Anglian Region Habitats Directive Review of Consents Stage 4

Summary Note
Technical approach, criteria and thresholds applied for inland sites

NORFOLK VALLEY FENS

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1. Introduction

In Stage 4 of the Habitats Directive Review of Consents (RoC) a Site Action Plan (SAP) and an Appendix 19 (list of licences to be affirmed, modified and revoked) has to be produced.

In Anglian Region the technical work that supports this process involves the production of a Site Option Plan (SOP). The SOP will be followed by Options Appraisal work if required.

The purpose of the Stage 4 Site Option Plan (SOP) is to confirm the predicted impacts of abstraction on the hydrological regime at the site in view of additional information that has become available since RoC Stage 3. The SOP then aims to identify whether these impacts are acceptable or unacceptable in terms of the effects on the ecology and structure and functioning of the site and therefore achieving the Environmental Outcomes for the site. The SOP will also identify any changes which the Agency believes are necessary to allow a conclusion of no adverse effect on the site to be reached and will make general proposals as to how those changes could be achieved.

2. Purpose of this Summary Note

The purpose of this note is to summarise the main features of the technical approach applied to RoC Stage 4 for inland sites in Anglian Region. In this note, the approach is illustrated and explained using examples from the application to the Norfolk Valley Fens SAC.
Further details on the site specific approach and the numerical models used can be found in the site specific SOPs and reports produced as part of the Regional Groundwater Modelling Strategy.

3. Overall Approach

From a RoC perspective it is essential that we are able to conclude that abstraction is not or will not have an adverse effect on site integrity and that our interpretation of Natural England's Environmental Outcomes can be achieved.

It is accepted that there are many pressures on these sites which can affect the hydrological structure and functioning and that all sites are subject to pressures and stresses.

The overall approach in the SOPs aims to allow definition of an acceptable level of abstraction based on an acceptable level of impact at the site. The SOP presents a detailed integrated hydrological and ecological conceptual understanding of the site based on all available information. Particular attention is given to the ecological history of the site and the hydrological functioning of the site in the location of the ecological features and under different climatic conditions.

The potential impact of abstraction at a site is assessed using a regional groundwater model. Through sequential chapters in the report the SOP aims to confirm the suitability of the model for use in the assessment by concluding that the model is adequately representing and reproducing our conceptual models at both a site and cell scale, where the cell is chosen to represent the location of the ecological features.

To provide a link between groundwater levels and available moisture in the plant root zone a soil moisture model has also been developed. This is used to assess the effects of abstraction on the soil moisture content above the water table.

Our interpretation of the Stage 4 Environmental Outcomes for the site agreed with Natural England, observations from the past and the modelled historical time series are used to develop site-specific model-based hydrological criteria against which different abstraction scenarios are then assessed.

Model results are generated for individual model cells (200m x 200m). Modelled water tables relate to the uppermost model layer in a whole grid square and can therefore not be compared directly to the real water table as observed in dipwells. 'Surrogate' model-based criteria and thresholds are therefore developed for the model cell used in the assessment. These 'surrogate' model-based hydrological criteria are designed to ensure the hydrological functioning of the site as a whole so that the Environmental Outcomes can be achieved.

4. Detailed Approach

The main steps of the approach are summarised in Box 1 for overview. The following text then gives more detailed explanation and examples for each of those steps.

Box 1: Main steps of approach

1. Collate and evaluate hydrological, geological and topographical information for the site and the surrounding catchment, in particular new information since Stage 3.
2. Characterise the abstraction licensing position (fully licensed) and history within the catchment.
3. Collate and evaluate information on site ecology and ecological history including Environmental Outcomes and Conservation Objectives provided by Natural England, in particular new information since Stage 3.
4. Develop updated integrated ecological and hydrological conceptual understanding.
5. Describe and evaluate the model representation.
6. Characterise the hydrological regime based on the model ('hydrological functioning') and evaluate if conceptual understanding is captured.
7. Based on ecological history establish if historical (actual) abstraction has been acceptable.
8. If historical (actual) abstraction apparently acceptable from an ecological point of view, assume that modelled historical time series (water levels and flows) represent acceptable conditions.
9. If historical abstraction <u>not</u> acceptable establish point in the past when level of abstraction <u>was</u> acceptable to identify acceptable hydrological conditions.
10. Use acceptable modelled historical time series (water levels and flows) for assessment cell to identify thresholds.
11. Compare time series (water levels and flows, soil moisture content) produced for the fully licensed abstraction scenario against the historical baseline and thresholds.
12. Decide whether or not the fully licensed abstraction scenario is acceptable.
13. If the fully licensed abstraction scenario is not acceptable identify scale of licence modifications and need for options appraisal (application of 'SOP decision table').

Step 1: Collate and evaluate hydrological, geological and topographical information for the site and the surrounding catchment, in particular new information since Stage 3

As a first step all information available from field investigations, hydrological monitoring and other sources is collated and evaluated to build up the conceptual understanding of the site and its surrounding catchment. How does the site and the catchment “work” hydrologically and hydrogeologically?

Example: Buxton Heath

See SOP Sections 3.1, 3.3, 3.4 and 3.6.

Step 2: Characterise the abstraction licensing position (fully licensed) and history within the catchment.

This step includes the characterisation of the ‘fully licensed’ abstraction licensing position with regards to size, distribution, uptake and general abstraction pressure in the vicinity of the site. It also summarises the development of abstraction over the last 35 years. The consideration of the ‘fully licensed’ situation includes new licences that have been issued under Reg. 48.

This provides information for the following key questions:

- How does the historical (actual) abstraction compare to the fully licensed situation that has to be assessed for RoC and will be modelled for the assessment?
- Is it likely that the licence uptake will reach 100% in the near future?

Although it might be likely that individual abstractions may take close to 100% of the fully licensed especially in dry years, this will not realistically happen with all licences included in the model area at the same time and not in every year, which is assumed for the fully licensed scenario in the model. In most of the catchments considered for the RoC Stage 4 work the recent actual abstraction represents 20-70% of the total fully licensed abstraction, with only a few individual abstractions reaching 90% or more of the full licensed quantity.

In general, licensed abstraction quantities are designed to meet the requirements in dry years rather than average years. Especially licences for spray irrigation are set up for peak demand in very dry summers periods. Therefore, actual abstraction in ‘normal’ years does generally not reach 100% of the full licence. Looking at the abstraction history, in a lot of catchments an almost constant ‘gap’ between licensed and actual abstraction can be seen from the early 1990s to today indicating that uptake of licensed abstraction has not significantly increased over the last 15 years.

If the demand increases in the future, it can be expected that this will require licensing of new sources and additional quantities before 100% of the current licensed abstraction is utilised in order to ensure security of supply also in future drought periods. Any applications for new sources and additional abstraction quantities will however go through the usual licensing process including environmental impact assessment.

- Has the actual abstraction over the last 10-15 years (i.e. including drought conditions in the 1990’s) been decreasing, increasing or comparably stable?

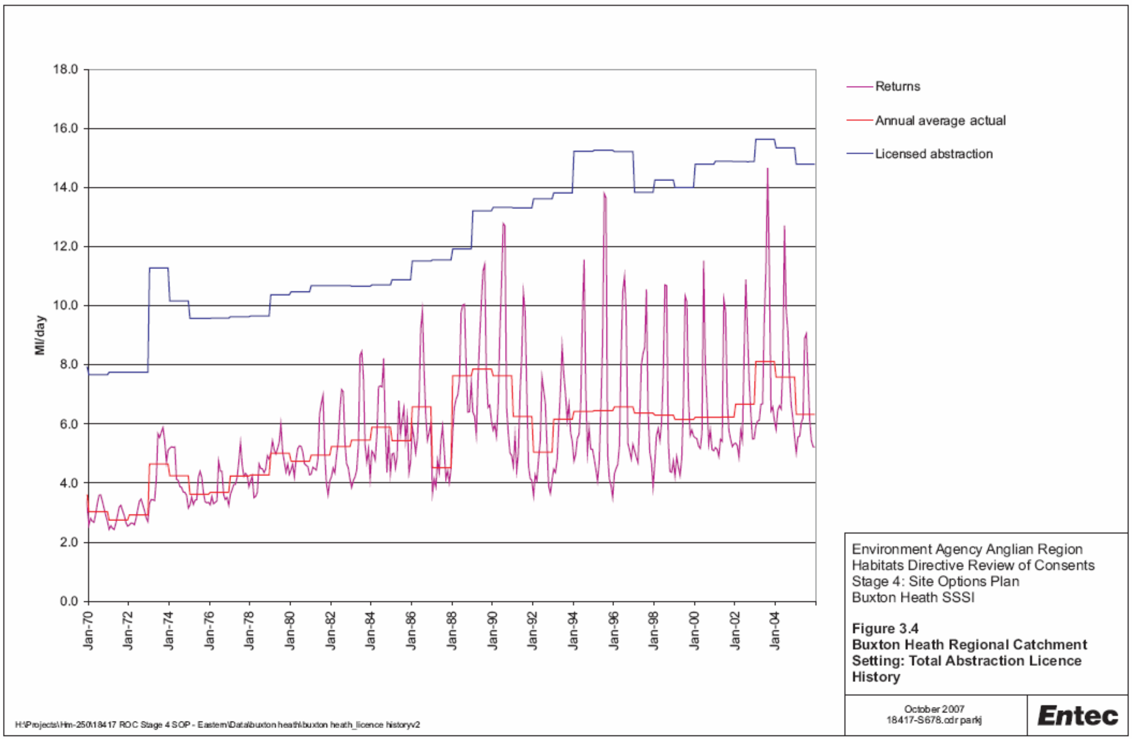
If actual abstraction has been *decreasing or stable* over the last 10-15 years it can be assumed that any impacts from abstraction on the ecology would have become apparent by now. If actual abstraction has been *increasing* any impacts from abstraction may not have become apparent yet due to time lag in the ecological response. In most of the catchments considered for the RoC Stage 4 work actual annual abstraction has been fairly stable since about 1991. Before then, abstraction has generally built up gradually throughout the 1970s and 1980s.

Understanding how actual historical abstraction has developed over time is also necessary to interpret modelled time series e.g. for water levels, for different abstraction scenarios. The scale of difference between water levels and flows in a naturalised (no abstraction) scenario and the historical scenario is a function of the level of abstraction in the vicinity of the site.

Example: Buxton Heath

See SOP Section 3.2.

Since the early 1990's actual abstraction in the vicinity of Buxton Heath has been more or less stable (see SOP Figure 3.4 below). The actual uptake of abstraction in 2005 was about 40% of the total licensed quantity.



Environment Agency Anglian Region
Habitats Directive Review of Consents
Stage 4: Site Options Plan
Buxton Heath SSSI

Figure 3.4
Buxton Heath Regional Catchment Setting: Total Abstraction Licence History

Step 3: Collate and evaluate information on site ecology and ecological history including Environmental Outcomes and Conservation Objectives provided by Natural England, in particular new information since Stage 3.

The current site ecology is recorded and the likely reasons for the development of the particular ecology explained. This step takes account of the Environmental Outcomes provided by Natural England and any documents that describe the requirements of the particular ecology, such as published ecohydrological guidelines. It also involves the collation and evaluation of all ecological survey data available and tries to establish if there is evidence for ecological change (and damage) based on changes to the extent, quality and number of characteristic species.

Example: Buxton Heath

See SOP Section 3.5.

Moderately to highly species rich M13. No clear evidence of ecological decline in terms of M13 extent and species-richness. Environmental Outcomes mainly referring to M13 requirements described in Ecohydrological Guidelines and also quoting that "It is the best professional opinion of NE staff that the Site is not under apparent water stress in non-drought years (under recent abstraction levels)."

Step 4: Develop updated integrated ecological and hydrological conceptual understanding.

This step pulls together all the information from steps 1 to 3 and develops an integrated ecological and hydrological conceptual understanding based on best available information.

- How does the site function ecologically and hydrologically?
- What are the key hydrological features that appear to support the ecology at a particular location, especially where the key habitats are found, e.g. water table close to ground surface in normal years, permanent upward flow of groundwater to the surface ("flushing"), characteristic relationship between water table and piezometric head in main aquifer?

Example: Buxton Heath

See SOP Section 3.7.

Step 5: Describe and evaluate the model representation.

The model representation of the saturated and unsaturated zone is described and compared to the conceptual model at a regional, local and single cell scale. The adequacy of the model at this particular location is evaluated. Model cells that best represent the condition at the European features and that will be used for the assessment are identified.

For sites where soil moisture content forms part of the assessment the soil moisture model for the assessment cell is calibrated against historical observation of wetness/dryness and water table data from dipwells, e.g. if a site appears to be generally wet in normal years ("water oozing from soil under foot") the modelled <u>historical</u> soil moisture content time series is calibrated to be above field capacity in non-drought years (soil moisture threshold applied for M13).

Example: Buxton Heath

See SOP Section 4.

The model adequately simulates the hydrological mechanisms that are believed to sustain the SSSI and ecological features within and is consistent with the WETMECS models.
Modelled soil moisture content is calibrated against anecdotal evidence and dipwell data. Ecology appears to currently be in good condition and not under apparent stress in normal years, depth to water table observed in dipwells, water level and wetness regimes ("water oozing from soil under foot") as described in Ecohydrological Guidelines.

Based on the above observations it is assumed that soil moisture conditions have been appropriate for M13 in the past. Therefore, the soil moisture model is calibrated such that the historical soil moisture content roughly stays within 'ooziness band' (i.e. between ooziness threshold and field capacity) in non-drought years but can go below in drought years. Using 1970-2004 climatic time series and modelled historical water level in top active layer the model is used to "re-create likely historical wetness conditions".

Step 6: Characterise the hydrological regime based on the model ('hydrological functioning') and evaluate if conceptual understanding is captured.

This step sets out the current understanding of the groundwater and surface water flow regimes around the site based on the regional groundwater model. The characterisation is based on the historical time series for the whole modelled time period (e.g. 1970-2005) and also its comparison with the non-abstraction ('naturalised') scenario for the same time period. Water balances for areas and cells of interest are calculated and hence, quantities are put against individual water balance components e.g. upward flow into uppermost model layer, discharge to stream cells, horizontal and vertical GW flow between different cells and layers

This step provides some key information:

- What is the general hydrological functioning under non-abstraction ('naturalised') and historical conditions, e.g. is any upward flow to the uppermost model layer permanent or does it reverse to downward flow in some years in the modelled time series even under naturalised conditions?
- Is the piezometric head in the main aquifer always higher than the water table or does this relationship vary between seasons or years under historical and naturalised (no abstraction) conditions?
- Does the modelled hydrological regime capture the key features of our conceptual understanding developed through steps 1 to 4, e.g. vertical hydraulic gradients, upward flow and discharge of groundwater at surface?

Example: Buxton Heath

See SOP Section 5.1.

Comparison between the naturalised (non-abstraction) and historical abstraction scenario (see Figure 5.16) shows that

- *water level in top active layer is very similar for both scenarios and effects of abstraction become more visible from late 1980's onwards due to higher level if abstraction. The maximum difference is only about 5 cm.*
- *upward hydraulic gradient between Chalk layer and top active layer is maintained throughout the whole time series for both abstraction scenarios although in some years the head difference is getting close to zero. Under the historical abstraction scenario the head difference is reduced by 5-10 cm at maximum.*
- *upward flow into top active layer from underlying layer is very similar for both abstraction scenarios with increasing difference from late 1980's onwards due to higher level of abstraction. Maximum difference is about 5 m3/day. Upward flow does not cease (i.e. fall below 0 m3/day) under both abstraction scenarios.*
- *discharge to stream cell is very similar for both abstraction scenarios with increasing difference from late 1980's onwards due to higher level of abstraction. Maximum difference is about 5 m3/day. Discharge to stream cell falls below 0 m3/day in a few drought years even under naturalised conditions.*

The above characterisation appears to capture the conceptual understanding and the hydrological functioning described in the Environmental Outcomes, e.g. groundwater flushing.

Based on the above it appears that historical (actual) abstraction has not significantly altered the hydrological functioning of the site. This would correspond with the finding that there is no clear evidence of ecological decline in terms of M13 extent and species richness (see Step 7).

Step 7: Based on ecological history establish if historical abstraction has been acceptable.

It is a key step in the whole approach to establish whether or not historical actual abstraction (i.e. as shown in a time series derived from actual returns) has been acceptable based on evidence for ecological change related to European features and abstraction history especially over the last 10-15 years, i.e. including drought conditions as experienced in the 1990s.

- Referring to outcomes of Step 2, has historical (actual) abstraction decreased or stayed the same over the last 10 – 15 years ie including the drought conditions as experienced in the 1990s?
- Referring to Step 3, is there any evidence that, overall, the site's condition has declined in a way that is attributable to changes in the hydrology of the site?

Abstraction may have caused some stress to the ecology, especially during drought periods, but if there is no evidence for change or damage to the European features e.g. in terms of extent, quality and characteristic species, it is assumed that the ecology has recovered from those stress periods.

If the answer to this step is yes, go to Step 8. If no, go to Step 9.

For most of the sites considered at RoC Stage 4 it has been concluded that there is no clear evidence for ecological change or damage that can be linked to historical abstraction. In a lot of cases, this step includes some uncertainty due to the lack of ecological monitoring data or survey methods differing over time.

Example: Buxton Heath

See SOP Sections 3 and 5.

For Buxton Heath it is concluded that there is no clear evidence to suggest that historical abstraction has caused any long-term damage to the M13 on site. Conditions during drought may have caused some stress but the ecology appears to have recovered from that. Hence, the modelled historical time series for the period 1970-2004 can be used as baseline for assessment of the fully licensed abstraction scenario.

Step 8: If historical (actual) abstraction apparently acceptable from an ecological point of view, assume that modelled historical time series (water levels and flows) represent acceptable conditions.

If Step 7 concludes that historical abstraction has been acceptable, it is assumed that

- modelled historical time series (water levels and flows) represent acceptable conditions that can be used as baseline to assess abstraction scenarios against; and
- European features have experienced hydrological conditions that are acceptable because they did not result in long-term damage (including less ideal conditions in droughts from which the ecology has subsequently recovered) and therefore should achieve the Environmental Outcomes.

The key conclusion is that broadly maintaining these acceptable historical conditions and hydrological structure and functioning will ensure that European features are not adversely affected and that Environmental Outcomes are achieved.

Step 9: If historical abstraction not acceptable, establish point in the past when level of abstraction was acceptable to identify acceptable hydrological conditions.

If Step 7 concludes that historical abstraction has not been acceptable, it is necessary to establish a point in the past when the hydrological regime has been acceptable and therefore what level of abstraction can be regarded as acceptable, e.g. in the 1970s before general build-up of abstraction when the modelled historical time series is very similar to the ‘naturalised’ (no abstraction) scenario. In detail, finding this point in the past depends on the abstraction history in the individual catchment surrounding the site and how changes in abstraction manifest themselves in the modelled time series.

Step 10: Use acceptable modelled historical time series (water levels and flows) for assessment cell to identify thresholds.

The modelled historical time series, from the period of time when abstraction was deemed acceptable for the assessment cell based on steps 8 and 9, is used to set thresholds, e.g. lowest historical water level. This threshold (“line on a graph”) is only used for the purpose of assessing other abstraction scenarios against the historical baseline. The thresholds cannot be used for comparison with actual water levels or flows observed on site.

If historical abstraction is judged to be acceptable, the thresholds are usually based on the ‘lowest historical’ in the modelled time period (usually 1970-2006)

If historical abstraction is judged not to be acceptable after a certain point in time, e.g. 1990, then the ‘lowest (level or flow) prior to that point in time’ could provide the threshold. In detail, this will be a case by case decision.

Setting this threshold does not mean that it would be acceptable to reduce e.g. water levels down to the lowest water level as experienced under drought conditions in every year. Since we are using fully licensed abstraction scenarios for the assessment, the modelled abstraction quantities are generally 100% of the licensed quantity in every year of the modelled time period. As a result, the general pattern of the time series, which is caused by the climatic conditions over the modelled time period rather than abstraction, is maintained and breaches of any thresholds will always occur in years with lower water levels first.

The model-based hydrological criteria and thresholds are related to specific water balance components such as the modelled water level in the top active model layer. Since the model maintains water balances, the different parameters are linked. For example, low water levels in the top active layer are generally linked with low discharge to stream cells. Therefore, by only choosing a threshold for one parameter, this, at the same time, sets a threshold for the other parameters (although there is no linear relationship and hence the lowest water level does not necessarily coincide with the absolutely lowest stream discharge) and hence encompasses a certain hydrological regime.

The proposed model based hydrological criteria for deciding acceptable levels of abstraction at a site are further divided into ‘Primary’ and ‘Secondary’ criteria:

- **Primary Criteria** ‘Hard’ targets with a presumption not to be breached; based partly on observations of site conditions during drought and non-drought years; usually only water level in top active model layer and soil moisture since those parameters can be related and calibrated to actual observations on site; related to critical periods in the seasonal cycle. The thresholds for those criteria will generally direct the assessment.
- **Secondary Criteria** ‘Soft’ targets which can be breached if the overall hydrological functioning is roughly maintained, e.g. stream discharge, hydraulic gradients and upward flow into top active model layer maintained. These secondary criteria provide additional guidance for the assessment and are related to hydrological mechanisms that cannot directly be observed, e.g. upward flow to top active model layer, and to less critical periods of the seasonal cycle. Secondary criteria also recognise the need for certain conditions of wetness during winter months and a year-on-year recovery from any water stress caused by abstraction.

Box 2 lists the primary and secondary criteria typically used for Norfolk Valley Fens.

Box 2: Primary and secondary criteria typically used for Norfolk Valley Fens.

Primary Criteria:

Drought summers

- Modelled water level in top active layer to remain above the lowest historical water level modelled.

Non-drought summers

- Modelled soil moisture content to remain above field capacity (as the lower limit of a range that represents conditions where “water oozes from soil under foot”) or above the stress threshold. (field capacity generally used for M13, M22 and M5, stress threshold generally used for M24, S24/25, W5 and W6; no soil moisture threshold used for Desmoulin’s Whorlsnail)

Secondary Criteria:

Drought summers

- Soil moisture content to remain above stress threshold (only if appropriate).
- Modelled flows to remain above the regime of upward flow and stream discharge associated with the lowest historical water level modelled in drought summers.

Non-drought summers

- Modelled water level in top active layer to remain above the lowest historical water level modelled in non-drought summers; flows to remain above the associated upward flow and stream discharge.

Drought winters

- Soil moisture to return to saturation (no soil moisture threshold used for Desmoulin’s Whorlsnail)
- Modelled water level in top active layer to recover to the lowest historical winter peak water level modelled in drought winters; flows to recover to the associated regime of upward flow and stream discharge.

Non-drought winters

- Soil moisture to return to saturation (no soil moisture threshold used for Desmoulin’s Whorlsnail)
- Modelled water level in top active layer to recover to the lowest historical winter peak water level modelled in non-drought winters; flows to recover to the associated regime of upward flow and stream discharge

Example: Buxton Heath

See SOP Section 5.2.

The following Primary Criteria were chosen for Buxton Heath:

***Drought periods -** Modelled water level in top active layer to remain above the lowest historical water level modelled.*
In this case, the threshold is 27.21 mAOD as modelled for July 1976 (see Figure 6.2). It should be noted that in this case, this threshold virtually represents the naturalised (non-abstraction) situation in July 1976.
The criterion for drought periods is directly linked to a statement in the Environmental Outcomes and makes sure that occurrence of drought conditions is not increased (in terms of frequency, intensity and duration) compared to what was experienced over the period 1970-2004. This means that, as soon as the modelled fully licensed abstraction is greater than the abstraction in the past, this threshold will be breached. In the first instance this will normally happen in the year on which the threshold was based, in this case 1976.

***Non-drought summers** – Modelled soil moisture content to remain above field capacity (as the lower limit of a range that represents conditions where "water oozes from soil under foot").*
This criterion is linked to the general requirement for M13 of a high water table and "oozy" soil moisture conditions in normal (non-drought years) as described in the Environmental Outcomes. Although the criterion only refers to soil moisture content, it is actually linked to the modelled water level in the top active layer. But rather than looking at changes in modelled water level, which cannot directly be compared to the actual water table on the site, the model looks at resulting changes in soil moisture content. High soil moisture content generally corresponds with a high water table but varies with soil type. By choosing a threshold related to soil moisture content this actually aims to maintain a certain range of water levels that maintain this soil moisture content under climatic conditions as experienced over the period 1970-2004. That means that in any given year (with certain climatic characteristics) of the modelled time series, reduction in soil moisture content occurs if the water level in the top active layer in the model is reduced as a result of increased abstraction. This is illustrated by the graphs in Figure 6.2.
This criterion cannot directly refer to the exact water table regime as described in the Environmental Outcomes, e.g. "The average 'normal year' shallow groundwater table should throughout a normal year not drop more than 10cm below ground level". However, it is thought to be an appropriate surrogate criterion that will ensure that required water table and soil moisture conditions are achieved on site.

Step 11: Compare time series (water levels and flows, soil moisture content) produced for the fully licensed abstraction scenario against the historical baseline and thresholds.

The fully licensed abstraction scenario is set up with actual historical climatic conditions as background but with abstraction from all licences in the model at 100% of their licensed quantity in every year of the modelled time period, e.g. 1970-2006. This scenario therefore presents a worst case situation.

The time series produced for the fully licensed abstraction scenario is compared against the historical baseline and thresholds.

- How often does the modelled time series breach the thresholds and by how much?
- Is the hydrological functioning significantly changed compared to historical (and naturalised) conditions, e.g. permanent reversal of vertical hydraulic gradient, cessation of upflow into to top active layer, cessation of stream discharge?

Since in most catchments fully licensed abstraction is greater than historical abstraction, and therefore modelled water levels/flows under the fully licensed scenario are lower than under the historical scenario, there is one default breach which occurs in the year with the lowest historical water level/flow on which the threshold is based. This is a function of the way the thresholds are set.
If, for example, the threshold is based on the historical water level modelled for the drought year 1991, the fully licensed scenario will normally breach this threshold under the same climatic conditions as in 1991, i.e. the time series graph for the fully licensed scenario falls below the threshold line on the graph.

Example: Buxton Heath

See SOP Section 6.1.

The appraisal of the abstraction scenarios against the thresholds of the primary and secondary criteria is summarised in Table 6.2.
Figures 6.1 and 6.2 illustrate how the time series for the fully licensed scenario compares to the naturalised and the historical scenario and against the thresholds.

Water levels:
See Figure 6.2. Up to the late 1980's the historical time series is very similar to the naturalised (no abstraction) time series due to the generally low level of abstraction. From the later 1980's a small difference is visible. Since the fully licensed scenario assumes the same abstraction quantity in every year, the difference between naturalised/historical and fully licensed therefore is larger in the 1970's and 1980's but becomes smaller from 1990 onwards.
The time series of the fully licensed scenario exceeds the drought summer threshold (primary criterion) in two years, 1974 and 1976, by up to 14cm. (Since 1976 was such an extremely dry year in East Anglia, breaches are likely to occur in this year for a large number of sites.)
Soil moisture content:
See Figure 6.2. The modelled soil moisture content for the fully licensed scenario goes below field capacity (primary criterion) in one non-drought year, 1975. This corresponds with 1975 also being the year with the lowest modelled water level in non-drought summers. In fact, the water levels in 1975 actually show similar or even lower levels as seen in some of the 1990's drought years such as 1989, 1992 or 1995.
The modelled soil moisture content returns to saturation in all drought and non-drought winters. This indicates that there are no cumulative effects on the soil moisture store. Therefore, it appears acceptable that the lowest winter peak water levels are not reached in every winter.
Upward flow to top active model layer:
See Figure 6.1. The modelled time series for the fully licensed scenario breaches the thresholds (secondary criteria) on several occasions. In 3 years out of 34, the upward flow goes below zero.
Discharge to stream:
See Figure 6.1. The modelled time series for the fully licensed scenario breaches the thresholds (secondary criteria) on several occasions. In 10 years out of 34, the discharge to stream goes below zero. However, this appears to happen also in 5 years under naturalised (no abstraction) conditions.

Step 12: Decide whether or not the fully licensed abstraction scenario is acceptable.

For the SOP there is a presumption that the fully licensed abstraction scenario is not acceptable if a threshold for a primary criterion is breached.

In some cases, specific reasons may be put forward, e.g. based on the model representation or some technical limitations, to allow breaches of thresholds to a certain degree.

Since there is usually one primary criterion for non-drought summers and one for drought summers, it is possible to further qualify the 'acceptability' of the fully licensed scenario. In a lot of cases, only the threshold related to drought summers is breached while the fully licensed scenario appears to be acceptable in non-drought summers.

Example: Buxton Heath

See SOP Section 6.2.

Since the fully licensed scenario results in breaches of primary criteria, the current conclusion in the SOP is that fully licensed abstraction is potentially greater than acceptable. That means that 'no adverse effect' cannot be concluded and that the Environmental Outcomes potentially can not be achieved. It is concluded that licences need to be modified in order to control actual abstraction, especially in drought periods.

If action would be taken and licences modified in such a way that the thresholds for the primary criteria are not breached this would also result in less breaches of the secondary criteria since the water balance components are linked.

Step 13: If the fully licensed abstraction scenario is not acceptable identify scale of licence modifications and need for options appraisal (application of 'SOP decision table').

If the fully licensed abstraction scenario is not acceptable based on the SOP, the necessary scale of licence modification and the need for options appraisal are then identified considering a risk-based approach.

The risk-based approach described below is strictly only applied to sites where historical levels of abstraction have been judged to be acceptable or where thresholds have been based on a period in time when historical levels of abstraction are thought to have been acceptable. For sites were historical levels of abstraction have been judged not to be acceptable site specific considerations and discussion with Natural England are required to establish an acceptable baseline or improvements that need to be achieved.

The need for this step involving a risk-based decision was identified for the following reasons:

For sites where we judge that historical levels of abstraction have been considered acceptable (see Step 8) the use of thresholds as described in steps 10 to 12 above inherently results in at least one threshold breach if the abstraction under the fully licensed abstraction scenario is greater than historical abstraction, which is the case in most catchments in Anglian Region. In addition to the one 'default' breach, there is often only a very small number of breaches (if at all) and most of the breaches may only be in the order of millimetres or a few centimetres or a few percentages of soil moisture content.

The historical time series is used as baseline because this is the only 'scenario' which has been experienced in the past and therefore can be compared with ecological and hydrological observations. In reality, adverse effects on site integrity may only start to occur once water levels and flows are somewhat lower than experienced in the past. Since this situation is outside of the range of our experience it is difficult to identify absolute thresholds when adverse effect will actually start to occur. Licence modifications may therefore not be necessary if hydrological impacts from fully licensed abstraction are only insignificantly greater than under the historical scenario, i.e. if the number and scale of threshold breaches is small, and if the risk of adverse effects on the site integrity actually occurring is judged to be sufficiently low.

We are therefore applying a **risk-based approach** that scales any licence modification based on the risk to the site.

The so-called 'SOP decision table' (also referred to as 'risk-matrix', see attached) is applied to scale the licence modifications by assigning a 'risk category' to each site (generally component SSSIs if a SAC/SPA consists of more than one SSSI). The 'SOP decision table' takes into account the scale and frequency of breaches to primary criteria thresholds, in the context of changes to the overall hydrological functioning, the general level of fully licensed and historical abstraction in the catchment surrounding the site and uncertainties around the ecological 'evidence' available, the conceptual understanding or the model representation. In addition, professional judgement will be applied to decide on the risk category as appropriate.

There is a presumption that, for sites which are assigned a 'low risk category', no abstraction licence modifications need to be investigated through the options appraisal process because the risk of adverse effect on site integrity and not achieving the Environmental Outcomes is sufficiently low despite some (small and infrequent) breaches of thresholds.

For sites in the 'medium risk' and 'high risk' categories the risk of adverse effect on site integrity is generally considered to be unacceptable and abstraction licence modifications will be investigated during the options appraisal process. The presumption is that licences would need to be modified so that the site then falls into the 'low risk' category.

The difference between 'medium risk' and 'high risk' is the scale of risk and therefore presumably the scale of abstraction licence modification that is required to reduce the risk to the site to an acceptable 'low'. The actual scale and detail of any modification will depend on the individual site and the licences implicated and will be investigated through the options appraisal. At the options appraisal stage, in addition to considering technical viability, we will also apply Habitats Regulations Principles (fair, reasonable, least onerous etc.) and compare options with regard to risks, costs, sustainability, social consequences and economic effects.

For SAC/SPAs with more than one component SSSI, the application of the 'SOP decision table' will direct the options appraisal work with regard to individual component SSSIs but does not predetermine the overall Stage 4 conclusion for the European site. If necessary, sites in the 'low risk' category could be reconsidered at a later stage, although this is not expected to happen in general.

Example: Buxton Heath

The application of the draft risk matrix has assigned a 'medium risk' category to Buxton Heath. This means that there would be a presumption that control over actual abstraction, e.g. through licence conditions, would be introduced.

SOP (Site Option Plan) Decision Table

Environment Agency Anglian Region

DEFINITION OF RISK CATEGORIES (Standard for Norfolk Valley Fens)

Proposal for SOP (site option plan) decision table

Risk to site integrity of fully licensed abstraction where historical abstraction appears to be acceptable

Criteria	Risk Category		
	Low	Medium	High
1) Performance against model-based hydrological criteria			
Scale of breach for water levels (related to threshold for drought summers)	≤ 5 cm	≤ 10 cm	> 10 cm
Frequency of breaches for water levels (related to threshold for drought summers)	≤ 1 out of 10 (= ≤ 3 out of 35)	≤ 3 out of 10 (= ≤ 9 out of 35)	> 3 out of 10 (= > 9 out of 35)
Scale of breach for soil moisture (related to threshold for non-drought summers)	≤ 5 %	≤ 10 %	> 10 %
Frequency of breaches for soil moisture (related to threshold for non-drought summers)	≤ 1 out of 10 (= ≤ 3 out of 35)	≤ 3 out of 10 (= ≤ 9 out of 35)	> 3 out of 10 (= > 9 out of 35)
Timing of breaches	droughts only	non-droughts only	droughts AND non-drought periods
Soil moisture returning to saturation in winters	always	not in a few winters	not in most winters
Impact on overall hydrological functioning	not significantly impacted	impacted in some years	significantly impacted in most years
2) Appraisal of resources and abstraction scenarios			
Modelled water level under fully licensed scenario similar to naturalised/historical or close to 50% LTA recharge scenario	similar to naturalised or historical	between historical and 50% LTA recharge abstraction scenario	close or above 50% LTA recharge abstraction scenario
Fully licensed abstraction as percentage of long-term average recharge (it is important to consider over which area the comparison is made)	0-20%	20-40%	>40%
Sensitivity of modelled water table to changes in abstraction (difference between abstraction scenarios)	small	medium	large
Sensitivity to water table fluctuations indicated by field data (site generally wet?)	small	medium	large
3) Uncertainties			
Evidence to allow judgement of no ecological change available and clear?	available and clear	available but not clear	not available
Development of historical abstraction levels over last 15 years (enough time for ecological effects to become apparent?)	~ stable or decreasing	slightly increasing	increasing
Model representation adequate?	adequate	less adequate	not adequate
Ecohydrological conceptual understanding clear and agreed?	clear and agreed	less clear, not agreed	not clear, not agreed
Field data available and sufficient?	available and sufficient	available but not entirely sufficient	not available and not sufficient

Further considerations that may influence the overall risk category:			
Add site specific considerations as appropriate…			
Example: Are the abstraction licences in the vicinity of the site in the majority seasonal (agricultural), annual abstractions or PWS abstractions?			

NOTE: This table shows the standard for Norfolk Valley Fens. For other sites the SOP decision table has been modified to account for different hydrological criteria and thresholds.