Report by Dr Jo Parmenter, Director of The Landscape Partnership.

An analysis of the Schedule of Documents accompanying the Agency's "minded to" decision.

Schedule of Documents: Catfield Abstraction Renewals

These documents are available on sharefile: https://ea.sharefile.com/i/i782703d1d0c4b099

Draft Determination Report - 17 November 2014

AMEC have modelled the change in pH resulting from the drawdown levels identified in their hydrological model as being 0.16 of a pH unit between naturalised and historical conditions. Natural England have expressed significant misgivings about the methodology used and shortcomings in the hydrological model itself[1] and are unable to indicate whether or not this value may be ecologically significant nor whether changes in pH predicted are likely to be an indication of the scale of impact of abstraction. Contrary to a statement in an AMEC report on fen management, increased summer rainfall only leads to a significant change in water chemistry if there is a loss of base rich groundwater at the same time, for example as a consequence of abstraction[2]. Natural England further note that the model indicates that there may be a potential path of change from water table changes to potential changes in pH,[3] and that, although the model has indicated that changes are small, the modelled decrease in pH is consistent with the direction of change in vegetation, which clearly shows a shift from species of more base-rich conditions to those of more acidic conditions.

A review of historic (1988[4]) and more recent (2005[5] and 2014[6]) surface pH data has shown a trend towards increasing acidification of water at the fen surface over the past c10 years.

Recent and ongoing work by RSPB is surveying pH levels in the interstitial soil water across Unit 3, to determine how this changes with depth. Data from a series of transects across the fen have been compared with data collected by Giller and Wheeler (1988).[7] The Giller and Wheeler data compared pH levels in *Sphagnum* dominated areas with areas of S2/S24e vegetation, and found that beneath the latter two vegetation types, the pH both at the fen surface and in the interstitial water at depths down to -150cm remained entirely within the range pH7-pH8. Conversely, the *Sphagnum* dominated areas had surface pH values between 4 and 5, but this gradually increased with depth, so that pH7 was reached at c-65cm. Thereafter the interstitial pH beneath the *Sphagnum* polster remained within the pH7-pH8 range. Conversely, the RSPB survey has measured surface pH as low as pH3.5 in some *Sphagnum* dominated areas, with the pH at depth both beneath *Sphagnum* and elsewhere in the fen being typically well below pH7 (ref TBC).

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[1] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

[2] The Landscape Partnership and Riches, O P 2014 CATFIELD FEN: A Response to the AMEC Technical Note: Notes on the Management of Catfield Fen. July 2014

[3] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

[4] Collins 1988; Atkins/HSI (2005); Ewan (2005). Data from these reports is reproduced at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289540/Catfield_Appendix_F_5B1_5D_324668.pdf

[5] Collins 1988; Atkins/HSI (2005); Ewan (2005). Data from these reports is reproduced at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289540/Catfield_Appendix_F_5B1_5D_324668.pdf

[6] The Landscape Partnership 2014 pH change at Catfield Fen. Unpublished report.

[7] Giller and Wheeler (1988). Acidification and Succession in a Flood-Plain Mire in the Norfolk Broadland, U.K. *Journal of Ecology (1988), 76, 849-866*

The deeper layers in the peat in general have higher electrical conductivity and higher calcium concentrations. [8]

There is a distinct correlation between the hydrochemistry and the quality of vegetation. As calcareous fen vegetation quality decreases and bog conditions are stimulated, so do all indicators for groundwater flow.[9]

The transition community with *Sphagnum fallax* is present in many locations in Catfield Hall Fen, and is characterized by accumulation of rainwater, with the groundwater input at surface being reduced. It is surmised that in recent years buffered groundwater discharge has reduced and as a consequence acid rainwater plays an increased role in the upper peat layers, stimulating *Sphagnum* growth. The balance in input with rainwater and groundwater has changed at many locations in favour of acid rainwater, thence decreasing suitability for rich fen vegetation. [10]

The number of locations in the east of Catfield Fen in which calcium-rich water is present at surface is very limited (as of spring 2014). The higher concentration in chloride and sodium at these locations prove previous discharge of groundwater that has passed through saline layers. The absence of rich fen conditions, including vegetation, at many locations is recent and the most likely explanation for the change is reduced groundwater input. [11]

The Determination report records that "It should be noted that no water chemistry variables were recorded in Lott et al. (2010) and therefore there is no definition available of the water chemistry requirements for the W31 (permanent wet mire) invertebrates which have been identified as being most sensitive to changes in water chemistry (Natural England, 2014l). There is however a broad indication that **species representative of W314 (assemblages associated with Page 44 of 76DRAFT – Minded To Consultation rich fen) prefer alkali rich conditions whilst species representative of W313 (assemblages associated with mesotrophic fen) prefer alkali poor conditions.**

A change in water chemistry may affect the balance of invertebrates present on site, with more alkali poor conditions leading to a transition from W314 towards W313 and potentially to W312 (assemblages associated with Sphagnum bog) which prefers very alkali poor (including ombrotrophic), conditions (Amec, 2014f). **It is unknown what degree of change in alkali richness would cause this shift in invertebrate assemblage. The invertebrate assemblage is one of the features for which the site is notified.**

[8] Pyne, E & Barendregt, A 2014 Characterization of the Relationship between Hydrology and Vegetation in Catfield Fen
[9] Pyne, E & Barendregt, A 2014 Characterization of the Relationship between Hydrology and Vegetation in Catfield Fen
[10] Pyne, E & Barendregt, A 2014 Characterization of the Relationship between Hydrology and Vegetation in Catfield Fen
[11] Pyne, E & Barendregt, A 2014 Characterization of the Relationship between Hydrology and Vegetation in Catfield Fen

Schedule of Documents (those with yellow highlight are 'new' or modified)

1 Alston (2014a) Snipe Marsh	Pg 1 – seems to be confusion about supply of water to Snipe Marsh. Mr Alston is under the impression that it is predominantly surface water fed and that it is not affected by pumping. Pg 2 -the absence of reed is much more likely to be due to grazing/mowing management, which would eradicate reed quite quickly. Typical S24 vegetation does contain reed but the absence or near absence of reed does not imply that S24 vegetation is also absent. Pg 3– in certain circumstances, extensive grazing may be an appropriate alternative to mowing, for management of S24 vegetation. Pg 3 – the River Ant is still relatively high in nitrate, even though Phosphate levels are reduced. Any nutrient input would reduce effectiveness of fen management and could result in coarser species becoming dominant. Pg 3 – ochre is typically released from peat when the peat is oxidised. *NB may be worth Chris looking at other points raised*
2 Alston (2014b) Catfield Fen	Much of this paper misquotes/misrepresents statements made in my report on peat stratigraphy Pg 1 Terrestrialisation is a natural feature of all fen systems, however it is substantially slowed by regular mowing management. The extent of Sphagnum dominated communities has increased substantially in the recent past, and the pH has been shown to have significantly reduced at the fen surface, and this suggests that the development of Sphagnum 'polsters' has been accelerated by decreased pH at marsh surface. This is likely to be due to an increased reliance on rainfall as opposed to groundwater, which would be slightly alkaline, and this observation is borne out by other studies (Mason, in prep). Water stagnation does not cause surface acidification. Water movement within fen sites is important in order to avoid stagnation for a variety of other reasons. Stagnation does not occur within the internal fen system, as water is allowed to flow out through the sluice. There are ecological benefits in cutting foot drains into the fen, however this action would not in itself increase water availability. The ditches throughout the internal fen system are currently well managed; there is no requirement to clean them out. At no point has Dr Parmenter suggested that water might be allowed to enter the internal system, from the river/broad. This would flush the site with water of a much higher nutrient status, which would be potentially very damaging to the low nutrient communities of the internal system. Many of the more uncommon species present within the internal system are reliant on low nutrient status (the internal system, is nitrate-limited) and would not compete with the taller vegetation which would result from regular flushing with nutrient rich water. Recent work has shown that the fen is declining due to surface acidification rather than a lack of water.

	Mr Alston's paper quotes me as saying that "… a move to just relying on rainwater (poor in nutrients) might be having an effect on reed growth and the site would benefit from more nutrients from the river/Broad." My report actually states that reed growth could be adversely affected by a water source which is more nutrient poor. It could be postulated, although there is no empirical data to support this, that a change in the balance of water irrigating the site towards a more rainwater dominated system would lead to reduction in available nutrients. At no time do I suggest that river water should be allowed on to the site, and in actuality I believe that this would be damaging to the fen. The fen orchid colony has increased significantly in the recent past due to regular rotational mowing management. The losses are due not to insufficient/inappropriate management, but to encroachment by sphagnum upon the colony and consequent acidification/smothering of plants. Pg. 2 My reference to 'nutrients' in my stratigraphy report is in the wider sense – minerals such as calcium, magnesium etc, and the reference was debating whether there had been a switch from groundwater-availability (and corresponding availability of calcium etc.) to a rainwater dominated system. Foot drains will assist water movement across the marsh, but are unlikely in themselves to reverse the acidification process, as this is considered to be due to reduced groundwater availability. Pg 3 Professor Tom Williamson (pers comm) speculates that the likely reason for abandonment of drainage of the internal system is that the rate of groundwater upflow was in excess of the capacity of the pump, and it proved impossible to maintain adequate drainage for grazing.
9 Amec (2014f) Main Groundwater Report Issue 2 (3 documents)	Doc actually saved under the name 'main report for Alston' -do we read anything into this? Pg 39 quotes an excerpt from my 1995 report on broadland fens: Peter Wright stated in 1993 that brining had taken place in the internal system. Peter Wright left NCC in the late 1980s, and so his comments can be taken as describing management prior to 1990. However the previous owner categorically states that he did not burn the site and so it must be surmised that his recollection is likely to be the correct one and that Peter Wright may have confounded the burning of piles of cut litter etc with wholesale burning. Pg 41 Richard Mason's paper (in prep) demonstrates dramatically reduced pH over a 30 year period on Unit 3, which does suggest that ongoing base depletion is potentially responsible for Sphagnum increase. Pg 44 There seems to be general agreement that acidification/base depletion is responsible for the changes, rather than accelerated vegetation succession due to drying. Pg46 Interestingly, Amec do not quote that part of the site history which states "This is a site of considerable botanical interest, unfortunately rather degraded through scrub invasion, and undergoing a gradual desiccation process due to water abstraction; the volume of water abstracted within 2 km of the site is 210 million gallons per annum. This is very worrying

	because of the reliance of many of the plant communities in this part of Catfield Fen on the groundwater supply." Pg 90 The depth profiles referred to are the ones which Mason has demonstrated have experienced a drop of 1-2 pH units between mid 80s and present: higher pH is no longer seen at 60cm below surface . There is still no attempt to link ecology with hydrology, or to explain the vegetation changes; and the conclusions simply relate the output of the model. The work undertaken by AMEC and the Environment Agency to date makes no reference to aluminium toxicity or phosphate deficiency and it is assumed that this aspect of acidification on rich fen plant communities has not been considered. Aluminium ions become soluble in waters lower than pH 6, with dramatically increasing solubility occurring below pH 5.5, and can subsequently be absorbed by plants[12]. Aluminium is known to inhibit root growth at toxic concentrations and bind readily with phosphates which can also lead to phosphate deficiency[13 14]. Common reed (*Phragmites australis*) is considered to be a good indicator of environmental conditions as it is provides an accurate representation of metals present in sediment[15]. Areas of common reed at Catfield Fen have been observed to be showing signs of decline, e.g. reduced vigour, slower growth rate, etc, with increasing acidity and it is therefore possible that bioaccumulation of aluminium is the cause[16]. It has already been discovered the acidification of Catfield Fen has led to the displacement of *Potamogeton coloratus* with *Potamogeton polygonifolius*, and other key species of flora at risk of being negatively affected by pH levels below 6 include *Liparis loeselii*, *Dactylorhiza traunsteinerioides*, *Carex appropinquata* and *Pyrola rotundifolia*.
11 Amec (2014h) Addendum to Main GW Report (2 documents)	**pH change** The EA conclude that the Model indicates the change in pH resulting from the drawdown levels identified in their hydrological model as being 0.16 of a pH unit between naturalised and historical conditions. Natural England have expressed significant misgivings about the methodology used and shortcomings in the hydrological model itself[17] and are unable to indicate whether or not this value may be ecologically significant nor whether changes in pH predicted are likely to

[12] Kabata-Pendias A (2011) *Trace Elements in Soils and Plants, Fourth Edition*. p325-327. Taylor & Francis Group, Boca Raton.
[13] McCormick LH & Yates Borden F (1972) Phosphate fixation by aluminium in plant roots. *Soils Society of America Proceedings*. 38: 799-802.
[14] Batty LC, Baker AJM & Wheeler BD (2002) Aluminium and Phosphate uptake by Phragmites australis: the Role of Fe, Mn and Al Root Plaques. *Annals of Botany*. 89(4): 443-449.
[15] Štrbac S, Šajnović A, Kašanin Grubin M, Vasić N, Dojčinović B, Simonović P & Jovančićević B (2014) Metals in sediment and Phragmites Australis (common reed) from Tisza River, Serbia. *Applied Ecology and Environmental Research*. 12(1): 105-122.
[16] Ayeni, O, Ndakidemi P, Snyman R & Odendaal J (2012) Assessment of Metal Concentrations, Chlorophyll Content and Photosynthesis in Phragmites australis along the Lower Diep River, CapeTown, South Africa. *Energy and Environment Research*. 2(1): 128-139.
[17] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

	be an indication of the scale of impact of abstraction. Natural England further note that the model indicates that there may be a potential path of change from water table changes to potential changes in pH,[18] and that, although the model has indicated that changes are small, the modelled decrease in pH is consistent with the direction of change in vegetation, which clearly shows a shift from species of more base-rich conditions to those of more acidic conditions. A review of historic (1988[19]) and more recent (2005[20] and 2014[21]) surface pH data has shown a trend towards increasing acidification of water at the fen surface over the past c10 years. Recent and ongoing work by RSPB is surveying pH levels in the interstitial soil water across Unit 3, to determine how this changes with depth. Data from a series of transects across the fen have been compared with data collected by Giller and Wheeler (1988).[22] The Giller and Wheeler data compared pH levels in *Sphagnum* dominated areas with areas of S2/S24e vegetation, and found that beneath the latter two vegetation types, the pH both at the fen surface and in the interstitial water at depths down to -150cm remained entirely within the range pH7-pH8. Conversely, the *Sphagnum* dominated areas had surface pH values between 4 and 5, but this gradually increased with depth, so that pH7 was reached at c-65cm. Thereafter the interstitial pH beneath the *Sphagnum* polster remained within the pH7-pH8 range. Conversely, the RSPB survey has measured surface pH as low as pH3.5 in some *Sphagnum* dominated areas, with the pH at depth both beneath *Sphagnum* and elsewhere in the fen being typically well below pH7 (ref TBC). Although the vertical pH gradients might be anticipated to change seasonally, such change is likely to be fairly minimal. The scale of change in pH over the 30 year period is very evident, and strongly corroborates the hypothesis that where groundwater discharge is reduced, rainwater infiltration occurs and that this initiates the process of acidification: fen soils have buffering capacity to withstand this process for a number of years, but ultimately, the residual buffering capacity is exhausted. Within a short period (2 - 4 years) the pH of the upper layers of peat will change from a pH-value of 6-7 to 5 or less. The impact of this trend can be seen clearly in vegetation change data presented by the RSPB and by ourselves, which demonstrates a degree of change from calcareous fen to more acidic fen; in particular populations of species. Several of the species for which the SSSI is designated, and which occur within the internal system, including *Carex appropinquata, Dactylorhiza traunsteineroides* and *Pyrola rotundifolia,* also exhibit a preference for base-rich conditions and are likely to be be at risk if the current trend towards acidification continues[23]. Consideration of replicated quadrat data from 2007-2012

[18] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

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[20] Collins 1988; Atkins/HSI (2005); Ewan (2005). Data from these reports is reproduced at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289540/Catfield_Appendix_F_5B1_5D_324668.pdf

[21] The Landscape Partnership 2014 pH change at Catfield Fen. Unpublished report.

[22] Giller and Wheeler (1988). Acidification and Succession in a Flood-Plain Mire in the Norfolk Broadland, U.K. *Journal of Ecology (1988), 76, 849-866*

[23] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

further showed that of the 8 rare and scarce indicator species (used in Condition Assessment to assess species objectives) which occur within Unit 3, 5 had declined[24]. A similar exercise comparing 1991 and 2013 data from Catfield Unit 11 (Catfield Hall Estate) showed that 4 out of 5 indicator species had shown significant decline[25]. At Sutton Fen, which is under broadly similar management regimes to Catfield Unit 3, all indicator species present at this site have increased (Richard Mason, RSPB, pers. comm.).

Invertebrates

The AMEC report (Amec, 2014h) correctly identifies that the Appropriate Assessment is required to consider invertebrate species and assemblages detailed in the Ramsar citation. The citation records that The Broads Ramsar site "supports outstanding assemblages of rare plants and invertebrates including … 136 British Red Data Book invertebrates*. Natural England have advised that wetland hydrology has a very significant influence upon the W31 (permanent wet mire) invertebrates, to which assemblages W313 and W314 belong and thus the Amec report focusses upon these assemblages. It does not, however, look in detail at the component species of these assemblages.

Catfield Fen is possibly the most important site in the Broads in terms of its invertebrate assemblage. Many of the species present are vulnerable to hydrological change. Water chemistry appears not to have been considered, although it is going to be key, for example for any species of pools and runnels.

Wetland hydrology has a very significant influence upon W31. However, there is no definition available of the water chemistry requirements for the W31 (permanent wet mire) invertebrates . There is however a broad indication that **species representative of W314 (assemblages associated with Page 44 of 76 DRAFT – Minded To Consultation rich fen) prefer alkali rich conditions whilst species representative of W313 (assemblages associated with mesotrophic fen) prefer alkali poor conditions.**

Amec state that these assemblages are in favourable condition because recent survey data indicate that they exceed minimum threshold values for assigning favourable condition. There is no attempt, however, to identify whether future changes in the fen (for example the rapid changes which might result form a tipping point having been reached, might impact upon invertebrate communities in the future.

Lott et al., 2010 found that assemblages in compartments which dried out in the summer contained fewer specialist permanent wet mire species. It is likely that fen hydrology is the most important variable since it also controls/influences other variables such as management (i.e. cutting or grazing is limited on permanently wet compartments) and vegetation structure (Amec, 2014h).

[24] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

[25] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

	The EA consider that the effects of fully licensed abstraction on invertebrates would not be significant on the basis that the model indicates that the number of days when the fen surface is wet or dry would not vary between naturalised and historical conditions. However, the assessment : a) does not take into account the recorded changes in higher plant frequency and abundance i.e. reduction on calciphile species (some of the less common invertebrate species present at the site area specific to plant species which are themselves in apparent decline at the site) b) does not consider whether a switch to a Sphagnum dominated vegetation at the site might affect the invertebrate assemblage, either due to i) chemistry (it would be reasonable to assume that a change to highly acidic Sphagnum dominated vegetation at the fen surface would have a very dramatic impact upon the W314 assemblage or ii) vegetation structure. Sphagnum polsters or lawns do not offer the same micoclimate and structure as, say, litter in the base of a reedbed. c) Does not consider the impact of abstraction upon the 2 specific invertebrate species for which SAC designated and also mis-identifies one of these species, citing Shining Ramshorn Snail *Segmentina nitida* as an Annex II species. The second species for which the SAC is designated is in fact a different Ramshorn snail: *Anisus vorticulus*, but this species is not known to occur at Catfield. The Broads is "the main stronghold of **Desmoulin's whorl snail *Vertigo moulinsiana*** in East Anglia" Desmoulins Whorl Snail is known to occur on Unit 3 (Butterfly Conservation Land). JNCC describes Desmoulins Whorl Snail as "restricted to calcareous wetlands", whilst the Concholoigcal Society record that it lives "in wet areas with high pH and calcium content". It normally lives on reed, grasses and sedges, such as reed sweet-grass *Glyceria maxima* and tussocks of greater pond-sedge Carex riparia and lesser pond-sedge *C. acutiformis*. This species is therefore dependant upon maintenance of vegetation structure. "Like all Annex II *Vertigo* species, it is highly dependent on maintenance of existing local hydrological conditions" and would thus be very sensitive to changes in vegetation composition and structure resulting from acidification (for example the replacement of reed and sedge fen by Sphagnum dominated communities) and also to the loss of calcareous groundwater. The habitat extent objective of the favourable Condition Tables for Desmoulins Whorl Snail is "no more than 25% reduction from baseline in core habitat area or abundance of food plant" and the distribution of the species as identified by a survey carried out in 2000/2001 must be maintained. The species has been known from Catfield from at least the mid 1980s, and was recorded at Unit 3 (TG368212) most recently in 2007. This part of the fen currently exhibits surface pH values of between 5.0 and 6.0; conditions which cannot be considered to be either 'high pH' or 'calcareous'. d) does not attempt to determine whether the assemblages, or indeed individual species frequency/distribution at Catfield have changed - because historic invertebrate data (for example from the late 1980s and 1990s work by Deborah Proctor and

	Andy Foster (Lott, Foster & Proctor 2002) was not considered, e) does not consider other rare invertebrate species which have previously been recorded from Catfield: Bidessus unistriatus and Graphoderus bilineatus (although this latter species is now presumed extinct in the UK
32 Environment Agency (2004) Ecohydrological guidelines	This document merely sets out the known hydrological requirements of each of the NVC communities covered. It was based upon information in existence at the time (pre 2004) and is widely acknowledged to be lacking in the sort of level of detail needed for assessment of the impact of abstraction at Catfield for some fen communities. For example, the Ecohydrological Guidelines state that the mean summer table for S24 communities is -16.7 cm. The optimal mean summer water level given in the Wetland Framework for S24 is 15 cm bgl. Wheeler et al (2004) note that "It is often difficult to know to what extent 'summer-dry' stands are natural or represent remnants of formerly wetter S24". Wheeler *et al* further note "…*that different sub-communities [of S24] tend to be associated with rather different sets of* [hydrological] *conditions*". The sub-community (S24e) is most associated with a very high water table (i.e. at or very near the surface throughout the year). It supports the greatest number of rare species, and is thought to have decreased in area and quality at Catfield, although NE have confirmed its continued presence[26]. Table 10.2 of the Ecohydrological Guidelines gives mean summer water levels of -14.3cm bgl for the S24d subcommunity and -3.4cm bgl for the S24e subcommunity. Mean water table data for the S25 community, also present at Catfield Fen, are not recorded in the Ecohydrological Guidelines. It should also be noted that although some data from other East Anglian sites is indicative of minimum water tables of -26.2cm for S24d vegetation, this – and indeed other water level ranges quote in the Guidelines **cannot necessarily be regarded as an acceptable minimum water level**. The fen sites from which the water table data in the Ecohydrological Guidelines were drawn occur across East Anglia, and include fen sites in both optimum and sub-optimum condition. The Wetland Framework acknowledges that "lower water-tables may be a feature of some sites, but it is difficult to establish whether this is a 'natural' state of affairs or remnant of formerly wetter S24".
37 Environment Agency (2010d) Ecohydrological guidelines (3 documents)	See 32 above
• Ecohydro_M24	
• Ecohydro_M9-3	This community does not occur at catfield
• S24_S27	
50 Environment Agency (2014a) Groundwater Summary Report - cover	Pg4 - Summary section states that there has been an observed increase in *Sphagnum* spp and that NE indicate that this could be due to reduced base-richness and therefore reduced pH within the supporting water table, and that this could be the consequence of reduced inflow of base-rich groundwater resulting from groundwater abstraction. Report purports

[26] Fojt, W. 2014 Natural England's preliminary advice on The Environment Agency's Groundwater Report in support of the Appendix 12. (dated 7.03.14.) Report 1. 17 March 2014.

note	therefore to expand on standard assessment methodology HD RoC to look in more detail at the water balances and water chemistry to assess the extent to which abstraction may be impacting on the base-richness of the fen. Pg7 - Given that the level of water abstraction has been constant since the early 1990s, the EA report contends that the historical condition could be used as a baseline for judging acceptability of the fully licensed level of abstraction. It is my professional view that a) changes in the vegetation could potentially take place over a longer timescale and that b) an appropriate baseline would be the pre-abstraction vegetation. Comparing post abstraction vegetation condition is not particularly meaningful. Pg10 - Natural England have recorded that the percentage of *Sphagnum* spp has changed within Unit 3 and Unit 11 since the late 1980s. Natural England have proposed that this could be due to a change in the balance of base-rich to base-poor water, which in turn could be due to hydrological changes. Pg14 -The water requirements of NVC communities S24 and S25, which occur within the internal system at Catfield are considered in the EA report. It should be noted that other fen communities which are a component part of the Annex 1 habitat, i.e. S27 and S2 also occur within the internal system at Catfield and appear not to have been considered in the EA report. Pg15 – The EA report states that the water requirements of the 'ecological features' at Catfield Fen are a winter water table at around the fen surface and a summer water table of "*no lower than 30-40cm below the fen surface*". These water requirements purport to have been taken from the "Ecohydrological Guidelines" (Wheeler *et al*., 2004 (updated 2010)). However, the Ecohydrological Guidelines state that the mean summer table for S24 communities is actually -16.7cm rather than -30-40 cm below ground surface. Wheeler et al also note that "It is often difficult to know to what extent 'summer-dry' stands are natural or represent remnants of formerly wetter S24". Wheeler *et al* further note "…*that different sub-communities [of S24] tend to be associated with rather different sets of* [hydrological] *conditions*". Table 10.2 of the 2004 report gives mean summer water levels of -14.3cm bgl for the S24d subcommunity and -3.4cm bgl for the S24e subcommunity. Mean water table data for the S25 community is not recorded in the 2004 report. There is clearly some significant disparity between the mean water tables given by Wheeler *et al* and those stated in the EA report. It is also worth pointing out that just because data from other Eats Anglian sites suggests minimum water tables of -26.2cm for S24d vegetation, this does not mean that this is an acceptable minimum level of water. The fen sites from which the water table data in the Wheeler report was taken occur across East Anglia, and include fen sites in both optimum and less than optimum condition. Pg16 – Pg 16 of the EA report presents dipwell readings taken from Middle Marsh between 1988 and 1990, which show a water table fluctuation in excess of 0.5m and readings for dipwells on the Butterfly Conservation land which show a water table fluctuation of up to 0.6m (a maximum of -0.4m bgl) between summer 2006 and summer 2010. It should be noted firstly that both these data sets relate to the period during which abstraction was taking place and therefore are not

'baseline' data, secondly, that these are small datasets for a very short time period, and thirdly, that -40cm bgl is well in excess of the minimum water table of -26.2cm for S24d observed by Wheeler.

Pg 22 – The EA report presents illustrative cross-sections which show the groundwater flowlines from the interfluve area into the discharge area. These suggest that Crag groundwater is able to flow directly into the peat at the eastern margin of Catfield Fen where the underlying clay layer is thought to be thin or not present. The report also presents illustrative sections which indicate that Unit 3 "*is slightly different in that the clay layer is believed to be thicker and more continuous*". The clay layer referred to in the EA report is the layer of estuarine clay deposited during the Breydon marine incursion (Breydon Formation clay).

The Breydon Formation clay found at Fenside and Sedge Fen (Unit 3) was deposited at the very maximum limit of the marine transgression, and therefore comprises 'Phragmites clay' rather than solid clay. Phragmites clay is a soft organic clay deposited during brackish conditions. It contains large amounts of partially decomposed and undecomposed reed rhizomes, which contribute to its permeability to water. Because the clay was deposited at the very maximum limit of the transgression, this is also a discontinuous layer, typically less than 0.5m thick, and in most parts of Unit 3, is likely to be quite permeable. Surveys undertaken by Giller (Giller & Wheeler, 1988 Past peat cutting and present vegetation patterns in an undrained fen in the Norfolk Broadland. *J Ecol* **74**, 219-247) clearly show that less than a third of Unit 3 is underlain by clay.

The subsequent argument that because *Sphagnum* occurs across Units 11 and 3, the proliferation of this species cannot be due to changes in base-rich groundwater availability (because the clay layer would block the upward movement of base-rich water) is therefore incorrect.

Pg18-19 – The EA report notes that the hydrochemical data is consistent with an upward flow of base-rich groundwater to the **Fen but questions the degree to which base-richness is determining pH in the peat layer of Catfield Fen. This view is not borne out by the evidence base.**

Pg21 – the conceptual cross sections fail to distinguish between solid peat and turbary. Whether a fen comprises solid peat or turbary has a significant impact upon the hydrological functioning of the groundwater-surface water system and thence upon the fen vegetation, with much of the Broads SAC fen communities being over turbary. The failure to recognise the differing behaviour of groundwater movement in solid peat as opposed to turbary is a significant limitation of the EA study.

Pg22 – The EA report recognises that Crag groundwater is able to flow directly into the peat at the eastern margin of Catfield Fen where the underlying clay layer is absent, but postulates that this is not the case in Unit 3 where the clay layer is believed to be thicker and more continuous. The above plan showing the distribution of clay at Fenside clearly indicates that over the majority of Unit 3, there is no impediment to Crag water moving up through the layers of peat. The argument that the increase in *Sphagnum* spp across both Unit 11 and Unit 3 cannot be influenced by groundwater is therefore

	incorrect. Pg 27 reports that "by comparing the naturalised and historical scenarios, that the proportion of Crag water at Middle Marsh is reduced by abstraction across the Area of Interest", but goes on to note that "despite the general reduction, the Crag proportion for the historical scenario largely stays within the range of variability of naturalised time-series". Despite this, the mean water level (bgl) is inarguably reduced at Middle Marsh Pg 27-30 – The EA report states that" it important to note that the ecological features at Sharp Street are in favourable condition and are not showing the changes in *Sphagnum* spp that have been seen at Catfield Fen, suggesting that the historical quantities of abstraction across the Area of Interest and the scale of impact at Sharp Street is not leading to potentially adverse changes in the ecology." It further notes that "somewhat larger changes are seen between naturalised and historical Crag proportion time-series at Cell J on Sharp Street. This is a floodplain margin similar to Middle Marsh on Catfield Fen. However, *Sphagnum* was not recorded on this unit in the most recent survey. The Crag proportion results for Cell J therefore indicate a level of change that is not leading to the ecological changes which have been reported for Middle Marsh and tend to confirm that the criteria proposed for judging the Acceptability of Abstraction in relation to Middle Marsh are precautionary". The above arguments are incorrect. Sharp Street is rather different ecologically and hydrologically to Middle Marsh. Unlike the northern and eastern parts of Catfield Fen, Sharp Street **is** hydrologically separated to quite a large extent from the underlying Crag by a thick layer of pure Breydon Formation clay (in excess of 200cm in depth – see above plan). The vegetation of Cell J could not therefore be expected to behave in the same way as the vegetation at Middle Marsh, and is actually much more akin to the floodplain fem communities of Reedham Marshes on the far side of the River Ant. To summarise: • Crag groundwater is able to flow directly into the peat at the eastern - and northern - margin of Catfield Fen where the underlying clay layer is thin or absent. • The hydrochemical data is consistent with an upward flow of base-rich groundwater to the eastern part of the fen • The proportion of the irrigating water derived from the Crag (Crag Water) at Middle Marsh is being reduced by abstraction • The arguments presented in the EA report as to why abstraction is not responsible for changes seen at Middle Marsh and Fenside, and in particular the proliferation of *Sphagnum* are incorrect, as shown above.
52 Environment Agency (2014c) Appropriate Assessment March 2014	The March 2014 Appropriate Assessment concluded that current levels of abstraction were sustainable in terms of maintaining the conservation status of the designated features, based on NE's Conservation Objectives. On this basis no adverse effect on site integrity from the proposed abstraction on the Ant Broads and Marshes SSSI (a component site of The

	Broads SAC, Broadland SPA and Broadland Ramsar) was concluded.
54 Environment Agency (2014e) Addendum to the Appropriate Assessment Dated 17 November 2014	The Addendum updates the March 2014 Appropriate Assessment with information provided by NE, BA, RSPB and our team. Natural England and the Broads Authority identified 109 separate issues or areas of concern with the March 2014 Appropriate Assessment. The Addendum considers each of these in turn, and records where issues have been resolved through further work or where issues are still outstanding. Only 27 have been resolved to date. The Addendum re-assesses the potential for adverse effect on site integrity at The Broads SAC, Broadland SPA and Broadland Ramsar from abstraction from the Plumsgate Road and Ludham Road boreholes both alone and in-combination with other abstractions and concludes that a) the hydrological functioning of the Ant Broads and Marshes SSSI, as a component part of The Broads SAC, Broadland SPA and Broadland Ramsar is likely to be maintained when considering the 'in isolation' impacts from both the Plumsgate Road abstraction and Ludham Road abstraction. b) The 'in combination' impact of the current fully licensed level of abstraction may compromise the hydrological functioning of the SAC. The in combination effect is specifically in relation to the predicted water level change at Snipe Marsh. The Environment Agency therefore cannot conclude beyond reasonable scientific doubt that there is no adverse effect from abstraction licences AN/034/0009/008 Plumsgate Road and AN/034/0009/009 Ludham Road when considered in-combination with other abstraction on the Ant Broads and Marshes SSSI. Given that a number of issues raised by NE and other parties remain unresolved, there is clearly uncertainty in a number of other areas. The Addendum considers other issues, such as pH change and impact upon fen invertebrates. **pH change** The EA conclude that the Model indicates the change in pH resulting from the drawdown levels identified in their hydrological model as being a maximum of -0.16 of a pH unit between naturalised and historical conditions. Natural England have expressed significant misgivings about the methodology used and shortcomings in the hydrological model itself[27] and are unable to indicate whether or not this value may be ecologically significant nor whether changes in pH predicted are likely to be an indication of the scale of impact of abstraction. Natural England further note that the model indicates that there may be a potential path of change from water table changes to potential changes in pH,[28] and that, although the

[27] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

[28] Report 7 (post EA appropriate assessment). The Environment have asked for NE's view on water chemistry aspects featured in the final Report on the Assessment of Abstraction within the Ludham-Catfield area in the vicinity of Ant Broads and Marshes SSSI (22 Aug 2014)

	model has indicated that changes are small, the modelled decrease in pH is consistent with the direction of change in vegetation, which clearly shows a shift from species of more base-rich conditions to those of more acidic conditions. A review of historic (1988[29]) and more recent (2005[30] and 2014[31]) surface pH data has shown a trend towards increasing acidification of water at the fen surface over the past c10 years. Recent and ongoing work by RSPB is surveying pH levels in the interstitial soil water across Unit 3, to determine how this changes with depth. Data from a series of transects across the fen have been compared with data collected by Giller and Wheeler (1988).[32] The Giller and Wheeler data compared pH levels in *Sphagnum* dominated areas with areas of S2/S24e vegetation, and found that beneath the latter two vegetation types, the pH both at the fen surface and in the interstitial water at depths down to -150cm remained entirely within the range pH7-pH8. Conversely, the *Sphagnum* dominated areas had surface pH values between 4 and 5, but this gradually increased with depth, so that pH7 was reached at c-65cm. Thereafter the interstitial pH beneath the *Sphagnum* polster remained within the pH7-pH8 range. Conversely, the RSPB survey has measured surface pH as low as pH3.5 in some *Sphagnum* dominated areas, with the pH at depth both beneath *Sphagnum* and elsewhere in the fen being typically well below pH7 (ref TBC). Although the vertical pH gradients might be anticipated to change seasonally, such change is likely to be fairly minimal. The scale of change in pH over the 30 year period is very evident, and strongly corroborates the hypothesis that where groundwater discharge is reduced, rainwater infiltration occurs and that this initiates the process of acidification: fen soils have buffering capacity to withstand this process for a number of years, but ultimately, the residual buffering capacity is exhausted. Within a short period (2 - 4 years) the pH of the upper layers of peat will change from a pH-value of 6-7 to 5 or less. The impact of this trend can be seen clearly in vegetation change data presented by the RSPB and by ourselves, which demonstrates a degree of change from calcareous fen to more acidic fen; in particular populations of species. Several of the species for which the SSSI is designated, and which occur within the internal system, including *Carex appropinquata, Dactylorhiza traunsteineroides* and *Pyrola rotundifolia,* also exhibit a preference for base-rich conditions and are likely to be be at risk if the current trend towards acidification continues[33]. Consideration of replicated quadrat data from 2007-2012 further showed that of the 8 rare and scarce indicator species (used in Condition Assessment to assess species objectives) which occur within Unit 3, 5 had declined[34]. A similar exercise comparing 1991 and 2013 data from Catfield Unit 11 (Catfield

[29] Collins 1988; Atkins/HSI (2005); Ewan (2005). Data from these reports is reproduced at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289540/Catfield_Appendix_F_5B1_5D_324668.pdf

[30] Collins 1988; Atkins/HSI (2005); Ewan (2005). Data from these reports is reproduced at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289540/Catfield_Appendix_F_5B1_5D_324668.pdf

[31] The Landscape Partnership 2014 pH change at Catfield Fen. Unpublished report.

[32] Giller and Wheeler (1988). Acidification and Succession in a Flood-Plain Mire in the Norfolk Broadland, U.K. *Journal of Ecology (1988), 76, 849-866*

[33] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

[34] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

Hall Estate) showed that 4 out of 5 indicator species had shown significant decline[35]. At Sutton Fen, which is under broadly similar management regimes to Catfield Unit 3, all indicator species present at this site have increased (Richard Mason, RSPB, pers. comm.).

Impact upon fen invertebrates

The AMEC report (Amec, 2014h) correctly identifies that the Appropriate Assessment is required to consider invertebrate species and assemblages detailed in the Ramsar citation. The citation records that The Broads Ramsar site "supports outstanding assemblages of rare plants and invertebrates including … 136 British Red Data Book invertebrates*. Natural England have advised that wetland hydrology has a very significant influence upon the W31 (permanent wet mire) invertebrates, to which assemblages W313 and W314 belong and thus the Amec report focusses upon these assemblages. It does not, however, look in detail at the component species of these assemblages.

Catfield Fen is possibly the most important site in the Broads in terms of its invertebrate assemblage. Many of the species present are vulnerable to hydrological change. Water chemistry appears not to have been considered, although it is going to be key, for example for any species of pools and runnels.

Wetland hydrology has a very significant influence upon W31. However, there is no definition available of the water chemistry requirements for the W31 (permanent wet mire) invertebrates . There is however a broad indication that **species representative of W314 (assemblages associated with rich fen) prefer alkali rich conditions whilst species representative of W313 (assemblages associated with mesotrophic fen) prefer alkali poor conditions.**

Amec state that these assemblages are in favourable condition because recent survey data indicate that they exceed minimum threshold values for assigning favourable condition. There is no attempt, however, to identify whether future changes in the fen (for example the rapid changes which might result form a tipping point having been reached, might impact upon invertebrate communities in the future.

Lott et al., 2010 found that assemblages in compartments which dried out in the summer contained fewer specialist permanent wet mire species. It is likely that fen hydrology is the most important variable since it also controls/influences other variables such as management (i.e. cutting or grazing is limited on permanently wet compartments) and vegetation structure (Amec, 2014h).

The EA consider that the effects of fully licensed abstraction on invertebrates would not be significant on the basis that the model indicates that the number of days when the fen surface is wet or dry would not vary between naturalised and

[35] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

	historical conditions. However, the assessment : a) does not take into account the recorded changes in higher plant frequency and abundance i.e. reduction on calciphile species (some of the less common invertebrate species present at the site area specific to plant species which are themselves in apparent decline at the site) b) does not consider whether a switch to a Sphagnum dominated vegetation at the site might affect the invertebrate assemblage, either due to i) chemistry (it would be reasonable to assume that a change to highly acidic Sphagnum dominated vegetation at the fen surface would have a very dramatic impact upon the W314 assemblage or ii) vegetation structure. Sphagnum polsters or lawns do not offer the same micoclimate and structure as, say, litter in the base of a reedbed. c) Does not consider the impact of abstraction upon the 2 specific invertebrate species for which SAC designated and also mis-identifies one of these species, citing Shining Ramshorn Snail *Segmentina nitida* as an Annex II species. The second species for which the SAC is designated is in fact a different Ramshorn snail: *Anisus vorticulus*, but this species is not known to occur at Catfield. The Broads is "the main stronghold of **Desmoulin's whorl snail *Vertigo moulinsiana*** in East Anglia" Desmoulins Whorl Snail is known to occur on Unit 3 (Butterfly Conservation Land). JNCC describes Desmoulins Whorl Snail as "restricted to calcareous wetlands", whilst the Concholoigcal Society record that it lives "in wet areas with high pH and calcium content". It normally lives on reed, grasses and sedges, such as reed sweet-grass *Glyceria maxima* and tussocks of greater pond-sedge Carex riparia and lesser pond-sedge *C. acutiformis*. This species is therefore dependant upon maintenance of vegetation structure. "Like all Annex II *Vertigo* species, it is highly dependent on maintenance of existing local hydrological conditions" and would thus be very sensitive to changes in vegetation composition and structure resulting from acidification (for example the replacement of reed and sedge fen by Sphagnum dominated communities) and also to the loss of calcareous groundwater. The habitat extent objective of the favourable Condition Tables for Desmoulins Whorl Snail is "no more than 25% reduction from baseline in core habitat area or abundance of food plant" and the distribution of the species as identified by a survey carried out in 2000/2001 must be maintained. The species has been known from Catfield from at least the mid 1980s, and was recorded at Unit 3 (TG368212) most recently in 2007. This part of the fen currently exhibits surface pH values of between 5.0 and 6.0; conditions which cannot be considered to be either 'high pH' or 'calcareous'. d) does not attempt to determine whether the assemblages, or indeed individual species frequency/distribution at Catfield have changed - because historic invertebrate data (for example from the late 1980s and 1990s work by Deborah Proctor and Andy Foster (Lott, Foster & Proctor 2002) was not considered, e) does not consider other rare invertebrate species which have previously been recorded from Catfield: Bidessus unistriatus

	and Graphoderus bilineatus (although this latter species is now presumed extinct in the UK **Management** As a result of comments received and reviewed by NE in response to the Site Management Technical Note (Amec, 2014e) the EA has clarified its position regarding the EA's consideration of land management, and has acknowledged that a number of the assumptions made within the Amec (2014e) technical note have since been shown to be incorrect. It is noted that the fen surface on a well managed site could rise over a period of time. As recorded in EA responses to consultation issues identified by NE and BA, the EA does not rule out the possibility that land management could have an effect on changes in vegetation. The EA has concluded that "land management within the Ant Broads and Marshes SSSI has the potential to contribute towards changes in species distribution. Land management practices can promote the onset of terrestrialisation which may result in the infilling of former pond areas and a general rise in the ground surface. Terrestrialisation has the effect of both lowering the water table and can lead to the spread of other species which are less sensitive to changes in water table." NE has confirmed that Catfield Fen Unit 11 is being well managed in accordance with the High Level Stewardship Scheme. Unit 3 was also, until recently in Unfavourable Recovering condition following improvements in the site management regime. It is notable that there has been an increase in long-rotation conservation management at other sites in the Ant valley, including Reedham Marshes, as well as at Catfield Fen. Reedham Marshes also has areas of *Sphagnum* dominated vegetation, however these areas are only recorded as expanding at Catfield[36]. Other sites throughout the broads are also likely to be subject to gradual terrestrialisation, but similarly, Catfield is the only site where acidification of the fen surface and dramatic *Sphagnum* proliferation has been recorded. The response of the EA to this point is to query whether a similar level of recording effort and scrutiny of the data has been undertaken for other sites in the Any valley, the implication being that were such effort to be expended, other sites might be found which exhibited a similar trend. The EA is correct in that a similar *Sphagnum* mapping exercise has not been undertaken. However, casual observations made by Dr Parmenter in 2013 at fen sites throughout the Ant valley is that *Sphagnum* areas elsewhere in the valley had not noticeably expanded. The purpose of the 2013 site visits was to assist a survey, coordinated by the Natural History Museum, for *Dryopteris cristata*, which is notable for its close association with *Sphagnum*. The 2013 survey found that a number of former sites for this species in the Ant valley had actually been lost. The EA has also argued that Catfield Fen is a highly sensitive site that has long been known to be prone to surface

[36] The Landscape Partnership and Riches, O P 2014 CATFIELD FEN: A Response to the AMEC Technical Note: Notes on the Management of Catfield Fen. July 2014

acidification, very small changes in fen surface elevation, resulting from terrestrialisation related to employing longer rotation management on parts of the site over the last 15-20 years, could alter the hydrological conditions at the fen surface sufficiently to reach a tipping point such that there is a subtle change in the balance of water supplying the fen surface, potentially leading to ecological changes. A more likely explanation for this phenomenon is the quite dramatic shift in surface water pH across the internal system, and the apparent reduction of upwelling calcareous groundwater as demonstrated by Erin Pyne in Unit 11 and Richard Mason in Unit 3.

It is understood that Mr Alston has raised questions about whether any changes to the ecology on Catfield Fen could be mitigated or reversed by changes to site management. NE have stated that the Fen is currently managed under a High Level Stewardship Scheme between NE and the landowner for conservation purposes. NE have confirmed that the agreement is being adhered to, and a site assessment in 2012 showed the site to be well managed (Natural England, 2014g).

The Addendum to the Appropriate Assessment does not consider the impacts from surface water management but the EA states that it is unable to rule it out as being a contributory factor to vegetation change on site, with the level of contribution being unknown. It is reiterated that the central feature of the management of water in the internal system now, and in the past, has been the use of the two sluices to maintain water levels on the fen. The current water management regime is as proposed by Natural England, on the advice of Dr Bryan Wheeler, and reflects previous water management by earlier owners. It is not inconceivable that the sluice holds back slightly acidic water on the fen following heavy rainfall events; but this is not a factor which is likely to have changed over the past 30-40 years given that sluice management has not altered. Sluice management cannot explain the dramatic changes in the pH of the underlying fen peat, which can only be explained by reduced upflow of groundwater.

Condition Assessment

Condition Assessment is inadequate for identifying early impacts of abstraction at Catfield. Most importantly, because the designated features are themselves broadly defined, there can be significant change within vegetation communities before this is picked up by CSM/CA. For example, fen condition assessment does not look at changes in the boundaries of NVC communities at a unit level, and this is a major shortcoming of the process[37]. The majority of the factors considered in the site-specific definitions are concerned with identifying unfavourable management and/or physical damage, and are not designed or intended as a mechanism by which harmful hydrological change might be identified in its early stages.

The 2013 Condition Assessment failed to identify the risk to the *Liparis* population from the expanding *Sphagnum* dominated community[38]. The 2013 Condition Assessment also failed to identify the loss of Potamogeton coloratus at Sedge Fen (Unit 3)[39].

[37] Parmenter, J M 2014 *Use of Condition Assessment at Catfield Fen.* Unpublished report on behalf of the Catfield Hall Estate.
[38] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014

The Conservation Objectives and definitions of favourable condition for features on the SSSI may be used to inform the scope and nature of any 'appropriate assessment' under the Habitats Regulations. However, appropriate assessment also requires consideration of issues specific to the individual plan or project. The habitat quality definitions used in Condition Assessment do not by themselves provide a comprehensive basis on which to assess plans and projects as required under Regulations 20-21, 24, 48-50 and 54 – 85, and further, are tailored towards assessment of management condition: they are not designed as a tool to assess hydrological change[40].

Natural England has stated that the reference in the 2013 condition assessment which records that "water levels were reported to be consistent with the hydrological needs of the communities" should be regarded as 'a snapshot in time', and not implied to mean that water levels are generally acceptable. It should also be noted that the 2013 condition assessment survey was carried out after a particularly wet year. The statement simply reflects that at the time of the assessment water levels were at a level usually expected for this vegetation community.

Favourable Condition may therefore meet the requirements of SSSI surveillance, but it does not provide evidence to support the detailed assessment required to judge the impact of water abstraction on fen sites around the Broads[41], and this is recognised by Natural England.

Aluminium toxicity

The work undertaken by AMEC and the Environment Agency to date makes no reference to aluminium toxicity or phosphate deficiency and it is assumed that this aspect of acidification on rich fen plant communities has not been considered.
Aluminium ions become soluble in waters lower than pH 6, with dramatically increasing solubility occurring below pH 5.5, and can subsequently be absorbed by plants[42]. Aluminium is known to inhibit root growth at toxic concentrations and bind readily with phosphates which can also lead to phosphate deficiency[43] [44].
Common reed (*Phragmites australis*) is considered to be a good indicator of environmental conditions as it is provides an accurate representation of metals present in sediment[45]. Areas of common reed at Catfield Fen have been observed to be

[39] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014
[40] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014
[41] The Landscape Partnership 2014 Condition Assessment at Catfield Fen: consideration of recent trends in distribution of Potamogeton and Liparis in Unit 3. June 2014
[42] Kabata-Pendias A (2011) *Trace Elements in Soils and Plants, Fourth Edition*. p325-327. Taylor & Francis Group, Boca Raton.
[43] McCormick LH & Yates Borden F (1972) Phosphate fixation by aluminium in plant roots. *Soils Society of America Proceedings*. 38: 799-802.
[44] Batty LC, Baker AJM & Wheeler BD (2002) Aluminium and Phosphate uptake by Phragmites australis: the Role of Fe, Mn and Al Root Plaques. *Annals of Botany*. 89(4): 443-449.
[45] Štrbac S, Šajnović A, Kašanin Grubin M, Vasić N, Dojčinović B, Simonović P & Jovančićević B (2014) Metals in sediment and Phragmites Australis (common reed) from Tisza River, Serbia. *Applied Ecology and Environmental Research*. 12(1): 105-122.

	showing signs of decline, e.g. reduced vigour, slower growth rate, etc, with increasing acidity and it is therefore possible that bioaccumulation of aluminium is the cause[46]. It has already been discovered the acidification of Catfield Fen has led to the displacement of *Potamogeton coloratus* with *Potamogeton polygonifolius*, and other key species of flora at risk of being negatively affected by pH levels below 6 include *Liparis loeselii*, *Dactylorhiza traunsteinerioides*, *Carex appropinquata* and *Pyrola rotundifolia*.
58 Environment Agency (2014i) Draft Determination report	Comments as above

[46] Ayeni, O, Ndakidemi P, Snyman R & Odendaal J (2012) Assessment of Metal Concentrations, Chlorophyll Content and Photosynthesis in Phragmites australis along the Lower Diep River, CapeTown, South Africa. *Energy and Environment Research*. 2(1): 128-139.