TECHNICAL NOTE

Drought Trigger Development: Pywr Modelling

SUBJECT
Work Package 1: Model Review and Run Log

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AUTHOR
AtkinsRéalis

DISTRIBUTION
Ben Sansom
Donald Rwasoka
Michael Sinden
Simon Parker
Faisal Butt

REPRESENTING
Southern Water Services

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1. Introduction

Southern Water (SWS) and Portsmouth Water (PW) are required to produce drought plans which will outline the actions each company will take to ensure that water can be supplied to their customers in the event of dry weather and drought conditions. The modelling work described in this report and WP2 will be used to support the 2027 Drought plan submission. During the last drought planning cycle (Drought Plan 2022, DP22), SWS undertook an assessment of their drought triggers based on the River Test and Itchen. The SWS Western Area Water Resources model was used to model the drought triggers to understand their performance and to test the sequencing of drought interventions set out in the Section 20 (S20) agreement.

This project has been commissioned by SWS to undertake further work with the use of the Pywr model to support the development of their DP27 submission, specifically the assessment and development of drought and recovery triggers for the Rivers Test and Itchen. Recovery triggers are required in line with the 2025 Drought Planning Guidance[1].

The assessment and development of drought and recovery triggers through this project has been broken down into the two work packages as set out in the scope.

- Work Package 1 (WP1): Review and preparation of the model
- Work Package 2 (WP2): Drought plan 2027 modelling

The purpose of this technical note is to capture the model review process undertaken as part of WP1, provide a finalised model run log ahead of WP2 and to summarise how this project will link to the Regional System Simulator held by WRSE.

[1] Water company drought plan guideline, 2025 - GOV.UK

2. Model Setup and Parameters

This section details the key features of the Hampshire Pywr model that have been reviewed as part of the model set-up phase prior to WP2. As part of the project scope SWS have requested that the following elements would need to be assessed to ensure the model is appropriate to run in WP2. Critically, **the model should include the existing SWS Section 20 arrangements on the use of the River Itchen and River Test, including the Candover Augmentation Scheme, during a drought.** Several elements including the Section 20 operating agreement on the Itchen and the Test as well as the Candover augmentation scheme previously existed in the model. These elements have been reviewed to confirm accuracy. Further detail on the Section 20 agreement and the Candover Augmentation is provided in Section 2.4.

1. ***The model should be able to run simulations with the Candover Augmentation scheme turned on or off, during the whole runs or for some time periods of the run e.g. post-2030.***
   The Candover augmentation scheme can be enabled or disabled between different model run scenarios. Should this augmentation scheme only be partially required, this can be controlled by the addition of a time-dependent parameter. Please see Section 2.4.1 for additional detail.

2. ***The model should include drought options i.e. Permits and Orders already included in the WRMP24/DP22 optioneering process and any other potential drought options for DP27.***
   We have reviewed the current representation of drought permits and orders within in the model alongside the Section 20 Agreement and Drought Plan 2022. The supply benefits to undertaking drought actions are primarily achieved through reduction in Hands off Flows. Demand side benefits are focused on the implementation of Temporary Use Bans (TUBs) and Non-Essential Use Bands (NEUBs). These were already present in the Pywr model and have been reviewed. No other potential drought options were identified by SWS for DP27.

3. ***The joint modelling system should be able to simulate flows at Riverside Park, Gaters Mill as well as considering the tidal limit at the mouth of the River Itchen.***
   All variants of the Hampshire area Pywr model consist of link node components which allow flows at the specified locations to be recorded. No significant changes have been identified as part of WP1.

4. ***The Gaters Mill abstraction from the Itchen and the PW bulk water supply into SWS should be represented dynamically.***
   The existing Hampshire model (SWS & PW combined) includes dynamic representation of the Gaters Mill abstraction and the PW bulk supply to SWS. The bulk supply is triggered based on flow volumes in the Rivers Test and Itchen and transfers either a sweetening flow of 0.4 Ml/d or a bulk transfer of up to 15 Ml/d responding to the needs of the system. The transfer is triggered ‘on’ when flows in the River Test drop below 440 Ml/d or when flows drop below 220 Ml/d in the River Itchen. The transfer is then turned off when flows recover to above 465 Ml/d in the River Test and/or 245 Ml/d in the River Itchen. Flow is transferred from the Itchen WTW (Portsmouth Water) to Otterbourne Hill (Southern Water).

5. ***Reconciliation of the model between WRSE and the variant used to support the T2ST SRO project.***

   A review of the work undertaken across various projects over the previous planning period was undertaken as part of WP1. The findings of this form part of a database in Appendix A, however all changes taken forward for this project have been summarised in this technical note. Most features relevant to this project were found in the Hampshire Area model used in the T2ST utilisation modelling project. That version of the model contains recent refinements to improve model reliability and performance. However, the T2ST SRO itself is not included due to not being part of the scope of this project as the existing timeline of implementation is in 2040 and therefore after the relevant time period modelled in this drought planning project (2027-2034). From this

baseline model, adjustments have been made to align with drought plan features required for the WP2 modelling.

6. ***Modelling baseline and time frame***

WP2 will assess four different time slices to capture the critical phases of the drought planning period amongst other expected changes:

1. 2027: The baseline and start of the drought planning period.
2. 2030: The section 20 agreement is due to expire in 2030, along with the existing Candover Augmentation license.
3. 2032: The end of the drought planning period, as well as the start of a next drought plan period.
4. 2034: When Havant Thicket Reservoir is expected to be online. It is important to quantify the impact of the integration of new storage into the system and how that may affect any drought triggers and dynamics that may occur, including the effect of predicted climate change on the system.

2.1 River Flow

The stochastic baseline dataset developed as part of WRSE AMP7 is used as the basis for flow data in the model, along with climate change scaling data in the 2034 time-slice. It is expected that the impact of climate change will generally reduce the flow across the region and lower the response time of the system. However, it is possible that some flows will increase in winter months due to the climate change.

2.1.1 Climate change scaling

Climate change will impact the amount and pattern of rainfall seen in the South East of the UK. The impacts of climate change are projected to become more adverse over time, and with hotter, drier summers projected for the future, the severity and frequency of droughts is expected to increase.

To model climate change impacts in WP2, a temperature-based equation, Equation 2-1, developed in the Climate Data Tools Scaling Report[2] was used to scale back the data to the appropriate time-slices.

Equation 2-1 Scaling equation

$$Scaled\ flow = Baseline\ flow + Scaling\ factor * (2070\ flow - Baseline\ flow)$$

400 stochastic replicates were generated for WRSE in AMP7 however only 21 of those replicates were selected for us in climate scenarios across the region. Therefore where climate flows are required in this modelling only those 21 traces are used. For this modelling we propose using the median climate impacted flows in the Western Area from the 28 climate models available as part of WRSE.

[2] Regional Water Resources Planning: Climate Data Tools – Draft operational framework for implementing the EA Supplementary Guidance on Climate change. Atkins, 2021

Figure 2-1 provided an illustration of the climate change impacted flows for the Alre inflow location in the Pywr model and indicates how flows vary between 2034 and the baseline position (climate change baseline, not the baseline for this modelling).

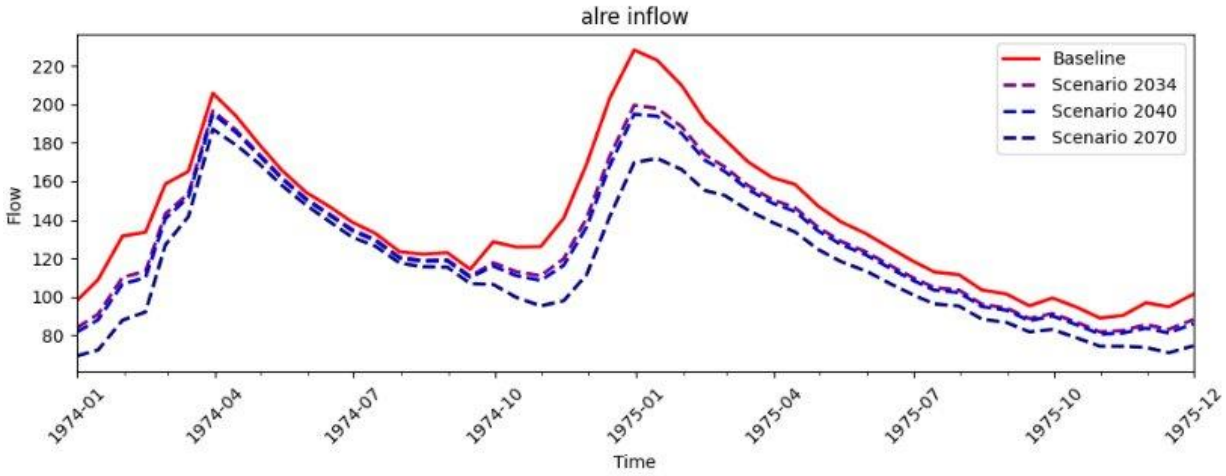

Figure 2-1 - Flow timeseries for the Itchen at Alre in 1975 for a single stochastic trace showing the impact of scaling climate change across the time-horizons.

2.2 Public Water Supply Demand

Public Water Supply demand in the Hampshire area is expected to decrease over the planning period due to proposals by the company to reduce demand through leakage reduction and demand management activity, alongside broader government measures to support reduced consumption. Demand data was provided from both SWS and PW and for each Water Resource Zone (WRZ). WRZ-level demands were then apportioned across the demand centres using existing splits in the Hampshire model, with these splits remaining constant across all run scenarios.

Table 2-1 and Table 2-2 show the demand values for the SWS and PW demand centres respectively. The demand values are representative of a Situation 4 ‘Core pathway’ demand from the 9 situations assess as part of WRMP24.

Table 2-1 - Modelled demand for SWS with all values in Ml/d

Demand Centre	2027	2030	2032	2034
DC10	3.322	3.174	3.105	3.024
DC11	17.556	16.986	16.811	16.532
DC12	34.716	33.227	32.879	32.297
DC15	1.338	1.280	1.267	1.245
DC16_Michelmersh	4.351	4.156	4.066	3.960
DC17	11.628	11.250	11.134	10.949
DC19	27.369	26.480	26.207	25.772

DC24	11.302	10.919	10.747	10.519
DC25	3.939	3.806	3.746	3.666
DC26_Barton_Stacey	0.773	0.747	0.735	0.719
DC30	37.986	36.753	36.373	35.769
DC42	3.624	3.502	3.446	3.373
DC53_Overton	1.022	0.993	0.959	0.941
DC54_Whitchurch	1.315	1.278	1.235	1.211
DC55_Littledown	0.046	0.045	0.043	0.042
DC56_Micheldever_Rd_Upper_Enham	12.694	12.339	11.922	11.694
DC57_Pill_Heath_Blagen_House	1.622	1.576	1.523	1.494
DC61_Chilbolton	0.270	0.262	0.253	0.248

Table 2-2 - Modelled demand for PW with all values in Ml/d

Demand Centre	2027	2030	2032	2034
Shedfield_Street_End	4.709	4.484	4.225	4.068
West_Meon	0.200	0.191	0.180	0.173
Firdown	1.605	1.528	1.440	1.386
Hambledon_Clanfied_Catherington_Horndean_Nelson	10.558	10.053	9.472	9.119
Knowle_Village	5.229	4.979	4.691	4.516
Hoads_Hill_Gosport	25.909	24.670	23.243	22.378
Dore_Avenue	0.862	0.821	0.774	0.745
Nelson_NOD	2.005	1.909	1.798	1.731
Southwick	0.868	0.826	0.779	0.750
George	11.040	10.512	9.904	9.536
Farlington	11.642	11.085	10.444	10.056

Portsmouth_average_demand	46.669	44.438	41.868	40.310
Racton_Walderton_Ratham_Lane_New_Lane	13.546	12.898	12.152	11.700
Lavant_Appledown_Highdown_Canada	31.967	30.439	28.678	27.611
Littleheath_Norehill	19.342	18.417	17.352	16.706
Madehurst_Slindon	1.421	1.353	1.275	1.228

2.3 Environmental Destination (ED)

ED refers to the plans by water companies to address risks of environmental issues stemming from the abstraction of water from natural sources, which may result in supply-demand challenges over the long term through limiting the amount of water that can be abstracted on a daily and an annual basis. This is often achieved in modelling terms through a reduction of the available daily and / or annual licence. Environmental Destination and associated licence reductions are expected to be in place by 2050 however there is a profiled approach to implementation. WINEP investigations across licences are on-going and the Easton licence has been confirmed to not require reduction. This has been included within this modelling. Any WINEP outcomes beyond January 2026 have not been included.

Only three of four of the time slices will use environmental destination as a constraint: 2030, 2032, and 2034. 2027 will not consider ED as no licence reductions are expected to be in place. For the SWS model section, high ED will be used for all runs using data collated during the T2ST projects. The license for Easton was updated during previous work, and the updated value is to be used here. For the PW section of the model, low ED is used in all modelling prior to a 2040 decision point. Since ED data from SWS is not projected annually, the intermediary years will use interpolated values. As PW ED values are available on a year-by-year basis this interpolation will not be required.

2.4 Drought Triggers / Actions

Existing triggers were reviewed and summated for initial understanding of operational response time and development as summarised in Table 2-3 below. The Section 20 Agreement with the EA sets actions related to drought level and requirements for actions for SWS to carry out before any demand savings and operational recharge schemes are to be undertaken. Initial Hands-off Flow limits for the Itchen and the Test are set at 198Ml/d at Allbrook and Highbridge, and 355Ml/d at the Test Tidal Limit (TTL) respectively. These limits may be lowered under pursuance of drought orders and permits determined by the agreement. Allbrook and Highbridge may be lowered to 160Ml/d under a drought order and the TTL may be lowered to 265Ml/d under a drought permit. This can be lowered further to 200Ml/d under a drought order.

Table 2-3 captures the existing Level 1, 2, 3 and Drought End Triggers. Drought level triggers for the Western area are based largely on flow level. Currently, Section 20 defined <60 day triggers for the HoF on the Itchen and TTF are the main drivers of Level 1, though Standardised Precipitation Evapotranspiration Index (SPEI) / Standard Precipitation Index (SPI) and groundwater levels are also considered secondary triggers. There are planning-related triggers within drought levels related to Section 20 HoF agreements to allow time to begin applying for related drought permits and orders. At level 3, three separate Itchen flow triggers relate to the application for the Candover Augmentation Scheme, the River Itchen Drought Order, and Level 3 Drought Order restrictions to reduce demand level (implementation of NEUBs). Further detail on these triggers and activities is captured in Table 2-4.

Table 2-3 - Existing Level 1, 2, 3, and Drought End Triggers for SWS Western Area.

Trigger	Level 1	Level 2	Level 3	Drought End
Groundwater level: West Meon	• GW level < 1in5year threshold **OR**	• GW level < 1-in-10-year trigger curve **AND** SPEI or SPI < 1-in-5-year threshold **OR**	• GW level < 1-in-20-year trigger curve **AND** SPEI or SPI < 1-in-5-year threshold **OR**	
SPI (6-Month): River Test	• SPEI or SPI < 1in5year threshold **OR**	• SPEI or SPI < 1-in-10-year trigger curve AND GW level close to 1-in-10-year trigger curve **OR**	• SPEI or SPI < 1-in-20-year curve AND GW level close to 1-in-20-year trigger curve **OR**	• SPEI > 0.0 **AND**
SPEI (6-Month): River Test (Downstream)	• TTF < 60day HoF 355 Ml/d	• TTF < 356 Ml/d Subsequent triggers through Level 2: • TTF < 35-day HoF 356 Ml/d	• TTF < 310 Ml/d Subsequent triggers through Level 3: • TTF < 285 Ml/d	• GW level > 1-in-10-year trigger curve **AND**
River flow: Test Total Flow (TTF)	Subsequent triggers through Level 1: • TTF < 35day HoF 355 Ml/d (DP application) • TTF < 50day, 60day, 35day to DP HoF 355 Ml/d **OR** • Itchen < 60day HoF 205 Ml/d	**OR** • Application threshold determined by flow forecasting and discussions with EA	**OR** • River Itchen flows < 205 Ml/d - Candover Augmentation Scheme Drought Order Application • River Itchen Flows < 200 Ml/d - apply for Level 3 Drought Order Restrictions • River Itchen flows < 198 Ml/d - Implement River Itchen Drought Orders	• TTF > 60-day HoF 355 Ml/d **AND** • Itchen > 60-day to 205 Ml/d threshold
River flow: Itchen — Highbridge & Allbrook				

Table 2-4 - Sequence of drought actions as specified in the S20 agreement.[3]

Ref	Activity	Comment		
1	Utilisation of SWS water sources and bulk supplies	Prior to any application for a drought permit or order, SWS will utilise its own existing water sources available to supply the Hampshire and Isle of Wight Water Resource Zones within the terms of their respective licences. This will include water available under the Portsmouth Water bulk supply scheme.		
2	Level 1 water use restrictions	Escalate demand-side water efficiency measures including media campaigns		
3	Level 2 water use restrictions	Implement partial temporary use bans (TUBs) pursuant to section 76 IA 1991 unless it is agreed with the Environment Agency that it is unnecessary because savings will be minimal		
4	River Test Drought Permit	Abstract from River Test Surface Water below the Environment Agency's proposed TTF Hands Off Flow (HOF) of 355 Ml/d down to 265 Ml/d pursuant to a Drought Permit		
5	Level 3 water use restrictions	Apply for a Drought Order to authorise partial Non-Essential Use (NEU) restrictions (Level 3 phase 1 drought restrictions).		
	Candover augmentation scheme	River Test Surface Drought Order	Level 3 phase 2 drought restrictions	Lower River Itchen Drought Order
6	When flows fall below 205 Ml/d at Allbrook and Highbridge on the River Itchen, abstract up to 27 Ml/d (limited to 20 Ml/d in certain months).	When TTF falls below 265 Ml/d, abstract down to a baseline of 200 Ml/d pursuant to a drought order.	When flows fall below 200 Ml/d at Allbrook and Highbridge implement full TUBS and NEUs (Level 3 phase 2 drought restrictions).	When flows fall below 198 Ml/d at Allbrook and Highbridge, as a measure of last resort, abstract below the 198 Ml/d HOF to a floor of 160 Ml/d. Coincident with this, Portsmouth Water will also need to abstract below the Riverside Park HoF of 194* Ml/d.

2.4.1 Candover augmentation scheme

Section 20 also sets out the operation of the Candover Augmentation Scheme. When flows breach the 205Ml/d limit at Allbrook and Highbridge, six boreholes may abstract up to 20Ml/d (27Ml/d in Sep-Apr) over a ramp-up period. This abstraction is discharged downstream of the Candover Stream confluence, augmenting the flow to the River Itchen. An example of the parameter's behaviour is shown below in Figure 2-2 comparing the flow at the Allbrook and Highbridge for a model run with and without the augmentation.

[3] https://southernwater.co.uk/media/1zegnmve/112-appx-2_summary-of-the-section-20-agreement.pdf

The Candover Augmentation Flow parameter within the Hampshire Pywr model captures the initial trigger for activation, then mirrors the ramp-up and ramp-down behaviour of the scheme. An environmental flow into the Candover Stream is additionally supplied pursuant to a drought order. The model includes a decay factor of 77%, representing the expectation that only 77% of actual abstraction will be seen at the Allbrook and Highbridge gauging station, as well as a daily reduction rate in supply from the boreholes. This is representative of the operational constraint of the boreholes, where for each day they are continuously supplying flow, they will lower daily yield until ramp-down begins.

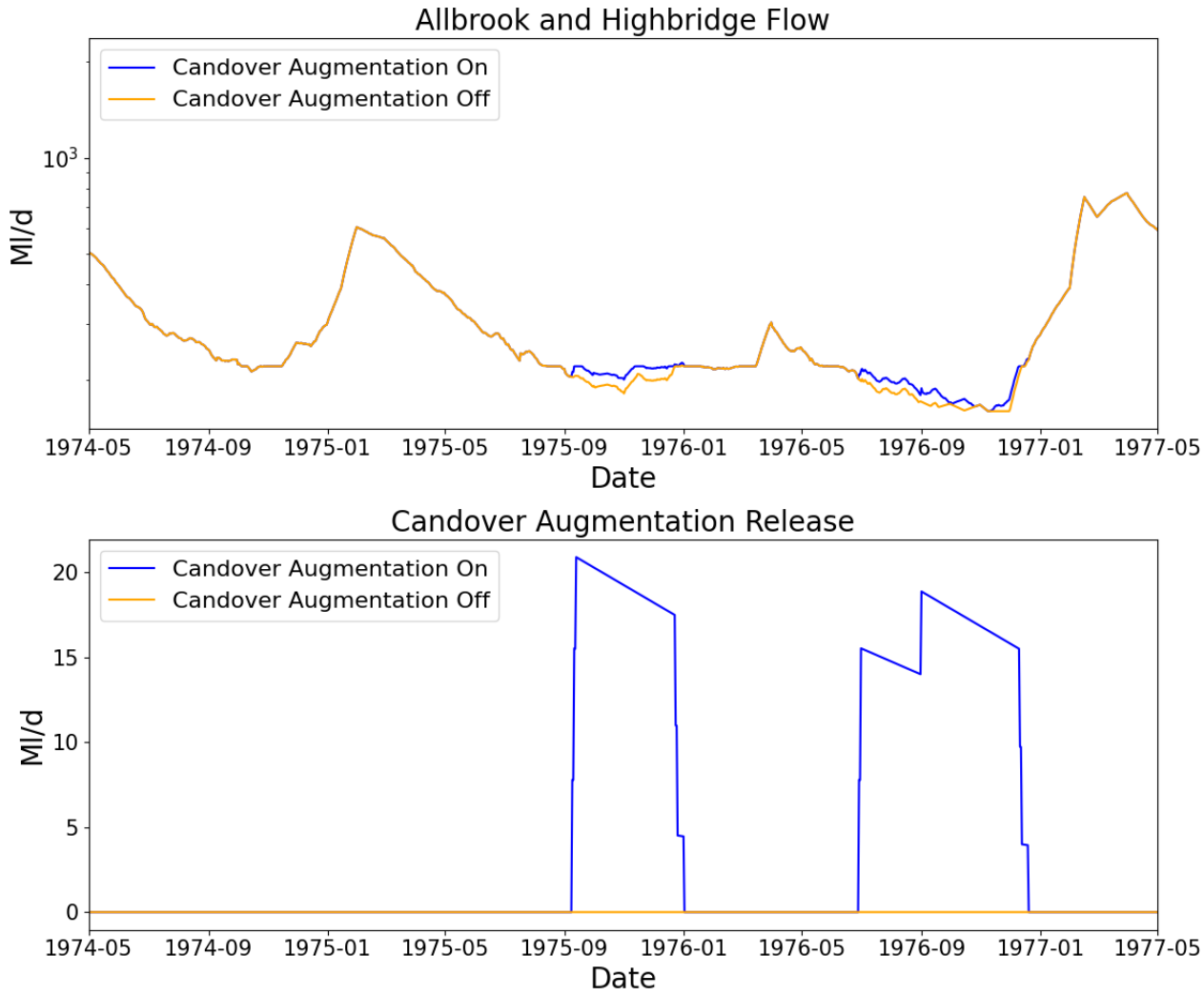

Figure 2-2 – Timeseries showing the Candover augmentation scheme for a historical run between 1974-1977 for both the Itchen and the augmentation source in the Pywr model.

2.4.2 Demand Savings

Demand saving measures such as Temporary Use Bans (TUBs) and Non-Essential Use Bans (NEUBs) have been reviewed in both the PW and SWS systems in the conjunctive model. For each demand centre of the model (except the Isle of Wight and any export nodes) demand factors are applied to reduce the baseline demand and are based on each companies' assumptions about levels of service. The Isle of Wight is not relevant here a sit is treated as a bulk export within the model.

For PW, TUBs and NEUBs are triggered in response to the daily Groundwater Level (GWL) at Idsworth Well. Idsworth Well is a static time-series input into the conjunctive model. TUBs and NEUBs demand savings and levels of service were agreed as part of the Regional Planning WRSE project during WRMP24. These are implemented as follows:

- TUBs for Portsmouth Water are implemented at the 1 in 20 year return period with benefits equating to a ~7.3% reduction in demand when implemented.
- NEUBs for Portsmouth Water are implemented at the 1 in 80 year return period with an additional 5% demand reduction applied when implemented.

For SWS, TUBs and NEUBs are triggered in response to flows in the River Itchen at Allbrook and Highbridge and to flows in the River Test at the Tidal Limit. These are captured using a custom parameter built specifically for the SWS Western area that relates demand savings reduction profiles to triggered drought levels based on the demand reduction triggers and operational changes at each drought level in the DP22 report. The demand factors applied within the Western Area are captured in Table 2-5 and have been provided by SWS.

Within the model, demand savings are triggered across all SWS demand centres in the Western Area whenever flow falls below the trigger curve of either river. For example, if the Test has only breached its TUBs trigger but the Itchen has breached its NEUBs trigger, NEUB demand savings will be triggered across the whole Western Area model. These curves are provided in Appendix B.

Table 2-5 - Demand Saving Factors for SWS Western Area

Month	TUBs Demand Factor	NEUBs Demand Factor
January	0.99	0.97
February	0.99	0.97
March	0.99	0.97
April	0.99	0.97
May	0.98	0.96
June	0.97	0.95
July	0.95	0.92
August	0.95	0.92
September	0.97	0.96
October	0.99	0.97
November	0.99	0.97
December	0.99	0.97

2.5 Havant Thicket Reservoir (HTR)

HTR will only be online for the 2034 time-slice. The modelled reservoir will have a capacity of 10,000Ml and a minimum capacity (or Dead Water volume) of 1,300Ml. Rainfall and compensation are assumed to be equal for the purposes of this modelling and are therefore not modelled. Abstraction from Havant and Bedhampton boreholes can supply a maximum inflow of 40 Ml/d to the reservoir and the modelled capacity of Budds Farm Water Recycling Plant inflow is 60Ml/d.

Evaporation is lost from the reservoir as a monthly profile as captured in Table 2-6.

Table 2-6 - Monthly Evaporation for Havant Thicket Reservoir

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evaporation (Mld)	0.75	0.85	1.59	2.82	3.44	3.8	3.64	2.93	2.3	1.3	0.8	0.56

HTR provides supply to Farlington WTW (max 25Ml/d) and Otterbourne WTW (max 90Ml/d with 5% loss factor). The export to Sussex North (Hardham WTW) has been disabled in the model in line with the T2ST modelling.

2.6 Managed Aquifer Recharge (MAR) Schemes

There are a number of Managed Aquifer Recharge (MAR) schemes within the Pywr model. These have been reviewed as part of WP1 and compared to recent updates made to the Hampshire Pywr model as part of the T2ST utilisation modelling. Following discussion with SWS this modelling has aligned to the T2ST setup and therefore the following schemes are removed from the model:

- River Itchen HW Catchment Management (CM) Source (3.27 Ml/d)
- River Itchen HSE CM Source (2.79 Ml/d)
- River Test HA CM Source (1.83 Ml/d)
- River Test HR CM Source (0.6 Ml/d)

The Testwood WTW CM scheme (5.5 Ml/d) remains in the model setup.

3. Model Run Log for Work Package 2

3.1 Assessment of current trigger suitability

Alongside the review of the model setup through WP1, discussions have been held with Southern Water to determine the approach to the assessment of the current triggers. 2022 and 2025 have been identified as recent dry years that could be used to review the existing triggers. Table 3-1 has been extracted from SWS's Summary of the Section 20 agreement appendix[4] and highlights how triggers developed must allow for a 35-day process to be undertaken prior to the implementation of a drought permit. The document also highlights that 'Formal pre-application consultation, based on draft application documentation, will commence with the Environment Agency and Natural England 60 days before the predicted flow'. To provide time for this process a 90-day trigger is also required. These requirements therefore describe the need for the existing 90, 60 and 35-day trigger curves and these three points will be assessed against recent data during WP2.

Table 3-1 - Drought Permit Process timeline from the S20 agreement.

Number of days after 35-day trigger is breached*	Action
0	Southern Water applies to the Agency, publishes last advertisement of application (if more than one advertisement is required) and gives notice of hearing on day 11.
1-2	The EA acknowledges receipt, contacts PINS/EA officer from another area/Counsel, and secures potential venues
7	Deadline for any objection
8-9	The EA decides if a hearing is necessary
11	Hearing (into non-ESOR matters). Hearing adjourned.
15	Southern Water gives ESOR update (could be day 16 or 17)
19	Reconvened hearing on ESOR
25	Latest date for the EA to receive report on application.
29	The EA uses reasonable endeavours to issue a decision whether to grant a Drought Permit
34	EA's decision on whether to grant a drought permit (long stop)
35	The Drought Permit is implemented if flows fall below 355 Ml/d on the River Test and Southern Water continues abstraction.

The existing drought trigger curves for the Rivers Test and Itchen are captured in Appendix B.

[4] https://southernwater.co.uk/media/1zegnmve/112-appx-2_summary-of-the-section-20-agreement.pdf

3.2 Proposed Trigger testing

It is assumed the existing triggers will need updating following the assessment of their suitability against 2022 and 2025 recent data. This technical note does not cover the trigger development methodology which will be captured in the WP2 report. However this note does outline the list of model runs against which the new triggers will be tested. The proposed model run log to undertake WP2 is presented below in Table 3-2. This ensures broad coverage of the scenarios required to inform inputs to DP27, and are to be undertaken for WP2. The run log provides variants across the following aspects (already discussed in Section 2):

- Time-horizons: There are a range of time-horizons: 2027 when the drought planning period will begin, 2030 when the Section 20 Agreement will expire and licence reductions related to Environmental destination will commence, 2032 when the drought planning period will end and 2034 when the Havant Thicket Reservoir is expected to be online.

- Hands off Flow (HoF) values on the River Itchen and River Test: SWS will require the model to be tested with different thresholds on both rivers, predominantly being driven by anticipated changes in the near future. For example SWS are currently in the process of discussing revisions to the HoFs on the River Itchen with the Environment Agency (EA) which may also be subject to licence changes for PW abstracting from the river at Gaters Mill.

- Stochastic flows: All model runs under the 2027, 2030 and 2032 time-horizons will be run with only the 400 baseline stochastic replicates without the impact of climate change, whereas the 2034 time-horizon will additionally be run with the 21-climate perturbed stochastic replicates. This was chosen as it has been assumed that 2034 will be when climate change will have likely manifested its greatest impact and will act as a sensitivity test. As the triggers will be developed against stochastic baseline flows it should be noted that testing climate change impacts in this method does open a risk that the triggers will need re-development if they prove suitable for baseline stochastics but not the climate impacted flows.

The 24 model scenarios vary in Hands-Off Flow (HoF) values for the River Itchen and the River Test. The flow rates at certain gauging stations are currently linked to time-based drought triggers at 90, 60, and 35 days to Hands-Off Flow. Varying the existing HoFs within each timestep aims to account for potential changes in HoFs as climate change effects materialise and regulatory constraints adjust. The River Itchen HoFs are proposed at a variety of values (221.4Ml/d, 219Ml/d, 250Ml/d, 270Ml/d, and 320Ml/d) across different time slices and scenarios. This ensures triggers are evaluated for several different future scenarios where the HoFs are likely to change. There are also scenario runs to change the HoF flow in the River Test, and also to vary the Testwood WTW rolling average to 55Ml/d.

Table 3-2 - Proposed Model Runs for assessment of new trigges

Model Run ID	Time Horizon	Candover Augmentation	Itchen HoF (Allbrook and Highbridge) (Ml/d)	Test HoF (Test Tidal Limit) (Ml/d)	Testwood WTW Constraint	Havant Thicket Reservoir	Environmental Destination	Stochastics	Drought Interventions (e.g. TUBs and NEUBs)
1	2027	On	221.4	355 / 390 *	Baseline	Offline	None	Baseline	Off
2	2027	On	221.4	355 / 390 *	Baseline	Offline	None	Baseline	On
3	2030	On	221.4	355 / 390 *	Baseline	Offline	High ED	Baseline	On
4	2030	Off	221.4	355 / 390 *	Baseline	Offline	High ED	Baseline	On
5	2032	On	221.4	355 / 390 *	Baseline	Offline	High ED	Baseline	On
6	2032	Off	221.4	355 / 390 *	Baseline	Offline	High ED	Baseline	On
7	2034	On	221.4	355 / 390 *	Baseline	Online	High ED	Baseline	Off
8	2034	On	221.4	355 / 390 *	Baseline	Online	High ED	Baseline	On
9	2034	Off	221.4	355 / 390 *	Baseline	Online	High ED	Baseline	On
10	2034	On	219	355 / 390 *	Baseline	Online	High ED	Baseline	On
11	2034	Off	219	355 / 390 *	Baseline	Online	High ED	Baseline	On
12	2034	On	250	355 / 390 *	Baseline	Online	High ED	Baseline	On

13	2034	Off	250	355 / 390 *	Baseline	Online	High ED	Baseline	On
14	2034	On	270	355 / 390 *	Baseline	Online	High ED	Baseline	On
15	2034	Off	270	355 / 390 *	Baseline	Online	High ED	Baseline	On
16	2034	On	320	355 / 390 *	Baseline	Online	High ED	Baseline	On
17	2034	Off	320	355 / 390 *	Baseline	Online	High ED	Baseline	On
18	2034	Off	221.4	355 / 390 *	55 Ml/d rolling average	Online	High ED	Baseline	On
19	2034	Off	221.4	SWS to confirm value prior to run	Baseline	Online	High ED	Baseline	On
20	2034	Off	221.4	SWS to confirm value prior to run	Baseline	Online	High ED	Baseline	On
21	2034	Off	221.4	355 / 390 *	Baseline	Online	High ED	Climate Change	Off
22	2034	Off	320	SWS to confirm value prior to run	Baseline	Online	High ED	Climate Change	Off
23	2034	Off	221.4	355 / 390 *	Baseline	Online	High ED	Climate Change	On
24	2034	Off	320	SWS to confirm value prior to run	Baseline	Online	High ED	Climate Change	On

* 355Ml/d in Jan-Feb, 390Ml/d for the remainder of the year.

4. Alignment with WRSE

WRSE currently host the water company Pywr models as part of a collection of repositories known as the Regional System Simulator (RSS). All code pertaining to company models, boundary conditions and data files are hosted on WRSE's Azure DevOps site, with the use of Git for version control similarly to how the Hampshire model has been hosted within AtkinsRéalis. For the upcoming round of regional planning, both WRSE and the water companies would like to ensure that modelling activities align with the WRSE RSS. This alignment will allow WRSE, the water companies and consultants to access models on a consistent platform. This will also reduce the effort required to undertake model handovers between projects.

This work package has reviewed the key elements of moving from the AtkinsRéalis repository containing the Hampshire Pywr model, to full use of the WRSE RSS. This section summarises how the RSS is structured and the preferred option for undertaking model runs as part of work package 2. As part of the review, the understanding of using the RSS has been discussed with James Tomlinson Associates (JTA) who currently maintain the repositories on behalf of WRSE.

4.1 Overview of packages

The original version of the WRSE RSS developed by AtkinsRéalis at the start of AMP7, as part of the project to initially develop the Pywr models or WRSE, was a single repository storing all company models and associated information such as core code, model files and connections between the companies. However the limitations of a single repository included difficulty in separation of the company models, often leading to standalone versions of the company models being further developed in isolation without being fed back to the regional level.

To achieve a better separation of the water company models but ensuring an alignment and a standardisation of methodologies at a regional level, the RSS now consists of eight different repositories also referred to as packages (also shown below in Figure 4-1) which are as follows:

- **Water company package** – There are a total of six individual packages for each of the water company models. Each package only contains model files relating to the respective water company, with any connections to other companies represented as a closed boundary condition. These packages also contain custom Pywr components that are unique to the respective water company.
- **WRSE's regional package** – This package contains model files that represented the dynamic connections between the water companies if a coupled model is required to be constructed and run. This is particularly important for this project as the Hampshire Pywr model comprises both the SWS Western Area and PW models. This package is not essential if models that are run do not require more than one water company model.
- **WRSE's common package** – This package contains the common code, nodes and parameters that are accessible by all water company packages as well as the regional package. For example, the code used to undertake a Deployable Output (DO) assessment will be stored in this package and imported when being used by a water company model. This package is not designed to run as a standalone but instead registered as a dependency of all other packages.

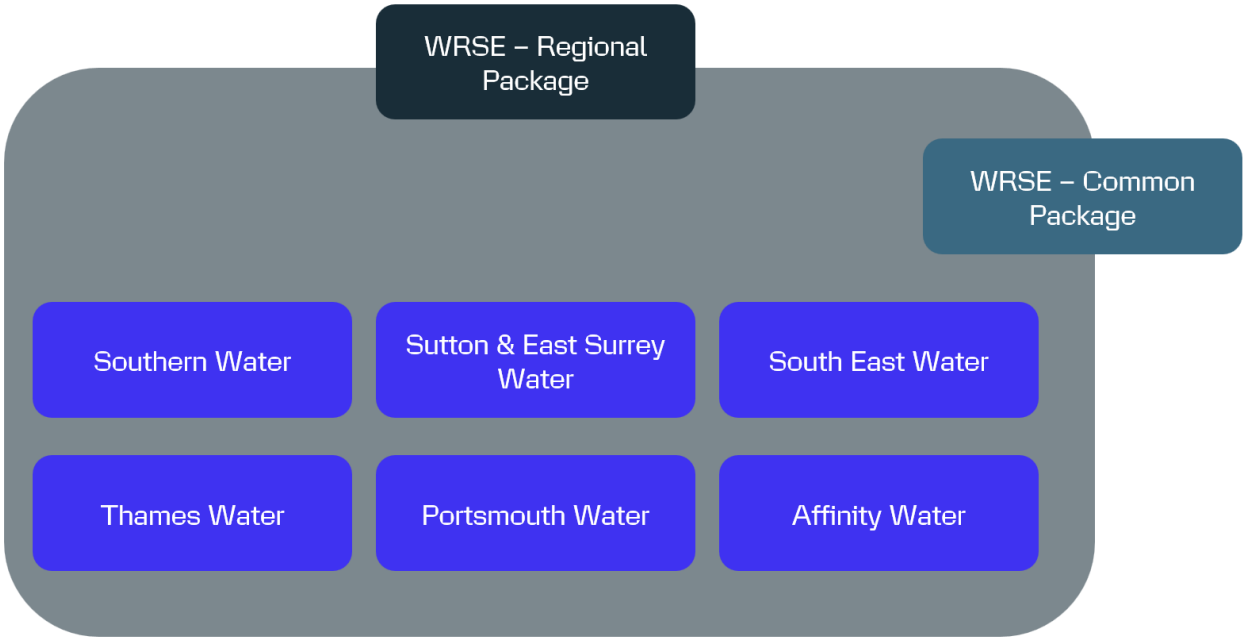

Figure 4-1 - Individual packages within the current WRSE RSS

4.2 Package requirements

Figure 4-2 highlights four of the WRSE RSS packages required to run the Hampshire Pywr model for this project when using the WRSE repository. The figure below also indicates:

- The Southern Water and Portsmouth water company packages will need to be accessed for this project as the Hampshire area model is made up of the SWS Western Area and PW supply area.
- The common package is a core requirement for a model to run regardless of whether this is standalone or coupled.
- The regional package will be required to connect the company models. For example, a model file in the regional package will be defined to connect the Gaters Mill abstraction made on the River Itchen in SWS to Hoads Hill reservoir in PW.

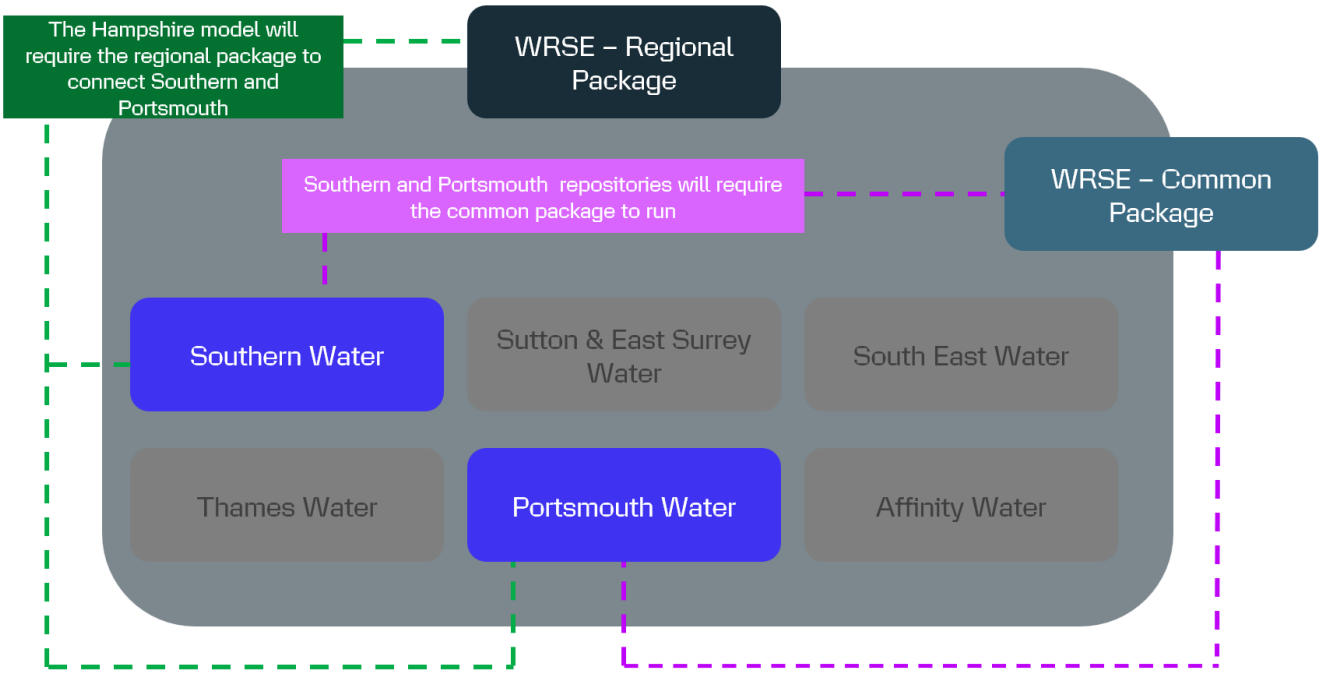

Figure 4-2 – The individual WRSE packages required to run the Hampshire model

4.3 WRSE updates

Following discussions with JTA, several developments to functionality in the common package have been made which will be used as part of this project. A review of the refinements made are as follows:

- Existing functionality remains in the RSS such as the ability to run a Scottish method DO assessment. Additionally, the model can be subsequently run at a particular demand factor if results from a DO run need to be further investigated.
- One limitation of the original version of the RSS was that the "single demand" runs described above would require a configuration file defined for a DO assessment. A refinement to this provides increased flexibility to define a model run with the configuration files. The main improvements are as follows:
  - Configuration files can be specifically defined for different types of runs (including Scottish and the English & Welsh DO methods, or a single timeseries run). The configuration files explicitly specify the run type which will minimise ambiguity.
  - A refined "patch" system is used to make modifications to a model prior to run time. A patch can either create, replace or remove a component, or update an attribute of a node or a parameter, offering more flexibility. This can either be specified as part of the main configuration file, similar to existing DO config files or a series of patches can be defined in a standalone file and the file path provided to the main configuration file.
  - All packages use the Astral "uv" library as a package manager[5].

[5] uv https://docs.astral.sh/uv/

4.4 WP2 approach to aligning with WRSE RSS

This project will need to consider the approach to using the WRSE RSS, particularly around collaboration with SWS and other consultants.

4.4.1 Review of collaboration methods

During the model development as part of Work Package 2, the check and review process will not only need to be undertaken by AtkinsRéalis but any key changes to the models will also need to be authorised by SWS and PW where appropriate prior to being merged onto WRSE RSS DevOps. Due to the ownership required, it is currently understood that the companies will need to be involved in part of the development process either through direct interaction on DevOps with the use of Pull Requests or being in regular contact during key development phases of the project.

The WRSE RSS aligns the model version that is to be used throughout the region, meaning other parties such as consultants will also have access to the repositories for separate projects. For this project it is understood that no significant work is being done in parallel, however care will need to be taken in the future should parallel work occur. Some considerations may need to be given around visibility of model changes being made during the project and local model development that would be more appropriate in the shorter term.

One water company package can contain multiple “sub-models” that can also be run as a standalone system. For example, the SWS package also contains the Central area comprising the Sussex North WRZ model and the Brighton & Worthing model. It also contains the Eastern area comprising Kent Medway, Thanet and the Sussex Hastings WRZ model joined to the Bewl-Darwell system. If separate projects require model changes to be made in parallel, there is a small risk of inter-dependencies on workflows resulting in potential git conflicts, which require additional effort to resolve. For example, a project looking at the Eastern area identifies an issue with a custom parameter which requires immediate rectification and changes to be applied across the package. All other projects or workstreams will depend on the completion of the change prior to progressing.

WRSE have proposed two possible options to address this:

- Option 1: Local development to interact directly with WRSE during push and pull changes.
- Option 2: Local development to only interact with WRSE for major releases and changes to code. A separate local DevOps repository owned by AtkinsRéalis would be used to store changes. At the end of the project or at key milestones, all changes will be pushed to the WRSE DevOps

4.4.2 Final decision for package management

Following a discussion with SWS on the 23 January 2026 it was decided that **Option 1 (referenced above) would be the preferred approach for this project**. Work Package 2 will involve a collaborative process with SWS and PW to understand how check and review will incorporate feedback and input from the companies.

5. Look ahead / summary

This document has outlined the model preparation and review that have been undertaken as part of Work Package 1 to prepare the Hampshire Pywr model to undertake assessment of the drought triggers curves on the Rivers Test and Itchen. Existing drought curves and triggers have been captured and will be initially reviewed against 2022 and 2025 flow data. These years have been selected as they contain recent drought events. The key features of the Hampshire Pywr model including proposed model inputs such as river flow, demand and potential licence adjustments as well as operational features such as the Candover Augmentation scheme and the impact of the Section 20 agreement have been highlighted.

Work Package 2 will see the development of new drought and recovery triggers if the existing curves are found non-suitable and the proposed run log for Work Package 2 is presented. The proposed model runs should provide a spread of modelling scenarios to inform the development of the new drought trigger curves where required. The new curves could also be tested against the 2022 and 2025 recent actual data to further understanding and compare modelling outputs to reality.

This technical note has also described the required process for integration with the WRSE regional System Simulator (RSS) repository. ‘Option 1’, where the project directly interfaces with the RSS, has been agreed with Southern Water as the preferred method for delivery of this work.

Appendix A. Model review log

The excel file named “WP1-Update-log.xlsx” is attached alongside this report and sets out a review of the model from the following sources:

- The SWS and PW models from the original WRSE model.
- The same models more recently updated from the T2ST utilisation and SESRO projects.
- Any additional information provided for this project.

Separately, additional excel tabs have been added to the spreadsheet that capture specific elements in more detail:

- Information on Havant Thicket taken from the T2ST utilisation report.
- The Managed Aquifer Recharge sources in the Hampshire Model.
- The Section 20 Agreement

Appendix B. Existing Drought Response curves for the Rivers Test and Itchen (Ml/d)

	River Test Drought Permit								River Test Drought Order				Itchen and Candover				
Month	90-day trigger	60-day trigger	35-day trigger	HOF	DP HOF	90-day trigger	60-day trigger	NEUBs & apply for Test DO	River Test Drought Order	River Test Emergency Drought Order	90-day trigger	60-day Candover Drought Order trigger	60-day Lower Itchen Drought Orders trigger	Candover Drought Orders	NEUB restrictions	Lower Itchen Drought Orders	Emergency Drought Orders
Jan	660	589	509	355	265	443	367	310	265	200	241	224	218	205	200	198	165
Feb	728	589	497	355	265	443	367	310	265	200	255	237	218	205	200	198	165
Mar	728	589	486	355	265	443	367	310	265	200	273	241	231	205	200	198	165
Apr	728	589	486	355	265	445	369	310	265	200	280	244	237	205	200	198	165
May	738	589	486	355	265	416	360	310	265	200	315	258	249	205	200	198	165
Jun	738	589	486	355	265	415	350	310	265	200	355	278	265	205	200	198	165
Jul	738	589	481	355	265	409	341	310	265	200	315	289	242	205	200	198	165
Aug	738	589	476	355	265	407	341	310	265	200	280	252	242	205	200	198	165
Sep	738	589	472	355	265	400	340	310	265	200	274	252	242	205	200	198	165
Oct	738	589	467	355	265	400	340	310	265	200	274	252	242	205	200	198	165
Nov	715	589	467	355	265	430	340	310	265	200	258	242	237	205	200	198	165

Dec	677	589	485	355	265	445	326	310	265	200	240	233	223	205	200	198	165