

**Upper Thurne Water Space:
Interim Management Plan
2006 – 2009**

December 2006



Dedication to Shaun Tusting

This Water Space Management Plan is dedicated to the life and work of Shaun Tusting, who was owner of Whispering Reeds boatyard in Hickling. Shaun was an active member of the Upper Thurne Working Group, and its predecessor, the Hickling Liaison Group. Representatives of the Upper Thurne Working Group wish to pay particular tribute to his participation, co-operation and collaboration over shaping the issues that this Plan seeks to address. This commitment, combined with his personal humility and respect for others and their interests, contributed intangibly and enormously to the growth of the Working Group and the development of this Plan. Furthermore, Shaun displayed remarkable personal courage on the face of pain and chronic fatigue that has been an inspiration to us all.

Professor Tim O'Riordan
Chairman, Upper Thurne Working Group
April 2006

Upper Thurne Water Space Interim Management Plan

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1. SCOPE OF THE WATER SPACE INTERIM MANAGEMENT PLAN

1.1 Purpose

The purpose of this plan is to provide an integrated and sustainable approach to managing the Upper Thurne water space, developed through a consensus-based process by the Upper Thurne Working Group.

The Plan considers the quality of natural and cultural features of this water space, in terms of its landscape and biodiversity, and the opportunities these provide for various forms of access and associated recreation, which in turn will contribute to a thriving local economy. The plan explores issues associated with the use of the water space features and identifies projects to reconcile areas of conflict.

The aquatic environment of the Upper Thurne water space is in an ecologically unstable state, and switches from a water plant dominated state to one where phytoplankton and/or macro-algae dominate. Under the Habitats Directive and Regulations the Upper Thurne is classified as being in an ecologically unfavourable state and, therefore, requiring restoration measures. Thus, this Plan is regarded as an interim plan for the next three years, during which time major research is underway to develop a sound understanding of the hydrological and ecological functioning of catchment. Findings from this research and ongoing monitoring of water quality, aquatic plants and wildfowl will better inform the future management of the water space.

1.2 Geographic Scope

This Interim Plan covers the water space and adjacent reed-fringed swamp margins of the Upper Thurne that lie within the Broads Authority Executive Area. It extends from the junction of the River Thurne with Candle Dyke to the upper reaches of Waxham Cut in the north, Catfield Dyke in the west and West Somerton Staithe in the east, as shown in Map 1.

Issues relating to the wider catchment, such as coastal defence and the management of water levels in the Brograve Levels and flood alleviation management, are not considered in any detail because they are the subject of other ongoing initiatives (Appendix 8). However, outputs from these initiatives will need to be considered in the successor to this Interim Plan.

1.3 Governance

The Upper Thurne Working Group was established by the Broads Authority in January 2001 with the overall aim:

'to develop by consensus a common vision and plan for sustainably managing the rivers and broads of the Upper Thurne, based on a sound understanding of the functioning of the hydrological and ecological catchment area, its importance for natural and cultural heritage, navigation and other forms of recreation, social and economic activities, and on the promotion of best environmental practice in its management.'

This aim is subject to a set of Objectives and Operating Principles, which are outlined in the Terms of Reference for the Working Group (Appendix 1).

The Working Group has an independent Chairperson, identified by its members in agreement with the Chief Executive of the Broads Authority.

It is current practice for policy and other recommendations from the Working Group to be considered by the Broads Forum and then members of the Broads Authority.

1.4 **Legal Framework**

The Norfolk and Suffolk Broads Act 1988, as updated by the Natural Environment and Rural Communities Act, provides an overall context for managing the Upper Thurne water space with respect to the general duty of the Broads Authority to manage the Broads in accordance with the principles of sustainable development for the purposes of:

- (a) conserving and enhancing the natural beauty, wildlife and cultural heritage of the Broads;
- (b) promoting opportunities for the understanding and enjoyment of the special qualities of the Broads by the public; and
- (c) protecting, conserving and developing the navigation

whilst also having regard to:

- (a) the national importance of the Broads as an area of natural beauty and one which affords opportunities for open-air recreation;
- (b) the desirability of protecting the natural resources of the Broads from damage; and
- (c) the needs of agriculture and forestry and the economic and social interests of those who live and work in the Broads.

The importance of the Upper Thurne for biodiversity is recognised under national and international conservation legislation. The Upper Thurne Broads and Marshes is designated nationally as a Site of Special Scientific Interest (SSSI) and internationally as part of the Broads Special Area of Conservation (SAC) and Broadland Special Protection Area (SPA) under the EU Habitat and Birds Directives, respectively. Hickling Broad and Horsey Mere were also designated in 1976 as Wetlands of International Importance especially as a Waterfowl Habitat under the Ramsar Convention. The whole Upper Thurne SSSI was subsequently designated as a Ramsar site in 1994.

Further legal considerations are covered in the appropriate description sections and in Appendix 2.

1.5 **Cultural and Recreational Framework**

Parts of the Upper Thurne water space are very important for recreational pursuits including sailing and angling, both of which date back from 100 to 150 years, and the boat hire industry which dates back to the 1930s. The water space is also important for other forms of recreational boating and land-based forms of recreation, such as walking and cycling. The Upper Thurne provides a popular destination for those seeking to experience and enjoy one of the best examples of the Broads scenery and associated wildlife.

1.6 **Timescales**

The three-year Water Space Management Plan will be effective from its recommended adoption by the Broads Authority in September 2006 and will be operational until 2009.

The supporting Action Plan will be reviewed on an annual basis until 2009, during which it will potentially be subject to a major revision to incorporate the findings of the hydrological and ecological research programme (Appendix 5).

2. 20 YEAR VISION

In 2026, the Upper Thurne water space comprises a series of shallow lakes and interconnected waterways, fringed by reedswamp vegetation and bordered by reed and sedge dominated fens and grazing marshland. Much of the system is slightly brackish, and therefore forms a marked contrast with the rest of Broadland, which is a predominantly freshwater ecosystem.

The drained marshland bordering the Thurne waterways, parts of which had been ploughed up during the 1980s and 1990s and used for growing arable crops, has been put back under grass and is being managed on a low intensity basis. In addition, following changes in agricultural practice, the watercourses are not receiving such large inputs of sediment and fertilisers from agricultural land.

These land use changes have ensured that nutrient inputs into the waterways are substantially less than they were twenty years ago and this is reflected in a major improvement in their ecology. More specifically, the latter no longer exhibit the marked oscillations between the aquatic plant and algal dominated state which constituted the Upper Thurne's ecology in the past.

Algal dominated communities, if present at all, tend to be transitory and far less well developed than they were in the latter part of the 20th century. As a consequence, the waterways are 'gin-clear' throughout the year. This has not only greatly improved their aesthetic appearance, but has favoured the development of an aquatic plant dominated community. The latter is helping to stabilise the sediment and render it more suitable for the growth of a greater variety of rooted water plants than was present 20 years ago. The highly diverse aquatic flora now found within the water space has in turn led to a marked improvement in the richness and diversity of the birds, fishes and invertebrates found in this part of the Broadland ecosystem.

The management regime now in place in the Brograve and Eastfield Levels has greatly reduced salinity levels and hence it has reduce the amount of ochre and salt being discharged by the Brograve pumping station into Waxham Cut. This has stabilised the salinity of Horsey Mere, reduced salinity levels in Hickling Broad and at the same time alleviated the sediment deposition problem previously encountered in the Cut and at its mouth. Equally important, the water in Horsey Mere is no longer discoloured by ochre.

The lakes support large numbers of wintering waterfowl where there are sufficient underwater plants for food and quiet water space for roosting.

These superb and unique open waters provide for waterborne recreation of all types and in all kind of vessels. This includes historical vessels, currently used water craft as well as those with new designs, constructed and containing new technologies that reflect this watery environment.

The fisheries in the Upper Thurne waters are of a high quality and offer good quality sport during the open season.

Mutual understanding and agreement about management of the water space has been reached by all interested parties, and the local economy is vibrant as many local people earn a livelihood in this protected landscape. High quality facilities supplying high quality goods and services are well used by visitors arriving in the area to enjoy the wildlife and opportunities for quiet recreation in a wild landscape.

Local people and visitors of all ages learn from the experiences of their visit to the Upper Thurne which is held in high regard as an example of what can be achieved in integrating different interests and uses into a special landscape.

People are so inspired that they often make return visits. For everyone, this is a place that's hard to leave.

3. **OVERALL DESCRIPTION OF THE UPPER THURNE WATER SPACE**

The Upper Thurne is situated in the north east of the Norfolk and Suffolk Broads, and comprises the River Thurne, and Hickling Broad, Heigham Sound and Duck Broad, Horsey Mere and Martham North and South Broad. A mosaic of reedbeds, fens, drained marshes and ditch systems further links this complex wetland system, which is closely influenced by its water supply and quality. The wild quality of the Upper Thurne is a haven for wildlife and creates a special place for people to enjoy the recreation opportunities it has to offer.

The boundary for this Management Plan for the Upper Thurne water space lies within the Broads Authority Executive Area.

The international importance of the site is reflected in European and Ramsar conservation designations. One of the features of the European designation is the aquatic plants, some of which are found nowhere else in the United Kingdom. These aquatic plants form the basis of a complex interaction between water quality, invertebrates, fish and animals such as otter, bittern and wintering waterfowl, which thrive where ecosystems are in a healthy condition. The Upper Thurne is a place where people can enjoy and learn about the environment as recognised in the National Nature Reserve designations.

The waters also provide space and good wind conditions for important sailing activity and local windsurfers. Hickling Broad hosts a calendar of national sailing events, and young people often begin their sailing careers here. Motorised craft can explore the area, mainly through marked channels reaching moorings at the furthest reaches of the navigable system or stopping for refreshment at locations close to the water.

The waters provide a diverse fishery with the area popular for traditional summer coarse fishing, and its nationally renown winter pike waters.

The Upper Thurne Working Group (UTWG) provides the basis for involving a range of interested parties, including statutory and non-statutory bodies with interests in natural resources, recreation and local community. Under its Terms of Reference, the UTWG has been tasked with developing and implementing the Upper Thurne Water Space Management Plan by the Broads Authority.

4. NATURAL RESOURCES DESCRIPTION

4.1 Climate

The Broads, and East Anglia generally, has a more continental climate than the rest of the UK, although the moderating effect of the North Sea tends to give lower maximum temperatures in the summer and higher minimum winter temperatures. In the winter, the Broads can freeze over for a few days. The prevailing winds, as for the rest of the country, are south-westerly. Precipitation levels are around 600 to 700 millimetres. Monthly sunshine hours are around 50 hours in January, 195 hours in July.

Climate change predictions for the Broads are for the climate to move towards a much more marked seasonality in rainfall and river flows, with for example increased winter and spring flooding and higher frequency of summer low flow events. Sea level rise, due to land sinking and polar ice cap melting is also likely to contribute to higher water levels in the future.

4.2 Geology

The geology of the Upper Thurne is complex. The whole area is underlain by a chalk aquifer. Above this lies a 50 – 60m deep layer of sand and gravel deposits and then the Crag, laid down during the Pleistocene. The Crag contains an important aquifer, separated from the much lower-lying chalk aquifer by a clay layer. The Crag layer dips to the east, where more recent, glacial deposits of alluvium and peat make up the relatively thin surface layer for most of the Upper Thurne catchment. Other irregular clay layers within the Crag disturb vertical water flow, resulting in perched aquifers at some locations.

The substrate of Hickling Broad and Horsey Mere basins comprises peat and marl layers, laid down over the last few thousand years. A dark, organic surface sediment layer of varying thickness, and of more recent origin, overlays this peat and marl. The Martham Broads have a much sandier, clay bottom due to their proximity to the coast and the position of the old River Thurne estuary. Their basins contain a lower amount of deposited organic material. For more details see Chapter 7 Landscape and Cultural Heritage Description, 7.1 Early History.

4.3 Soils

On the land, acidic peat and clay-peat, layered soils are common, with acid sulphate horizons within 30cm of the surface in the Brograve, Stubb Mill and West Somerton levels. These soils are susceptible to acidification and leaching of soluble iron (Fe^{2+}). Iron pyrites (FeS_2) is found in soils where saline water was present at the time of soil formation, such as within the Upper Thurne. When the water table is lowered, the iron content oxidises, with the resultant release of soluble iron and sulphuric acid. In areas where there is relatively little calcium carbonate (chalk), which neutralises the acid, the drainage water can become highly acidic. Ochre (ferric hydroxide) forms when the soluble iron precipitates out and becomes suspended in drainage ditch water, giving the water an orange colour.

4.4 Water

Hydrology

At one time, the River Thurne flowed out to sea between Winterton and Horsey, through a complex estuary of mud-flats and salt marshes, sand bars and gravel shoals, until the sand spit at its mouth, near Winterton finally closed off the estuary. Post-closure, the hinterland began the process of terrestrialisation, building up peatlands where river flowed amongst the old salt marshes of the former estuary. It is not known when the River Thurne changed direction of flow, or whether it was due to accretion of beach deposits, or a hastened process to prevent flooding of the hinterland. However, it was sealed by 1794, as Faden's map shows, a continuous line of dunes and marks the Hundred stream as a 'dike' terminating before the dunes.

Later drainage of the salt marshes reclaimed land for grazing. Medieval peat and clay extraction, followed by flooding after sea levels rose, left the open waters of Hickling Broad, Martham Broads and Horsey Mere. These lakes and the River Thurne itself have since been embanked to enable drainage of farmed land into the waterways. This means that the system is in effect isolated from and higher than much of its own catchment and hence highly dependent on inputs from land drainage pumps.

There is a brackish influence throughout the system, due to remnants of the former estuary, and as the freshwater aquifer remains in contact with the sea. Marine deposits present within the Crag also create brackish conditions in the surface water on the drained levels.

Water Levels

The Upper Thurne water space and adjacent fens are experiencing consistently high water levels. This may have an impact on erosion of reedswamp and can prevent reed and sedge cutting being carried out. High water levels mean that larger vessels are unable to get under the bridge at Potter Heigham.

Possible causes of higher water levels are rising sea levels, dredging works further down the system in the River Bure and/or flood walls dividing the river from its natural floodplain.

Water Quality

Nutrient and Salt Sources

The water quality of the Upper Thurne is influenced by diluted seawater entering via the pumped drainage system, by nutrients leached from the catchment soils in rainwater and from nutrients and salt coming in on upstream currents from the Rivers Thurne and Bure.

The influence of the tide is minimal in the Upper Thurne but wind conditions can generate considerable movement upriver. The high retention time of the Thurne water is due to tidal action further downstream backing water up the river, together with the flat topography of the area allowing the effect to extend far upstream.

Salinity

The salinity levels of the water bodies within the Upper Thurne are primarily determined by the background inputs through the rivers and aquifers, which are enhanced by saline inputs through land drainage pumps.

The salinity levels in the Upper Thurne waters also vary depending on the state of the tide and strength of the onshore wind onto the coast. Hickling Broad and Horsey Mere are both affected by upstream saline groundwater. The salinity in Horsey Mere is consistently higher than that in Hickling Broad. This is due to the combined effect of saline inputs from the pumped drainage system via the Brograve Pump and background inputs through the aquifers and river. Hickling Broad is a brackish lake primarily due to the inputs of saline water from Horsey Mere entering Hickling Broad via Meadow Dyke.

The saline water element brings in high levels of nutrients potassium, calcium, magnesium, sulphate, bicarbonate and chloride.

The amount of chloride ion in the water is one method of measuring salinity in the aquatic environment. The background level of chloride in Hickling Broad in early 1900s was around 60mg^l⁻¹ and in Horsey about 1000mg^l⁻¹. The levels in Hickling Broad are currently around 1800 to 2000 mg^l⁻¹ depending upon the balance between freshwater inflow and summer evaporation, and at around 2900mg^l⁻¹ in Horsey Mere. The breaching of sea defences in 1938 and 1953 increased salinity levels to almost double their normal levels, which due to flushing returned back to their levels prior to the breaching. Increases in salinity since the 1950s are mainly due to the intensive drainage and pumping of the Brograve level, bringing ochre and saline water into the Upper Thurne. Until the late 1970s, records show Martham Broads salinity levels consistently at a mean of 1000mg^l⁻¹. When the water table was lowered in the Somerton Level in 1979, the salinity underwent wide fluctuations with a maximum of 2000mg^l⁻¹. Currently salinity levels within the Martham Broads are around 1500mg^l⁻¹. (chloride figures from Brian Moss presentation to Broads Research Advisory Panel meeting 16 February 2006).

Table 1: Salinity in the Upper Thurne Water Bodies (mg^l⁻¹).
Source: Brian Moss presentation BRAP February 2006

	Hickling Broad	Horsey Mere	Martham Broads
1900s	60	1000	1000
2006	1800 - 2000	2900	1500

Pumped Drainage System

The Upper Thurne system receives input from the pump drainage system from adjacent low lying agricultural land (Map 2). The discharge from these pumps ranges from slightly brackish to brackish depending on the proximity of the sea.

Horsey Mere receives pumped water via Waxham Cut, which carries water from the drained marshes in the Brograve Level and further upstream from Hempstead and Lessingham marshes. The deep drainage of these marshes has created a high salt and ochre loading into the system, which is eventually delivered via the Brograve pump into Horsey Mere. This flushes further down into Hickling Broad and Heigham Sound.

Martham North and South Broads lie on a spur of the original River Thurne/Hundred Stream, and are separated from the influence of the Brograve Pump. Martham Broads receive pumped fresh water from agricultural land via the Somerton south pump. Somerton north pump by-passes the Martham Broads and delivers lower quality pumped water directly into the River Thurne.

Nitrogen and Phosphorus

Key nutrients nitrogen and phosphorus are leached from soils in the catchment. From

the early 1970s an additional phosphorus loading entered Hickling Broad as excreta from a large roost of black-headed gulls. The gull numbers had built up over a century, but declined by the 1990s. The phosphorus remains held within the Broads sediment in various forms.

Table 2: Contribution to phosphorus levels in Hickling Broad from the catchment and gull roost. Source: Broads Authority report (October 1999)

Year	1970s	1980	1980s onwards	1998	2004	2005
Annual average TP (μg^{-1})	200+	120-90	60	45		
From catchment (μg^{-1})	55	55	60	45		
From gull roost (μg^{-1})	103-164	0	0	0		
Release from sediment (μg^{-1})		45				
Annual mean TP (μg^{-1})					93	45

In the early 1970s, total phosphorus (TP) in Hickling Broad was over $200\mu\text{g}^{-1}$, with the catchment contributing $55\mu\text{g}^{-1}$ and the black headed gulls $103\text{-}164\mu\text{g}^{-1}$. The landfill site, where the gulls were feeding closed by the late 1980s, and the TP level reduced to around $60\mu\text{g}^{-1}$. The nutrients from the gull guano have gradually washed downstream, although it is thought that some background release continues from the sediment. The relative contribution to the nutrient budget is unknown.

Since 1980 the TP has reduced from around $120\mu\text{g}^{-1}$ to $60\mu\text{g}^{-1}$, to a point where the pumped drainage water now accounts for virtually all the nutrient budget. A wet year can bring levels down to around $45\mu\text{g}^{-1}$, which was the case in 1998.

The scatterplot in Fig 1 shows summer mean concentrations of Total Phosphorous in the Upper Thurne water bodies and how increasing phosphorous levels results in increasing levels of phytoplankton (measured by chlorophyll a concentration). It also shows the relative levels of TP across the Upper Thurne water bodies, with low levels in Martham South broad, middling levels in Horsey and mid to high levels in Hickling Broad.

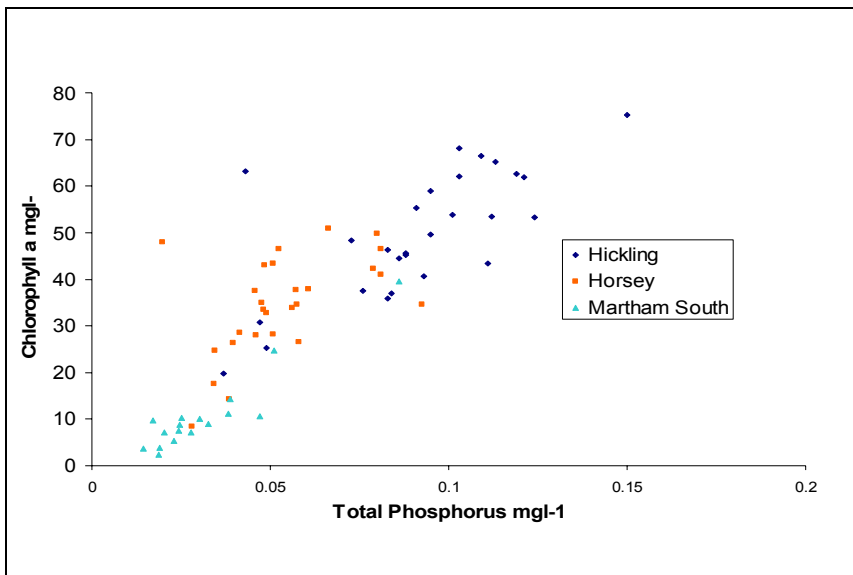


Figure 1. Total Phosphorous concentrations plotted against Chlorophyll a concentrations for the Upper Thurne water bodies

Nitrogen levels for the Upper Thurne catchment tend to be modest (less than 2mg l^{-1}) as the catchment is not as intensively farmed as other Broadland catchments. However, nitrate, ammonia and phosphate enter via the pumped drainage system during the winter when pumped water volumes are highest. These nitrogen levels support spring growth of algae, which reduce accumulated nutrients, die off and thus add nutrients to the sediment. Any summer algal growth is then dependent on recycled nutrient from the surface of the sediment.

Sediments and Dredging

Once the Upper Thurne broads were flooded after peat digging ceased, the process of sedimentation began. Sources of sediment arise from organic inputs (leaves, algae, plant material), erosion of reed swamp margins, run off from land in the catchment as well as silt and ochre inputs via land drainage.

Sedimentation rates in Hickling Broad were below 0.25 cm yr^{-1} until the 1930s and 1940s, and then increased to a rate of about 0.5 cm yr^{-1} by the late 1970s (Moss 1977). Current core sampling gives a siltation rate of about 1 cm yr^{-1} which is typical for many of the water bodies in the Broads.

A channel was dredged across Hickling Broad between 1968 and 1974, but has largely been lost due to slumping of sediment from adjacent areas.

A substantial part of Horsey Mere was dredged for the first time in the mid-1960s. Material was deposited on the south side of the Mere. Waxham Cut mouth has been dredged on a number of occasions since the 1960s to maintain navigation as the ochre discharged from the Brograve pump creates shallow water and tends to form a delta into Horsey Mere. The Cut itself is dredged by the Broads Authority to remove the ochre deposition.

Recent dredging work on the Upper Thurne involved the Catfield approach channel in 2000/2001. Assessment using sediment cores measured silt layers of between 30 and 46 cm. Dredging took place at 36cm to leave the channel peat bed intact. Silt curtains were used to protect Intermediate stonewort (*Chara intermedia*) beds. The dredged material was taken off the water at Pleasure Boat dyke and by dumper truck for application to land at Smee Loke. The cost of this project was around $\text{£}30\text{-}35\text{ m}^{-3}$.

The material from Catfield approach channel was applied to arable land to establish its nutrient value to farmers. Theoretically, the nutrient laden silt should benefit agriculture. Grass was established on the dried sediment but the experiment was not completed due to poor weather conditions affecting the success of the crops within the disposal area and adjacent control fields. Other uses for material 'won' from dredging activity has been used for some localised floodbank repair and local land raising for structures (e.g. Hickling Broad Sailing Club clubhouse).

The Broads Authority is currently working up Waterways Specifications for standardising water depths. The depths proposed for the Upper Thurne are 1.5 metres in the main channel, and 1.3 metres outside the main channel. These are general proposals and have not been agreed with relevant Authorities or interested parties.

4.5 Habitats and Species

Designations

The Upper Thurne has been designated under various national and international conservation designations (see Map 3):

Table 3: Upper Thurne nature conservation designations

Designations	Area of Upper Thurne included
Ramsar site under the Convention on Wetlands of International Importance especially as Waterfowl Habitat. The Convention was ratified by the UK in 1976.	Hickling Broad and Horsey Mere are part of the Broadland Ramsar designated originally in 1976, then 1994 incorporating the whole Upper Thurne area.
Special Area of Conservation (SAC) under the European Habitats Directive. Special Protection Area (SPA) under the European Birds Directive. Implemented in the UK through the Conservation (Natural Habitats etc.) Regulations 1994, known as the Habitats Regulations.	Part of the Broads SAC, adopted 1992. Part of the Broadland SPA, adopted 1979.
Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way Act 2000.	Upper Thurne Broads and Marshes SSSI, includes Hickling Broad, Horsey Mere and Martham North and South Broads.
National Nature Reserve under the Wildlife and Countryside Act 1981.	Upper Thurne NNRs are Hickling Broad and Marshes and the Martham Broads.
Area of Special Protection under Wildlife and Countryside Act 1981.	Horsey Estate ASP on land to the west and south east of Horsey Mere.

Table 4 below, shows the features of the SAC and SPA relating to the Upper Thurne water space that, under Government Public Service Agreements (PSA) targets, are required to be in favourable or unfavourable recovering condition by 2010. Ramsar features are also listed to show the outstanding assemblage of protected species and habitats in the Upper Thurne water space.

Table 4: The features of the SAC, SPA and Ramsar designations relating to the Upper Thurne water space

	Feature	Broads SAC	Broadland SPA	Ramsar
Habitats				
	Natural eutrophic lakes with <i>Magnopotamion</i> or <i>Hydrocharition</i> type vegetation (plant assemblages including Pondweeds (<i>Potamogeton sp.</i>) and Stoneworts (<i>Chara sp.</i>)).	Yes	as a habitat for birds	as a habitat for birds
	Hard oligo-mesotrophic waters with benthic vegetation of stoneworts (<i>Chara sp.</i>)	Yes	as a habitat for birds	as a habitat for birds
Birds				
Annex 1 species of European	Marsh harrier Hen harrier Bittern		Yes	Yes

	Feature	Broads SAC	Broadland SPA	Ramsar
importance				
Migratory species of European importance	Gadwall Shoveler		Yes	Yes
Species contributing to the SPA wintering assemblage ¹	Great crested grebe Cormorant Wigeon Teal Pochard Tufted duck Coot ²		Yes all	
Additional Ramsar bird species	Cormorant Wigeon Teal			Yes all
Mammals				
	Otter (<i>Lutra lutra</i>)	Yes		Yes
Invertebrates				
	Desmoulin's Whorled snail (<i>Vertigo moulinsiana</i>) Norfolk Hawker dragonfly (<i>Aeshna isosceles</i>) Swallowtail (<i>Papilio machaon britannicus</i>)	Yes		Yes Yes Yes
Flora				
	<i>Najas marina</i>	These species form part of the SAC habitat interest		Yes
	<i>Chara connivens</i>		Yes	
	<i>Chara curta</i>		Yes	
	<i>Chara intermedia</i>		Yes	
	<i>Chara pedunculata</i>		Yes	
	<i>Chara aspera</i>		Yes	
	<i>Nitellopsis obtusa</i>		Yes	

One of the key drivers for the European SAC and SPA designations is to: 'maintain at or restore to favourable conservation status, natural habitats and species of wild flora and fauna of Community Interest (Article 2.2).'

The current condition of the lake features is given below. These conditions are defined in Appendix 6: A Working Summary of Favourable Condition Criteria for Upper Thurne Large Water Bodies.

Hickling Broad	Unfavourable declining
Heigham Sound	Unfavourable recovering
Horsey Mere	Unfavourable – no change
Martham North and South Broads	Favourable

BAP Habitats and Species

The UK Government's 'Biodiversity: the UK Action Plan' has created a framework for action to maintain and increase indigenous species populations and habitat areas.

¹ Wintering assemblage applies to SPAs that regularly support over 20,000 birds. SPA species that have at least 1% of the GB population present qualify under SPA selection criteria 3.

² Goldeneye duck are also present in locally important numbers.

The overall aim of biodiversity planning is to reduce the threat to species and habitats to a position of 'no net loss'. The priorities from the National list which apply to the Upper Thurne water space are listed below. These have National and Norfolk Biodiversity Action Plans.

Table 5: Priority BAP habitats and species relating to the Upper Thurne water space

BAP Priority Habitats and Species in the Upper Thurne water space	National BAP www.ukbap.org.uk	Norfolk BAP www.norfolkbiodiversity.org
Mesotrophic lakes, including reed swamp margins	Yes	Yes
Otter	Yes	Yes
Water vole	Yes	Yes
Bittern	Yes	Yes
Holly-leaved naiad	Yes	Yes
Stoneworts: Starry Stonewort (<i>Nitellopsis obtusa</i>) Convergent Stonewort (<i>Chara connivens</i>) Bearded Stonewort (<i>Chara canescens</i>) Baltic Stonewort (<i>Chara baltica</i>) Intermediate Stonewort (<i>Chara intermedia</i>)	Yes <i>Chara intermedia</i> covered by Norfolk BAP	Yes

Reedswamp Margins

The reedswamp margins around the shallow lakes comprise the following National Vegetation Classification (NVC) communities

Table 6: National Vegetation Classification reedswamp communities in the Upper Thurne

	NVC Vegetation Community	English Version
S4	<i>Phragmites australis</i> swamp and reedbeds	Common reed swamp
S6	<i>Carex riparia</i> swamp	Great pond sedge swamp
S8	<i>Scirpus lacustris</i> ssp <i>lacustris</i> swamp	True bulrush swamp
S13	<i>Typha angustifolia</i> swamp	Lesser reedmace swamp
S20	<i>Scirpus lacustris</i> ssp. <i>taubernaemontani</i> swamp	True bulrush swamp
S24	<i>Phragmites australis</i> – <i>Peucedanum palustre</i> tall herb fen	Reed and milk parsley fen

The marginal reedswamps are largely dominated by Common Reed (*Phragmites australis*) and Lesser reedmace (*Typha angustifolia*) with True bulrush (*Schoenoplectus lacustris*) having very limited distribution. These plant communities form part of the complex wetland mosaic, functioning as a protective margin against wave wash, stabilising broad margins, providing habitat for breeding birds notably bittern and bearded tits, as well as refuges for small fish fry and young fish.

Reedswamp margins have undergone rapid decline in some parts of the Upper Thurne, partly due to high numbers of feral Greylag and Canada geese as well as swans grazing on the vegetation, and poor water quality. The goose activity also includes nesting and recruiting large numbers of young with localised addition of nutrients to the water.

As reedswamp condition deteriorates, wind and wave action move broken sections of reedswamp away from their anchor. With high nutrients in the water, the reed rhizomes can remain active as they acquire nutrients without having to anchor deep into the sediments.

Methods of protecting reedswamp from further decline includes management of goose recruitment and installing protective barriers to keep geese from the reedswamp. Recent monitoring indicates reedswamp recovers behind the protective barriers, but declines elsewhere as the birds move to graze on unprotected margins.

Aquatic Plants

Monitoring, survey and research has identified that aquatic plant communities pass through three phases in response to water quality. Summaries of these phases can be found in George 1992, Moss, Madgwick and Phillips 1996 and Moss 2001. The three phases are summarised as:

Table 7: Aquatic plant community phases

Phase I	<p>Rivers and Broads in their pristine state.</p> <p>Elements still present in Martham Broads.</p> <p>Hickling Broad moved into this Phase in the late 1990s into the early 2000s.</p>	<ul style="list-style-type: none"> • Low levels of phosphorous and moderate nitrogen with high calcium carbonate. • Water plant communities include Stoneworts (<i>Chara</i> sp), Holly-leaved naiad (<i>Najas marina</i>) and low growing waterweeds such as Reddish pondweed (<i>Potamogeton alpinus</i>) and bladderwort (<i>Utricularia intermedia</i>) • Phytoplankton virtually absent • Wealth of invertebrate life • Water crystal clear
Phase II	<p>Usual Phase for Horsey Mere as at 2005/06.</p> <p>Hickling Broad lies between Phase I and Phase II.</p>	<ul style="list-style-type: none"> • Gradual rise in nutrient loading • Robust, taller, nutrient demanding plants colonise with competitive advantage over Phase 1 communities. Plants such as Horned Pondweed (<i>Zanichellia palustris</i>), Fan-leaved Water-crowfoot (<i>Ranunculus circinatus</i>), Hornwort (<i>Ceratophyllum demersum</i>), Greater bladderwort (<i>Utricularis vulgaris</i>), Yellow Water-lily (<i>Nuphar lutea</i>), White water-lily (<i>Nymphaea alba</i>), Spiked and Whorled Water-milfoils (<i>Myriophyllum spicatum</i> and <i>M verticillatum</i>) and Fennel-leaved pondweed (<i>Potamogeton pectinatus</i>) • Increase in periphyton (epiphytic algae) growing on plants, which Phase 2 species able to withstand better than Phase 1 • High biological productivity, exemplified by large populations of diverse fish species, a wealth of invertebrate species
Phase III	<p>Hickling Broad during the 1970s and 1980s.</p>	<ul style="list-style-type: none"> • Phytoplankton dominance • Major reduction in the biomass and diversity of the aquatic flora • Increase water turbidity • Phosphorus levels greater than 100µg l⁻¹ • Accelerated rate of sediment deposition • Loss of aquatic invertebrate diversity

A table showing the submerged aquatic plants occurring in the Upper Thurne is in Appendix 3.

Hickling Broad and Heigham Sound:

Stoneworts (*Charophytes*) were a key component of the macrophyte flora of Hickling Broad until the 1960s. In the 1940s and 50s the aquatic plant component was similar to that seen in Martham Broads today. By the late 1940s, robust aquatic plants and filamentous algae increasingly appeared and began to constitute most of the biomass. By the late 1970s the submerged macrophyte flora was sparse with *Potamogeton pectinatus*, *Hippuris vulgaris* and *Myriophyllum sp.* *Charophytes* appeared once again in the mid 1990s. Hickling Broad is still the richest location in Britain for recorded *Charophytes*. Beds of Holly leaved Naiad (*Najas marina*) are present, notably in Heigham Corner.

Martham North and South Broads support one of the richest aquatic floras in the Broadland system with Holly leaved Naiad (*Najas marina*), a rich assemblage of stoneworts, including *Chara intermedia*, *C. aspera*, *C. pedunculata* and *Nitellopsis obtusa*. Nationally scarce species *Potamogeton friesii* and *Myriophyllum verticillatum*, also occur.

Horsey Mere currently has a poor assemblage of aquatic macrophytes, *Chara baltica* is regularly recorded with sparse *Chara intermedia*. Low-growing *Chara aspera* is a historical record.

Managing Aquatic Plants

The increase in distribution and species of aquatic plants in Hickling Broad by the 1990s, after many years of restricted presence, resulted in navigation problems for sailors and other boat users.

In 1994, after experimental cutting trials, a cutting and monitoring programme for Spiked Water-milfoil (*Myriophyllum spicatum*) and Pondweed (*Potamogeton sp*) began in Hickling Broad, covering about one third of the open water (116ha) known as the 'buoyed' area. This programme continued until 1998 when Hickling Broad became clear for the first time in several decades and Intermediate stonewort (*Chara intermedia*) grew in excess of 100cm high.

In September 1998, the Broads Authority, with agreement from English Nature, cut a 50m x 50m plot of *Chara intermedia* to 50cm above the bottom of the broad. Its condition was monitored to assess the impact of cutting. The following key points from this trial were:

- Windy conditions made the operation difficult, causing some plant uprooting.
- Bird grazing and bedding down resulted in no significant height difference between cut and uncut areas by February 1999. The cut area has a slightly lower density of plant material.
- Uprooted plants mostly died leaving areas of bare substrate by March 1999. Some plant fragments re-grew.
- In cut and uncut areas new shoots appeared a nodes on old stems. By April 1999 the *Chara intermedia* beds were increasing in height.

In May 1999, further trial plots were cut to establish whether uprooting damage to *C. intermedia* by the weed harvester could be avoided by raising the cutter to 30cm and 40cm above the bed of the broad. The Broads Authority also put forward a recommendation to cut 14.85ha of the area covered by the *C. intermedia* out of a total

coverage of 38ha. This proposal required Appropriate Assessment under the Habitats Directive 1994, and therefore any further cutting was suspended during 1999, whilst an Appropriate Assessment Panel (see Appendix 4) convened to recommend the future of any cutting regimes.

The Appropriate Assessment Panel recommended that half the 14.85ha should be cut in equal cut and uncut control plots, and that the impact on grazing wintering birds should be monitored. The Broad Authority carried this out in July 1999, with the aim to reverse the plots in 2000. The weed harvester cutter blade was raised to 60cm in some places as difficulty was experienced in cutting at 40cm above the bed of the Broad.

Bird distribution was monitored throughout the 1999/2000 winter to assess the cutting impact on their feeding (see Armitage, M.J.S., Holloway, S.J. and Rehfish, M.M. 2000).

By 2000, the condition of Hickling Broad had deteriorated due to an increase in nutrient levels, resulting in turbid water and a lower height and density for the *C. intermedia* lawns. The Appropriate Assessment Panel concluded that the 1999 experimental cuts had not resulted in any detectable impacts on water quality, water clarity, regrowth of *C. intermedia* or overwintering birds.

Since 2000 the condition of *C. intermedia* has continued to be monitored (see Table 8). An experiment to test the effect of limited year-on-year cutting was re-established in June 2004 (see Map 4 for location of trial plots) due to some recovery of the *C. intermedia* lawns during 2003. A second cut was not carried out in 2004 as the *C. intermedia* had shown poor growth. This has continued into 2005 and 2006 with virtually no *C. intermedia* present. Factors influencing the condition of the *Chara intermedia* appear to relate to water depth and quality, water clarity, bird grazing leading to loss of cover and release of nutrients, mobile sediment and reduction of Spiked Water-milfoil as a support for young, growing *Chara intermedia*.

Table 8 : Extent of dense Intermediate stonewort lawns on Hickling Broad 1994 - 2005. Total area monitored is 116ha.

Year	Area (ha)	Annual Increase (ha)	% of Broad (based on 116ha)
1994	13.6		11.7
1995	17.1	3.5	14.7
1996	25.8	8.7	22.2
1997	33.3	7.5	28.7
1998	39.0	5.7	33.6
1999	48.5	9.5	41.8
2000	18.8	-29.7	16.2
2001	No data for whole broad		
2002	No data for whole broad		
2003	31.2	12.4 (since 2000)	26.9
2004	20.5	-10.7	17.7
2005	11.0	-9.5	9.5

A set of cutting prescriptions for aquatic plants outside the main channel has since been agreed by Broads Management Committee (18 March 2004), to include the following scenarios:

- no cutting
- limited cutting (for recreational or experimental purposes), or
- large scale experimental cutting (up to 14.85ha, including any area subject to limited cutting, as above).

The favourable condition criteria for implementing these prescriptions are set out in Appendix 7 of this Management Plan.

In addition, the Appropriate Assessment Panel and the British Trust for Ornithology concluded that it was no longer possible to repeat the 1999 cut in reverse design (mirror image) because the distribution of *C. intermedia* (principal food source for overwintering waterfowl) was now radically different and the *C. intermedia* was no longer present as dense beds. Any large scale experimental cutting design would have to be worked up to take into account the location of the dense beds. One option considered by the Panel was the depletion modelling approach, which would examine the relationship between plant biomass, bird numbers and the influence of any recreational activities on their activity.

The conditions required to enable the limited cutting experiment to progress are for the spring growth of *C. intermedia* to be as vigorous as in spring 2003, even if the water remains turbid (Broads Management Committee 17 June 2004). This cutting experiment is designed to provide information about how *Chara intermedia* responds to a cutting regime and to inform whether the cutting regime could be extended more widely in the future.

The practical criteria for the limited experimental *Chara* cutting are as follows:

Practical criteria for limited experimental *Chara* cutting (as at 2004)

- Total area cut should not exceed 10% of total area of dense *Chara intermedia*
- This total area includes all areas cut for experimental and recreational purposes
- The experimental design is based on three sets of three cut plots (50m x 50m)
- Plant height in experimental cutting area has to exceed mean maximum height of 50cm
- Plots will be marked with buoys to enable relocation using a minimum number of buoys and avoiding areas heavily used by sailors (see Map 4b).

Other aquatic plants are cut on a more routine basis. The Broads Authority cuts aquatic plants within Catfield Dyke to a height of 30cm, and Catfield Approach Channel within Hickling Broad to 40cm. Horsey Channel, Waxham Cut and Somerton Dyke are also cut annually as the growth determines. In the past, excessive growth of Spiked Water-milfoil has been cut on Hickling Broad, Heigham Sound and in Horsey Mere. Uprooted plant material has also been collected for disposal. Cut material is loaded onto a wherry for disposal at broad edge.

The Broads Authority cutting machine is also used for cutting the experimental cutting plots.

Wintering Waterfowl

As part of the Broadland SPA, the Upper Thurne is internationally important for the numbers of waterfowl, which overwinter on its waters (see Table 9 on page 19 and Footnote 1 on page 13 relating to wintering bird assemblages).

Birds are counted on a monthly basis as part of the national Wetland Bird Survey (WeBS). This data has been collected nationally for many years, but more recently has been additionally recorded on a sector basis in the Upper Thurne to include bird distribution as well as numbers.

Table 9: Waterfowl (excluding geese) present on Hickling Broad, Horsey Mere and Martham Broad (1999/2000 to 2003/04)

	5 year average peak count	Monthly winter average	Favoured locations
Hickling Broad	4170	2000	Pleasure Island Bay, Sailing Club Bay, Heigham Corner, Lings Mill Bay, Heigham Sound all have about 250 on each winter count, Duck Broad typically has over 100 birds present.
Horsey Mere	3500	2377	All open water. Birds are mainly wigeon and teal.
Martham Broad	2324	820	All open water. Birds are mainly wigeon and teal.

The waterfowl use the water for roosting and feeding, and are therefore susceptible to disturbance from water-borne users. Voluntary winter waterfowl refuges have been established in various ways to meet an agreed target of 50% of the Upper Thurne open water as winter waterfowl refuges³:

- Hickling winter refuges in Pleasure Island Bay, Lings Mill Bay, Heigham Corner and Duck Broad from November to February.
- Martham Broads refuges South Broad all year, with limited permits for angling in North Broad.
- Horsey Mere closed to angling by boat from November to February inclusive. A pilot scheme to allow limited angling by permit only was established during winter 2005/06.

These refuges were originally agreed for 2004/05 (see Map 5) following a review of previously existing refuges. Monthly WeBS counts continue to be carried out with an additional monitoring count relating disturbance events to bird numbers.

Relating disturbance events to wintering waterfowl numbers has not been conclusive and the voluntary winter refuges and monitoring have continued during winter 2005/06.

Upper Thurne Fishery

Fish on the Upper Thurne live a largely migratory existence, with roach, perch, rudd, pike, bream, tench and eel colonising the upper river and broads during the summer months. Roach are numerically and biomass dominant (70-85%). The winter fishery is dominated by pike on the main broads, with roach overwintering in huge numbers in the dykes and boatyards, including those in the Middle Thurne at Potter Heigham.

³ This target is not agreed by Hickling Broad Sailing Club, and any further extension of winter refuges from the current position is not supported (January 2006)

Numbers of estuarine and salt water species are increasing such as bass, flounder and smelt.

The important features for this fishery include good freshwater quality, which is essential for preventing outbreaks of *Prymnesium parvum*. High freshwater levels are also essential for holding back salt tides that regularly invade the system. Important natural habitat features for the fishery include stable mixed aquatic and marginal plant communities. Refuges for fish include the aquatic plant beds, as well as vegetated shallow margins and particularly the dykes off main broads and river to provide protected areas of retreat for fish and fry, especially during the winter months. At these times, special protection for the fish from salt incursions is essential.

Prymnesium parvum

Proliferations of the phytoplankton, *P. parvum*, along with salt surges presents the greatest problem to the Upper Thurne fishery. In early spring *P. parvum* is generally inhibited by moderate levels of ammonium, during which time diatoms use up ammonium in preference to nitrates. Later in the spring when diatom numbers drop, due to lack of silicates, ammonium levels are low enough for *P. parvum* to proliferate, making use of the nitrates in the water. In conditions where phosphorus levels are limited the *P. parvum* cell membranes break down to release ichthyotoxins, which are extremely toxic to fish.

In 1969 *Prymnesium* decimated the entire Upper Thurne fishery, 250,000 fish perished. Although this was the first year a fish kill in Upper Thurne was directly attributed to *Prymnesium*, heavy mortalities are recorded in these waters for 1894, 1914, 1922, 1925, 1934, 1954, 1965, 1966 and 1967. Bowler (1971) suggests *Prymnesium* is responsible for some of these incidents. Ichthyotoxins killed fish in the Hickling/Horsey area in 1970, 1973, 1975, and intermittently between 1980 – 2000.

The 1985 outbreak followed the largest known algal bloom recorded in the Thurne system. Most roach and bream were able to escape to the Bure as they were still on the river prior to migrating into the broads. However many pike perished throughout the system. The most recent outbreak occurred in 2000, and was the first recorded to last throughout the winter. The numbers of pike killed have not been quantified by the Environment Agency, but is likely to be thousands. The pike fishery on the Upper Thurne has not fully recovered as recovery estimates are around 6 to 7 years.

The numbers of fish to die in these outbreaks is not clear. Anglian Water records show only 300 fish died per annum from the mid 1970s onwards in these outbreaks, dropping to about 50 in 1986 and 87. These figures are not supported by anglers, as many of the dead fish sank and are not counted in the estimates.

Most fish species can tolerate salt surges once acclimatised, however sudden exposure leads to osmoregulatory problems, which may result in death.

Fish moving away from salt surges often run into dead ends such as boat basins and dykes. Many thousands of fish overwinter in these areas. Once trapped by salt water huge mortalities can occur. A tidal barrier was installed at Wood's boatyard at Potter Heigham by Environment Agency (on the advice of Broads Angling Steering Group), and has been successful in protecting fish from saline incursions.

4.6 **Research and Monitoring**

Current research studentships studying environmental aspects of the Upper Thurne, particularly aiming to provide insight into the instability of the ecosystem are listed in Appendix 5. The outcomes of this research will inform the successor Management Plan. Some relevant papers relating to the Upper Thurne water space are listed in the Reference and Documentation in section 11.

The Environment Agency and its predecessor organisations have been monitoring water quality and aquatic biology for many years. The first complete sub-aqua water plant survey was undertaken in 2000, and was jointly funded by English Nature and Broads Authority. This is due to be repeated in 2006 as part of the six year SSSI monitoring cycle. The Broads Authority routinely monitors Intermediate stonewort (*Chara intermedia*) biomass condition and location in Hickling Broad and carries out annual aquatic plant surveys. Wetland birds are monitored monthly for the National Wetland Birds Survey (WeBS). Other aquatic macrophyte surveys are carried out by the Broads Authority.

4.7 **Specified Limits for Natural Resources**

The following provides a summary of the limits for a range of attributes which links to Appendix 6 'A Working Summary of Favourable Condition Criteria for Upper Thurne Large Water Bodies'.

Good water quality

Phosphorous

Upper limit: annual mean is $30\mu\text{g l}^{-1}$ total phosphorus (from the latest favourable condition tables).

Nitrogen

Upper limit: Targets for nitrogen are not yet available from the current state of knowledge.

Chloride

Upper Limit for Hickling Broad: 600 mg l^{-1}

Upper Limit for Horsey Mere: 1000 mg l^{-1}

Upper Limit for Martham North and South Broads: 1000 mg l^{-1}

Clear water

Upper limit: Secchi disc visible to bottom of water column throughout the water bodies.

Aquatic plant beds

Upper limit: Present across the water bodies, except in marked channels

Actively growing margins

Upper limit: Not determined

Lower limit: Not determined

Disturbance free winter bird refuges

Upper limit: 50% of the total area of the Upper Thurne

Lower limit: 44% of total area of the Upper Thurne (position in 2005)

Waterways Standard⁴

Main channel

Upper Limit: 1.5 metres deep

Outside main channel

Upper limit: 1.3 metres deep

⁴ 1.3 metres is not achievable or desirable throughout the water space, but gives options for provision of a water depth suitable for sailing. Water depth specifications will be developed as part of the Sediment Management Strategy 'Waterways Specifications'. These have not been widely agreed amongst stakeholders and are likely to require Environmental Impact Assessment and Appropriate Assessment.

5. ACCESS AND RECREATION DESCRIPTION

5.1 Access Policy and Objectives

The Broads Authority's 20-year aim for access to land and water, as set out in the Broads Plan (2004 p40), is:

'The Broads will be easily accessible for all to enjoy recreation activity on land and water. Access will be sensitively managed, and of a kind and an intensity that respects and preserves the special qualities and ambience of the Broads, its landscapes and delicate ecosystems'.

Norfolk Wildlife Trust's access policy in relation to Hickling Broad, is to allow and promote access to the open water, whilst ensuring that the nature conservation features are not damaged. Access is not allowed to the water space of Martham South Broad. Martham North Broad is accessible by angling permit only. Public footpaths enable walkers to overlook the site.

The National Trust's access policy, in co-operation with the Horsey Estate in relation to Horsey Mere, is to promote permanent preservation for the benefit of the nation. The National Trust Acts establish its responsibility for conservation and where conflict arises, conservation will take precedence over access.

5.2 Access and Recreation Provision

Landownership and Rights

All the Upper Thurne broads are privately owned having been allotted by the Enclosure Awards. Sporting and fishing rights were allotted to the private owners.

Hickling Broad and surrounding fens, as well as Martham North and South Broads are owned or managed by Norfolk Wildlife Trust.

Horsey Mere is owned by the National Trust and managed on a long term lease by the Horsey estate.

Fishing

Angling on the Water

There is a right to fish from the water where it is tidal. The limits of tidal action in the Upper Thurne has not been determined in modern times, except that the current Ordnance Survey shows the Normal Tidal Limit to the mouth of Heigham Sound and to Dungeon Corner on the River Thurne. A previous court case in 1892 determined that the Upper Thurne waters are not tidal⁵.

⁵ The 1892 case of Micklethwait and Eyre versus Vincent sought an injunction restraining Vincent from shooting or fishing over northern Hickling Broad. The judge rules that as Hickling Broad has been allotted in 1808 by the Enclosure Commissioners, the sporting and fishing rights were vested in the owner Mr Micklethwait. The other issue raised was whether or not the Broad was subject to tidal action. Witnesses for the plaintiff claimed that water levels in Candle Dyke only fluctuated by three quarters of an inch (1.9cm) even at spring tides, whereas those appearing for the defendant claimed fluctuations greater than this. In the event the judge preferred the evidence presented by the plaintiffs and ruled against the greater fluctuations. He did however accept that the public's right of access to the site was not restricted to the marked channel. (source M. George 1992 p 52)

As the Upper Thurne broads are privately owned the following access and permit arrangements are made for angling, subject to the closed season from 15 March to 15 June inclusive:

- Hickling Broad: Fishing is by permit and subject to voluntary agreements for the winter waterfowl refuges at Pleasure Island Bay, Lings Mill Bay, Heigham Corner and Duck Broad from November to end of March inclusive.
- Martham Broads: Fishing permits are issued for Martham North Broad between October and March inclusive. Fishing is not permitted on Martham South Broad.
- Horsey Mere: Permits are issued to boat anglers at all times, except when Horsey Mere is closed to angling by boat from November to February inclusive*, and during the closed season.

*In 2005/06 a permit system for one angling boat, three days a week just beyond Meadow Dyke into Horsey was trialled, monitored and then reviewed. This pilot will continue in 2006/07 for seven days a week using an extended area of marginal water.

Environment Agency rod licences apply to all fished areas of the Upper Thurne water space. Anglers with more than two rods require two licences.

Angling from Banksides

Very little of the Upper Thurne water space is accessible from banksides.

During the fishing season, permitted fishing is available from Horsey staithe and Catfield Angling Club members have access to fish south of Catfield Dyke from the bankside. Non-permitted fishing takes place along the river edge from Martham Boat Dyke to Dungeons Corner and along Candle Dyke, wherever anglers can find access from the bank to the river. Anglers can fish from Broads Authority 24 hour moorings, but have to give way to mooring boats.

Eel Fishing

There are currently no eel net licences in the Upper Thurne apart from the demonstration eel sett in Candle Dyke, which has an Environment Agency licence.

Navigation

Navigation can be exercised across the waters of the Hickling Broad complex and Horsey Mere. The public have a right of navigation throughout the Upper Thurne to the ends of the system at Waxham Cut, Catfield Dyke and West Somerton boat dyke. Navigation to West Somerton staithe is via the channel only between Martham North and South Broads. Navigation on these two Broads is not permitted. Fishing permits are available for Martham North Broad only.

Mooring

The Broads Authority provides free 24hour moorings at Deep Go Dyke, Deep Dyke, and Catfield Dyke through various lease agreements. Private short and long stay moorings are available, with a range of payment arrangements at Whispering Reeds, Hickling Parish Staithe, Pleasure Boat Dyke, Catfield Dyke, West Somerton Staithe, Horsey Staithe and Martham Ferry Boat Dyke.

Informal moorings are used at various locations, where there are no facilities, such as mooring posts, boarded staithe or information. Problems arise where informal mooring becomes long term and causes damage, particularly to the reedswamp margins.

Staithe

There are numerous staithe throughout the Upper Thurne. Most of them are privately owned and have arrangements for public use by permission and fees. Other staithe have some public right of use.

Wayleaves

None that impact on the management of the water space.

5.3 Use of the Upper Thurne for Access and Recreation

Introduction

The Upper Thurne has been and remains a popular, and well-known location for quiet recreation, such as sailing, angling and wildlife watching. Although wildfowl shooting no longer occurs over the rivers and broads, some shoots are operational on land adjacent to the water.

The early navigation of the channels in the Upper Thurne was by keel then wherry, transporting goods to and from the village staithe. The wherry ‘Emily’ was particularly associated with Hickling Broad. However, with the decline in the use of the waterways for transportation and their increasingly shallow water, wherries visit the Upper Thurne less frequently. However, The wherry ‘Hathor’ has visited Hickling regularly in the last few years, but went aground in the main channel in 2006.

Boating

Today, hire and private craft, along with many cruising and racing sailing vessels make recreational use of the Upper Thurne. Boats can be hired from within the Upper Thurne from Whispering Reeds at Hickling or from Martham Boat Building Development Company. At Potter Heigham, Phoenix, May Craft and Woods Boatyards all hire boats on a day or longer basis. Hire craft can originate from boatyards anywhere in the system but the low bridge and high waters at Potter Heigham tends to limit access from the south into the Upper Thurne.

Census data on boat movements is taken over three days in August every four years. The census point in the Upper Thurne at Candle Dyke shows the following boat movements, for all boats passing:

Table 10: Boat census totals from Candle Dyke

Year	1976	1986	2002	2006
Total number of boats passing	786	656	2404	To be carried out August 2006

In 2002, the total number of boats counted throughout the Broads during the census was 16433, of which 14.6% passed the Candle Dyke census point.

Sailing

Hickling Broad is the largest area of open inland water in Norfolk, set in an open landscape without bankside trees and in close proximity to the sea, which gives a sea breeze on hot days throughout the summer unlike other broads in the system. These features create excellent sailing conditions, which give Hickling Broad high value as a nationally important sailing venue.

During the 1900s sailing events included using Pleasure Island for the village fair and regatta. On Easter Monday 1931 the first seven Herbert Woods Norfolk dinghies raced to Hickling and back. This event was repeated on Easter Mondays in 1981, 1991 and 2006 (in the reverse direction), when 42 or more Norfolks participated. In addition, pre-war sailing events were held on Hickling as part of the Potter Heigham regatta.

The only sailing club based in the Upper Thurne, Hickling Broad Sailing Club, was established in 1950. The Club uses the open water of the broad for racing from late March until late November (see Map 6). The Club also has a cruising membership, which sails over the whole of the Upper Thurne navigable water. The clubhouse and a dinghy park were built in 1960 on dry dredgings from Hickling Broad. The membership is set at a ceiling of 550. The Club runs a calendar of events, youth and adult sailing training and is the venue for numerous national and regional sailing competitions. Hire sailing vessels from Womack, Upton, Horning and Martham all visit Hickling to enjoy its premier sailing conditions.

Boat Trips

Hour-long boat trips have been run from Pleasure Boat Inn by a private individual. Norfolk Wildlife Trust promotes boat trips on the 'Wildlife Water Trail' using a traditional reed lighter, which takes in the watchtower giving visitors aerial views across Hickling Broad and Heigham Sound. Visitor numbers for the trail are around 1800 from May to September, including children on educational trips.

Windsurfing

Hickling Broad is an important location for windsurfing, as autumn and spring winds are strong on these waters.

In 1980 a windsurfing school was established at Hickling Broad, working from the Pleasure Boat quay, and using the beach opposite the Dyke. This caused problems on the water and for the Pleasure Boat Inn car park. Hickling Windsurfing Club opened in 1984, and in 1996, a new launching beach was constructed adjacent to New Dyke with access from Staithe Road along with a Club car park.

In 1995 the Windsurfing Club signed a condition to avoid the area of water behind Pleasure Island and the bay south of Catfield Dyke for the protection of wintering birds between 1st November and 1st March. This was in return for planning permission for the new launching beach.

Membership of the Club is agreed at 250, and spaces for cars at 45, in return for planning permission to erect new changing room facilities. Every June, the club holds

an open day and holds a race week for a charitable organisation known as the Sea Vets.

Canoeing and Rowing

There are no established canoeing or rowing facilities on the Upper Thurne. Rowing boats can be hired from Whispering Reeds or Maycraft. Any activity is on an informal basis, either by individuals or groups organising their own visit.

Angling

The Upper Thurne has a long and famous history as a pike fishery. The following table shows the British rod records from the Upper Thurne:

Table 11: British pike records from the Upper Thurne

Year	February 1968	February 1986	Summer 1986
Weight	40lb 1oz	41lb 6oz	42lb 2oz (same fish as February)
Location	Horsey Mere	River Thurne, Martham	River Thurne, Somerton
Angler	Peter Hancock	Neville Fickling	Derek Amies

Due to outbreaks of the alga *Prymnesium parvum* and salt tide surges, pike fishing in the Upper Thurne is not as productive as it was in the 1980s. However, it is one of the few places in England that can produce pike of over 35lbs.

Summer fishing is popular with visiting and local anglers, and is good for roach, rudd, perch and bream. In Hickling up to 30 anglers can be present at one time. In the 1960s a World Championship fishing match was held on the river above Martham. It was won by the French team with a catch of small perch.

Due to its proximity to the sea, the Upper Thurne fishery is constantly under threat from salt surges and the effects of the toxic alga *Prymnesium parvum*. In 1969 *Prymnesium parvum* decimated the entire stocks of the Upper Thurne, putting to an end one of the finest fisheries in England. Some recovery has been made but subsequent outbreaks hold it on a knife edge. (Further information on *P. parvum* see the Natural Resources: Upper Thurne fishery).

Viewing Water Space from the Land

Views across the water space from the land are limited. Norfolk Wildlife Trust encourages access to its nature reserve at Hickling, which include the visitor centre and car parking, together with a network of paths, including disabled access. Visitors are able to learn about the Upper Thurne, enjoy a wild landscape and view Hickling Broad. Some views are available from the Weaver's Way long distance path, including from a bird hide along the route. Other public footpaths give public views across the Upper Thurne.

The sails of boats on Hickling Broad can be seen from the A149 and from various roads around Catfield and Potter Heigham, and also from Hill Common. The viewing tower south of Hickling Broad, which is only available as part of the NWT boat trip, gives good views over the Hickling Broad complex and various hides on Hickling

Broad Nature Reserve also afford good views. The Horsey viewing point on the edge of the Mere is the best location for looking across Horsey Mere. Horsey Mill gives good views across Horsey Mere and adjacent marshes.

Enjoying Wildlife

Visitors come to the Upper Thurne for its wildlife interest. Birdwatching occurs from boats as well as from hides available at Hickling Nature Reserve and from the Horsey viewing point. A particular feature is the raptor roost at Hickling where up to 60 people can gather to watch the birds at dusk.

Education

The Norfolk Wildlife Trust visitor centre and education centre at Hickling provides a venue for environmental education events and courses for school children and adults. The National Trust opens Horsey Mill from 1st March to 31st October, showing a collection of photographs depicting life at Horsey, including the 1953 flood.

The Broads Authority organises five events a year at the eel sett.

HBSC train young people to sail.

Schools, colleges, universities and other educational institutions also visit the Upper Thurne primarily for environmental and ecological study.

5.4 Access to the Upper Thurne

This section describes how visitors and locals can reach and travel within the site. Map 6 shows the key access points.

The Broads Local Access Forum (BLAF), set up under section 5 of the Countryside and Rights of Way Act (2000), has a remit to advise on open air access for recreational purposes in the countryside. This includes advice on access to water.

On Foot

The main public footpath route through the Upper Thurne is via the Weavers Way, which leads from Potter Heigham, then south of Hickling Broad and northwards to Stalham. Other public footpaths in this area run south of the River Thurne and around Martham South Broad. From West Somerton Parish Staithe this public footpath courses around Martham North Broad finishing on the Horsey Road. From Horsey Drainage Mill a further public footpath leads north of Horsey Mere, along the Waxham Cut and turns east towards Horsey Corner. Permissive access on foot is available at Norfolk Wildlife Trust's Hickling Broad Nature Reserve, and from here a further public footpath connects to the Weavers Way close to Hickling parish staithe.

By Boat

Navigation access points into the Upper Thurne are along the River Thurne between the two Martham Broads to West Somerton Boat dyke, but not as far upstream as West Somerton Staithe. Candle Dyke gives access into Heigham Sound and to Hickling Broad. Meadow Dyke leads from Heigham Sound into Horsey Mere, which gives access to Waxham Cut.

The Broads Authority has produced a draft slipway and staithe strategy (2005). Further consultation work will be required before projects for improvements within the Upper Thurne are put forward, including an Environmental Impact Assessment.

Public Transport

Bus services to the Upper Thurne are infrequent.

By Cycle

Cycles can use the quiet country lanes around the Upper Thurne. There are no current promoted cycle routes in the area.

5.5 Infrastructure

Access to the Water

The current infrastructure for public water access includes: marked navigation channels, slipways, moorings, visitor information, speed restriction signs and the launch beach for windsurfers near the Pleasure Boat Inn.

Parking and Land-based Access

Car parking is available at the following locations:

Location	Permissions
Hickling Parish Council land on Staithe Road	Berth holders and parishioners only
Pleasure Boat Inn	Patrons only
HBSC car park	Members only
Windsurfers car park	Members only
Horsey Staithe	Payment 30p per hour. National Trust members free.
Hickling Visitor Centre	Members free; non-members purchase permit.
Eel Set	Informal parking used mainly by anglers

Disabled Access

Provision for disabled parking and pathways have been made at Horsey Staithe, with well-surfaced paths and gentle gradients for wheel chair users.

An 800m disabled access path gives access to bird hides and views over Hickling Broad. Disabled access is also possible to the Visitor Centre and Education Centre.

Interpretation

Information boards are provided at Horsey Staithe and Hickling Nature Reserve Visitor Centre. There are information boards at intervals along the route of the Weavers Way.

Hickling Parish Council notice board close to the parish staithe carries local and visitor information relevant to the Upper Thurne water space.

Toilets and Waste Disposal

Public toilets are located by the Pleasure Boat Inn car park and the car park at Horsey Staithe. Hickling Nature Reserve Visitor centre also has toilets available for visitors to the reserve.

Holiday Accommodation and Eating Out

B&B type accommodation is provided in most of the villages around the Upper Thurne. Most of the villages have pubs, with one in Hickling, the Pleasure Boat Inn located beside the water. Refreshments can be obtained from the National Trust outlet at Horsey, and Norfolk Wildlife Trusts visitor centre at Hickling. A small shop at Pleasure Boat dyke carries general provisions.

Boatyards

Whispering Reeds has moorings and dry berths for around 90 boats. Catfield boatyard has moorings and dry berths for 20, which are parish owned and let mainly for people in surrounding villages.

Two boatyards provide pump out and fuel facilities. One of these also has disposal of chemical toilet waste and for boat refuse.

6. INTERESTED PARTIES DESCRIPTION

The Upper Thurne Working Group is the forum for engaging interested parties in planning for the future of the Upper Thurne water space. Its members range from statutory and non-government organisations to recreation interest groups and representatives of the local community. This group has been assigned by the Broads Authority to draw up, and then implement the Upper Thurne Water Space Management Plan.

Details of the Terms of Reference and membership can be found in Appendix 1.

The following table sets out the Statements of Interests for the organisations or group represented.

Organisation	Statement of Interest
Broads Authority	<p>The Broads Authority is a Special Statutory Authority established under the Norfolk and Suffolk Broads Act 1988, with a general duty to manage the Broads for the purposes of:</p> <ul style="list-style-type: none"> • conserving and enhancing the natural beauty of the Broads; • promoting the enjoyment of the Broads by the public; and • protecting the interest of navigation. <p>None of these three purposes takes precedence. Management is based on principles of sustainable development with respect to the natural and cultural heritage, people and economy of the Broads.</p> <p>The Authority has statutory responsibility for both planning and navigation within the Broads. It is a member of the National Park family.</p> <p>www.broads-authority.gov.uk</p>
Broads Angling Strategy Group	<p>BASG is a group of experienced Norfolk anglers whose objectives are to promote and expand all forms of angling throughout the Broads system. The aspiration of the group is that angling can be improved through various measures including improved access and good fisheries management.</p>
Broads Hire Boat Federation	<p>The Broads Hire Boat Federation is part of the British Marine Federation, representing all the holiday boats on the Norfolk and Suffolk Broads. The future aspiration for the Broads is to keep the navigation open so that the public can enjoy cruising and seeing the beauty of the Broads.</p>
Broads Society	<p>The Broads Society is open to anyone wanting to help secure a sustainable future for the Broads as a unique and protected landscape in which leisure, tourism and the local economy can thrive in harmony with the natural environment. It is uniquely placed to help reconcile those often conflicting interests, ones which have been demonstrated within the Upper Thurne waters. Formed in 1956, it pioneered the creation of the Broads Authority when the future of the Broads looked bleak.</p> <p>www.broads-society.org.uk</p>

Organisation	Statement of Interest
Catfield Parish Council	<p>Catfield parish includes much of the southern half of Hickling Broad, most of Whiteslea & Deep Dyke, part of Heigham Sound and the southern bank of Meadow Dyke. It also includes much of the fens to the south & west of those places, mostly owned by NWT.</p> <p>Catfield has three staithes; Crowe's Staithe on the river Ant, Woodend Staithe on Barton Broad and Catfield Staithe near Hickling Broad. Catfield Staithe is owned by Catfield United Charities (formerly Catfield Poores' Trustees) on a block of land allotted to them in the Enclosure Award of 1808. The Staithe is connected to Hickling Broad by Catfield Dyke, a continuation of Guttermere Dyke (via an IDB pump), the principal stream feeding directly into Hickling Broad. These Dykes are part of the straight-line boundary between Catfield and Hickling parishes.</p> <p>The Staithe has access from the Hickling to Potter Heigham road and is about a mile from Catfield village along New Road. The Staithe is partly leased out as a small boatyard while part of it is kept as free 24-hour mooring. The fishing on the Staithe and along the southern bank of Catfield Dyke is reserved for local people to use as members of Catfield Fishing Club. The Trustees also own and manage an adjoining piece of fen on the southern side Catfield Dyke and provide a permissive path around it.</p>
DEFRA (Rural Development Service)	<p>The Rural Development Service is one of the main deliverers of the England Rural Development programme, a package of 10 schemes, which provide opportunities to protect and improve the countryside to develop sustainable enterprises and to help rural communities to thrive.</p> <p>Our schemes are primarily land-based, but have an indirect relevance to the water space by encouraging resource protection, wildlife and landscape protection/enhancement, public access and the development of sustainable rural business.</p> <p>RDS is currently part of Defra, but will be joining with English Nature and the Landscape, Access and Recreation section of the Countryside Agency in Autumn 2006. At that point out socio-economic schemes will move to the Regional Development Agencies, but we will continue to deliver the agri-environment schemes, including the Environmentally Sensitive Areas, Countryside Stewardship and the new Environmental Stewardship.</p> <p>www.defra.gov.uk/rds</p>

Organisation	Statement of Interest
Electric Hire Boatyards	<p>Norfolk boatyards and engineers are in the forefront of development and design of electric boats and propulsion systems. At present there are about 20 electric day boats for hire in the Broads. Electric powered boats are favoured as they do not emit exhaust fumes or noise, allowing peaceful movement along the waterways with fewer disturbances to wildlife. The boats tend to cause less wake and less banks erosion. Electric charging points are available in the Upper Thurne system at Hickling and Potter Heigham.</p> <p>www.electric-boat-association.org.uk</p>
English Nature	<p>English Nature is the Government agency that champions the conservation of wildlife and geology throughout England. English Nature have notified the Upper Thurne Broads and Marshes Site of Special Scientific Interest (SSSI), and declared the Hickling Broad National Nature Reserve (NNR) and Martham Broad NNR. We are charged by Government with enabling the achievement of favourable condition for the natural features of these sites through our own work and through encouraging other public bodies to fulfil their duties and further the enhancement of SSSIs.</p> <p>www.english-nature.org.uk</p> <p>These responsibilities will transfer to Natural England, which will come into effect from October 2006.</p> <p>www.english-nature.org.uk/About/naturalengland.htm</p>
Environment Agency	<p>The Environment Agency is the lead non-departmental public body for protecting and improving the environment in England and Wales.</p> <p>Our vision is for a healthy, rich and diverse environment, working to the environmental goal of sustainable development. Our activities range from influencing Government policy and regulating major industries, right through to day-to-day monitoring and pollution clean up operations at a local level. The Environment Agency also has an important role in warning people about the risk of flooding, and in reducing the likelihood of flooding from rivers and the sea.</p> <p>Much of our work is delivered in partnerships, with Government Agencies, local businesses, councils and interest groups. We aim to work together to achieve enhanced environmental benefits and work towards sustainable development.</p> <p>www.environment-agency.gov.uk</p>

Organisation	Statement of Interest
Hickling Broad Sailing Club	<p>The main objective of the Hickling Broads Sailing Club is to promote and facilitate the sport of yachting. Any person whether or not the owner of a yacht or boat, who is keen and interested in sailing is eligible as a candidate for membership. There is also provision for temporary membership for sailors visiting the Broads area. The club operates from a clubhouse, dinghy park and car park situated just south of the Pleasure Boat dyke on land partly leased and partly freehold. It provides all the usual facilities of a sailing club including training for adult and child members, a full racing programme (including open meetings) and rescue boat cover for organised events. It is affiliated to the Royal Yachting Association and the NSBA.</p> <p>www.hicklingbroad.com</p>
Hickling Broad Windsurfing Club	<p>Norfolk's premier windsurfing club is situated on Hickling Broad. The club has a private launch beach and rigging area, private car park and changing facilities. Club members can learn to windsurf, sail the club's boards or use their own.</p> <p>www.hicklingbroad.co.uk</p>
Hickling Parish Council	<p>Hickling parish offers a cordial and sincere welcome to people arriving by car, coach, boat, staying in a holiday home or hiring a boat. Hickling parish is a large and scattered village with wide open spaces, fields and farms, and one third is marsh and common land with a large expanse of water.</p> <p>The village sign shows an artists impression of the old priory ruins and depicts the reed cutter, swallowtail butterfly, the bittern and peat digger.</p> <p>www.hickling-village-norfolk.co.uk</p>
Horsey Estate Trust	<p>Horsey Estate was acquired by the National Trust in 1948 from the Buxton family, who continue to manage the estate with nature conservation as a priority.</p>
Horsey Parish Council	
Kings Lynn Consortium of Internal Drainage Boards	<p>Kings Lynn Consortium of IDBs is the largest of its kind in the UK and is a governing authority for flood protection throughout Norfolk. Working closely with English Nature, Environment and other bodies, We ensure that the highest levels of water level management for land and property owners, as well as wildlife conservation are adhered to under current UK and European legislation.</p> <p>www.klcidb.co.uk</p>

Organisation	Statement of Interest
Martham Parish Council	<p>Described as 'a village twixt the sea and the Norfolk Broads' Martham has a population of over 3000. The parish borders the southern bank of the River Thurne and rises gently up the side of the valley to higher ground and the village centre. The village hosts a post office, a couple of pubs, a supermarket, doctor's surgery, a pharmacy and other shops. Over 30 businesses are based in the village.</p> <p>www.martham.gov.uk</p>
National Trust	<p>The National Trust is Europe's leading conservation charity, and is completely independent of Government. The Trust relies on income from membership fees, donations and legacies and revenue raised from commercial operations. There are 3.4 million members of the National Trust. It works to preserve and protect coastline, countryside and buildings, and has many long term programmes in place to help educate people about the importance of the environment and of preserving our heritage for future generations.</p> <p>www.nationaltrust.org.uk</p>
Norfolk and Suffolk Boating Association	<p>NSBA works to serve, protect and promote the interests of private users of pleasure craft in the Norfolk and Suffolk Broads. It has forty organisations directly affiliated with a combined membership in the region of 9000 people. In its affiliation to the Royal Yachting Association, NSBA is committed to helping safeguard the well-being and special character of the Upper Thurne in harmony with the traditional rights, use and access to the waters for recreation.</p>
Norfolk Wildlife Trust	<p>Norfolk Wildlife Trust, part of the national network of Trusts, has 25,000 members and owns or manages 40 nature reserves and other protected sites around the County. It works for the protection and enhancement of Norfolk's wildlife and wild places, to secure a better future for wildlife, and improve its understanding and appreciation. Hickling Broad, Heigham Sound and the surrounding wetlands are owned, leased and managed by the Trust. Its main aim is to work with others to protect and restore the sites' wildlife, whilst at the same time recognising the area for appropriate recreation, access and education.</p> <p>www.norfolkwildlifetrust.org.uk</p>
Potter Heigham Parish Council	

Organisation	Statement of Interest
RSPB	<p>The RSPB is the UK charity working to secure a healthy environment for birds and wildlife, helping to create a better world for us all. Founded in 1889, the RSPB is now Europe's largest wildlife conservation charity, with more than 1 million members. Areas of work range from conservation policy to education and from wildlife law enforcement to land purchase. The RSPB tackles wide-ranging issues from climate change to damaging local developments.</p> <p>www.rspb.org.uk</p>
Sailing Hire Boatyards	<p>Sailing Hire Boatyards are located at Eastwood Whelpton at Upton, Norfolk Broads Yachting Co. at Horning, Hunters Yard at Womack, Martham Development Boatyard, Martham. These yards between them have approximately 75 cabin sailing yachts for hire. Hunters, Martham Development and Whispering Reeds all hire out sailing half-deckers.</p>
Somerton Parish Council	

7. LANDSCAPE AND CULTURAL HISTORY DESCRIPTION*

7.1 Early History

During the Bronze Age and Iron Age, that is up until about 2000 years ago, the Broads area was relatively high and dry with low sea levels and probably with sand spits separating the sea from both the Upper Thurne valley and the Halvergate Marshes area. The landscape was one of freshwater fens with alder and willow carrs which decayed to form the deep layer of Brushwood Peat which was later exploited by mediaeval peat diggers.

Before Roman times, rising sea levels and perhaps storms caused the destruction of the spit across the mouth of the Halvergate marshes and brought about the "Marine Transgression", when the Broads area became an estuary. During Roman and early Saxon times estuarine clay and silt known as "Upper Clay" was deposited over the brushwood peat except in the upper reaches of valleys. It seems that the sand bar from Happisburgh to Winterton remained largely intact, with perhaps only a narrow gap, so that the estuarine clay deposited in the Thurne valley arrived via the Halvergate estuary. This clay thins out to be absent at Hickling and Waxham, only a mile or so from any potential Thurne estuary.¹ The Marine Transgression reached its zenith around 400AD. During Saxon times sea level changes and the development of the sand spit on which Yarmouth now stands caused the estuary to silt up; then the Broads area returned to freshwater fens and the "Upper Peat" layer was formed.

It is likely that in Saxon and early Mediaeval times the river Thurne flowed out to sea along the course of the Hundred Stream, through a narrow gap in the sand bar rather than a wide estuary. The river Ant drained to the sea via the Thurne and probably at times the Bure did as well.² The Thurne outlet, like the rest of the coastline between Happisburgh and Winterton must have been at least a mile further out to sea than at present. Areas of low-lying upland as well as marsh and fen have been lost since the fourteenth century by erosion, including most of Eccles and Little Waxham. The latter must have lain to the east of Horsey as the last few acres of Little Waxham are now in Horsey parish on the north side of the Hundred Stream near the present sand dunes.³

7.2 The Middle Ages: Origins of the Broads

By late Saxon times the upper Thurne valley was high and dry enough for large-scale peat and clay digging to take place to a depth of 1 to 1.5 metres.⁴ Most of Hickling Broad was dug for the deeper brushwood peat which made a better fuel than the *phragmites* peat near the surface. It is thought that Whiteslea, Heigham Sound, Martham Broad and Horsey Mere were dug primarily for the "Upper Clay". Joyce Lambert's sections across three of those broads show that large amounts of clay must have been removed but the reason is not clear. It has been assumed that it was to supply a local pottery industry but there is no evidence for that other than the name "Potter Heigham". The prefix "Potter" was added to distinguish it from Heigham near Norwich and is first recorded as *Hegham Pottere* in 1182.⁵ Such prefixes or suffixes were added to parishes with the same name in the Middle Ages and the name of a manorial lord was often used such as Swanton Abbot, Swanton Novers or Swanton Morley; perhaps Potter was a mediaeval land owner!

* Sections 7.1 to 7.6 are from a paper produced by Keith Bacon, UTWG representative from Catfield Parish Council

Alternative uses for the clay could include the creation of embankments around broads or for sea defences. These broads are in parishes where the Abbot of St Benet's was the manorial lord or a major landowner. Monasteries were wealthy and powerful enough to undertake such works and did so in other parts of the country. It is not clear when manorial control of turbary (peat digging) began but records of it exist for St Benet's Abbey regulating peat digging in the upper Thurne valley from the mid-twelfth century.⁶ The peat was used locally and was also transported on the Broads' rivers to Yarmouth and Norwich.

7.3 Upper Thurne:c. 1500 to 1800

By the sixteenth century the records of St Benet's (of the Bishopric of Norwich after 1536) no longer mention turbary but do mention valuable fisheries and eel setts at the same locations.⁷ Climate change and sea level change probably caused the flooding of the peat diggings during the fourteenth century. This commenced with the dramatic sea breach caused by a storm in December 1287 when Hickling church was flooded and 180 parishioners were drowned.⁸ During the fourteenth and fifteenth centuries large-scale digging for the deep brushwood peat ceased as conditions became increasingly too wet. In the Ant valley small-scale shallow digging of the *phragmites* peat continued until the early twentieth century and this may well have been the case in the Thurne valley.

Up until the 1800s the upper Thurne valley was a landscape of vast common wastes of fen and open water with adjoining common heaths on the upland and in places some reclaimed grazing marshes. The local population could exploit, officially or unofficially, the natural resources of peat, reeds, sedge, fish and wildfowl with a degree of control by the manorial courts. A copy exists from 1677 of the presumably much older regulations governing the Bishop's manorial wastes in Ludham, Catfield and Potter Heigham.⁹ It fixed dates and times for cutting various fen crops and it laid down penalties for breaking the rules. It said that only "...ancient tenants shall presume to reap any profit" from the commons. "Ancient tenants" meant the owners and occupiers of messuages and tenements with rights appurtenant or appendant, i.e. farms and houses with ancient common rights, so excluding many parishioners but this was probably not strictly enforced. This way of life was to be severely curtailed by the enclosure acts in the 1800s and 1810s.

7.4 Parish Boundaries

The Hundred and parish boundaries in the Thurne Valley tend either to follow the water courses as they existed about 1000 or more years ago, or they were aligned to give parishes access to peat and clay diggings at that time. The boundary between the hundreds of Happing and Flegg follows the river Thurne and the Hundred Stream which was probably the old course of the River Thurne. The boundaries between Hickling and Potter Heigham to the west and Horsey, Waxham and Palling to the east may have been the former course of the upper reaches of the River Thurne. This line is now marked by the Hickling Wall and Eelfleet. Heigham Holmes, an island of low upland with its marshes, is now cut off from the rest of Potter Heigham parish by Heigham Sound and Candle (Kendal) Dyke. It is likely that Candle Dyke was only created when Heigham Sound became a broad around 1300 and at the same time or later, Meadow Dyke and Candle Dyke replaced Eelfleet as the main course the upper Thurne.

A narrow portion of Catfield parish stretches for about three miles across Hickling Broad, Whiteslea, Heigham Sound and along Meadow Dyke to Blackfleet Broad as a wedge between the parishes of Potter Heigham and Hickling. This gave Catfield a

share of the peat and clay excavations in those broads.¹⁰ Long sections of Catfield's boundaries are straight lines, probably created in Saxon times or the early Middle Ages when the broads were first being dug in these fens. The lines are lines of sight looking southeast towards Winterton and West Somerton churches. This is confirmed in Catfield parish registers in 1610 when it states in a perambulation of the boundaries that the sight line is taken standing on Guttermere Bridge along Catfield Dyke.¹¹

7.5 Enclosure

Before 1800 much of the upper Thurne valley, especially the peaty areas, was common waste as fen and water. Some parts, especially on the estuarine clay, had been enclosed and drained privately centuries earlier by some of the larger landowners to form grazing marshes. This includes some of the grazing marshes around Heigham Holmes by the Bishopric of Norwich, formerly St Benet's Abbey estate, and also parts of Horsey and Waxham.¹² A later example of such reclamation was the Brograve Level in Waxham drained by the eccentric Berney Brograve of Waxham Hall using the Brograve Mill built in 1771.¹³

In the 1800s and 1810s all the upper Thurne parishes had enclosure acts passed by Parliament (except Waxham which was entirely owned by the Brograve family and had no common waste or open field left).¹⁴ The resulting enclosure awards tidied up remaining open fields on the arable uplands, which were extensive in some parishes such as Martham and Somerton. The awards privatised and reclaimed common wastes, which were mostly fens but included a large common heath on the upland to the west of Hickling Broad in Catfield and Hickling. Much of the northern upper reaches of the Thurne Valley in Eccles, Hempstead, Lessingham, Palling, Ingham and particularly Hickling had their peaty areas reclaimed to form grazing marshes, heavily reliant on windmills to drain them. Many small broads were drained and reclaimed in Hickling and the northern valley on the peat, as were several others on the estuarine clay in Horsey, Winterton and Somerton. Most of these broads are shown on Faden's map of 1797, except the broad between Ingham and Hempstead which is on an enclosure map.¹⁵ Those broads which were not drained by Parliamentary enclosure were embanked and left as open water and reedswamp.

The main channel of the river and some of the main dykes were embanked with flood walls and rands and these were usually allotted to the Parish Drainage Commissioners created for the purpose. Some maps drawn as part of the enclosure process show ownership plots of marsh extending to the river's edge before enclosure, implying that the river had not previously been embanked and that the marshes must have been frequently flooded.¹⁶ Faden's map of 1797 and the enclosure maps show that Hickling Broad had several irregularly-shaped extensions which under the enclosure awards for Hickling and Potter Heigham were cut off from the broad by new embankments and drained.¹⁷

The enclosure awards allotted the broads to private owners. The Lords of the various manors were regarded as owners of the soil of the common wastes and this included "land covered with water". The Enclosure Commissioners allotted land by value rather than by area and this was done in proportion to the land owned by value before enclosure. A proportion of the total value of land was allotted to the lord of the manor, as owner of the soil of the common wastes. Reedfens were valued at a much lower level than grazing marshes or arable land and open water lower still. In the upper Thurne as elsewhere in the Broads, the lords of the manors and principal landowners chose to have large areas of low-value fens and broads as part of their allotment. Thus Hickling Broad, Whiteslea and Heigham Sound were allotted to Mr

Micklethwait for the pieces in Hickling parish and to Mr Cubitt for those pieces in Catfield and Potter Heigham.¹⁸ Cubitt's allotment number 23 in Catfield amounted to 306 acres of water and fen which was almost all of that part of the upper Thurne Valley in Catfield parish.¹⁹ The gentry were keen to own these large tracts of very low value property for prestige and for the sporting rights of shooting and fishing. In 1842 Cubitt was leasing 113 acres of Hickling Broad to a marshman W Applegate for only £2.3s.0d per annum (about 4 old pence per acre) whilst keeping the shooting rights for himself.²⁰

On many occasions, notably in 1287, 1608, 1791 and 1938, the sea breached the sand dunes protecting the Thurne Valley causing extensive flooding. In 1791 there were nine breaches at Horsey and Waxham which were repaired by 1806 by the engineer and geologist William Smith, working for the Commissioners of Sewers set up in 1801.²¹ Smith also proposed a scheme to drain and reclaim the upper Thurne for agriculture just as was done in the Fens of Cambridgeshire and Lincolnshire.²² This was to include the complete draining of Hickling Broad and all the other broads in the upper Thurne. Fortunately Smith's scheme was not taken up by the principal landowners, who opted instead for the less ambitious schemes which were carried out under the enclosure awards.

7.6 Ownership Since Enclosure

From about 1780 to 1901 the Hickling Hall estate belonged to the Micklethwait family of Taverham Hall. It then passed to relatives, the Mills family who still own that part of Hickling Broad within Hickling parish.²³ The Cubitt family owned the Catfield Hall estate from 1740 until it was sold to Mr Lubbock in 1866, including since the enclosure awards the portions of Hickling Broad in the parishes of Catfield and Potter Heigham plus Whiteslea and Heigham Sound.²⁴ Just before World War One Lord Lucas, together with Mr Montague and Sir Edward Grey, bought those parts of the Catfield Hall estate from the Lubbock family and also leased the rest of Hickling Broad from Colonel Mills.²⁵ How this estate then passed to Lord Desborough, then to the Cadbury family and the Norfolk Naturalists Trust is explained in detail by Stewart Linsell in "*Hickling Broad and its wildlife*".²⁶

Most of the parishes of Horsey, Waxham and Palling belonged to the Brograve family of Waxham Hall from 1733 and it passed by marriage to Mr Conyers in the 1820s. In 1803 they sold Horsey to Robert Rising whose family were large landowners in West Somerton and Martham.²⁷ Rising's estate included Horsey Mere and he had a new road built to link Horsey and Somerton; prior to this the coast road literally went along the coast between Horsey and Winterton.

The conflict between ownership of broads and the rights of others to sail and fish on them came to a head in the legal case of Micklethwait versus Vincent in 1893.²⁸ It was fought by Walter Rye the honorary solicitor for the Norfolk Broads Protection Society representing Vincent, a local marshman. The plaintiff was Mr Micklethwait, the owner of Hickling Broad in Hickling Parish, whose title comes from the allotment of the Broad to his family by the Hickling Enclosure Award of 1808.²⁹ The case confirmed the public right to sail over all the water of the Broad and not just a channel across it. Rye claimed that the Broad was tidal and as such the bed of the Broad belonged to the Crown, as did that of the river Thurne. Therefore it could not be allotted into private ownership by an enclosure award. The Court of Appeal refused to believe that the Broad was tidal and refused to overturn the enclosure award. In the 1890s everyone assumed that the broads were lakes of natural origin and did not consider them to be flooded quarries, as has since been established. Had this been known at the time it would probably have supported the case for the legitimacy of

private ownership by means of an enclosure award as “land covered with water” but it would not have affected what rights might exist over it. (See also footnote on page 23)

7.7 Shooting

Since late medieval times this wetland provided a living for many local people, harvesting the fen products, fish and wildfowl. Hunting, trapping and shooting would have been mainly for the “pot”: Duck Broad in particular was a noted hunting ground. The area would have been held by various landowners along with the fowling, fishing and hunting rights. The advent of the railways brought the era of the shooting estate to the Broads.

In the 1800s and early 1900s Whiteslea estate established a reputation as a shooting lodge and estate. One well-known owner, Lord Lucas, dedicated part of the estate as a nature reserve and developed the area to provide wildfowl habitats (especially for migratory birds). Under the expert management of Jim Vincent it was acclaimed the finest duck shoot in the country. Lady Lucas later purchased Horsey Estate and declared it as a nature reserve and some remaining rights were leased from Colonel Mills.

Coot shooting was carried out to control numbers, as they were seen as pests eating aquatic food plants for migrating wildfowl. Between December 1894 and February 1935, around 33,546 coots were shot as part of the conservation management of the area.

7.8 Fishing

As with shooting, many local people would have depended on fishing these waters for their livelihood, for the pot or to sell excess. Most marshmen would have been equipped with an eel spear and nets.

As the railways brought leisure fishing to the Broads, landowners sought to enhance their fisheries. Excellent water quality and abundant reed swamp would have provided very good conditions. Deep Dyke was noted for its bream fishery and the whole area was renowned for pike fishing.

A reduction in water quality coupled with major natural pollution events affected the fishery profoundly. In 1938 the sea breached a Horsey and thousands of fish were killed, only the eel survived with its unique capacity for adapting between salt and fresh water.

7.9 Eel Sett Candle Dyke

There is a long history of eel fishing in the Broads with several techniques being used ranging from eel baskets to eel spears to fyke netting. One of the older techniques was that of netting using an “Eel Sett”. This involved a large net being stretched across the river or dyke running top to bottom and tapering into 2-3 long pods. The net would be weighted on the bed whilst not in use and then pulled/winch up on an ebb tide to catch the eels. Fishing was carried out at night when the eels were more active and the rivers less busy with boat traffic. The eel catcher would fish for several nights and so the equipment included a wooden or canvas hut where the eel catcher would doze keeping a lookout for boat traffic.

Records for the eel sett on Candle Dyke date from late 1880s. Originally there would have been 3 or more along this stretch of dyke, but when fyke netting took off the eel setts dwindled and now the last one in the Broads is at Candle Dyke.

7.10 Establishment of Nature Reserves in the Thurne System

Hickling Broad was the first of the Upper Thurne nature reserves to be established, when Norfolk Naturalists Trust purchased the Whiteslea estate in 1945 from Lord Desborough's daughter Lady Gage. Grants from Mr Christopher Cadbury, the RSPB, the Pilgrim Trust and Society for the Promotion of Nature Reserves helped fund the purchase.

In 1948, Horsey Estate was donated to the National Trust by Major Anthony Buxton, and is managed on a lease-back arrangement by the Buxton family. The Mere, marshes and fens have been managed as a nature reserve since then.

Martham North and South Broads became a Norfolk Naturalists Trust reserve when they were leased in 1971. The reserve was subsequently purchased for the Norfolk Naturalists Trust by Christopher Cadbury.

Notes:

All source references are to documents in the Norfolk Record Office unless otherwise indicated.

The principal printed sources for the landscape history of the upper Thurne valley are listed in Chapter 11 References and Documentation.

¹ Lambert p46; Moss pp46-49; George pp18-20.

² Williamson pp74-77; Moss pp90-91; George pp39-40.

³ BR276/0422 Little Waxham map 1829; MC175/1 Horsey enclosure map 1816.

⁴ Lambert pp42-46 & fig 32.

⁵ E. Ekwall, *Oxford Dictionary of English Placenames*, pp220-221.

⁶ Lambert pp70-74.

⁷ Lambert pp99-102.

⁸ Lambert pp100-101; George p314.

⁹ Church Comm 164297-164304 Ludham manor court books.

¹⁰ George p84; K. Bacon, *History of the Landscape of Catfield*, 1991 (unpublished) pp9-14.

¹¹ Bacon pp9-14; Catfield church registers-perambulation.

¹² Bacon pp214-215; PC18/1 & C/Ca1/50 Potter Heigham enclosure maps 1806.

¹³ Bacon p215; W. Marshall, *The Rural Economy of Norfolk*, 1787.

¹⁴ Bacon pp191-196.

¹⁵ *Faden's Map of Norfolk, 1797*; C/Ca1/29 Hempstead et al enclosure map 1812; BR90/40/28 Ingham enclosure survey 1820.

¹⁶ C/Ca1/50 & PC18/1 Potter Heigham enclosure maps 1806.

¹⁷ *Faden's Map of Norfolk, 1797*; C/Ca1/50, PC18/1 & C/Ca1/30 Potter Heigham & Hickling enclosure maps 1806 & 1808.

¹⁸ C/Sca2/151, C/Sca2/219 & C/Sca2/67 Hickling, Potter Heigham & Catfield enclosure awards 1808.

¹⁹ Bacon p211; C/Sca2/67 Catfield enclosure award 1808.

²⁰ Bacon p211; MC665/M533631 Catfield Hall estate sale catalogue 1842.

²¹ EAW2/120 W. Smith, *Report on Sea Breaches to the Commissioners of Sewers*, 1803.

²² DN/MS6/6 W. Smith, *Report to Commissioners for Draining Hickling & Heigham Marshes 1804*.

²³ Linsell p39.

²⁴ MC1843/8-10 Conveyance of Catfield Hall estate 1866.

²⁵ DLV/1/108 schedule & [PRO] IR127/6/315 maps Inland Revenue Survey 1910.

²⁶ Linsell pp37-43.

²⁷ MC90/1 R. Porter, *A Stranger's Guide to the Polite Village of Martham*, 1830.

²⁸ Walter Rye, *The Hickling Broad Case, Micklethwait v Vincent*, 1893.

²⁹ C/Sca2/151 & C/Ca1/30 Hickling enclosure award & map 1808.

8. MANAGEMENT OBJECTIVES

AIM:

To achieve and subsequently maintain an ecologically healthy aquatic system of broads, rivers and dykes in favourable condition, whose special features are conserved in harmony with the maintenance and sustainable management of traditional rights and access to the broad for the purposes of navigation and recreation and the promotion of viable local livelihoods.

1. To achieve and maintain Favourable Condition⁶ for the international, national and locally important features of the open water and margins of the Upper Thurne.

As a minimum the following conditions would need to be met (as defined in Appendix 6):

- Good water quality.
- Clear water .
- Extensive aquatic plant beds present throughout the water bodies.
- Actively-growing reed swamp margins.
- Suitable habitat to support healthy winter waterfowl populations.

2. To maintain recreational access across the Upper Thurne water space as a resource for public enjoyment.

As a minimum the following conditions would need to be met:

- Maintain adequate water depth⁷ for boating throughout the water space, without prejudice to navigation rights.
- Maintain adequate⁸ water space for recreation.
- Maintain access to and develop opportunities for boat moorings
- Promote eco-friendly boating with sails, electric power, or pollution-free motorboats.
- Maintain access on foot.
- Maintain access for angling.

3. To promote and enhance engagement with interested parties in the management of the Upper Thurne rivers and broads.

- Maintain shared responsibility for water space management, through a process that builds trust by open communication and consensus building, and deliver a water space management plan for the shared use of the Upper Thurne rivers and broads.

⁶ Favourable Condition is defined as 'good ecological health that can be maintained in the longer term'. The requirements of favourable condition are defined by English Nature.

⁷ Water depth specifications will be developed as part of the Broads Authority Sediment Management Strategy 'Waterways Specifications'. Note that these have not been widely agreed yet amongst stakeholders, and are likely to require Environmental Impact Assessment. and/or Appropriate Assessment under the Habitats Directive.

⁸ Hickling Broad Sailing Club definition is that "the overall aim will be to maintain and enhance the current water space".

4. **To facilitate research into the restoration and management of aquatic habitats and species.**
 - Regularly monitor the status and condition of the system with respect to European and national conservation status using key indicators.
 - Identify and fill in the gaps in understanding the system and the requirements for its restoration.

5. **To promote greater public understanding of the natural, cultural and social heritage values of the site in order to inform and develop appropriate use of the site.**
 - Provide readily accessible, well interpreted information on the natural, cultural and social heritage of the Upper Thurne.
 - Promote the Upper Thurne at an appropriate level and in a consistent manner with respect to its values and services.

6. **To allow for a changing landscape in a sustainable manner, whilst protecting physical resources of cultural heritage significance.**
 - Identify, protect, retain and/or record and interpret cultural heritage resources.
 - Engage in key catchment-wide initiatives which influence landscape change, including future coastal defences, flood alleviation works, changes to farming practices and renewable energy initiatives.

7. **To encourage a viable local community and a thriving local economy**
 - Encourage initiatives within the objectives of this plan which enable people to develop the local economy.

Guiding Principles

The Upper Thurne Water Space Management Plan objectives will be implemented in a sustainable manner and in line with the Guiding Principles set out in the 2004 Broads Plan, particularly with reference to the following:

Guiding Principle 1 *The Broads will be promoted as a national park, accessible to people of all abilities and social backgrounds to enjoy in quiet and environmentally sustainable ways that are in keeping with its distinctive natural and cultural beauty and that are appropriate to a nationally and internationally protected area.*

Guiding Principle 5 *Water resources within the catchment will be managed sustainably to ensure the proper functioning of the Broads as a wetland system. Habitats, with their associated plants and animals, will be maintained and enhanced to protect them from damaging development, and degraded habitats will be restored to good ecological status. Opportunities will be sought to create new habitats to counter historic trends in the fragmentation and degradation of habitats, and to increase the capacity of the flood plain to function more naturally.*

Guiding Principle 7 *The enjoyment of the waterways is part of the culture of the Broads. The waterways will be maintained and enhanced for purposes of navigation and their safe enjoyment and understanding by the public.*

Guiding Principle 9 *Where there are likely threats of serious or irreversible damage to the environment, as a precaution, cost-effective measures will be taken to prevent environmental degradation in the absence of full scientific certainty of the outcome of such threats.⁹ Such precautionary action will be based on assessment of the costs and benefits of action, and transparency in decision-making.*

In addition, rights of access, as documented in Chapter 5, and relevant legislation as summarised in Appendix 2 and Section 1.4, will provide the overarching framework for the implementation of these objectives.

⁹ Based on the definition of the Precautionary Approach in the *Rio Declaration on Environment and Development*, 1992.

9. IMPACT ASSESSMENT: CONSTRAINTS AND RATIONALE

9.1 Constraints

This section reviews the major impacts that may constrain achievement of the management objectives of the Upper Thurne Water Space Management Plan.

Category	Impact
Natural trends	
Growth of underwater vegetation	Restricts access for sailing and potentially causes safety problems for water craft users.
Salinity	Saline water enters the upper Thurne via land drainage and salt surges up river bring in saline water. This can promote outbreaks of the toxic alga <i>Prymnesium parvum</i> , which leads to changes in the overall fish composition for many years. Increasing salinity can also stress <i>Chara</i> growth and may lead to its decline.
Geese and swans grazing on reed swamp	Loss of marginal reedswamp habitat, already under pressure from increasing nutrient levels, is hastened by grazing and trampling, and opens the margins to erosive wave wash in strong winds. In addition, fish refuges are reduced. The decline in reed vigour reduces its growth into open water where boating might take place, but can leave peat baulks as underwater hazards.
Waterfowl grazing on submerged aquatic plants	Waterfowl grazing reduces vigour of aquatic plants. This could be a natural method of controlling excessive aquatic plant growth, which could be a recreational benefit.
Man-induced trends	
Diffuse pollution entering catchment from agriculture, roads, discharges and air	Sediments, from land sources, accumulate in the water, bringing nutrients into the aquatic environment. High nutrient levels cause proliferation of algal growth and dominance by phytoplankton. Aquatic plant communities become unstable and switch into unfavourable condition. Turbid water reduces light levels within water column. Populations of species such as bittern, otters, fish and invertebrates, become unsustainable. Angling quality declines due to poor water quality impacting on fish populations.
Drainage	Increases saline water entering water bodies with increases in ochre production. The associated problems such as turbid water, smothering of plants and animals and poor water quality impacts on populations of wetland species, such as otter, fish, dragonflies and aquatic plants. The ochre looks unsightly, and can impact poorly on visitor experience.
Sediment accumulation	If left unmanaged causes shallow water and eventual loss of open water. This impacts on recreation activity, restricting boat access on the water and from land to water where dykes silt up. This is identified as a particular problem in northern end of Hickling Broad. Accumulated sediment is incompatible with clear water objectives, if disturbed. Some species, such as the nationally protected Holly-leaved Naiad will grow in accumulated sediment.
Mud pumping and Dredging	Removes phosphate source. Either operation could cause localised changes water chemistry with potential impact on fisheries. Also can result in removal and exposure of aquatic plant seed and vegetative sources. Dredging changes the lake morphology, altering the current range of substrates (shallow gravel margins and deep soft sediment) and water depths. Deeper water will be darker.
Aquatic plant cutting	Cutting can change composition and condition of aquatic plant beds, removes seed and growth for next season. Additionally, there is a potential impact on water quality as nutrients are released into the water if plant material is left to decompose in the water.

Category	Impact
	Without the cutting, there is an impact on the recreational importance of area. Cutting reduces food supply for wintering waterfowl and cover for other wetland species. Overall, cutting and removal of cut plants has less impact on water quality than no cutting and feeding by waterfowl, given that waterfowl effectively release nutrients locked up in the plants via their guano. Lack of aquatic plant diversity impacts on productive fishery.
Boat use	Heavy use can damage the composition and extent of aquatic plant beds. Increasing pressure on water space can lead to damage of natural and cultural features.
Wintering waterfowl disturbance	Bird numbers decline if roosting and feeding areas are continually disturbed. Birds can lose condition, which impacts on winter mortality and summer breeding reducing recruitment into the population. Winter refuges restricts some access for recreational angling and boating.
Non-native and invasive species	Contribute to unstable ecosystem, for example greylag geese grazing on reed margins. Non-native species impact on native wildlife for example mink on protected species water vole.
Lack of awareness	Of conservation status, importance and interest of the site and its fragility amongst users. Failure to recognise and value the unique features of Hickling Broad for sailing. Lack of awareness of status, importance and interest of site for angling and as a fishery amongst other users. Communication fails to bring about changes in behaviour.
Lack of facilities	Loss of reputation as place to visit, so decline in visitors. This will impact on businesses in the area. Loss of navigable water, also a facility, could add to loss of reputation.
Appropriate sign posting	Without co-ordinated signage and information, confusion and lack of understanding and awareness of issues can result.
Land based recreation	Enables greater understanding and appreciation of the area. Joined up with water recreation could create high value recreation/tourism opportunity with careful management in high value conservation areas
Decline in local economy	Less future investment into maintaining recreational and conservation features. Seasonality of tourist trade can result in unviable businesses.
External factors	
Coastal breach	If coastal defences are not maintained, and longer-term measures to protect the Upper Thurne from salt water flooding are not in place, then changes to the biological functioning of the Upper Thurne could be dramatic.
Pollution	Inputs of nutrients, including saline water and ochre, from the pumped drainage system continue to influence the condition of the water space. Other sources are mainly from agriculture. Intermittent discharges from sewers, septic tanks and soakaways may have an impact.
Flood management	Maintenance of floodbanks on their existing line could raise water levels, as more space for water may be required with rising sea levels and impacts of climate change. However, unmanaged floodbanks could cause localised flooding.
Legal constraints	
	Duties under the main Acts relevant to the waterways are outlined in sections 4 and 5. These sections do not include all Acts that may affect the use of the site.

Category	Impact
Duties under the following Acts apply	Norfolk and Suffolk Broads Act 1988 Conservation (Natural Habitats etc) Regulations 1994 Wildlife and Countryside Act 1981 Countryside and Rights of Way Act 2000 Occupiers Liability Act 1996 Health and Safety at Work Act 1974 Town and Country Planning Acts
Other legislation (see Appendix 2)	Port Marine Safety Code 2001 (voluntary code) Water Framework Directive 2000 (not part of the UK legislation so not a duty yet).
Constraints of tenure	The water space is owned or leased by Norfolk Wildlife Trust, National Trust and Horsey Estate.
Constraints of access and shared use of water space	Access to the water space has a number of differing constraints. On Hickling, voluntary waterfowl refuges are marked with buoys from November to March. Windsurfers are restricted from entering the Pleasure Boat island winter refuge; boat users are requested to avoid or modify their use of the refuges during this period. Horsey Mere waterfowl refuge is closed to angling by boat from November to end of February, and other boat users voluntarily avoid use of the water during this period. Angling access to the mouth of Horsey Mere at Meadow Dyke was piloted during winter 2005/06. Access is not permitted to Martham North or South Broads, unless by angling permit to Martham North subject to permit conditions. At other times the water space is shared by beginner and racing sailing craft, fishing dinghies, pleasure craft, motor and sailing cruising crafts and other small craft. There is a potential for conflict between users.
Health and safety of employees	All works carried out on site must be done in full compliance with the Health and Safety at Work Act (1974), and by implementing relevant organization's own Health and Safety procedures, particularly those applying to lone working. The sites are deemed to be hazardous due to the presence of water.
Management constraints	
Management constraints	Staff and financial resources from partner organisations are limited. Generally resources are available to maintain present situation in the Upper Thurne. However, additional resources will be required for implementing the Action Plan.

9.2 Rationale

This section is concerned with identifying and describing, in outline, the management considered necessary to meet the management objectives. This could include maintenance or restoration of features to favourable conservation status. Those that link to action plan projects are highlighted in **bold** (see Chapter 10).

Water Quality

The nutrient levels in the Upper Thurne water space remain largely too high to meet favourable condition criteria as required under the Countryside and Rights of Way Act 2000. This is in spite of a decrease in phosphorus levels resulting from the dispersal of the black-headed gull roost on Hickling. Diffuse pollution from agriculture and inputs via the pumped drainage system are identified as input sources. **Further research is currently underway** into the functioning of these nutrient sources, nutrient cycling and potential longer-term solutions. The **reporting back and actions from this research** will influence further actions to improve water quality. **Annual water quality monitoring carried out by the Environment Agency** should

continue to help in assessing further improvement works. Environmental Quality Standards will be determined for the Water Framework Directive and will establish a framework for nutrient thresholds in the aquatic environment of the Upper Thurne. However, the Habitats Directive is more requiring than the Water Framework Directive, and tighter threshold targets will need to be implemented.

Salinity levels are high within the Upper Thurne water space in a system that is generally brackish, but having additional inputs from a pumped drainage system. Reducing the salinity could bring about a marked improvement in the ecology of the Upper Thurne water space, and options have been put forward for raising water levels in the Brograve catchment and for re-design of some of the ditch carrier system and modifying the IDB pumps to **take off fresh top water rather than the contaminated bottom water**. Based on the Broads Research Advisory Panel seminar (February 2006) a **target for chloride at 1600mg l⁻¹** was proposed as a realistic target to aim for initially.

Aquatic Plant Communities

Aquatic plants respond in various ways to water quality improvements. The recovery of intermediate stonewort *Chara intermedia* in Hickling Broad in 1998 is a good demonstration of this effect. However, since 1998, the condition of the *Chara intermedia* beds has fluctuated, with improved, vigorous growth in 2003, to a decline again by 2005/06. This highlights the unpredictability and unstable nature of the aquatic ecosystem. Procedures for experimental cutting of *Chara intermedia* plots were established during 1999 and reviewed in 2004. In effect, if the condition of the *Chara* should recover such that the plant exceeds a mean height of 50cm in 50% of the sampling stations then the experiment and monitoring will proceed. Ideally this experimental cutting would be carried out in successive years to determine the impact of year-on-year cutting, and thus feed into the Broads Authority's work on plant cutting standards. However, this situation has not yet been reached. The condition of the *Chara intermedia* beds should continue to be **monitored annually** to establish their condition and when this cutting experiment can continue.

Monitoring is an important aspect of the work determining the condition of aquatic plant communities and their response to changing nutrient and salinity and should be maintained for all other water bodies in the Upper Thurne.

Clear Water

Clear water promotes the growth of submerged aquatic plants. The fisheries will potentially flourish in aquatic conditions that support a diverse aquatic plant community with low nutrient inputs. Clear water is not a condition particularly required by watercraft users, although it is welcomed and appreciated by many users. HBSC prioritises plant-free water depth over clear water.

Aquatic Plant Cutting

Flourishing aquatic plants can cause access problems for users of boating and sailing craft if the growth remains unmanaged. Since the 1960's, boaters and sailors have generally experienced aquatic plant-free conditions and hence developed patterns of use that utilise the majority of the Upper Thurne water space. Whilst the water quality and condition of the aquatic plant communities are internationally important conservation features, the recreational importance of the area necessitates the exploration of some level of intervention. Questions have been posed, such as 'How far can aquatic plants be managed, primarily by cutting, to retain the

international conservation features in favourable condition, as well as enabling people to enjoy the recreational waters'? This question has not been answered yet, due to the fluctuating condition of the aquatic plants, particularly *Chara intermedia*. However, agreement has been reached guided by an Appropriate Assessment Panel about criteria for carrying out cutting experiments to provide data towards answering this question. This situation does not satisfy the immediate needs of watercraft users, but elements have been incorporated into the experimental design to try to accommodate some of their requirements. However, these elements have not been found to be at all effective by sailors.

The **annual monitoring of the condition of the water and the *Chara intermedia* lawns** informs a **decision on the season's experimental cutting**. This work should continue to **inform and guide the decision making process**.

Other aquatic plants, such as Water milfoil and Mares tail, which can produce luxuriant summer growth, are cut as part of the Broads Authority's plant cutting programme. Aquatic plant cutting within the Special Area of Conservation (SAC) is carried out according to Appropriate Assessment under the UK Habitats Regulations, and as knowledge of plant condition and cutting process advances, so the prescriptions for cutting will develop. The sailing community assist with informing the Broads Authority of the growth of the plant beds. **Further work should continue to monitor and inform** cutting prescriptions for managing aquatic plant communities.

Wintering Waterfowl

The Upper Thurne waters have a national reputation as a winter pike fishery. Record weights of pike have been caught between January and March. This period is also critical for the large population of wintering waterfowl, which arrive during October and begin to depart by March. Disturbance free roosting and feeding is important for their survival and condition for returning to their breeding grounds. In response to the requirements of the birds, **Horsey Mere is closed to angling by boats** during the winter period, currently during the months from November to February inclusive. **A pilot scheme to allow limited angling** during these months was established at the entrance to Horsey Mere for the 2005/06 winter months. This pilot has been monitored and the data collected during this pilot has enabled further decisions about this scheme for future winters. Angling from boats is available elsewhere in the Upper Thurne system, but with **voluntary exclusion zones on Hickling Broad refuges**, where anglers and other boat users are requested to avoid using or to modify the way they use the refuges if it cannot be avoided. Martham North Broad has a permit system established to enable angling three days a week during October to March, and is closed to all craft the remainder of the year. Martham South Broad is closed to craft all year.

Communicating this information to anglers and greater understanding by the wider public is key to the success of the refuges. A range of methods are currently used such as leaflets, written articles and information boards as well as anglers being involved themselves as wardens and bailiffs. These mechanisms need to be **regularly reviewed and improved** where necessary. **Improving the system of marking refuges, using buoys**, will add further to communication.

There has been a high voluntary commitment from both angling and non-angling boat owners to providing quiet refuges for the wintering waterfowl. However, as a further measure, a **mechanism for enforcing** the closed access is in place under the Countryside and Rights of Way Act 2000 (CroW Act). This covers those who recklessly and intentionally disturb the wintering waterfowl, and are therefore subject

to a fine of up to £20,000. Although working together through a shared understanding is by far the preferable route to managing access and wintering waterfowl, there will be some situations where these stronger measures may be required. English Nature, Norfolk Wildlife Trust, National Trust and Broads Authority will continue to **monitor the refuges** and **put communication mechanisms in place**, but also to enforce the CroW Act where the situation and evidence warrants.

Reedswamp Communities

Some marginal reedswamp communities are being lost around Hickling and Martham South Broad. High nutrient levels, impacts of geese grazing and high water levels contribute to this recession. Protecting the Hickling margins with geese barriers appears to have halted the regression in places, however, the long-term sustainability of these measures, including their impact on the landscape, is under discussion and review. **Monitoring the effectiveness of the barriers should continue**, and **discussions about other control measures for geese** should take place. Consideration will need to be made about whether reed fringe can co-exist with geese grazing if it is healthy and actively growing before further goose control measures are implemented. **Short-term protection and restoration of the reed fringe margins of Martham South Broad** under the Lakes PSA scheme will be an interim measure, but longer-term solutions achieved by **lower water levels and improvements to water quality** are more likely through longer-term projects such as the Broads Flood Alleviation Project and **changing farming methods** through the Environmental Stewardship programme.

Sediment Management

The landscape and environmental quality of the Upper Thurne is part of the recreational experience, and gaining adequate access to the water space is an integral part of the experience. Different types of activity require different water depths. For sailing 1.3m is sufficient but canoeing can use shallower water. The water depth in the Upper Thurne is currently at between 0.6m in the gravelly margins and 1.5m in the main channels. About 80% of Hickling Broad is less than 1.3 metres deep. A wholesale dredging programme for Hickling Broad in particular might not necessarily be desirable, cost effective, or feasible for a variety of reasons. On the other hand some level of dredging work may meet the needs of both recreational access and improvements to the conservation condition of the broad, providing opportunity for aquatic plants to flourish and stabilise. **Essential dredging work of access routes** will continue, subject to any assessments required under the Habitats Directive. **Further investigations, experimentation and assessment should be made into potential for a larger scale operation.**

Access Infrastructure

Many local businesses depend on visitors coming to and making use of the facilities offered in the Upper Thurne. Access to and on the water is provided by the various moorings, slipways, staithe and public rights of way. Peoples' perception of the experience on offer can be coloured by the quality and extent of facilities, failure to meet expectations can result in business going elsewhere. It is essential that the **facilities are of a good quality** and of an extent that does not compromise the experience itself, environmentally or visually. **More could be made in marketing** the Upper Thurne as a place to visit for a high quality experience, and **an assessment of this, the infrastructure required and how this would impact on the environment people visit to experience** would be required.

10. **THREE YEAR ACTION PLAN RELATING TO OPERATIONAL OBJECTIVES, OUTLINE PRESCRIPTIONS AND PROJECTS**

10.1 **Long Term Opportunities**

In the long-term the character of the Upper Thurne could undergo dramatic changes as a result of changes to local coastal defences, land management at the catchment scale and changes to the flood embankments through the Broads Flood Alleviation Project, which could offer opportunities for wetland creation and enhancement.

In addition, the emerging Natural Environmental and Rural Communities Bill may give new opportunities to fully develop the following longer term projects:

1. Creating natural habitat on the coast to act as a natural barrier for the Upper Thurne against the sea.
2. Working with landowners to address diffuse pollution from agriculture and promote Environmental Stewardship take up and the Catchment Sensitive Farming initiative. This will also target salinity and ochre inputs in the Upper Thurne.
3. Creating new areas of washland, wetland and/or open water, including recreating reedswamp, to provide new opportunities for wildlife and recreation.

The principles and projects from this Upper Thurne Water Space Management Plan will also need to be incorporated into the Local Development Framework, the spatial planning document replacing the Broads Local Plan (May 1997)

10.2 **Broads-wide Projects**

Whilst not proposing specific projects under this Water Space Management Plan, the Upper Thurne Working Group recognises and is supportive of the following Broads-wide projects and areas of work (not in any priority order):

1. Develop a rural skills base as part of a wider Broads programme.
2. Support the Norfolk Biodiversity Action Plan (BAP) and emerging Broads Local BAP.
3. Work with Broads-wide initiatives to improve water quality in the catchments
4. Draw together Broads-wide information on feral geese, their movements and methods for controlling if necessary.
5. Review boat speed limits and requirements for any reductions.
6. Review the use of electric charging points for boats.
7. Encourage all Broads boat users to switch to more environmentally friendly fuels, including biodiesel.
8. Promote a minimal use of antifoul or biocide-free principle on boats using the Upper Thurne or elsewhere in the Broads.
9. Encourage the Broads Local Access Forum to pursue registration of unregistered Rights of Way by 2020 (CROW Act).
10. Monitor moorings condition and implement Moorings Strategy, where appropriate, in the Upper Thurne.

UPPER THURNE ACTION PLAN (2006 – 2009)

BA	Broads Authority	HE	Horsey estate	RDS	Rural Development Service
BASG	Broads Angling Strategy Group	IDB	Internal Drainage Board	UTWG	Upper Thurne Working Group
EA	Environment Agency	NT	National Trust		
EN	English Nature	NWT	Norfolk Wildlife Trust		

Natural Resources

Operational Objective	Outline Prescription	Project	Suggested partnerships	Timescale in years
Achieve and maintain good water quality and quantity	Maintain adequate supply of good quality water	Assess feasibility of modifying IDB pumps to take off fresh top water rather than contaminated bottom water.	IDB, with BA, EN	2006/07
	Reduce nutrients and salinity to produce clear water conditions	Monitor water quality.	EA, IDB	annual
		Identify options for lowering salinity to below the threshold of 1600mg/l ¹	EN, BA, EA, RDS, IDB	
		Monitor fish population, phytoplankton and <i>Prymnesium</i> levels.	EA	annual
		Carry out feasibility study to investigate combating salinity increases by pumping freshwater.	EA, IDB, EN, RDS	2006/07
Achieve and maintain extensive plant beds	Promote recovery of aquatic plants in open water	Monitor <i>Chara</i> condition and extent on Hickling Broad.	BA	annual
		Assess <i>Chara</i> cutting experiment.	BA, EN	annual
		Investigate experimental re-establishment of aquatic plants.	BA, EN	2007/08
		Experiment with suction dredging to bed of broad on partitioned area of broad.	BA	2006
	Survey and monitor aquatic plant and animal communities	Carry out annual macrophyte survey.	BA	annual
		Monitor aquatic plants on a six yearly basis in all Upper Thurne water bodies.	BA, EN	2006

Natural Resources

Operational Objective	Outline Prescription	Project	Suggested partnerships	Timescale in years
Achieve and maintain actively growing reed swamp margins	Manage impact of pest species	Monitor effectiveness of goose barriers around Hickling Broad.	NWT, EN, BA	ongoing
		Assess current programme of Canada and greylag geese control and continue if appropriate.	EN, BA, NWT, NT	2006/07
	Gather data on habitat extent	Map extent of reedswamp from aerial photos and compare with maps of 1970s.	EN, BA, NWT, NT	2006/07
	Restore and enhance habitat	Restore reedswamp margins along Martham South Broad and Duck Broad.	NWT, BA, EN	2006/07
		Manage scrub encroachments onto reed margins.	BA, NWT, NT	annual
Achieve and maintain winter waterfowl population	Monitor wintering waterfowl and refuges	Monitor population of wintering waterfowl annually using WeBS counts.	NWT, NT, HE	annual
		Monitor effectiveness of voluntary refuges in relation to disturbance of wintering waterfowl.	BA, EN, NWT, NT HE	annual
		Manage seasonal buoys on Hickling Broad and Horsey Mere.	BA, NWT, NT, HE	annual
		Review distribution of wintering waterfowl refuges.	BA, EN, NWT, NT HE	annual
	Provide information about management methods within the water space	Communicate with water space users about voluntary winter waterfowl refuge system.	BA, EN, NWT, NT HE	annual
	New opportunities for wetland and water space	Investigate restoration of Horsey Island.	BA, EN, NT, HE	2006/09

Access and Recreation

Operational Objective	Outline Prescription	Project	Suggested partnerships	Timescale in years
Maintain appropriate water depth for sailing	Produce Waterway specifications	Develop management prescriptions for aquatic plants.	BA, EN, UTWG	2006/07
		Develop best practice to minimise floating material from the weed cutting operation.	BA, UTWG	2006/07
	Plan for and implement dredging works	Assess experimental sediment removal on enhancing water depth for recreational sailing and impacts on the SAC condition.	BA with UTWG	2006/07
		Cut aquatic plants according to cutting prescriptions and Appropriate Assessment.	BA with UTWG	annual
	Provide beneficial re-use of dredging material	Restore sites currently storing dredged material around the Upper Thurne.	BA, NWT,NT, HE with UTWG	2007/08
Enforce speed limits and promote eco-friendly boating	Ensure appropriate and safe marking and signage for navigation	Regularly patrol the waters.	BA	ongoing
		Review aging navigation markers along the main channel.	BA	2006/09
Maintain and monitor access on foot	Develop new opportunities for land access in relation to the water space	Encourage landowners to develop permissive paths particularly through Environment Stewardship scheme.	RDS, BA,	2006/09
		Develop circular routes and provide viewpoints across the water space.	BA, PCs	2006/09

Access and Recreation

Operational Objective	Outline Prescription	Project	Suggested partnerships	Timescale in years
Maintain access for angling	Enhance slipway provision	Ensure partners in the UTWG are informed of the recommendations from slipway strategy. Jointly develop proposals to implement recommendations where environmentally acceptable.	BA, UTWG	2006/09
	Enhance angling access from land and water	Enhance bankside angling stations	EA, BASG	2006/09
		Trial controlled, limited access for angling to Horsey Mere during winter months	HE, NT, EN, BA	2006/07

Enhance Engagement with Interested Parties

Operational Objective	Outline Prescription	Project	Suggested partnerships	Timescale in years
Maintain shared responsibility for water space management	Provide co-ordination for delivery of the Management Plan	Keep up-to-date with funding opportunities and schemes for delivering projects.	UTWG	ongoing
	Ensure UTWG is fully participative in delivery of the Management Plan	Consult on the Upper Thurne Water Space Management Plan.	UTWG	2006
		Develop a Memorandum of Agreement for the UTWG to work together to deliver the Management Plan.	BA with UTWG	2006
		Produce a Management Plan summary and launch.	UTWG	2006
		Annually record progress with the Plan and review by March 2009.	UTWG	annual
		Provide administrative support to the UTWG.	BA	ongoing
	Communicate the Water Space Management Plan to wider stakeholders	Engage the wide public, and local stakeholders in the development of plans and projects.	UTWG	ongoing

Research into the Restoration and Management of Aquatic Habitats and Species

Operational Objective	Outline Prescription	Project	Lead and partners	Timescale in years
Monitor condition and status of system using key indicators		Carry out boat census every 4 years.	BA	2006
		Carry out condition monitoring of fish and bird populations, phytoplankton levels, aquatic plants and water quality.	EA, BA, EN, NWT, NT, HE	annual
		Monitor water space depth by repeat hydrographic survey.	BA	2006/07
Encourage study and research	Contribute towards MSc and PhD projects	Carry out research into aspects of tolerance of stoneworts and other macrophytes to various pressures including salinity. This may include transplantation projects.	BA	2006/09
		Identify actions from the Upper Thurne research programme as projects or part of the longer term strategy.	BA	2006/07
		Investigate carrying out research into movements of Upper Thurne birds, within and to outside the Upper Thurne in response to food supply, roost sites and disturbance.	BA, EN, NWT, NT, HE	2006/07

Promote Greater Public Understanding

Operational Objective	Outline Prescription	Project	Suggested partnership	Timescale in years
Provision of good quality interpretation material and facilities	Provide effective communication materials	Continue to up date leaflet on wintering waterfowl	BA, EN, NWT, NT, HE, BASG	annual
		Improve signage on water and land throughout the Upper Thurne	UTWG	2006/09
		Develop projects with local schools	UTWG	2006/09
Promote the Upper Thurne in an appropriate way	Develop projects to promote the Upper Thurne	Develop a system of long distance viewing points on land to include roadside pull ins and facilities such as telescopes	UTWG	2006/09
		Provide web site information on special features of the Upper Thurne and opportunities for people to enjoy and experience them	UTWG	2006/09

Protected and Recorded Landscape and Cultural Heritage

Operational Objective	Outline Prescription	Project	Suggested partnership	Timescale in years
Protect, record and interpret cultural heritage resources	Develop understanding and knowledge of Cultural Heritage resource	Ensure cultural features such as windmills, staithes and rights of way in the Upper Thurne are recorded and researched.	UTWG	2006/09
		Carry out research on windmills and other key buildings.	UTWG	2006/09
	Develop projects to promote the Cultural History of the Upper Thurne	Develop permanent verbal and visual records of the cultural history of the Upper Thurne.	UTWG	2006/09

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12. GLOSSARY

Competent Authority

Competent authorities are those that have statutory functions, duties and responsibilities to act, consent or authorise plans or projects under the Habitats Directive (e.g. public bodies, Broads Authority).

Diatom

A microscopic alga, in which the cell wall is composed of silica and consists of two halves.

Eco-Friendly boating

Refers to locally environmentally-friendly and whole life sustainability considerations; these principles are guided by Broads Research Advisory Panel Sustainability Workshop and the Eco-Boat seminar 2004. Considerations include noise, fumes, clean and efficient fuel type, antifouling paint and hull design.

Epiphytic

A plant or animal that uses another plant for its physical support but does not draw nourishment from it.

Phytoplankton

A community of largely microscopic algae suspended or floating in natural waters. They comprising mainly diatoms in cooler waters, and include the bloom-forming blue-green algae.

Public Service Agreement (PSA)

Defra high level target of 95% of all SSSIs in favourable or unfavourable recovering condition by 2010.

SSSI Condition

The condition of SSSI land in England is assessed by English Nature using categories agreed across England, Scotland, Wales and Northern Ireland through the Joint Nature Conservation Committee. There are six reportable categories: favourable, unfavourable recovering; unfavourable no change; unfavourable declining; part destroyed and destroyed. English Nature's web site has more details www.english-nature.org.uk.

Total Phosphorous (TP)

TP includes all phosphorous bound to suspended particulate matter, contained within the phytoplankton and the phosphate dissolved in the water column.

Zooplankton

Zooplankton are aquatic organisms that drift with water movements, generally having no locomotive organs. They include protozoans, small crustaceans and in early summer the larval stages of many larger organisms. Zooplankton which feed on diatoms may show weak locomotory powers.

Upper Thurne Working Group: Terms of Reference

CONTEXT

The Upper Thurne lies in the north-eastern corner of the Norfolk and Suffolk Broads. It comprises Hickling and Martham broads, and Horsey Mere. All are interconnected by a system of rivers and dykes that drain surrounding agricultural land, both arable and grazing marshes. Hickling, with 116 hectares of open water, is the largest of any of the broads in Norfolk and Suffolk.

Hickling Broad is partly owned and much of the remainder leased by the Norfolk Wildlife Trust. The Trust also owns Martham North and South broads. Horsey Mere is owned by the National Trust and leased to the Horsey Estate Trust by whom it is managed. Public rights of navigation exist throughout the Upper Thurne, although in practice this is limited to areas of sufficient depth for navigation.

The Upper Thurne is among the most important stretches of rivers and broads for nature conservation within the Broads Authority's executive area. The Upper Thurne Broads and Marshes is a Site of Special Scientific Interest (SSSI), notified on account of its extensive areas of open water, fen and grazing marsh habitats that support a diversity of nationally rare plant and animal species. Some of this diversity reflects the prevailing brackish conditions, unique to this part of the Broads system, and the near pristine condition of Martham Broad.

The international importance of the Upper Thurne for nature conservation is reflected in its inclusion within Broadland Special Protection Area and the candidate Broads Special Area of Conservation, designated under the European Birds and Habitats directives, respectively. Features reliant upon aquatic habitats include *Chara* vegetation, the diverse assemblage of pondweeds, bittern, shoveler and gadwall. It also forms Hickling Broad and Horsey Mere and part of Broadland, both designated as a Wetlands of International Importance especially as Waterfowl Habitat under the Ramsar Convention. The pertinent features include: the open water communities, the rare holly-leaved naiad and the stoneworts *Nitellopsis obtusa*, *Chara intermedia* and *Chara connivens*; outstanding numbers of wintering waterfowl, including notable populations of wigeon, gadwall, mallard, teal, and shoveler; notable populations of, mute swan and pochard; and the marginal swamp that provides breeding habitat for water rail, gadwall, garganey and particularly significant numbers of pochard.

Parts of the Upper Thurne are very important for recreational pursuits, particularly sailing, the boat hire industry and angling, all of which date back from 100 to 150 years. Hickling Broad is internationally renowned as a prime inland water for sailing¹⁰, as well as being considered the best broad on which to sail because of its large size and close proximity to sea breezes. It is one of only 13 sites on the broads available for year round navigation and supports a number of local boatyards, as well as both sailing and windsurfing clubs. With respect to angling, by the 1950s the Broads had gained the reputation of being Britain's finest fishery and Hickling is best known for its pike, with 34 of 40 years of record catches being from this location.

The Upper Thurne broads are also important for other forms of recreational boating and land-based forms of recreation such as walking and cycling. They provide a popular destination for those seeking to experience and enjoy among the best examples of the Broads scenery and its associated wildlife.

¹⁰ English Nature accepts that Hickling Broad is renowned for sailing but does not accept its international status.

AIM

The overall aim of the Upper Thurne Working Group is to develop by consensus a common vision and plan for sustainably managing the rivers and broads of the Upper Thurne. This will be based on a sound understanding of the functioning of the hydrological and ecological catchment area, its importance for natural and cultural heritage, navigation and other forms of recreation, social and economic activities and on the promotion of best environmental practice in its management.

OBJECTIVES

1. To develop a common understanding among stakeholders of:
 - (a) the importance of the Upper Thurne for natural and cultural heritage, navigation and other forms of recreation, and social, cultural and economic activities;
 - (b) the hydrological and ecological functioning of the catchment and the way that this offers opportunities and provides constraints to possible management options; and
 - (c) the legal framework under which the site will be managed.
2. To define and agree by consensus a process and schedule for formulating a long-term management plan (10 years or so) for the Upper Thurne, focused on maintaining the environment and waterways in good, sustainable ecological condition in harmony with the traditional use of and access to Hickling and other broads for navigation and other forms of recreation¹¹.
3. To develop a management plan within the framework provided by the European Habitats Directive/Regulations, given that the Upper Thurne forms a part of the Broads candidate Special Area of Conservation and Broadland Special Protection Area, and other relevant national and international legislation, including the Norfolk and Suffolk Broads Act and the Ramsar Convention.
4. To be responsible for the development of the management plan through a consensus-building approach, based on the results of a proposed three-year Upper Thurne Research Programme.
5. To review present management arrangements for Hickling Broad in the light of its current, changing ecological conditions and by consensus recommend a suite of interim measures, including possible scientific experiments to inform future management, to cover the short-term (i.e. next three years or so, while the Upper Thurne Research Programme is underway).
6. To ensure that lessons and experience learnt from the Upper Thurne process contribute to the development of an overall strategy for rivers and broads that is planned by the Broads Authority, and to ensure that the vision and plan for the Upper Thurne is integrated with this strategy.

¹¹ This is based on the minutes of the Broads Authority meeting on 16 May 2001 which read as follows: "The Chairman of the Environment Committee proposed that the recommendations of the Assessment Panel be endorsed by the Broads Authority and this was seconded by the Vice-Chairman of the Navigation Committee on the assurance that Broads Authority's policy, in respect of Hickling Broad, would continue to maintain the broad in a good sustainable ecological condition in harmony with the traditional use of and access to the broad for boating and in particular sailing."

SCOPE

The geographical remit of the Upper Thurne Working Group will cover the entire catchment area of the Upper Thurne (i.e. upstream of the junction of the River Thurne with Candle Dyke), while focusing specifically on that part of the catchment which falls within the Broads Authority's executive area.

The management plan will focus on providing an integrated strategy for achieving conservation and recreation objectives with respect to the rivers and broads of the Upper Thurne. Such a strategy will need to include recommendations on measures for mitigating against land use and water management practices in the surrounding catchment area that adversely impact on achieving such conservation and recreation objectives.

The management plan will need to be phased in view of the proposed three-year programme of research and the hydrological study commissioned by the Environment Agency and undertaken by ENTEC, which is designed to improve current knowledge of the hydrology and ecology of the Upper Thurne ecosystem as a basis for future management.

OPERATING PRINCIPLES

1. The Upper Thurne Working Group will be established by the Broads Authority.
2. The Working Group will be administered by the Broads Authority. The Chairperson will be identified by the Group in agreement with the Chief Executive of the Broads Authority.
3. The Working Group will be represented on the Advisory Board of the Upper Thurne Research Programme and ensure that these two initiatives are properly integrated with each other, under the overall guidance of the Broads Research Advisory Panel.
4. The Working Group will comprise representatives of conservation, recreational and local community interest groups listed at the end of this paper. Duplication of representation of a given interest group will be avoided in the interests of the Working Group being small, cohesive and effective.
5. Members of the Working Group may co-opt a substitute in the event of being unable to attend a particular meeting.
6. The Working Group will co-opt experts and representatives of other relevant interest groups by consensus as necessary.
7. Statutory bodies, such as English Nature, represented on the Working Group will participate in an informal advisory capacity and such input shall not prejudice any formal opinion or advice.
8. The Working Group will coordinate the formulation of the management plan through a consensus-building process, based on the active agreement of all members. Where consensus cannot be reached on any matter, the reasons for disagreement will be established and attempts made to address the matter through other means as appropriate, such as via subgroups and/or independent conflict resolution. Meanwhile, the Working Group will move on to other aspects of its agenda.
9. The management plan will be developed within the framework of relevant local, national and international legislation and policies, including the European Habitats and Water Framework directives and the Ramsar Convention.

10. Members of the Working Group will be expected to take an active interest and participate in initiatives and events concerned with the future management of the Upper Thurne, including the series of four *Hickling Gatherings* beginning in October 2000.
11. Members of the Working Group will be responsible for consulting with their respective constituencies and affiliated bodies on all proposed policies and management measures.
12. The Working Group will develop appropriate mechanisms for consulting beyond the constituencies represented by its membership, so that the wider public and local residents and businesses may have opportunities to express their interests and contribute to the management planning process.
13. In the interests of providing for informal discussion and debate, meetings will not be formally minuted. Notes will be taken of topics discussed, points of agreement and disagreement, and action points.
14. The Terms of Reference of the Working Group will be considered to have been completed on production of the management plan, for which the Broads Authority will have ultimate responsibility for progressing its implementation. Thereafter, future needs for such a group will be reviewed.

Interest groups to be represented on Working Group

Broads Authority
 English Nature
 Environment Agency

Parish Councils

- Catfield
- Hickling
- Horsey
- Martham
- Potter Heigham
- Somerton

Broads Angling Strategy Group
 Broads Hire Boat Federation
 Broads Society
 Electric hire-boat yards
 Hickling Broad Sailing Club
 Hickling Broad Windsurfing Club
 Horsey Estate Trust
 Internal Drainage Boards
 National Trust
 Norfolk and Suffolk Yachting Association
 Norfolk Wildlife Trust
 RSPB
 Sailing hire-boat yards

Note: Each interest group will be represented by one person, except for the Broads Authority which will be represented by an appropriate number of officers.

Taken from Final Draft November 2004.

Legislation

Nature Conservation

International Legislation

Ramsar Convention:

The Convention on Wetlands of International Importance, especially as Waterfowl Habitat'. This is a global convention, signed at Ramsar in Iran in 1971, and ratified by the UK in 1976. The three main aims are:

- designation of wetlands as Ramsar sites,
- promoting the 'wise use' of wetlands, and
- international co-operation.

The Upper Thurne is part of the Broads Ramsar site (see Map 2).

EU Legislation

Habitats Directive:

This Directive promotes maintenance of biodiversity by requiring member states to take measures to maintain or restore habitats and species at 'favourable conservation status', with national governments reporting to the EU every 6 years. It includes designating a series of protected sites (Special Areas of Conservation SAC), which together with SPAs classified under the **Birds Directive** (see below), makes up an EU-wide network of sites (the **Natura 2000** series).

Birds Directive:

This Directive requires member states to take steps to protect listed bird species and the habitats on which they depend by classifying Special Protection Areas (SPA). The Upper Thurne is part of the Broadland SPA.

Both the Habitats and Birds Directives are enshrined in UK legislation under the Conservation (Natural Habitats &c) Regulations 1994, otherwise known as the '**Habitats Regulations**'. The Upper Thurne forms one of the component parts of the Broads-wide Natura 2000 site.

Water Framework Directive:

Establishes a framework for integrated and co-ordinated management of all waters in England and Wales, through an environmental outcome driven approach. It aims to ensure all waters meet 'good status' by 2015 by identifying environmental problems through risk-based assessment and target resources efficiently to address these problems. The Directive requires member states to establish river basin districts and management plans, to be reviewed every 6 years.

UK Legislation

Wildlife and Countryside Act 1981 (as amended):

This underpins statutory nature conservation in the UK, and most significantly, makes provision for the notification by English Nature of Sites of Special Scientific Interest (SSSI), and where appropriate, National Nature Reserves managed by 'approved bodies' other than EN. IN the Upper Thurne Hickling Broad and Heigham Sound with adjacent fens, reedbeds and wet woodland, and Martham Broads are NNRs.

Countryside and Rights of Way Act 2000

The Wildlife and Countryside Act 1981 is supplemented and amended by the CRoW Act 2000, which strengthens protection of SSSIs by giving English Nature greater enforcement powers, and makes provision for open public access to certain types of

land (defined as mountain, moor, heath, and down). Section 28 places a duty on all public bodies, including the Broads Authority, to enhance the special interests of SSSIs.

The provisions of the 1995 Environment Act (Section 62) and 2000 CRoW Act (Sections 85 and 97) confer statutory duties on 'relevant authorities', which include statutory agencies and local authorities, to have regard to the purposes of national parks, Areas of Outstanding Natural Beauty and the Broads.

Biodiversity Action Plans:

The production of BAPs derived from the UK's ratification of the Convention on Biological Diversity, itself one of the outcomes of the Earth Summit in Rio in 1992. BAPs provide a framework for achieving biodiversity conservation based on targets for habitats and species. These are identified and planned for at local, regional and national level, and usually implemented by local partnerships. They cover broad habitats (e.g. open waters of the broads) to species such as stoneworts or otter.

Access and Recreation Legislation

Norfolk and Suffolk Broads Act 1988 ('The Broads Act')

Pursuant to the Norfolk and Suffolk Broads Act 1988 the Broads Authority is constituted as the statutory harbour and navigation authority for the Broads Navigation Area as defined in the Act. The Broads Authority is also a harbour authority within the terms of the Harbours Act 1964.

The Broads Act places a duty on the Authority to maintain the Navigation Area, for the purposes of navigation to such standards as appear to it to be reasonably required and to take such steps to improve and develop the Navigation Area as it thinks fit. In this respect the Authority is given specific powers to maintain and improve the waterways (along with the rest of the Navigation Area) and to deepen, dredge, scour and excavate it. There is a power to remove and dispose of wrecks. Persons (other than statutory undertakers) engaged in works which may affect the Navigation Area are required to obtain a license from the Authority, which is also given powers to deal with unsafe moorings, structures etc.

The Act also gives the Authority certain powers to make byelaws for navigational purposes and to give formal directions to those in charge of vessels via its appointed Navigation Officer.

Broads Authority Byelaws

The Authority has used its powers under the Broads Act to make four sets of byelaws. These are:

- Broads Speed Limit Byelaws 1992, which regulate the speed of power driven vessels within the Navigation Area,
- Broads Navigation Byelaws 1995, which control the navigation of vessels and such matters as the steering, mooring and anchoring of vessels.
- Broads Registration Byelaws 1997 require the registration of vessels using the navigation area and the payment of navigation tolls, and;
- Broads Vessel Dimension Byelaws 19?? Impose maximum dimensions for vessels regularly using parts of the Navigation Area, including Barton Broad and the River Ant.

The Authority is currently promoting byelaws that will impose Boat Safety Standards on vessels using the Navigation area. All previous navigation and related byelaws have been repealed, however the East Suffolk and Norfolk River Authority Byelaws, under the Water Resources Act, 1963 and Rivers (prevention of pollution) Acts, 1951-1961 remain in force pursuant to which it is an offence to discharge sewage from any power driven vessel which does not proceed to sea beyond Great Yarmouth.

The Broads Authority also has duties imposed on harbour authorities by the Common Law, including to take reasonable steps to remove or make navigational users aware of hazards to navigation for example by navigational marking. Common Law principles relating to the management and availability of harbour and navigational facilities may also apply as appropriate to the Broads Authority and facilities under its control

Public Right of Navigation

Under the Common Law there is a presumption of a public right to navigate in tidal waters. The Authority's Navigation Area is defined in the Broads Act in terms of those waters, which were in use for navigation by virtue of public right at the commencement of the Act (1st April 1989). The right of the public to navigate within the Navigation Area is expressed to be subject only to payment of the tolls and navigation charges as prescribed in the Broads Registration Byelaws. The Broads Act also empowers the Broads Authority to close defined parts of the Navigation Area to navigation for certain closely defined periods and purposes. It would be unlawful for any other person to seek to close or deny navigational access by the public to any part of the Navigation Area.

Public Right of Fishing

Under Common Law (Magna Carta) there is a public right to fish in tidal water. Environment Agency Fisheries Byelaws, Anglian Region 2002, apply which include a closed season for rod and line fishing between March 15 and June 15 inclusive. Eel fishing is allowed with appropriate licensed fyke nets.

Statutory Regulations

The Broads Authority is a Competent Harbour Authority within the terms of Pilotage Act 1987. This obliges the Authority to consider whether pilotage should be compulsory within any part of its Navigation Area, and if so, to provide a pilotage service. As a competent Harbour Authority the Broads Authority is also required to comply with the provisions of the Port Marine Safety Code, which requires the Authority to manage all navigational and related risks in accordance with established risk assessment principles and to put in place a Safety Management System which will ensure that all risks are managed so as to be as low as reasonably practicable.

The Broads Authority is also bound by the Merchant Shipping (Oil Pollution, Response and Cooperation) regulations 1998 to prepare and keep updated an approved contingency plan to deal with spillages of oil into its waters, and to have in place measures for containment and clean up of oil spillages. The Authority is required regularly to exercise its contingency plan.

Submerged Aquatic Plants

Species	National Red Data Book status	British status	Location in Upper Thurne	Comments on ecology
<i>Chara aspera</i> Rough stonewort			Hickling Broad, historically from Horsey Mere, Martham North and South Broads, Somerton channel, a few ditches	Extensive beds on firm substrates in shallow water north and south Hickling Broad
<i>Chara baltica</i> Baltic stonewort	Vulnerable	4 sites since 1970: Cornwall, Devon, Shetland, Hickling Broad. BAP priority species	Hickling Broad, Horsey Mere, Martham North and South Broad	Slightly brackish species. Found in central part of the broad.
<i>Chara canescens</i> Bearded stonewort	Endangered	1 site since 1970 in Cambridgeshire; Hickling record 1959	No recent records	Brackish species
Species	National Red Data Book status	British status	Location in Upper Thurne	Comments on ecology
<i>Chara connivens</i> Convergent stonewort	Endangered	3 sites since 1970: Devon and upper Thurne. BAP priority species.	Hickling Broad, Martham North and South Broads, formerly Heigham Sound	Able to grow amongst larger stoneworts. Mainly associates with <i>C. aspera</i> lawns
<i>Chara curta</i> Lesser bearded stonewort		Insufficiently known; 13 sites since 1970; Hickling record 1949 rediscovered 1998. BAP priority species.	Hickling Broad	Grows amongst <i>C. aspera</i> . Unlikely to spread into softer sediments away from the broad edge
<i>Chara contraria</i> Opposite stonewort		Nationally scarce	Hickling Broad small quantities, but no recent records	Distribution poorly known
<i>Chara globularia</i> Fragile stonewort			Hickling Broad, Martham North and South Broads	Occurs with Milfoil and Charophyte dominated areas. Widely and sparsely scattered.
<i>Chara hispida</i> Bristly stonewort			Hickling Broad, Martham North and South Broads	Occurs with Milfoil and Charophyte dominated areas. Widely and sparsely scattered.
<i>Chara intermedia</i> Intermediate stonewort	Endangered	Rare; 5 sites since 1970; all upper Thurne. BAP priority species	Hickling Broad, Martham North and South Broads, sparse in Horsey Mere	A robust species of calcareous lakes and broads near the sea. Extant populations are subject to extreme fluctuations

Species	National Red Data Book status	British status	Location in Upper Thurne	Comments on ecology
<i>Chara pedunculata</i>			Martham South Broad	
<i>Chara vulgaris</i> Common stonewort			Hickling Broad, Martham North and South Broads, Somerton channel	North eastern corner. May have been overlooked in other areas.
<i>Nitellopsis obtusa</i> Starry stonewort	Vulnerable	2 sites since 1970; upper Thurne. BAP priority species	Hickling Broad, Martham Broad, Somerton channel and intermittently in Heigham Sound	
<i>Tolypella glomerata</i>			Only in Somerton channel	
Vascular plant species				
<i>Callitriche</i> sp. Water starwort			Occasionally in trace amounts	
<i>Ceratophyllum demersum</i> Hornwort			Occurred widely and sparsely in 1980s	Often associated with nutrient rich conditions
<i>Elodea canadensis</i> Canadian pondweed			Occasionally in trace amounts	
<i>Fontinalis antipyretica</i> Water Moss			Occurred widely and sparsely in 1980s	Often associated with nutrient rich conditions
<i>Hippuris vulgaris</i> Marestalk			Heigham Sound, Martham North and South Broads, Somerton channel and Horsey Mere	
<i>Najas marina</i> Holly leaved naiad	Vulnerable	Confined to the Broads in the UK. Listed under schedule 8 of the Wildlife and Countryside Act 1981 and a BAP priority species.	Heigham Corner (abundant), Hickling Broad, Martham Broads, West Somerton channel, Heigham Sound	Develops July onwards. Prefers open aquatic vegetation on soft sediments.
<i>Myriophyllum spicatum</i> Spiked Water-milfoil			Hickling Broad	Most abundant species and forms the main vascular plant community

Species	National Red Data Book status	British status	Location in Upper Thurne	Comments on ecology
<i>Potamogeton crispus</i> Curled pondweed			Throughout	Mainly on Milfoil beds fringing the central channel
<i>Potamogeton pectinatus</i> Fennel pondweed			Throughout	Component of the Milfoil community
<i>Potamogeton pusillus</i> Slender pondweed			Throughout	Sparsely in Milfoil dominated and mixed Milfoil/Charophyte areas
<i>Sparganium emersum</i> Submerged bur-reed			Only in Somerton channel	
<i>Zanichellia palustris</i> Horned pondweed			Throughout in trace amounts	

Appropriate Assessment Panel

EU Habitats Directive and Appropriate Assessment

The EU Habitats Directive (92/42/EEC), implemented in England by the Habitats Regulations 1994, makes provision for carrying out an Appropriate Assessment for any project not necessary for the conservation management of a European site (Special Area of Conservation SAC). This assessment must only address the impacts of the proposals (project) on the nature conservation interest. It does not enable assessment of impacts on recreation, socio-economic or human interests.

The Habitats Regulations 48(3) also sets out arrangements for a competent authority, which in the case of assessing the proposed experimental cutting of *Chara intermedia* in Hickling Broad, is the Broads Authority. The Competent Body appoints an Assessment Team to carry out the Appropriate Assessment.

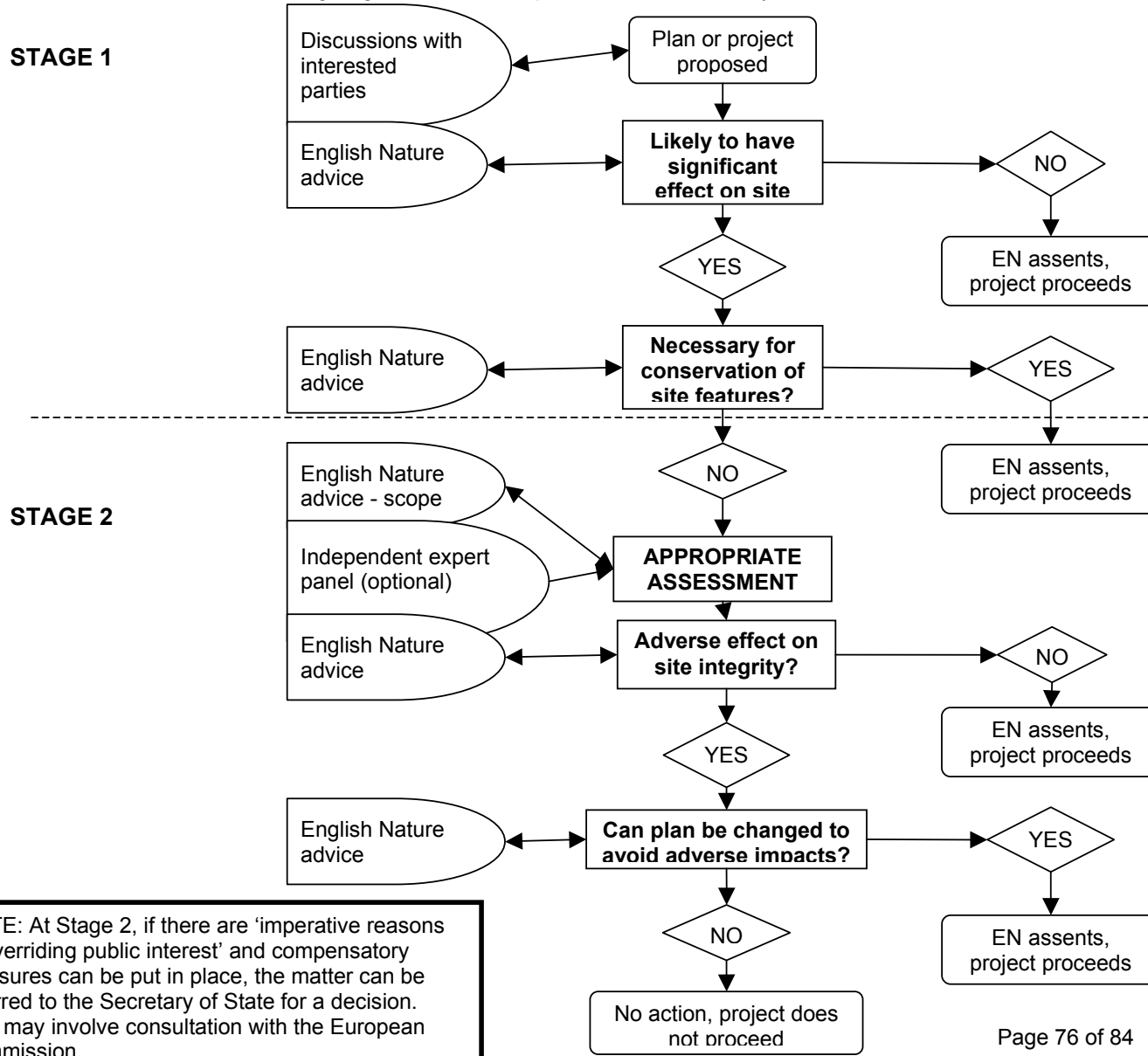
The Assessment Panel was established by March 1999, and comprised the following members:

Appropriate Assessment Panel members	
Dr JW Eaton	University of Liverpool (Chairman)
Ms J. Harris	Independent consultant, Norwich
Professor B Moss	University of Liverpool
Mr J Sharpe	RSPB, Norwich (to 17 June 1999)
Dr K Smith	RSPB, Sandy (from 18 June 1999)
Mr NF Stewart	Independent consultant, Crediton
Professor P Wathern	University of Wales, Aberystwyth

This Panel was supported by Broads Authority officers being called upon as required, with advice obtained from English Nature, the Environment Agency, Norfolk Wildlife Trust and the University of East Anglia, together with other individuals with specialist knowledge of the Upper Thurne Broads.

ASSESSMENT PROCESS FOR PROJECTS IN THE BROADS SAC/SPA

It is the responsibility of the Competent Authority (likely to be the Broads Authority) to produce the Appropriate Assessment through consultation with and advice from others, including English Nature. The process for the Authority is shown in **bold**.



Notes on the Process

The planning stage is crucial.

The Broads Authority will discuss the plan or project with interested parties, including English Nature. The aim should be to produce a plan or project which will not have a significant effect on the site.

If this can be achieved, it will not be necessary to proceed further and the project can be carried out.

Should a plan or project have a likely significant impact on site integrity, and not be necessary for conservation of site features, an Appropriate Assessment would be required.

The Broads Authority, independent experts and English Nature aim to respond as quickly as possible and ensure that mechanisms are in place to resolve issues quickly.

The Upper Thurne Working Group will be contacted within a month. English Nature maximum response time is 21 days.

The speed of any response will be related to how much information is available on the subject, hence the importance of continuing research.

NOTE: At Stage 2, if there are 'imperative reasons of overriding public interest' and compensatory measures can be put in place, the matter can be referred to the Secretary of State for a decision. This may involve consultation with the European Commission.

Upper Thurne Management Research

Research Studentships

Deriving a Catchment Mass Balance for a lowland wetland system: a case study of the Upper Thurne catchment, Norfolk Broads

University of East Anglia (UEA)
Supervisor: Kevin Hiscock
Student: Faye Horn

The Broads are a nationally important lowland wetland. The local climate, soil and the wetland nature of the area influence the major agricultural activities that include arable farming (particularly cereal and beet crops) and cattle grazing. Potential negative effects of such agricultural land use include eutrophication and loss of biodiversity of the rivers and lakes resulting in catchment runoff of agrichemicals via both interflow and groundwater discharge to surface water courses.

Pollution by agrichemicals (nitrogen (N) and phosphorus (P)) can result from direct application of inorganic fertiliser and from nitrification of cattle manure. Research has shown that direct measurement of nitrate in drainage waters following application of N fertilizers can give a range of concentrations. This research is also interested in the correlation between nitrate and nitrous oxide.

It is possible that in lowland wetlands, such as the Broads, the marsh system can act beneficially as sites for attenuation of N and other nutrients along a flow path from the marsh surface to the final pumped water discharge to the external drainage system.

To test this possibility, this research is directed at determination of nutrient inputs to and outputs from the system. Any difference in the balance equation will suggest nutrient transformations (e.g. nitrification and / or denitrification) occurring within the marsh environment. Quantification of these nutrient transformations will contribute to an informed assessment of the beneficial effects of the marsh as a possible zone of attenuation.

Understanding the causal relationships between salinity problems and land drainage and the prospects for engineering solutions

Cranfield University
An EPSRC funded CASE PhD studentship sponsored by the Kings Lynn Consortium of Internal Drainage Boards
Supervisor: Ian Holman
Student: Trevor Simpson

The Thurne catchment in north-east Norfolk is an extremely important part of the Broads national park, a Special Area of Conservation (SAC). Extensive engineered land drainage of the marshes of this coastal catchment has led to land subsidence and the need for drainage pumps to control water levels sufficiently below sea-level to maintain agricultural productivity. Consequently, seawater from the North Sea has intruded into the underlying Norwich Crag (sand) aquifer and brackish groundwater enters some land drainage channels, thereby raising their salinity (Holman *et al.*, 1998).

There is increasing interest in changing the engineering, operation and management of the drainage systems away from a focus on intensive agriculture towards fulfilling multiple

functions for extensive agriculture, biodiversity and fluvial and coastal flood defence. This should enhance the water quality of the Broads (shallow lakes) and the river Thurne into which the brackish water is discharged by the drainage pumps. Options previously identified include sealing drainage channels, engineering a new coastal interceptor drain, raising water levels or re-siting the pumps to discharge directly to the sea.

However, there is insufficient fundamental understanding of the relationship between the engineering design and operation of the drainage system and the saline intrusion of the aquifer (Holman & Hiscock, 1998). Such understanding is a fundamental prerequisite for re-designing the system to balance environmental and flood protection issues. This research project therefore aims to provide a sound scientific basis on which to assess the likely consequences of engineering solutions to the salinity problem within the catchment.

An Integrated Catchment Scale Model of Lowland Eutrophic Lakes and River System: Norfolk UK

Cranfield University
Supervisor: Sue White
Student Jodie Whitehead

A sound understanding of the Thurne system and its wider catchment is required, particularly with respect to nutrient cycling. In appreciating the functioning of the Thurne system future management strategies may be implemented to restore the system to good ecological status.

The aim of this study is to build a catchment scale model of water and nutrient sources in the Thurne system and its wider catchment (Rivers Bure and Ant). The model will be used to simulate hypothetical scenarios to allow the identification of both land use and water management strategies, which will enable the restoration of the system to good ecological status. To accomplish this aim the following objectives will be pursued:

- To identify and evaluate spatially and temporally varying sources of nutrients to the system
- To undertake intensive sampling to monitor the short term dynamics of the system
- To understand the movements of water and nutrients within the system.

Understanding the Hydrodynamics of the Upper Thurne System

Cranfield University
Supervisor: Sue White
Student: Sofia Martinez
Work to be completed by: Sue White working with Karen Fisher (an independent consultant)

Hydrodynamic modelling will be used to investigate the in-river flow process and saline inputs/outputs at Hickling Broad. The model will estimate the inputs from pumps and use real tide level variation and scaled up flow data to account for the whole catchment.

The model will be run to include different pumping, climate and land use scenarios. Worst-case pumping scenarios will be assessed, investigating water levels likely if pumps are switched off and impacts on suspended sediments, plant growth and turbidity.

Characterising the photoautotrophic response to the spatiotemporal variability in underlying environmental conditions in shallow eutrophic lakes through airborne remote sensing. Case Study: The Upper Thurne, Norfolk, UK

University of Sterling

Supervisors: Andrew Tyler, David Gilvear, Nigel Willby

Student: Peter Hunter

It is now recognised that shallow and eutrophic freshwater lakes have two possible alternative stable states: (1) a clear water state characterised by abundant submerged vegetation, and (2) a turbid state where the water body is dominated by the growth of phytoplankton with little or no submerged vegetation. It is suggested that the mechanism(s) of alternation between these polar states is an intricate function of cascading trophic interactions responding, in part, to underlying but fundamental changes in the bioavailability of major nutrients and the underwater light climate.

The aim of this research is to use a combined in-situ spectroradiometric and airborne remote sensing led approach to gain a greater understanding of the potential photoautotrophic (phytoplankton and macrophytes) response to changes in the underlying environmental conditions (particularly nutrient status) within the shallow Broadland lakes of the Upper Thurne. The combined approach enables the key spectral reflectance characteristics of water quality parameters and photoautotrophic leaf and pigment properties to be established, allowing the remote sensing instrumentation configuration (CASI) to be optimised, imagery to be interpreted, and appropriate image analysis procedures to be identified and validated.

Anticipated Outputs and Wider Benefits

- A superior spatial understanding of the environmental controls that regulate eutrophic processes and the episodic switches between stable states within the Norfolk Broads (and shallow eutrophic lakes as a whole) identifying 'hot spots' for further research
- The provision of input and validation data for spatially distributed models of the Upper Thurne system
- The provision of data from which future Broadland management strategies can be developed and validated
- An evaluation of the potential role of remote sensing in monitoring ecological and physico-chemical quality parameters with respect to EU WFD requirements

Switching mechanisms, biodiversity and ecosystem stability in complex shallow lakes

Liverpool University

Supervisor: Brian Moss

Student: Tom Barker

Wetland lake systems can exist in alternative states of plant or plankton dominance. Each is stabilized by biological mechanisms, and nutrient-influenced switch mechanisms are required to convert one to the other. There is circumstantial but little experimental evidence for switch mechanisms. Also the restoration of diverse plant dominated systems is often unstable, perhaps because nutrients have been insufficiently controlled. Recent changes in Hickling Broad, Norfolk, offer an opportunity to test three hypothesis: that salinity can act as a switch, that nitrogen, rather than phosphorus, is the more important controlling nutrient, and that the stability of the system is determined by plant diversity, which in turn is controlled by nitrogen loading. A major experiment will be carried out in controlled mesocosms to test the three hypotheses.

**Working Summary of Favourable Condition Criteria for
Upper Thurne Large Water Bodies**

This summary should not be assumed to be definitive or inclusive and is only intended to assist the Upper Thurne Working group. In doubt, reference should be made to the complete Favourable Condition tables produced by English Nature.

To achieve Favourable Condition in the Upper Thurne broads, at least the following conditions would need to be met:

- Good water quality
*Targets of no more than 35µg/l¹ total phosphorus.
Targets for nitrogen are not yet available from the current state of knowledge.*
- Clear water
This is a pre-requisite for good quality aquatic communities.
- Aquatic plant beds present across the whole of the water bodies, except in marked channels (e.g. main channel across Hickling Broad and side channel connecting it to Catfield Dyke).
*These should consist of high biomass species which are accessible to feeding SPA birds¹². Low growing species such as *Chara aspera* would only be acceptable in shallow water, deeper water would require species such as *Chara intermedia* which are capable of reaching to or near to the surface from greater depths.*
- Actively growing margins
To provide feeding areas for bittern and feeding, breeding and shelter for other species of birds, fish and mammals, and for bank erosion protection.
- Disturbance free winter bird refuges over 50% of the total area of the Upper Thurne
Including areas for feeding as well as resting/sleeping. Particular emphasis should be given to Horsey.

Note:

The maximum area of 14.85 hectares of Hickling Broad originally agreed in 1999 for experimental cutting of *Chara intermedia* remain current, subject to criteria laid down by the Appropriate Assessment Team and agreed by the Broads Management Committee at its meeting in March 2004. Whilst giving rise to a reduction in biomass and abundance of *Chara intermedia*, such cutting is considered not to have an adverse effect on the integrity of the site. This would not be the case were the area to be increased.

¹² Special Protection Area (SPA) under the EU Birds Directive legislation, include gadwall, shoveler, wigeon, teal, pochard, great crested grebe, coot, tufted duck, and cormorant.

FAVOURABLE CONDITION CRITERIA USED TO DETERMINE CUTTING PRESCRIPTIONS AT HICKLING BROAD
(from Broads Management Committee report 18 March 2004)

Favourable condition criteria Cutting prescription ¹³	Water clarity (Chlorophyll and/or secchi depth)	Plant abundance (Biomass) ¹⁴	Water quality (mean summer total phosphorus)	Winter birds (food and disturbance)	Marginal reedswamp
No cutting ¹⁵	Turbid	Declining or low AND no significant improvement	<35µg l ⁻¹	To be defined in terms of adequacy and availability of food plant biomass, and degree of disturbance.	Regenerating
Limited cutting ¹⁶	Turbid	Building phase ¹⁷	<35µg l ⁻¹		Regenerating
14.85ha experimental cutting ¹⁸	Clear ¹⁹	Extensive, dense, healthy <i>Chara intermedia</i> lawns ²⁰	<35µg l ⁻¹		Regenerating
More extensive cutting ²¹	To be defined	To be defined	<35µg l ⁻¹		Regenerating

 Water clarity and plant abundance (shaded columns) are the critical favourable condition criteria used to trigger the cutting prescription.

¹³ Cutting prescriptions are based on the recommendations of the Appropriate Assessment Team.

¹⁴ Plant biomass will be used in preference to abundance, once it has been calibrated with plant height and cover in 2004.

¹⁵ It is agreed and understood that aquatic plants be routinely cut, as necessary, in the marked channel and approach to Catfield Dyke to maintain access to the Hickling Broad and the Dyke, respectively.

¹⁶ Limited cutting may be for recreational (e.g. around sailing marks) or small-scale experimental purposes.

¹⁷ Defined as: *Chara intermedia* (intermediate stonewort) shows year-on-year increase in abundance and height. Mean maximum height of *C. intermedia* exceeds 50 cm in at least 50% of stations sampled in the monitoring area; OR mean maximum height of *Myriophyllum spicatum* (spiked water-milfoil) exceeds 60cm AND abundance exceeds 50% cover in at least 50% of stations sampled in the monitoring area.

¹⁸ Cutting should seek to achieve an average height of 40cm above the bed of the broad. It is subject to all previously agreed monitoring requirements and safeguards. It should not continue beyond 31 August.

¹⁹ Clear water is defined as at least 90% compliance with an average secchi disk reading of at least 1 m at 40 locations randomised within the monitoring area, but not in the marked channels.

²⁰ Defined as: Growth of *C. intermedia* is vigorous, with continuing year-on-year increase in abundance and height. Mean maximum height of *C. intermedia* exceeds 50 cm in at least 90% of stations sampled in the cutting area; AND dense *C. intermedia* lawns extend over at least 39 ha of the Broad.

²¹ More extensive cutting will be considered only when there is sufficient evidence that such cutting is unlikely to have any significant short- or long-term impact on the favourable status of the open water features, namely water quality, water clarity, submerged rooted macrophytes and wintering birds.

Long Term Issues Impacting on the Management of the Upper Thurne

This Water Space Management Plan covers the short to medium-term issues of management relating to features of conservation interest and recreation interests and requirements of the Upper Thurne. Beyond the artificial boundary drawn around the water space for the purposes of this Management Plan, other plans are underway and will need to be incorporated into longer term planning for the area. These are summarised below. Their output will have an influence on future management planning for the Upper Thurne.

Ochre and Salinity in the Brograve Catchment

A Water Level Management Plan (WLMP) was produced by the Kings Lynn Consortium of Inland Drainage Boards (KLCIDBs) in March 2001 to cover the Brograve drainage district lying within the Happisburgh to Winterton IDB. An assessment of water quality within the WLMP showed that past drainage works have significantly affected water quality, with salinisation and acidification being an acute problem. Discharges from the Brograve pump affects the water quality of Horsey Mere, which is part of the Upper Thurne Broads and Marshes SSSI and Broads Special Area of Conservation (SAC) site, and is impacting on its international features. One of the Nature Conservation Objectives of the WLMP was to ensure that discharges from the Brograve pump do not compromise the water quality of the receiving waters.

The first step in furthering this objective was the study and production of a report entitled 'Ochre in the Brograve Catchment Causes and Cures' (April 2002 by Mike Harding, Ecology, Land and People). This report identified the problems and proposed a range of short term measures and longer-term solutions. This was further developed in the 'Feasibility Study for Solutions to the Salinity and Ochre Issues in the Brograve Catchment' in November 2005 by Ecology, Land and People (ELP) and Institute of Water and Environment, Cranfield University.

Kelling to Lowestoft Shoreline Management Plan

A Shoreline Management Plan (SMP) is a non-statutory, policy document for coastal defence management which forms part of an overall Defra strategy for coastal and flood defence. The SMP provides a large-scale assessment for addressing the risks to people and to the environment (historic, natural and developed) in a sustainable way.

This stretch of coastline from Kelling to Lowestoft has a rich diversity of features including cliffs and low lying plains fronted by dunes and beaches. The coast is characterised by a number of towns and villages along the coastal fringe interspersed by extensive areas of agricultural land. This combination of assets creates a coastline of great value, with a tourism economy of regional importance.

The Broads, and in particular the Upper Thurne, is situated inland from this coast, with national and internationally important freshwater and brackish habitats. The recreation and tourism importance of the Broads is also recognised, and the fact that any coastal management strategy will need to carefully consider the impacts of policies on these resources.

The short-term aims for the SMP are to protect existing communities against flooding and erosion. In the long-term a more sustainable approach is promoted, allowing coastal processes to function more naturally to provide benefit for the coastal defence, landscape character and biodiversity in social and economic terms.

A consultation period for the SMP was held during 2005. However, the Plan had not been fully adopted by April 2006.

Broads Flood Alleviation Project

In May 2001 Broadland Environmental Services Limited (BESL) was awarded a 20 year contract by the Environment Agency to improve and maintain flood defences in Broadland. The Agency's approach to flood alleviation in Broadland was adopted in the 1990s and is based on a strategy consisting mainly of bank strengthening and erosion protection and reducing the risk of banks breaching. BESL updated this strategy and is now carrying out improvement works throughout 40 individual flood compartments in Broadland.

The major improvement works will be undertaken during the first ten years of the Project; thereafter the banks will be subject to regular condition monitoring and maintenance work as required.

The compartments involving the Upper Thurne water space are:

Compartment 6 (Womack to Candle Dyke)

Compartment 7 (Thurne Dyke to Shallam Marshes to West Somerton)

All of these banks are in need of strengthening, and about 5 kilometres of asbestos piling needs management. The current timing for these works is 2009 –2010, and BESL have begun discussions with landowners to work up the most sustainable solutions, which could potentially include areas of wetland creation.

Environmental Stewardship

Environmental Stewardship is a new agri-environment scheme launched on 3rd March 2005, which provides funding to farmers and other land managers in England who deliver effective environmental management on their land.

The scheme is intended to build on the recognised success of the Environmental Sensitive Areas scheme and the Countryside Stewardship Scheme. Its primary objectives are to:

- Conserve wildlife (biodiversity)
- Maintain and enhance landscape quality and character
- Protect the historic environment and natural resources
- Promote public access and understanding of the countryside
- Natural resource protection

Within the primary objectives it also has the secondary objectives of:

- Genetic conservation
- Flood management

Further information is available at www.defra.gov.uk/erdp

