Method Statement: Calculation of deployable output

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Executive Summary

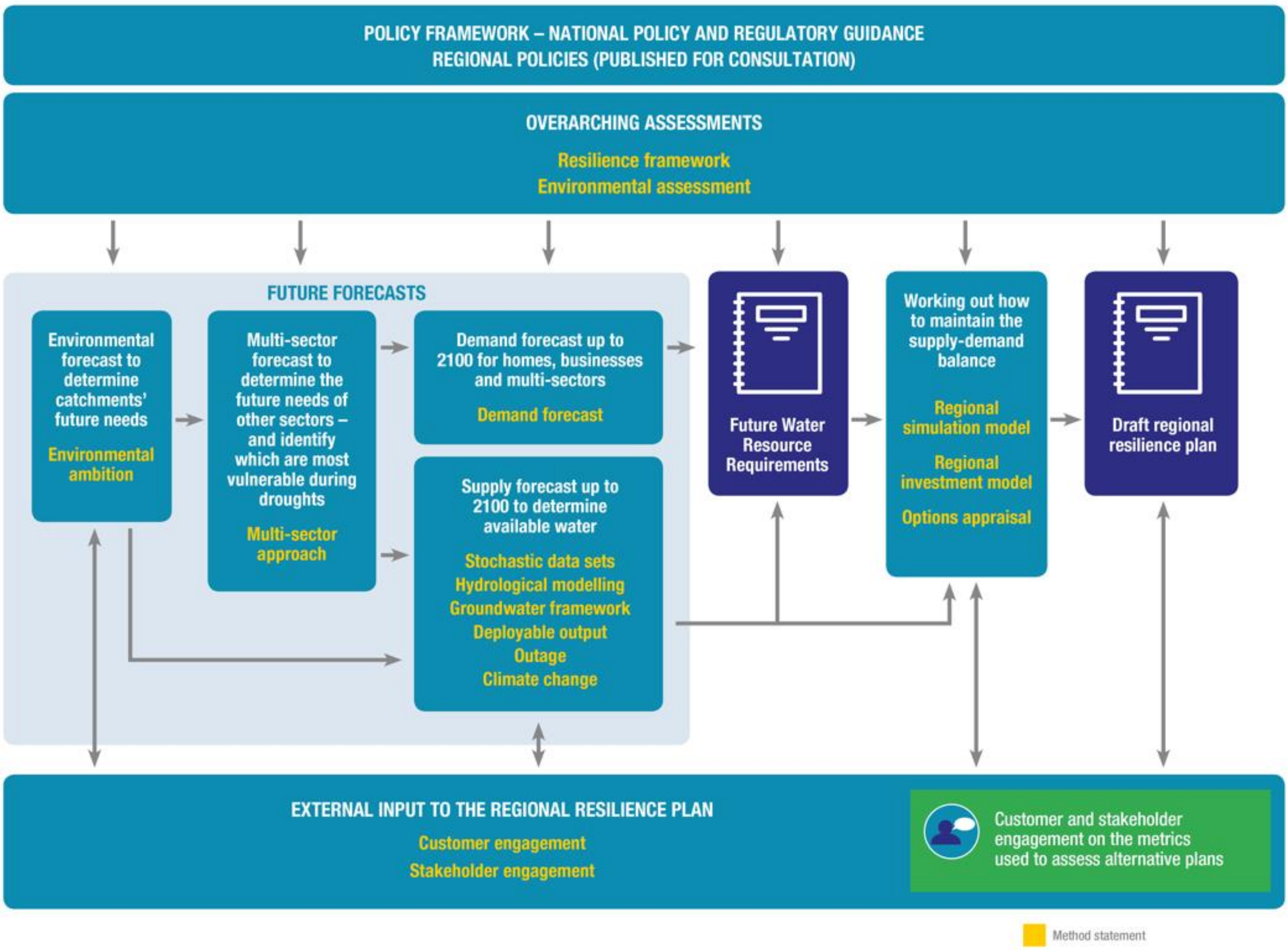
Water Resources South East (WRSE) is developing a multi-sector, regional resilience plan to secure water supplies for the South East until 2100.

We have prepared method statements setting out the processes and procedures we will follow when preparing all the technical elements for our regional resilience plan. We are consulting on these early in the plan preparation process to ensure that our methods are transparent and, as far as possible, reflect the views and requirements of customers and stakeholders.

Figure ES1 illustrates how this deployable output method statement will contribute to the preparation process for the regional resilience plan.

Deployable output is a key building block of the supply-demand balance and is the metric used to determine the supply capability of a water resources supply system in the UK. Consideration of water resources on a regional scale and the development of a regional water resources model for the South East have implications for the calculation of deployable output, and so this method statement outlines how deployable output will be calculated as part of the WRSE regional plan.

Figure ES1: Overview of the method statements and their role in the development of the WRSE regional resilience plan



1 Introduction

1.1 This method statement outlines the methodology that will be followed when using the 'Regional System Simulator' (Regional Simulation Model method statement) to calculate Deployable Output (DO).

1.2 DO is a key metric in water resources planning, used as a measure of the supply capability of a water supply system, and a component of the supply-demand balance. DO is also used to quantify the impact that climate change is forecast to have and assess the benefits that different interventions may have on supply capability.

1.3 By way of clarification, this method statement does not cover a WRSE-consistent approach to the calculation of Source Deployable Output (SDO) values. SDOs are values which state the supply capability of individual sources, while 'system' DO considers the supply capability of a water supply system, potentially involving many different sources and different source types. This method statement is focussed on this 'system' DO assessment, and where 'DO' is used in isolation, this is what is meant. If source deployable output is referred to, the abbreviation SDO is used.

1.4 DO is defined as the supply capability for a water resources system under specified conditions, as constrained by: hydrological yield; licensed quantities; the environment (via licence constraints); abstraction assets; raw water assets; transfer and/or output assets; treatment capability; water quality; and levels of service, as defined by the Water Resource Planning Guidelines.

1.5 Recent changes have been made to the required standard of resilience for which water companies must plan. For WRMP24, companies must define their DO as a supply capability which is resilient to drought of an approximate return period of once in five hundred years, where return period is determined based on 'system response' (as opposed to being based on rainfall/other drought metrics). This is otherwise stated as there being a 0.2% annual probability of 'failure' of a water supply system. In this context, 'failure' means the expected imposition of emergency drought orders (exceptionally severe demand restrictions). Droughts which cause a '1 in 500-year' system response are likely to be different for different Water Resource Zones (WRZs).

1.6 The development of the Regional System Simulator (RSS) allows WRSE water companies to use methods considered advanced in this guidance, such as 'behavioural modelling' (see Environment Agency Water Resource Plan Supplementary Guidance on 1 in 500 drought – not yet published). The development of the RSS also provides a consistent basis for methods to be applied on.

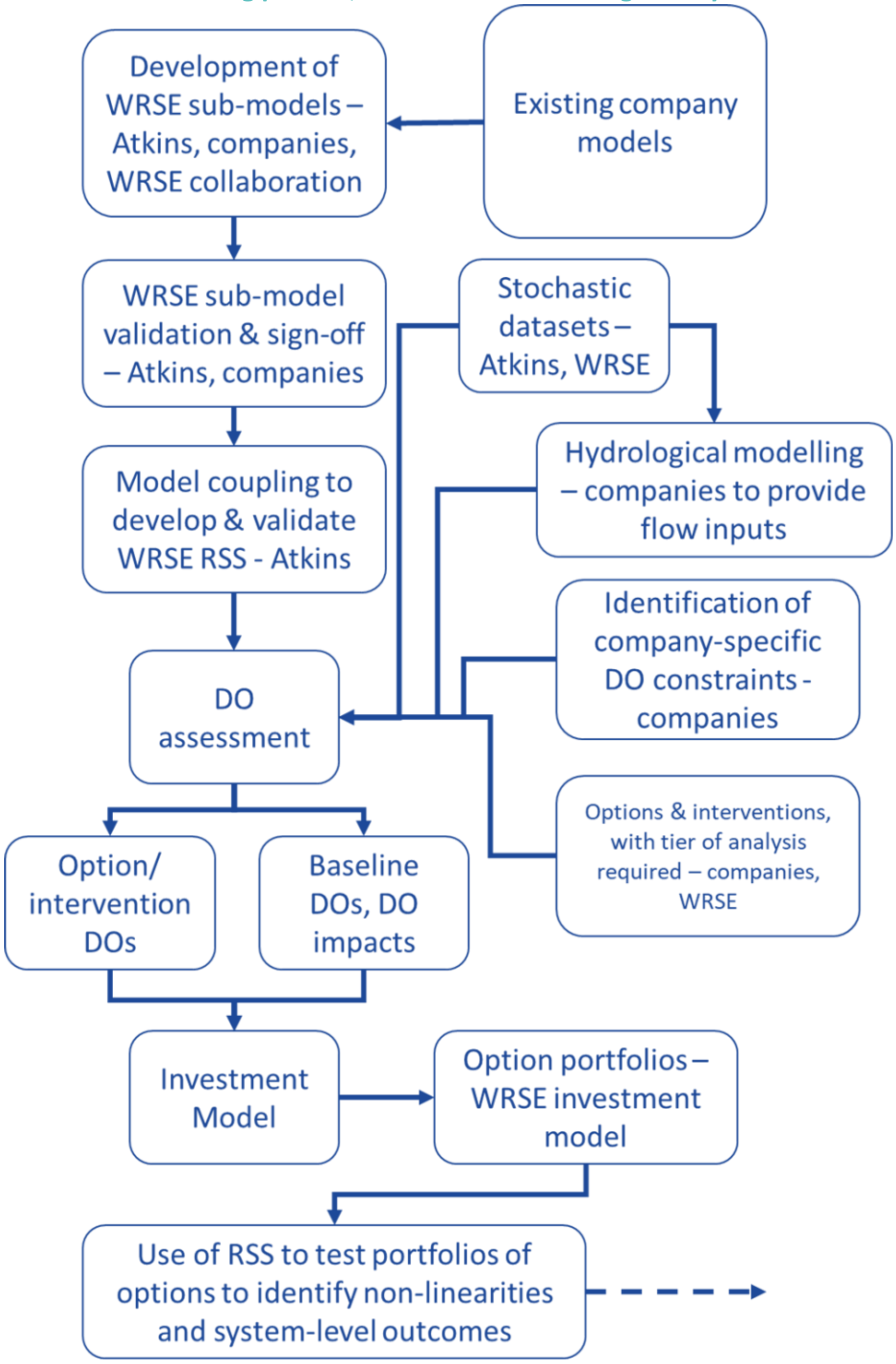
1.7 While this document aims to define a deployable output methodology to be applied across the WRSE region, it is recognised that the RSS may provide a more accurate representation of some WRSE sub-systems than others. As such, individual companies must decide whether the WRSE RSS and this method of determining DO are suitable for determining DO for each of their WRZs. If companies feel that the model and/or method are not suitable for determining DO in one/some of their WRZs, they may apply their own methods. If companies do not accept the WRSE method/model, it will be incumbent on them to provide values which are required for the integrated risk model and investment model, and which are as far as possible consistent with WRSE methods. This is an acceptable fallback position, because the RSS will be used in two phases: an initial phase in which DO is the focus, and a second phase in which the RSS will test outcomes that portfolios of options result in. This second phase of modelling will provide valuable information and would be impossible to do using a company-specific model.

1.8 Figure 1 is a flow chart showing an RSS-centric view of WRSE modelling that is being undertaken.

1.9 This document contains the following sub-sections:

a) Inputs to the regional system simulator (RSS) model specifically relevant to the calculation of DO
b) Characteristics of a successful method for the calculation of DO
c) Methodology for calculation of baseline DO
d) Application of methodology to the calculation of DO benefit for options and interventions

Figure 1: A view of the WRSE modelling process, centred around the regional system simulator



2 Methods and approach

Input Data

2.1 A significant amount of data will be included within the RSS model. The RSS method statement (Regional Simulation Model method statement) gives a comprehensive account of the data which will feed the RSS, with a summary of some items which are of particular significance for DO calculation provided here.

2.2 Weather data is one key input to the RSS, specifically rainfall and potential evapotranspiration (PET). This rainfall & PET data comprises four hundred 48-year sequences, a total of 19,200 years of stochastically generated data (400 x 48 years). This has been designed to be representative of the latter half of the 20th Century, but which represents different versions of what could have happened, given the underlying climatic drivers that occurred during this baseline period. A separate method statement covers the generation of this data (stochastic datasets method statements). To account for more of the hydrological uncertainty in assessing the system's response to a range of droughts, it would be preferable to use all this data to determine DO. Where it is not possible to use all this data, some selection of replicates/events will be carried out. In this context, a 'replicate' is one of the four hundred 48-year sequences, and an 'event' is a time series from within a replicate (shorter than 48 years). This selection will be described in a separate method statement but can largely be classified into pre- and post-DO run selection. Pre-DO run selection is that which will be used for the generation of inputs to the RSS. Post-DO run selection will select events/replicates based on results from the RSS and will be used to inform drought events which should be focussed on where the full 19,200-year record cannot feasibly be used.

2.3 Hydrological data in the form of river flows are important inputs for DO runs. This hydrological data is being developed as part of a separate workstream, and the methodologies used to develop this can be found in the Hydrological Modelling method statement. This hydrological data will be generated for all rivers across the South East region for all four hundred 48-year replicates and will also be generated for all required climate change scenarios.

2.4 Alongside this hydrological data, there are also 'algorithms' being generated in order to assess the impact of groundwater-surface water interactions for some specific cases. These algorithms are specifically being developed for cases where significant abstraction reduction is planned and their impacts have the potential to impact DO in downstream WRZs, but where the identification of streamflow benefit from groundwater source abstraction reduction is non-trivial. This work is further described in the Hydrological Modelling method statement.

2.5 Groundwater yields are being considered in more detail for the regional plan than they have in the South East for previous WRMPs. The groundwater framework (Groundwater Framework method statement) has identified three categories of representation within the regional simulator: profile; time series; and dynamic. Profile representation involves a repeating yearly profile of groundwater yield. Time series representation involves the development of a time series of groundwater yields which is coherent with stochastically generated climatic inputs. Dynamic representation involves the inclusion of lumped parameter groundwater models and/or triggers to represent flow constraints or drought permits and will involve the calculation of groundwater yields and their availability within the RSS.

2.6 One component of the WRSE demand workstream has been the development of 'dynamic demand' models (Demand Forecast method statement). These models are able to generate WRZ-level demand sequences coherent with input weather data, using rainfall, temperature, and other variables as inputs. For the RSS, demand profile sequences will be generated using the climate data that will also feed the hydrological and hydrogeological inputs, such that all of these elements can be considered to be coherent. The methodology used to calculate DO involves applying different levels of demand within the model, measuring the supply capability of a system by applying demands and observing outcomes, and so a profile, rather than absolute demand values, is applicable. These profiles will be normalised (i.e. with an average of 1) for each WRZ, either with a yearly average of 1, or with an average of 1 across a given 48-year replicate, or with an average of 1 across the 19,200-year sequence, as appropriate for a given analysis.

Characteristics of a Successful Method for the Calculation of DO

2.7 The methodology presented in the following section is based on the characteristics of a successful methodology as discussed here.

2.8 The methodology must produce outputs which are consistent with the requirements of water resource planning tables. This means that the methodology must adhere to Environment Agency guidelines for values to be produced. In many cases within the RSS, groundwater will be aggregated to beyond source level, but source-level information is required in the EA tables. Completion of tables requiring source-level information may require some back-calculation of results and/or further analysis.

2.9 Outputs from the calculation of DO and DO benefit of interventions must also be compatible with requirements of the investment model and integrated risk model (Investment Programme Development and Assessment method statement).

2.10 The method should be clear and understandable not only for those working within water resources planning, but also for stakeholders. The WRSE regional plan will be extensively consulted on and the more easily readers can understand methods, the more meaningfully they will be able to engage.

2.11 Water resource plans benefit from consistency between forecasts. Outputs are more likely to be consistent if methodologies are consistent. As such, methods should be consistent with previous company approaches, where this is sensible. Differences are to be expected, since some company methods will change to bring regional consistency, but where differences exist, it should be possible to explain why.

2.12 The more well-aligned individual company plans are with the regional plan, the better. As such, it should ideally be possible for companies to extract information for their WRMPs directly from the WRSE regional plan. The WRSE DO methodology will, therefore, produce outputs that companies can use to form the basis of their WRMPs. A key implication of this is that analysis will be carried out on a water resource zone (WRZ) level, or results from analysis will need to be disaggregated from sub-region to WRZ level, as consistent with current company approaches. As stated above, however, some back-calculation may be required to obtain source-level information for water resources planning tables.

2.13 Regarding assumptions during DO runs, this WRZ-level focus is kept in mind. There are many cases where WRZs/sub-regions interact, for instance those where there are upstream/downstream interactions (i.e. abstractions and discharges in one WRZ/sub-region impact flows in another zone). DO runs will be conducted for each WRZ/sub-region individually, and assumptions across the region should be such that boundary conditions for determining a WRZ/sub-region's DO should be consistent with 'baseline' conditions at the beginning of the planning period.

2.14 Bulk supplies and transfers should generally not be included in baseline deployable output. Instead DO benefit and disbenefit for recipient and donor zones respectively should be calculated for bulk supplies and transfers, whether these are existing transfers or options. However, in some cases bulk supplies and transfers have very important system response implications (for example releasing 'locked-in' DO). In situations where there is sound reasoning for doing so, companies may include inter-zonal/inter-company transfer(s) in baseline deployable output. In such cases, however, it must be made explicitly clear that this is being done, explain why this is necessary, and both zones/companies involved must adopt the same approach.

2.15 From the perspective of performing modelling as efficiently as possible, there are two particularly important criteria. Firstly, DO runs should be as parallelisable as possible, as this allows different levels of demand to be applied at the same time, and different replicates to be run simultaneously, reducing overall runtimes for DO runs. Secondly, processes should be automatable, and it should be possible to run a given 'DO' run from start to finish with no manual intervention.

2.16 As mentioned above, while it is hoped that the WRSE RSS will be universally applicable across all companies' WRZs, it may be that some WRZ/sub-region sub-models produce results which differ materially from expectations, and companies will require further investigations to be carried out to understand the differences in expectation versus outputs, before committing to the outputs. In these instances, it will not be mandatory for companies to adopt baseline DO and/or option DO values calculated via this method until the uncertainty is resolved. An important implication of this is that this method should be sufficiently flexible that companies/WRZs can be excluded from analysis and not render the whole method invalid.

Methodology for Calculation of Baseline DO

2.17 Based on the characteristics of a good method identified in the previous section, the DO calculation methodology is outlined in this section.

2.18 The baseline DO methodology does not attempt to calculate a 'regional DO'. Instead, DO will be calculated for each WRZ (or sub-region) individually, with coherent datasets, methods, and assumptions across the region.

2.19 The RSS will be used to generate a 'simulated' system DO for all WRZs where it is applied.

2.20 Baseline DO runs will be based on running all four hundred 48-year replicates through the RSS and observing system outcomes.

2.21 WRZ-level DO will be based on applying different levels of demand to a WRZ and observing system response, particularly modelled 'Levels of Service' (LoS) and overall system-level ability to meet demand. There is a WRSE-wide policy workstream regarding the alignment of LoS; it is not yet known, however, whether LoS will be aligned across the region. If LoS are aligned, WRSE will make clear LoS to be applied; if LoS are not aligned, companies must document LoS to be considered as DO constraints.

2.22 For a given WRZ, the number of events which cause the modelled imposition of emergency drought orders at each level of demand will be counted. The return period of emergency restrictions will be determined from this figure.

2.23 It is assumed that in the majority of cases the DO will be based on an indication from the model that emergency drought restrictions would be required. All LoS will, however, be considered as constraints (for example, for a company's stated LoS that the imposition of non-essential use bans (NEUBs) is not more than once every fifty years, if a certain level of demand implies the imposition of emergency drought orders only once every 1000 years but the imposition of NEUBs every 49 years, this would be considered a failure). It may be necessary for companies to change their control curves in order to comply with their stated Levels of Service.

2.24 Where the modelled imposition of emergency drought restrictions is the governing constraint on DO, the baseline DO will be defined as the highest level of demand which causes a modelled imposition of emergency drought orders not more than once every 500 years.

2.25 Emergency storage in raw surface water storage reservoirs is an allowance that companies make to ensure that water will still be available even if drought more severe than that which is planned for occurs. Emergency drought restrictions are often defined based on the point at which companies enter their emergency storage allowance. It is recognised that different companies within WRSE make different assumptions around dead storage and emergency storage requirements due to the nature of different reservoirs and reservoir systems and the way that they operate. As such, WRSE will not align assumptions regarding emergency storage requirements. Companies must clearly define how and why their emergency storage volumes have been calculated.

2.26 Individual companies will state the conditions under which emergency demand restrictions would be applied. Generally this will be associated with either a 'demand centre failure' (i.e. in the model a demand centre requires a certain amount of water to be supplied to it, but sources of supply cannot supply enough to meet this requirement), or a failure associated with a 'Level 4' LoS trigger (generally reservoir storage going below a control curve). The mode of any 'failure' should be recorded by the RSS, to help with the identification of DYCP/DYAA/MDO events.

2.27 Individual companies will also state the conditions/triggers under which other demand restrictions would be imposed.

2.28 Companies may choose whether to apply demand restrictions within DO calculation. It is important that the benefit that demand restrictions would bring is included in the supply-demand balance, but this should not be double counted. If a company would trigger demand restrictions based on a different zone this can be included in the model, either via input time series or via the inclusion of numerous zones/sub-regions in a given zone/sub-region's DO model run.

2.29 DO will be determined for each WRZ/sub-region individually (i.e. DO runs will not involve placing 'DO-consistent' levels of demand on all WRZs in the region simultaneously).

2.30 Where DO is being found for one WRZ/sub-region, all other WRZs in the RSS will have WRMP19 Year 5 Final Plan Dry Year Demand as the demand placed on them (other WRZs may also have dynamic demand and demand savings included).

2.31 The RSS is a model which is formed of WRZ/sub-system/company sub-models. The DO calculation for a zone will use the minimum model complexity required to adequately capture boundary conditions. This is best explained using examples. Where a WRZ has no other WRZs upstream and is not impacted by demand in other WRZs, use of the WRZ sub-model will be sufficient. Where there are several WRZs upstream of a given WRZ, determining the flows arriving at this WRZ depends on the abstractions and effluent returns from upstream zones. Where this is the case, more RSS component sub-models may be required, or boundary conditions may be determined by conducting an individual run of other sub-models. WRSE's modelling ambition is to improve these conjunctive assessments. Where this is not possible the assessment will utilise assumptions not worse than those used historically by company-only assessments.

2.32 Baseline deployable output will be calculated using demand steps of no more than 0.5% of DO. This means that a WRZ/sub-region with a DO of 100Ml/d would have a DO known to be 100 +/- 0.5Ml/d, while a WRZ/sub-region with a DO of 1000Ml/d would have a DO known to be 1000 +/- 5Ml/d.

2.33 The RSS may allow companies to calculate a fully simulated DYAA, DYCP and minimum DO for each WRZ, should they wish to do so. The inclusion of climate-dependent dynamic demand profiles means that peak demand factors will be included explicitly in modelling. There is a significant challenge in determining from model results the 'type' of failure (i.e. is a failure associated with DYAA/DYCP/MDO), but should it be reasonable to overcome this companies may use the model to generate these values. This may involve either 'on-the-fly' classification of failures, or post-processing of model results. The use of dynamic demand within simulation modelling may require companies to revise definitions of 'peak demand' and peak demand periods; many company assessments are currently made based on pre-determined peak periods.

Application of Methodology to the Calculation of DO Benefit for Options and Interventions

2.34 Options and interventions here include those things traditionally thought of as water resources 'options' (e.g. new sources of water, transfers, reservoirs, etc.), as well as sustainability reductions, the use of drought permits, and changes to failure criteria.

2.35 It is recognised that the DO calculation methodology is computationally intensive. Using this methodology (i.e. running 19,200 years' worth of data) to assess the impact of climate change and to determine the DO benefit that all possible options and interventions bring is infeasible due to the sheer computational burden involved.

2.36 As such, a tiered approach to the calculation of DO benefit for options and interventions will be taken.

2.37 Tier 1: Where intervention benefit is deemed to be highly dependent on climate and/or triggers and/or there are significant conjunctive-use implications associated with an intervention, it is proposed that the same DO calculation methodology will be used as for the baseline DO benefit (i.e. use of all four hundred 48-year replicates and determination of DO based on the frequency of imposition of emergency drought restrictions). The DO benefit shall be calculated as the DO with the intervention in place, minus the baseline DO. It may be that the number of schemes that can be analysed using 'tier 1' analysis is limited, due to the computationally intensive nature of this approach.

2.38 Tier 2: Where intervention benefit is deemed to be slightly dependent on climate and/or triggers and/or there are potentially minor conjunctive-use implications associated with an intervention, a 'drought library' approach will be taken. In this approach, results from the 'baseline DO' assessment will be used to highlight and select a number of droughts of approximate magnitudes (based on baseline system response) ranging from 1 in 500 to 1 in 50 years (selection being more heavily weighted towards more severe drought). A wide range of pre-intervention magnitudes is included due to the recognition that interventions can change the relative severity of different droughts. In this approach, the 'yield' of the baseline system will be calculated for each drought in the 'library' (yield being defined as the demand just below which emergency restrictions would be required for a specific drought event); the yield would then be recalculated for each drought in the library with the intervention in place. The yield benefit for each drought in the library would, therefore, be found. If it is found that there is significant variability in the yields found under different droughts, a 'check' will be undertaken using the full sequence and the estimated DO to ensure that the system response at the new DO is as expected. If this check is failed, Tier 1 analysis may need to be undertaken (note, this is a potential feedback loop). Otherwise, the DO benefit of the option should be found using the interpolation of DO benefit values for droughts of different return periods, taking the DO benefit to be that predicted for a return period of 500 years. A range of drought magnitudes may be required to provide the relevant information into the "states of the world" analysed in the investment model (e.g. 1:200, 1:500).

2.39 Tier 3: Where intervention benefit is not expected to be dependent on climate inputs and/or triggers and/or where there is little/no conjunctive-use impact, DO benefit of an intervention will not be calculated via modelling in the RSS. Preferred options are still likely to be built into the RSS for future 'resilience testing' model runs of the preferred plan (i.e. the output from investment modelling).

2.40 Should DO benefit associated with differing drought severities be required as an explicit input for the WRSE investment model, the 'Tier 2' method above may be adapted/repeated with a different upper resilience level specified. Results from 'Tier 1' and 'Tier 3' analyses will be able to give DO benefit values for all return periods implicitly.

2.41 The investment model is based on an additive assumption regarding DO benefits of different options. As such, DO benefits will be calculated for different interventions independently.

2.42 For joint options and transfers, the same 'minimum complexity required' approach to determining sub-models used in determining DO benefit/disbenefit will be taken, but with consideration given to the intervention being investigated.

2.43 For transfers, it may be the case that the DO benefit/disbenefit is not zero-sum under different rule configurations, due to differing vulnerabilities of different WRZs.

2.44 The DO benefit that options and transfers may bring, as well as the costs associated with them, can be dependent on the rules governing their operation. In this case, the DO benefit of an option may need to be calculated under different triggers and rules, with each combination of option and rule configuration considered a separate option. For instance, if a given transfer is assumed to be 'always on', it is likely to have a different DO benefit/disbenefit to a transfer which is on as a 'last resort'. Rules for transfers will not be optimised, and different rule scenarios will instead be tried.

2.45 For transfers and joint options, the RSS will not seek to maximise the DO-benefit brought by a given option by dynamically allocating water to participating companies/WRZs (options and transfers being a supply-demand issue, not a supply capability issue). Instead, rules regarding transfers and joint options must be pre-specified, though these rules could be based on the relative drought severity affecting different areas if it is possible to implement this in the model and if it would be possible to write the rules into a contractual agreement. This reflects the necessity of water resource modelling to represent what would happen during a drought situation. As mentioned above, final assessment in the RSS will be full conjunctive "simulation" of the region to address any integration/non-linear issues.

Decision Points & Documentation

2.46 As described throughout this method statement, there are several decision points when producing models and calculating deployable outputs. Examples of decisions to be made are: determining which uses a given sub-model is suitable for; determining whether to use the RSS or company models/ assessments for calculating baseline deployable output; which tier of assessment to be applied for a given option.

2.47 For key decisions, keeping appropriate documentation is valuable for later justifying outcomes and decisions further down the modelling chain. In this section, key decision points are identified. Decision makers, those collating decisions across the region, and required documentation are described for identified decisions. There are of course many small decisions made during the course of building a water resources model and it is infeasible that all decisions would be recorded, although all decisions should be justifiable if questioned. This section only focusses on high-level decisions.

2.48 Identification of key assumptions to underly deployable output assessments which will not be aligned across WRSE - Water companies should document and justify key assumptions which will underly their deployable output; WRSE will collate assumptions from companies. Assumptions considered 'key' will vary between companies and WRZs and so companies should identify those assumptions that they see as key for given WRZs. Examples of key assumptions include Levels of Service, emergency/dead storage assumptions, control curves, the point at which Level 4 restrictions would be implemented, and inclusion/exclusion of the benefits of demand restrictions from baseline DO.

2.49 Identification of suitability of model for different purposes - As part of the model build process, Atkins are undertaking a model validation process in collaboration with water company leads. Company model leads will 'sign off' models for use in different circumstances based on the validation evidence presented to them.

2.50 Choice between application of WRSE Deployable Output Methodology and WRSE Regional Simulation Model for determining baseline deployable outputs, or application of company models & methods - Companies will need to document and justify a decision that does not apply the WRSE DO methodology and/or WRSE Regional Simulation model.

2.51 Inclusion of bulk supplies/transfers in baseline deployable output - If any inter-zonal or inter-company transfers are to be included in baseline deployable output, this should be justified and documented by the relevant company. If it is an inter-company transfer, the company should inform the other company involved to ensure a consistent approach. WRSE should be informed of all cases where transfers are to be included in baseline deployable output.

2.52 Choice regarding tier of analysis required for different options - Companies will be required to advise Atkins on how options should be included within the system simulation model. The template sent to companies will include fields asking the relative impact of weather on DO (none/minor/major) and an advised tier of analysis. Atkins will liaise with WRSE to confirm tiers of analysis for different options (noting restrictions on the depth of analysis that can be achieved during the project timescale).

Confidence Grades

2.53 It is recognised that a methodology will be required for assigning confidence grades to deployable output. However, this has not yet been determined.

3 Summary

3.1 This method statement has outlined how deployable output will be calculated as part of the WRSE regional planning process.

3.2 The input data used in the deployable output assessment has been described, particularly noting those datasets which are significantly different to those used in WRMP19.

3.3 The characteristics of a successful methodology have been described, in order that the methodology that follows may be assessed by the reader against these criteria.

3.4 The deployable output methodology was then detailed.

3.5 The different circumstances under which the deployable output methodology will be applied were then detailed, including cases where adaptations of this method may be required.

4 Next steps

4.1 We are consulting on this method statement from 1st August 2020 to 30th October 2020. Details of how you can make comments can be found here – (consultation page).

4.2 We will take into account the comments we receive during this consultation process, in updating the Method Statement. Alongside this, the Environment Agency will shortly be publishing its Water Resource Planning Guidelines (WRPG) on the preparation of regional resilience plans. We may need to update parts of our method statements in response to the WRPG. We have included a checklist in Appendix 1 of this method statement which we will use to check that our proposed methods are in line with guidance where applicable.

4.3 If any other relevant guidance notes or policies are issued then we will review the relevant method statement(s) and see if they need to be updated.

4.4 When we have finalised our Method Statement, we will ensure that we explain any changes we have made and publish an updated Method Statement on our website.

Appendix 1 Checklist of consistency with the Environment Agency WRMP24 Checklist

The Environment Agency published its WRPG on XXXXXX 2020, including the WRMP24 Checklist. The following table identifies the relevant parts of the checklist relating to this Method Statement, and provides WRSE's assessment of its consistency with the requirements in the Checklist.

No.	Action or approach	Method Statement ref:	WRSE assessment of consistency