Appendix 5.3.A.3 - PR19 Catchment interventions to control nitrates

Wessex Water

September 2018

Wessex Water
YTL GROUP

Business plan section		Supporting document	
	Board vision and executive summary		
1	Engaging customers		
2	Addressing affordability and vulnerability		
3	Delivering outcomes for customers		
4	Securing long term resilience		
5	Markets & innovation: wholesale	5.1	Protecting and enhancing the environment
		5.2	Using water efficiently
		5.3	**Providing excellent drinking water quality**
		5.4	Minimising sewer flooding
		5.5	Bioresources
		5.6	Maintaining our services
		5.7	Accommodating growth and new development
		5.8	Water resources bid assessment framework
		5.9	Water resources RCV allocation
		5.10	Bioresources RCV allocation
6	Markets & innovation: open systems & DPC		
7	Markets & innovation: retail		
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9	Aligning risk and return		
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11	Accounting for past delivery		
12	Securing trust, confidence and assurance		
13	Data tables and supporting commentaries		

PR19 catchment intervention to control nitrates

Wessex Water

December 2017

1. Introduction

Nitrate concentrations in groundwater continue to represent a significant water quality issue for Wessex Water. Much progress has been made by the Catchment Delivery team since work started at four sites in 2005 (AMP4). To date no new nitrate treatment plants have been constructed.

This paper seeks to justify the ongoing delivery of catchment management at twelve existing sites and the inclusion of six new sites in 2020 (AMP7).

Existing Catchment Management Sites (AMP4, AMP5, AMP6 & AMP7)	Proposed Catchment Management Sites (AMP7)
Alton Pancras	Briantspuddle
Belhuish	Cherhill
Deans Farm	Diversbridge
Eagle Lodge	Goodshill
Empool	Litton Cheney
Fonthill Bishop	Shepherds Shore
Forston	
Friar Waddon	
Hooke	
Milborne St Andrew	
Shapwick & Sturminster Marshall	
Sutton Poyntz	

Please note that all sample results are expressed in mg N/L. The regulatory limit when nitrate is expressed in this unit is 11.3mg/l.

2. Site selection process

These twelve existing sites comprise two of the original four AMP4 (2005 – 2010) sites, Eagle Lodge and Empool where the nitrate trends have stabilised. Catchment management here will be minimised but continued in order to maintain the water quality improvements gained since the start of the programme. Of the other two sites, Deans Farm continues to demonstrate rising nitrate trends with peaks that exceed compliance. At Deans Farm, compliance is achieved through an existing blending arrangement that utilises the nitrate removal plant at Clarendon source. Catchment management here will be reduced to minimum to continue to reduce nitrate levels in the long term. Winterbourne Abbas source demonstrated a number of water quality issues of which nitrate was one. Assessment of the management options led to the mothballing of the source and the subsequent cessation of catchment management in 2014.

Of the eight sites where catchment management commenced in AMP5 (2010 – 2015), Bulbridge was mothballed in 2016 due to continued high nitrate peaks and the operational costs of upgrading the chlorination system to bring it back into supply while the nitrate trends at Chirton, Dunkerton and Wylye stabilised fairly quickly so that by 2011 catchment management was reduced to a watching brief and subsequently stopped in 2015. This left four sites Hooke, Fonthill Bishop, Sturminster Marshall and Shapwick.

At Hooke the nitrate trend more or less stabilised in 2013-14. Catchment management continues at a minimal level in order to maintain the improved trend. At Fonthill Bishop and Sturminster Marshall/Shapwick (which due to their proximity are managed as one catchment) the nitrate trend is still high and rising with peaks that exceed compliance levels. At Sturminster Marshall/Shapwick the nitrates are blended between the boreholes to maintain compliance. However, as this depends on one borehole at Sturminster Marshall being 2 – 2.5 mgN/l lower than the other boreholes there is concern that the blending options will be more challenging in the future as levels continue to rise and so an asset solution (involving the import of treated N water from Black Lane source) has been proposed for the business plan. At Fonthill Bishop there is no permanent blending arrangement and so compliance is achieved through a temporary set up that involves the tankering in of low nitrate water from other sites (in Somerset) with temporary storage tanks and pumps on site. The proposal for the business plan is to install a permanent blending arrangement for Fonthill Bishop. At both these sites catchment management will be reduced to minimum in order to secure long term stabilisation of the nitrate trend.

At the beginning of AMP6 (2015 – 2020) six new sites were added to the catchment management portfolio. These were Alton Pancras, Belhuish, Forston, Friar Waddon, Milborne St Andrew and Sutton Poyntz. As Wessex Water's modelling work suggests that these nitrate trends will continue to rise, catchment management is proposed to continue at all of these sites in order to stabilise and reverse the nitrate trends.

The nitrate trends have been analysed using a simple linear regression technique (described in Appendix A). Sites that exhibit a rising trend and that are not currently under catchment management were subject to more detailed modelling by external consultants AMEC Foster Wheeler and RukHydroUK that looked at the "peaks" and "shoulders" of the trends (described in Appendix B). From this process two more sites have been identified,

Briantspuddle and Cherhill that are expected to breach nitrate compliance levels within the next 18 years (to 2035). More detailed predictive modelling has been carried out by AmecFW and RUKHydroUK has provided further justification for the inclusion of these two sites into the nitrate catchment management portfolio.

A further four sites have also been included on the basis that nitrates levels are already high and to varying extents threaten compliance. These are sites where there is already a solution in place in the form of operational borehole blending. At these sites the intention is to use catchment management to minimise and ultimately remove the need for the blending requirement.

Figure 1 seeks to summarise the above information.

Figure 1 – Summary of status of nitrate catchment management at groundwater sources

3. Water quality trends, status and catchment management strategy

Nitrate in groundwater continues to affect water quality at a number of Wessex Water sources. As part of Wessex Waters business planning process a review of nitrate trends has been carried out. As a result eighteen sources (twelve existing, six proposed) where catchment management is the preferred means of nitrate management have been identified.

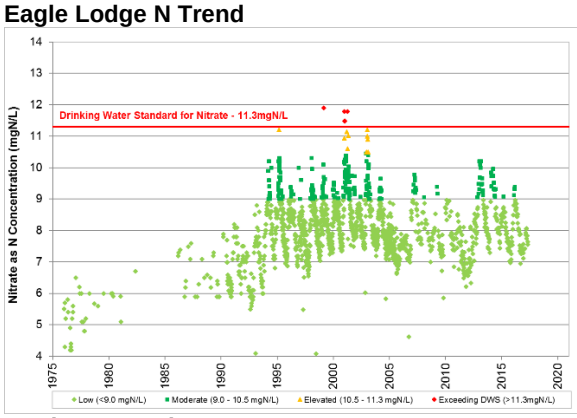
The process for selecting the sites for catchment management intervention is summarised in Section 1. In order to clarify Wessex Water's catchment management strategy for each of the 18 sites high nitrate sites they have been divided into four main categories. These categories are based on the status of the trend.

3.1 Category 1

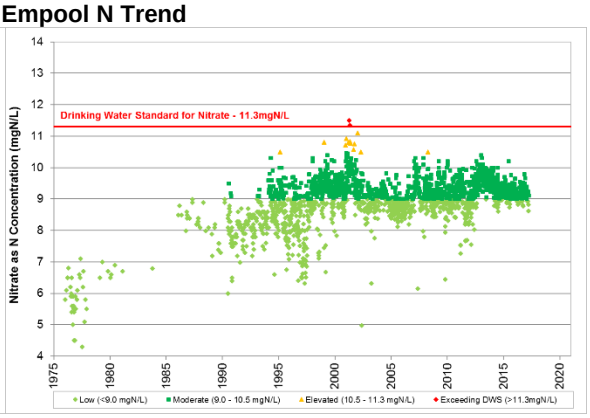
Sites with no ion exchange nitrate treatment or other asset solution where the nitrate trend had been rising but where catchment management intervention appears to have stabilised the trend. At these sites catchment management will continue at low levels to maintain improvements.

Site	Status	Comment
Eagle Lodge	Existing (AMP4)	
Empool	Existing (AMP4)	
Hooke	Existing (AMP5)	

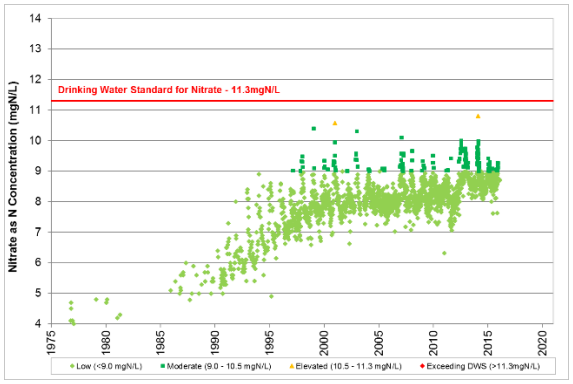
Eagle Lodge N Trend



Empool N Trend



Hooke N Trend

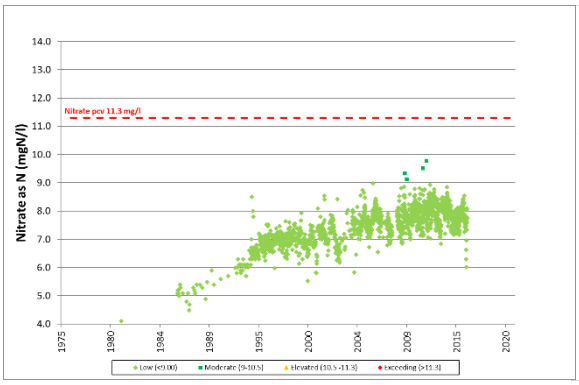


3.2 Category 2

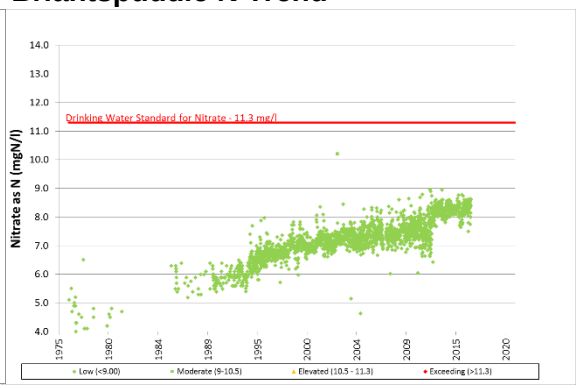
Sites with no ion exchange nitrate treatment or other asset solution where a rising trend of nitrate is predicted to reach compliance levels within the next 18 years (to 2035). At these sites catchment management is proposed (to continue or commence) in order to stabilise the nitrate trend before it threatens compliance.

Site	Status	Comment
Alton Pancras	Existing (AMP6)	
Briantspuddle	Proposed	See RukHydro report Appendix A. Site included in WINEP2
Cherhill	Proposed	See RukHydro report Appendix A. Site included in WINEP2
Forston	Existing (AMP6)	
Friar Waddon	Existing (AMP6)	
Sutton Poyntz	Existing (AMP6)	

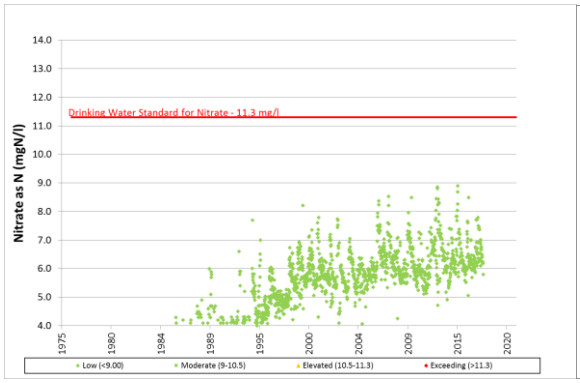
Alton Pancras N Trend



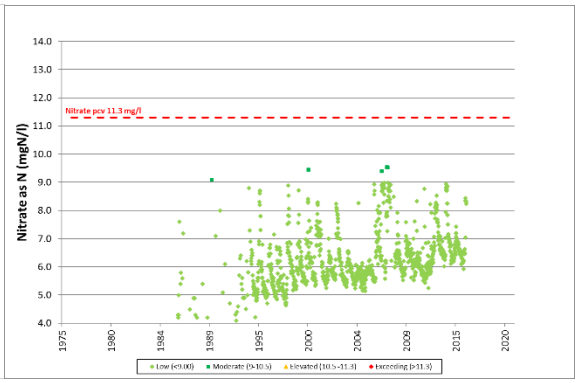
Briantspuddle N Trend



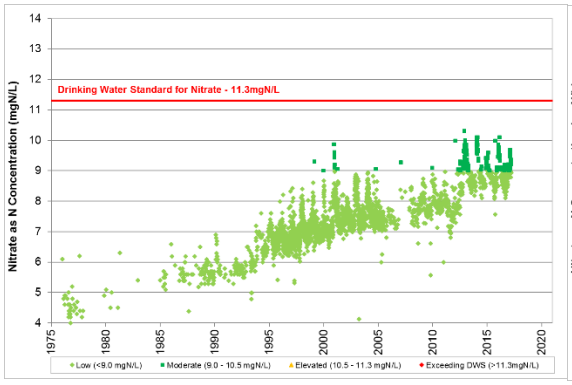
Cherhill N Trend



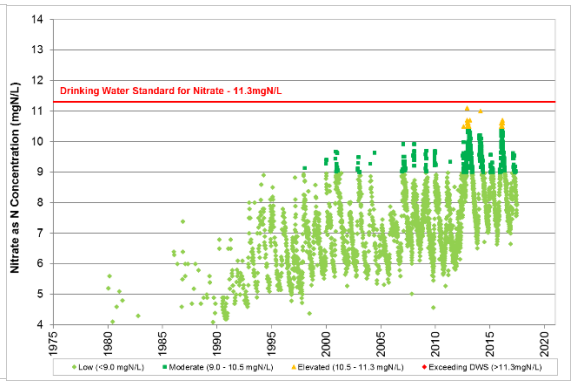
Forston N Trend



Sutton Poyntz N Trend



Friar Waddon N Trend

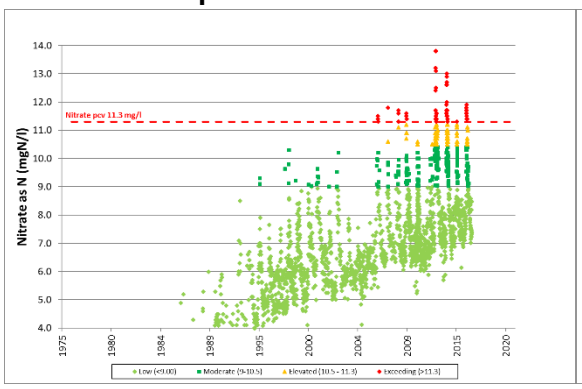


3.3 Category 3

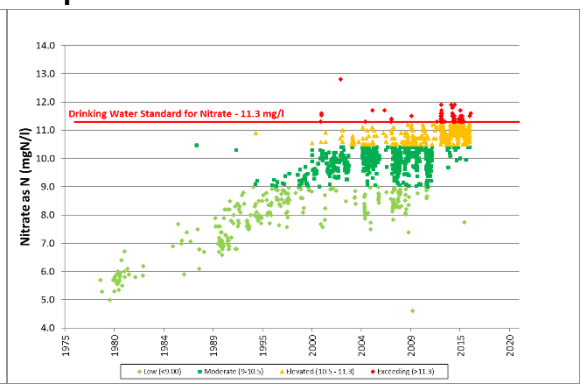
Sites with no ion exchange nitrate treatment or other asset solution and nitrate peaks that are already breaching compliance. At these sites catchment management is proposed to stabilise the trends and reduce the nitrate peaks in order to supplement a proposed asset solution (blending).

Site	Status	Comment
Fonthill Bishop	Existing (AMP5)	Asset solution proposed for PR19
Shapwick	Existing (AMP5)	Asset solution proposed for PR19
Sturminster Marshall	Existing (AMP5)	Asset solution proposed for PR19

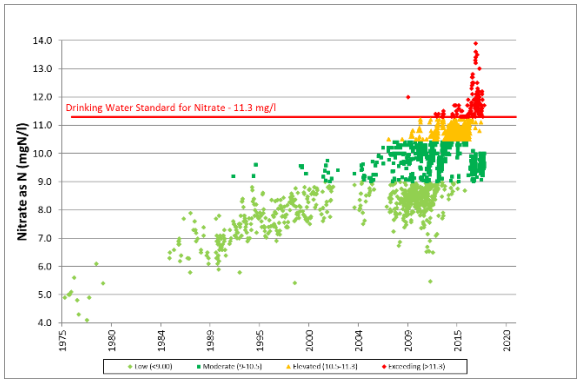
Fonthill Bishop N Trend



Shapwick N Trend



Sturminster Marshall N Trend

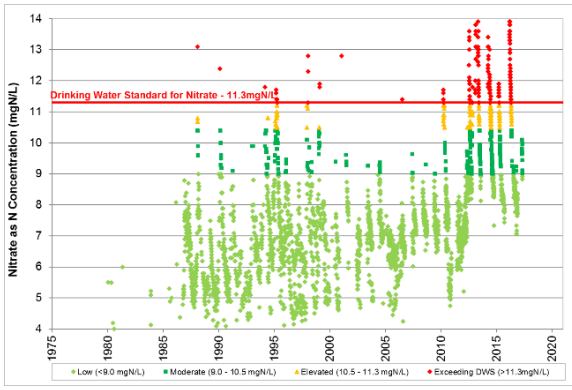


3.4 Category 4

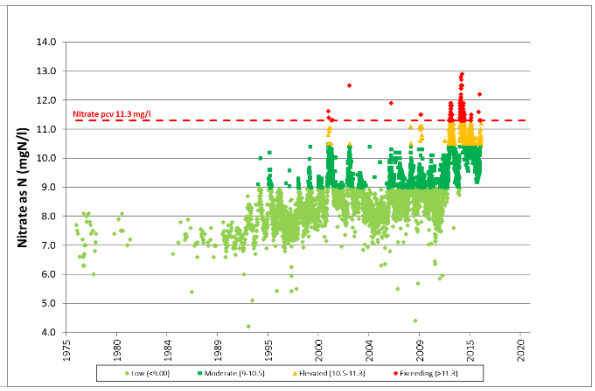
Sites with an existing asset solution where catchment management is proposed to minimise and ultimately remove the need of that asset solution.

Site	Status	Comment
Belhuish	Existing (AMP6)	Substituted by backfeed from Blackhill Res
Deans Farm	Existing (AMP5)	Blending available from Castle Hill Res.
Divers Bridge	Proposed	Blending available. Site included in WINEP2
Goodshill	Proposed	Blending available. Site included in WINEP2
Litton Cheney	Proposed	Blending available. Site included in WINEP2
Milborne St Andrew	Existing (AMP6)	Substituted by backfeed from Blackhill Res
Shepherds Shore	Proposed	Blending from Bourton/Bishop Cannings. Site included in WINEP2

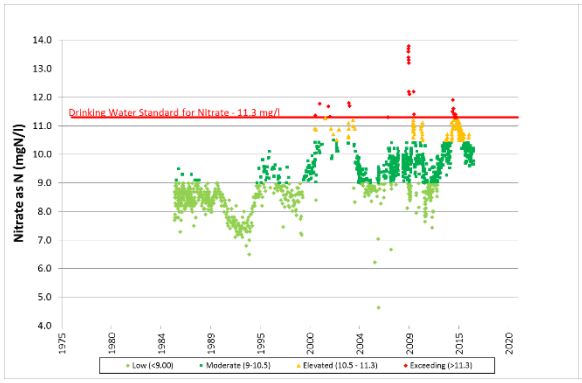
Belhuish N Trend



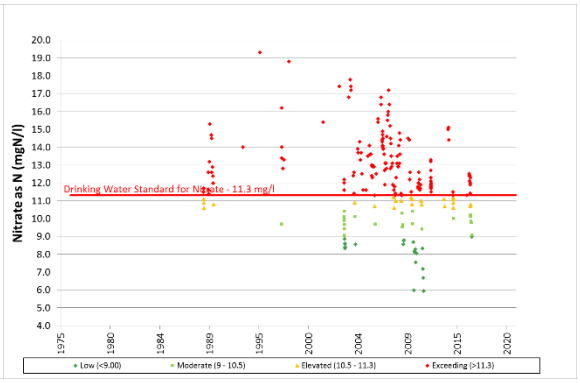
Deans Farm N Trend



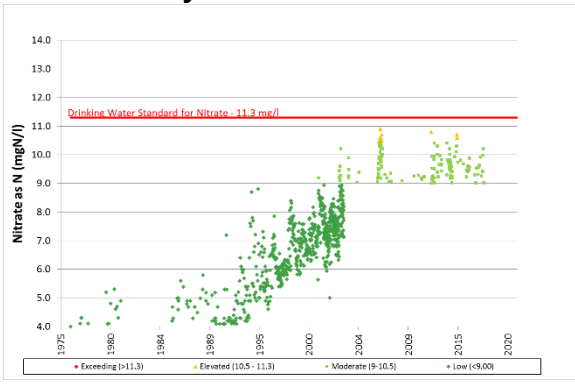
Diversbridge N Trend



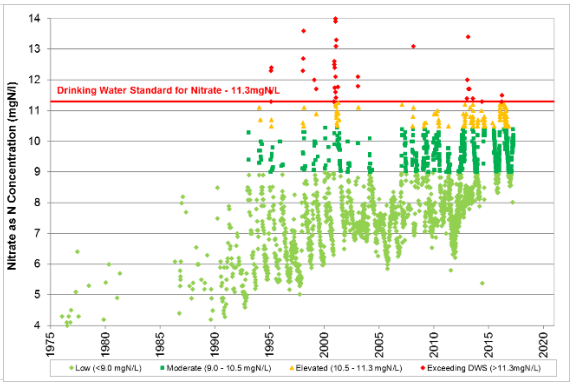
Goodshill N Trend



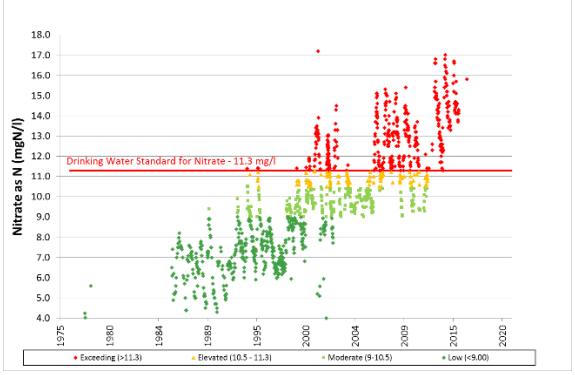
Litton Cheney N Trend



Milborne St Andrew N Trend



Shepherds Shore N Trend



4. Nitrate management proposals

Catchment management is an effective tool to manage nitrates. This report identifies the need to apply catchment management in a number of scenarios; to maintain stable nitrate trends where improvement have already been realised; to stabilise rising trends where compliance has not yet been reached; to provide long term improvements in nitrate trends where an asset solution is proposed to deal with peaks, and to provide improvements in the nitrate trend where there is already an asset solution in place to limit the blending or treatment requirements.

Eighteen sites are proposed for PR19, twelve existing sites and six proposed. Continuation of catchment management at the existing sites is justified by their ongoing high nitrate trends albeit that some have begun to stabilise. Support for the inclusion of new sites into the existing nitrate groundwater portfolio is provided by the observation of current trends and peaks that exceed compliance level, by linear regression analysis and by more sophisticated trend analysis (RukHydro UK).

The Environment Agency (EA) have confirmed that any existing sites will not be supported in the Water Industry Environmental Improvement Programme (WINEP). This is because they are no longer considered novel or innovative but rather ought to be considered part of Wessex Water's ongoing operational costs for each site. However, they have accepted that the new sites, where the efficacy of catchment management as yet to be proven will be included and supported by the WINEP.

The six new sites (Briantspuddle, Cherhill, Diversbridge, Goodshill, Litton Cheney and Shepherds Shore) are included in WINEP2. At the time of writing of this report, three of the sites (Briantspuddle, Cherhill and Litton Cheney) are in WINEP2 as red. This means that some further justification is required to support their final inclusion. The EA have confirmed that these three sites are being considered for designation as Safeguard Zones (SGZs) under Water Framework Directive legislation. The level of evidence required to get them designated, will allow their status to go green in WINEP3. The remaining three sites (Diversbridge, Goodshill and Shepherds Shore) are already designated as SGZ and so are green in WINEP2.

Once confirmed in WINEP a scope will be agreed for each of these new sites. This will comprise annual reporting of progress for the EA to demonstrate farmer engagement, uptake of measures, reduction of nitrate leaching and, ultimately, stabilisation of the nitrate trend and reduction of nitrate peaks.

The remaining twelve sites not included in WINEP will be included in PR19, funded from operational budgets as 'business as usual' items. They will also be subject to annual progress reporting to the EA on the same basis as for the WINEP sites because they are all designated SGZs for which the EA remain the responsible body..

All reporting will be available to the Drinking Water Inspectorate (DWI).

Nitrate trends at the above mentioned three Category 3 sites (Fonthill Bishop, Shapwick and Sturminster Marshall) have been reviewed and, in the light of ongoing high and rising nitrates, the option of carry out 'enhanced' catchment management was considered. This would comprise spending significantly more money in pushing the catchment famers to implement much more radical and long-term measures such as full grassland reversion. However, the costs involved here, which would have to include some consideration for the farmers on the loss of capital land value, set against the risks of not achieving compliance mitigate against it as a cost effective approach. As a result, the decision has been to include an asset solution (improved blending) in PR19 for these three sites (in practice two sites, as Shapwick and Sturminster Marshall are considered as one catchment).

It is envisaged that catchment management will continue at these sites in order to maintain momentum and attempt to try and reduce the blending requirements.

5. Recommendations

It is recommended that these eighteen sites be included in PR19 for catchment management to control nitrate levels. Three of the eighteen sites will have baseline catchment management to take place in conjunction with a required new asset soluton (improved blending).

Six new sites will be supported through the WINEP process. The remaining twelve existing sites will be funded as ‘business as usual’ items through operational budgets because we have shown that such work can be effective and should therefore be extended to ensure capital investement is prevented where possible. This is in the best interests of both our consumers and the environment.

Appendix A. Selecting Sites for AMP7 Catchment Management (Rukhydro Hydro)

The report below provides a description of the work undertaken by Rukhydro in 2017 to update nitrate trend predictions for a number of Wessex Water groundwater sites.

Wessex Water Catchment Science 2017
Selecting Sites for AMP7 Catchment Management

1. Introduction

1.1 Purpose of this Document

This note provides a description and review of work undertaken in 2017 to update nitrate trend predictions for a number of Wessex Water Services Ltd ("WW") groundwater supplies.

The work has involved inputs from the WW Catchment Management team and supporting consultants (AMEC Foster Wheeler and Rukhydro). The WW Catchment management team have prepared their own report on AMP7 water quality predictions, but this Rukhydro document provides an independent overview and review suitable for submission to DWI.

1.2 Supporting Documents

1.2.1 Rukhydro/WW Catchment Science Documents

The concepts behind and approaches to WW's nitrate trend modelling were primarily developed in discussion with consultants and academics between 2008 and 2013 and are detailed and summarised in the following reports prepared by Rukhydro for WW:

- Rukhydro (2013a). Wessex Water Catchment Science 2013 - Predicting Nitrate Trends: Approaches and Results. Rukhydro document 00028N285i3 dated 31 October 2013, 24pp.
- Rukhydro (2013b). Wessex Water Catchment Science 2013 - Predicting Nitrate Trends: Summary. Rukhydro document 00028N295i2 dated 31 October 2013, 18pp.

The detail in these documents is not repeated in this 2017 review and it is assumed readers have access to these documents.

1.2.2 WW Catchment Management Team 2017 Report

The WW Catchment Management team have prepared a report describing their evaluation of water quality trends at different sites to aid planning for AMP7. That document includes a review of sites potentially at risk of non-compliance for nitrate in AMP7 and beyond and is entitled:

- WW (2017). Catchment Management – Water Quality Review and AMP7 Prediction - Nitrate, Pesticide and Nutrients (Algal by products). WW document DM#1788471, July 2017 draft.

1.3 Prepared by

This document has been prepared by Nick Rukin of Rukhydro Limited for WW in discussion with the WW catchment management team as part of Rukhydro Limited's contract to WW (B0428 'Understanding Nitrate Trends in Raw Water Supplies'). Nick Rukin has been supporting Wessex Water's catchment management work since shortly after its inception.

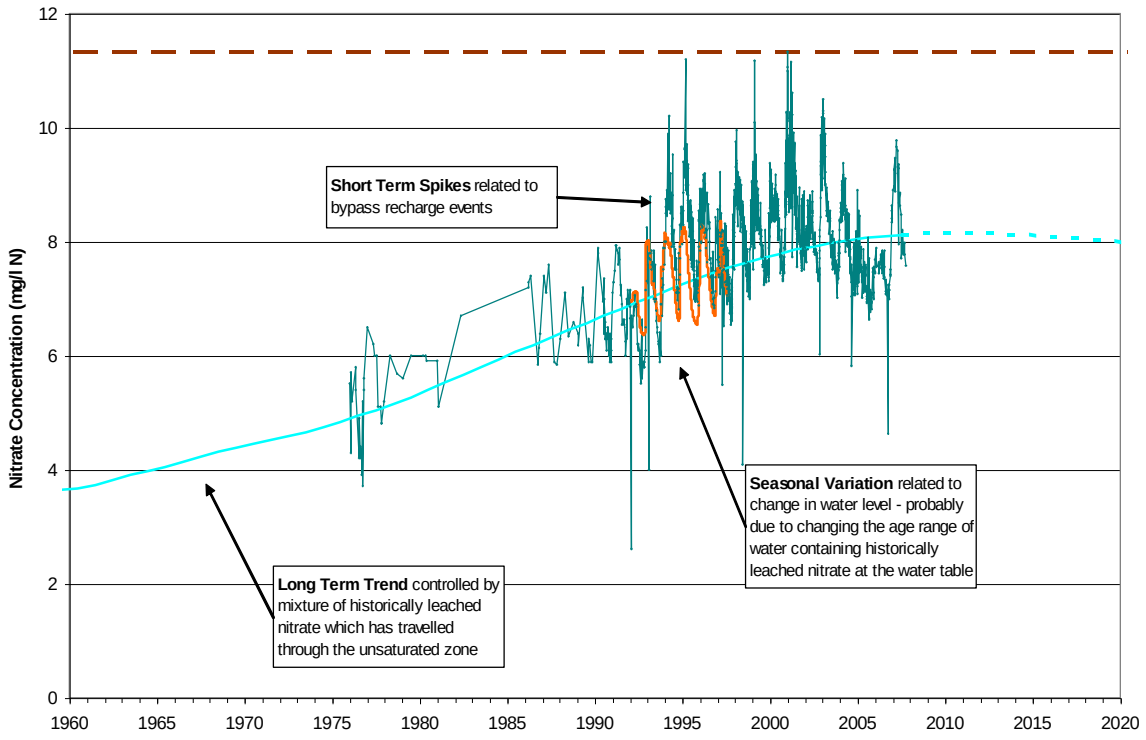
1.4 Layout of this Document

Following this introduction, Section 2 provides a reminder on components of nitrate trends, Section 3 describes work done to identify additional sites at risk of non-compliance for nitrate, and Section 4 provides conclusions and recommendations.

2. A Reminder of the Components of Nitrate Trends

Box 2.1 illustrates the components of WW nitrate trends.

Box 2.1 Components of Long Term Nitrate Trends and How We Model Them



This figure is as shown in Entec (2008); a report produced for WW as part of the R&D it contracted.

The measured nitrate concentration data are shown in Box 2.1 together with:

- a **modelled long-term nitrate trend** which uses data from the best available groundwater resource model, the Environment Agency catchment delineation tool of choice and a trend modelling approach developed for WW by Entec (now AMEC Foster Wheeler) based on widely accepted principals of water and nitrate movement.
- A **seasonal nitrate trend** which often correlates closely with groundwater levels, but as yet the controlling mechanism (bypass recharge or groundwater level rise) is not constrained and remains the subject of WW research.
- **Short-term spikes** which appear to be related to intense rainfall events, but again for which the controlling mechanism is not constrained and remains the subject of WW research.

3. Overview of Work Undertaken in 2017

3.1 WW Catchment Team Screening and Linear Trending of Sources

The WW (2017) report describes how the Catchment Management team have reviewed their measured nitrate concentration data "*to identify drinking water sources that continue to be at risk and that might become at risk in future from nitrate, pesticide and nutrient trends in terms of compliance.*"

The WW (2017) report describes the update of the company nitrate data spreadsheet (DM#1292659 v2) and linear trend analysis (DM#1788727). WW then categorised sources into those where the nitrate trend is rising and compliance levels are expected to be reached prior to AMP10 and those with rising trends that are expected to reach compliance level post AMP10. Table 3.1 reproduces a table from the WW (2017) report summarising the outcome of the trend analysis.

Table 3.1 WW Review of Additional Sites at Risk of Compliance Failure

Source	Trend description	AMEC model trend ranking	Predicted Date of Compliance Failure	
			Date	AMP period
Briantspuddle	Strong rising trend	9	2020	AMP7
Stubhampton	Strong rising trend	8	2032	AMP9
Cherhill*1	Strong rising trend	8	2034	AMP9
Pole Rue*2	Rising but starting from low base	8	Post AMP10	
Mere*2	Strong rising but starting from low base	8	Post AMP10	
Corfe Mullen	Rising	8	Post AMP10	
Newton Toney	Slightly rising but stabilising	8	Post AMP10	
Dewlish	Slightly rising but stabilising	8	Post AMP10	
Maiden Newton	Slightly rising but stabilising	8	Post AMP10	
Tatworth	Slightly rising but stabilising	8	Post AMP10	
Corscombe	Stabilised	8	Post AMP10	
Brixton Deverill	Stabilised	8	Post AMP10	
Shrewton	Rising	7	Post AMP10	
Yatesbury	Stabilising	7	Post AMP10	
Heytesbury	Rising	6	Post AMP10	
Ashton Gifford	Rising	5	Post AMP10	
Waterloo Farm	Rising	5	Post AMP10	
Cattistock	Rising	5	Post AMP10	
Bourton	Rising	4	Post AMP10	
Codford	Rising	4	Post AMP10	
Compton Durville	Rising	2	Post AMP10	
Lake	Rising	1	Post AMP10	

*[1] Funded in AMP5 but trend stabilised, now predicted to fail at end of AMP9
*[2] Possible candidates for early start catchment management

In addition to fifteen sites already undergoing catchment management, the WW team identified five new sites as potential candidates for catchment management from AMP7. These were Briantspuddle, Cherhill, Stubhampton, Pole Rue and Mere. The latter two were

included because, according to WW, "*although their nitrate concentrations are relatively low, an early start approach was considered for catchment management under AMP7 in order to attempt to stabilise the strongly rising nitrate trends.*"

3.2 AMEC Foster Wheeler Long-Term Trend Predictions

The WW linear nitrate trending approach does not take into account the potential future stabilisation (and possible subsequent improvement) in nitrate trends that is likely to eventually occur as more recent, improved land management water reaches the water table and flows to the abstractions in the WW catchments.

To check whether linear increasing trends were likely as far as 2040, WW commissioned AMEC Foster Wheeler to produce new long term nitrate trend models for Mere, Newton Toney and Pole Rue. Long term trend workbooks for these sites were provided to WW in June 2017 together with accompanying reports documenting the delineation of the sites' catchments, calibration of the models and a discussion of uncertainties.

There were existing AMEC Foster Wheeler long-term trend workbooks for Briantspuddle, Stubhampton and Cherhill and for the 15 sites already undergoing catchment management.

AMEC Foster Wheeler's reports noted for:

- Mere (AMEC Foster Wheeler, 2017a) – there is Upper Greensand in the catchment, the unsaturated zone is thin in parts of the catchment and the standard model (unsaturated zone only) produces a poor fit to the measured data. A calibrated model using lower unsaturated zone porosity and total travel time approach (to take into account the Upper Greensand) produces an improved, but still rather poor fit. So there is relatively low confidence in the Mere long term trend, but the trend is not predicted to exceed the drinking water standard.
- Newton Toney (AMEC Foster Wheeler, 2017b) – this is a wholly Chalk catchment, but the standard model does not reproduce the recent relatively flat observed trend in nitrate. The model fit was improved by assuming the grassland in the catchment is predominantly low or zero input grassland rather than intensively managed grassland. The improved model predicts that nitrate concentrations will slowly decline in the future and that "peak nitrate" has passed.
- Pole Rue (AMEC Foster Wheeler, 2017c) – there is Upper Greensand in the catchment and groundwater level data were limited to the borehole only; the latter compromising the approach with regard to unsaturated zone thicknesses and travel times across the wider catchment. Using assumed water levels and a total travel time model (as for Mere) produced a reasonable fit to the measured nitrate data. A rising trend is predicted to peak in the 2040s at ~9 mg/l N and so not to exceed the drinking water standard.

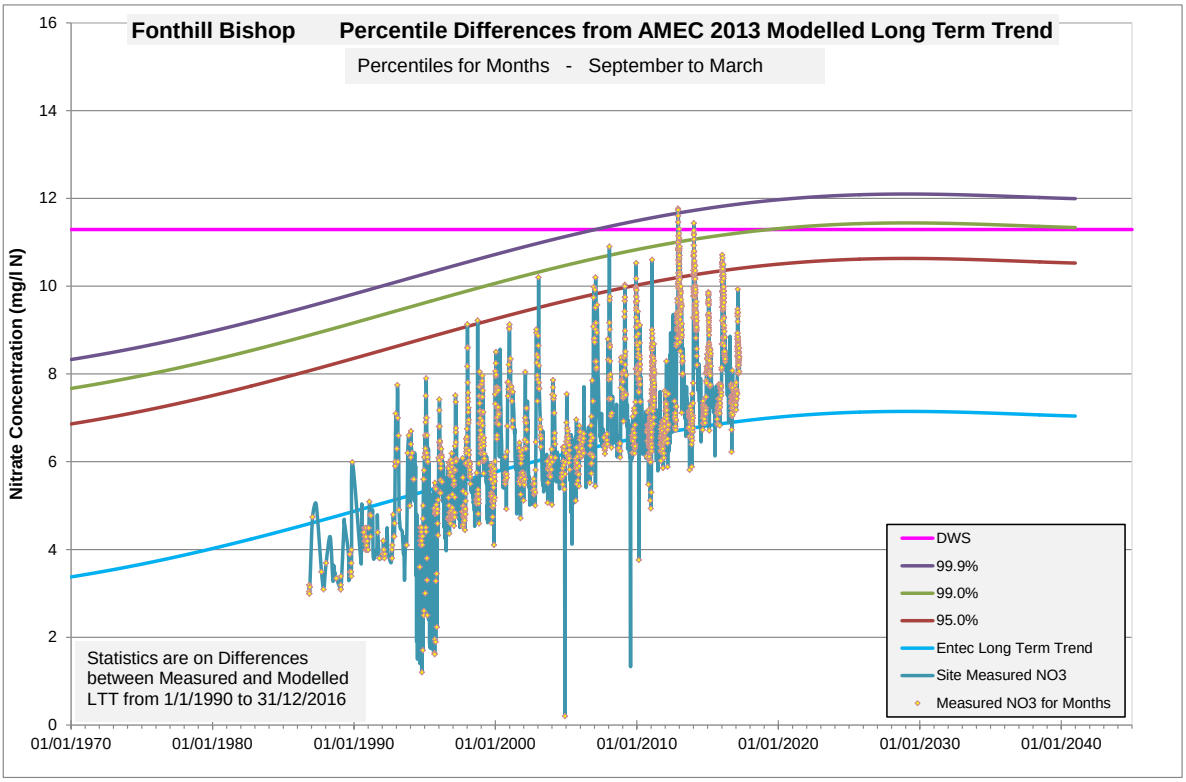
3.3 Rukhydro Percentile Workbooks

3.3.1 Approach

As noted in Section 2, the mechanisms controlling seasonal variation and short-term spikes in nitrate concentration are not yet fully understood, although plausibly are related to variations in recharge and groundwater level. Due to uncertainty in the controlling mechanism and future recharge and groundwater levels, the future variability in nitrate concentrations has been evaluated using an empirical approach.

As noted in Section 4.4 of Rukhydro (2103b), in 2010, WW and Rukhydro developed an approach to calculate percentiles of the differences of measured nitrate concentrations from modelled long term trends (LTT). The 95th, 99th and 99.9th percentiles on these differences were then added to the predicted long term trend values to allow predictions of shorter term variability from this long-term trend. These predictions were then used in WW's assessment of blending for AMP6. A 2017 example of a percentile difference chart is shown in Box 3.1.

Box 3.1 Example of Percentile Difference from Long Term Trend Chart



Note: This chart is from a WW / Rukhydro worksheet developed in 2010 and updated in 2017 and uses the most recent long term trend available (AMEC 2013). The percentile lines are based on differences between the long term trend and monitoring data available for the period 01/01/1990 to 31/12/2016. For this report the monitoring data have been updated to 30 March 2017.

Separate charts are available in the workbooks with statistics on three periods; winter (September to March), shoulder (April to June) and summer (July and August), although only the summer version is shown in Box 3.1. Winter usually shows the greatest variation from the long term trend line. The approach is very useful in blending scheme assessment, and the first predictions made 2010 had reasonable success at allowing for the wet winter of 2012/2013. The percentile differences do not however forecast what nitrate may be in the coming days, weeks or months based on recent weather or catchment management efforts and thus have limitations for more detailed operational use.

3.3.2 Sites Evaluated

WW selected ten sites for evaluation using the percentile workbook approach in 2017. The sites evaluated are listed in Table 3.2 together with information regarding the long-term trend used and other assumptions.

Table 3.2 Sites Evaluated Using Percentile Workbooks

Site	AMEC Long Term Trend Workbooks				Rukhydro Percentile Workbooks	
	Year of AMEC FW LT Trend	Extended to 2040	Basis of LT Trend	Other Factor	Start date for Statistics	End date for Statistics
Briantspuddle	2014	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Cherhill	2012	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Deans Farm	2013	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Fonthill Bishop	2013	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Mere	2017	Already to 2017	Total travel time at low water levels		01/01/2010	31/12/2016
Newton Toney	2017	Already to 2017	Unsaturated zone only at low water levels	Assume grassland is rough grazing	01/01/1990	31/12/2016
Pole Rue	2017	Already to 2017	Total travel time at low water levels		01/01/1990	31/12/2016
Shapwick	2013	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Stubhampton	2014	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016
Sturminster Marshall	2013	by Rukhydro in 2017	Unsaturated zone only at low water levels		01/01/1990	31/12/2016

Note: Text in red show departures from the standard approach. For the Mere trend, statistics were generated from 2010 rather than 1990 as the fit of the modelled long term trend prior to 2010 was particularly poor.

Existing AMEC Foster Wheeler long term trend workbooks were extended from a prediction date of 2035 to 2040 by Rukhydro (after consultation with AMEC Foster Wheeler).

The Rukhydro percentile workbooks were provided to WW in June 2017.

3.4 Review Meeting of June 2017

The modelled long-term trends and accompanying percentile workbooks for the ten sites listed in Table 3.2 were reviewed at a meeting held at WW Claverton Down offices on 8 June 2017. The meeting was attended by WW staff of the catchment management, compliance and science strategy teams and by Nick Rukin of Rukhydro.

The catchment management team provided background information related to the need for nitrate trend predictions. Rukhydro gave a presentation on the predictive nitrate modelling approach, in particular long-term trending work as carried out by AMEC Foster Wheeler, and on the percentile trends approach. The modelled long-term trends and percentile workbooks were then reviewed by the meeting attendees.

There was discussion regarding confidence in the long-term modelling approach, but it was accepted that although uncertainties remained, the approach had proven reasonably reliable to date, was now used by AMEC Foster Wheeler for other water companies and represented the best available predictive tool for the Wessex Region.

Taking into account the goodness of fit of the modelled long-term trend to the general visual trend in the measured data, each site's percentile trends were reviewed and a group decision was made as to whether that site appeared to be at risk of non-compliance as set out in Table 3.3.

Table 3.3 Outcome of Review of Percentile Workbooks for Catchment Management

Source	Recommendation of 08 June 2017 Meeting Attendees
Mere, Newton Toney, Pole Rue, Stubhampton	Case insufficiently strong to put forward for catchment management in AMP7.
Briantspuddle, Cherhill	Fund active Catchment management in AMP7
Deans Farm, Fonthill Bishop and Sturminster Marshall/Shapwick	Continue with catchment management but with enhanced measures. Review catchment area to ensure effective coverage of measures. Prepare for enhance blending or even treatment should catchment management fail to deliver improvements in AMP 6 and 7.
Alton Pancras, Belhuish, Bulbridge, Eagle Lodge, Empool, Forston, Friar Waddon, Hooke, Milborne St Andrews, Sutton Poyntz,	Continue with catchment management*

Note: (*) These sites were not reviewed using percentile workbooks in 2017 or reviewed at the meeting, but are included for completeness and are as shown in WW (2017).

Following the review of the sites which had been screened and then recommended for catchment management, there was a discussion on sites where blending is undertaken due to elevated nitrate concentrations, but where no programme is in place to address the pollution sources. It was noted that the Nitrate trends at four sites; Goodshill, Litton Cheney, Divers Bridge and Shepherds Shore remain elevated or continue to rise on an upward trajectory based on linear trends and as such present a threat to the sustainability of the blend. It was recommended that these sites should also be considered for catchment management through funding in AMP7. It was also noted that AMP6 schemes at Milbourne

St Andrews and Belhuish sources targeting winter shut-downs due to peak nitrate concentrations have been particularly effective at reducing outage.

4. Conclusions and Recommendations

4.1 Conclusions

WW have used the following lines of evidence to screen in and then evaluate in more details the potential for sites to exceed the drinking water standard for nitrate in AMP7 and beyond:

- Linear trending of measured concentration data;
- Modelled long term average nitrate trends mechanistically taking into account likely historical nitrate leaching, travel times through the unsaturated zone and within the aquifer;
- Percentile workbooks which calculate the variation of measured concentration data from the modelled long term average nitrate trend and then add that variation to the modelled future long term trend for different seasons of the year.

A review meeting considered confidence in data and modelled trends and used these lines of evidence to conclude two new sites should be added to those receiving catchment management efforts. Four sites were also identified where blending was undertaken, but the sources themselves had non-compliant, and in some cases rising, nitrate concentrations. To protect the sustainability of the blend these four sites were also recommended for catchment management through AMP7 funding. A total of six additional sites were therefore recommended for catchment management.

4.2 Recommendations

4.2.1 Long-term trend model evaluation

The AMEC Foster Wheeler long term nitrate trend approach is based largely on work undertaken by Nick Rukin (then at Entec) for Wessex Water in 2007-2009. AMEC Foster Wheeler has modified the approach based on support from Nick Rukin and their own efforts. The main modelling development has been on catchment delineation rather than on controls on nitrate concentration.

Although the long-term trend approach has proven quite reliable and has been adopted by the Environment Agency and a number of other Water Companies with Chalk groundwater supplies, some of the more recently modelled trends have shown relatively poor fits with measured data.

Whilst some of the poor fits may be related to the absence of water level data (so data paucity) rather than approach, there should now be sufficient models to appraise under what circumstances good, moderate and poor model fits are achieved. Such circumstances include:

- Sites with a predominance of waters of a certain age range (thus highlighting likely strengths and weaknesses in the historical nitrate leaching assumptions);
- Sites with a predominance of waters of a certain land use (thus highlighting possible errors in historical nitrate leaching assumptions or effective rainfall correction factors);

- Sites with soils and strata other than Chalk;
- Sites in areas of more steeply dipping Chalk which are likely to have lower effective porosities in the unsaturated zone and thus more rapid transport;
- Sites with more seasonal and short term variation which may signify more bypass recharge and less steady plug-flow recharge;

Such an evaluation could lead to either recommendations for improvements to the 2007-9 modelling approach or an improved understanding of likely errors for certain sites.

4.2.2 Performance review for the percentile workbooks

It is recommended that the percentile workbooks are used to evaluate their success in predicting future trends. This could be done with the 2017 percentile workbooks by changing the evaluation period for the statistics from 1990 to 2016 to 1990 to 2010 and then comparing predicted versus actual 95th, 99th and 99.9th percentiles for the 2011 to 2016 period.

4.2.3 Short-term nitrate trend research

Past efforts to mechanistically model seasonal and short term variations in nitrate have had mixed success (Rukhydro, 2013a, b). This work has included work on behalf of WW and independently by the British Geological Survey (2009).

Return on research investment in this area is therefore unclear. If the controls could be understood then it may help yield valuable information on the effectiveness of catchment management or indeed may help in catchment management and operational management of sites.

It is however recommended, that as part of the recommended evaluation of the long-term trend modelling approach set out in Section 4.2.1, short term variability is reviewed in terms of characteristics of catchments where variability is large or small. The 2010-11 drought and the very wet summer and winter 2012/2013 provide extremes for testing concepts.

Long and short term variation in sulphate should also be evaluated as this may provide an independent signature and evidence of more rapid transport.

5. References

AMEC Foster Wheeler, 2017a — Technical Note: Nitrate Trend Prediction – Mere PWS. AMEC ref: 39667n008i1, dated April 2017.

AMEC Foster Wheeler, 2017b — Technical Note: Nitrate Trend Prediction – Newton Toney PWS. AMEC ref: 39667n012i1, dated May 2017.

AMEC Foster Wheeler, 2017c — Technical Note: Nitrate Trend Prediction – Pole Rue PWS. AMEC ref: 39667n010i1, dated May 2017.

BGS, 2009 — Nitrate fluctuations in groundwater: review of potential mechanisms and application to case studies. Groundwater Science Programme, Open Report OR/08/046. Authored by Stuart M E, Chilton P J and Butcher A S. 2008. http://nora.nerc.ac.uk/7021/

Entec, 2008 — Prediction of Nitrate Trends in PWS Groundwater Sources. Prepared for Wessex Water Services Ltd by Entec UK Ltd. (2008)

Rukhydro, 2013a — Wessex Water Catchment Science 2013: Predicting Nitrate Trends: Approaches and Results. Rukhydro Technical Note for Wessex Water, ref 00028N285i3 dated 31 October 2013. 24pp.

Rukhydro, 2013b	Wessex Water Catchment Science 2013 - Predicting Nitrate Trends: Summary. Rukhydro document 00028N295i2 dated 31 October 2013, 18pp.
UKWIR, 2008	WAgriCo: Modelling Nitrate Concentrations with Variations in Time, Annex 53 of the Final Technical Report of the EU Life project number LIFE05 ENV/D/00182, Report Ref. No. 08/WR/26/7 Published by the UK Water Industry Research Ltd.
WW, 2017	Catchment Management – Water Quality Review and AMP7 Prediction -Nitrate, Pesticide and Nutrients (Algal by products). WW document DM#1788471, July 2017 draft.

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