

The results for West WRZ are presented in Figure 13.2 and give a measure of the resilience of each scenario to meet variations in the supply/demand balance (SDB) due to increases in water demand.

		% Increase in Demand (DI)		
WRZ	**Option**	**0%**	**5%**	**10%**
West	Carmoney WTW to Strabane Trunk Main (Option 6)			
	Derg Bankside Storage (Option1)			
	Killyhevlin WTW to Lough Bradan Trunk Main (Option 5)			
	Lough Neagh, New WTW and Trunk Main Transfer (Option 2)			
	New Groundwater Source in Fermanagh (Option 4)			
	Caugh Hill WTW to Strabane Trunk Main (Option7)			

Key:

Demand and headroom fully met.

Demand fully met but headroom only partially met.

Demand partially met with headroom not met.

Figure 13.2 Demand Sensitivity Analyses

These results show that:

- Carmoney to Strabane and Caugh Hill to Strabane are highly resilient to increases in DI in excess of 10%;
- The other scenarios are not resilient to increases in demand, with headroom being impacted for increases in DI up to 5%.

Sensitivity analyses have been carried out to test the resilience of each option to reductions in deployable output and a similar pattern emerged. It should be noted that an allowance for variation in these is also included within the headroom assessment. The average headroom figures range from 3% to 8.5% over the planning period. However, they are considered worthy of including further in the sensitivity analysis as they provide a further test on the resilience of particular options.

The sensitivity analysis is discussed further in Section 13.6 where it is referred to as the ‘Test of Robustness’.

13.6 Programme Appraisal

13.6.1 Introduction

The water resource and resilience options to be considered in the programme appraisal have been identified. All the costs (CAPEX, OPEX, Carbon, E&S) have been established for these options and modelled to determine the least whole life cost option for various scenarios as well as the AIC and AISC. Tests of Robustness have been undertaken on these options to determine their sensitivity to changes in supply and demand. The option dossiers and the SEA have assessed the various non-monetary issues with each option and identified any key constraints. The final stage in the assessment is the Programme Appraisal which compares all aspects monetary and non-monetary of the options to determine the preferred option.

13.6.2 Identified issues to be appraised

The plan needs to identify solutions that meet the following drivers:

- Supply Demand Deficit in the South WRZ;
- Supply Demand Deficit in the Central WRZ;
- Supply Demand Deficit in the West WRZ.

13.6.3 Recommendations not requiring further appraisal

Water Efficiency Package 1 is the only viable demand management package. Only one feasible option has been identified to address deficit in South WRZ and only one feasible option has been identified to address deficit in Central WRZ. Therefore, these do not require further appraisal for the reasons outlined below:

13.6.3.1 Demand Management

The results in Table 13.6 have identified that Water Efficiency Package 1 has a negative NPV and AISC. This means that over the life of the plan there will be a reasonable return in demand savings for very little required investment. Therefore, Water Efficiency Package 1 is to be recommended throughout Northern Ireland. This comprises of the following options:

- Option 12 – targeted non-household water audits (key accounts);
- Option 17 – Schools water audit and retrofit;
- Option 19 – Hotel & Hospitals water audit and retrofit;
- Option 23 – Farm Audits.

13.6.3.2 Castor Bay WTW to Ballydougan SR Trunk Mains Upgrade

As discussed in Section 9.7.1, there is a forecast SDB deficit of 12.9 Ml/d in the South WRZ by 2042 for the dry year critical period (DYCP). While Castor Bay WTW has sufficient output to meet this deficit, the existing 95 Ml/d trunk main between Castor Bay WTW and Ballydougan SR currently has insufficient transfer capacity to meet this additional DYCP demand. This means that either the transfer capacity between Castor Bay to Ballydougan needs to be increased, or some other option is required to be developed to meet this deficit.

In addition, once the capacity of the trunk main from Carland to Cookstown has been increased by 2.6 Ml/d (see Section 9.7.2), this would enable the forecast DYCP of deficit of 1.9 Ml/d in the Central WRZ to be met from Castor Bay via the South WRZ, but would increase the DYCP deficit in this zone from 12.9 Ml/d to 15.5 Ml/d by 2042. In addition, an investigation of the Summer 2018 High Water Demand Event (see Section 14.7) showed that the DYCP deficit could increase by a further 4.2 Ml/d in the South WRZ, which would result in the forecast deficit rising to 19.7 Ml/d by 2042.

Through the development of this Plan, and as detailed in Section 10, there is only one feasible option with no significant constraints identified for meeting the deficit in the South WRZ, which is the Castor Bay to Ballydougan transfer (Option 8). A small DYCP deficit is forecast for the South WRZ by 2020, although this would be greater for the high water demand event, so this option will need to be promoted for implementation as early as funding provisions permit, in order to meet these forecast deficits. It is therefore recommended to construct the proposed Castor Bay to Ballydougan trunk main to a capacity of 20 Ml/d, to accommodate this extreme dry weather condition. This option has thus been put forward in the Plan.

13.6.3.3 Carland to Cookstown Transfer - Booster Upgrade

As discussed in Section 10, it is has been determined that the identified Central zone deficits can be best met by a booster pump upgrade to the existing Carland to Cookstown transfer (Option 9), therefore avoiding the need to implement any further resource development measures in this zone. This solution is thus also a recommendation of the Plan.

13.6.4 Eliminated Options

A number of options were identified for the West WRZ. However, with a high level comparison it is clear that some of these constrained options are not feasible when compared with other constrained options. These options tend to be those that are based on increasing the potable water capacity in the supply system rather than using existing headroom in the system to meet the deficits. For the purpose of a more focussed appraisal these options have been eliminated. The options eliminated and the reasons for doing so are outlined below.

13.6.4.1 Lough Neagh, New WTW and Trunk Main Transfer

Option 2 – This option has an AISC significantly more than the 3 least cost options. It also has a significantly higher carbon cost. There are a number of constraints on this option including the requirement for a new abstraction licence and planning approval for the WTW. Due to the constraints and extensive project scope the lead-in time for this project is around 5 years. This would expose NI Water’s customers to a prolonged period of reduced security of supply given there are critical period deficits now. This option is considerably less attractive with no significant benefits when compared with most of the other options. It is therefore not considered any further.

13.6.4.2 New Groundwater source in Fermanagh

Option 4 – This option has a NPV cost that is almost £14M higher and the AISC almost 4 times that of the 3 least cost options. It also has a significantly higher carbon cost. There are a number of risks and constraints with this option including the uncertainty over the reliability of the source, the requirement for new abstraction licences and planning approval for the WTW. Due to these risks and constraints the lead-in time for this project is around 5 years. This would expose NI Water’s customers to a prolonged period of reduced security of supply given there are critical period deficits now. This option is clearly considerably less attractive with no significant benefits when compared with most of the other options. It is therefore not considered any further.

13.6.4.3 Rationalise small West WRZ sources and supply from increased Killyhevlin WTW

Option 3 – This option has a NPV cost that is almost £25M higher and the AISC over 2 times that of the 3 least cost options. It also has a significantly higher carbon cost. There are a number of constraints with this option including the requirement for a new abstraction licence and planning approval for the WTW. Due to the constraints and extensive project scope the lead-in time for this project is around 5 years. This would expose NI Water’s customers to a prolonged period of reduced security of supply given there are critical period deficits now. This option is clearly considerably less attractive with no significant benefits when compared with most of the other options.

This option is not considered further as a potential option to meet the deficits in the West WRZ. However, as noted in 12.6.3 it is considered further as potential resilience option when considering the need to replace Killyhevlin WTW. Therefore, in the context of resilience it is considered further in section 12.7.5.

13.6.4.4 Caugh Hill WTW to Strabane Trunk Main

Option 7 – This option is very similar to the Carmoney to Strabane trunk main. The reason for its consideration was that during the options appraisal there was deemed to be a risk that the abstraction licence at the River Faughan (supplying Carmoney WTW) was in danger of being reduced. During the development of this plan it has been established that this risk is minimal and that the Carmoney to Strabane trunk main has the potential to be a robust option provided the remaining uncertainty over abstraction volumes can be resolved. Therefore, as the Caugh Hill to Strabane option requires a longer length of pipeline than the Carmoney to Strabane option the whole life costs and environmental impact are higher. There are no discernible benefits when compared with Carmoney to Strabane so this option is not considered any further.

13.6.4.5 Further Leakage Reduction Options

Option 10 – This option has a NPV cost that is almost £30M higher and the AISC more than 10 times that of the 3 least cost options if they are to provide the savings required to eliminate the deficit. The high cost required to achieve relatively small reductions in demand make these options cost prohibitive and the EBSD model does not select them. Therefore, these options are not worthy of further consideration.

13.6.4.6 Water Efficiency Packages 2, and 3

Water Efficiency Package 2 includes Options 16, 21 and 22. Water Efficiency Package 3 includes Options 11, 18 and 20.

The EBSD model was run for all the water efficiency packages but it never selected packages 2 and 3. This is because the costs per Ml rise considerably in comparison with Water Efficiency Package 1. Although the AIC and AISC is similar to some of the other options in particular zones it must be remembered that water efficiency options must be implemented in all WRZs.

On review of Table 13.6 it can be seen that if, for example, Water Efficiency Package 2 was selected the total cost of implementing the option throughout the country would be approximately £5.5M. However, it would only provide a reduction in the SDB of 0.19Ml/d and 0.75Ml/d in the West and South WRZs respectively. Therefore, other options detailed in this report would still be needed to meet the deficit. Furthermore the demand reductions from these schemes are uncertain and diminish with time. Finally they do not provide much in the way of a resilience benefit. Therefore, these water efficiency packages will not be considered further.

13.6.5 Further Options Appraisal

Having already identified a number of options to be brought forward to the preferred Plan and eliminated a number of other options the final stage is to appraise the remaining options and thus finalise the recommendations for the Plan. The remaining options to be appraised in more detail are as follows:

- Option 6 – Carmoney WTW to Strabane Trunk Main;
- Option 1 – Derg Bankside Storage;
- Option 5 – Killyhevlin WTW to Lough Bradan Trunk Main.

As detailed in Section 13.4 of this report, Option 6 is included in Plan Alternative 1, Option 1 is included in Plan Alternative 2 and Option 5 is included in Plan Alternative 3.

13.6.6 Multi-Criteria Analysis

The options detailed in 13.6.5 have been subject to a multi-criteria analysis. The options have each been assessed on the basis of the following key criteria which were discussed and agreed with stakeholders:

- Environment including Land and Planning (discussed in more detail in the SEA);
- Resilience including ability to deal with an industrial action;
- CC Adaptability;
- Lead-Time;
- Promotability; and
- Test of Robustness (based on the sensitivity analysis).

The criteria for each option are scored on the basis of Red, Amber, and Green.

The results of the multi-criteria analysis are presented in Table 13.8.

Table 13.8 Multi-Criteria Analysis

Plan Alternative	Option / Description	Environment (incl Land and Planning)	Resilience including - Ability to deal with Industrial Action	Climate Change Adaptability	Lead-Time	Promotability	Robustness
		G - Postive impact A - No/insignificant impact R - Significant issues	G - Significant improvement in resilience A - Minor or no improvement in resilience R - Reduced resilience	G - Reduced vulnerability A - Some vulnerability or no change R - Increased vulnerability	G - No risk (1-2 years) A - Minor risk (2-3 years) R - Significant risk (3+ years)	G - No major issues A - Some issues R - Major issues	G - Robust option under changes to DO and Demand A - Negative impacts of change to DO and Demand R - Failure of option if changes to DO and Demand
A1	**6 - Carmoney/Strabane Transfer**	The proposed pipeline passes through the Sperrin Area of Outstanding Natural Beauty, and crosses the River Faughan SAC and ASSI. The pipeline route corridor passes through a small area of Ashbrook Historic Park and Garden. There are a number of Scheduled Monuments and Listed Buildings close to the route corridor. All these issues can be mitigated with good environmental management.	Improved resilience as 2 WRZs connected with a major pipeline. This provides flexibility in the event of industrial action or other event. Makes use of additional headroom in the North WRZ.	The River Faughan is a river source so more vulnerable to impacts of climate change.	Minor risk in obtaining land.	No significant issues.	No impact as significant surplus in North WRZ.
A2	**1 - Derg Bankside Storage**	- Planning and land both required. - Potentially an adverse ecological impact for area dammed, dwelling in close proximity, WFD assessment required for abstraction. The river Derg which is part of the River Foyle and Tributaries SAC and ASSI is adjacent to the proposed reservoir.	Provides resilience against raw water quality incident from Derg or Strule. Does not provide resilience for a WTW failure and no further protection against events such as industrial action. As no alternative source provided resilience benefits are limited.	Strule and Derg are river sources which could be vulnerable to climate change impacts.	Significant risk due to Planning and Land requirement.	May be some difficulty in promoting from an environmental perspective.	Increases in demand or reductions in DO will increase the required size of the Bankside Storage and therefore the costs to meet deficit.
A3	**5 - Killyhevlin to Lough Bradan transfer**	- No significant costruction issues - Positive impact of water efficiency measures	Improved resilience as 2 WRZs connected with a major pipeline. This provides flexibility in the event of industrial action or other event but this is limited due to low headroom in South West WRZ.	Lough Erne not vulnerable to climate change.	Minor risk in obtaining land.	No significant issues.	Increases in demand or reduction in DO will result in option not meeting the SDB due to small surplus in the South West WRZ.

13.6.7 Option Selection

The MCA shows that the option which provides the most benefit and the least risk is the Carmoney to Strabane Transfer, which is part of Plan Alternative A1. The environmental risks for this option would not be considered to be significant. The option can be implemented in a relatively short period and would be acceptable to the public. However, the major benefit that this option brings is its resilience. The option makes use of existing headroom in the North WRZ and provides a link between 2 WRZs. While Killyhevlin to Lough Bradan also provides a link between 2 WRZs its resilience benefits are limited as there is very little headroom in the South WRZ as evidenced from the Tests of Robustness.

The whole life cost of this option is not markedly higher than any other option and it provides significant resilience benefits. Therefore, the Carmoney to Strabane Transfer is recommended as the preferred option to meet the deficits in the West WRZ.

There remains the issue with licence review for the Carmoney WTW source on the River Faughan discussed in 10.3.1.6. The abstraction licence at the River Faughan which supplies Carmoney WTW is currently being reviewed by NIEA. A Habitat Regulation Assessment has recently been carried out and no issues have been identified and therefore the risk is considered to be very low that the approved abstraction would be reduced below the current Carmoney WTW output.

A summary of the options process for the recommended options is shown in Table 13.9 below.

Table 13.9 – Summary of Option Selection Process

Option Ref	Option Name	Proceed through Unconstrained Options Y/N	Proceed through Constrained Options Y/N	Plan Recommendations
Water Resource Options				
	Glenedra Dam	N		
	Glenedra Bankside Storage	N		
	Glendergan Dam	N		
	Derg Pumped Storage	N		
1	Derg Bankside Storage	Y	Y	N
2	Lough Neagh, New WTW and Trunk Main Transfer	Y	N	
	New Abstraction from the Foyle	N		
	Raw Water transfer from New Kesh	N		
	Enlarge Lough Bradan Impoundment	N		
3	Rationalise small west WRZ sources and supply from increased Killyhevlin WTW	Y	N	
28	Increase Killyhevlin WTW Capacity	Y	Y	N
	Increase Castor Bay WTW Capacity to address deficit in the West	N		
	Increase output from Moyola	N		
	Increase output from Dunore Point	N		
	Refurbish Belleek WTW	N		
4	New Groundwater Sources in Fermanagh	Y	N	

Option Ref	Option Name	Proceed through Unconstrained Options Y/N	Proceed through Constrained Options Y/N	Plan Recommendations
	Recommission former groundwater sources	N		
6	Carmoney WTW to Strabane Trunk Main	Y	Y	Y
7	Caugh Hill WTW to Strabane Trunk Main	Y	N	
5	Killyhevlin to Lough Bradan Trunk Main	Y	Y	N
8	Castor Bay WTW to Ballydougan SR trunk Mains Upgrade	Y	Y	Y
9	Booster upgrade on Carland to Cookstown Trunk Main	Y	Y	Y
	Desalination	N		
	Effluent Reuse	N		
	Aquifer Storage & Recovery	N		
Demand Management				
10	Further leakage Reductions	Y	N	
	Supply Pipe Free Repairs	N		
	Supply Pipe Replacement	N		
11	Water Audits (Household)	Y	Y	N
12	Water Audits (Non Household)	Y	Y	Y
	Education talks at schools	N		
	Retrofit dual/variable flush	N		
	Cistern displacement devices	N		
	Water saver shower heads	N		
	Tap aerators and flow restrictions	N		
13	Rainwater harvesting and water butts	Y	N	
	Greywater re-use	N		
15	Incentives for new water saving appliances	Y	N	
16	Incentives for new water saving fittings	Y	N	
14	Promotion of water efficient white-goods and sanitary wear in new build houses	Y	N	
17	School water audit and retrofits	Y	Y	Y
	Bath volume reducers	N		
18	Free water saving devices	Y	N	
19	Hospital and Hotel Audits and retrofits	Y	Y	Y
20	Hotel efficiency packs	Y	N	
21	Collaborated water & efficient retrofits	Y	N	
	Retrofits dual or variable flush	N		
	Non household on-line account info	N		
	Installing domestic showers	N		
22	Social housing refurbishment	Y	N	
23	Farm Audits	Y	Y	Y

13.7 Recommendations to meet the SBD Deficits

The Plan has shown that all 7 of NI Water WRZs have sufficient water available for the Dry Year Annual Average scenario. However, the critical period analysis has identified that for short periods 3 of the 7 zones which are the South, West and Central WRZs, have potential deficits that require investment to ensure supplies are maintained for the planned level of service.

The Plan makes the following recommendations (Plan Alternative A1) to meet SDB deficits and provide additional resilience in the South WRZ, Central WRZ and West WRZ:

Water Resource Recommendations

1. Castor Bay WTW to Ballydougan SR 20 Ml/d Trunk Main Upgrade (This includes 4Ml/d for resilience in addition to the SDB requirements, see Section 15.3 below for further details). This WRZ currently shows a small deficit under the dry year critical period planning scenario and so the scheme will be promoted for implementation as early as funding provisions permit in order to meet this and the emerging deficit;

2. Carmoney WTW to Strabane 17 Ml/d Trunk Main. This scheme is included in PC15 as a nominated output and was funded by the UR in the final determination pending clarification of abstraction licence conditions and risk. NI Water will continue to consider the priority of this and other schemes within its overall PC15 funding allocation taking into account other emerging priorities identified in the period. Any proposed changes would be requested through the formal change control process.;

3. Addition of booster pumps to the recently constructed transfer pipeline from Carland to Cookstown, to increase the transfer capacity from 2.4 Ml/d to 5.0 Ml/d.

Demand Management Recommendations (across all of Northern Ireland)

1. Targeted non-household water audits (key accounts);

2. Schools water audit and retrofit;

3. Hotel & Hospitals water audit and retrofit;

4. Farm Audits.

14. Supply Resilience Enhancements

NI Water's supply system can be vulnerable to particular events such as climatic events, outages and industrial action. All of these can compromise the security of supply for its customers. A number of potential resilience issues have been identified and options developed to address these issues. The options have been assessed further resulting in the elimination of a number of options as the justification for them was weak. The remaining 5 resilience options have been recommended for further consideration during the early stages of the WR&SR Plan period to determine their scope, whether they are necessary and whether they would prove cost beneficial for improving the resilience provided to NI Water's customers. These include additional trunk mains to improve interconnectivity for particular areas and an upgrade at Killyhevlin WTW to replace older technology with a modern plant similar to most of NI Water's other WTWs.

14.1 Background

To improve the security of supply for the future for its customers NI Water aims to improve the supply resilience of its system where there are confirmed vulnerabilities and it is cost beneficial to do so. NI Water's supply system can be vulnerable to particular events such as climatic events, outages and industrial action. All of these can compromise the security of supply for their customers. This section identifies potential resilience issues and considers options that could be made to improve NI Water's resilience regarding these.

NI Water is undertaking other studies and projects outside of this Plan that will improve the resilience of the supply system. This includes review of SR capacity and improving interconnectivity in certain areas. Any resilience options identified in this Plan for further investigation will need to be considered further along with these other projects/schemes to ensure an integrated approach to addressing resilience is taken and the most cost beneficial interventions are taken forward.

14.2 Process for establishing Resilience Options

The process for selecting resilience options involved 3 key stages:

Stage 1 involved meeting with Operational staff to determine potential vulnerabilities in the system.

Stage 2 involved considering the impacts of an outage at all WTW's. In the event of an outage at each WTW the following questions were considered:

- Is there currently an alternative source of supply available for the majority of customers in the affected supply area?
- If there is currently no alternative source is there a potential source nearby that if interconnected could be used to supply the majority of customers in the affected supply area?
- Are the interventions required to provide the additional interconnectivity reasonable, proportional and not cost prohibitive?

Stage 3 involved consideration of other risks at sources such as water quality or any other known major supply risks.

A number of options to address the particular issues have been identified in section 14.3. These options were assessed in more detail with some options discounted in section 14.4. The remaining options have been recommended for further consideration during the Plan period with the reasons for this explained in section 14.5.

14.3 Resilience Options, Description and Assessment

A number of resilience issues were identified through the process detailed in section 14.2. Below are a list of options that could address each particular issue. The merits or otherwise of each option are explained further in sections 14.4 and 14.5.

14.3.1 Resilience Option i - Dorisland Resilience

The purpose of this option would be to provide an additional source of supply to the area north of Carrickfergus.

This option proposed a resilience link between Hydepark SR and Whiteabbey Lower SR, to enable water from Dunore Point to be transferred to the Dorisland supply zone in the event of an outage at Dorisland WTW. The main would be sized for 15 Ml/d as this is the approximate demand of the supply from Dorisland WTW to this area.

14.3.2 Resilience Option ii - North East WRZ Resilience

The objective of this option would be to improve the resilience of the North East WRZ. Dungonnell WTW and Dunore Point WTW supply most of the WRZ including towns such as Antrim and Ballymena. However, while some parts of the WRZ can be supplied by more than one source, it was considered that there were parts of the WRZ which could only be supplied from one WTW and would be vulnerable in the event of a WTW outage.

This option includes provision of new network pumping stations to enable temporary rezoning of flows between Dungonnell WTW and Dunore WTWs (and their associated supply networks). This would reinforce both networks in the event of a failure in either of the WTWs. The measures proposed would allow 7Ml/d of flow to be transferred between the WSZs thus increasing the security of supply of the North East WRZ. The quantity has been selected on the basis that it is the maximum that would likely be available from Dungonnell once the normal demands from the WTW have been met and it is also the quantity that could be transferred between each WSZ without the need to provide new pipelines. The benefit of this scheme would be that it could provide the additional resilience without the need for the construction of additional pipelines.

14.3.3 Resilience Option iii - Lough Fea WTW & Moyola WTW Resilience

NI Water Operational staff have identified that during times of stress they are unable to transfer as much water from the Moyola Magherafelt / Moyola Unagh Mormeal WSZs to the Lough Fea Cookstown WSZ as they need. Therefore, a link to increase the transfer capacity between these WSZs was proposed. Consideration has also been given to enabling this link to transfer water in the other direction in the event of a problem at Moyola WTW. The option would involve the provision of new trunk mains and pumping stations in the Central WRZ to enable increased transfer of water, between Moyola WTW and Lough Fea WTW thus increasing the resilience in the Central WRZ.

The option would provide a new 450mm DN trunk main between Unagh SR and the CWT at Lough Fea to increase the transfer capacity to 10Ml/d from the Moyola to Lough Fea WSZs. The quantity has been selected on the basis that it is the maximum that would likely be available from Moyola once the normal demands from the WTW have been met and it is also the quantity that makes the most efficient use of existing infrastructure. The installation of new booster pumps on the existing infrastructure between Unagh SR and Mullaghbouy SR is included to allow for flow to be supplied back to Moyola WSZ if required and improve resilience further.

14.3.4 Resilience Option iv - Ballinrees Resilience

The North WRZ supplies Coleraine and major tourist towns around the North Coast, which hold significant interest for the NI Tourist industry. As well as this the Royal Portrush Golf Club is due to host major golfing events in the coming years. Most of the supply area has no alternative source. Therefore, this option was proposed to provide a back-up supply and provide additional resilience to the North WRZ.

The option proposes upgrades to the trunk main network between Caugh Hill WTW and Ballinrees WTW in the North WRZ. There are existing trunk mains between Ballinrees Coleraine and Caugh Hill Dungiven WSZs but these are designed to transfer water from east to west. The upgrades are proposed to allow for capacity within the Caugh Hill distribution network to be utilised in the Ballinrees distribution in the event of an outage at Ballinrees WTW by transferring from west to east.

It is not considered feasible to provide alternative supply to meet the needs to the entire WSZ. Therefore, a transfer of 20Ml/d between the zones has been selected as this makes the best use of the existing trunk mains infrastructure. There is a new 400mm DN section linking Moys SR with the existing Caugh Hill supply to Corrody SR. Additional pumps are required on the main to pump from Corrody to Ballinrees.

14.3.5 Resilience Option v - Killyhevlin to Lough Bradan Trunk Main

Option 5 of the water resource options included for a link from Killyhevlin to Lough Bradan. This option has been ruled out of the water resource options (see Section 13) but due to the additional flexibility it provides in linking the South West and West WRZ it is considered a potential resilience option.

The option proposes the construction of a new strategic main between Killyhevlin and Lough Bradan WTWs. The route of the main proposed would be similar to that proposed in Option 5 with flow provided in the opposite direction.

The main has been sized at 700mm DN and would have a capacity of 25Ml/d. The size has been selected on the basis that this is the balance between what would be needed in the event of an outage and what would be available once the existing demands were met with some restrictions in place.

14.3.6 Resilience Option vi - Upgrade Killyhevlin WTW

Killyhevlin WTW is a strategically important WTW in the south west of the country and is the sole supply for most of that area including the town of Enniskillen. The process at Killyhevlin relies on old technology which requires modernising. In order to improve the resilience of the WTW it would be preferable to upgrade the plant using newer technology consistent with what is typically installed at most other NI Water's WTWs. Furthermore there is already investment required in the next 10 years as a significant Capital Maintenance refurbishment is scheduled for the WTW. Therefore to increase the security of supply of the area it was felt it made sense to consider replacement of this plant prior to any refurbishment with a conventional DAF process.

This option involves the construction of a new replacement WTW at Killyhevlin adjacent to the existing works. The new works would have the capacity to supply the whole South West WRZ, including the Belleek distribution area. The plant would be a DAF plant with a 40Ml/d capacity to replace the existing plant.

It should be noted that Option 3 of the SDB options was to rationalise small West WRZ sources and supply from increased (66 Ml/d) Killyhevlin WTW. This is also considered as an alternative to the 40 Ml/d upgrade.

14.3.7 Resilience Option vii - Killyhevlin to Belleek Trunk Main

During the review of the WRZ boundary for the South West WRZ NI Water Operations identified that the Belleek Garrison WSZ was quite isolated and only very small quantities of water could be transferred to this WSZ in the event of a failure at Belleek WTW. This is a small WTW in quite a remote location. Therefore, this option considers providing a trunk main transfer from Killyhevlin Enniskillen WSZ to the Belleek Garrison WSZ to improve the interconnectivity in the South West WRZ. Killyhevlin WTW has been selected as it is the closest WTW to Belleek WTW and has spare capacity almost all of the time.

The option proposes the construction of a trunk main from Killyhevlin WTW to the distribution network around Belleek. A 280mm DN pipe and new pumps at Killyhevlin would be required to provide a maximum flow of 3Ml/d to the network in Belleek.

14.3.8 Resilience Option viii - Cabragh SRs to Glencuil SR Trunk Main

In order to further improve the interconnectivity of the supply system, consideration was given to providing a transfer main between the South WRZ and the South West WRZ. This would enable the strategically important and secure Lough Neagh water to be transferred to the west of the country in the event of an issue in the South West or West WRZs.

The option would involve the construction of a new trunk main between the SRs at Cabragh in the South WRZ, around the town of Ballygawley and Glencuil SR in the South West WRZ. The new link would provide 5Ml/d of surplus capacity in the South WRZ to the South West WRZ, increasing the resilience within the zone and also allowing for onward transfer of water from Killyhevlin to the West WRZ providing option v is implemented.

The new main would vary from 250mm DN gravity main to 300mm DN pumped main, with an intermediate pumping station required.

14.3.9 Resilience Option ix - Seagahan to Clay Lake Trunk Main

During the review of the WRZ boundary for the South WRZ NI Water Operations identified that the Clay Lake Keady WSZ was particularly isolated and only very small quantities of water could be transferred to this WSZ in the event of a failure at Clay Lake WTW. Furthermore Seagahan WTW is deemed by NI Water operations to be a reliable plant and to have a large treatment capacity, but concerns over falling levels of the source dam have been expressed in recent years. Therefore, it was decided that an option should be considered to provide a bi-directional trunk main transfer between Seagahan Armagh WSZ and Clay Lake Keady WSZ to improve the interconnectivity in the South WRZ and improve security of supply in both WSZs.

The option proposes the construction of a new strategic trunk main between the WTWs at Clay Lake and Seagahan, to enable the transfer of treated water between the works if required. The proposed main would be 10km in length, with a 250mm DN and 5Ml/d capacity. Installation of pumps at Seagahan would ensure the main can act bi-directionally. The size has been selected on the basis of the supply available and the demand from Clay Lake WTW.

14.3.10 Resilience Option x - West WRZ Resilience, Trunk Main Upgrades and Links

During the review of the WRZ boundary for the West WRZ NI Water Operations identified that it does not have the flexibility to transfer water round this WRZ as it needs. This has resulted in difficulties during times of stress when the water has been available but it has not been able to transfer as much of it as needed to supply particular areas.

This option outlines improvements which could be made within the West WRZ to better facilitate flow between all the 4 WTWs in the zone and around the Omagh area. The proposals aim to ensure that in the event of a failure at any of the works or supply sources, the distribution area can be supplemented from the other works within the zone. There are already links between the various WSZs but operations staff expressed the view that these were insufficient and needed to be augmented. This requires further investigation, but on the assumption that this is the case the following proposals were developed.

To ensure sufficient quantities of water could be supplied to the Lough Bradan Drumquin and Loughmacrory Beragh WSZs new pump locations were identified on existing trunk mains to allow flow to be reversed from alternative supplies.

An upgrade to the 400mm DN trunk main between Derg WTW and the rest of the WRZ was proposed to allow an increased capacity of 14Ml/d to be transferred to and from the works. This link would provide additional resilience to the Lough Bradan Drumquin, Glenhordial Omagh and Loughmacrory WSZs from Derg supply, and also secure Derg in the event of any outage.

A new 6Ml/d trunk main between Derg/Bradan and Killybrack SR (Omagh) would allow bidirectional flow between areas, meaning Bradan and/or Derg can be supplemented from the Omagh supply. This would supplement the existing 6Ml/d main currently in operation.

A new 12Ml/d transfer between Killyclogher SR and the two 6Ml/d mains mentioned above would ensure bidirectional flow can be facilitated between west of the zone and east to Loughmacrory.

14.4 Resilience Options discounted in the WR&SR Plan

Following appraisal of the need and scope it has been determined that these options are not considered further as part of this Plan. The reasons for this are detailed below. While NI Water may in the future consider these options the WR&SR Plan will make no further recommendations regarding these.

14.4.1.1 Option i - Dorisland Resilience

Dorisland Resilience was considered because it was thought to provide an alternative source for an isolated supply area. In the last year the output from Dorisland has at times been reduced for planned operational reasons. During this time Operators were actually able to supply large areas from Dunore Point by making various adjustments in the network proving that reasonable levels of supply can be maintained. Furthermore there is no record of any significant historical problems at Dorisland WTW. Therefore, taking both these factors into account Dorisland Resilience will not be considered any further as part of this plan as justification for progressing the option is low at this time.

14.4.1.2 Option ii - North East WRZ Resilience

The reason for initially considering the North East WRZ Resilience was that areas around Ballymena were thought to be isolated in terms of supply resilience. Under closer scrutiny though, most areas can be supplied from an alternative source if rezoning measures are put in place. Due to this, the need for the scheme is not seen as critical. As well as this there have not been historical problems in the North East WRZ. The overall risk is deemed to be minimal and justification for progressing the option is low at this time.

14.4.1.3 Option v – Killyhevlin to Lough Bradan Resilience

The decision not to progress this scheme at this point is based on consideration of other schemes being proposed in this report. The Carmoney to Strabane 17 Ml/d pipeline, proposed to meet the SBD deficit in the West WRZ, provides additional resilience to the West WRZ. As well as this, there is infrastructure in place to supply the Derg WTW from the River Strule, supplementing its existing supply and improving the resilience of the West WRZ.

Although this option would improve resilience between the West and South West WRZs it has not been included in the recommendations of this plan for further investigation for the reasons outlined above.

14.4.1.4 Option vii - Killyhevlin to Belleek Trunk Main

Upon review of the South West WRZ's distribution system with NI Water, it was identified that there is a certain level of flexibility between the Killyhevlin and Belleek supply zones and transfer of water between the two can be undertaken although not for the full demand. The source at Belleek on Lough Erne is considered to be very secure and the WTW does not have a history of outage. Furthermore the cost of a new trunk main would be disproportionate to the number of customers who would stand to benefit. For these reasons this option has not been included in the recommendations for further investigation in this plan. The option could be considered in future plans if there was a requirement to remove the supply from Belleek WTW.

14.4.1.5 Option viii - Cabragh SRs to Glencuil SR Trunk Main

This pipeline would transfer supplies from the South WRZ into the South West WRZ in County Fermanagh. Under further scrutiny it is considered that there is limited advantage in this resilience measure and that there is minimal justification for its inclusion at this stage. It is a small pipeline which is on periphery of both WRZ's and is only serving more remote rural areas. The number of customers benefiting from the scheme would be very small. Finally there are no known existing problems that have been reported in this area.

14.5 Resilience Options Recommended

Following further appraisal the following options have been identified as recommendations of the WR&SR Plan for further investigation. This means that during the early stages of the WR&SR Plan period further consideration should be given to the need for their implementation. Further investigation of each option should be undertaken to determine their scope, whether they are necessary and whether they would prove cost beneficial for improving the resilience provided to NI Water's customers. Furthermore, each option should be considered in light of other studies and projects being undertaken by NI Water to improve the resilience provided to customers. This integrated approach will ensure that multiple schemes are not implemented in the same area to ultimately address the same problem and that the most cost beneficial interventions are taken forward.

14.5.1 Option iii - Lough Fea WTW & Moyola WTW Resilience

The actual quantities of water that can be currently transferred between Lough Fea and Moyola WTW's are considered by Operations as being lower than what is needed during times of stress. This is based on previous experience of struggling to meet demand in the Cookstown area in particular. The new pipeline from Carland to Cookstown will improve this but there remains concern that NI Water will have difficulty meeting all their customer's demand in this area.

Therefore, it is recommended that this scheme is considered further as part of the WR&SR Plan to improve security of supply. However, more investigation is needed to establish the need and scope for this option. In particular it needs to establish the impact of the new Carland to Cookstown pipeline, the exact infrastructure needed to supply the additional quantities and the impact of any other projects such as increases to SR capacity in the area.

14.5.2 Option iv - Ballinrees Resilience

As detailed in the option description the area supplied by Ballinrees WTW is very important for Northern Ireland's tourist industry and hosts a number of high profile events. Therefore, while Ballinrees WTW has secure source and has not had any significant outages in recent past, the consequence of a failure at the WTWs or on a major trunk main from it could be very significant.

Therefore, it is recommended that this scheme is considered further as part of the WR&SR Plan. Further investigation is required to assess the SR storage in the supply area and consideration should be given to other projects which may improve resilience and security of supply in the WRZ.

14.5.3 Option vi - Upgrade Killyhevlin WTW

As outlined in 14.3.6 Killyhevlin WTW relies on older technology which requires modernising. Therefore, maintaining the existing WTW is unlikely to be a long-term viable solution for the future of Killyhevlin WTW over the 25 year plan period. And an upgrade to newer technology consistent with most of NI Water's other plants should be considered. Furthermore cognisance needs to be taken of future maintenance upgrades that would be required in the next 10 years when committing investment.

Providing a new Killyhevlin WTW based on a conventional DAF process would improve the areas security of supply.

Consideration was given to upgrading the plant to 40 Ml/d to closely match the existing design capacity or whether to increase it to 66 Ml/d to facilitate decommissioning of a number of smaller WTWs in the West WRZ as detailed in Option 3 detailed in 10.4.1.3. However, the land and planning issues for the 66 Ml/d WTW and the significantly higher NPV cost make that option less attractive.

This report recommends that upgrading Killyhevlin WTW to 40 Ml/d with a conventional DAF process should be considered further.

14.5.4 Option ix - Seagahan to Clay Lake Trunk Main

As mentioned in the option description Clay Lake WSZ is a reliable but somewhat isolated supply area with no alternative source. The source for Seagahan is prone to emptying very quickly during periods of sustained dry weather. Therefore, a bi-directional link between the Clay Lake WSZ and Seagahan WSZ would help reduce supply risks in both areas. Seagahan does have limited links with Castor Bay WTW but this only account for a small proportion of the demand.

Therefore, this report recommends the option of a new bi-directional trunk main between Clay Lake and Seagahan to improve the resilience of the South WRZ is considered further. Further investigation is also required to confirm the need which should include consideration of other related interconnectivity such as reinforcing the Castor Bay to Seagahan Link.

14.5.5 Option x - West WRZ Resilience, Trunk Main Upgrades and Links

The actual quantities of water that can be currently transferred between the four WTWs in the West WRZ are considered by Operations as being lower than what is needed during times of stress. This is based on previous experience of struggling to meet demand in the parts of the West WRZ particularly in and around Omagh. This option proposes a number of measures to improve the transfer of water between these WTWs thus improving the WRZ’s resilience and ensuring the demands can be met throughout the zone.

Therefore, it is recommended that this scheme to improve the security of supply of the WRZ is considered further as part of the WR&SR Plan. Further investigation is required to determine the exact capability of the existing infrastructure and clearly identify the exact areas where improved interconnectivity is required.

14.6 Summary of Supply Resilience Recommendations

The table below summarises the recommended resilience options that should be considered further during the early stages of the WR&SR Plan period and the key actions required to better understand the need and scope.

Table 14.1 Recommended Resilience Options

WRZ	Recommended Resilience Option	Key Actions to Confirm Need and Scope
Central	Lough Fea WTW & Moyola WTW Resilience	• Investigate the impact of the new Carland to Cookstown pipeline on the resilience of the WRZ. • Consideration of the impact of NI Water planned SR storage improvements in the WRZ. • Further assessment of the existing infrastructure to identify the exact scope of works needed to meet the required demand.
North	Ballinrees Resilience	• Investigate the existing storage capacity and resilience of the existing WSZ
South West	Upgrade Killyhevlin WTW	• Investigate how the current Killyhevlin WTW could be replaced with a new and improved plant. • Review what investment is required for planned maintenance on the existing WTW.
South	Seagahan to Clay Lake Trunk Main	• Review and integrate with study into interconnectivity in the South WRZ.
West	West WRZ Resilience, Trunk Main Upgrades and Links	• Investigate the exact capability of the existing infrastructure.

All options should consider other resilience projects being undertaken by NI Water to ensure an integrated approach to supply resilience.

14.7 Summer 2018 High Water Demand Event Review

14.7.1 The increase in Peak demand

Towards the end of June 2018 Northern Ireland, the Republic of Ireland and other parts of the UK experienced unusually high temperatures and dry soils. In Northern Ireland, this increase in temperature coincided with schools breaking up for the summer holidays and the water network had to cope with an unprecedented peak in summer demands. Figure 14.1 illustrates how the increase in DI followed the increase in temperature.

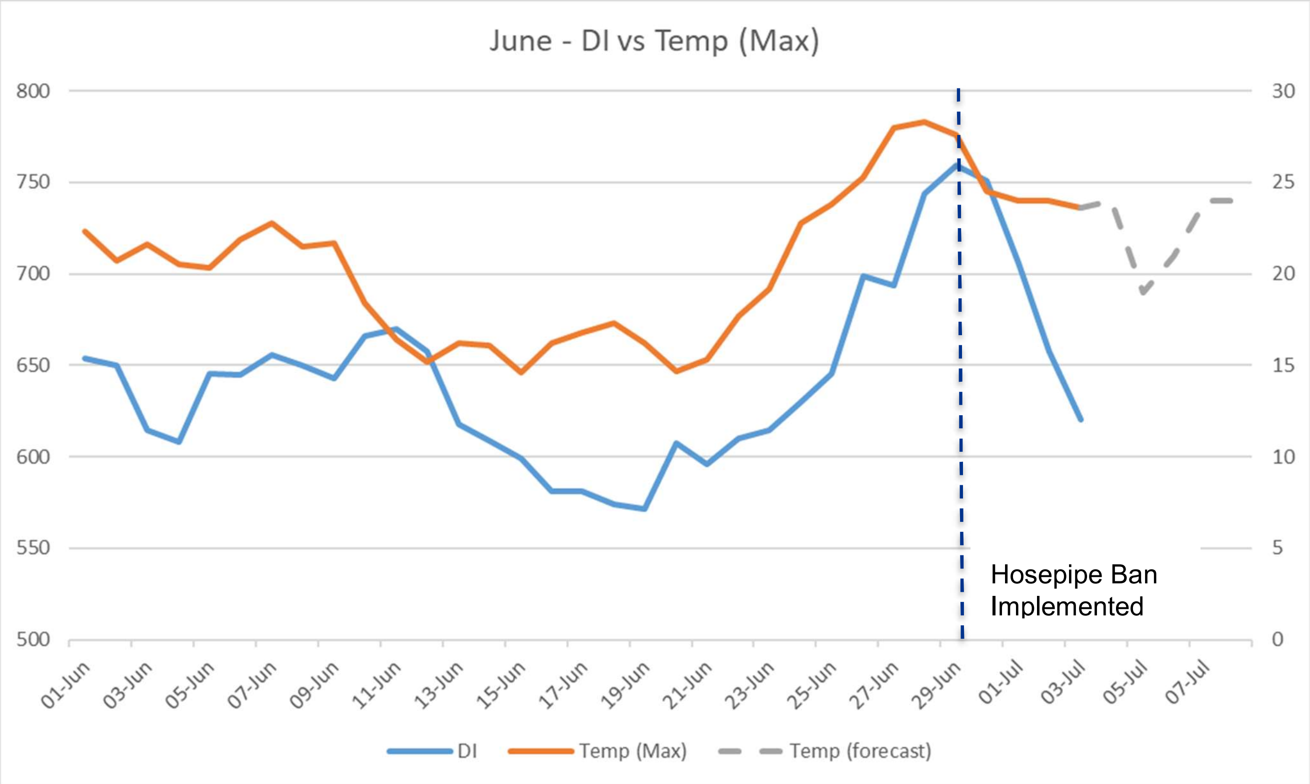


Figure 14.1 June 2018 increase in temperature and Distribution Input (DI)

This peak in demand was higher than the Dry Year Critical Peak (DYCP) values modelled as a planning scenario in this report. All Water Resource Zones (WRZs) showed an increase in peak demand. In most WRZs, the increases were minimal, between 1-2%, but the increases in the East WRZ and the South WRZ were significant (Table 14.2).

Table 14.2. Increase in peak demand during summer 2018 dry weather in the East WRZ and South WRZ.

WRZ	DYCP Increase in demand	Summer 2018 Dry Weather increase in demand	Ml/d Change in SDB at 2043 based on Summer 2018 Dry Weather	% Change in SDB at 2043 based on Summer 2018 Dry Weather
East	13.0%	26.9%	-32.40	-12.6%
South	19.7%	23.2%	-4.23	-2.6%

Including the impact of additional peak demand similar to the summer 2018 demands results in deficits at 2043 of 10.4 Ml/d in the East WRZ and 17.2 Ml/d in the South WRZ.

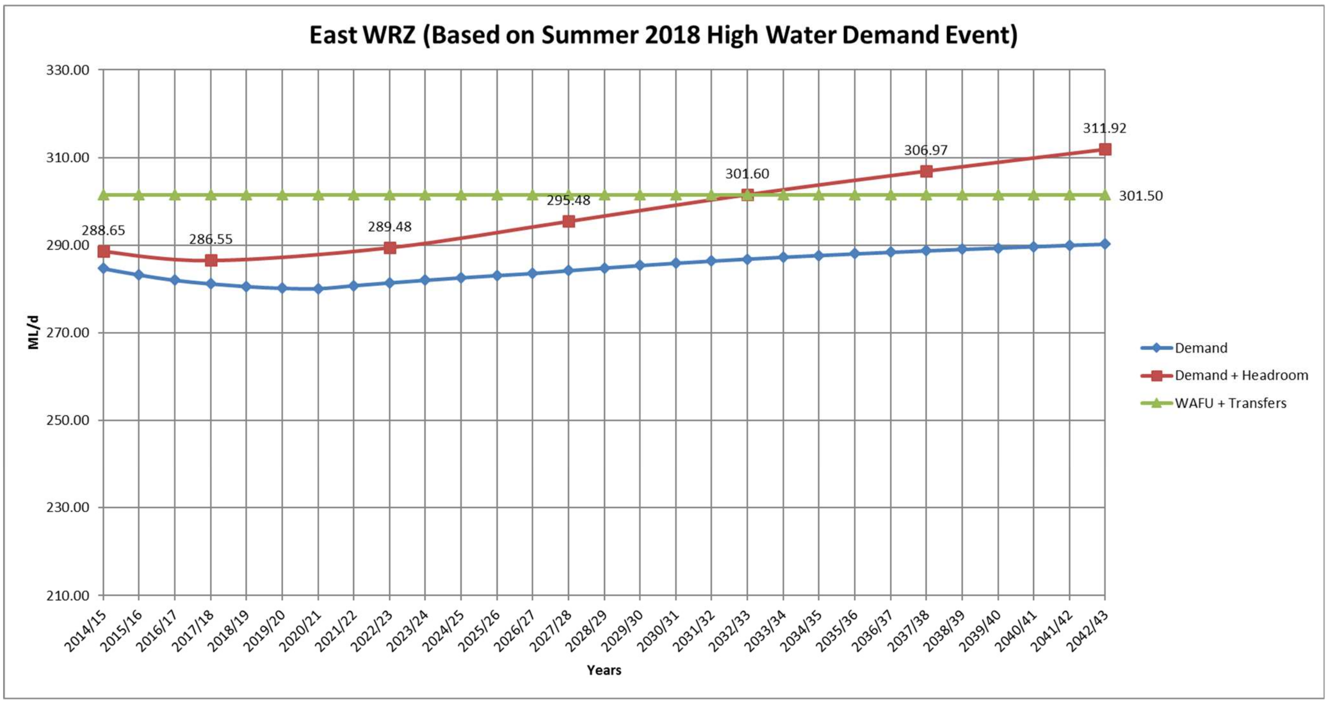


Figure 14.2. Resulting deficit of 10.4 Ml/d in 2043 in the East WRZ when considering summer 2018 peak demands

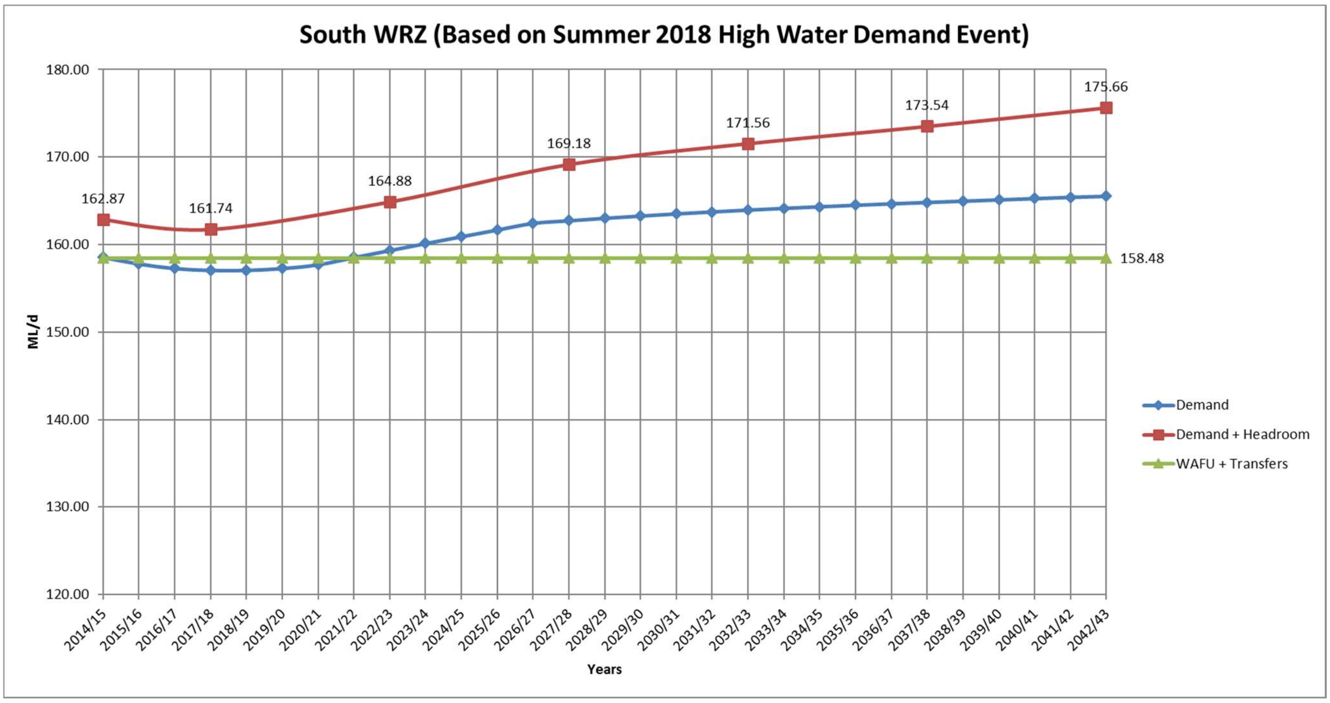


Figure 14.3. Resulting deficit of 17.2 Ml/d in 2043 in the South WRZ when considering summer 2018 peak demands

14.7.2 Mitigation options

An increase in peak demand can be accommodated in the East WRZ by a few actions (Figure 14.4):

- Firstly, to provide additional resilience for a peak demand deficit in the South WRZ, the transfer from Castor Bay WTW to East WRZ will have to be reduced from 30 Ml/d to 24 Ml/d, to allow a 20 Ml/d transfer to Ballydougan in South WRZ for DYCP, resulting in a further deficit of 6 Ml/d.

- This further deficit of 6 Ml/d can be accommodated by an increase Drumaroad WTW (East WRZ) output by 6 Ml/d from 124 Ml/d to 130 Ml/d for peak periods.

- The remaining peak deficit of 10.4 Ml/d can be accommodated by increasing the transfer from Dunore Point WTW in the North East WRZ to East WRZ by 11 Ml/d from 110 Ml/d to 121 Ml/d

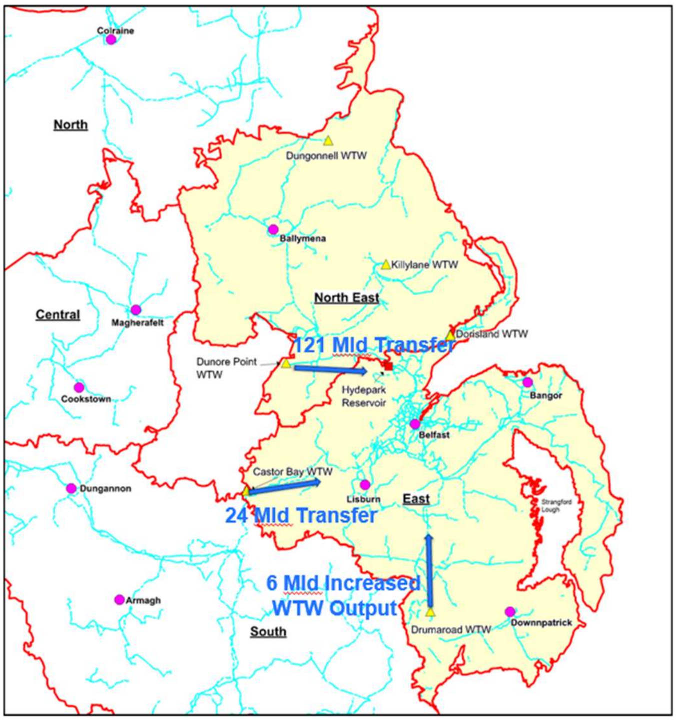


Figure 8.4. Dry weather resilience mitigation actions for the East WRZ

An increase in peak demand can be accommodated in the South WRZ by a few actions (Figure 14.5):

- As stated in the mitigation options for the East WRZ, an increase in the capacity of proposed transfer pipeline from Castor Bay to Ballydougan (South WRZ) to handle the supply/demand deficit from 16 Ml/d to 20 Ml/d provide the additional water during peak demands.

- This transfer will be able to utilise the 20.7 Ml/d surplus capacity at Castor Bay WTW.

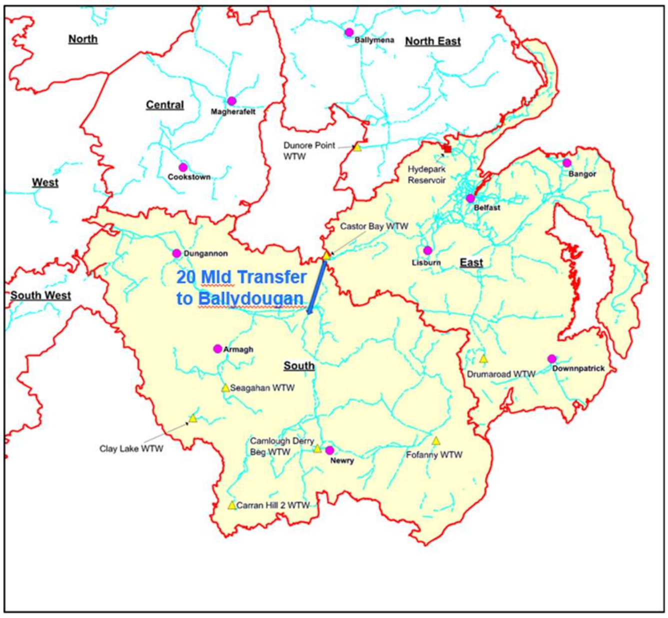


Figure 14.5. Dry weather resilience mitigation actions for the South WRZ

14.7.3 Demand management mitigation options

As shown in Figure 14.1, the system demand followed the increase in temperatures during the summer of 2018. Had demand continued to increase, the network of pipes and surface reservoirs would have been under severe pressure. It is important to monitor demand and keep it within levels that are planned for to preserve reservoir stocks in case a drought occurs and to keep the distribution network in good working order.

A demand monitoring and communication strategy should be developed to:

1. Watch levels of DI, temperature as well as drought reservoir triggers
2. Create clear messages to defined audiences i.e. public and stakeholders, using communication channels such as print media, radio, television and social media, to request that customers reduce demand if either demand increases too much or supply reduces too much (due to drought)

15. Recommendations

15.1 Water Resource Recommendations

The plan makes the following recommendations to meet SDB deficits in the South WRZ and West WRZ:

Water Resource Recommendations

- Castor Bay WTW to Ballydougan SR 20 Ml/d Trunk Main Upgrade (includes 4 Ml/d increase from original 16 Ml/d proposal to satisfy requirements of Summer 2018 High Water Demand Event). This WRZ currently shows a small deficit under the dry year critical period planning scenario and so the scheme will be promoted for implementation as early as funding provisions permit in order to meet this and the emerging deficit;

- Carmoney WTW to Strabane 17 Ml/d Trunk Main. This scheme is included in PC15 as a nominated output and was funded by the UR in the final determination pending clarification of abstraction licence conditions and risk. NI Water will continue to consider the priority of this and other schemes within its overall PC15 funding allocation taking into account other emerging priorities identified in the period. Any proposed changes would be requested through the formal change control process.

- Addition of booster pumps to the recently constructed transfer pipeline from Carland to Cookstown, to increase the transfer capacity from 2.4 Ml/d to 5.0 Ml/d.

Demand Management Recommendations (across all of Northern Ireland)

- Targeted non-household water audits (key accounts);
- Schools water audit and retrofit;
- Hotel & Hospitals water audit and retrofit;
- Farm Audits.

15.2 Resilience Recommendations

The following schemes to improve the resilience of the supply system should be considered further to determine their scope, whether they are necessary and whether they would prove cost beneficial for improving the resilience provided to NI Water's customers:

- Lough Fea WTW & Moyola WTW Resilience;
- Upgrade Killyhevlin WTW;
- Seagahan to Clay Lake Trunk Main;
- West WRZ Resilience, Trunk Main Upgrades and Links;
- Ballinrees Resilience.

15.3 Dry Weather Resilience Recommendations

- In order to accommodate intensive peaks in demand such as experienced in summer 2018;The Castor Bay WTW to Ballydougan SR Trunk Main Upgrade should be increased from 16 Ml/d (as previously planned) to 20 Ml/d.

A demand monitoring and communication strategy is currently being developed to prevent demand from exceeding planned levels of distribution input.

15.4 Other Associated Recommendations

Throughout the production of the Plan and following review of responses received from the Consultation, a number of other recommendations have been made to improve on future planning exercises. These should be included in the scoping of future plans and are summarised in Table 15.1 below.

Table 15.1 – Associated Recommendations

No.	Recommendation	Timescale
1	Further investigation of raw water intake structures for surface water sources to understand constraints at sources such as Lough Fea and Lough Bradan. The Lough Fea intake in particular requires investigation work as an immediate priority.	1-5 Years
2	Further investigation into changes in technology that may lead to more cost effective leakage reduction.	Yearly
3	Monitoring changes in UK Water industry best practice in areas such as: • definition of WRZs • treatment of uncertainty and risk in the Supply/Demand balance • environmental and customer levels of service • consideration of extreme events • effects of Climate Change on both supplies and demands.	Yearly
4	Monitoring changes in the cost of carbon.	5-10 Years
5	Study of changes in customer behaviour through the Annual Information Returns (AIR).	Yearly
6	Improve data collected on outages at WTW.	1 year
7	Collection and assessment of further data to improve model inputs such as: • Low flow measurement in catchments inflowing into the reservoirs • Asset data and hydraulic capacities of intakes and upland diversions structures • Reservoir capacity and sedimentation checks • Measurement of abstraction as well as water leaving the WTW	5 Years

No.	Recommendation	Timescale
8	Further investigation and data collection on operational rules, storage control curves for impounded reservoirs and exact intake arrangement details etc. before the next WR&SR Plan. This will further improve the robustness of the Deployable Output assessments.	5 Years
9	Negotiations with NIEA on possible sustainability reductions due to future revisions to abstraction licences.	5 Years
10	Revisiting of UKCP18 Climate Change projections which will provide an improved understanding of future hydrological conditions.	2 Years
11	Revisit Climate Change implications in North and South WRZ's.	2 Years
12	Ongoing collection of raw water quality to assess impact of gradual pollution on sources.	Yearly
13	Establish an evidence base for the effectiveness of water saving measures	1-5 years
14	Consideration will be given to future UK &NI Government strategies e.g. NI Energy Strategy and to linking water and energy efficiency through trials and feedback from other UK water companies.	1-5 years
15	Undertake project level Habitats Regulation Assessments to take account of detailed design and final route or site locations.	2-5 Years
16	Update Drought Plan following any changes to the water supply infrastructure.	1-5 Years
17	The Drought Plan should specify trigger points and when and how measures will be implemented and communicated to consumers. Supporting messages should also be developed.	Yearly
18	Develop engagement and communication plans targetting efficient water use.	1-5 years
19	Following review of the latest E&W Water Resource Planning Guidance consideration will be given to the commission of an independent audit of Water Resource and Supply Resilience Plan, in line with UK Water Industry process.	5 Years
20	Work with CCNI to establish a local evidence base including customer research, to assess acceptable customer levels of service.	5 Years