VEOLIA WATER PROJECTS LIMITED

WATER RESOURCES MANAGEMENT PLAN

APPENDIX 2 - RESILIENCE

INTRODUCTION

Am emphasis has been placed upon resilience as a major factor when developing a Water Resources Management Plan. This appendix considers the following aspects that influence resilience:

1. **Ground Water Levels** – Consecutive dry years will negatively impact on ground water levels leading to drought.

2. **Drought** – This is covered by the VWP Drought Management Plan but a summary of critical information is also included in this appendix for ease of reference

3. **Flooding** – an impact of climate change will be sudden heavy rainfall events that may cause a risk of flooding. Prolonged rainfall events can also result in high ground water levels

4. **Water Quality** – Ground water quality can be affected by nitrates, pesticides and contamination. The network is subject to compliance water quality checks and this is also referenced in this section.

5. **Freeze – Thaw** – an impact of climate change will be sudden variations in weather. There have been past examples of sudden variations in temperature resulting in a significant outbreak of leakage

6. **Security Emergency Measures Directive (SEMD)** – the assets associated with water distribution need to be secure from threat. Such mitigation measures by definition are secret, but an overview and reference to national policy is given. Risk assessments of network assets has been considered as part of this activity

7. **Cyber Security** – This is a specific external threat, but is again referenced is made to national standards as this has been addressed by Corporate and local policy

8. **Business process risk assessments** – Due to its relative small size VWP is more prone to single points of failure when it comes to process which is influenced by personnel. The team is relatively small when compared to larger organisations.

9. **Uncertainty** – Headroom has been included in the demand analysis to provide resilience against uncertainty.

1 GROUND WATER LEVELS

1.1 Clanville Lodge Gate and OBH1 Ground Water Levels

There is an observation borehole OBH1 that is monitored to determine the level of water at boreholes 2, 3 and Chalkpit. This data is available back to 1998 when the local network was developed.

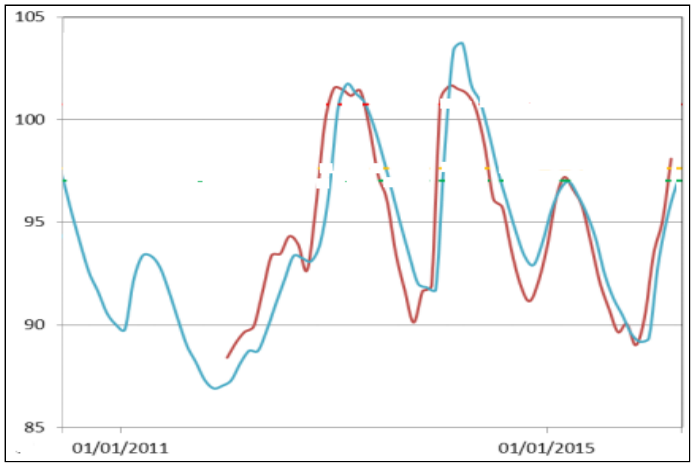
However, there is a British Geologic Survey (BGS) borehole at Clanville Lodge Gate with levels dating back to 1963.

It has been possible to prove a correlation between the borehole OBH1 and Clanville Lodge Gate ground water levels:

Clanville Lodge Gate data is shown in blue and was adjusted by 11.48m to align with Tidworth

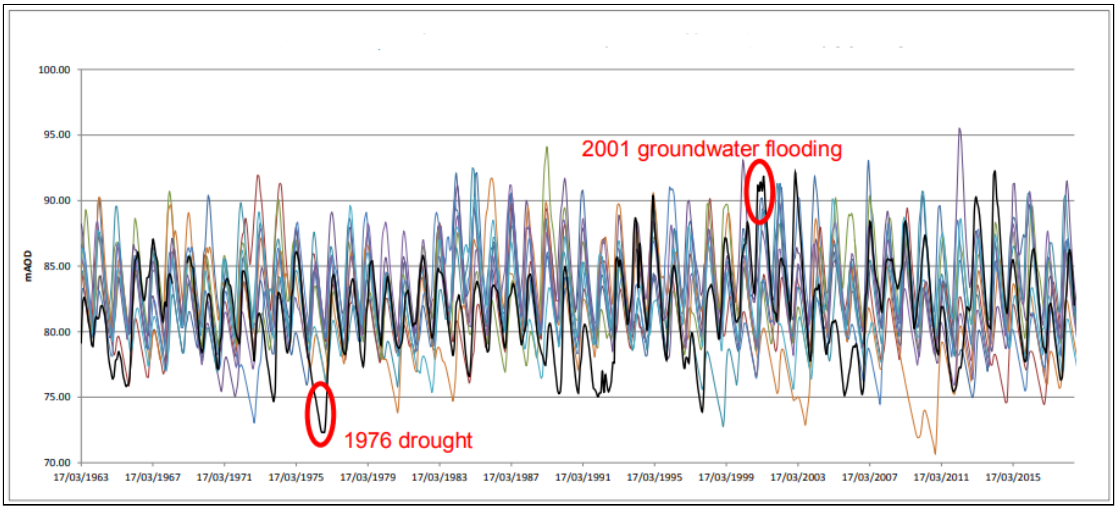
This then indicates that Clanville Lodge Gate levels agree closely with OBH1 observation borehole levels.

This therefore expands on the historic ground water data that is available to VWP.



1.2 Historic Ground Water Levels

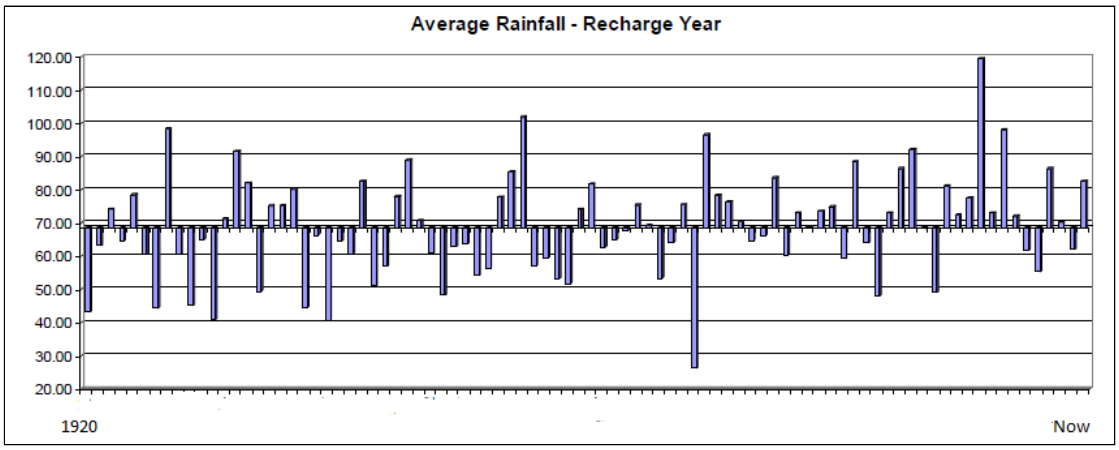
It is then possible to look at historic ground water levels and one can observe 2 events of interest between 1963 and 2018 relating to low ground water levels in 1976 and high ground water levels in 2001 which could have resulted in drought and ground water flooding respectively.



1.3 Historic rainfall data

Historically the Tidworth area has a very reliable set of long reaching rainfall data validated by the Met Office, which dates back to 1920. As part of a data share agreement with the EA, VWP records and submits rainfall data from a gauge at the STW. This data is then used to help VWP to asses on a month by month basis the water resources situation.

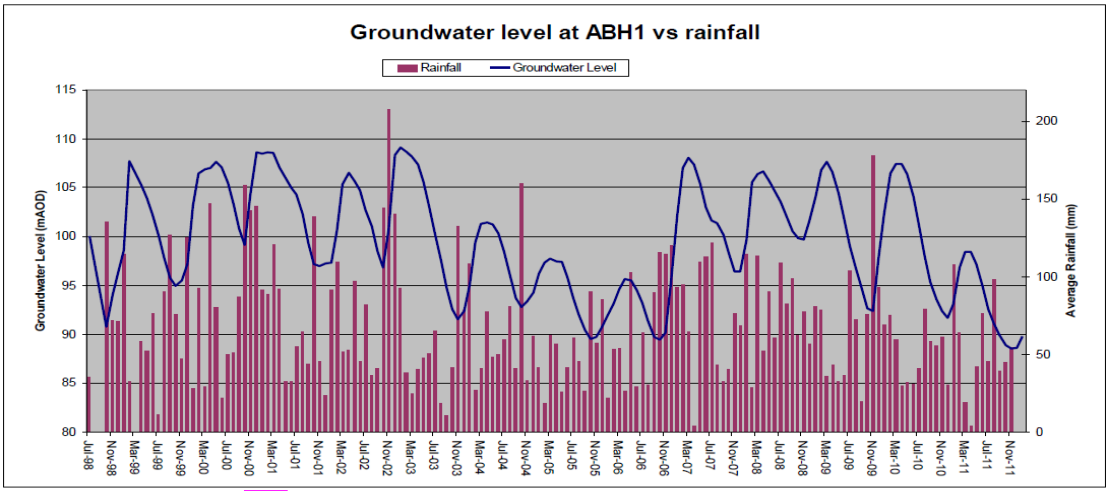
The following graph shows the deficit or surplus from the average rainfall over the 'recharge period'. It highlights the lack of deficit years experienced in the last 40 compared to the previous 60 years.



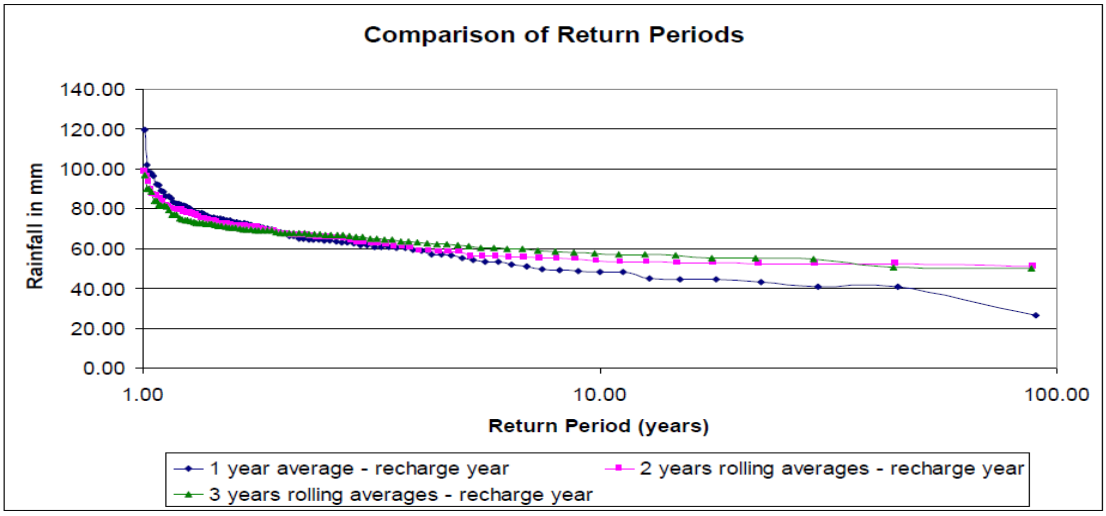
This shows clearly the deficit in terms of rainfall during 1976 (the drought year) and the surplus in 2001 (the period most at risk due to ground water flooding).

1.4 The link between rainfall and ground water levels (recharge)

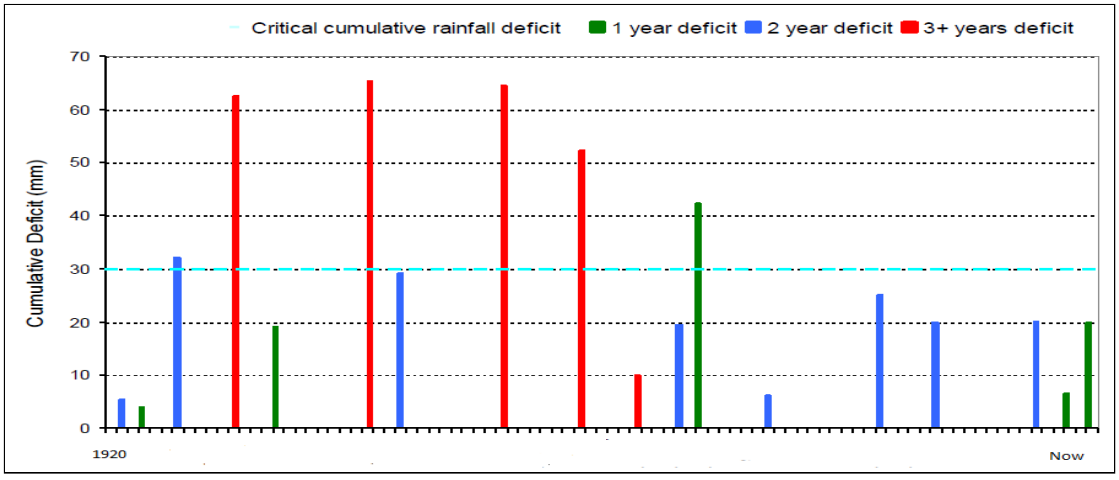
It is therefore possible to determine a link between historic rainfall volumes and ground water levels experienced at Clanville Lodge Gate and this is indicative of levels at the observation borehole at Tidworth.



Using the Weibull analysis, this binomial distribution shows the probability of rainfall events (during the recharge season only) relating to single years or multiple years average. The figure below demonstrates that in a single year the range of events is quite spread with extreme high and low recharge occurring. When examining 2 and 3 year rolling averages this pattern is not as pronounced but still exhibits a large range. This is crucial considering groundwater resources are usually resistant to single year droughts and it is multiple year recharge events that cause problems. Although most of the data shows a trend for high average rainfall some low level events have occurred and are likely to occur in the future.



The resilience of groundwater means VWP can experience poor recharge years and even consecutive years of below LTA rainfall and have sources able to deliver their deployable output (DO). The figure below shows where deficits have occurred in the cumulative rainfall over the recharge period. Over the last 50 years there have not been any deficits spanning 3 years or more. There have been a few of 2 years in length, but none of these exceeded 25mm total. This shows a period of consistently good recharge with any poor years being off-set by better rainfall during the following years.



The historic analysis indicates that ground water levels only start to be impacted when there are two or more consecutive dry years when ground water levels have been observed to drop to 87m. There have been no instances of 3 consecutive dry years since 1963, but there is evidence of 5 such events prior to 1963.

The following table is a simple linear representation of likely minimum ground water levels when compared to number of dry consecutive years:

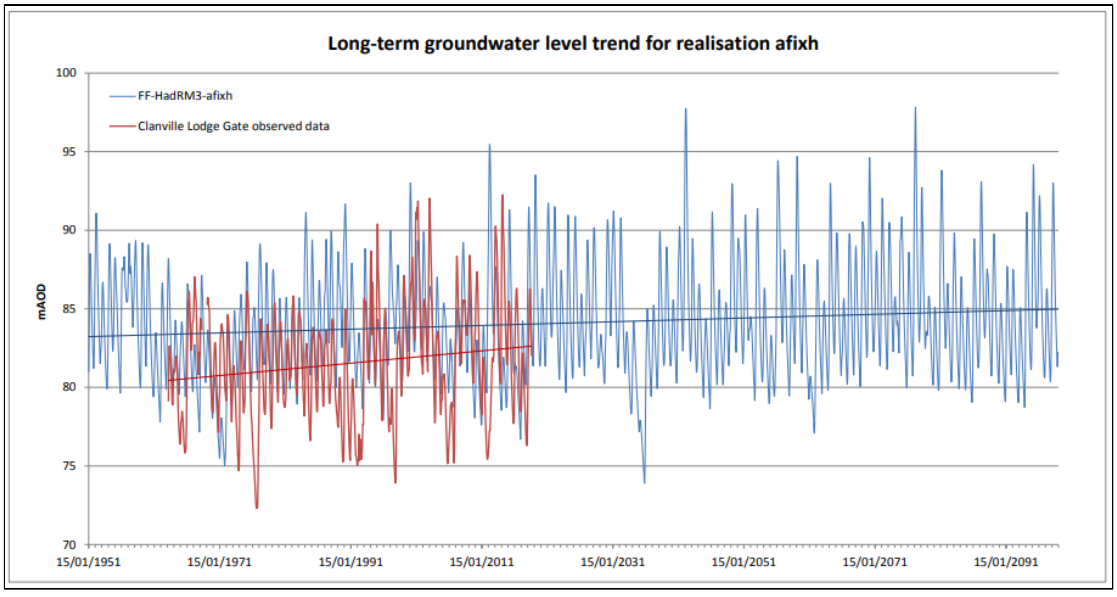
Consecutive dry years	Lowest borehole level observed	Number of events in 100 years
1	92m	5
2	87m	7
3	82m	5
4	77m	0
5	72m	0

1.5 Prediction of future ground water levels

Although past performance indicates a low probability of consecutive years of low rainfall, climate change may change the frequency of such events.

Future ground water levels have then been predicted using climate change modelling. The climate change methodology used is outlined in Appendix 3.

The graph below shows the predicted Clanville Lodge Gate levels from 1951 to 2091 (shown in blue) and this prediction has been compared to historic ground water levels (shown in red)



Up to 2091 two events may occur which have a similar impact to the 2001 and 2011 events. In fact ground water levels are predicted to increase slightly.

This analysis provides a time frame of 1920 to 2091 and allows the determination of the likelihood of drought and flood events.

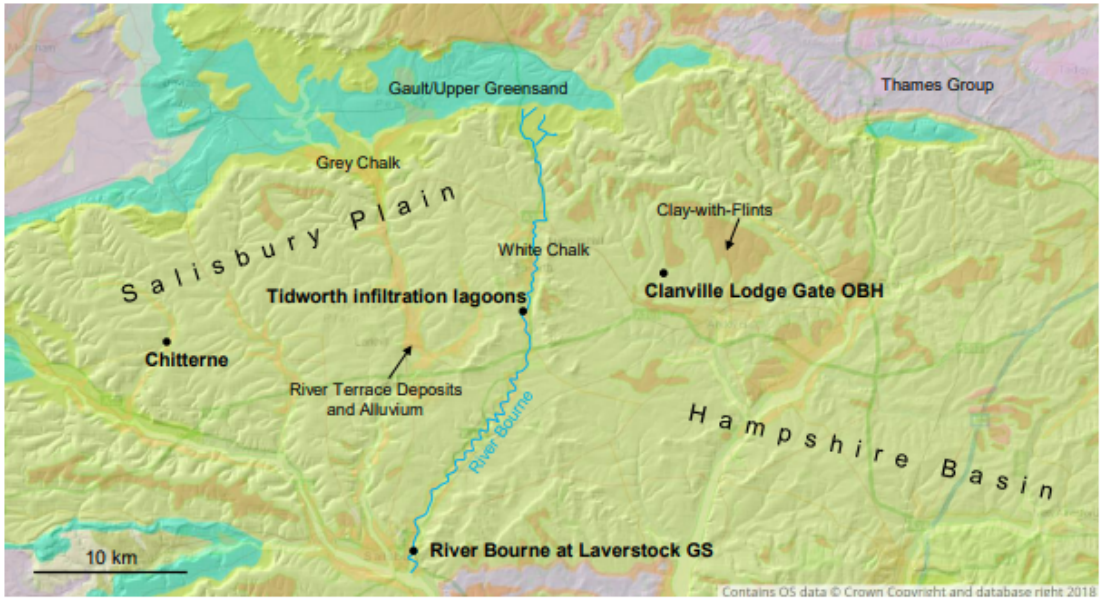
1.6 Interaction between neighbouring organisations

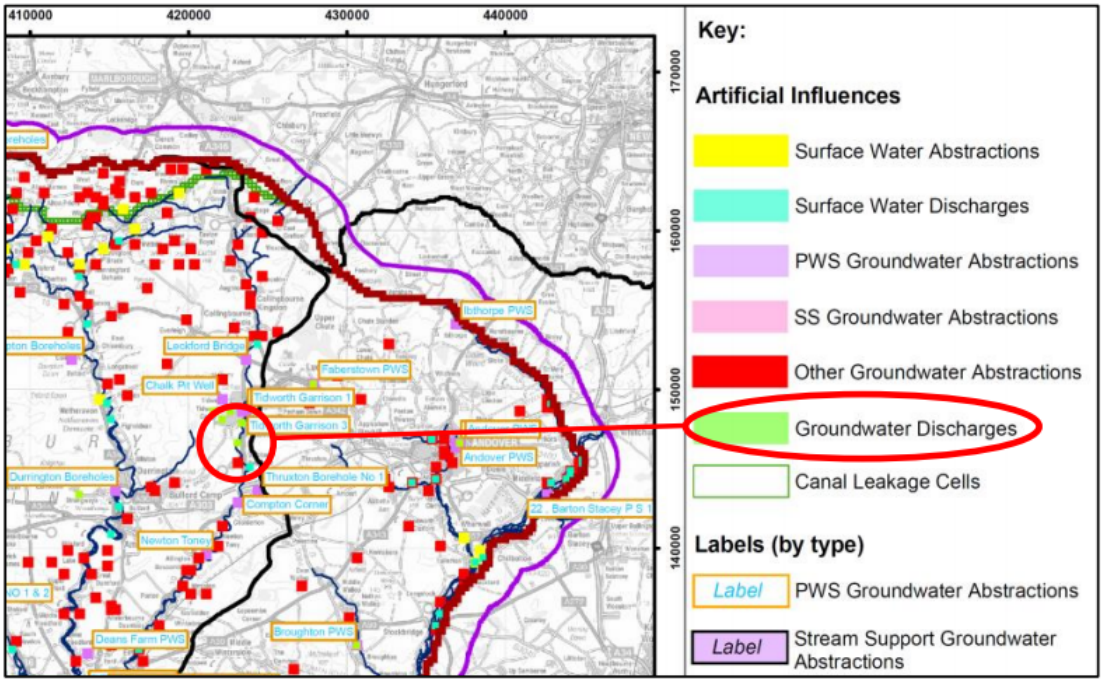
There are several organisations in the water resource basin whose activities can impact on the water table and the resultant impact on river flows and the natural habitats that rely on surface water for their survival.

The main organisations are:

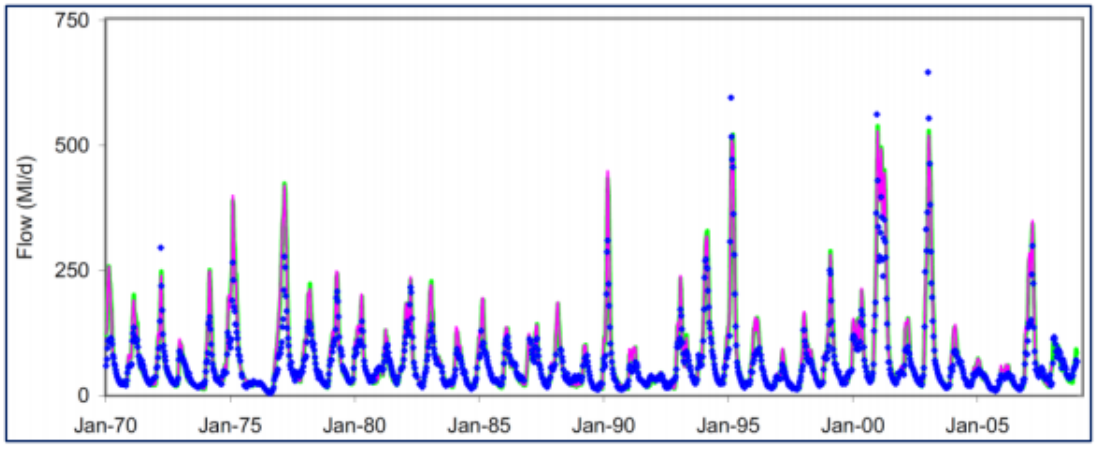
- Wessex Water (West of the catchment)
- Southern Water (East of the catchment)
- Ministry of Defence (Throughout the catchment)
- VWP (Central catchment location)

There is a Wessex Water catchment ground water model that is being used to assess the impact of the interaction of these organisations and also the impact of climate change.

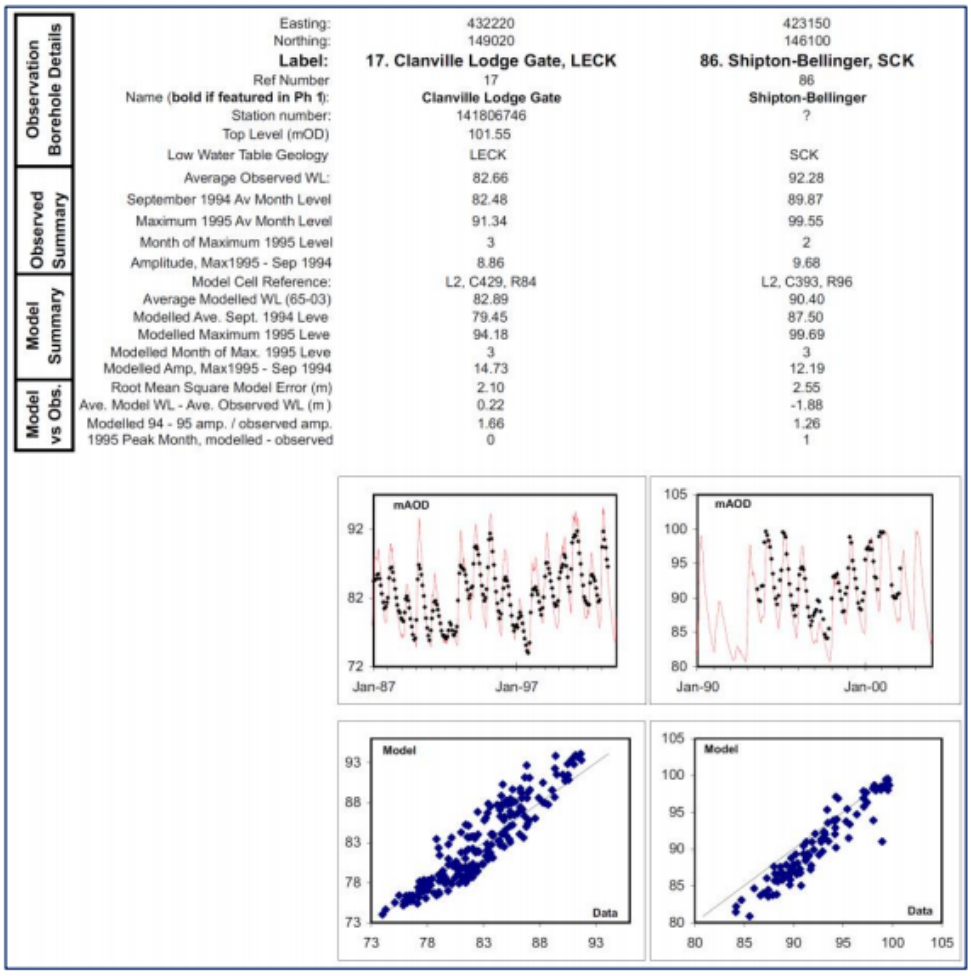




This model includes the Chalk aquifer of the Salisbury Plain and the River Bourne and appears to be well calibrated in the area in question. It simulates levels and flows for the period 1970-2009 and the calibration of the model is specifically documented for flows in the River Bourne at Laverstock and groundwater levels at Shipton Bellinger and Clanville Lodge Gate:



Observed and modelled flows in the River Bourne at Laverstock from the Wessex Basin Groundwater Model (Entec, 2011)



Observed and modelled groundwater levels from the Wessex Basin Groundwater Model (Entec, 2011)

This model is being used by the Salisbury Hydrology Group of which VWP is a part to assess long term impact of abstraction on ground water levels and surface water flows downstream of VWP activity.

The outcome of this analysis will meet the needs of WINEP – Water Industry National Environmental Programme which will be based upon the findings of this model. It is unlikely that VWP will need to fund any form of capital programme regarding the impact due to VWP's relatively small size of operation when compared to the other organisations in the river basin area.

1.7 Time table of modelling activities

Feb 2019 – Water Resources measures specification form to be completed for Veolia. This form is a standard template and will be used to provide information for ground water modelling. All the information is being fed into a single model. There may be a small cost associated with running options for Veolia. An indication of possible cost will be provided by Woods the consultant running the combined model.

End of 2019 - The MoD will provide data and consider modifications to non-potable water abstraction at their sites. It is proposed to tie in Veolia data provision with this work as part of the Salisbury Plain Hydrology Group (Veolia already attends these meetings).

End of 2020 - Andover reduction in abstraction by Southern Water will be analysed to determine the improvement of flow in Pilhill Brook (initial models indicate 98% of the impact is due to Southern and 2% due to Veolia boreholes 2 and 3).

Summer 2021 - Wessex and MoD modelling of operational impact on Nine Miles River will be completed with deadline for full completion by March 2022. The impact on River Bourne will also be included in the results as will all other ground water / surface water features but these elements play no part in the scenario and option assessments.

2 DROUGHT

Drought conditions will likely occur as a result of low borehole water levels due to more than 3 consecutive dry years. The lowest ever observed borehole level was 87m and the climate change analysis indicates no situations where the water level would drop below this value.

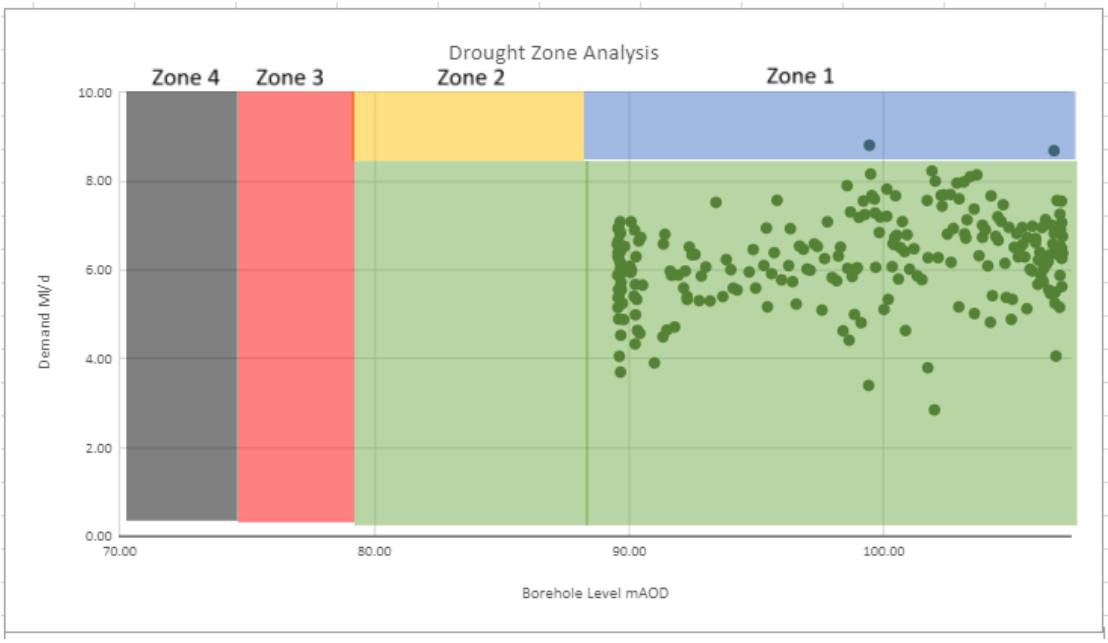
2.1 Trigger alarms for concerns about low ground water levels

Zone	OBH1 mAOD	Demand (Ml/d)	Description
1	> 90	8.4	High demand
2	90 - 80	8.4	High demand and low water table
3	80 - 75	8.4	Hosepipe Ban and non-essential business use of water
4	< 75	8.4	Emergency Drought Order

The table above indicates the points at which the observation borehole level becomes a concern.

From past monitoring of borehole level it is apparent that 2011 as well as 2001 experienced a drop in borehole level to 87m which would place the situation of zone 2 in terms of drought risk.

Borehole levels are being monitored and reported on a monthly basis using a new analysis tool. Demand and borehole level are being monitored against the drought trigger alarms:



The aim is to automate this technique and incorporate it into new Veolia Corporate reporting tool called Power BI.

From historic assessment of performance and recent regular assessment over the recent dry 2018 period the risk to levels of service to VWP customers is outlined in the table below:

2.2 Levels of service to VWP customers

Zone	Situation	Impact to Customers	Probability	Historic Events
1	High Demand	No restrictions	1 in 5 years (20%)	0
2	2 years of High Demand	Proactive approach to water efficiency	1 in 10 years (10%)	0
3	Temporary Ban	Hosepipe Ban and non-essential business use	1 in 50 years (2%)	0
4	Drought Order	Emergency drought order and Possible rota-cuts in worst case scenario	1 in 200 years (0.5%)	0

The probability for an emergency drought order has been assessed as 1 in 200 years given real data from 1920 and a prediction of ground water levels up to 2091.

The probability of the drought zones being triggered was compared to Wessex Water as they neighbour VWP and sits within the same river basin

area and have access to longer data sets. There are some differences because:

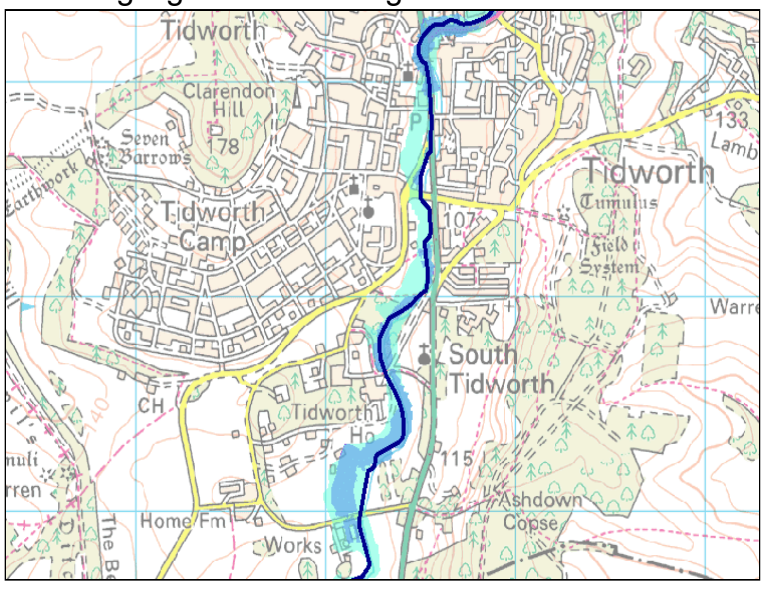
VWP has embedded within its regulated network a number of sites that belong to the Ministry of Defence (MoD). The MoD accounts for the vast majority of all business use. Before any temporary ban is considered the MoD would be approached to consider options in relation to reducing their use. This may involve the military relocating units to other barracks and reducing the use of water to wash military vehicles. It is likely that this mitigation action by the MoD would remove the need to implement a hosepipe ban. The probability of needing to approach the MoD can be considered 1 in 50 year likelihood, but in turn this would reduce the likelihood of a hosepipe ban. For the moment (until the Drought Plan is updated in 2020) the incident has been included as a single line entry called 'Temporary Ban'.

VWP have created a Drought Management Plan that provides additional information regarding the assessment of drought and the strategy that will be employed should a drought be triggered. This plan is due for review before the end of 2020 and as part of that action the classification of each drought situation will be considered along with a confirmation of probability.

3. FLOODING

The ground water modelling analysis has indicated that the worst incident regarding prolonged high water table levels was 2001. Investigation has revealed no evidence of any flooding at any of the VWP sites.

According to the EA regional flood model maps produced for Tidworth, none of the clean water Above Ground Assets (AGA's) are at risk from a flooding event. All Below Ground Assets (BGA's) are resistant to the effects of flooding (all gravity fed network) with the exception of accessing them in the event of an extreme flood in the areas highlighted in the diagram below



Several waste water assets are at risk of flooding. Two pumping stations are very low risk due to their position in the 1 to 100 year (+) zone. Actions could be taken to minimise their use and make alternate arrangements such as tankering of sewage. The STW is a slightly greater risk as it sits in the 1 in 75 year zone (1.3% chance).

The risk has been added to the company risk register allowing for criticality scoring against other company risks. Climate change could increase the risk from 1 in 75 (1.3%) to 1 in 25 (4%) due to higher ground water tables. A project is ongoing to investigate this in more detail. This impacts on waste water infrastructure only and will be included in a future Drainage and Waste Water Management Plan.

4. WATER QUALITY

4.1 Catchment area

100% of the raw water supply derives from groundwater sources from an unconfined chalk aquifer via boreholes. The boreholes have a long history of good bacteriological quality and have proved robust and reliable within Thames Water (TWUL) and VWP operating history.

These sources provide sufficient water to meet the needs of VWP customers as well as providing bulk supplies to a neighbouring Water Company - Wessex Water (WW) via Leckford Bridge.

The diagram on the previous page indicates the catchment area from which the boreholes draw their water. This is a strip of land called the ‘Ground Water Safezone’ that stretches 6 km due north from the boreholes with an approximate width of 1 km.

Much of the catchment area falls within a MoD firing range. The MoD have stopped using pesticides, which were historically used to control plant growth near to security fencing.

There is a single farm that appears to fall within the catchment and again farmers have used less pesticides over recent years.

There is domestic housing near to the boreholes and work on a road junction of the A338 just north of boreholes 2 and 3 has resulted in the proposal to strip the surface of a rugby pitch to assist in alleviation of flooding that may result due to the road modifications. VWP have raised concerns that such an activity may increase the likelihood of ground water contamination near to the boreholes.

A project is now ongoing to assess the likely impact of this, headed by Aspire working on behalf of the MoD who have contacted the EA as part of the permit process to complete the road layout modifications. VWP will continue to monitor this project closely to ensure that risk to the catchment due to these works is minimised.

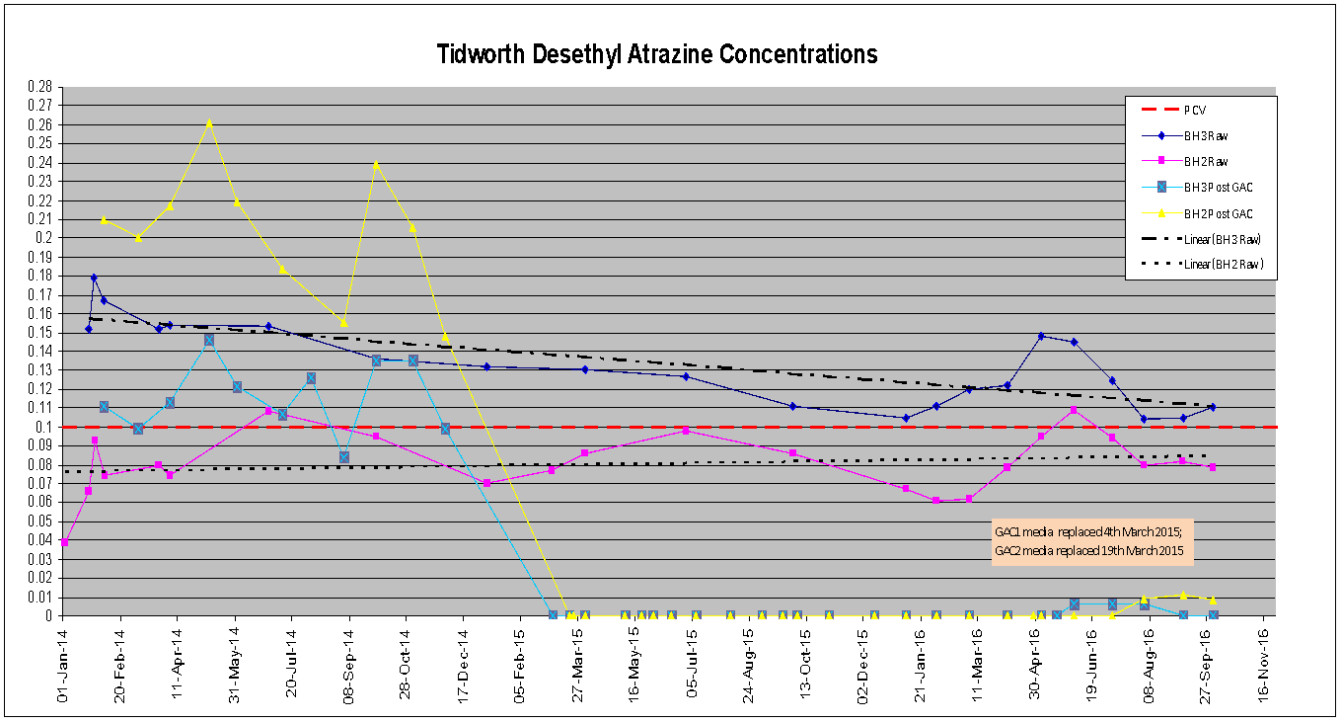
4.2 Ground water quality

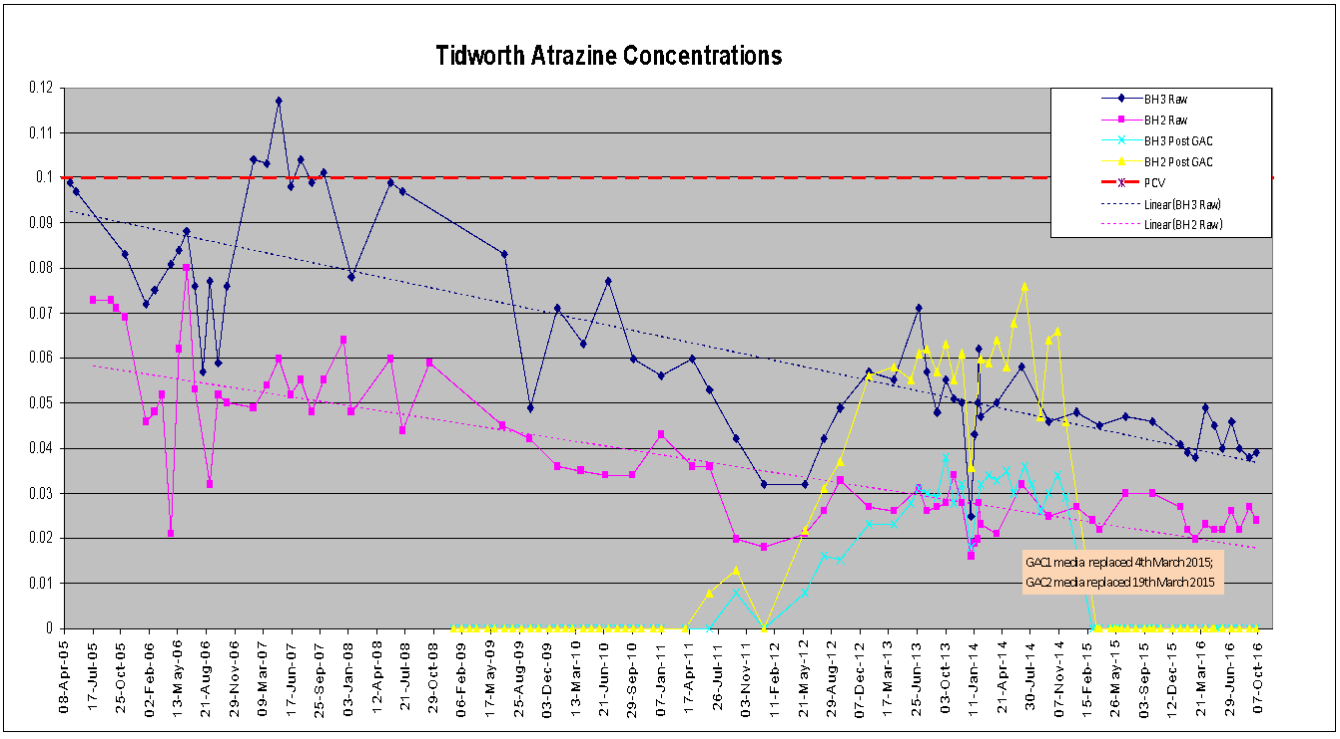
Nitrate and pesticide levels are continuing to improve. Boreholes 2 and 3 are treated through a GAC filter. Originally there was some concern regarding restrictions that this treatment process was placing upon the ability to pump required volumes of water into the network.

This has since been resolved by cleaning of the GAC filters.

The GAC process will be retained as a safeguard even though nitrate and pesticide levels are well below target and continue to improve. The quality of the raw water will continue to be monitored to ensure that this improvement is sustained.

4.3 Ground water quality results





4.4 Ground Water Constraints

The table below indicates performance during 2017/18 reporting period.

Date	Tidworth No 2 Daily Flow	Chalkpit Daily Flow	Tidworth No 3 Daily Flow	Tidworth Group Daily Flow
Output				
Average	2.20	1.85	2.26	6.30
Peak Day	2.55	3.02	4.50	9.04
Licence				
Average	3.68	3.64	3.68	9.02
Peak Day	4.32	4.69	4.32	12

4.4.1 Tidworth Borehole 1 (BH1)

Tidworth BH1 is abandoned and now removed from the licence due to pesticide contamination (Atrazine). It was not seen as cost effective to implement treatment on site or move raw water to another treatment site.

4.4.2 Tidworth Borehole 2 and 3 (BH2 and BH3)

The DO's for BH2 and BH3 are essentially linked as they share treatment process and licence restraints. Both boreholes are operated via common GAC filters.

A subsequent investigation has revealed that the pumps themselves are adequate in terms of condition and performance. The main concern is the restriction caused by the GAC treatment process after the pumps. The GAC filters have been back washed and restrictions on performance have been removed. Observed peak output during 2017/18 was 7 Ml/d.

Although Atrazine and Desethyl Atrazine concentrations continue to drop the GAC process will be retained due to the relatively low cost of maintenance compared to the significant resilience provided against ground water contamination.

The quality of water at BH2 and BH3 will continue to be monitored to ensure compliance with water quality standards. Should raw water quality performance drop then consideration will be given to borehole surveys as part of preventative maintenance.

4.4.3 Chalkpit (CP)

The treatment process at this site has been improved, including the complete replacement of the disinfection cabinet, gas fittings and associated equipment resulting in increased reliability.

CP site has a number of complex issues affecting its DO. The borehole arrangement has two pumps that individually can deliver flows of 38 l/s (3.3 Ml/d) and 35 l/s (3.02 Ml/d), Combined, they can deliver peak Licence (4.75Ml/d). However pumping tests have shown this figure cannot be achieved as turbidity spikes have occurred at these higher rates, shutting down the source. Assuming one pump running at full capacity (24 hours) the source would produce 3.0 Ml/d DO. This rate was achieved in 2017/18.

However, condition 9.4 of the Abstraction Licence states that the abstraction should routinely and preferentially be taken from BH2 and BH3, before any use is made of CP due to concerns over the Nine Mile River (9MR) as highlighted by an EA investigation, which indicates approximately 1% of the abstraction from CP impacts on the flows to this river.

Due to this restriction, and the quality constraint, the DO of this source can be considered to be lower than the Licence and has been set here as 2 Ml/d average and 3 Ml/d peak. Although in times of emergency or failure of one of the other boreholes it has the capability of producing its full licensed volumes.

The quality of water at CP will continue to be monitored to ensure compliance with water quality standards. Should raw water quality performance drop then consideration will be given to borehole surveys as part of preventative maintenance.

5. FREEZE – THAW EVENTS

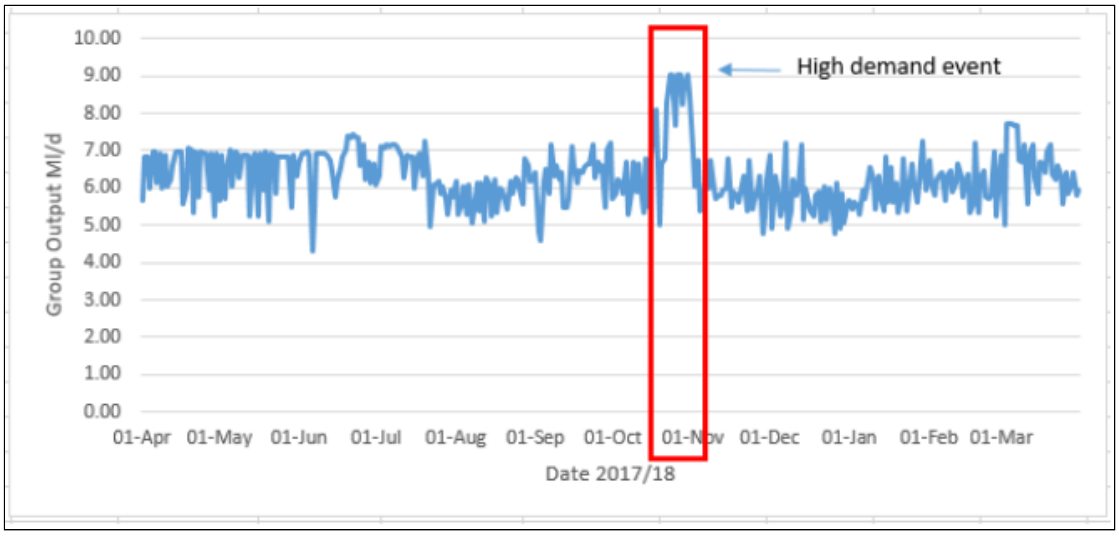
During March 2018 there was a significant drop in temperature and high localised snow fall. There was no observed increase in burst mains. There was an observed increase in background leakage, but this was not significant as leakage levels did not exceed historic values and leakage rates were quickly reduced.

Many of the mains have been laid at significant depth due to the MoD background to the network. Because the mains have been laid at greater depth there appears to be little risk of a dramatic increase in demand due to sudden variation in temperatures.

The same holds true for prolonged dry spells resulting in hard ground conditions followed by ground movement due to sudden rainfall. No evidence exists of concerns in relation to these severe weather events.

Work is ongoing to monitor demand and weather conditions as part of an operational report to back up these operational observations with hard data.

There has been a period of very high demand on record that further helps support the resilience of the network.



There was a high demand situation that occurred from 1st June to 19th June 2017. The deployable output of the boreholes was increased to 9 Ml/d in response to the observed increase in demand which adds confidence in the supply and distribution system to meet high demand events.

All customers received adequate supplies during the event with no need to implement the drought management plan. However lessons were learned from this event and have been incorporated into the drought plan.

A subsequent investigation revealed a number of reasons for this high demand event which are not attributed to normal environmental peak demand conditions:

- Work had commenced on installing improved treatment facilities at Chalkpit and this impacted on the reliability of the output of the plant. This was resolved once the permanent treatment process was fully installed. Project work will not occur during periods of predicted high demand.

- Wessex Water took more water from the Leckford Bridge export than was being reported. Closer communications with Wessex Water have been organised to allow better management of the transfer of flow. Daily flow to Leckford Bridge is now being recorded.

- A 6 inch wheel valve was subsequently discovered to be fully open allowing in excess of 1 Ml/d of water to escape in an uncontrolled fashion to a vehicle washing facility within the military complex. All such valves have been locked to prevent unauthorised and wasteful operation.

Better monitoring of existing telemetry data will provide early warning of problems with reliability at Chalkpit, increased Leckford Bridge export and significant non-legitimate demand occurring within the military facility.

- This event indicates that the existing sources are capable of meeting exceptional weather events and predicted growth in demand.

- The network is also able to cope with high instantaneous flow as many of the mains have been sized with Crown Fire Fighting Standards in mind.

- There is 48 hours of storage available at Clarendon and Mathew Tanks. Most water distribution networks are designed to provide only 24 hours storage. This enhanced design provides VWP time to react to sudden changes in demand brought on by extreme weather events.

6. SECURITY EMERGENCY MEASURES DIRECTIVE (SEMD)

VWP does not trigger the 25,000 population threshold in terms of the SEMD. However, security of operational sites is of great importance and an SEMD plan has been produced in line with best practice.

VWP attend SEMD meetings to ensure that company policy reflects national policy.

An annual update on progress regarding implementation of security techniques is communicated to the authorities in April of each year to ensure that improvements are being implemented.

Although the MoD is a critical user, the MoD has their own SEMD plan. VWP have monthly communications with the MoD and regularly assess security arrangements to ensure a common goal when considering security.

7. CYBER SECURITY

VWP are following the Network and Information Systems directive strategy with regards to essential IT systems that are associated with the provision of essential services.

The corporate IT systems are certified to ISO 27001.

Risk assessments are in place to consider upstream failures due to suppliers being adversely impacted by an event of this nature. Risks considered at the moment are:

- **Loss of power supply** – There is power generation at Chalkpit and the site is capable of providing a reliable output of 3 Ml/d. This would meet approximately half the average demand and storage at Clarendon and Mathew Tanks would extend the survival time to more than 3 days.

- **Chemical deliveries disrupted** – Chlorine is stored in line with SEMD requirements to guard against disruption to deliveries due to extreme weather events (deep snow for example)

- **Loss of Supervisory Control and Data Acquisition (SCADA) systems** – The VWP network is relatively simple to control manually. A loss of SCADA has occurred during 2018 and operations were able to maintain control of the system by implementing regular site visits

8. BUSINESS PROCESS RISK ASSESSMENTS

A structured method of assessing risk across VWP has been implemented on the Local Management System (LMS).

A regional summary of risk by contract (including Tidworth PFI) is regularly assessed.

Risk areas	Resources	QHS&E	Financial	Commercial	Operational / Delivery	Supply Chain
	Skills availability (inc. training) Employee relations Reliance on agency workers TUPE transfer Employee regulations (inc. data protection)	Site standards (inc legal compliance) Health & Safety training Induction Leading Indicator Performance Accident/Incident Performance Environmental Permit Verbal & Physical Abuse Procedures / Processes Audit results (internal & external)	Financial Performance Variations to be agreed/paid Cash flow Expediture Insurance claims Investments (inc. limited or none) Fraudulent / Theft	Contract obligations (inc liability) Contract changes / variations Clients relations Client feedback (postive or complaint) Litigation disputes Client default Partner / JV default	Service delivery (inc. KPI's) Technical performance (inc. maintenance) Management team (resource & capability) Design & construction activities IT infrastructure & system Support functions Business continuity Veolia policies & procedures	Approved suppliers Supplier dependence Terms & conditions Contractor peformance Planning (inc. RAMS) Cost control Quality of deliverables
Contracts						
AWE						
Airports						
Gibraltar						
PAC						
PFI						
Southern Region						
Wholesale						
Retail						

Individual risks are then identified and mitigation measures identified.

Project Risk Chart with current levels of Mitigation (Residual Risk)					
Impact	1	2	3	4	5
Likelihood	Minor	Significant	Serious	Major	Catastrophic
5 Likely More than 80%					S2
4 Probable 50% to 80%	R2	F4,F14,W6	R5,R7,R8,P4,P7,F3,F10,F21,F22,S1,S15,S49,T12	F33	
3 Possible 20% to 50%	S36	R3,R11,S30,W1,W2,T2,T20	A7,A10,R1,R4,P1,P3,P14,F5,F9,F25,S10,S12,S14,S18,S21,S24,S28,S29,S32,S37,S45	R6,R10,P6,F1,F12,F13,F26,F27,F32,S6,S23,S31,S41,S50,W3	A11,G3,P12,S19,S22
2 Remote 5% to 20%		F7	F15,F29,F31,S38	G4,S13,S20,W4	P5,F2,F19,S40
1 Improbable less than 5%	S16,T16	T3,T5,T10,T17	T4,T9,T18	T6,T7,T8,T11,T13	A1,S51,T1,T14,T15

It is critical to monitor the business process risks in detail given the relatively small size of the VWP activity.
Entries with the letter F represent risks associated with the VWP Tidworth PFI activities. The single item identified of immediate concern is understandably the need to balance income (which is controlled by the regulatory requirement to mirror Wessex and Southern charges) and the need to maintain the asset condition and performance.

Risks will continue to be assessed and mitigation measures planned in accordance with the VWP Local Management System processes.

9. UNCERTAINTY

There are two elements to consider related to uncertainty, outage and headroom. These are in effect a safety margin that a company should consider when assessing the long term supply / demand balance of the water network.

9.1 Outage Assessments

Outage is also calculated as part of Water Supply, it is defined as:

A temporary loss (less than 3 months) of Deployable Output and it can be as a result of power loss, pollution events and other reasons.

The original analysis of outage assessment remains valid and has been retained as part of the update to the WRMP.

Assessments were mainly based on interviews with operational staff and management experiences with each source and historical data was used as an aid to completing the analysis.

A Monte-Carlo based statistical model using excel (random number generator), which was created specifically for this outage assessment. A Monte-Carlo model was created for the single resource zone, with source outages and duration being summed to give a total outage value for the resource zone. The results are shown in the following two tables for the average and peak outages.

Outputs of Monte-Carlo analysis on average DO figures:

Average Outage					
Resource Zone	**Average DO**	**Average Outage Ml/d**			
		10%ile	**50%ile**	**90%ile**	**95%ile**
1	5.52	1.38	1.79	1.8	2.2
% of DO		23	30	31	38

Outputs of Monte-Carlo analysis on peak DO figures:

Peak Outage					
Resource Zone	Peak DO	Average Outage Ml/d			
		10%ile	50%ile	90%ile	95%ile
1	7.05	1.7	2.09	2.03	2.48
% of DO		26	32	31	38

This Monte-Carlo analysis used on the Pro-forma data show a ‘worse case’ than expected as they included ‘one off’ events that have been mitigated against, e.g. surface water flooding at CP where a small barrier wall has been built to reduce the effect of similar SW flooding occurring in the future.

Events such as an E.Coli spike that caused a voluntary outage have been included, even though the robust disinfection process treated the microbiological issue. Concerns over why it had occurred led to the borehole outage as more raw water samples were taken.

These factors added to the fact that VWP Tidworth does not have any ‘economies of scale’ as it is a small operation with only 3 raw water sources, any small outage will result in a significant percentage of the DI being affected. This will result in any outage assessment showing a less secure source reliable output (SRO) than that with which VWP actually operates.

The Average Outage table uses the average DO against outage events. The most likely situation shows that between a 1 in 1 and a 1 in 2 year outage event of under 2Ml/d will affect VWP.

Although this is almost 30% of the companies DO for that day, the network can comfortably deal with this kind of outage as it has large reservoir storage in comparison to demand (48 hours of storage) and only peak demand would see these significantly depleted.

This value has been skewed by the turbidity issues (mainly due to minor surface run-off events) at CP. 1 in 10 and 1 in 20 year event show a similar level of outage as 1 in 1 year event, which again demonstrates VWP lack of economies of scale in source outputs.

Clearly the less likely event will remove a more secure source, but as there are only 3 in total it will not have a meaningful effect. The fact that a 1 in 20 year event indicates a lower outage than 1 in 10 year indicates the lack of operational data/knowledge at VWP Tidworth (more known events at a 1 in 10 year frequency).

As a result these figures are not reflective of the 'true' effect outage has on VWP. A more useful method of looking at outage is on an event basis as duration of outage events are key to impacts on VWP LoS.

The table below shows the total event outage value in Ml, these would be amounts per year. They show the more likely events are very small volumes annually and they do not pose a threat.

Monte-Carlo assessment of outage per event (in 1 year):

Outage per event (Ml)				
	10%ile	**50%ile**	**90%ile**	**95%ile**
Average DO	2.3	4.6	10.78	13.92
Peak DO	2.8	5.6	11.6	15.9

These are again worse case and mainly revolve around pump failure and concerns over getting replacements ordered and delivered. Improvements in supplier management techniques has reduced this level of risk.

- This situation has been addressed as part of VWP Asset Management Plan (AMP) which identifies greater operational risks and helps quantify asset life spans more effectively.
- Operational incidents are being recorded on a database and performance of assets are being closely monitored as part of the company key performance indicators.
- Detailed risk assessments (refer to Section 8) further provide a mechanism for reducing Outage concerns.
- A worst case situation of a 15.9 Ml outage over the year has been assumed which is equal to 0.04 Ml/d on average.

9.2 Target Headroom

Target headroom has been defined as:

The minimum buffer that a prudent water company should allow between supply (including raw-water imports and excluding raw-water exports) and demand to cater for specified uncertainties (except those due to outages) in the overall supply-demand resource balance.

Target headroom is defined as the minimum buffer introduced into the annual supply-demand balance to ensure that the chosen level of service can be achieved. Available headroom is the actual difference between Water Available For Use (WAFU) and demand at any given point in time. Where available headroom falls below target headroom a supply-demand balance deficit is introduced and as a result the level of service for WR cannot be met.

The complicating factor affecting the assessment of Supply versus Demand in this PFI Inset Appointment is best described as the" Military Uncertainty Factor". Increases in consumption are highly uncertain due to the transient nature of MoD planning.

The original WRMP prediction was for a military demand of 1.79 Ml/d, however the demand analysis for 2016 / 2017 indicates that this demand currently stands at 2.27 Ml/d.

Estimates of additional personnel (based on local knowledge) indicate 1,040 additional troops based on the site (as personnel return from Germany). Assuming a Per Capita Consumption of 130 l/h/d then this would result in an additional demand of 0.135 Ml/d (a small increase given the existing demand of 2.27 Ml/d).

A peaking factor of 1.4 x average demand has been applied to all demands with the exception of leakage which remains the same as for average demand conditions. The actual peak demands will be compared to predicted demands to ensure accuracy.

The deployment of troops on Operations and Exercise also produces some more nebulous consumption assessments of actual consumption throughout the year. There is no reliable advanced warning of these activities for obvious reasons of security and their effect may be to reduce military occupancy to a very small percentage of the total established levels for several months at a time. The corollary of this situation maybe that an influx of Units consisting many hundreds of troops deploy to Tidworth and its environs on Salisbury Plain thus inflating consumption of services. This scenario often occurs several times per annum and can last for 2-3 weeks at any one time.

The Headroom components that are included in the methodology are:

Supply Related;

S5 Gradual pollution of sources causing a reduction in abstraction
S8 Uncertainty of climate change on yield
S9 Uncertain output from new resource developments

Demand Related;

D1 Accuracy of sub-component data
D2 Demand forecast variation
D3 Uncertainty of impact of climate change on demand

The six headroom components shown above have been considered within the target headroom assessment.

S5 – Gradual pollution of sources

VWP concern is over nitrate levels within the aquifer that its two main sources draw from. Nitrate concentrations appear to be stabilising, however there still remains a level of risk associated with high nitrate levels.

S8 – Climate Change on supply

Climate change and potential reduction of groundwater levels by significant amounts is seen as a risk to one abstraction site in particular. However, due to the lower outputs required from CP, this does not impact on DO. Impacts of climate change on CP could also be mitigated against by increasing abstraction at BH2 and 3 to their licence capacities as required, however this will require significant investment.

S9 – Uncertainty of new sources

This refers to VWP sources not delivering predicted capacity and has been included into the headroom calculations.

D1 – Accuracy of sub-component data

As the VWP bottom up approach uses Netbase. There are assumptions that this method uses which can decrease confidence. However current operation figures show we are meeting demand and output level from sources is being regularly monitored.

D2 – Demand forecast variation

The largest risk is under predicting future use from the new developments, together with the aspirations of the Military, the headroom calculation will attempt to consider this risk.

D3 – Climate change on demand

This is not considered to have as much impact as it would have on supply, factor in the significant change in civilian population over the next planning period and any climate change increased demand will not be relevant. This can be discounted from headroom calculations as a result.

The following table shows the outputs from the headroom analysis at 5 year intervals. The original WRMP 2014 analysis remains valid.

Results from headroom analysis

Target Headroom		2012	2017	2022	2027	2032	2040	2045
Company Average Baseline	%	4	5	6	7	8	9.5	9.5
	Ml/d	0.220	0.275	0.330	0.385	0.440	0.5225	0.5225

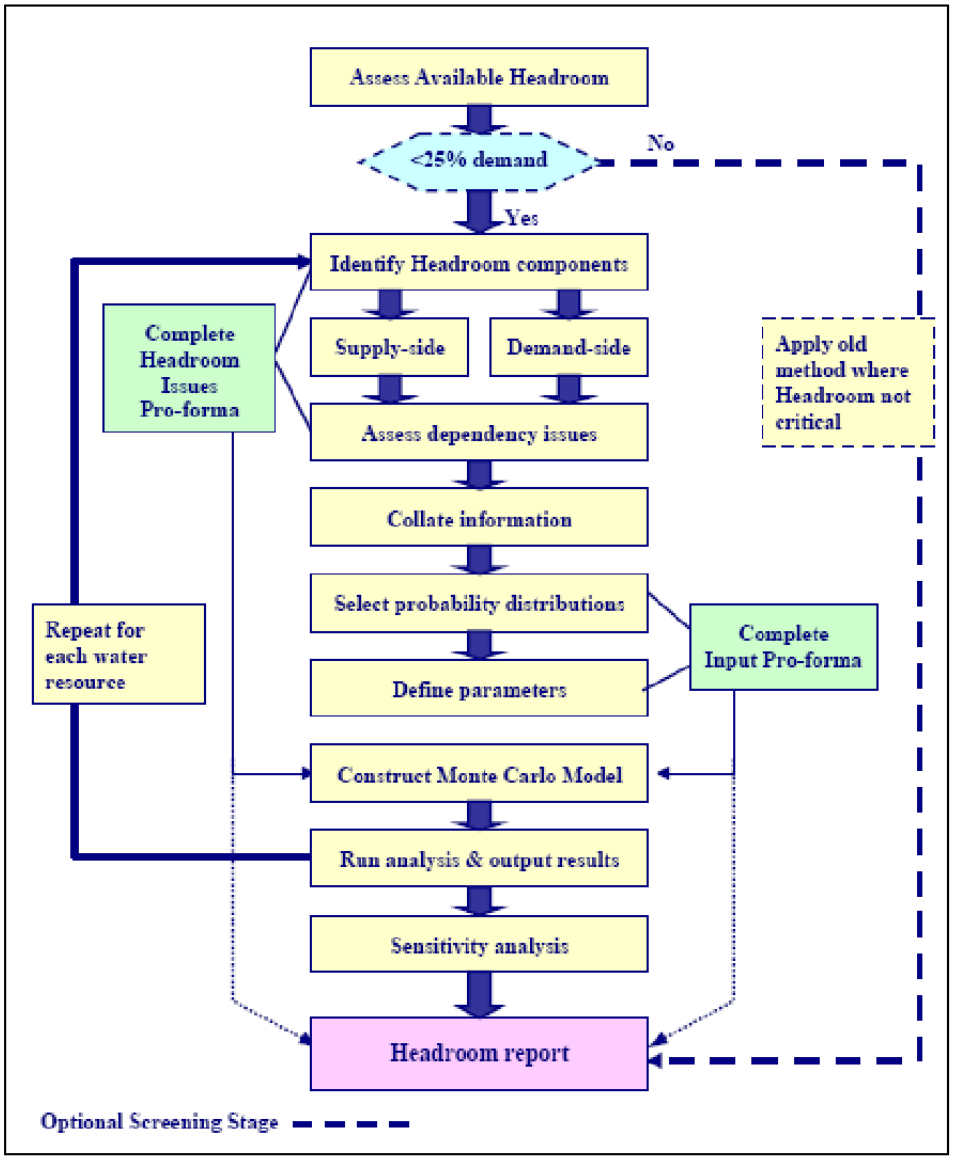
The headroom figures range between 4 and 9.5%. Considering the size of VWP, the military uncertainty and the level of DI combined with the flexible

distribution network, a headroom of 9.5% is a reasonable figure. 9.5% has been retained as a long term target for 2045.

- A worst case headroom of 0.52 Ml/d has been considered as being appropriate for supply / demand purposes.

9.3 The headroom and outage assessment process

The original process has been retained for the WRMP.



Water Available For Use (WAFU) = Deployable Output (DO) – Outage

Headroom = WAFU – Demand

Headroom = DO – Demand – Outage

Therefore:

Headroom + Outage = DO - Demand

- VWP need to ensure that Deployable Output exceeds demand by 0.52 Ml/d + 0.04 Ml/d = 0.56 Ml/d. This has been included in the planning supply / demand tables over the WRMP period up to 2045.

10. CONCLUSIONS

10.1 Ground Water Levels

VWP is resilient against 4 consecutive dry years and such an event has not been observed in the last 100 years of rainfall historic data and is not predicted in climate change modelling up to 2091.

Consecutive dry years	Lowest borehole level observed	Number of events in 100 years
1	92m	5
2	87m	7
3	82m	5
4	77m	0
5	72m	0

VWP is involved in the Salisbury Hydrology Group and data is being provided to the Wessex Ground Water model that is being used to assess the combined impact of organisations such as the MoD, Wessex Water and Southern Water.

Given the small scale of VWP activities when compared to these companies and the close proximity of VWP abstraction to discharge points (only 5 km from each other) then impact on ground water levels is likely to be limited.

10.2 Drought Risk

Zone	Situation	Impact to Customers	Probability	Historic Events
1	High Demand	No restrictions	1 in 5 years (20%)	0
2	2 years of High Demand	Proactive approach to water efficiency	1 in 10 years (10%)	0
3	Temporary Ban	Hosepipe Ban and non-essential business use	1 in 50 years (2%)	0
4	Drought Order	Emergency drought order and Possible rota-cuts in worst case scenario	1 in 200 years (0.5%)	0

The likelihood of drought was compared with Wessex Water. There are differences in likelihood due to VWP having a large MoD user within the

network. However, this may be beneficial in that close cooperation with the MoD would reduce the likelihood of a hosepipe ban within the regulated network.

The classification of drought situations and probability of a drought itself will be assessed as part of ongoing work by VWP to update its Drought Management Plan by the end of 2020.

VWP have been able to consider more data when determining the probability of a drought by accessing a longer history of British Geological Survey (BGS) borehole levels and then proving a correlation to observation borehole levels at Tidworth. This together with climate change prediction scenarios up until 2091 indicate that a drought order will likely occur every 200 years and a hosepipe ban every 50 years (assuming no mitigation by VWP and MoD cooperation).

10.3 Flooding Risk

Potable water assets are not at risk of flooding.

Climate change modelling has indicated that there may be an increased risk of flooding local to Tidworth STW's. There has been no operational knowledge of flooding, even during the record wet year of 2001 however this situation is being monitored as part of the waste water side of the business.

10.4 Water Quality and Deployable Output

The catchment area for the VWP ground water sources has been identified and a risk assessment indicates no upstream commercial users who may pose a risk to ground water quality.

Planned work north of boreholes 2 and 3 related to flood alleviation as part of an improved junction of the A338 has been identified by VWP as a potential risk of local ground water contamination. This project is being closely assessed by VWP and concerns have been raised with the project team.

Pesticide and Nitrate levels continue to fall due to reduced use of contaminants by the MoD and farmers north of the VWP boreholes.

GAC is being retained and maintained as it provides good resilience to boreholes 2 and 3.

Improvements to chlorine dosing at Chalkpit have improved the reliability of this source.

The sources are now capable of providing a constant peak output of 9 Ml/d and so are capable of meeting extreme demand events.

Date	Tidworth No 2 Daily Flow	Chalkpit Daily Flow	Tidworth No 3 Daily Flow	Tidworth Group Daily Flow
Output				
Average	2.20	1.85	2.26	6.30
Peak Day	2.55	3.02	4.50	9.04
Licence				
Average	3.68	3.64	3.68	9.02
Peak Day	4.32	4.69	4.32	12

10.5 Freeze – Thaw Risk

During March 2018 there was a significant drop in temperature and high localised snow fall. There was no observed increase in burst mains. There was an observed increase in background leakage, but this was not significant as leakage levels did not exceed historic values and leakage rates were quickly reduced.

There was a high demand situation that occurred from 1st June to 19th June 2017. The deployable output of the boreholes was increased to 9 Ml/d in response to the observed increase in demand which adds confidence in the supply and distribution system to meet high demand events.

10.6 Security Emergency Measures Directive (SEMD)

VWP does not trigger the 25,000 population threshold in terms of the SEMD. However, security of operational sites is of great importance and an SEMD plan has been produced in line with best practice.

10.7 Cyber Security

VWP are following the Network and Information Systems directive strategy with regards to essential IT systems that are associated with the provision of essential services.

The corporate IT systems are certified to ISO 27001.

VWP have the capability to cope with a loss of power supply for greater than 3 days due to power generation and reservoir storage. The loss of the telemetry system has occurred but due to the small size of the network operations were able to manually operate the system. Chemicals are stored to guard against disruption to deliveries due to adverse weather events.

10.8 Business Process Risk Assessments

The VWP employs advanced risk assessment tools due to its small size and possible single points of failure.

The main risk identified is to successfully balance investment in the asset management plan when compared to having to mirror Wessex and Southern tariffs (which are beyond the control of VWP).

10.9 Uncertainty

A combined value of 0.56 Ml/d has been used in the long term supply / demand planning tables to ensure against uncertainty.

Regular communication with the MoD guards against sudden changes in strategy relating to sale of land for new development purposes.

11. RECOMMENDATIONS

11.1 Ground Water Modelling

VWP will continue to be actively involved in the Salisbury Hydrology Group and will provide data to feed into the existing ground water model as per the plan below:

Feb 2019 – VWP to provide data for inclusion within the model

End of 2019 - The MoD will provide data and consider modifications to non-potable water abstraction at their sites.

End of 2020 - Andover reduction in abstraction by Southern Water will be analysed to determine the improvement of flow in Pilhill Brook

Summer 2021 - Wessex and MoD modelling of operational impact on Nine Miles River will be completed with deadline for full completion by **March 2022**.

11.2 Monitoring of Performance and Risk

These tools and techniques are in place and continue to be developed in line with best practice (refer to Appendix 6 – Innovation for more information)

11.3 Drought Management Plan

VWP will continue to develop the existing Drought Management Plan (DMP) and aim to produce a new draft version by the end of 2020. This DMP will take on board guidance produced during 2019.

The DMP will review the classification of the DMP zones (taking into account the existence of the MoD within the network) and will confirm probability of

such events taking into account mitigation that is likely due to close VWP and MoD cooperation.

Development of the DMP has been added to the implementation plan.

12. PLAN OF ACTION

S/N	Element of Work	Pre S/N Req	2019				2020				2121				2022				2023			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
12	Climate Change Methodology	-																				