Water Resources in the South East Group

Progress towards a shared water resources strategy in the South East of England

Final Report (Version 8)

April 2010

Caveat

This report consists of a main report plus appendices and a summary report. It summarises the outcome of the most recent phase of modelling work completed in Autumn 2009. It has been written jointly by the Environment Agency and the seven water companies involved. The Environment Agency has led on drafting and making changes following comments. Despite considerable efforts by all parties over the last six months it has not been possible to agree a universally acceptable report. Two companies – South East Water and Thames Water – have stated that they are not in a position to sign off the report as it stands. The Environment Agency believes that there are only a few issues not agreed but considers that these are unlikely to be resolved before the forthcoming public inquiries are held into the two companies' draft water resources management plans.

Both the Environment Agency and South East Water have included substantial extracts from the reports and referred to the WRSE modelling work within their respective evidence to the public inquiry on the South East Water draft water resources management plan.

The Environment Agency notes that Thames Water has referenced the report in its statement of case to the public inquiry on the Thames Water draft water resources management plan.

The Environment Agency has decided to release this final draft report, without full acceptance of all the companies involved, in the interests of transparency. The Environment Agency believes that this approach will assist all parties involved and will be helpful to the planning inspectors when making their respective decisions.

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Executive summary

Over the next 25 years, the pressure on water supplies in the South East is expected to increase due to climate change, population growth and environmental protection. If we do nothing, unconstrained demand for water is forecast to rise, and the volume of water currently available for use is likely to reduce. It is proposed that this challenge is met through a combination of demand management (reducing the amount of water we use) and resource development. It is up to Government, water companies, the Environment Agency, Ofwat, and all stakeholders, to help and encourage people and businesses to use water more efficiently, and to ensure that resource development is economically justified, reliable, and sustainable. To help achieve this the Water Resources in the South East (WRSE) group was set up to explore opportunities for existing and new water resources to be shared in the most efficient and effective way whilst maintaining security of supply, protecting the environment and minimising costs to customers. The WRSE group is made up of seven water companies[1] that supply customers in the South East, led by the Environment Agency, with the engagement of Ofwat, the Consumer Council for Water, Natural England, SEEDA, and the South East Partnership Board.

The Environment Agency leads regional options selection modelling with the WRSE Group of companies and Ofwat, working to guidelines on the "economics of balancing supply and demand" (UKWIR / Environment Agency 2002). Regional modelling carried out in the late 1990s led to the implementation by 2005 of a further four bulk transfers between water companies in the Environment Agency Southern Region. From 2006 to 2009 the model was updated and expanded to incorporate of the three Thames Region water companies with the intention of the results being used to inform water companies' water resources management plan (WRMP) and business plan submissions in 2008 and 2009. This Report summarises the outcome of the final phase of that modelling which was completed in Autumn 2009.

Using figures for a dry year supplied by the water companies in Spring 2009, 5,239[2] Ml/d can currently (2009/10) be supplied from reliable resources to meet average demand of 4,967 Ml/d, including target headroom. Therefore, at a regional level there is a surplus of water available for use of 272 Ml/d (supplies available from reliable resources are 6% greater than demand, including target headroom). This masks a more detailed picture where some Water Resource Zones (WRZs) are in surplus, and others are in deficit.

The WRSE group work also considers the dry year peak week demand relative to reliable peak outputs from sources as a potential "critical period" water resources planning scenario. In this scenario, the WRSE water companies have a reliable output of 5,827 Ml/d and they forecast current (2009/10) dry year peak week demand to be 5,707 Ml/d, including target headroom. Therefore, at a regional level in the critical period scenario, there is a surplus of water available for use of 120 Ml/d (supplies available from reliable resources are 2% greater than demand, including

[1] Southern Water, South East Water, Portsmouth Water, Veolia Water Southeast, Thames Water, Veolia Water Central and Sutton and East Surrey Water.

[2] This figure and the following figures are calculated based on the water company WRZs used in the WRSE regional modelling only.

target headroom). Again, this masks a more detailed picture where some WRZs are in surplus, and others are in deficit. For some water companies, or in some WRZs, this scenario *is* the actual supply-demand investment 'driver' because expected peak outputs from sources can not meet forecast peak demand (and target headroom) sometime within the planning period.

In their WRMPs, the water companies forecast a net dry year annual average resource requirement of 441 Ml/d by 2035 (470 Ml/d for the critical period scenario). The key elements determining this net requirement are as follows:

- A 61 Ml/d forecast reduction in demand resulting from the demand management measures assumed within water companies' plans. In the peak week demand scenario, the forecast reduction in demand is 49 Ml/d;
- A 178 Ml/d increase in target headroom due to future uncertainties. For the peak week demand scenario, the forecast increase in target headroom is 198 Ml/d;
- An estimated reduction of existing resource outputs of approximately 188 Ml/d resulting from climate change. In the critical period scenario, the forecast reduction in existing resource outputs is 205 Ml/d; and
- A 136 Ml/d reduction in resource output to protect the environment, predominantly for the River Itchen in Hampshire. In the critical period scenario, the forecast reduction in demand is 116 Ml/d.

To satisfy the net resource requirement of 441 Ml/d resulting from these forecast changes in the dry year annual average supply-demand balance, the water companies are proposing to increase the water available for use by 480 Ml/d. In the critical period scenario the net resource requirement is 470 Ml/d and the water companies are proposing to increase water available for use by 584 Ml/d. Therefore, if the water companies plans are endorsed, the measures proposed are successfully implemented, and the forecasts made prove to be correct, there will be a regional surplus above target headroom[3] of 311 Ml/d at the end of the planning period (234 Ml/d for the critical period output) which is equivalent to 6% of forecast demand plus target headroom (4% of forecast critical period demand).

Approximately 90 Ml/d of water resources are already shared amongst the seven water companies in the WRSE group. The main focus of the Group has been to investigate the opportunities for increasing the amount of water that could be shared across the South East. This has been achieved using a least-cost supply side options selection model that seeks to minimise the cost of resource development within the planning period.

The model selects the least-cost set of supply schemes needed to satisfy the supply/ demand balance for a number of scenarios across the WRZs of the seven water companies for the planning period to 2035. Demand management schemes are built

[3] Target headroom is a buffer between supply and demand designed to cater for specified uncertainties

into the demand forecasts applied in the model. The flexibility of the model allows the exploration of a range of alternative scenarios including: housing growth; changes in the amount of water used per person; reductions in water supply for environmental reasons; the reliability of source outputs; option costs; environmental and social costs and carbon costs. Sensitivity tests have also examined the role of particular options and data assumptions. Data used in the modelling work has been provided by the water companies, from their respective WRMPs and/ or Business Plans. As far as possible this data has been used consistently with how the companies used it in preparing their plans. However some aspects of the companies data have been applied in the regional modelling so as to maximise consistency across companies within the regional model itself. This means some application of data may vary from an individual company's application. For example, environmental and social costs and carbon costs of options are excluded in the primary regional modelling application of companies option cost data but have been introduced in sensitivity tests.

Thirty three scenarios have been modelled. Scenario 1 closely represents what is in water companies' WRMPs by using only the water companies' preferred supply options. There are, however, minor differences to the water companies' plans in the way the model utilises the preferred options. Scenario 2 uses the same supply-demand balance data but allows the model to select resource and transfer options to achieve a regional solution on a least-cost basis.

Scenario 2 arrives at a solution that requires a combined resource development of 325 Ml/d at a cost of £262 million (discounted), compared to Scenario 1 which includes a combined resource development of 449 Ml/d at a cost of £762 million (discounted). Therefore, scenario 2 costs around £501 million less (discounted) over the planning period. Scenarios 1 and 2 result in a surplus over target headroom at 2035 of 311 Ml/d and 187 Ml/d respectively (equivalent to 234 Ml/d and 105 Ml/d in the critical period respectively).

A further 31 scenarios have been run. Some scenarios explore higher sustainability reductions which result in lower availability of resource, some explore variation in demand both higher and lower, and some consider resource reliability.

Water companies forecast that current dry year water use is around 170 litres/head/day in the South East, with peak demands from 200 to 300 litres/head/day. Some water companies are predicting average demand to increase towards 180 l/h/d, while others forecast it to reduce to between 134 l/h/d and 149 l/h/d. Scenario 3 of the WRSE regional modelling work shows that if a dry year average per capita consumption (pcc) of 136 litres/head/day (l/h/d) was achieved across the South East by 2030, with peak demands of up to 170 l/h/d, the supply-side investment needed would be around £108 million less (discounted) than might be required in scenario 2 and around £609 million less (discounted) than the cost of scenario 1. Scenario 3 results in a surplus over target headroom at 2035 of 242 Ml/d (361 Ml/d in the critical period output) and includes 124 Ml/d of new resource (145 Ml/d in critical period scenario). The demand forecast in scenario 3 is 257 Ml/d less than the demand forecasts for scenarios 1 and 2 at 2035. The cost of achieving this lower demand is not included in the model but the model indicates how much less supply-side investment would be needed assuming the lower demand. This gives an indication of the value of achieving this lower demand, excluding valuation of the

wider benefits of using less water.

The WRSE regional modelling work has also explored the possible pressures of people using more water and the potential need to reserve more water for environmental protection. If personal use of water across the South East were to be a dry year annual average of 168 litres/head/day in 2030, with peak demand of 210 l/h/d, the additional resource needed to supply this demand would cost an additional £817 million (discounted) compared to the cost of satisfying the water companies demand forecasts (scenario 2), assuming both scenarios were solved by the model as a regional solution. In the future, water companies are likely to have to reduce abstraction in places where it is proven to be causing environmental damage. This will require additional demand management or new resources to maintain the supply-demand balance. The largest environmental reductions considered in the model are 743 Ml/d by 2030. This figure includes the reductions already included in company plans. To satisfy the supply-demand balance in this scenario it would cost up to a further £1,344 million if the water was replaced by new resources.

The modelling has identified that the variability in the assumptions underpinning individual water companies' demand forecasts is likely to have had an impact on the solutions arrived at by the model. The WRSE regional modelling work should be developed to include economic selection of demand management options to help address this issue.

A synopsis of the regional solutions is provided in section 4 of the main report.

The table below summarises the regional solutions costs of the modelling scenarios highlighted in this executive summary.

	Solution Cost		Difference between regional solution and company plans	New resources by 2034/35		Surplus over target headroom (DYAA)		Surplus over target headroom (DYCP)	
	£(million)		£(million)	(Ml/d)		(Ml/d)		(Ml/d)	
	Undiscounted	Discounted	Undiscounted	DY AA	DY CP	At 2009 /10	At 2034/ 35	At 2009/ 10	At 2034/ 35
Water company plans	1738	762	N/a	449	549	272	311	120	235
MODEL									
Base case	943	262	Saving of 795	325	404	272	187	166	105
168 l/h/d pcc	2254	1079	Increase of 516	577	670	137	130	25	243
136 l/h/d pcc	293	154	Saving of 1,445	124	145	137	242	56	361
Severe sustainability reductions	3723	1344	Increase of 1,985	878	1000	272	133	166	79

Notes: In the table, (i) Demand management costs are not included in any of the solution costs in the table. (ii) The 136 l/h/d scenarios implicitly involves more demand management than the water companies plans and the Base case. The 168 l/h/d scenario implicitly involves less. (iii) "New resources" exclude improvements 'committed' by 2015 and, in water company plan scenario, some small groundwater schemes that are included in South East Water's plan but are not included in the model.

The overall finding of the WRSE regional modelling work is that, on a like for like scenario basis, the regional solutions will typically cost less than the sum of the individual company plans. This is because the regional solutions include ways to share existing and new resources in a more efficient and effective way to maintain the supply-demand balance. All the scenarios explored in the WRSE regional modelling work have satisfied the target headroom assumed by the water companies to be necessary in their plans. The regional solutions and the water companies plans provide surplus resource above target headroom but less surplus is provided by regional solutions. Scenarios that result in less surplus headroom, or rely on behavioural change, may present higher future risks.

Many of the resource sharing opportunities identified by the WRSE regional modelling work were not consistently included in the preferred solutions of the current company WRMPs or Business Plans at April 2009, because these options were not sufficiently developed when water companies plans were being prepared.

It has not been the intention that the WRSE regional modelling work would give a single definitive solution that should automatically override the more detailed modelling work carried out by the individual water companies. The WRSE regional modelling, by considering the South East as though it was under the jurisdiction of a single company, has identified resource sharing options that should be considered by water companies within their individual plans. In this context, the WRSE regional model considers all the capital and operating costs of these options in deriving its least-cost solutions but it has not yet considered the profit margin that one company might seek if selling water to another. These additional costs, along with any others identified as a result of further reviews of infrastructure and other capital costs (as options are reviewed in more detail), can be considered in further modelling refinements when water companies can offer data. The profit element should be marginal relative to the capital and operating costs already considered in the model. The WRSE regional modelling approach identifies resource sharing opportunities that can reduce costs to the customers of those water companies who are sharing resources, so long as profits that may be sought around a particular option do not exceed the margin of cost that has led to the model favouring selection of that particular option over another. If the sought profit causes a scheme cost to increase to this point, the option will no longer be a benefit to the receiving customers and that option will no longer be favoured. The views of Ofwat, the economic regulator, would also be expected to be taken into consideration in the event of such a situation arising.

The regional scope of the WRSE group modelling is intended to benefit customers and the environment by optimising resource development across water companies within the South East. The modelling results confirm there is potential to achieve these benefits over the planning period.

Conclusion and recommendations

The conclusions and recommendations of the WRSE group arising out of the latest round of modelling are as follows:

- The WRSE group concludes that further regional modelling work should be carried out in the next three years;

- A firm timetable should be established for the further work. The Environment Agency, Ofwat and Defra, should consider formalising this timetable which should be consistent with the reporting guidelines for the WRMP and Business Plans;

- This further work needs to be planned so that water companies can take the results of the modelling into account at the very earliest stages of preparation for their next WRMPs (due 2014), and have time to give serious consideration to the resource sharing opportunities arising out of the modelling;

- The WRSE group should convene in early Autumn 2010 to establish and agree the objectives and scope of the proposed further work, distinguishing appropriately between what needs to be explored further in relation to Southern region, Thames region, and the South East as a whole. The group should also discuss and look at the following:
    - the development objectives for the model, and whether a revised model specification should be put out to tender;
    - agreement of option costing 'rules' and an option review and option costing timetable. This could include consideration of appointment of option costing consultants to the WRSE group; and
    - a firmer process of more detailed exploration of shared resources opportunities to be established between water companies from the outset.

- Specifically, the further modelling work should look at the following:
    - development of the approach to include demand management options within the least-cost options selection process; and the
    - inclusion of environmental, social and carbon costs within primary data (dependent on a fuller more consistent data set); and

- More broadly, the WRSE group should encourage work to reduce future uncertainties, particularly with regards to reductions in water supply for environmental reasons and the impact of climate change on resources. The timetable should include a commitment by the EA to provide notification of the requirements for reasonable long term scenario forecasts of sustainability reductions in time for the next round of WRMPs. It should also include a requirement for Ofwat, the Environment Agency and UKCIP to reach agreement and provide guidance on the use of the UKCIP09 scenarios.

1 Introduction

The Water Resources in the South East (WRSE) group has carried out water resource options modelling at a regional scale to explore the potential opportunities for water companies to share water resources in the south east of England. This work aims to help overcome the constraints imposed on the distribution of water resources by the fragmented supply systems operated by the water companies in the region.

In 2003, the Environment Agency contracted Halcrow to establish and maintain a new regional water resource investment model. The model works to the principles and practice of the economics of balancing supply and demand (EBSD)[4] guidelines, choosing supply options that contribute to a least-cost solution over the planning period.

The model has been populated with resource development options and transfer options established in a process of consultation and discussion with the water companies over several years. The current round of modelling is now completed and the results are an essential consideration for water companies, regulators and Government in planning the future of water resources in the South East of England.

1.1 Purpose of this report

This report describes the background to the WRSE regional modelling, including earlier work leading up to the current round of modelling. It outlines the particular challenges in the South East of England that need to be addressed by the individual water companies and by the WRSE group at a regional scale in the context of the water resources planning process.

The main purpose of the report is to describe the work of the WRSE group in helping to identify and evaluate inter-company responses to these regional planning issues. The report describes the application of the regional investment model to address these issues; the results from the modelling; and the implications of the results from the modelling on the future planning of water resources in the South East.

1.2 Background

The water companies of the South East have worked jointly on aspects of water resources management since the early 1990's. Impetus to create a joint working group of water companies came following a recommendation in a Monopolies and Mergers Commission (MMC) inquiry, in the mid 1990's, into the proposed takeover of

[4] UKWIR and the Environment Agency (2002) The economics of balancing supply and demand

Mid Kent Water by the then Veolia owned water companies South East Water and Folkestone and Dover Water (now called Veolia Water Southeast). The recommendation indicated the benefits of more formal regional co-operation between the water companies. The Water Resources in the South East (WRSE) group was formed in 1996, led by the Environment Agency, with Ofwat, the economic regulator for the water industry, and the water companies of Environment Agency Southern Region.

Discussion of options and regional level least-cost options selection modelling led to identification of four new bulk water transfer schemes between 1997 and 1999, which were implemented between 2000 and 2005.

In 2006, the WRSE group was expanded to include the three water companies of Environment Agency Thames Region, though Thames Water had been an observer since the group was formed.

The WRSE group currently includes representatives from the following, according to the level of the group and need: Environment Agency, Ofwat, Water Companies (Southern Water, South East Water, Veolia Water Southeast, Sutton and East Surrey Water, Portsmouth Water, Veolia Water Central and Thames Water), Natural England, Consumer Council for Water, SEEDA and SEERA (now South East England Partnership Board).

The WRSE group meets at Managing Director, technical and specialist sub-group level and is chaired by the Environment Agency and water companies, depending on the level of the meeting. The technical group has undertaken regional modelling work at various stages over the years, and on significant occasions to help inform decisions on the formulation of water companies' Water Resources Management Plans (WRMPs) and Business Plans, including the Periodic Reviews of 1999, 2004 and 2009, respectively PR99, PR04 and PR09.

The aim of the WRSE group is to develop a strategy to share water resources within the study area.

1.3 Overview of WRSE study area

The WRSE study area covers an area of some 21,000 km^2 in the South East of England (see Figure 1). The seven water companies currently supply 18.5 million customers, with average demand forecast to be 4,967 Ml/d in a dry year, rising to 5,708 Ml/d for a peak week during the summer period.

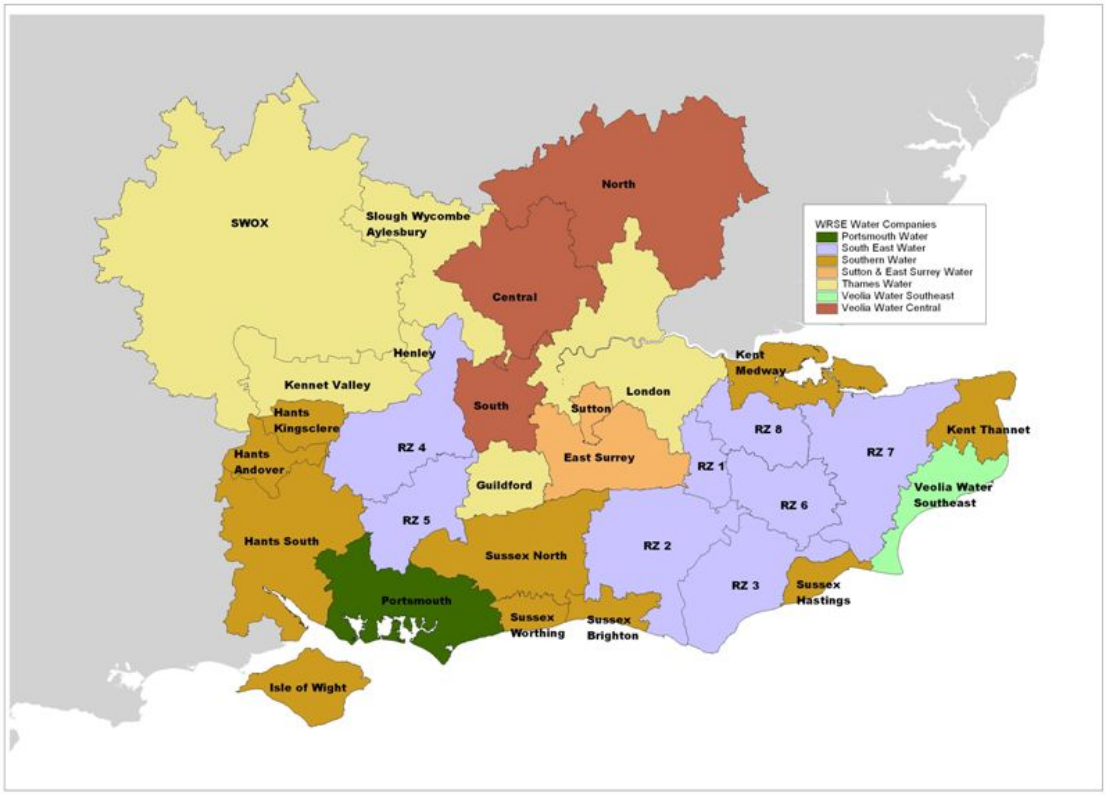

Figure 1: Water Resource Zones (WRZs) of the seven water companies involved in WRSE regional modelling

Water resources planning is carried out by individual water companies for each of their Water Resource planning Zones (WRZ). These WRZs are designated by water companies to be the largest area in which all customers bear the same risk of supply failure from a resource shortfall. The seven water companies of the WRSE group plan according to 31 WRZs in total. The WRZs are shown in Figure 1. The regional modelling approach to these WRZs is described in more detail in section three.

1.3.1 Nature of the supply system

The water supply system within the study area is the result of the historic development and integration of local systems over more than a century. The structure of the system and pattern of WRZs is complex, due to the fragmented geographical areas of some water company supply systems, and inter-connections between a number of the water companies in the region.

1.4 The scale of the supply-demand planning problem

1.4.1 Balancing supply and demand

Water companies must ensure that there are sufficient supplies to meet forecast demand. Since 1999, water companies have produced 25-year WRMPs. Every five years, each company produces a revised WRMP that sets out its estimate of the future supply and demand and its proposals for ensuring that it has sufficient water to meet forecast demand. The Environment Agency produces a guideline[5] that provides a standard recommended approach for water companies to follow. Each plan has covered a twenty-five to thirty year planning period as recommended by the guideline.

Water companies plan to ensure there is sufficient water available in a 'dry' year. A dry year is a year when reliable supplies are low as a result of a period of low rainfall but the company is still able to meet demand without the need for any restrictions on use. As well as having less water available for supplies, there can also be higher demand in a dry year than in an average year. The difference between the supplies available and anticipated demands in a dry year is known as the dry year supply-demand balance or available headroom. As estimates of both supply and demand are uncertain, a design buffer is included in the supply demand balance called target headroom (Figure 2). Water companies plan to have sufficient water available to meet anticipated dry year demand plus target headroom. A 'surplus' is deemed to exist if available headroom exceeds demand plus target headroom, while a 'deficit' exists if reliable supplies fall short of demand plus target headroom.

Demand for water and the supplies available are not uniform throughout the year. For example, demand tends to be highest in summer. Hence, water companies must solve the supply-demand balance at an annual time step and for these critical periods within year.

[5] Environment Agency (November 2008) Water resources planning guideline

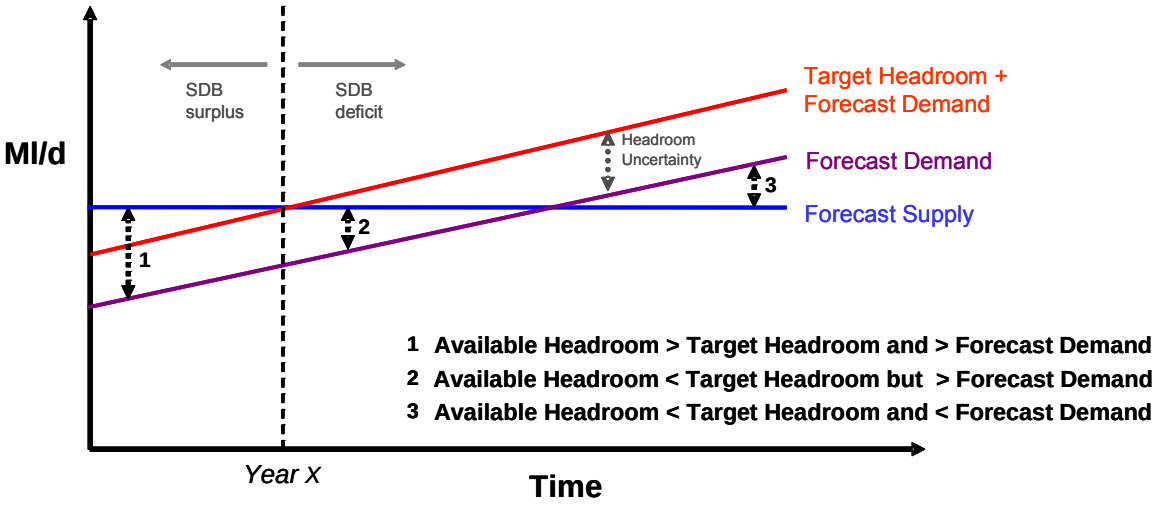

Figure 2: The relationship between headroom, demand and supply in the supply demand balance

1.4.2 The supply-demand planning problem of the South East

Tables 1 and 2 show the supply-demand balance for each of the 31 WRZs that make up the seven water companies of the WRSE group for the years 2015 and 2035, for both the dry year annual average (DYAA) scenario and the dry year critical period (DYCP) scenario. The data shown is a summary of that used in the WRSE regional model: the latest data provided by or agreed with the water companies. The forecast demand and target headroom are the latest data provided by water companies representing their final planning demand forecasts, inclusive of forecast demand growth, with planned metering, leakage control and other water efficiency measures. Surplus or deficit is calculated as available supplies minus demand and target headroom. Figure 2 shows the basic relationship between available supplies, demand and target headroom.

The "available supplies" in Tables 1 and 2 are a result of:

- source by source deployable outputs (DO) expected at 2009/10 but, minus 'outage' allowances and process losses;
- *known* reductions to be implemented by 2015 for environmental reasons;
- existing imports and exports between WRZs, including inter-company transfers up until expiry dates of current agreements; and
- reductions in DO of existing sources forecast to occur as a result of climate change by 2035.

These tables shows that by 2035 there is not enough available supply to meet expected demand in some WRZs, while others remain in surplus, This highlights that resources are not always available in the right place and that the existing supply systems constrain the transfer of resource. Water companies can address these deficits by choosing schemes to reduce demand, enhance existing supplies, remove

constraints or develop new resources. The WRSE work aims to help water companies explore opportunities to share resources from the WRZs with surpluses to the WRZs with deficits, as well as consider the most optimal way to establish new resources across the region to ensure target headroom is achieved and maintained within every WRZ.

Table 1: Scale of supply demand problem on annual average in dry year (DYAA)

DYAA	Dry year forecast at 2015				Dry year forecast at 2035			
	Available supplies (Ml/d)	Forecast demand (Ml/d)	Target headroom (Ml/d)	Surplus (deficit) (Ml/d)	Available supplies (Ml/d)	Forecast demand (Ml/d)	Target headroom (Ml/d)	Surplus (deficit) (Ml/d)
Water Companies								
Guildford RZ	63	41	4	18	63	41	4	17
Henley RZ	25	13	0	11	25	14	0	11
Kennet Valley RZ	141	102	6	33	141	103	7	31
London RZ	2093	1899	154	40	2025	1894	201	-70
SWA RZ	177	126	8	43	176	126	9	41
SWOX RZ	292	268	13	11	289	266	17	6
Thames Water	2790	2449	186	155	2718	2443	239	36
Central RZ	548	470	25	53	542	462	41	39
Northern RZ	322	260	25	37	300	262	32	5
Southern RZ	139	136	8	-6	155	137	13	6
Veolia Water Central	1009	866	57	85	997	861	85	51
East Surrey RZ	123	100	11	12	122	102	14	5
Sutton RZ	79	73	7	0	80	74	7	0
Sutton and East Surrey Water	202	173	18	12	202	176	21	5
Thames Region subtotal	4001	3489	261	252	3918	3481	346	92
Veolia Water Southeast	48	40	5	3	44	40	8	-4
Portsmouth Water	216	185	10	21	209	196	3	10
RZ 1	42	40	2	0	37	44	5	-11
RZ 2	78	71	6	1	72	79	13	-19
RZ 3	70	62	5	3	60	70	9	-18
RZ 4	216	185	10	21	224	203	15	6
RZ 5	57	38	2	18	47	40	4	3
RZ 6	69	66	3	0	64	75	5	-16
RZ 7	19	21	1	-3	15	24	1	-10
RZ 8	96	84	3	9	102	102	4	-5
South East Water	**647**	**567**	**32**	48	**622**	**637**	**56**	-70
Hampshire	134	170	9	-45	132	180	8	-56
Isle of Wight	36	35	1	0	38	37	1	0
Andover	21	16	1	4	21	17	1	3
Kingsclere	8	5	0	3	8	5	0	2
Sussex North	48	66	3	-21	52	69	3	-19
Sussex Worthing	43	39	3	1	47	41	2	3
Sussex Brighton	92	77	4	11	88	80	4	4
Sussex Hastings	26	24	2	0	29	25	1	3
Kent Medway	129	114	6	9	117	119	5	-7
Kent Thanet	54	42	2	9	51	45	2	5
Southern Water	**592**	**588**	**32**	-27	**584**	**618**	**29**	-62
Southern Region subtotal	**1502**	**1380**	**78**	**44**	**1460**	**1491**	**95**	**-126**
Whole WRSE region	5503	4869	339	296	5378	4971	441	-34

Table 2: Scale of supply-demand problem on critical period in dry year (DYCP)

DYCP	Dry year forecast at 2015				Dry year forecast at 2035			
	Available supplies (Ml/d)	Forecast demand (Ml/d)	Target headroom (Ml/d)	Surplus (deficit) (Ml/d)	Available supplies (Ml/d)	Forecast demand (Ml/d)	Target headroom (Ml/d)	Surplus (deficit) (Ml/d)
Water Companies								
Guildford RZ	74	62	4	8	74	61	5	9
Henley RZ	26	19	1	6	26	19	0	6
Kennet Valley RZ	166	133	6	26	159	132	6	21
London RZ	2070	1899	154	17	2025	1894	201	-70
SWA RZ	209	165	12	32	208	162	12	33
SWOX RZ	340	344	22	-26	336	341	25	-29
Thames Water	2885	2622	200	63	2828	2609	250	-30
Central RZ	624	555	31	38	607	535	46	27
Northern RZ	366	319	31	16	354	317	36	1
Southern RZ	210	182	12	16	203	178	16	9
Veolia Water Central	1200	1056	74	70	1165	1029	98	37
East Surrey RZ	160	149	18	-8	156	152	24	-21
Sutton RZ	120	109	12	-1	124	110	14	0
Sutton and East Surrey Water	280	258	30	-8	280	262	38	-21
Thames Region subtotal	4364	3936	304	124	4272	3900	386	-13
Veolia Water Southeast	61	46	6	9	58	46	9	2
Portsmouth Water	259	249	10	0	264	265	1	-2
RZ 1	54	48	3	3	48	56	6	-14
RZ 2	96	86	9	1	91	100	17	-26
RZ 3	84	78	6	1	75	91	12	-29
RZ 4	230	216	8	6	235	247	13	-25
RZ 5	63	52	3	9	57	57	5	-5
RZ 6	88	84	4	0	87	99	5	-17
RZ 7	27	27	1	-2	20	32	2	-14
RZ 8	111	107	4	0	117	135	5	-24
South East Water	**753**	**698**	**38**	18	**730**	**817**	**67**	-155
Hampshire	173	210	11	-49	171	225	10	-64
Isle of Wight	46	44	2	0	45	47	2	-4
Andover	25	20	2	4	25	21	2	2
Kingsclere	9	7	0	2	9	7	0	2
Sussex North	86	81	4	1	75	86	4	-14
Sussex Worthing	51	46	4	1	52	49	3	0
Sussex Brighton	110	90	5	14	110	94	5	11
Sussex Hastings	30	28	2	0	34	29	2	3
Kent Medway	160	135	8	17	137	141	7	-11
Kent Thanet	60	53	3	4	60	56	3	0
Southern Water	**751**	**714**	**41**	-4	**718**	**755**	**38**	-75
Southern Region subtotal	**1824**	**1707**	**95**	**23**	**1770**	**1883**	**116**	**-230**
Whole WRSE region	**6189**	**5643**	**399**	**147**	**6042**	**5783**	**502**	**-243**

1.4.3 Addressing a supply-demand deficit

Water companies follow a 'twin-track' approach to balancing supply and demand. This comprises the parallel approach of reducing demand through demand management measures whilst planning for and developing new resources as required. Figure 3 shows that demand side options have an incremental effect on the supply demand balance, whereas supply side options result in step changes in available supply and tend to create surplus over and above target headroom persisting for a period of time.

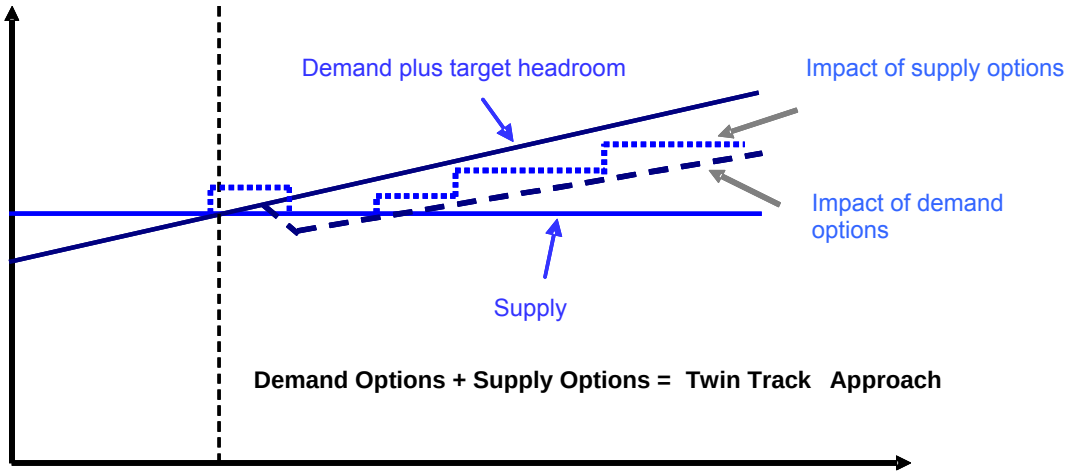

Figure 3: The impact of both demand and supply options on the supply demand balance

1.4.4 Balancing supply and demand: broad approach to options

The generic demand-side options normally considered include:

- meter installation (and tariff development);
- leakage reduction; and
- water efficiency initiatives.

The generic supply-side options normally considered are:

- reservoirs (new or enlarged);
- surface water or groundwater abstractions;
- bulk transfers;
- aquifer storage and recovery;
- desalination;
- effluent re-use; and

- production improvements (such as wastewater recovery).

Water companies follow the recommended standard approach to options selection and appraisal:

- consider all possible options – both supply and demand side;
- screen the options to those technically, environmentally and socially feasible. Calculate the costs of feasible options, including the environmental and social costs;
- use a mathematical function or model to find the least cost sets of options that provide solutions;
- when choosing the final options set, consider risks and uncertainties that cannot be given a cost; and
- possibly choose to implement a set of options that is not least cost, if the risks of the least cost programme are considered too high or the benefits of the non-least cost outweigh the additional costs.

1.5 The statutory water resources planning process

WRMPs have been prepared by water companies for a number of years (in 1999 and 2004) on a voluntary basis but, the 2003 Water Act required the preparation of WRMPs as part of a statutory process that must include public consultation.

1.5.1 Overview of WRMP process

The statutory consultation process for the 2009 WRMPs allowed each company to develop its plan to its own timetable subject to achieving some set milestones as follows:

- pre-consultation with the Environment Agency, Ofwat and Natural England;
- publication of draft WRMP which was subject to public consultation;
- a consultation period of at least 12 weeks, for receipt via Defra of any representations;
- a “statement of response” to the representations received, recording and explaining changes to the plan made as a result of these representations;
- a decision by Defra, based on advice from the Environment Agency on the Statement of Response; and
- the Defra decision concluded one of three positions with each company:
    - Permission to publish;
    - A request for further specified information to be provided to Defra within eight weeks; or

- Calling-in of the plan to either a public hearing or public inquiry to further consider specific issues.

Each company is at a different stage in development of their plans, as might be expected by the nature of the requirements of the statutory process. Table 3 shows, as at April 2010, the status of the WRMP for each of the water companies within the WRSE group.

1.5.2 The Business Planning process

Water companies are expected to use their WRMP to help them prepare the supply-demand elements of their five-yearly Business Plan submissions to Ofwat. The Business Planning round of 2009 is the fifth Periodic Review (PR09) of price limits to customers by Ofwat, and was determined by Ofwat in November 2009, setting price limits to customers for the period, 2010 to 2015. A brief overview of the business planning process and timetable is given below:

- *December 2007* – Water Companies submitted their Strategic Direction Statements, setting out their vision for the next 25 years;
- *August 2008* – Water Companies submitted their Draft Business Plans;
- *October to November 2008* – Ofwat provided feedback on Water Companies Draft Business Plans;
- *December 2008* – Ofwat published its draft capital expenditure baseline for each water company;
- *April 2009* – Water Companies submitted Final Business Plans;
- *July 2009* – Ofwat published its draft determination;
- *September 2009* – Water Companies made final representations to Ofwat; and
- *November 2009* – Ofwat published its final determinations.

1.5.3 WRSE regional modelling, the statutory water resources management planning process and Ofwat's 2009 Periodic Review of water company Business Plans

Figure 4 shows the sequence of WRSE group work undertaken since 1996, including the sequence undertaken since 2004, geared toward informing water companies 2009 WRMPs and Business Plans. The WRSE regional modelling work has aimed to provide information to aid the preparation of the WRMPs and Business Plans. Figure 4 highlights that WRSE regional modelling was carried out and results made available before or during each main step of PR09 planning cycle. However, the water resources management planning milestones became increasingly out of synchronisation with the PR09 Business Planning steps and it became more difficult to carry out the WRSE regional modelling work using data and to milestone dates that suited both processes.

Table 3: Water company progress through WRMP statutory process

Stage	Sutton and East Surrey Water	Thames Water Utilities Limited	Veolia Water Central	Southern Water	South East Water	Portsmouth Water	Veolia Water Southeast
Publication of dWRMP	06/05/2008	07/05/2008	05/05/2008	01/05/2008	2/05/2008	2/05/2008	1/05/2008
Public consultation	06/05/2008 – 01/08/2008	07/05/2008 – 27/08/2008	05/05/2008 – 29/08/2008	2/05/2008 - 25/07/2008	2/05/2008 – 25/07/2008	2/05/2008 – 25/07/2008	1/05/2008 – 24/07/2008
Publication of Statement of Response	03/02/2009	27/02/2009 Additional information on 13/05/2009	29/01/2009	29/01/2009	30/01/2009	30/01/2009 amended on 12/03/2009	20/01/2009 amended on 3/03/2009
Secretary of State decision letter	03/08/2009 Publish final plan	03/08/2009 Public inquiry	03/08/2009 Supplementary information required	3/08/2009 Publish final plan	3/08/2009 Public inquiry	3/08/2009 Public hearing	3/08/2009 Publish final plan
Supplementary information	N/A	N/A	12/10/2009	N/A	N/A	N/A	N/A
Date for publication of final plan	12/03/2010	After completion of the public inquiry	Unknown	1/10/2009	After completion of the public inquiry	After completion of the public hearing	1/11/2009

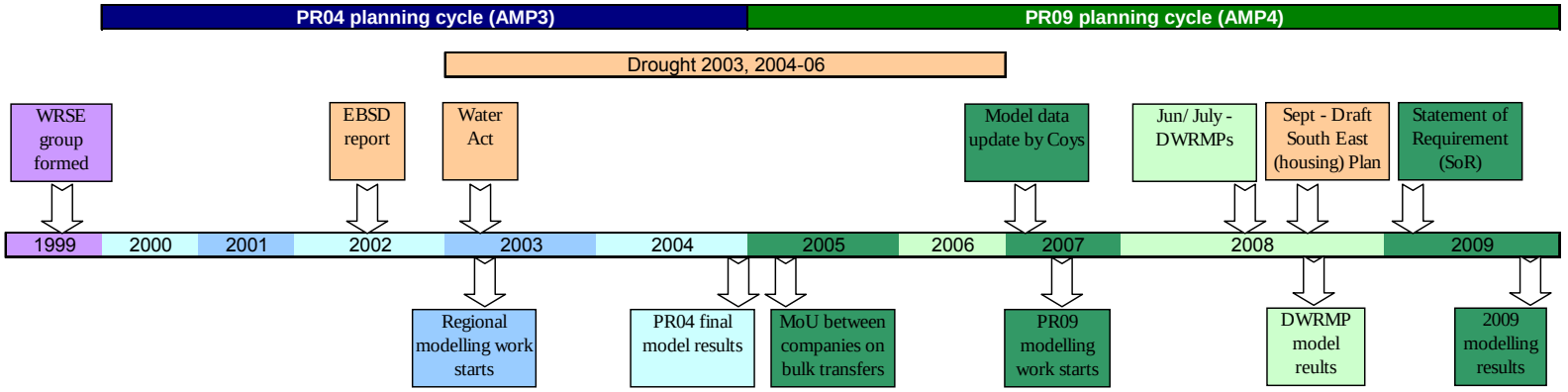

Figure 4: WRSE regional modelling and the WRMP statutory process

1.6 Issues and challenges for water resources planning in the South East

Water companies must deal with a number of challenges to develop a cost-effective and environmentally sustainable plan for maintaining the security of water supplies to their customers. Whilst many of these challenges are not confined to the South East, many of them are particularly acute in this region.

The South East has a number of characteristics that make water resources planning more challenging than other parts of the country. These characteristics include a higher than (national) average per capita consumption (pcc), relatively low rainfall and a high population that is predicted to increase. There are also a number of challenges specific to the South East region as a result of the fragmented nature of the existing supply systems across the study area.

Section 1.6 provides a brief overview of the challenges water companies face when planning water resources. These challenges are also pertinent to exploring opportunities for shared resources strategy across the South East.

1.6.1 Levels of service

Water companies plan to maintain an unrestricted supply of water to their customers in most years. During droughts, water companies may have to restrict water use to conserve supplies. Water companies agree a "level of service" with their customers. The "level of service" sets out how frequently the water company expects to impose restrictions on the use of hose-pipes, sprinklers and other non-essential uses. The water company's drought plan also sets out how often a water company expects to apply for drought permits and drought orders seeking temporary increased abstraction of water from the environment.

The WRSE group has discussed whether levels of service should be more consistent across the South East. Table 4 summarises the current intended levels of service of the seven water companies of the Group, expressed in terms of planned (company policy) frequencies of hosepipe bans, non-essential use drought orders and rota cuts or standpipes.

Table 4: Water company levels of service

Company	Hosepipe ban	Drought order	Rota cuts/standpipes
Southern Water	Once every 10 years	Once every 20 years	Only in civil emergency
South East Water	Once in 10 years	Once in 40 years	Unacceptable
Thames Water	Once every 20 years	Once every 20 years	Never
Veolia Water Central	Once in 10 years	Once in 40 years	Unacceptable
Sutton and East Surrey Water	Once in 10 years	Once in 20 years	Only be required in the most extreme droughts or emergency situations
Portsmouth Water	Once in 20 years	Once in 50 years	Unacceptable
Veolia Water Southeast	Once in 10 years	Once in 40 years	Unacceptable

The study area has experienced droughts in 1972-73, 1975-76, 1984, 1989-91, 1995-97, 2003 and most recently during 2004-06. These droughts resulted in some water companies applying restrictions more frequently than implied by their intended levels of service shown above. Such challenges may become more apparent in the future because of climate change. However, resource developments, supply improvements and leakage control have been implemented by water companies since the early 1970's. At the same time, since the early 1970's various reassessments of reliable outputs of sources have been made, and so interrogation of the relationship between historical, actual and planned levels of service is complicated.

1.6.2 Population and growth

The number of households that will need to be supplied with water will grow significantly under the Government's plans for new houses. This issue is especially acute in the South East. The study area falls under various Regional Spatial Strategies including the South East Plan, the London Plan and the East of England Plan. Together, these plans predict approximately 65,000 houses every year for the next 25 years for the WRSE modelling area.

The 2009 WRSE regional modelling uses water company assumptions for housing growth. For six of the seven WRSE companies these are based on, a "most likely" forecast constructed by consultants Experian, working for the water companies. The Experian "most likely" forecast assumes more housing growth than is set out in the Regional Spatial Strategy (RSS) for the South East. Thames Water has used Experian's "policy" household growth forecast which is consistent with RSS.

1.6.3 Government aspirations to reduce consumption

The Government has stated its commitment to reduce water use, especially in household demand, through decreased pcc. In Defra's water strategy, 'Future Water'[6], the Government set an aspiration of reducing normal year average pcc to 130 litres per head per day (l/h/day) by 2030. The Regional Economic Strategy suggests that this figure should be adjusted (brought forward) to reflect the acute problems faced in the region. SEEDA's Regional Economic Strategy suggests pcc should be reduced to 135 l/h/day by 2015. The cost benefit of these aspirations was not considered.

1.6.4 Climate change

Water resources planning guidance[5] encourages the potential affects of climate change to be considered in preparing WRMPs. Key findings from the UKCIP09 work suggest that all areas of the UK will get warmer and that there will be little change in the annual precipitation but it is more likely to occur in winter with the summers becoming drier. The magnitude of this change is, however uncertain. The Environment Agency national Water Resources Strategy for England and Wales, "Water for people and the environment"[7]) also suggests that rainfall variability may be greater, and so though winters may become wetter on average, there may also be more extreme dry winters. Climate change will affect both the demand for water and the water available for water companies to use. It also needs to be considered in assessing which future supply-demand options will be most resilient.

WRMPs should address the probability that climate change will increase the frequency, duration, seasonality and magnitude of drought events.

An allowance for climate change has been included by all water companies in their WRMPs. Allowances can be included within three components of the WRMPs supply-demand forecast: within the demand forecast; as a reduction of existing source deployable output; or as part of the uncertainty allowance included as target headroom. The 2009 WRSE regional modelling includes allowances for climate change assumed by the water companies.

1.6.5 Energy use

Increased consideration of climate change has increased the focus on energy use in the water industry. Whilst the financial cost of energy has always been a significant component of the industry's operating and planning processes, the potential environmental costs associated with greenhouse gas emissions are now an

[6] Defra (2008) Future Water – The Government's water strategy for England

[7] Environment Agency (March 2009) Water for people and environment – Water resources strategy for England and Wales

important consideration. The increased focus on energy use extends not only to existing operations but is now a factor in the evaluation of potential new resource developments.

1.6.6 Environmental and social impact

The EBSD guideline[4] recognises the need to take environmental and social impacts into account when evaluating costs of different options. Environmental impacts can be valued in monetary terms in order that they can be added to, or subtracted from, other items with monetary value such as capital or operating costs. A number of techniques that exist for estimating the value that society has placed on the environment are summarised in The EBSD guideline[4]. It is also recognised that not all factors can be given a monetary value.

1.6.7 Environmental sustainability and the impacts of environmental legislation

The environmental sustainability of existing abstraction licences has been under review in recent years, partly because of new European Union (EU) and national legislative requirements. The Environment Agency is responsible for interpreting European environmental legislation, including the Habitats Directive and the Water Framework Directive (WFD). The Environment Agency's Restoring Sustainable Abstraction (RSA) programme considers whether reductions in existing abstraction licences might be needed for environmental reasons. Any required reductions are known as "sustainability reductions" within water resources planning work, wherein the reduction is quantified with respect to reliable outputs (DO) of the affected sources.

The Environment Agency informed water companies of known required sustainability reductions in advance of water companies preparing their draft WRMP in 2008. These reductions of DO are included in water company WRMPs and the WRSE regional modelling. Further details are given in Section 3.6.1.4

River Basin Management Plans have now been submitted to Defra and in SE England there are a number of water bodies identified as not currently achieving Good Ecological Status and cited as suffering from low flows, potentially exacerbated by abstraction. River Basin Management Plans identify further investigations of these problems. These investigations may identify further sustainability reductions that could be needed in future.

The water resources planning guideline[5] states that water companies should not plan for any further reductions beyond those that water companies have been informed of by the Environment Agency. Some water companies believe, however, that higher sustainability reductions are very likely to be required under WFD, resulting from the further investigations set out in River Basin Management Plans. These may be material to water resources planning. The WRSE regional modelling work has

explored a range of higher sustainability reductions than currently planned for, and which water companies believe they could face in future. Further details are provided in section 3.6.1.4.

Since the WRSE modelling work was undertaken, the Environment Agency has provided indicative future sustainability reduction scenario figures to some companies for consideration in assessing the potential impact of the WFD as part of their sensitivity analyses.

1.6.8 Providing 'best value' for customers

Ofwat is the economic regulator of the water industry. Its role is to ensure customer bills should not rise by more than is absolutely necessary. Therefore, a least-cost solution remains the focus for WRMPs and the WRSE regional modelling.

WRMPs and the WRSE regional modelling also seek solutions that provide 'best value' for customers. However a regional "least-cost" solution may not always align with an individual company's "least-cost" solution. Ofwat, the economic regulator of the water industry, will need to be involved in helping to decide how such a situation should be resolved equitably between companies involved in resource sharing schemes so that financial benefits are shared across all the customers involved, no customers are disadvantaged and security of water supply will be as expected. The way the regional modelling approach covers these issues is discussed in more detail in section 3.6.4.1.

1.6.9 Designation as an 'area of water stress'

The entire WRSE study area falls within a wider area that has been designated as an "area of serious water stress". Water companies in this designated area have been directed by Defra to consider compulsory metering as an option in their WRMPs. (The area of serious water stress was established for this purpose).

1.6.10 Economic prosperity

The South East is the most affluent area in the country and includes the country's capital, London. As such, the region makes an invaluable contribution to the country's economy. The provision of a reliable water supply system is essential to maintain the economic prosperity of the region and the country, although it is also important to recognise there are less-affluent areas within the South East, and that these must also have reliable water supplies.

1.6.11 Bulk transfer agreements

Over the years, water companies of the South East have introduced a number of schemes to increase the security of supplies by improving the connectivity between different WRZs, including some agreements between water companies. These existing inter-company agreements each have their own contractual periods, terms and conditions, including financial arrangements. The WRSE regional model looks at whether further shared resources or bulk transfers could be part of regional solution but it has also been used to explore roles of the existing arrangements.

1.6.12 Resource development constraints in the South East

There are many constraints on new water resource development in the South East. The Environment Agency has for many years not allowed an increase in abstraction from groundwater for consumptive purposes. Furthermore, high population density, and the designation of large areas of the South East as Areas of Outstanding Natural Beauty, significantly reduces the options available for new abstraction, storage, treatment and supply infrastructure. There are also few sites with suitable topography and geology that might be acceptable for new reservoirs.

Many water companies believe that all the appropriate strategic sites for potential development of new resources during the planning period, and possibly beyond, should be recognised and given the appropriate level of land use planning protection, provided they are socially, economically and politically acceptable and environmentally sustainable.

1.6.13 WRSE regional modelling and statutory processes

The WRSE regional modelling aims to provide information to aid preparation of water company WRMPs and Business Plans. The WRSE regional modelling became out of step with the statutory WRMP and Business Planning process as these processes became out of step with each other. This undoubtedly made it more difficult for water companies to incorporate the regional work in WRMPs and Business Plans. Figure 4 shows the sequence of WRSE regional modelling work that has been undertaken to date

2 Principles and intentions of the Water Resources in the South East group

2.1 Introduction

Seven water companies work together as the WRSE group: Southern Water; South East Water; Veolia Water Southeast; Portsmouth Water; Sutton and East Surrey Water; Veolia Water Central and Thames Water. The group is led by the Environment Agency with the engagement of Ofwat, Natural England, Consumer Council for Water, SEEDA and SEERA (now South East England Partnership Board).

The WRSE group accepts the importance of inter-company co-operation in strategic planning, as well as the need for consistency in the interface between water companies and regulators. The group is working towards the shared strategic development of water resources in South East England.

The development of a regional water resources investment model has been central to the work of the WRSE group. This modelling not only provides indications of potential least-cost regional water resource development strategy but also provides a focus for the discussion of supply demand investment options and water resources planning issues.

The group formed in 1996, originally with just the five (then)[8] Environment Agency Southern Region water companies, and identified four new bulk supply agreements for inclusion in water companies 1999 WRMPs and Business Plans:

- Southern Water to Veolia Water Southeast, formerly Folkestone and Dover Water (2 Ml/d);
- South East Water, formerly Mid Kent Water to Veolia Water Southeast, formerly Folkestone and Dover Water (2 Ml/d);
- Portsmouth Water to Southern Water (15 Ml/d); and
- Southern Water to South East Water (8 Ml/d).

These schemes were funded within Ofwat's determination of its 1999 Periodic Review (PR99) of water company Business Plans. The water companies agreed final terms and conditions, with engagement of Ofwat in some cases and the four schemes were implemented by 2004/5.

[8] Mid Kent Water and the former South East Water (individual companies at the time of the formation of the WRSE group) merged and now form South East Water.

The group agreed to pursue shared resource opportunities further in preparation for revising water resources plans in 2004.

2.2 Principles of the WRSE group

The results of the WRSE work between 2002 and 2004 had shown that there was no unique regional strategy identified on the basis of cost alone. A number of different combinations of schemes and timings could solve the regional supply-demand balance, including each of its WRZs.

The following general principles underlying the need for consistency in Water Resources Plans for PR04 supply were agreed in a Memorandum of Understanding in 2004 between the (then) five water companies operating in Environment Agency Southern Region. Those principles affecting supply side options were:

- The joint development, where appropriate, of major regional resources, mainly considered to be new or enlarged reservoirs; and
- Prior to the development of a regional resource, the provision of inter-company bulk transfers from existing resources or the development of local schemes.

It was agreed that consistency between water company's WRMP could be accomplished by, for planning purposes, all water companies agreeing and using in their 2004 plans:

- Common start dates for the introduction of regional resource schemes that would be jointly promoted and developed i.e. reservoirs;
- Common start dates for the provision of inter-company bulk transfers - water companies would need to state conditions and assumptions under which these transfers could be provided; and
- Making provision for further investigations required between 2005 and 2009 to refine the selection of options.

The WRSE group undertook a series of meetings during 2005 and 2006 to establish how to take the regional modelling work forward to help water companies prepare their statutory WRMPs, due in 2009. Principles and commitments were agreed through the WRSE Senior Management (Managing Directors) Group (See first yellow box). The Environment Agency and Ofwat also issued a joint position statement in March 2007 setting out their expectations (See second yellow box).

The three Environment Agency Thames Region water companies were formally included in the WRSE group and the regional modelling work in 2006, particularly to expand on the modelling representation of opportunities to transfer resources between those water companies and the Environment Agency Southern Region water companies. Thames Water had participated as an observer prior to 2006.

Ofwat and Environment Agency, WRSE strategy position statement.

We support the current primary objective of the WRSE group: to develop an efficient, sustainable, economic and robust strategy that meets the needs of customers and the environment. The group should work to this purpose within the framework of the statutory water resource planning process and PR09.

Options for further development of shared resources and / or bulk supplies should be proactively considered within the WRSE group effort.

We consider it possible that a regional solution can be found that is economically and environmentally more optimal than the sum of individual company plans. Potential regional and sub-regional solutions should be explored.

We recognise that any regional solution will have to have persuasive, equitable benefits if it is to be agreed to be advantageous over individual company preferences. However regional solution elements have been equitably included in previous Periodic Review determinations and we expect to be able to do this again.

We recognise that exploration of regional solutions will complement each company's individual water resources planning. If a regional or sub-regional outcome is not the outcome preferred in a company plan the company will need to explain its preference. Thorough exploration of regional solutions is just as fundamental to explaining why an individual company approach is preferable as it is to explaining why a regional solution is preferable.

If a regional solution is preferable, we hope the WRSE group effort will lead to companies recognising its merits as well. The Environment Agency could consider using its powers to direct companies to consider specific bulk supplies where it feels justified, but hopefully any such element of regional solution will be persuasive without needing to resort to this.

During the preparation of the strategy it will be necessary to achieve more consistency of data provision and assumptions across companies, recognising this may not be possible (or necessary) on all aspects. We do envisage a need to improve cost and other information on options. This needs some priority attention now. We will indicate the further declaration of option costs we believe necessary in order for the group to understand its eventual strategy properly. Companies may also like to suggest information that is necessary.

WRSE EBSD modelling effort contributed strongly to the development of strategy for PR99 and to the development of the 'further investigations' memorandum of understanding between the five Southern Region companies included in water resources plans and business plans in PR04. We anticipate this work can continue to help derive a shared strategy, though we recognise the modelling itself will not determine a strategy. Serious discussion of options and scenarios is also required.

Source: Paper to the Water Resources in the South East (WRSE) Managing Directors Group meeting, March 16th 2007,

In November 2006, the WRSE Managing Directors Group was asked to endorse that:

(i) ***The primary objective of the WRSE group is to develop an efficient, sustainable, robust strategy meeting the needs of customers and the environment;***

(ii) ***The further development of strategy is concerned with identifying and promoting the best use of future strategic resource development and demand management options. This will include exploring further shared resource and / or bulk supply arrangements;***

(iii) ***Strategy development must progress now and suit PR09 and statutory water resource planning timetables;***

(iv) ***The WRSE strategy work will cover all companies in Environment Agency Thames and Southern Regions, though the group recognises the discretion of each individual company to adopt the WRSE group findings;***

The technical group and it's sub-groups will progress formulation of a strategy for consideration by the Managing Directors group, by :

- ***technical review and discussion of the role and contribution of the various strategic supply-demand management options, aided by least cost options selection scenario modelling;***
- ***helping to progress resolution of water resources planning issues, so WRSE strategy can be formed to an agreed framework of assumptions.***

Source: 061113 WRSE Strategy Dev paper to MD's final.doc

2.3 Benefits of a regional solution

There are a number of benefits arising from the development of a regional strategy, including the following:

- It avoids the potential for the selection of mutually incompatible or even mutually exclusive schemes to be selected by individual water companies;
- It can avoid unnecessary developments being promoted by individual water companies which could result in the creation of excessive headroom, greater environmental impact and higher customer bills than necessary;
- It creates the opportunity to make the optimum use of limited resources, and realise any potential for economies of scale with minimum impact/cost; and
- Given intended equitable implementation of options identified within regional least-cost solutions, all customers involved in these schemes will benefit from lower bills.

The WRSE regional modelling work sets out to determine if, by sharing existing and future resources between water companies, it may be possible to derive a different permutation of resource developments and transfers and so arrive at a cheaper solution for the region as a whole. There are four underlying reasons why this should be possible:

- In some locations existing resources exceed forecast demand and required headroom, and so these surpluses can be transferred to locations where current or future resources are inadequate;
- Water companies' individual plans tend to create more surplus capacity, over and above that required to achieve target headroom;
- Future resource development needs can be better optimised when water company boundaries are ignored and a regional view is taken; and
- The regional model considers more options for transferring existing or future resources between WRZs and between water companies than water companies consider within their individual options selection.

Figure 5 highlights the fundamental water resource planning supply-demand balance concepts which the WRSE regional modelling work is based upon: existing available supplies may currently be and may continue to be in *surplus* over-and-above target headroom or surplus can be created in maintaining target headroom because the capacity of preferred schemes exceeds target headroom. Some of these surpluses can be large enough and persist for long-enough to present opportunities to share these resources to neighbouring WRZs within the water company or to other neighbouring water company WRZs. This can provide more economic solutions. Section 1 has shown that these surplus and deficit balancing opportunities exist across the WRZs of the study area within the current supply-demand balance. Section 4 discusses the current modelling and the opportunities that exist across the planning period.

The EBSD guidelines[4] and the water resources planning guideline encourage these options to be identified and investigated in preparing WRMPs. Where these opportunities exist between water companies, they could be pursued as shared

resource developments (shared investment and so, shared asset) or as bulk supply contracts between a donor and recipient company.

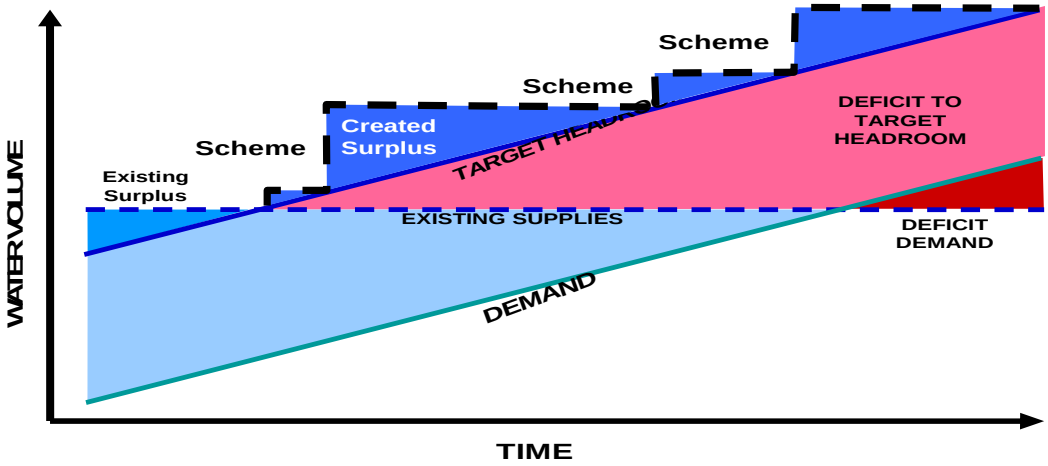

Figure 5: Supply-demand balance concepts

3 Development and application of the WRSE regional model

3.1 Introduction

The development and application of a regional water resources investment model has been central to the work of the WRSE group. It has helped to identify potential strategic options that can be integrated across the region for improving the security of the supply demand balance in a cost effective way.

This section outlines the conceptual basis of the model along with its development, evolution and application. It describes the inputs to the model relating to supply-demand data as well as the costs, capacities and constraints (if applicable) associated with the source and transfer options being considered. The treatment of planning assumptions such as the treatment of water company levels of service, target headroom, pcc and sustainability reductions are described. The planning scenarios explored by applying the model are summarised along with the key outputs from the model runs.

3.2 The Regional investment model

The WRSE regional model has been developed and applied to support the water resources planning process set out in the EBSD guidelines[4], mandated in the water resources planning guideline[5].

3.3 The role of the WRSE regional model

The role of the WRSE regional model within the EBSD planning process is illustrated in Figure 6. In its current form, the WRSE regional model identifies optimal sets of supply-side options to balance supply and demand, over the planning period, that are least-cost whilst meeting the requirements and satisfying the constraints of the water resource planning process across the WRSE region. The WRSE model does not consider demand side measures or wider benefits that may accrue from such options but it could be developed to do this in future.

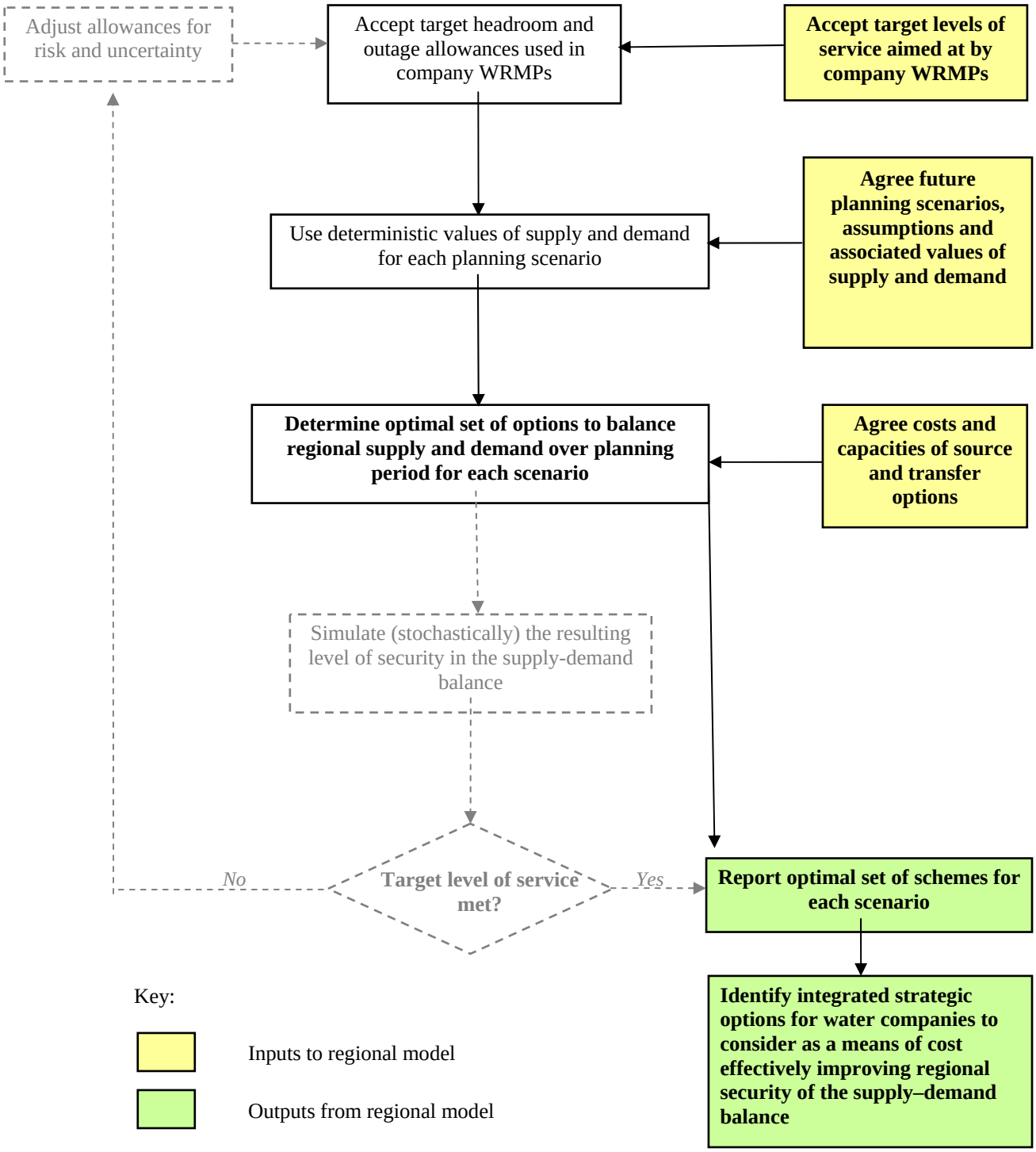

Figure 6: The WRSE regional model and EBSD

The process applied to regional planning, within the WRSE regional model, is derived from the EBSD 'intermediate level' water resources planning process described in the EBSD guidelines and report[4], and is (at this stage) a partial implementation of the 'intermediate level' planning process. That is, the latest WRSE regional modelling work remains a supply-side least-cost optimisation, with the resultant optimal set of schemes reported on a scenario by scenario basis, with a common target headroom allowance used across all scenarios. Furthermore the WRSE regional modelling work has not yet implemented the (stochastic) simulation to determine the resulting level of security in the supply-demand balance.

However, Halcrow has previously carried out some work developing and testing a Monte-Carlo simulation capability that can be used in conjunction with the regional optimisation model and so aim to address (at least some of) the stochastic concept of the 'intermediate' level planning process set out in the EBSD guidelines. This work was exploratory, and it involved tests at 'proof-of-concept' level that:

- derived generalised probability distributions of headroom uncertainty based on data supplied by water companies;
- applied these to supply and demand values in a regional model solution set; and
- explored (using Monte-Carlo simulation) the effect of this uncertainty on the potential likelihood and severity of imbalances between supply and demand.

This work is described in the 2005 WRSE EBSD Modelling Phase 2 report by Halcrow. This further step of EBSD intermediate level approach has not been carried out in the latest work but could be in future.

The influence of varying target headroom by a fixed proportion of the water company value across all WRZs has also been explored in earlier work in 2004-2005. The WRSE regional model was applied to explore the cost implications at a regional scale of varying target headroom thereby (assumed) increased or decreased level of supply-demand security over the region as a whole was explored. This exercise provided insight into the trade-off between cost and reliability of supply at a regional scale with respect to influence on the options selected and the overall solution costs. This aspect has not been revisited in the latest work but could be in future.

3.4 Construction of the WRSE regional model

The WRSE regional model has been constructed within MS Excel™ using an optimisation software package *WhatsBest!*, developed by Lindo Inc. The same software has been used by several water companies (including Southern Water and South East Water) to aid the preparation of their individual company WRMPs.

3.5 Formulation of the WRSE regional model

The WRSE regional model derives a least-cost optimal solution (from a set of potential supply-side schemes) that balances available supplies with demands to ensure that a supply-demand balance can be maintained across the WRSE area and in each WRZ throughout the entire 25-year planning period (2010 – 2035), under both DYAA and DYCP conditions, for a specified planning scenario.

At the core of the model, there are two types of equation:

- an *objective function, that* guides the model to minimise the aggregate cost of the options it brings into the solution set (described in more detail in Section 3.6.5.4); and

- *constraint equations* that force the solution to both satisfy the planning requirements (including scenario assumptions) and to meet the physical constraints within which a water balance must be found.

The *objective function* drives the model to identify a mix and sequence of schemes whose implementation would be at a minimum cost across the region as a whole by minimising the total cost (CAPEX and OPEX) of all the new sources and bulk transfer links brought into the optimum set of schemes. The way in which costs are represented in the model is described in Section 3.6.5.

The fundamental physical constraint in water resources planning is to balance supply and demand (see Figure 7). The supply-demand balance is calculated at annual time steps throughout the planning period. The model solves the supply-demand balance for each year by selecting new resource and / or transfer schemes when necessary on the basis of their cost and availability.

The model is formulated to select an option set that matches supply with demand values for both DYAA and DYCP conditions in a single run of the model. This approach has been shown to be computationally more efficient than running the model first to derive separate DYAA demand and DYCP demand solutions. It also provides single solution to both scenarios rather than independent solutions to each.

In addition to the water balance constraints, an additional constraint has been applied on resource development and transfer options. This constraint has been termed a "ratchet". This prevents reductions in DO from resource, or of flow in a transfer in succeeding years once they have been selected by the optimisation model. This is intended to prevent the model from choosing "interim" solutions which then fall into disuse later when a preferred scheme (which could not be implemented earlier due to constraints on its earliest start date) can be implemented. The ratchet constraint has been applied to resource development options and inter-company transfer options in all the scenarios that have been modelled. It has not been applied to transfers between water resources zones of the same company.

The current version of the model has not considered the economic selection of demand management options. It has used the final planning demand management schemes assumed by the water companies, embedded in the demand forecasts applied as input data to the model. However, on a scenario basis, alternative demand forecasts have been modelled, thus implicitly including different levels of demand management (metering, tariffs, leakage control and water efficiency). These alternative forecasts have not been explicitly costed but their basis is discussed in section 3.6.1.2 and their overall cost implications are discussed in section 4. The results of the alternative demand forecast scenarios have been used to place a value on the implicit demand management measures in terms of the resultant saved resource development investment. In the future, the model could be developed to include demand management options as part of the least-cost options selection.

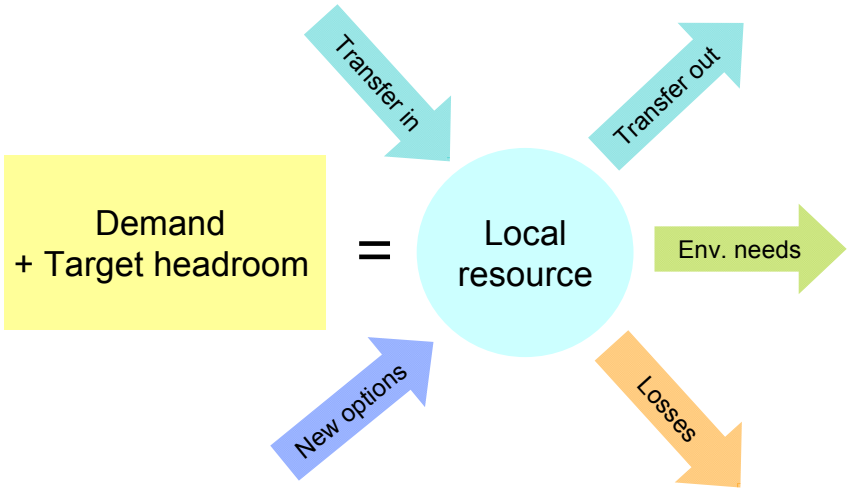

Figure 7: Conceptual structure of the water balance equations in the WRSE regional model

3.5.1 Purpose of the model

The WRSE regional modelling work carried out between 2006-2009 was not intended to provide a single, definitive solution that should override the more detailed modelling work of the individual water companies. However, by investigating a number of different scenarios, for example alternative demand forecasts or more severe sustainability reductions, in the modelling work, it should be possible to identify those schemes which are most commonly selected across a range of scenarios. The results from the modelling also identify the most frequently selected ways of allocating or sharing such resource developments thus creating potential building blocks for a regional solution. Though of course, some scenarios may be considered more important or more realistic than others.

It has been intended that individual water companies and the WRSE group further explore these schemes and that water companies work together to investigate and secure shared resource or bulk supply schemes. In this way, the results of the WRSE regional modelling work should be used to inform the formulation of the individual water company's strategy and further work by the individual companies should feed into the regional modelling. In this way a single strategy could emerge over time.

3.5.2 Development of the WRSE regional model

The development of the current (2009) WRSE regional model was commissioned in 2003. It was first built in 2004 and has since been refined, in phases, in response to Periodic Reviews and other events (as indicated in Figure 4).

Key milestones in the evolution of the WRSE regional model were as follows:

- 1998-1999 – Environment Agency Southern Region and its (then) five water companies developed a regional water resource planning model (RESPLAN) in collaboration with consultant, Chris Page. A preferred regional solution was identified. This was fed into the finalised company WRMPs. The bulk transfers that featured in the agreed solution received funding from Ofwat and were thus scheduled for implementation by water companies between 2000 and 2004;
- 2003 – Following the publication of EBSD framework, the Environment Agency commissioned Halcrow to implement the EBSD intermediate framework in the regional context;
- 2004 – 2005 - A regional water resource options selection model was constructed and populated with PR04 water company data. Model results formed a basis for the Memorandum of Understanding signed between water companies in 2005;
- 2006 – 2007 – The WRSE regional model was updated with PR09 options and input data and scenarios were run to explore prospects for further regional cooperation;
- 2008 – The WRSE regional model was expanded to include the three water companies of Environment Agency Thames region;
- 2008 – Draft WRMP data was included in the model and model scenarios were run; and
- 2009 – Statement of Response data and/or Final Business Plan data included in the model and model scenarios were run. It should be noted that water companies were asked to submit their most up to date data in Spring 2009. The status of this data varied across water companies dependent upon where they were with regards to their WRMP.

Table 5 lists the reports Halcrow produced in the course of the above modelling work.

3.5.3 Schematisation of the model

The WRSE water companies are divided in to 31 WRZs (See Table 6), out of which 25 are included in the regional model (See Figure 8). The remaining six WRZs were considered to be less integrated with the rest of the South East region and were not included in the current model. This assumption could be revisited in future development of the model.

Table 5: Halcrow reports / technical notes list

	Title	Type of document	Date
1	Evaluation of Water Resources for SE England	Report	1998
2	WRSE EBSD Modelling Phase 1 report	Report	2003
3	WRSE EBSD Modelling Phase 2 report (including model user guide)	Report	2005
4	WRSE additional modelling in response to Barker report	Technical note	2005
5	Bewl-Darwell testing	Technical note	2005
6	Further exploration of "ratchet" setting	Technical note	2006
7	Halcrow assessed costs for transfer options	Technical note	2007
8	Model runs scenarios and results October 2006 – March 2007	Technical note	2007
9	Model update and run time review	Technical note	2007
10	Cost calculation	Technical note	2007
11	Preliminary WRSE regional options selection modelling for PR09	Report	2007
12	Cost consistency review	Report	2007
13	London Growth Cost	Technical note	2008
14	Residual Cost	Technical note	2008
15	WRSE PR09 shared water resources strategy for the South East regional options selection model extension and scenario runs 2007/08	Report	2007
16	Cost consistency review	Report	2008
17	Independent technical review of the formulation and structure of the regional model	Technical note	2009
18	Sensitivity tests and robustness analysis of the regional model	Technical note	2009
19	Cost consistency - review of the detailed costs of a sample of the options presented by Southern Water and South East Water	Report	2009
20	Model cost data summary	Technical note	2009
21	Clarification of costs included in the regional model	Technical note	2009

Table 6: Water company WRZs

Water company	WRZ	WRSE representation
Southern Water	Hampshire South	Included
	Hampshire Kingsclere	Not included in the model as very small and not inter-connected in company strategy
	Hampshire Andover	
	Isle of Wight	Included
	Sussex North	
	Sussex Worthing	
	Sussex Brighton	
	Sussex Hastings	
	Kent Medway	
	Kent Thanet	
South East Water	RZ1	Included
	RZ2	
	RZ3	
	RZ4	
	RZ5	
	RZ6	
	RZ7	
	RZ8	
Veolia Water Southeast	Company wide zone	Included
Portsmouth Water	Company wide zone	Included
Sutton and East Surrey Water	Sutton	Included and combined as one zone
	East Surrey	
Veolia Water Central	Central	Included and combined as one zone
	Northern	
	Southern	Included
Thames Water	London	Included
	Swindon and Oxfordshire	Included
	Henley	Not modelled, as considered isolated from, and not relevant to, regional considerations
	Guildford	
	Kennet Valley	
	Slough, Wycombe and Aylesbury	

Following discussion between water companies and the Environment Agency, the Sutton and East Surrey WRZs, and the Central and Northern (Veolia Water Central) WRZs, were combined (as indicated in Table 6). These assumptions could be revisited in future development of the model. In particular it may be necessary to model both of Sutton and East Surrey Water's WRZs in future to better understand the opportunities for the company to participate in the regional solution economically.

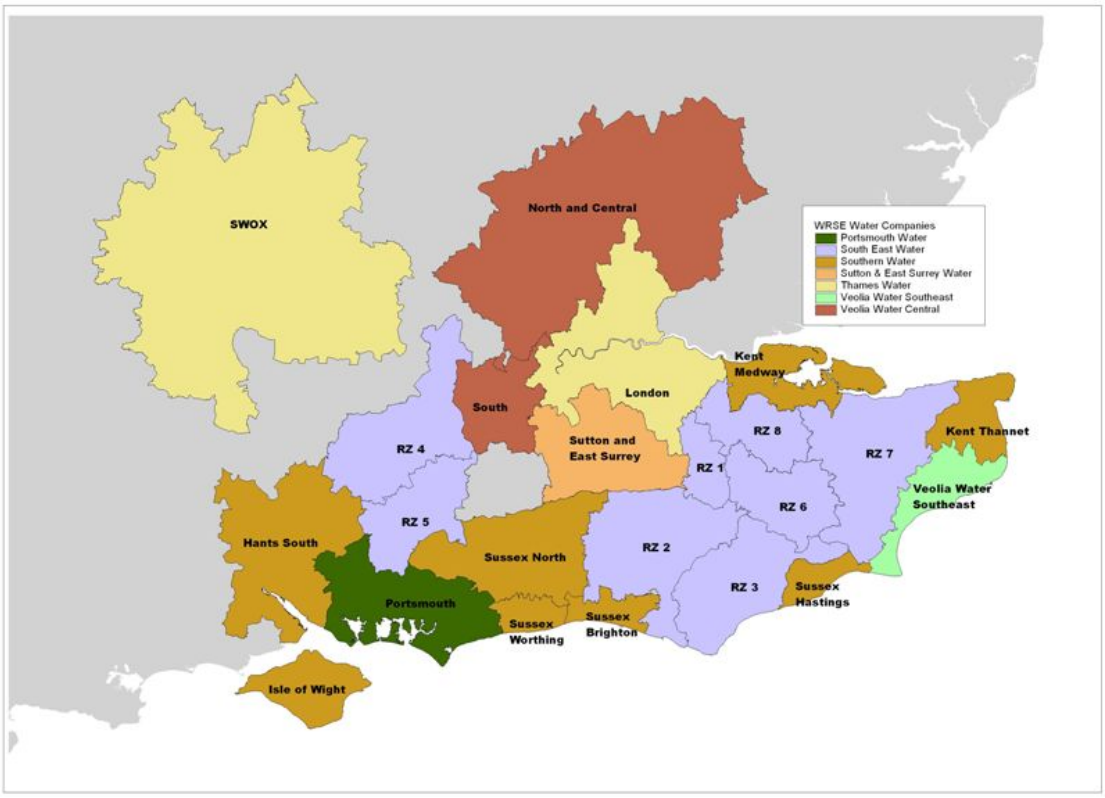

Figure 8: Map to show WRZs included in the WRSE regional model

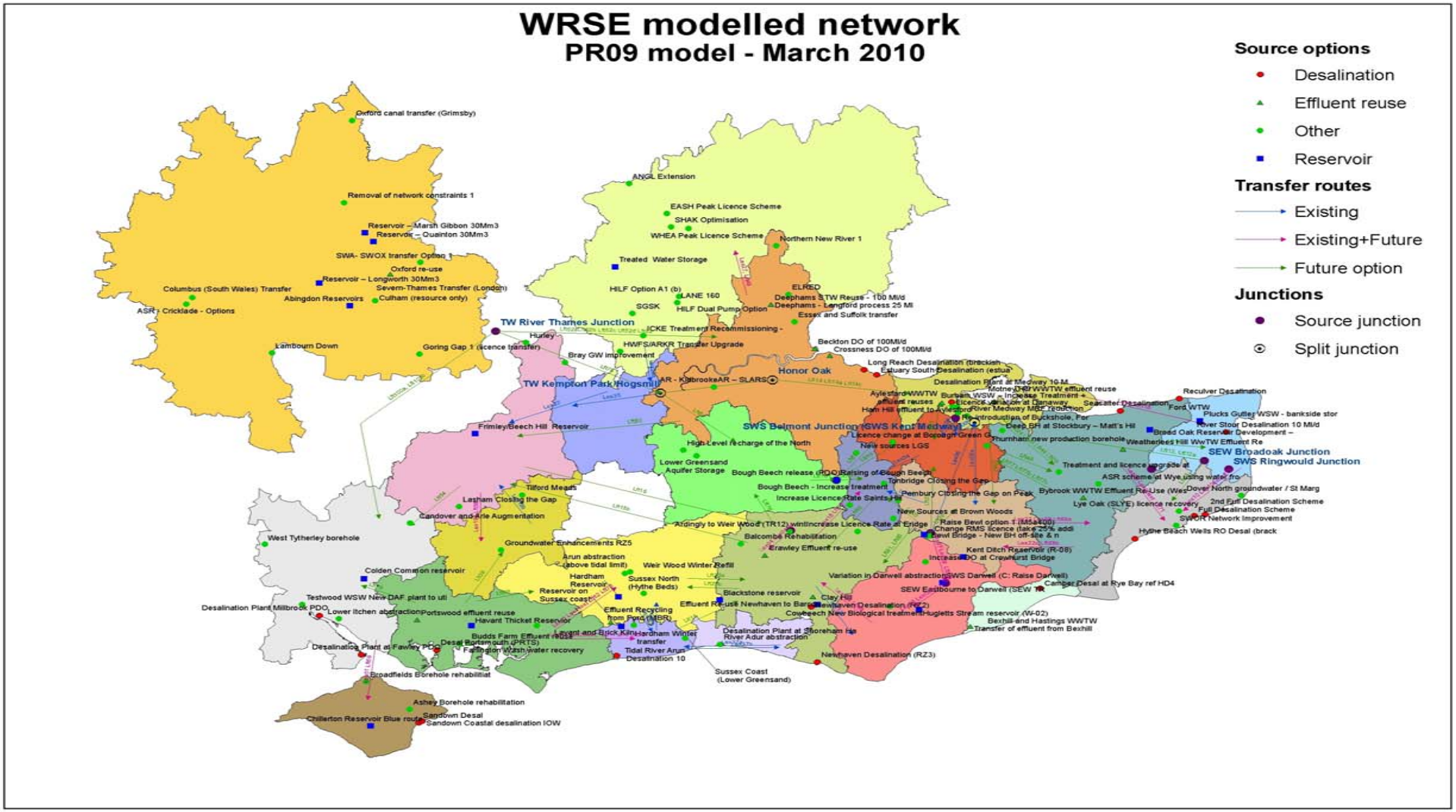

Figure 9: WRSE regional model network diagram

3.5.4 Application of model

The base case input data is provided by the water companies and has been subject to consistency checks by the Environment Agency and Halcrow. It is assumed that, as the data is provided by the water companies, these data should be consistent with that used in the water resources modelling carried out by the water companies themselves.

The WRSE regional modelling work requires iteration to and from the models/data updates of the water companies and the WRSE regional model/data. The process comprises:

- A 'bottom-up' approach, whereby the water companies provide updates of their data, and feasible company "options" for use in the WRSE regional model, together with indication of the individual company-preferred solution;
- A 'top-down' approach, whereby Halcrow, on behalf of the Environment Agency, runs the WRSE regional model, who in turn feeds back the regional results to the water companies for comparison/use within their models;
- Working between these two approaches to progress towards an integrated solution; and
- The Environment Agency has also written to the water companies suggesting options the company could consider in working toward a regional solution.

The application of the WRSE regional model has included scenario analyses to explore the implications of different future planning assumptions and conditions on the schemes selected. Scenario analysis is also a means of indicating the robustness of a given solution under alternative underlying assumptions.

Some of these scenarios involve some adjustment to the base case data. These adjustments have been made by the Environment Agency or Halcrow and have been presented to the water companies for agreement. Scenarios of alternative sustainability reductions have involved the water companies providing different assumptions (section 3.6.1.4).

In addition, sensitivity analysis has been carried out by varying selected input data (such as changes in DO and sustainability reductions and the potential loss of sources affecting supply data; and changes in forecast demand as a result of metering; more efficient water use; and new tariff structures). By re-running the model using these variations, the implications of such changes can be assessed and resulting savings in supply-side investment have been used to highlight the potential value of investment in demand management measures.

3.5.5 Base case assumptions

The base case data was provided by the water companies and is consistent with the latest data available in Spring 2009 (Statement of Response to Final Business Plans). The data should be based on the Environment Agency's water resources management planning guideline:

- Demand - This represents final planning demand, therefore taking into account forecast pcc, the forecast populations and households, leakage and also the benefit of demand management schemes the company is implementing as part of its individual preferred solution;
- Sustainability reductions - The sustainability reductions that were included in the Environment Agency PR09 National Environment Programme as advised to water companies to include in their WRMP. These reductions are listed in appendix 5;
- DO- Baseline DO including any committed schemes;
- Outage*;*
- Other losses (for example process losses) were also included;
- Target headroom*;* and
- Climate change allowances*.*

3.6 Model inputs

3.6.1 Supply-demand data

3.6.1.1 Deployable Output of existing sources

In the base model runs, existing sources were modelled using DO values provided by water companies consistent with the most up to date data in Spring 2009. DO data was provided both with climate change allowances(WCC) and without climate change (NCC) to allow sensitivity tests to be carried out.

The Environment Agency's review of the WRMPs had highlighted differences in DO design event severity between water companies. As a consequence, the Environment Agency created two scenarios, for regional modelling purposes, to reflect what might result if all the water companies used the same severity of event. These two scenarios are:

- 1 in 50 year return period DO with climate change; and
- 1 in 100 year return period DO with climate change.

These Environment Agency constructed scenarios are recognised to include a number of assumptions and judgements, although some analytical information was also used. They are only intended to provide a 'direction of travel' indication of the DO of the chosen severities and are considered to provide a useful initial modelling test of this issue, although the source by source DO assumptions in these scenarios should not be used in any definitive way. These two scenarios are also only 'nominal': there is no expectation in current guidance that water companies should have planned to one or the other, or tested either. These constructed scenarios can be found in Appendix 2.

3.6.1.2 Distribution input (DI) and per capita consumption (pcc)

Demand was represented in the WRSE regional model using final planning distribution input data provided by the water companies. In order to explore the impact of alternative demands on the regional solution, the Environment Agency constructed three alternative demand datasets. These were based on applying alternative pcc assumptions at year 2030:

- "130 pcc" – 136 l/h/d pcc with company housing growth 2008;
- "145 pcc" – 152 l/h/d pcc with company housing growth 2008; and
- "160 pcc" – 168 l/h/d pcc with company housing growth 2008.

In each scenario the assumed pcc was applied at year 2030 in each WRZ, with a linear trend applied from year 2010 pcc. In constructing these scenarios the Environment Agency have acknowledged that Defra's Future Water pcc aspiration of 130 l/h/d was a "normal" year figure and so an 'uplift' factor was applied to form the dry year demand scenarios explored in the model. The assumed uplift factors and resulting dry year pcc figures are summarised in Table 7.

Table 7: Uplift factors used to calculate alternative demand scenarios

Normal Year PCC	Normal year to DYAA uplift factor	DYAA PCC	DYAA to DYCP uplift factor	DYCP PCC
130	1.05	136	1.25	170
145	1.05	152	1.25	190
160	1.05	168	1.25	210

These data sets were constructed using housing and population growth forecast reported in draft WRMPs (see Appendix 3). The alternative demand forecasts constructed by assuming different pcc at 2030 have a different effect on a water company and individual WRZ level due to the degree of change in trends relative to water company forecasts. Table 8 summarises the assumed differences in dry year demand that result in the alternative DYAA and DYCP demand forecasts at year 2030, for each company. Appendix 3 provides further detail of this comparison at

resource zone level. The Basecase figures in Table 8 and Appendix 3 are from water companies Spring 2009 data. The other demand scenarios shown in Table 8 and Appendix 3 were constructed by the Environment Agency using the housing and population data provided by water companies in their draft WRMPs. The Environment Agency did not update the scenario forecasts with respect to any revisions water companies' made to their forecasts of housing and / or population within their Spring 2009 data. The Environment Agency considered these changes to be marginal relative to the scenario assumptions about pcc. (Previous modelling in 2007 and 2008 did explore alternative demand forecast scenarios which included alternative housing growth assumptions).

Table 8: Comparison of different forecast demand for year 2030/31 (Ml/d)

Distribution input at 2030/31 in the following scenarios:	Basecase		136 l/h/d pcc		152 l/h/d pcc		168 l/h/d pcc	
	DYAA	DYCP	DYAA	DYCP	DYAA	DYCP	DYAA	DYCP
Southern Water	567	696	543	624	581	671	618	716
South East Water	619	787	546	666	580	709	624	749
Portsmouth Water	192	260	156	186	167	199	178	213
Veolia Water Southeast	39	45	42	48	45	51	48	55
Thames Water	2138	2217	2105	2161	2236	2296	2584	2431
Veolia Water Central	849	1014	816	940	869	1006	922	1072
Sutton and East Surrey	174	260	145	174	155	187	166	200

3.6.1.3 Target headroom

Target headroom data provided by water companies as presented in Appendix 4 was used in all model runs. For all WRZs except SESW, the target headroom values were the same for WCC and NCC scenarios.

For Southern region, the increase in total target headroom from 2009/10 to 2034/35 is 45% (DYAA) and 52% (DYCP). The increase in target headroom is much greater for Thames region: 84% (DYAA), 78% (DYCP).

The WRSE regional model does not vary target headroom for each scenario run to take account of the uncertainty associated with the different assumptions applied. The modelling undertaken by some of the water companies has assessed the implications of varying headroom allowances. The Environment Agency regards the water companies target headroom estimates as a reasonable allowance across the range of scenarios that have been considered in the WRSE regional modelling but acknowledges that target headroom should ideally, and if practicable, be re-evaluated on a scenario by scenario basis.

All the scenarios explored in the WRSE regional modelling work have satisfied the target headroom assumed by the water companies to be necessary in their WRMPs, subject to the commentary in section 4.1.2 concerning residual deficits in some scenarios. The regional solutions and the individual water company solutions provide surplus resource above target headroom. Regional solutions generated by the model tend to include less surplus above target headroom, because water is transferred from areas of surplus to areas of deficit. The WRSE regional modelling approach identifies more optimal solutions but they are not perfectly optimal in that they still include surplus over and above satisfying target headroom. The reasons for sub-optimality of regional solutions are two-fold:

- lack of inter connectivity between WRZs for distributing surpluses between them; and
- technical constraints on scheme start dates preventing selection of schemes in a more optimum way.

3.6.1.4 Sustainability reductions

In the future water companies may have to reduce abstraction in places where it is proven to be causing environmental damage. These reductions are known as sustainability reductions. In all base runs, the WRSE regional model has allowed for the sustainability reductions that were included in the Environment Agency PR09 Environment Programme as advised to water companies as they prepared their draft WRMPs. The Environment Agency only advised companies of reductions it was certain of and to be implemented by 2015. SWS Hampshire has the largest sustainability reduction, which accounts for over 50% of the regional overall sustainability reductions currently included in the model.

The Environment Agency has stated that water companies should not include further future sustainability reductions in their WRMPs beyond those that it has specifically told water companies about as explained above. It has told water companies that it would give them sufficient time for them to plan for any future sustainability reductions should these be confirmed to be needed. The Environment Agency recognises this means the cost implications of longer term requirements are not included in company investment plans or prices to customers but believes this is a better approach than including allowances that would be too speculative at this time. Water companies requested the opportunity to model the impact of potential higher future sustainability reductions so that the potential longer term effect on customer bills could be assessed and to provide information to help customers offer an opinion on affordability. The Environment Agency does not have sufficient information to create a realistic scenario of any future potential reductions. The water companies were therefore invited to provide their own assessments of future potential reductions for these scenarios. Hence, the figures used for these scenarios of higher potential future sustainability reductions are based on individual water companies' views of the likelihood of these reductions occurring in their supply area. These views may not be consistent between water companies.

Two scenarios were set up to explore the impact of higher and more severe sustainability reductions on the regional solution. These were:

- Scenario A: Higher sustainability reduction; and
- Scenario B: Severe sustainability reduction.

Scenario A includes sustainability reductions that total 3% of existing resources in 2034/35. Scenario B is termed severe as it includes sustainability reductions corresponding to 14% of existing resources in 2034/35. These reductions are far greater than those required to date. The figures included in Scenario B are speculative. They were suggested for inclusion as a WRSE modelling scenario by the water companies, not the Environment Agency. (Subsequently the Environment Agency has provided some similar indicative 'worst-case' figures to some companies for their own scenario work).

A further two scenarios were run using sustainability reduction scenario A and B as described above but combined with the 168 pcc demand dataset to apply greater supply demand stress. (If more sustainability reductions are required, demand management should be considered alongside resource development. However, in solving these modelling scenarios the model has only used resource development options).

Base-case sustainability reductions were also affected as a consequence of the development of the other scenario datasets below:

- 1 in 50 yr: sustainability reduction associated with 1 in 50 yr DO estimate of existing sources (Environment Agency estimate based on base scenario); and
- 1 in 100 yr: sustainability reduction associated with 1 in 100 yr DO estimate of existing sources (Environment Agency estimate based on base scenario).

A comparison of these sustainability reduction data sets by WRZs is shown in Appendix 5.

3.6.2 Options

The WRSE regional model comprises of 164 resource development options and 96 transfer options. Table 9 summarises these modelled options into different types and summarises the different mixes of options offered to the regional modelling by each company. These options represent the water company's collective feasible options lists. There are, however, transfer options which do not feature in the water companies feasible options list but have been included in agreement with the water companies with costs provided by the water companies or shared with the water companies following estimations by Halcrow. (The few remaining Halcrow-derived costs have been accepted by companies as suitable initial estimates). For the Thames Region alternative options sensitivity some very approximate costs were provided by the Environment Agency.

There are options in the model which, in the main scenarios, were switched off and were therefore unavailable to the model. These options were included for the purpose of sensitivity runs. Appendix 1 describes these options.

Table 9: Options included in the model (includes options that are default off – see Appendix 1)

Resource development or transfer options											
Water company	**Data**	**Desalination**	**Effluent reuse**	**GW / ASR**	**Other**	**Reservoir**	**River abstraction**	**Transfer**	**Transfer from outside the model boundary**	**WTW**	**Grand Total**
	Number of options			5		1	2	1	1	3	**13.0**
3V	ADO (Ml/d)			15		0	10	17	36	27.5	**105.5**
	PDO (Ml/d)			49.63		9.14	70	27	44	40.5	**240.3**
	Number of options	3		2	1			5			**11.**
F&DW	ADO (Ml/d)	15		5.04	0.735			12.19			**33.0**
	PDO (Ml/d)	15		4.33	0.735			17.08			**37.1**
	Number of options	1	2	1	1	1					**6.0**
PRTS	ADO (Ml/d)	25	47	5.2	4.4	23					**104.6**
	PDO (Ml/d)	25	47	5.2	4.8	30					**112.0**
	Number of options			2	3	1		3		1	**10.0**
SESW	ADO (Ml/d)			0	15	9.2		44.2		0	**68.4**
	PDO (Ml/d)			10	17	0		35		25	**87.0**
	Number of options	4	5	20		6		34		2	**71.0**
SEW	ADO (Ml/d)	29.95	31.2	43.21		108.09		370.61		4.5	**587.6**
	PDO (Ml/d)	34.4	31.2	72.29		182.38		423.51		7.8	**751.6**
	Number of options	15	12	9	1	11	7	20	3	6	**84.0**
SWS	ADO (Ml/d)	216	122.3	29.23	1.7	84.09	90	339	3.5	91.5	**977.3**
	PDO (Ml/d)	294.3	133.5	44.85	0	64.83	115	339	3.5	91.5	**1086.5**
	Number of options	3	7	12	1	13		13	16		**65.0**
TW	ADO (Ml/d)	215	465	57.8	4.9	1939.5		1267.5	454.53		**4404.2**
	PDO (Ml/d)	215	465	79.22	4.9	1841.5		1295.5	156.53		**4057.7**
Total No. of options		**26**	**26**	**51**	**7**	**33**	**9**	**76**	**20**	**12**	**260**
Total ADO (Ml/d)		**500.95**	**665.5**	**155.4**	**26.73**	**2163.9**	**100.0**	**2050.5**	**494.0**	**123.5**	**6280.6**
Total PDO (Ml/d)		**583.7**	**676.7**	**265.5**	**27.43**	**2127.9**	**185.0**	**2137.1**	**204.0**	**164.8**	**6372.1**

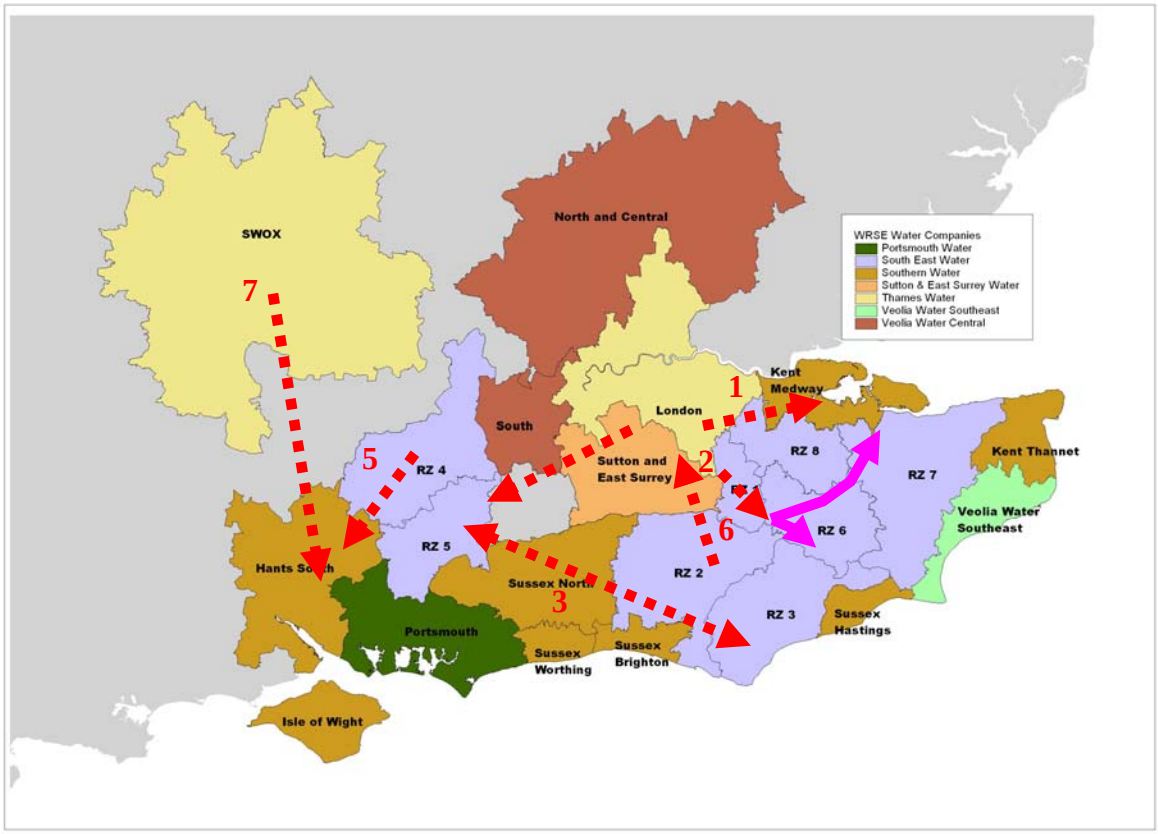

Figure 10: Inter-regional transfers in WRSE regional model

The following new inter-regional (Thames region – Southern Region) transfer options were included in the WRSE regional model. These are shown by the red arrows in Figure 10:

1. Honor Oak (TW London) reservoir to Burham water treatment works (SWS Kent Medway);
2. Bough Beech reservoir (SESW) to SWS and/or SEW via (i) River Medway or (ii) new transfer pipelines;
3. SEW Northern Zone to SEW Mid Sussex;
4. Additional abstraction at Bray (Stage IV) – dependent on additional resource from Thames Water;
5. SEW Northern Zone to SWS Hampshire;
6. SEW (Whitely Hill service reservoir) to SESW; and
7. Upper Thames reservoir (UTR) to SWS Hampshire

3.6.3 Existing bulk transfers and extensions

A number of inter-company transfers of water, which take place under conditions stated in the relevant bulk supply and shared resource agreements between respective water companies, have been developed over the last 50 years. The WRSE regional model includes these bulk supplies and also the option to extend these agreements. The existing shared resources and bulk supply arrangements included in the model are summarised below (note the model also includes the option to extend each individual bulk supply agreement to the end of the planning period). The WRSE group approach has encouraged exploring the further potential for bulk transfers in the regional model, while it has also explored the planning scenario utilisation of the existing agreements (See section 3.5).

- Weir wood reservoir to South East WRZ 2;
- Darwell reservoir to South East Water resource zone 3;
- South East WRZ 8 to Veolia Water Southeast;
- Southern Water Kent Thanet to Veolia Water Southeast;
- Portsmouth Water to Southern Water Sussex North; and
- Portsmouth water to Southern Water Sussex Coast

In practice, the volumes to be transferred in bulk transfers are agreed between water companies and are set out in contracts. However, in modelling exercises in previous years, the model runs showed some unrealistic results when existing bulk transfers were represented in this way: in some situations the model was creating deficits in host water company WRZs in order to supply the constant bulk supplies to receiving water company. Therefore, in the 2009 modelling runs, the normal setting is to allow regional model to be free to select the volume transferred through bulk transfers each year between water companies (except in one sensitivity test – Scenario 15). (However, sensitivity to this normal setting has been explored).

The 'ratchet' constraint (section 3.5) has been applied on extension of existing bulk transfers.

3.6.4 Option Costs

Water companies have been asked to provide a full breakdown of the costs of each option to be considered by the WRSE regional model. The cost data template sent to water companies to gather cost data is presented in Appendix 6.

A breakdown of costs was requested under the following headings to understand consistency between water companies in the way in which costs were estimated and provided for use in the modelling work, although not all of this information was available for all of the options:

- Option investigation and feasibility;
- Design, planning and promotion costs;

- Capital costs (CAPEX), broken down into main elements:
    - Source works;
    - Treatment;
    - Pumping stations;
    - Service reservoirs; and
    - Capital distribution and improvements.
- Operating costs (OPEX), broken down into fixed and variable components but excluding tariff charges (e.g. margin) made by a company in exporting water to another company;
- Environmental and social mitigation;
- Carbon cost; and
- Other environmental and social costs.

The EBSD Main Report[4] specifies that the following cost categories can be included in the optimisation model within the EBSD planning process:

- Financial costs – these include the various categories of capital and operating expenditure (i.e. elements of CAPEX and OPEX) that are incurred as a result of implementation of the option;
- Environmental costs – arising from environmental impacts, positive or negative, that the option might have; and
- Social costs – arising from the loss in enjoyment caused by the option.

The water companies provided the best option cost data they could at the time of data submission to the regional modelling work.

3.6.4.1 The economics of resource sharing or inter-company bulk supplies.

The WRSE regional model treats capital and operating costs for each option in a manner that is consistent with the way they would be treated if they were within a single water company, deriving a least-cost solution to balance supply with demand. Hence, the WRSE regional model identifies a least-cost solution by treating the South East region as though it were under the jurisdiction of a single water company.

A regional "least-cost" solution may not always align with each individual company's "least-cost" solution. For example:

(i) The regional model might select a transfer from company B to resolve a deficit in company A because the combined cost of this solution across company A and company B is cheaper than the company A and company B solutions when derived individually, without the transfer selected.

However, company A will have a least cost solution from within its own options, so it will not want the transfer based solution to be more expensive than its within-company solution, otherwise its customers would be disadvantaged.

(ii) The regional model might select a large scheme from company C's options that helps solve a deficit in another company or companies. It may choose this in preference to one of company C's smaller cheaper schemes which would have been sufficient to solve company C's deficit alone. Company C will not wish to incur costs greater than those it needs to incur to solve its own deficit, so it will want appropriate cost sharing or bulk supply income from the other companies if it develops its larger option to share with them or to provide bulk supply.

The current WRSE regional modelling approach identifies least-cost supply-side solutions including resource sharing opportunities between companies. In identifying these solutions across companies the regional model identifies least-cost solutions of benefit to the customers of all of the companies involved in these resources sharing opportunities. The philosophy of the WRSE approach is that opportunities identified in the regional modelling should be negotiated by the companies involved with the intention that costs are apportioned so that the lower-cost benefits of the regional solution are shared by the companies involved. The expectation is that no customers will be disadvantaged as a result. All customers should benefit, recognising that the negotiations need to balance good value and security of water supply for each individual company's customers within the agreement of terms. Ofwat, the economic regulator of the water companies, will need to be involved in helping to decide how such terms should be resolved equitably across companies and their customers.

The capital costs of any resource development necessary to provide or maintain a bulk supply or shared resource are already included in the model, as are the costs of the main new infrastructure to facilitate the transfer and all the operating costs of these facilities. However, all of the ancillary infrastructure costs of moving surpluses within a resource zone to or from the point of transfer may not yet be included in the modelled costs because companies need to look at these aspects further. Also some of the operating costs of utilising *existing* supply surpluses for transfer are only modelled nominally. These costs need to be understood and should be considered in further regional modelling work.

In the context of bulk supply transfers, the profit margin that one company may seek to charge another when providing a bulk supply falls outside the scope of the costs envisaged in Stage 10 of the EBSD planning process (as described in the EBSD Guidelines[4]), but can be taken into account in Stages 12 and 13 of the planning process. The regional modelling work accommodates EBSD Stage 10 but it has not yet tried to account for Stages 12 and 13: the profit margin element of a schemes costs. The model assumes all existing bulk supply transfers continue to the end of the planning period or until the end of the bulk supply agreement. Where these end within the planning period, the model has the option to extend the existing bulk supply to the end of the planning period within its selection of the least-cost regional solution.

The Environment Agency expects any profit margin to be small in relation to the direct capital and operating costs associated with a bulk supply scheme that are already included in the WRSE regional modelling least-cost calculations. However the inclusion of a profit margin in the bulk supply cost may cause the cost of such a scheme to increase to a level where the option may no longer be favoured by the receiving company. The WRSE regional view is based on the principle that no customers should be disadvantaged by the implementation of a regional solution involving shared resources and/or bulk water transfers. Hence if a profit margin caused a scheme to become unfavourable in this, the regional view would not persist with the scheme, although Ofwat might be asked to ensure that unfair profit was not sought.

Alternatively, resource developments could be implemented as permanently shared assets. Resource transfers identified in the modelling work do not necessarily have to be implemented as bulk supplies from one water company to another. The model makes no assumption that an option will be implemented as a shared asset or as a bulk supply. This is for negotiation between companies.

In the WRSE regional modelling work undertaken to date, the regional options selected by the model are envisaged to be the first step of an iterative process that initiates discussion between water companies on resource sharing, or bulk transfers, and their terms and costs. The model does not attempt to apportion regional solution costs between companies, though it does allocate the resource in the way that it utilises it to solve the respective WRZ deficits. The model can be used to help understand the solution costs with and without resource sharing options active, giving a first approximation of the least-cost boundaries within which companies could discuss and negotiate shared schemes. This discussion between companies can address, *inter alia,* a profit margin which the donor company may wish to charge the recipient as a transfer payment for taking on the business and operational risks in providing the bulk transfer. The model can be used with such refined cost information, including profit allowances, to re-test the solution with respect to least-cost.

The regional scope of the WRSE group modelling is intended to benefit customers and the environment by optimising water resource development across water companies. The modelling results confirm there is potential to achieve these benefits over the planning period.

3.6.5 Representation of costs in the model

The cost of options in the model is represented in terms of three components: capital cost (CAPEX); fixed operating costs (Fixed OPEX); and variable operating costs (Variable OPEX). The data for each scheme or option has been given by water companies in the form of undiscounted financial costs.

Existing sources and transfers are assumed to have zero capital cost and a nominal operating cost.

The following outlines the treatment of these cost components in the model.

3.6.5.1 CAPEX

CAPEX represents the construction cost incurred over the period over which the scheme is constructed. CAPEX cost is annutised over the whole asset life in the model, and then the annuitised cost stream is only included up to the end of the planning period. The annutised cost stream is then discounted to the base year for calculating present value (PV). This enables the model to make an unbiased choice between schemes brought in at different times during the planning period.

In cases where the water company has indicated a construction period and has provided annual breakdown of construction costs from year to year, these have been represented in the regional model. In the absence of such information, the following assumptions were made:

- If no construction period has been provided for a new scheme, a default construction period of one year has been assumed. This could influence the PV of costs for large schemes that have construction periods of greater than a year, and for this reason more accurate data has been used wherever this is available. The one-year default construction period has only been applied to small schemes; and
- If a construction period is given, but no annual breakdown of construction costs, the total construction cost has been divided by the construction period and CAPEX has been distributed equally between each year of construction.

The way in which this was applied is described in detail in Halcrow technical note entitled “Cost calculation” (WB/ROSE/11, May 2007).

3.6.5.2 Fixed OPEX

Fixed OPEX is the annual overhead cost of maintaining a resource or a transfer irrespective of the level of utilisation of the scheme.

3.6.5.3 Variable OPEX

Variable OPEX is the cost of delivering water from a source, or through a bulk transfer link, and is specified as a cost per m^3 of water delivered. The annual Variable OPEX is then calculated by multiplying the unit cost by the volume of water delivered and / or transferred each year in order to balance supply with demand.

3.6.5.4 Objective function

The objective function used in the WRSE regional model is as follows:

Minimise $\sum(CAPEX_{PV}+OPEX_{PV})_{sources} + \sum(CAPEX_{P}+OPEX_{PV})_{links}$

Where $OPEX_{PV} = FixedOPEX_{PV} + VariableOPEX_{PV}$

The subscript PV denotes that the CAPEX and OPEX cost streams for each scheme have been discounted to derive the 'present value' (PV) for each year (within the planning period) during which the scheme has been brought by the model into its solution set. The use of discounted costs ensures that schemes can be compared and selected on the basis of their 'present values'.

The model must work to the above function while satisfying the condition and must solve the supply-demand deficit in so far as it is able to with the options it is given, working within any constraints put on them.

3.6.5.5 Environmental and social costs

Water companies have expressed an interest in incorporating environmental and social costs into the model. The Environment Agency has taken the view that, whilst it ideally would like to do this (and it is an expectation in guidelines), the environmental and social cost data provided by the water companies is currently too sparse or inconsistent to be included as base-case data. Therefore this aspect of option costs has not been modelled, except in sensitivity tests.

To some extent, this limitation is partially addressed within other stages of the derivation of the options that have been included in the model (for example, in the 'screening' of options) or, it influences the judgements of "earliest practicable start" dates for schemes applied within the model. It is important to note that environmental and social costs could have a material impact on a scenario run solution, although it is also important to recognise that some environmental and social costs are difficult to attribute to anyone, and do not feed directly into customer bills.

It remains a future option to treat it as base data in the regional model, subject to receiving a full and consistent data set on it.

3.6.5.6 Discount rates

In previous modelling, a discount rate of 5.5% was used to annualise future costs. The water company WRMPs have assumed 4.5% (as endorsed and advised by

Environment Agency and Ofwat guidelines), although the Treasury 'Green Book' suggests 3.5%. All model runs since September 2008 have used a discount rate of 4.5%.

3.6.6 Cost consistency review summary

Cost data used in the WRSE regional model has undergone a series of cost consistency reviews (in 2007, 2008, and in May 2009). These indicated a need for greater consistency in the build up of cost data provided by the water companies.

Halcrow completed its cost consistency review in October 2008, and their report was discussed at the WRSE technical group meeting on 20 October 2008. The report concluded that *'the level of consistency between costs of schemes in the model had improved but there remained scope for improvement, with the possibility that some schemes were costed relatively poorly"*. There remain some concerns around the influence that poorly estimated scheme costings could have on the selection or otherwise of the scheme by the WRSE regional model. Overall, the quality of the cost data included in the model has improved from 2007 to 2008 and from 2008 to 2009. However, the quality of costs provided remain variable. Transparent and accurate costs have always been and remain a principal requirement for this work to reach a successful conclusion.

Despite recognising the above concerns (reported by Halcrow) and endorsing them with its own view that cost consistency and transparency should be improved further, the Environment Agency believe the cost data pertinent to the most 'head to head' decisions the model takes between resource options is the more detailed data received and so most likely to be the more robust. *Overall, the cost data used in the model is adequate relative to the way the model results are being used at present.* The remaining concerns about option cost data need to be addressed in future work so that the modelling outputs can be used confidently in more detailed discussions and agreements of regional solution options before water companies next plans are prepared.

3.6.6.1 Cost consistency review - general findings (2007 – 2009 review)

- Cost information submitted by all water companies has continued to improve over the period 2006-2009. This also increased the level of confidence that can be associated with the most recent model runs;
- Costing methodology apparently varies between water companies;
- There is not enough evidence to confirm that estimates include all ancillary works required to utilise output in every case;
- It appears that the level of consistency between costs for a given type of scheme is generally poor; and
- Cost is a key factor in the selection of schemes by the optimisation model, but not the only one. The basic supply-demand balance criterion or other technical

dependencies that may affect implementation timing, for example, can also be important.

As a result of the above findings, further review was undertaken of a sample of the more detailed cost data available from Southern Water and South East Water in May 2009.

3.6.6.2 Replacement and refurbishment cost consistency

The water companies have used different assumptions in estimating replacement and refurbishment costs of options over their life time. To explore whether these assumptions had an impact on the regional solution a series of five sensitivity tests were carried out by Halcrow. These were:

a) Scenario 1 - No replacement cost has been included in the model;
b) Scenario 2 – Civils and M&E replacement costs are included with varying asset life assumption (Reservoir – 80yr, desalination plant – 25yr and all other – 60yr);
c) Scenario 3 - Civils and M&E replacement costs are included with 80yr asset life for all options;
d) Scenario 4 – Only M&E replacement costs are included with 80yr asset life for all options; and
e) Scenario 5 – Only M&E replacement costs are included with varying asset life assumption (Reservoir – 80yr, desalination plant – 25yr and all other – 60yr).

After discussion of these sensitivity test results within WRSE technical group, replacement cost Scenario 2 was agreed to be appropriate for the base case application of replacement costs throughout the remainder of the 2009 WRSE regional modelling.

3.7 Model outputs

In each scenario run, the WRSE regional model finds the least cost solution that satisfies the supply demand balance for that particular scenario. The model selects the start years and utilisation of each option (both source and transfer) in order to meet the supply demand balance.

For each scenario the model produces the following outputs:

- Cost summary – high level summary showing both discounted and undiscounted solution cost of the model run. Total solution cost is subdivided by water companies or sub regions within WRSE region. It also shows modelled utilisation of options and existing source/transfers;

- Selection summary – Start year, first year of utilisation and maximum output for each selected option by WRZ;
- Chronosummary - Chronological order of options selection;
- Network Annual – Model output in annual interval;
- Network 5yearly– Model output in five yearly interval;
- Resource balance – resource balance for each WRZ; and
- Deficit – Summary of WRZ deficit that could not be met under a particular scenario.

3.8 Scenario analysis

Thirty-three scenario runs were run in the WRSE regional model. The data used to create these scenarios and the scenario settings are summarised in Table 10.

The following model parameters were also varied in different sensitivity tests, as described in the sections below.

3.8.1 Water company preferred options

Scenario 1, 1b and 1c have been run only using the options featured in water companies preferred solution as specified in water companies' Statements of Response. These runs are intended to closely represent the water company solutions. There are slight differences due to the way the model utilises these schemes compared to the volumetric utilisation assumed in the company solutions over the planning period.

Southern Water and South East Water use different design events to estimate DO of existing reservoirs and design DO of reservoir raising options, and, as a result, the Environment Agency proposed two sets of DO and transfer capacities. Scenario 1 has been simulated using the Environment Agency generated data constructed as a compromise between the two different views. Scenarios 1b and Run 1c have been run using South East Water and Southern Water positions respectively.

3.8.2 Bewl PDO benefit

In the option data provided to this round of modelling by Southern Water, the company did not attribute any peak DO (PDO) benefit to the Bewl reservoir raising options. The Environment Agency and South East Water feel this approach

underestimates the benefit of these reservoir raising options, and a set of scenarios (14, 17-27) have been undertaken with a Bewl PDO benefit applied. The PDO assumed in these runs for four Bewl raising options are 1.49, 3.74, 7.47 and 11.20Ml/d. These values were suggested by the Environment Agency based on previous yield assessment work by Southern Water. The equivalent annual average DO (ADO) assumed for the Bewl raising options are 1.66, 2.97, 5.89 and 9.44 Ml/d.

3.8.3 Bray Stage IV sensitivity test

In some model scenarios the Bray Stage IV abstraction from the River Thames has been selected. In order for this option to go ahead, the River Thames' abstraction licensing arrangements have to be reviewed between South East Water, Thames Water and the Environment Agency. Due to the uncertainty associated with this option, scenario 18 has been carried out without this option (i.e. this option has been turned OFF) to explore what alternative options might be selected.

3.8.4 River Itchen sustainability reduction

To recognise remaining uncertainties associated with implementation of Southern Water's preferred solution to the River Itchen Habitat Directive's sustainability reduction requirements, scenario 18 has been undertaken without the inclusion of the Lower Itchen abstraction to explore the alternatives.

In scenarios 18a and 18b, as detailed in Table 10, the following options were also turned OFF:

- Colden Common Reservoir;
- Candover Arle option; and
- Testwood WTW upgrade options.

3.8.5 Environmental and social costs, including carbon costs

Three model runs were carried out to explore the sensitivity of environmental and social costs and carbon costs on the model solution:

- Scenario 19 Hybrid carbon cost – company carbon cost included where available with remaining gaps in-filled by Halcrow estimate of carbon cost (Halcrow technical note, 2008);
- Scenario 20 Halcrow carbon cost – Halcrow 2008 estimate of carbon cost used for all options; and

- Scenario 21 Hybrid carbon and social and environmental cost – same as Run 19, but social and environmental costs a re included where provided by water companies.

3.8.6 Alternative Thames Region options

The alternative Thames Region options sensitivity run included some additional resource options for Thames Water. These options had not been included in the company's draft water resources management plan as they were subject to significant uncertainties and required further study. Longdon Marsh was included in Thames Water's feasible list in its revised draft water resources management plan. The purpose of the run was to help ascertain whether the options should be investigated further, as part of a least-cost solution, should they be shown to be feasible. The Environment Agency provided a very approximate cost estimate for each scheme and therefore the costs of these options are not calculated to the same level of detail as the other costs used in the model. The additional schemes available to be selected in this run were as follows:

- Longdon Marsh reservoir;
- Deephams effluent reuse (25Ml/d and 95Ml/d) using the Langford method; and
- A transfer from Essex and Suffolk Water.

It should be noted that the Longdon Marsh options do not include any costed allowance for the provision of floodplain compensation and so it does not represent the full cost of the scheme. Also, Thames Water does not consider the Langford method to be an acceptable basis for the treatment of effluent prior to using it under an effluent reuse scheme. Thames Water considers that more intensive treatment would be required, probably including reverse osmosis.

3.8.7 Existing bulk transfers

As stated in section 3.5, in most of the 2009 modelling runs, the WRSE regional model is free to select the volume transferred through bulk transfers each year between water companies. Scenario 15 was run as a sensitivity test with these volumes set to their contracted capacities.

Table 10: runs explored in with the WRSE regional model

Run #	Run description	Completed	Replacement cost scenario	WCC/NCC	DO	DI	Sustainability reduction	Flow in existing bulk transfers	Bewl PDO benefit	Effluent re-use schemes	Alternative Thames region options	Bray Stage IV	Lower Itchen abstraction	Colden Common Reservoir	Candover Arle option	Testwood option	Carbon cost	Other social and environmental cost
1	Company preferred run	Y	2	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
1b	Company preferred run - SEW position	Y	2	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
1c	Company preferred run - SWS position	Y	2	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
2	Base run	Y	2	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
3	130pcc run	Y	2	WCC	base	**130pcc**	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
4	Higher sustainability reduction run	Y	2	WCC	base	base	**A**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
5	Base run without replacement cost uplift	Y	**2 (no uplift)**	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
6	Base run NCC	Y	2	**NCC**	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
7	145pcc run	Y	2	WCC	base	**145pcc**	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
8	160pcc run	Y	2	WCC	base	**160pcc**	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
9	160pcc higher sustainability reduction + run	Y	2	WCC	base	**160pcc**	**A**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
10	No effluent re-use run	Y	2	WCC	base	base	base	variable	none	**OFF**	OFF	ON	ON	ON	ON	ON	not included	not included
11	50year run	Y	2	WCC	base	base	base	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
12	1:100yr DO	Y	2	WCC	**1:100yr**	base	**1:100yr**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
13	1:50yr DO	Y	2	WCC	**1:50yr**	base	**1:50yr**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
14	Bewl raising with PDO benefit	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	not included	not included
15	Constant bulk transfer volume run	Y	2	WCC	base	base	base	**Constant at capacity**	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
16	Alternative Thames region options	Y	2	WCC	base	base	base	variable	none	ON	**ON**	ON	ON	ON	ON	ON	not included	not included
17	SEW sensitivity test 1 - Bewl PDO, Alt Bewl WTW constraint, Alt transfer constraint and capacities	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	not included	not included
18	Lower Itchen + Bray IV sensitivity	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	**OFF**	**OFF**	**OFF**	ON	ON	not included	not included
18a	Bray Stage IV, Tidal Lower Itchen, Colden Common reservoir and Candover Arle option OFF	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	**OFF**	**OFF**	**OFF**	**OFF**	ON	not included	not included
18b	Bray Stage IV, Tidal Lower Itchen, Colden Common reservoir and Candover Arle option and Testwood OFF	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	**OFF**	**OFF**	**OFF**	**OFF**	**OFF**	not included	not included
19	Carbon cost - hybrid	N	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	**Hybrid**	not included
20	Carbon cost - Halcrow	N	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	**Halcrow estimate**	not included
21	Carbon cost - hybrid + Social and environmental costs	N	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	**Hybrid**	**Included where available**
22	Severe sustainability reduction + Bewl PDO	Y	2	WCC	base	base	**B**	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	not included	not included
23	Severe sustainability reduction + 160pcc + Bewl PDO	Y	2	WCC	base	**160pcc**	**B**	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	not included	not included
24	Desal and ER costs increased by 10%	Y	2	WCC	base	base	base	variable	**Applied**	ON	OFF	ON	ON	ON	ON	ON	not included	not included
25	Severe sustainability reduction	Y	2	WCC	base	base	**B**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
26	Severe sustainability reduction + 160pcc	Y	2	WCC	base	**160pcc**	**B**	variable	none	ON	OFF	ON	ON	ON	ON	ON	not included	not included
27	SEW sensitivity test 2 - as run 17 + 25% share of Bewl raising resource to RZ7	Y	2	WCC	base	base	base	variable	Applied	ON	OFF	ON	ON	ON	ON	ON	not included	not included
28a	Future sharing OFF	N	2	WCC	base	base	base	variable	Applied	ON	OFF	ON	ON	ON	ON	ON	not included	not included
28b	Existing and future sharing OFF	N	2	WCC	base	base	base	variable	Applied	ON	OFF	ON	ON	ON	ON	ON	not included	not included

4 WRSE regional modelling work and conclusions

The WRSE regional options modelling work reported here has used supply-demand balance data supplied by the water companies in Spring 2009. Based on this information, as used in the WRSE regional model, a reliable output (water available for use) of 5,239 Ml/d[2] can currently (2009/10) be supplied from resources licensed to the WRSE water companies. This is greater than the forecast current (2009/10) "dry year" (water resources planning scenario) average demand of 4,967 Ml/d, including target headroom. At a regional level there is a surplus of 272 Ml/d (6% of demand plus target headroom) in the DYAA water resources planning scenario. This masks a more detailed picture where some WRZs are in surplus, and others are in deficit.

Many of the WRSE water companies also consider the DYCP demand relative to reliable peak outputs from sources as a potential "critical period" water resources planning scenario. For some water companies or in some WRZs this scenario is the actual supply-demand investment 'driver'. In this scenario the WRSE water companies have reliable output of 5,827 Ml/d and they forecast current (2009/10) dry year peak week demand to be 5,708 Ml/d, providing a DYCP surplus, at regional level, of 120 Ml/d (2% of DYCP demand plus target headroom). Again, this masks a more detailed picture where some WRZs are in surplus, and others are in deficit.

In total, the water companies forecast a net resource requirement of 441 Ml/d by 2035 (470 Ml/d for DYCP output). The key elements determining this net requirement are as follows:

- A 61 Ml/d forecast reduction in DYAA demand resulting from the demand management measures assumed within water companies'' plans. In the peak week demand scenario, the forecast reduction in demand is 49 Ml/d;
- A 178 Ml/d increase in target headroom due to future uncertainties. For the peak week demand scenario, the forecast increase in target headroom is 198 Ml/d;
- An estimated reduction of existing resource outputs of approximately 188 Ml/d resulting from climate change. In the DYCP scenario, the forecast reduction in existing resource outputs is 205 Ml/d; and
- A 136 Ml/d reduction in resource output to protect the environment, predominantly for the River Itchen in Hampshire. In the DYCP scenario, the forecast reduction in demand is 116 Ml/d.

These are aggregate figures for the whole WRSE area. Such aggregation masks different assumptions about different elements of the supply demand balance across and within water companies. For example, the 61 Ml/d forecast reduction of demand results from the demand management measures assumed within water companies final planning forecasts. That is, meter programmes, reduced leakage, and water efficiency. These vary from water company to water company. Water companies assumptions on housing growth, population growth and consumption of water per person also vary. All the water companies have allowed for housing growth in line

with or greater than regional government plans. Southern Water, Thames Water, Veolia Water Central and Veolia Water Southeast forecast per capita consumption to reduce.

The WRSE regional model is populated with representations of the DYAA planning scenario and the DYCP planning scenario. The WRSE regional model derives a least-cost optimal solution (from a large set of potential schemes) that balances available supplies with demands to ensure that the supply demand balance can be maintained across the WRSE area throughout the entire 25-year planning period (2010 – 2035), under DYAA and DYCP conditions. The model solves the DYAA and DYCP supply-demand balance problems together. In the following presentation and discussion of results the solutions costs and solution composition (schemes) that are discussed are those which satisfies the DYAA and DYCP planning scenario together.

4.1 The water companies' solutions

To satisfy the net resource requirement of 441 Ml/d (470 Ml/d at DYCP), the water companies are proposing to increase the water available for use by 480 Ml/d (584 Ml/d at DYCP). Therefore, if water companies plans are endorsed, the measures proposed are successfully implemented, and the forecasts made prove to be correct, there will be a regional DYAA surplus above target headroom of 311 Ml/d at the end of the planning period (equivalent to 6% of forecast demand plus target headroom). At DYCP this surplus will be 234 Ml/d. Again, this regional summary of surplus masks a more detailed picture where some WRZs are more in surplus than others during or at the end of the planning period.

Major components of the water companies' programmes are as follows:

- Upper Thames Reservoir in 2025/26 (Thames Water);
- Clay Hill Reservoir, in 2020/21 (South East Water);
- South London Artificial Recharge Scheme, in 2021/22 (Thames Water);
- Havant Thicket Reservoir, in 2021/22 (Portsmouth Water);
- Increased abstraction at Testwood within existing licence, in 2015 (Southern Water);
- Broad Oak Reservoir, in 2027/28 (South East Water);
- Aylesford effluent reuse, in 2032(Southern Water / South East Water); and
- Enlarging Bewl reservoir, in 2023 (South East Water).

Table 11 and Table 12 show DYAA and DYCP surplus over target headroom in company plans and a selection of the model runs.

Table 11: Surplus over target headroom for whole WRSE region study area (DYAA)

DYAA	Demand			Target headroom			New resources by 2034/35	Surplus over target headroom		
	Ml/d			Ml/d			(Ml/d)	(Ml/d)		
	At 2009/10	At 2014/15	At 2034/35	At 2009/10	At 2014/15	At 2034/35	2034/35	At 2009/10	At 2014/15	At 2034/35
Water company plan	4726	4585	4666	241	324	419	449	272	377	311
MODEL										
Base case	4726	4585	4666	241	324	419	325	272	340	187
168 l/h/d pcc	4861	4762	4974	241	324	419	577	137	276	130
136 l/h/d pcc	4861	4629	4409	241	324	419	124	137	330	242
Severe sustainability reductions	4726	4585	4666	241	324	419	878	272	325	133

Table 12: over target headroom for whole WRSE region study area (DYCP)

DYCP	Demand			Target headroom			New resources by 2034/35	Surplus over target headroom		
	Ml/d			Ml/d			(Ml/d)	(Ml/d)		
	At 2009/10	At 2014/15	At 2034/35	At 2009/10	At 2014/15	At 2034/35	2034/35	At 2009/10	At 2014/15	At 2034/35
Water company plan	5430	5259	5381	278	377	476	549	119	285	234
MODEL										
Base case	5430	5259	5381	278	377	476	404	166	214	105
168 l/h/d pcc	5597	5411	5509	278	377	476	670	25	77	243
136 l/h/d pcc	5597	5259	4860	278	377	476	145	56	156	361
Severe sustainability reductions	5430	5259	5381	278	377	476	1000	166	214	79

4.1.1 Cost of the aggregated water companies' preferred solutions

The individual company preferred solutions have been represented in the WRSE regional model solution as a "company-preferred solution" scenario. We have labelled this scenario 1. This closely represents the water company solutions, although there are minor differences due to the way the model utilises these options. In this scenario, the WRSE regional model is not allowed to choose any other options, it is only being used to calculate the total solution cost and provide a presentation of this cost in the same format as it does when it makes its own selection of options. The solution cost (NPV) of the supply side schemes of aggregated water companies' plans preferred solution is £762 million.

In the previous modelling round (2008), the equivalent solution cost was £835 million. The latest company-preferred solutions include less resource development cost mainly because lower demand forecasts have been adopted by some water companies since their draft WRMPs. (But, see also section 4.1.2 below).

Three variations on the inclusion of the company-preferred solutions have been applied in the model to explore sensitivity to the difference in opinion between South East Water and Southern Water as to the reliable yield of their existing shared River Medway Scheme. The different assumptions applied by each company appear to make little difference to the overall solution cost. A full presentation of these solution costs is included in Appendix 7 and Table 14.

4.1.2 Deficits in the WRSE regional model version of the company plan

The WRSE regional model aims to find solutions that fully meet the demand (including target headroom) of each WRZ. However, this is not always possible as the model works within the resource constraints of individual scenarios. The resource development options deemed available, their nominated earliest start dates and transfers available might not be sufficient to meet the demand in every modelling scenario.

The main resource constraint is posed by the earliest start years of options relative to dry year supply demand deficits in the earliest years of the planning period, including some that are caused by the assumed (modelling) implementation of sustainability reductions. Table 13 summarises the deficits in the WRSE regional model base case (Scenario 02), indicating that maximum deficit occurs in 2009/10, then reduces and is solved from 2013/14.

The WRSE regional model base case (scenario 02) has the identical supply-demand balance scenario and model set-up as applied in scenario 01 (the company preferred solution), except that the regional model is allowed to choose (on a least-cost selection basis) the options that provide the supply-demand balance solution.

In applying the water companies' plans preferred solution (Scenarios 01, 01b and 01c) the only options available to the model are the company–preferred options. Table 13 shows that in these runs, demands are not completely met at all times during the planning period and that the occurrence of deficits is greater than in scenario 02. Therefore, the solution cost presented by the model for the company-preferred solution potentially under-estimates the total cost of solving the regional supply-demand balance.

Some of these deficits do not occur in the water company solutions:

- Some deficits occur within Southern Water WRZs in the WRSE regional model version of the water companies' planned solution because the regional models tests a different supply demand scenario than used by Southern Water. The WRSE regional model data exaggerates the Southern Water supply-demand imbalance in some WRZs because it sets DYAA demand against minimum deployable outputs, while Southern Water correctly sets these minimum deployable outputs against an estimate of (the lower) dry year demand relevant to the critical period of the minimum DO (MDO). (The Southern Water data was applied in this way in the WRSE regional model to maintain greatest 'scenario' consistency with the data available from other water companies); and
- Small deficits occur in some South East Water WRZs due to the omission of several small schemes. This omission was due to misunderstanding by the Environment Agency surrounding the presentation of South East Waters' company preferred options in the company's Statement of Response). The Statement of Response only summarised schemes planned by 2030, omitting several small groundwater schemes used by the company post-2030. These additional groundwater schemes were subsequently identified to the Environment Agency by South East Water.

When the WRSE regional model is allowed to *select* from the options that have been included in it, the only deficits that it can not solve are:

(i) the ones early in the planning period, before the first options are available (according to their modelled earliest start dates). This result is common across all the modelled scenarios and does not affect the comparison of solutions and their costs. It is influenced by the application of base case sustainability reductions in the model.

(ii) Some small (mostly very small) deficits late in the planning period in the very high sustainability reduction scenarios. These arise because the model does not have sufficient resource and / or transfer options to solve al of the large additional stress imposed on the supply-demand balance in these scenarios.

A full summary of the unsolved deficits is provided in Appendix 14. These deficits are not a failing of the model, rather they highlight that it does not always have available options at the right time. They do not prevent the results being compared and used in the way they are being used at present.

Table 13: Deficits occurring during "company preferred solution" scenarios.

		Run02			Run01			Run01b			Run01c		
		Maximum deficit	Max deficit year	Last deficit year	Maximum deficit	Max deficit year	Last deficit year	Maximum deficit	Max deficit year	Last deficit year	Maximum deficit	Max deficit year	Last deficit year
		DYAA											
WRZ02	SWS I.o.W				7.1	2034/35	2034/35	7.1	2034/35	2034/35	7.1	2034/35	2034/35
WRZ03	SWS Sussex North	21.6	2009/10	2013/14	21.6	2009/10	2013/14	23.3	2010/11	2013/14	23.3	2010/11	2013/14
WRZ04A	SWS Sussex Coast East	3.5	2009/10	2009/10	3.5	2009/10	2010/11	3.5	2009/10	2009/10	3.5	2009/10	2009/10
WRZ13	SEW Mid Sussex (RZ 2)								-		0.9	2018/19	2019/20
WRZ14	SEW Eastbourne (RZ 3)							7.8	2034/35	2034/35			
WRZ15	SEW Medway (RZ 1)	3.9	2009/10	2011/12	3.9	2009/10	2011/12	3.9	2009/10	2033/34	2.6	2017/18	2018/19
WRZ16A	SEW RZ 6										0.2	2018/19	2024/25
WRZ16B	SEW RZ 7										6.7	2009/10	2034/35
		DYCP											
WRZ02	SWS I.o.W				8.0	2034/35	2034/35	8.0	2034/35	2034/35	8.0	2034/35	2034/35
WRZ03	SWS Sussex North	2.2	2009/10	2009/10	2.2	2009/10	2009/10	2.2	2009/10	2009/10	2.2	2009/10	2009/10
WRZ04A	SWS Sussex Coast East	3.5	2009/10	2009/10	3.5	2009/10	2010/11	3.5	2009/10	2010/11	3.5	2009/10	2010/11
WRZ07	SWS Kent Thanet				1.3	2031/32	2031/32	2.1	2034/35	2034/35			
WRZ11	SEW Northern North (RZ 4)				7.6	2034/35	2034/35	7.6	2034/35	2034/35	7.6	2034/35	2034/35
WRZ13	SEW Mid Sussex (RZ 2)										2.0	2019/20	2019/20
WRZ14	SEW Eastbourne (RZ 3)				4.2	2033/34	2033/34	9.3	2033/34	2034/35	4.7	2031/32	2034/35
WRZ15	SEW Medway (RZ 1)	2.2	2009/10	2009/10	6.5	2031/32	2033/34	6.5	2031/32	2033/34	7.8	2033/34	2033/34
WRZ16A	SEW RZ 6				0.8	2031/32	2031/32	2.4	2023/24	2034/35	4.8	2026/27	2034/35
WRZ16B	SEW RZ 7				3.1	2026/27	2026/27	8.1	2033/34	2033/34	8.2	2026/27	2033/34
WRZ19	SESW Company	6.4	2011/12	2011/12	6.4	2011/12	2011/12	6.4	2011/12	2011/12	6.4	2011/12	2011/12
WRZ23	TW SWOX	19.7	2009/10	2011/12	19.7	2009/10	2011/12	19.7	2009/10	2011/12	19.7	2009/10	2011/12

4.2 WRSE regional modelling solutions

The sum of the individual water company solutions creates a surplus of 311 Ml/d (234 Ml/d in DYCP) over and above target headroom at year 2034/55 in DYAA scenario across the WRSE area. The WRSE regional modelling set out to determine if, by sharing resources between water companies, it may be possible to avoid, or defer beyond 2035, some of the expenditure on resource development, and hence arrive at a lower-cost solution for the region as a whole. In determining this, the WRSE regional model can choose different options to those preferred by the water companies in their individual company plans.

4.2.1 Main findings – regional solutions costs

Table 14 below summarises the solutions' costs of four of the WRSE regional modelling scenario solutions, compared to the company plans' preferred solution. The table provides a high level comparison of the cost savings or increases relative to the amount of resource development included in the solution and indicates the degree to which overall surplus is created, over and above achieving target headroom.

The overall finding of the regional work is that, on a like for like scenario basis, the regional solutions will typically cost less than the sum of the individual company plans. This is because the regional solutions include ways to share existing and new resources in a more efficient and effective way to maintain the supply demand balance. All the scenarios explored in the WRSE regional modelling work have satisfied the target headroom assumed by the water companies to be necessary in their plans. The regional solutions and the water companies' solutions provide surplus resource above target headroom but less surplus resource is provided by regional solutions. However, it could be argued that scenarios that result in less surplus headroom, or rely on behavioural change, may present higher future risks.

Table 14: Solution costs

	Solution Cost		New resources by 2034/35		Surplus over target headroom (DYAA)		Surplus over target headroom (DYCP)	
	£(million)		(Ml/d)		(Ml/d)		(Ml/d)	
	Undiscounted	Discounted	DYAA	DYCP	At 2009/10	At 2034/35	At 2009/10	At 2034/35
Water company plan	1738	762	449	549	272	311	119	234
MODEL								
Base case	943	262	325	404	272	187	166	105
168 l/h/d pcc	2254	1079	577	670	137	130	25	243
136 l/h/d pcc	293	154	124	145	137	242	56	361
Severe sustainability reductions	3723	1344	878	1000	272	133	166	79

Notes: In the table, (i) Demand management costs are not included in any of the solution costs in the table. (ii) The 136 l/h/d scenarios implicitly involves more demand management than the water companies plans and the Base case. The 168 l/h/d scenario implicitly involves less. (iii) "New resources" exclude improvements 'committed' by 2015 and, in water company plan scenario, some small groundwater schemes that are included in South East Water's plan but are not included in the model.

The composition of the WRSE regional modelling base case scenario (scenario 02) has been described in section 3. It includes water companies forecast demand, including their forecast DYAA and DYCP per capita consumption.

The base case arrives at a solution that requires a combined DYAA resource development of 325 Ml/d, at a cost of £262 million, compared to water company solutions which include a combined resource development of 449 Ml/d, at a cost of £762 million. Therefore, the base case represents a saving of around £501 million. Both water companies' plans and the WRSE regional model base case result in a surplus over target headroom at 2035, of 311 Ml/d and 187 Ml/d respectively.

The solutions that the WRSE regional model produces do not satisfy the supply-demand balance exactly. The solutions still include surpluses over target headroom because existing or new resources cannot be shared perfectly. The model does not include sufficient options to achieve perfect integration, nor is there any aspiration to develop it to that extent. The WRSE regional model solutions contain less surplus over target headroom than results from the aggregation of water companies' plans preferred solutions.

A full comparison of the options preferred in the water companies plans and those selected in the WRSE regional model base case is included in Appendix 8.

4.3 Alternative demand scenarios

The Government, in 'Future Water'[6] set an aspiration to reduce normal year per capita consumption to 130 l/h/d by 2030 (equivalent of dry year pcc of 136 l/h/d). Water companies forecast that current dry year water use is around 170 litres/head/day in the South East. Some water companies are predicting this to increase towards 180 l/h/d, while others forecast it to reduce to between 134 l/h/d and 149 l/h/d.

The modelling considered future variations in demand. The three scenarios considered were:

- Scenario 03 : 136 litres per person per day (l/h/d) at year 2030 - an Environment Agency constructed DYAA equivalent of Defra's 'Future Water' strategy[6] 130 l/h/d normal year aspiration;
- Scenario 07: 152 litres per person per day (l/h/d) at year 2030 - an Environment Agency constructed DYAA equivalent of achieving 145 l/h/d in a normal year; and
- Scenario 08: 168 litres per person per day (l/h/d) at year 2030 – an Environment Agency constructed DYAA equivalent of demand remaining around 160 l/h/d in a normal year.

The WRSE regional modelling investigation of alternative demand (per capita consumption) scenarios draws attention to the differences that exist across water companies demand forecasts. In parts of the region, the company per capita consumption forecasts diverge (some increasing, and some decreasing) to the extent that the difference between them has a very material influence on the relative resource development needed by each company and in turn affects the degree to which resource sharing opportunities are selected as part of the least-cost solution or not. This is a dominant factor in the current WRSE regional modelling work.

The higher demand scenario (168 l/h/d) also draws out issues of contrasting a standard demand scenario across the whole model area compared to using company forecasts that diverge.

The variability in the assumptions underpinning individual water companies' demand forecasts is likely to have had an impact on the solutions arrived at by the model. The WRSE regional modelling work should be developed to include economic selection of demand management options to help address this issue.

4.3.1 Achieving 136 l/h/d (scenario 03)

The modelling showed that, if a dry year average per capita consumption of 136 litres/head/day (l/h/d) was achieved across the South East by 2030, the supply-side investment needed would be around £108 million less than might be required by the

Base Case (scenario 2) and around £609 million less than current water company solutions (scenario 01). If pcc reduced to an average of 136 litres per person per day, the DYAA forecast would be 257 Ml/d less than the demand forecasts for scenarios 1 and 2 at 2035. The peak week demand modelled in scenario 03 is 521 Ml/d less than the peak week demand assumed by water companies (e.g. scenario 01 and 02). Scenario 03 results in a surplus over target headroom at 2035 of 242 Ml/d and includes 124 Ml/d of new resource. (361 Ml/d and 145 Ml/d respectively relative to the peak week demand). New resource developments would still be needed primarily because of 'timing' issues. For example, the Southern Water Lower Arun scheme will still be needed because the lower pcc will not be achieved quickly enough to achieve supplies to recover the existing deficit position in Southern Water's Sussex North zone.

The WRSE regional model does not take into account the cost of achieving the lower consumption which would need to be achieved by a combination of metering, tariffs, other demand management measures, legislation, and behavioural change through education. Base demand management cost information gathered from water companies has proved difficult to use either to provide a consistently based estimate of the demand management costs included in the water companies forecasts or to estimate the additional (though not necessarily proportionately higher) costs that might be incurred to achieve lower demand. Further work needs to be done on this within a regional context.

The demand forecast in scenario 3 is 257 Ml/d less than the demand forecasts for scenarios 1 and 2 at 2035. The cost of achieving this lower demand is not included in the model but the model indicates how much less supply-side investment would be needed assuming the lower demand. This gives an indication of the value of achieving this lower demand, excluding valuation of the wider benefits of using less water.

Some water companies consider there to be many risks around achieving this lower consumption. The Environment Agency recognises that such lower consumption will not happen without co-ordinated and focussed effort by a number of different parties and stakeholders. However, the Environment Agency also considers that, relative to the cost of infrastructure projects, it should be economic for water companies to develop and implement the tariff measures that can make a significant contribution.

4.3.2 Higher demand: pcc of 168 l/h/d (scenario 08)

The WRSE regional modelling work has also explored the possible pressures of people using more water, and the potential need to reserve more water for environmental protection. If personal use of water across the South East were to remain at a dry year average of around 168 litres/head/day in 2030 (scenario 08), the additional resource needed to supply this demand would cost £317 million compared to water companies demand forecasts, assuming both scenarios were solved by the model as a regional solution.

4.3.3 Achieving 152 l/h/d (scenario 07)

The modelling has explored an intermediate scenario of achieving a normal year pcc of 145 l/h/d, equivalent to 152 l/h/d in a dry year. A pcc of 152 l/h/d reduces the overall cost of the regional supply solution by around £208 million compared to water company plans.

The reduction in cost is distributed approximately 79% across Thames Region and 21% across Southern Region, with company by company proportions related to the degree to which each company's forecast pcc varies from 152 l/h/d.

If pcc was on an average 152 l/h/d the demand forecast would be 26 Ml/d more than the demand forecasts for scenarios 1 and 2 at 2035. This indicates that forecast pcc across the total area modelled is less that 152 l/h/d. For this scenario the model results in a surplus over target headroom at 2035 of 135 Ml/d and includes 299 Ml/d of new resource.

4.4 Sustainability reduction scenarios

The Environment Agency advised water companies that their WRMPs should only include the sustainability reductions which are part of the PR09 Environment Programme. All the base runs of the WRSE regional model have included these sustainability reductions.

The WRSE regional model was used to explore the inclusion of further, and more severe, sustainability reductions:

- Scenario "A" – further reductions to the base case; and
- Scenario "B" - much higher further reductions.

By 2035 the total of sustainability reductions in scenario A are 165 Ml/d in a dry year and 150 Ml/d in a critical period. For scenario B the total by 2035 is 743 Ml/d in a dry year and 740 Ml/d in a critical period. A more detailed breakdown of the sustainability reductions included in scenario A and scenario B can be seen in Appendix 5.

In the future, water companies are likely to have to reduce abstraction in places where it is proven to be causing environmental damage. This will require additional demand management or new resources to maintain the supply-demand balance. The largest environmental reductions considered in the model are 743 Ml/d by 2030 (scenario 25). This figure includes the reductions already included in company plans. To meet this scenario would cost up to a further £1,082 million more that the WRSE base case, if the water was replaced by new resources.

The results show that, compared to the base case (scenario 02) solution, scenario A sustainability reductions cost £47 million more, providing 65 Ml/d more resource. Scenario B, however, costs £1.1 billion more and provides 553 Ml/d extra resource.

Pending the results of the further investigations stipulated in River Basin Management Plans, these scenario results provide an indication of the potential costs of maintaining public water supplies relative to the requirement to meet the ecological targets of the Water Framework Directive by 2027.

4.5 Alternative DO scenarios

The Environment Agency constructed two sets of alternative DO data to explore what might result if all water companies used the same severity of design event. Scenarios representing return periods of 1 in 100 years (scenario 12) and 1 in 50 years (scenario 13) were constructed. The scenario DO figures are shown in Appendix 2.

Results show that, compared to the base case (scenario 02) solution the 1 in 100 year scenario costs £450 million more and provides 102 Ml/d of extra resource. The 1 in a 50 year scenario, however, costs £16 million less and provides 31 Ml/d extra resource.

4.6 Carbon costs and environmental and social costs

Three carbon cost scenarios have been explored in the WRSE regional model. These are:

- Scenario 19: Hybrid carbon data - Water company carbon costs (where provided) and Halcrow carbon data used where no water company data was provided;
- Scenario 20 : Halcrow generated data; and
- Scenario 21: Hybrid carbon data in addition to environmental and social costs provided by water companies.

Compared to the base case (scenario 02), the hybrid carbon cost scenario is £244 million more expensive and provides an extra 152 Ml/d of resource. This amounts to 339 Ml/d surplus over target headroom, 152 Ml/d extra compared to the base case.

The scenario using Halcrow generated carbon data is £2 million more expensive and provides an extra 115 Ml/d resource than the base case.

Finally, the hybrid carbon data including environmental and social costs is £401 million more expensive than the base case providing 7 Ml/d less resource. A surplus of 179 Ml/d is created in this scenario. The environmental and social costs include water companies assumed benefits (particularly for reservoir schemes) of £63 million (discounted). The benefits offset the carbon costs and the capital and operating costs of the solution in this scenario.

There has been concern raised over the carbon implications of both desalination and effluent reuse schemes. The results of these scenarios show that the addition of carbon costs to the WRSE regional model data has altered the selection of effluent reuse and desalination schemes, although they continue to form part of the regional solution.

4.7 Results by type of option

4.7.1 Reservoir options

Solutions developed by the WRSE regional model are generally less dependant on reservoirs than the aggregate of the solutions in water companies' plans.

The WRSE regional modelling work indicates that the Broad Oak Reservoir development currently being investigated by South East Water, Thames Water's 'large' Upper Thames Reservoir (100 Mm^3) and Portsmouth Water's Havant Thicket reservoir are not regularly selected as part of the regional least-cost solution. These options are, however, selected in the scenarios which put more stress on the supply demand-balance (e.g. higher demand and / or greater sustainability reductions).

South East Water's Clay Hill reservoir option is selected in many of the modelling runs undertaken.

In 2008 and earlier modelling, the option to enlarge Bewl reservoir were considered to provide a DYAA and a DYCP increase in output. However, for the latest work, Southern Water indicated the option might not provide any peak resource benefit and so the peak output of the option has been set as default zero in the current work. For this reason, Bewl reservoir enlargement is not so frequently selected as a least-cost option as it cannot be used to alleviate peak deficit which is present in relevant WRZs of Kent and East Sussex. In some sensitivity tests (scenarios 14 and 17-27) a peak resource benefit has been allocated to the Bewl raising options. They then feature regularly in the regional solution. The assumption that Bewl raising options do not provide peak resource needs to be explored in more detail as, for example, no hydrological assessment has been carried out to assess the impact of the assumed PDO on ADO. The infrastructure requirements to achieve peak output benefit relative to DYAA benefits also need to be reviewed. For example, this could concern the treatment works capacities at Burham (Southern Water) or Bewl (South East Water).

4.7.2 Effluent reuse and desalination options

Effluent reuse and desalination options may provide resilient resource relative to climate change pressure or environmental pressures that may impinge on conventional resources, though this assumes that effluent will be treated to very high (environmentally acceptable) standards before discharge to the water environment for re-abstraction for supply. The Environment Agency encourages water companies to consider these options in options appraisal and selection.

It may be argued that effluent reuse and desalination schemes raise some particular questions around energy use and carbon footprint, which will have to be considered further relative to energy and carbon costs of other schemes. The WRSE regional modelling has explored this provisionally and found these schemes to be a viable part of a least-cost solutions.

In addition to the carbon cost scenarios that have been tested, scenario 24 explored adding 10% to the cost of effluent reuse and desalination options.

Effluent reuse and desalination schemes which feature most frequently in the WRSE regional modelling solutions are:

- Aylesford effluent reuse;
- Deephams STW reuse; and
- Long Reach desalination.

4.8 Sensitivity of modelling results to particular assumptions

Some of the 'miscellaneous' sensitivity tests explored were:

4.8.1 Asset life and planning period

The model resolves the supply demand deficits over the 25 year planning period, taking account of the costs incurred during this period. However, as most of the resource options contain long life assets, it is relevant to test the solution over a longer period. A judgement can then be made as to whether solutions costs projected beyond the planning period should influence the choice of solution within the planning period. Scenario 11 has tested a 50-year period to 2060.

4.8.2 Altering default settings

Other sensitivity tests have explored switching some options “off” (unavailable for selection) when they are normally “on” (e.g. scenarios 18, 18a, 18b).

4.8.3 Bulk Supply utilisation

Scenario 28a and 28b explores different allowable utilisation of existing bulk supplies. The default model setting allows the model to determine utilisation within capacity. Scenario 15 fixes the existing bulk supplies at contracted capacity.

4.8.4 Effluent reuse and desalination costs

In addition to the carbon cost scenarios that have been tested, scenario 24 explored adding 10% to the cost of effluent reuse and desalination options.

4.8.5 Constraint variations

Scenarios 17 and 27 explored varying some of the default constraints around some South East Water options.

4.9 Wider interrogation of WRSE regional modelling results

The summary of the WRSE regional modelling solutions in the sections above focuses on some specific WRSE regional model scenario solutions. However, a total of 30 WRSE regional modelling runs have been undertaken, in addition to the three scenarios of the ‘company preferred solution’. A number of the thirty runs explore quite distinct scenarios, while a number represent finer sensitivity tests around main scenarios. The scenarios have been described in Section 3 and table 10 of this report.

Overall analysis has reflected on the frequency of selection of an option across all of the scenarios that have been run. The frequency of selection of an option has also been examined according to sub-set groupings of scenarios, A to F, as described in Table 15. Analysis has also reflected on the selections of options in particular scenarios, though mainly concentrating on the group A scenarios in doing so.

These groupings have been chosen on the principle that they form a collection of runs with scenario settings that present a similar level of, what might be called, ‘supply-demand balance stress test’. Group A contains the scenarios considered to

be the most ‘realistic’. In contrast, group B includes more severe scenarios, such as extra and larger sustainability reductions, increased demand or reduced (but more reliable) one in 100-year existing supplies. Group C contains sensitivity tests. Most of these involve switching certain options to unavailable (“off”), or, they include alternative options that are normally “off”. Group D contains only the 136 l/h/d pcc and the no climate change allowances scenario and group E which explores all scenario runs and sensitivity tests together. Finally, group F contains carbon cost and environmental and social cost scenarios. There are differences of opinion within the WRSE Group as to which scenarios should be considered to be the most “realistic”. That is, care should be taken in using the groupings too literally.

Table 15: Run groupings

	Run Name	Run Number
Group A	Base case	2
	Base case with no uplift	5
	Sustainability reduction Set A	4
	1:50 year DO	13
	Bewl Raising with PDO benefit	14
	Constant bulk transfers	15
Group B	Sustainability reduction A with 160 l/h/d pcc	9
	160 l/h/d pcc	8
	1: 100 year DO	12
	Sustainability reductions B	25
	Sustainability reductions B + 160 l/h/d pcc	26
Group C	Bewl PDO with Lower Itchen and bray stage IV off	18
	Bewl PDO with desalination and effluent re-use costs increased by 10%	24
	145 l/h/d pcc	7
	No effluent re-use schemes	10
	Alternative Thames region options	16
	Bewl PDO with sustainability reduction B	22
	Future sharing off	28a
	SEW sensitivity 2	27
	50 year planning period	11
	Bray stage IV, tidal lower Itchen, Colden Common reservoir and Candover Arle schemes off	18a
	Bray stage IV, tidal lower Itchen, Colden common reservoir, Candover and Arle option and Testwood schemes off	18b
	Bewl PDO with sustainability reduction B and 160 l/h/d pcc	23
	SEW sensitivity 1	17
	existing and future sharing off	28b
Group D	130 l/h/d pcc	3
	Base case with No CC	6
Group E	All	All
Group F	Carbon costs – hybrid	19
	Carbon costs – Halcrow	20
	Carbon costs – hybrid and environmental and social costs	21

A selection of frequency bar-charts for all runs and individual groups A to F can be seen in Appendix 9.

From inspection of the frequency of scheme selection in group A, it is clear that a number of both supply and transfer schemes are selected in every run. For example, Southern Waters' new Lower river Arun abstraction scheme, while some options are not selected in any of these runs. For example, Broad Oak reservoir is not selected.

Schemes selected frequently in Group B are also selected frequently in Group A. However, the more severe scenarios introduce the selection of a range of extra options that do not appear in group A scenario solutions. Examples of less frequently selected options include: Thames Waters Abingdon Reservoir scheme; the extension to the small existing Bulk Supply to Veolia Water Southeast from Southern Water; and Broad Oak reservoir.

The group D selections confirm that, even with lower demand across the region, there is still the need for resource development and transfer options, emphasising the need to follow a twin-track planning approach.

From the inspection of schemes selected frequently in group F, it is clear that a similar group of resource schemes are chosen to those in group A. Frequently selected transfers in group F are also similar to those selected frequently in group A although a wider range of transfers are selected, but infrequently.

A summary of the conclusions from the regional solution options is given in Table 16 noting the relative importance of each element of the solution with respect to its categorised selection frequency. Appendix 10 provides a fuller representation of this assessment, categorising each option included in the model according to selection frequency.

Table 16: Scheme selection frequency across all runs

Group E					
Selected in 15 - 30 scenarios					
Licence change at Borough Green Group	**30**	Removal of network constraints 1	**30**	Removal of network constraints 2	**30**
Removal of network constraints 3	**30**	Removal of network constraints 4	**30**	Removal of network constraints 5	**30**
Variation in Darwell abstraction licence (environmental provision refinement)	**30**	Arun abstraction below tidal limit 10 Ml/d abstraction and 75Ml storage	**29**	Cowbeech New Biological treatment work	**29**
Dover North groundwater / St Margaret enhancement	**29**	Goring Gap 1 (licence transfer)	**29**	Goring Gap 5	**29**
Increase DO at Crowhurst Bridge	**29**	Increase Licence Rate at Eridge	**29**	Increase Licence Rate Saints Hill	**29**
Lambourn Down	**29**	Lye Oak (SLYE) licence recovery	**29**	New sources LGS	**29**
Pembury Closing the Gap on Peak	**29**	Testwood WSW New DAF plant to utilise full licence	**29**	Thurnham new production borehole and treatment upgrade	**29**
Tonbridge Closing the Gap	**29**	Bewl to SEW mid-sussex zone	**29**	Darwell to SEW Eastbourne (Bulk supply) extension	**29**
AR - Kidbrooke	**28**	Bray GW improvement	**28**	Candover and Arle Augmentation scheme	**28**
ELRED	**28**	Farlington Wash water recovery	**28**	Northern New River 1	**28**
Bewl to SEW Medway (Pembury)	**28**	Bulk supplies from Bewl to SEW RZ 6 (via Burham works)	**28**	PRTS to SWS Hampshire link (Petersfield to Otterbourne)	**28**
PRTS to SWS Sussex North (Lex11 improvement)	**28**	SWS Coast to SEW Mid-sussex	**28**	SWS Weir Wood Res. to SEW Mid - Sussex extension	**28**
Aylesford WWTW effluent reuse (10-15)	**27**	Aylesford WWTW effluent reuse (5)	**27**	Aylesford WWTW effluent reuse (5-10)	**27**
Bewl Bridge - New BH off-site & new 4 Ml/d WSW at Bewl Bridge	**27**	Goring Gap 3	**27**	PRTS to SWS Sussex North extension	**26**
AR – SLARS	**25**	Ashey Borehole rehabilitation	**25**	Aylesford WWTW effluent reuse (15-18)	**25**
Deephams STW Reuse - 25 Ml/d	**25**	Lasham Closing the Gap	**25**	Transfer from Bewl to Best Beech (RZ7 - RZ2)	**25**
Bough Beech - Increase treatment capacity to 70Ml/d	**24**	Groundwater Enhancements RZ5	**24**	Clay Hill	**23**
Long Reach Desalination (brackish GW)	**23**	SWS Medway (Burham works) to SEW RZ 6	**23**	SWS Medway (Burham works) to SEW RZ 7	**23**
Bexhill and Hastings WWTW effluent reuse	**21**	Deal Import Continuation after 2012	**21**	Treatment and licence upgrade at borehole at Hoplands Farm	**20**
Cross Solent Main 20 Ml/d	**20**	Sussex North – 5 Ml/d (Hythe Beds)	**18**	Balcombe Rehabilitation	**17**
River Medway MRF reduction	**17**	West Tytherly borehole rehabilitation	**17**	Hurley	**15**
Barham Import Continuation beyond 2014/15	**15**				
Selected in 5 - 14 scenarios					
Deep BH at Stockbury – Matt's Hill distribution input	**14**	New Sources at Brown Woods	**14**	Bybrook WWTW Effluent Re-Use (Westwell)	**13**
Newhaven Desalination (RZ3)	**13**	Bulk supplies from SWS to SEW RZ 7 (via Bewl)	**13**	Broadfields Borehole rehabilitiation	**12**
Effluent Re-use Newhaven to Barcombe Reservoir Conventional 5 Ml/d	**12**	Burham to RZ8 Distribution Mains Only	**11**	Broad Oak Reservoir Development – Option 1 (41.5mAOD with 55 Ml/d transfer capacity)	**10**
Ford WTW	**10**	Lower Itchen abstraction	**10**	Raise Bewl option 4	**10**
Broadoak to Ashford (55Mld)	**10**	Beckton DO of 100Ml/d	**9**	Goring Gap 2	**9**
Tilford Meads	**9**	Effluent Re-use Newhaven to Arlington Reservoir Conventional 5 Ml/d	**8**	Surface Storage Reservoir at Hardham	**7**
SWS Darwell to SEW Eastbourne	**7**	Transfer from SEW Northern North to SWS Hants (Bray to Otterbourne via Whitedown TR3)	**7**	ASR - Cricklade Option 1 (A: Blunsdon)	**6**
Chillerton Reservoir Blue route	**6**	Crossness DO of 100Ml/d	**6**	Desal Portsmouth (PRTS)	**6**
Desalination Plant at Medway 20 Ml/d, ref M2b	**6**	Reculver Desalination	**6**	Bray Stage IV	**6**
SEW Northern to SEW Mid Sussex	**6**	Columbus South Wales B (LON)	**5**	Oxford reuse	**5**
Removal of network constraints 6	**5**	Sussex Coast - 10 Ml/d (Lower Greensand)	**5**	SEW Mid Sussex to SEW Northern North	**5**
Transfer RZ8 to RZ6 (Canterbury to Maidstone) 30Ml/d	**5**				

Selected in 1 - 4 scenarios					
ASR scheme at Wye using water from Kingston	**4**	Desalination Plant at Medway 10 Ml/d, ref M2a	**4**	EASH Peak Licence Scheme	**4**
Havant Thicket Reservoir	**4**	HWFS/ARKR Transfer Upgrade	**4**	ICKE Treatment Recommissioning - New Licence Option	**4**
Reservoir - Abingdon 150Mm3	**4**	SHAK Optimisation	**4**	WHEA Peak Licence Scheme	**4**
Ashford to Bewl Trunk Main (duplicate)	**4**	Barham Import Increase	**4**	Bewl to Ashford Trunk Main (duplicate)	**4**
TW London to Honor Oak - 45Mld	**4**	UTMRD to London (267Ml/d) with Sop134d	**4**	UTMRD to SWOX (40Ml/d) with Sop134d	**4**
Estuary South Desalination (estuarine)	**3**	Sandown Effluent reuse (2.5Ml/d)	**3**	Seasalter Desalination	**3**
Tidal River Arun Desalination 20 Ml/d	**3**	Transfer of effluent from Bexhill and Hastings WWTW to augment storage within Powdermill reservoir (4.6Ml/d)	**3**	Bulk supplies from SWS to SEW (via Selling Fleete Main)	**3**
UTMRD to SWS Hants (30Ml/d)	**3**	2nd Full Desalination Scheme	**2**	ANGL Extension	**2**
Crawley Effluent re-use	**2**	Culham (resource only)	**2**	Estuary South 150	**2**
Frimley/Beech Hill Reservoir	**2**	Hythe Beach Wells RO Desal (brackish water)	**2**	ICKE Treatment Recommissioning + ARKS/BUGR Transfer Maximising ARKN + BUGR/PREP	**2**
Sandown Effluent reuse (10Ml/d)	**2**	Severn-Thames Transfer (London)	**2**	Severn-Thames Transfer (SWOX)	**2**
SWS Colden Common reservoir	**2**	Treated Water Storage	**2**	Bulk supplies from SWS to SEW RZ 8	**2**
Deal High Extension (bulk transfer)	**2**	Honour Oak (London Water Ring Main) 10 Ml/d	**2**	PRTS to SEW Northern South (Clanfield to Tilmore Transfer)	**2**
SEW Mid Sussex to SEW Medway	**2**	Transfer RZ8 to RZ6 (Canterbury to Maidstone) 15Ml/d	**2**	Bough Beech release (PDO)	**1**
Broad Oak Reservoir Development – Option 2 (43mAOD with 65 Ml/d transfer capacity)	**1**	Burham WSW – Increase Treatment + Mains Capacity (10Ml/d)	**1**	Deephams - Langford process	**1**
Deephams STW Reuse - 100 Ml/d	**1**	Desalination Plant at Fawley PDO 45Ml/d, ref HTD4-40	**1**	Essex and Suffolk transfer	**1**
LANE 160	**1**	Raise Bewl option 1	**1**	Raising of Bough Beech	**1**
Reservoir - Abingdon 100Mm3	**1**	River Stour Desalination 10 Ml/d	**1**	River Stour Desalination 20 Ml/d	**1**
30Ml/d Bulk Supply from Thames Water to SESW	**1**	5Ml/d treated water transfer from South East Water to SESW	**1**	Bough Beech to Blackhurst	**1**
Broadoak to Ashford (65Mld)	**1**	Duplicate Medway-Thanet Transfer + Water Quality Resolution	**1**	Honor Oak to Burham	**1**
Honour Oak (London Water Ring Main) 20 Ml/d	**1**	New Medway abstraction at Forestall (contingent upon release from Bough Beach release to Medway)	**1**	Portsmouth Water Supply to Coast	**1**
PRTS Eastgate to Hardham via Whiteways Lodge (duplicate Lex11)	**1**	PRTS to SWS Sussex Coast (Lex20 improvement)	**1**	SWS Medway (Burham works) to SEW RZ 8	**1**
Transfer RZ8 to RZ6 (Canterbury to Maidstone) 10Ml/d	**1**	UTMRD to London (178Ml/d) with Sop134e	**1**	UTMRD to SWOX (20Ml/d) with Sop134e	**1**

4.10 Summary of regional solutions

An interrogation of the overall results concludes the following regional solution summary. Some commentary is included in relation to the main changes in this 2009 work compared to the conclusions drawn in 2008.

4.10.1 Thames Region to Southern Region transfers (or Southern Region to Thames Region)

No Thames to Southern Region transfers are selected in any of the group A scenarios. However, in the more extreme scenarios such as the severe sustainability reduction or higher pcc scenarios, some are selected near the end of the planning period. This contrasts to the previous modelling work conducted in 2007 and 2008, when the WRSE regional model did show some favour to selection of one or other Thames to Southern Region transfer option as part of the regional least-cost solution. The selection of these options prompted further analysis of these options. As a result, more detailed cost estimates were undertaken which proved to be more expensive than the original estimates.

Since transfers between Thames Region and Southern Region do not feature strongly in the latest WRSE regional modelling, we can describe the regional modelling solution in terms of independent Thames and Southern Region solutions.

4.10.2 Thames Region solution

- The Upper Thames Reservoir (UTR) is selected in the highest sustainability reduction supply-demand balance scenarios (scenarios 22, 23, 25 and 26) and in a carbon scenario (scenario 19).
- The WRSE regional model tends to favour effluent reuse and desalination to satisfy Thames Water's London resource zone demand An effluent reuse plant at Deephams is frequently selected towards the middle of the planning period. Desalination, particularly the Long Reach option, is frequently selected towards the end of the planning period. In more extreme scenarios further effluent reuse at Beckton and Crossness is selected. Artificial recharge is also frequently selected and makes an important contribution to Thames Water's demand early in the planning period.
- In Thames Water's SWOX resource zone removal of network constraints and small groundwater schemes are sufficient to meet demand except in the most extreme scenarios.
- In most scenarios, no resource development or transfer schemes are required for Veolia Water Central. (The company's WRMP shows the

company in surplus throughout the planning period). In the higher pcc runs the model selects borehole re-commissioning and booster pumping station options.

- Sutton and East Surrey's option to develop the peak treatment capacity at its Bough Beech reservoir water treatment works is selected in most scenarios except in runs with a lower per capita consumption than assumed by the company. It is not selected in the 136, 152 or 168 litres per person per day scenarios because these are lower than the company's forecast dry year average per capita consumption.

4.10.3 Southern Region solution

- The WRSE regional model endorses the least-cost nature of Southern Water's preferred solution to the River Itchen sustainability reductions in Hampshire. This comprises some increased abstraction from the river Test (within existing licence limits) and the re-licensing of the Candover – Arle groundwater augmentation scheme, together with, possibly, some development of effluent reuse or desalination on the Isle of Wight. However, in case all the environmental concerns about these schemes can not be overcome, based on sensitivity tests with the regional model, we recommend that the following options are kept under review: new abstraction at the tidal limit of the river Itchen; desalination plant at Fawley, Millbrook or elsewhere in South Hampshire; effluent reuse to (some of) the Fawley oil refinery water demand; and resource transfer from Portsmouth Water, supported by a Portsmouth Water resource option.
- The WRSE regional modelling endorses the immediate need for the new abstraction from the tidal river Arun in West Sussex that has recently been applied for by Southern Water. Beyond this, the WRSE regional modelling highlights some resource sharing opportunities between Southern Water and Portsmouth Water in West Sussex and Hampshire that need more consideration and refinement before any further options are implemented.
- Havant Thicket reservoir is only selected in the most extreme scenarios, but it may yet be justified as support to resource sharing arrangements with Southern Water in West Sussex or Hampshire.
- The WRSE regional modelling frequently selects transfer options that share existing and new resources in Kent and East Sussex between Southern Water and South East Water: the development of the Aylesford effluent reuse scheme; the enlargement of Bewl reservoir, or a combination of these two new resource options is also frequently selected; and, of a smaller scale of supply benefit but relevant to revising existing shared resource arrangements, licence variations of the existing Bewl-Medway and Darwell reservoir schemes. These should be pursued to see if they are environmentally acceptable.
- Effluent re-use schemes at Aylesford (Kent Medway) and a smaller scheme based around Bybrook (Kent, Stour) feature strongly in the WRSE regional modelling least-cost preferences.

- South East Water's Clay Hill reservoir is selected regularly with the exception of the lower demand runs. In previous work, this option was over-looked by the model selection in favour of transfer from South East Water WRZ 4 or resource transfer from Southern Water, Sussex North, supported by resource development to Southern Water Hardham. However, the cost of the transfer pipeline option from WRZ 4 has been increased since the previous work, while the link from Southern Water Hardham has been deemed unavailable ("off") in the current modelling pending further review of its viability and cost.
- Desalination schemes at Newhaven, Shoreham, and possibly Medway estuary also feature in some scenarios, though typically toward the end of the planning period. A small desalination plant is likely to be the least-cost way for Veolia Water Southeast to gain more supply resource should its demand not reduce as planned.
- The model also frequently selects a number of small groundwater enhancements by South East Water and some by Southern Water, within existing licence limits.
- Broad Oak reservoir is not selected in any of the Group A runs but is selected in 4 group B runs and 5 group C runs and 2 group F runs. Some of these selections include the reservoir close to the end of the planning period.
- There are some evident sensitivities in the Southern Region solutions. For example:
    - Bewl reservoir enlargement is more favoured if it is assumed to have a PDO benefit. This assumption needs to be properly tested by hydrological analysis and with respect to infrastructure requirements; and
    - As well as some influence from the selection of the Aylesford effluent reuse scheme, other South East Water options seem to be favoured over its Broad Oak reservoir option. For example, Bybrook effluent reuse and / or Reculver (poor quality / brackish) groundwater are favoured in a number of runs when Broad Oak is not selected.

  These sensitivities should be explored in further work.

The above options should provide more than enough new supply resource, and so every scheme listed above may not be needed.

5 Recommendations

The conclusions and recommendations of the WRSE group arising out of the latest round of modelling are as follows:

- The WRSE group concludes that further regional modelling work should be carried out in the next three years;

- A firm timetable should be established for the further work. The Environment Agency, Ofwat and Defra, should consider formalising this timetable which should be consistent with the reporting guidelines for the WRMP and Business Plans;

- This further work needs to be planned so that water companies can take the results of the modelling into account at the very earliest stages of preparation for their next WRMPs (due 2014), and have time to give serious consideration to the resource sharing opportunities arising out of the modelling;

- The WRSE group should convene in early Autumn 2010 to establish and agree the objectives and scope of the proposed further work, distinguishing appropriately between what needs to be explored further in relation to Southern region, Thames region, and the South East as a whole. The group should also discuss and look at the following:
    - the development objectives for the model, and whether a revised model specification should be put out to tender;
    - agreement of option costing 'rules' and an option review and option costing timetable. This could include consideration of appointment of option costing consultants to the WRSE group; and
    - a firmer process of more detailed exploration of shared resources opportunities to be established between water companies from the outset.

- Specifically, the further modelling work should look at the following:
    - development of the approach to include demand management options within the least-cost options selection process; and the
    - inclusion of environmental, social and carbon costs within primary data (dependent on a fuller more consistent data set); and

- More broadly, the WRSE group should encourage work to reduce future uncertainties, particularly with regards to reductions in water supply for environmental reasons and the impact of climate change on resources. The timetable should include a commitment by the EA to provide notification of the requirements for reasonable long term scenario forecasts of sustainability reductions in time for the next round of WRMPs. It should also include a requirement for Ofwat, the Environment Agency and UKCIP to reach agreement and provide guidance on the use of the UKCIP09 scenarios.