Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS001b

Ant Broads and Marshes SSSI - Exemplar Diffuse Water Pollution Plan and Action Plan

The Broads Special Area of Conservation (SAC)

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Foreword

The **Improvement Programme for England's Natura 2000 sites (IPENS)**, supported by European Union LIFE+ funding, is a new strategic approach to managing England's Natura 2000 sites. It is enabling Natural England, the Environment Agency, and other key partners to plan what, how, where and when they will target their efforts on Natura 2000 sites and areas surrounding them.

As part of the IPENS programme, we are identifying gaps in our knowledge and, where possible, addressing these through a range of evidence projects. The project findings are being used to help develop our Theme Plans and Site Improvement Plans. This report is one of the evidence project studies we commissioned.

Water pollution has been identified as one of the top three issues in all Natura 2000 rivers. It also affects many terrestrial and some marine and coastal Natura 2000 sites. Diffuse Water Pollution (DWP) Plans are a joint Natural England and Environment Agency tool used to plan and agree strategic action in relation to diffuse pollution at the catchment-scale. They are the most frequently identified mechanism for improving water quality on Natura 2000 sites.

To enable effective targeting of measures DWP plans should be detailed, well evidenced and spatially specific to the catchment. Good practice for DWP planning and delivery is best led by example. This report is the result of one of the two Natura 2000, which were 'fast-tracked' to provide exemplar plans.

The results will be used by Natural England and others to help implement the actions required to achieve compliance with water quality targets and favourable condition for the Ant Broads and Marshes SSSI. This work will also be used to help develop and implement DWP plans for other Natura 2000 sites.

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Ant Broads and Marshes SSSI

Exemplar Diffuse Water Pollution Plan & Action Plan

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1. Introduction

1.1. Purpose statement

The purpose of this plan is to reduce the impact of diffuse water pollution (nutrients and sedimentation) on the Ant Broads and Marshes Site of Special Scientific Interest (SSSI). Where diffuse pollution is preventing SSSIs from achieving favourable condition, this plan:

- Identifies the causes, evidence of impacts and knowledge gaps;
- Identifies remedies and actions to be taken; and
- Identifies monitoring required to validate remedies.

1.2. Structure & Content

The DWPP has been divided into two parts:

- **Part 1: Summary of Evidence & Action Plan** – Sections 2 to 3: the measures that could be implemented in order to improve the condition of the SSSI in relation to diffuse pollution, including action owners and timings; and
- **Part 2: Supporting Evidence** – Sections 4 to 10: a summary of the scientific information that provides the evidence base for action. This summary evidence base is supported by technical appendices where appropriate.

1.3. DWP implementation

This Diffuse Water Pollution Plan is a live document and needs to be used and updated regularly.

The Plan is owned by Natural England who, in partnership with other national regulatory stakeholders, local stakeholders and delivery partners, will implement actions to achieve compliance with water quality targets and achieve favourable condition for the SSSI.

1.4. Key contacts

Organisation	Role	Current contact
Natural England	Catchment Sensitive Farming Officer	Victoria Fradley
	SSSI Responsible Officer: Ant Broads and Marshes	Adrian Gardiner
	Lead on WFD delivery in Broads	Chris Bielby
	Lead for the DWPP – Ant Broads and Marshes	Kate Waters
Environment Agency	Senior Environment Officer, Norfolk EM team	Lisa Turner
	Area PSA co-ordinator	Rob Dryden
Broads Authority		Dan Hoare

PART 1 – SUMMARY OF EVIDENCE & ACTION PLAN

2. Summary of evidence for DWPP Actions on the Ant Broads and Marshes SSSI

2.1. What is the scale of the problem?

The Ant Broads and Marshes have been assigned phosphate targets to achieve favourable conservation. There is also significant historical interest concerning the rate of sedimentation in the SSSI. Both these pressures have been considered through this DWP Plan as follows:

- Phosphates have been investigated using model outputs from SEPARATE[1], SAGIS[2] and the Review of Consents process; and
- Sediment has been investigated using model outputs from SEPARATE, FARMSCOPER[3], and the outputs of the NE project on sediment source tracing.

An assessment of water quality compliance was undertaken for Barton Broad and Crome's Broad from 2006 and 2013. For Barton Broad, compliance was only met in one year; all other years were non-compliant against water quality objectives. Compliance against the water quality target is achieved in Crome's Broad however, with the exception of 1 year (2012).

2.2. Phosphate

The Review of Consents process (Entec, 2009) concluded that 51% of phosphate came from consented discharges and 49% from agricultural/background inputs. The SEPARATE source apportionment model outputs provide further insight into the other sectors responsible for phosphate in the environment: they show smaller influences from septic tanks (8%), storm tanks (8%) and agriculture (7%), with the remaining 7% from urban sources, CSOs, bank erosion and atmospheric deposition collectively. These are model outputs and therefore should be used as a guide only.

The Source Apportionment GIS (SAGIS) model has been used to understand the phosphate levels in the water bodies in the SSSI catchment (i.e. the water bodies containing, as well as contributing to, the Ant Broads and Marshes SSSI). Table 2.1 shows the SAGIS estimated phosphate loads for each WFD water body and ranks these data. It should be noted that the ranking of loading is influenced by the size of the water body, in terms of flow and catchment area. Therefore, in order to normalise for this factor, the Q95 (the flow that is exceeded for 95% of the time) is presented and also ranked. The results show that the largest three water bodies, in terms of Q95, also have the highest phosphate load. These data provide the justification for the prioritisation of the actions required in terms of which water bodies should be focused on first.

The water bodies contributing the highest phosphate load are the 'Ant downstream' (also known as the 'Ant (Dilham to R. Bure)'), the 'Brumstead' and the 'Ant upstream' (also known as the 'Ant upstream (N Walsham and Dilham Canal)'). These latter two are the water bodies with the highest Q95. The Brumstead also shows high phosphate loads and Q95 volume.

[1] **SEPARATE**: SEctor Pollutant AppoRtionment for the AquaTic Environment. This comprises outputs from a Defra-funded project (WQ0223, running between 2012-2015) to develop a field tool kit for ecological targeting of agricultural diffuse pollution mitigation measures. The outputs include a spreadsheet with the apportionment of phosphate, sediment and nitrogen for each WFD water body. More information here: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=17813 Model output available here: http://www.rothamsted.ac.uk/sites/default/files/attachments/2014-02-05/Collins_SEPARATE%20outputs_Defra%20WQ0223.xlsx

[2] The **agricultural inputs** in the **SAGIS** model are calculated from the agricultural census data for 2004 built into an ADAS model called PSYCHIC. The load data from Sewage Treatment Works in the regional SAGIS model are based on data provided by the water companies for the period 2008-2010.

[3] **FARMSCOPER**: FARM SCale Optimisation of Pollutant Emission Reductions is a Defra-funded tool developed to help understand nutrient losses from different farm types and to identify the farm scale measures that are most likely to help reduce these losses.

Table 2.1: SAGIS outputs for Q95 and phosphate load in each SSSI water bodies that contribute to the SSSI

WB_ID	Waterbody name	Q95	Rank Q95	PO4 Load (Kg/yr)	Rank PO4 Load
GB105034055710	Ant upstream	11.2	3	171.6	3
GB105034055670	East Ruston	1.1	5	103.2	4
GB105034050910	Brumstead	13.6	2	375.8	2
GB105034050890	Smallburgh	2.8	4	67.5	5
GB105034051330	Ant downstream	22.7	1	1056.3	1

The traffic light colours give an indication of the relative contribution of water volume and phosphorus load with red and orange indicating the water bodies contributing higher loadings, and yellow and green indicating lower loadings.

2.3. Where is the phosphate coming from?

The SAGIS model also gives an indication of the source apportionment at a catchment level. The results, shown in Figure 2.1, indicate that STWs dominate the phosphate load overall, with the next biggest inputs coming from arable farming and the onsite wastewater treatment works (OsWwTWs) which includes septic tanks and package treatment plants which are legally allowed to discharge treated water directly into a watercourse. Intermittent discharges are also responsible for a large portion of the phosphate load to the site. This covers direct surface water run-off, combined sewer overflows, WwTW storm tank overflows and highway runoff. Urban and livestock pressures have relatively small contributions overall, when compared to other sources (7% each).

Figure 2.2 shows a SAGIS longitudinal profile along the main River Ant, including the Ant Broads and Marshes SSSI reach, indicating the sources potentially responsible for phosphates in the different parts of the river. The reaches are marked on the plot and are also provided in the accompanying conceptual diagram at the bottom of Figure 2.2. STW discharges are also marked with numbers. This longitudinal plot shows that in the uppermost ~15 km, urban sources are an important contributor. At approximately 2 km and 19 km there are marked step increases in the overall phosphate level. These increases are related to inflows from Southrepps STW and Stalham STW. Downstream of Stalham STW, the most significant component of phosphate balance is derived from the effluent discharges of sewage treatment works.

The same source apportionment information is available in summary form for each SSSI-contributing water body within the wider catchment. This information is presented in Figure 2.3, and gives a higher spatial resolution to the pressures at a contributing water body level. As such it has been used to help set the priorities for action within the DWPP.

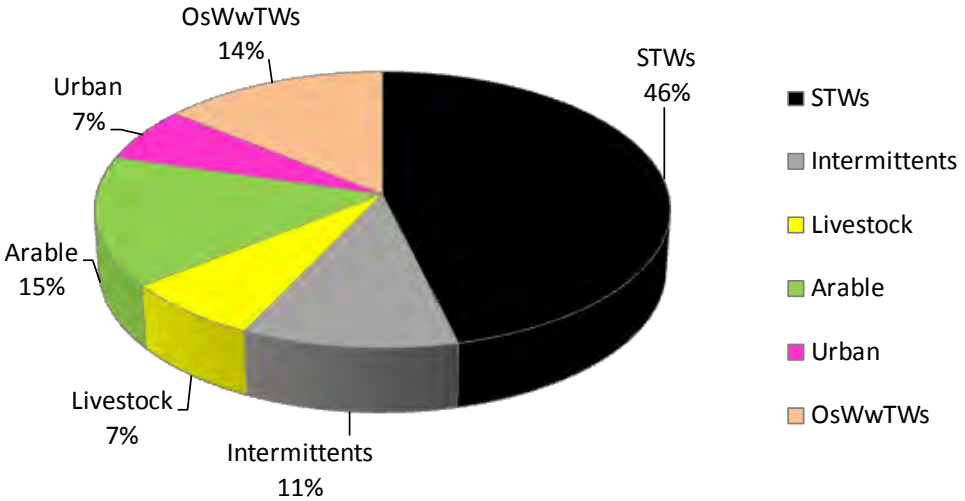


Figure 2.1: Overall catchment source apportionment
(Derived from SAGIS data)

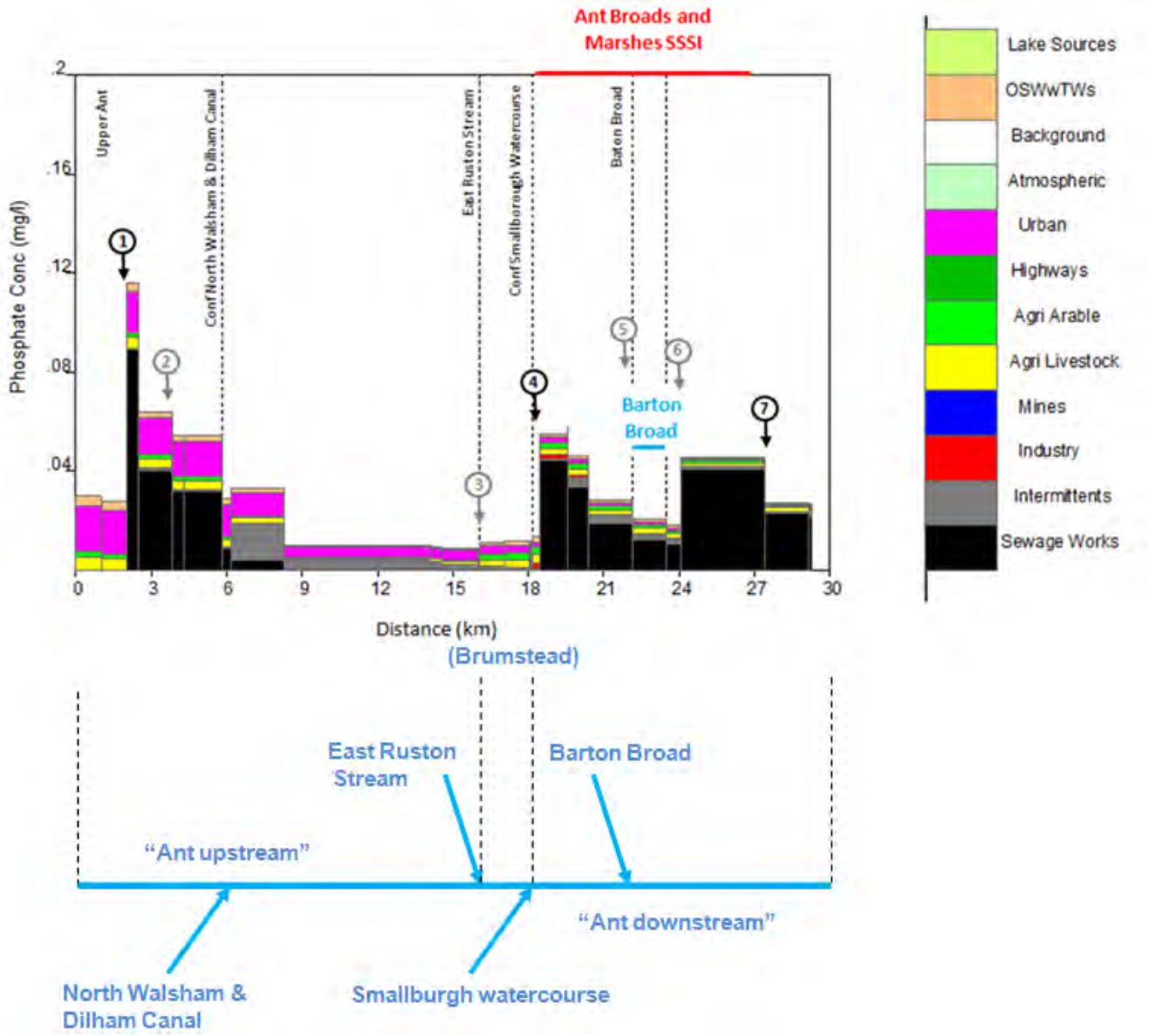


Figure 2.2: SAGIS longitudinal cumulative source apportionment profile for the main River Ant including the Ant Broads and Marshes SSSI
NB the STWs are numbered as follows: 1 (Southrepps); 2 (Trunch N); 3 (East Ruston); 4 (Stalham); 5 (Barton) 6 (Neatishead); and 7 (Horning).

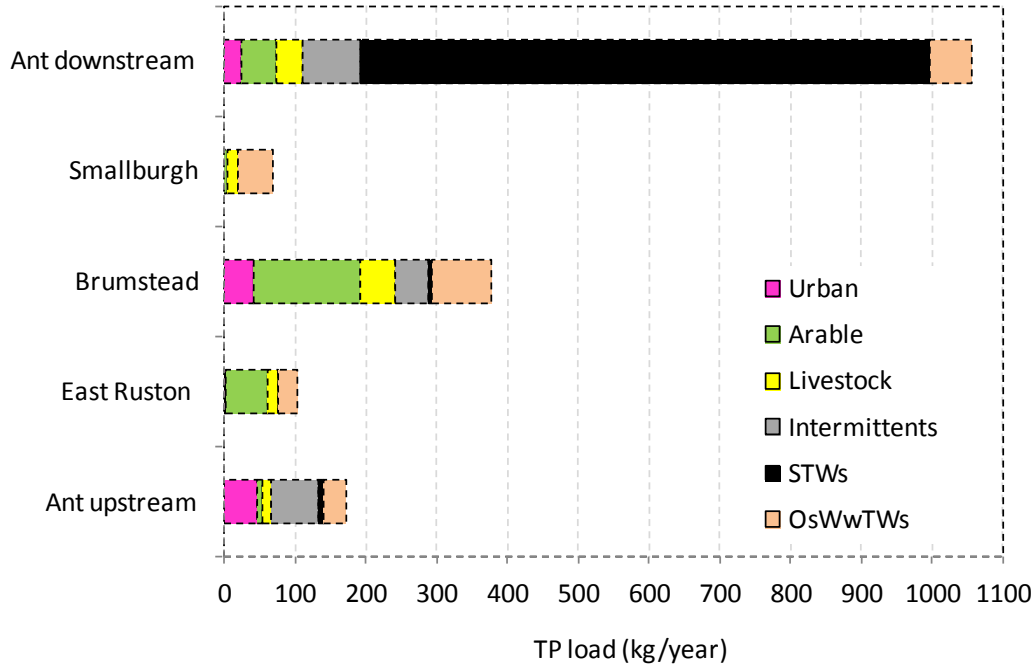


Figure 2.3: Total phosphorus source apportionment of the water bodies contributing to the SSSI water body
(Data derived from SAGIS. The figure shows the load generated from each individual water body, not cumulatively.)

It is clear from these results that, irrespective of the overall catchment source apportionment (Figure 2.1 and Figure 2.2), the source apportionment results for each different water body reflects different local pressures.

The most dominant feature on Figure 2.3 is the high phosphate load seen in the 'Ant downstream' water body, which is derived mostly from STW sources. This is not surprising given that the bulk of the STW discharges in the SSSI catchment are within this water body (the Horning, Neatishead, Barton and Stalham STWs all discharge into this water body). The Brumstead water body shows the next highest phosphate load but with a different source apportionment; here the dominant sources are arable farming and OsWwTWs (including septic tanks); with smaller portions from livestock, intermittent discharges and urban sources. The majority of phosphate in the East Ruston water body is coming from arable sources, reflecting its rural nature. The source apportionment for the 'Ant upstream' water body shows more population-focused pressures (including intermittent sources, urban and OsWwTWs). The reason why the sewage treatment works is not a dominant source of pollution in this water body despite the large town, is because the North Walsham WwTW no longer discharges into the catchment following diversion of the effluent to the North Sea as part of a campaign to reduce phosphorus loads in the River Ant in the 1980s (Wade *et al.*, 2003).

It should be noted however, that even though diffuse sources do contribute to overall phosphate levels within the SSSI, and within water bodies that contribute to the SSSI, the largest source is sewage treatment works, with consistent inputs from OsWwTWs and/or intermittent discharges and urban influences throughout the catchment.

The SAGIS data has been further interrogated carefully to try and help identify priorities for action in each SSSI contributing water body; these data are available in Appendix F and the key decisions on priorities set out in Table 2.2.

It should be noted that Table 2.2 sets out priorities for addressing phosphates only: the source apportionment shown in Figure 2.3 also indicates the sectors where additional measures could help support these priorities.

Table 2.2: Decision matrix and prioritisation for phosphate related DWPP Actions

Waterbody name	Is water body in top 5 for P load?	Is STW contributing >25% of total water body P load?	Is intermittent contributing >25% of total water body P load?	Is livestock contributing >25% of total water body P load?	Is arable contributing >25% of total water body P load?	Is Urban contributing >25% of total water body P load?	Is OSWwTWs contributing >25% of total water body P load?	Priorities (PRIORITY 1 = water body is in top 5 for overall load; PRIORITY 2 = outside of top 5)	Secondary priorities (i.e. sector shown in source apportionment but not identified as a primary target in the decision matrix)
Ant upstream	Y	N	Y (39%)	N	N	Y (27%)	N	PRIORITY 1 action Target intermittent & urban	OsWwTWs
East Ruston	N	N	N	N	Y (57%)	N	Y (26%)	PRIORITY 2 action Target arable farming	n/a
Brumstead	Y	N	N	N	Y (40%)	N	N	PRIORITY 1 action Target arable farming	OsWwTWs
Smallburgh	N	N	N	N	N	N	Y (74%)	PRIORITY 2 action Target OSWwTW	n/a
Ant downstream	Y	Y (76%)	N	N	N	N	N	PRIORTY 1 action Target STW	Intermittent, OsWwTWs, arable

2.4. Sediment

Whilst there are no specific targets for sediment in the River Ant catchment, Barton Broad or Crome's Broad, there has been significant historical interest concerning the rate of sedimentation in Barton Broad. Suction dredging was undertaken between 1996 and 2001 to remove sediment bound phosphorus in Barton Broad. Immediately after dredging, the sediment phosphorus concentration was lowered to 50% of its original levels for a period of 5 years after dredging. However, recent studies show that the dredging has had little long-term effect on sediment TP concentration or vertical profiles within the sediments of Barton Broad. Phosphorus levels in the surface sediment of the Broad rapidly increased after dredging, probably as a result of the deposition of algal rich material settling out coupled with inputs from the river.

The key evidence sources and tools used to understand sediment pressures in the Ant Broads and Marshes SSSI include SEPARATE, FARMSCOPER, SCIMAP, the Defra Erosion Risk Model; and Natural England Studies. Models have been used as it is believed that there is no ongoing sediment monitoring data for the catchment.

The results of the SEPARATE model in Figure 2.4 show that the majority of sediment in the River Ant is derived from agriculture, with nearly 60% of the estimated soil sediment in rivers from this source. River bank erosion also contributes a large amount of sediment to the River Ant (c. 40%). Urban and sewage treatment sources provide smaller quantities of sediment on an annual basis.

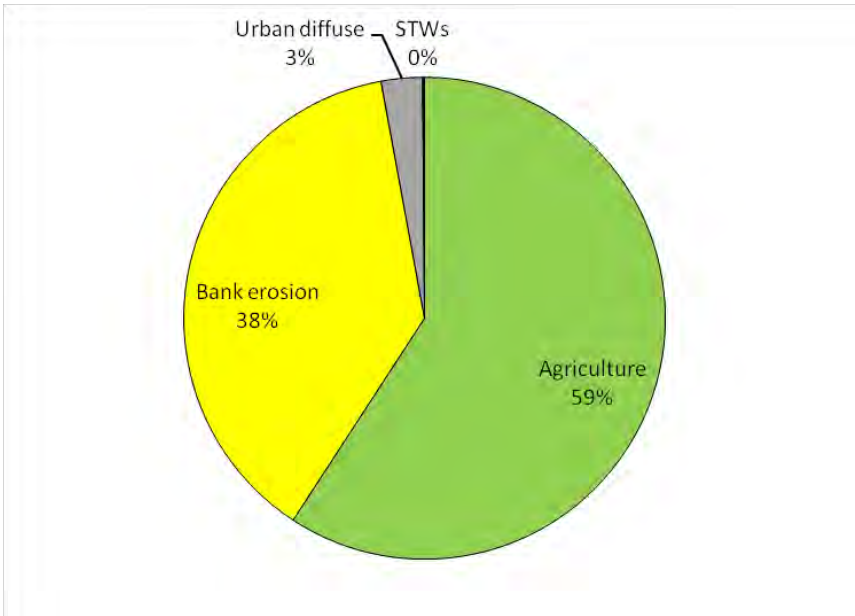


Figure 2.4: SEPARATE model outputs for sources of phosphate in the River Ant catchment

The Natural England sediment source tracing framework project investigated the provenance of fine-grained bed sediment and associated organic matter in the River Ant. The results of this project mostly agree with the SEPARATE model outputs, in that approximately 60% of the sediment load in the catchment is estimated to arise from agricultural land; with 20% from the erosion of river banks; and a further 20% from urban sources such as street dust and road verges.

Within this agricultural component, the FARMSCOPER model has been used to understand potential sediment loss from agricultural sources within the SSSI catchment. The model outputs indicate that higher rates of sediment loss are expected from arable farms compared with lowland grazing farms. This is pertinent to the Ant Broads and Marshes SSSI as its catchment has more arable farms compared within other farm types.

It should be noted however, that the dataset on farm types within the catchment is incomplete: Defra suppresses data when there are fewer than 5 holdings in a water body for confidentiality reasons. In these cases the data is marked with "#" to give an indication of the degree of uncertainty (i.e. farms are likely to be present in these water bodies, but as the number and type are unknown it has not been possible to account for their sediment and phosphate losses, or the savings that could be made by implementing measures). Therefore this needs to be considered when interpreting the potential effectiveness of measures. The nature of the incomplete data is as follows:

- **Smallburgh water body**: data for five robust farm types were suppressed in the categories of Cereals; Horticulture; Specialist pigs; Dairy; and Unclassified.
- **Ant (downstream):** data for two robust farm types were suppressed in the categories of Mixed; and Unclassified.
- **East Runton Stream**: data for five robust farm types were suppressed in the categories of Cereals; Horticulture; Specialist Poultry; Dairy; and Lowland Grazing.
- **Ant (upstream)**: data for three robust farm types were suppressed in the categories of Horticulture; Dairy; and Unclassified; and
- **Brumstead**: all data has been suppressed.

2.5. What can be done?

The priorities set out in Table 2.2 have been used to drive the measures in the Action Plan. These measures need to be implemented to help achieve compliance against the water quality targets.

Where the evidence identifies STW or intermittent discharges as being a priority for action, this has been identified as a measure within the DWPP Action Plan and assigned to other parties. This is because these sources are considered as point source pollution pathways, not diffuse sources, and therefore cannot be actioned under the DWPP. However it is important that the action is recorded to indentify that it is required.

Where evidence indicates phosphate and sediment pressures are arising from diffuse pathways such as urban, OsWwTWs (including septic tanks) and agricultural sources, mitigating measures have been suggested in the Action Plan.

In the case of where agriculture is identified as an important source, specific measures have been identified that should be targeted to the individual farms within the affected water body.

Other measures in the Action Plan have been identified with the purpose of raising awareness, maximising the effectiveness of existing measures and recommending further investigations that may be needed.

2.6. How effective might the measures be?

The DWPP sets out measures to help address phosphates and sediments from the diffuse sources identified within the SSSI catchment. The FARMSCOPER outputs indicate which measures would best be applied in the agricultural sector to reduce phosphate and sediment losses at a farm level. The top five most effective measures for any given farm type and pressure (phosphate and sediment) have been selected and modelled separately. The outputs, see Table 2.3, essentially give a percentage reduction in phosphate or sediment losses (the “savings” that could be made) from a particular farm type, and these reduction factors have been applied to the Agricultural Census data to understand, at an individual water body level, the potential for phosphate or sediment savings from applying measures on the type of farms (arable and livestock) within each water body. See Part 2 of the plan for a full discussion of the magnitude of the potential phosphate and sediment savings

Table 2.3 Summary of the top five measures modelled by FARMSCOPER

Farm	Top 5 Phosphorus measures	Top 5Sediment measures
Arable	4 – Establish cover crops in the autumn	4 – Establish cover crops in the autumn
	8 – Cultivate compacted tillage soils	8 – Cultivate compacted tillage soils
	9 – Cultivate and drill across the slope	13 – Establish in-field grass buffer strips
	13 – Establish in-field grass buffer strips	15 – Loosen compacted soil layers in grassland fields
	15 – Loosen compacted soil layers in grassland fields	106 – Plant areas of farm with wild bird seed/nectar flower mixtures
Livestock	76 – Fence off rivers and streams from livestock	8 – Cultivate compacted tillage soils
	35 – Reduce the length of the grazing day/grazing season	35 – Reduce the length of the grazing day/grazing season
	61 – Store solid manure heaps on an impermeable base and collect effluent	39 – Construct troughs with concrete base
	78 – Re–site gateways away from high-risk areas	78 – Re-site gateways away from high-risk areas
	39 – Construct troughs with concrete base	106 – Plant areas of farm with wild bird seed/nectar flower mixtures

It is important to note that these "savings" are relative to farm-level phosphate or sediment losses – they are not directly proportional to in-stream concentrations. Thus a similar reduction factor will probably not be seen for in-stream phosphate or sediment. However, the figures do give a useful indication of the **potential** for agricultural measures to help reduce phosphate or sediment mobilisation within the overall SSSI catchment.

The effectiveness of the top five most effective agricultural measures applied to all farms within each water body are shown in Table 2.4 and Table 2.5, and have been categorised as Low, Moderate or High[4].

Table 2.4 Magnitude of theoretical effectives of Phosphate measures

Waterbody name	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Ant upstream	Moderate	Low	Low
East Ruston	Moderate	Moderate	Low
Brumstead	n/a	n/a	n/a
Smallburgh	Moderate	Moderate	Low
Ant downstream	Moderate	Low	Low

Due to data suppression, it was not possible to represent the Brumstead water body in the FARMSCOPER model.

Table 2.5 Magnitude of theoretical effectives of Sediment measures

Waterbody name	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Ant upstream	High	High	Low
East Ruston	High	High	Low
Brumstead	n/a	n/a	n/a
Smallburgh	High	High	Low
Ant downstream	High	High	Low

Due to data suppression, it was not possible to represent the Brumstead water body in the FARMSCOPER model.

This shows that there is some potential for reducing agricultural phosphate losses by applying measures at a farm level. The potential outcomes are slightly higher for the arable farming sector (the arable measures are generally more effective, and also there are more arable farms overall within the catchment compared with livestock farms). Table 2.5 indicates a higher potential for reducing sediment through applying top five measures to arable farms compared.

Actions to control sewage, industrial and urban discharges would currently appear to provide a greater likelihood of success. The key point arising from the evidence, is that the degree of non-compliance with the phosphorus targets is not large. Given the relatively small contribution likely to be coming from diffuse (agricultural) sources, and the relatively large contribution from point sources, the most effective strategy to secure compliance would be modest further improvement to consented discharge.

[4] Where: **Low** = 0 - 25% reductions in farm scale phosphate or sediment losses; **Moderate** = 26 - 60% reductions in farm scale phosphate or sediment losses; **High** = 61% - 100% reductions in farm scale phosphate or sediment losses. NB these "savings" are expressed as a percentage of the overall agricultural phosphate or sediment losses (as modelled by FARMSCOPER based on Agricultural Census Data), not as a percentage of the overall water body phosphate load (modelled in SAGIS). Furthermore, these percentage savings assume the top five measures are applied correctly on every farm in every water body, not just on the priority water bodies set out in the Action Plan.

3. Action Plan

Table 3.1 The Diffuse Water Pollution Plan Action Plan for the Ant Broads and Marshes SSSI

Note that the Action Plan is also presented in a spreadsheet format to allow tracking of progress against each action.

Scale/ location	Investigation/ Advice/ Scheme/ Regulation	Sector	Action Ref No.	Action Title	Action Description	Pollutant(s) the action will tackle	Type of action/measure	How?	Criteria for WB selection	Ant: GB105034055710	East Ruston Stream : GB105034055670	GB105034050910	Smallburgh Watercourse GB105034050890	Ant: GB105034051330	Who?
SSSI catchment	Investigation	Agriculture & Land Management	**A_DWPP_001**	Review the existing Agri-Environment implementation	Undertake a review of the extent of Agri-environment measures uptake including: where active engagement has been successful; where resource protection measures have been implemented; what extent of the catchment is taking up resource protection options; are these measures being located in the right places relative to the risk (overlay erosion risk map and agricultural risk map) and where there is a known issue (link to water quality monitoring/SAGIS outputs for load concentrations on a sub-catchment level). This will help identify, at a sub-catchment level, a prioritisation plan that is linked to specific pressures in individual water bodies.	Phosphorus and Sediment	Evidence investigation & site specific action plan	Natural England – Review of CSF and Agri Environment	Catchments where agricultural pressures (leading to sediment or phosphate loss) are evident in the source apportionment. In the case of phosphate, where agriculture is contributing >25% of the water body's phosphate load.	N	Y	Y	N	N	Natural England
Specific catchments	Scheme	Agriculture & Land Management	**A_DWPP_002**	Re-focused agri-environment priorities	Use the outputs A_DWPP_001 (review of existing agri-environment implementation) to implement advice and schemes that are more targeted to phosphate and sediment reduction in areas where there is an issue (based on evidence) or higher risk (based on available evidence). NB The current form of agri-environment (ELS/HLS) has now come to a close with interim arrangements in place for expiring 2014 classic schemes only. When Defra confirms the new scheme this action can be put into action.	Phosphorus and Sediment	Scheme	Existing NE Agri-Environment scheme	Catchments where agricultural pressures (leading to sediment or phosphate loss) are evident in the source apportionment. In the case of phosphate, where agriculture is contributing >25% of the water body's phosphate load.	N	Y	Y	N	N	Natural England
SSSI catchment	Investigation	Rural	**A_DWPP_003**	Septic tank risk mapping	Undertake a risk mapping exercise using GIS, sewer network map, and undertake a distance to watercourse assessment to produce risk hot spot map to define areas where the water bodies are at increased risk from septic tanks (location and distance to source assessment).	Phosphorus	Evidence investigation	EA study	All sub-catchments within the SSSI catchment should be subject to risk mapping in order to understand where the risk is and further targeting etc.	Y	Y	Y	Y	Y	Environment Agency/ Natural England/ Water Company
Specific catchments	Advice	Rural	**A_DWPP_004**	Action on poor septic tank management/mis connections	Dependent on the outcomes of A_DWPP_003 undertake septic tank risk mapping, take action: for example where poor septic tank management is possibly causing an issue, investigate on site on a case by case basis. Also investigate septic tank issues in the EA's National Incident Recording System (NIRS) NIRS complaints system	Phosphorus	Advice/ Regulatory	EA study	Prioritise water bodies where OsWwTWs contribute >25% of phosphate load (marked as Y here).	N	Y	N	Y	N	Environment Agency/ Natural England/ Water Company
Specific catchments	Advice	Rural	**A_DWPP_005**	Septic tank management communications	Depending on the outcomes of A_DWPP_003, formulate material and communications plan to advise people of the importance of good septic tank management. Refer to/use/ incorporate/build upon the EA's standard advice document for householders with private sewage treatment plants	Phosphorus	Advice	EA/NE/Water Company study	SAGIS shows OsWwTWs as a recurring issue across the SSSI catchment and therefore this measure should be applied to all water bodies	Y	Y	Y	Y	Y	Environment Agency/ Natural England/ Water Company
Specific catchments	Investigation	Urban	**A_DWPP_006**	Investigation into intermittent discharges affecting the SSSI catchment	Investigate the source of intermittent discharges affecting the SSSI catchment and liaise with appropriate body to address the issues through other non-diffuse mechanisms. NB The EA currently investigates intermittent discharges as recorded through its National Incident Recording System (NIRS) complaints system.	Phosphorus	Investigation/ regulatory mechanism	EA study	Water bodies where intermittents are responsible for >25% of phosphate load	Y	N	N	N	N	Environment Agency
SSSI catchment	Investigation	Rural	**A_DWPP_007**	Road run-off investigations	Undertake a risk mapping exercise using road network, slope and connectivity to water course to understand the relative risks from road run-off. Ground-truth with site visits to verify.	Phosphorus and sediment	Evidence investigation	EA, Local Authority, Highways Agency study	Water bodies with a significant urban component in the source apportionment. In this case, water bodies that show >25% of phosphate loading from Urban sources have been targeted as priority.	Y	N	N	N	N	Environment Agency/ Natural England
Specific catchments	Scheme	Rural	**A_DWPP_008**	Road run-off pathway disruption techniques	Depending on the outcomes of A_DWPP_007 (Road run off risk mapping and investigations) implement pathway disruption techniques so that roads are not channelling rural run-off directly into water courses.	Phosphorus and sediment	Scheme	EA, Local Authority, Highways Agency study	TBC (dependent on outcomes of related task A_DWPP_007)	TBC	TBC	TBC	TBC	TBC	EA, Local Authority, Highways Agency
Specific catchments	Investigation	Urban	**A_DWPP_009**	Assessment of SUDS potential within the catchment	Investigation into SUDS potential to reduce urban diffuse run off in certain areas of the catchment where urban pressures are present.	Phosphates, sediment, metals	Evidence investigation	EA guidance to local planning initiatives (for new builds) and EA/NE work with Local Authorities to retro fit SUDS where	Key focus on water bodies where large (>25%) portion of the source apportionment is attributed to urban. These are marked as Y here as they are considered priorities.	Y	N	N	N	N	Natural England (driving), Environment Agency and Local Authorities/

Scale/ location	Investigation/ Advice/ Scheme/ Regulation	Sector	Action Ref No.	Action Title	Action Description	Pollutant(s) the action will tackle	Type of action/measure	How?	Criteria for WB selection	Ant: GB105034055710	East Ruston Stream : GB105034055670	GB105034050910	Smallburgh Watercourse GB105034050890	Ant: GB105034051330	Who?
								appropriate							Councils etc
SSSI catchment	Policy review	Agriculture & Land Management	**A_DWPP_010**	Review of phosphate and sediment reducing measures available through HLS and ELS	NB The current form of agri-environment (ELS/HLS) has now come to a close with interim arrangements in place for expiring 2014 classic schemes only. In the meantime conduct a review of existing agreements and their effectiveness, in order to identify the possibility to re-negotiate options if deemed appropriate and if a priority for protected areas.	Phosphates and sediment; with some benefit for other determinands.	Evidence investigation	Defra and Natural England	TBC	n/a	n/a	n/a	n/a	n/a	Natural England, Defra, Environment Agency
SSSI catchment	Advice	Agriculture & Land Management	**A_DWPP_011**	FARMSCOPER 1-2-1s	Farm visits to targeted farms to introduce FARMSCOPER and how it can help plan measures and how much it will cost/save the farmer. This could be prioritised where farmers currently are not engaged or where they are engaged and influential with nearby farms (providing a leading by example type approach). This measure will also provide support to farmers in producing nutrient management plan on a farm level.	Phosphates and sediment as primary focus, with some benefit for nitrates, pesticides. In some cases, additional benefits for biodiversity.	Advice and Scheme	Catchment Sensitive Farming (ECSFDI), Natural England catchment officers and ESS delivery officers	Priority catchments marked here include those where arable or livestock are contributing >25% of phosphate load within the catchment; further prioritisation exercise should be undertaken based on local knowledge, contacts and engagement rates	N	Y	Y	N	N	Natural England
Specific catchments	Schemes	Agriculture & Land Management	**A_DWPP_012**	Engagement with the Rivers Trusts to maximise wider benefits	Work with the Rivers Trusts (RT) to review their Catchment Based Approach programme of work to see if there is the potential for multiple-wins, or where key DWPP messages could be delivered through RT-to-farmer engagement.	Phosphates and sediment as primary, with some benefit for nitrates and pesticides. In some cases, additional benefits for biodiversity.	Advice and Scheme	Catchment Based Approach	TBC after having engaged with the Rivers Trust	TBC	TBC	TBC	TBC	TBC	Natural England and Rivers Trusts/ Broads Authority
SSSI catchment	Advice	Agriculture & Land Management	**A_DWPP_013**	Timetable for external communications	Set out a timetable that covers the duration of the RB planning phase which identifies the key farm shows and local events. Ensure attendance to deliver the DWPP message and outcomes. Also engage agronomists to help reinforce the message through their farm contracts. The overall objective of this measure is to spread the DWPP message and encourage farmers to take ownership of the issue and work alongside NE to help solve the problem.	Phosphates and sediment as primary, with some benefit for nitrates and pesticides. In some cases, additional benefits for biodiversity.	Advice delivery	Farm shows/local communication routes	All catchments selected as this isn't an activity that is specifically tied to water bodies.	Y	Y	Y	Y	Y	Natural England
SSSI catchment	Advice	Agriculture & Land Management	**A_DWPP_014**	Engagement with local NFU and CLA representatives	Proactive engagement with the local NFU and CLA to present the evidence base and promote a positive relationship.	Sediment and phosphate	Advice delivery	Meetings/ presentations	All catchments	Y	Y	Y	Y	Y	Natural England
SSSI catchment	Monitoring outcomes	Agriculture & Land Management	**A_DWPP_015**	Monitoring change in practice	For the annual review report: • Track change in practice by asking the Central Team for the number of advice visits and the uptake of agri-environmental options in the catchment for the reporting year • Report on the progress against each of the actions in the Action Plan	All	Monitoring outcomes and compliance	Through the annual review of the DWPP	All catchments	Y	Y	Y	Y	Y	Natural England
SSSI catchment	Investigation	Agriculture & Land Management	**A_DWPP_016**	Bank erosion investigation	Investigation into sources of phosphate /sediment from bank erosion (as identified by SEPARATE model) through targeted catchment walkovers	Sediment and phosphate	Evidence investigation	Catchment Sensitive Farming (ECSFDI), Natural England catchment officers and ESS delivery officers	All catchments with an agricultural component of the source apportionment in order to determine risk	Y	Y	Y	Y	Y	Natural England/ Environment Agency
Specific catchments	Investigation	Agriculture & Land Management	**A_DWPP_017**	Understand better the extent of agricultural data suppression	Investigate further the issue of suppressed agricultural data, which included: Smallburgh water body (cereals; horticulture; specialist pigs; dairy; and unclassified) ; Ant (downstream): (Mixed; and unclassified); East Runton Stream: Cereals; Horticulture; Specialist Poultry; Dairy; and Lowland Grazing; and Ant (upstream): Horticulture; Dairy; and Unclassified.	Sediment and phosphate	Evidence investigation		All water bodies with suppressed agricultural census data	Y	Y	N	Y	Y	Natural England & Defra
Specific catchments	Advice/ Schemes: Arable – General cropping	Agriculture & Land Management	**A_DWPP_018**	Arable farming measures for General Cropping farm types –	Liaise with farmers within the high priority areas to push top 5 measures for phosphorus reductions on this farm type: 4 – Establish cover crops in the autumn; 8 – Cultivate compacted tillage soils; 9 – Cultivate and drill across the slope; 13 – Establish in-field grass buffer strips; 15 – Loosen compacted	Phosphates as primary, with some benefit for nitrates, sediment,	Advice delivery and schemes	CSF/NE Agri-Environment combination	All general cropping holdings should eventually be targeted however the priorities set out here are for water bodies that show >25% of phosphate load from arable sector (East Ruston and	Y	Y	Y	N	Y	NE and landowners

Scale/ location	Investigation/ Advice/ Scheme/ Regulation	Sector	Action Ref No.	Action Title	Action Description	Pollutant(s) the action will tackle	Type of action/measure	How?	Criteria for WB selection	Ant: GB105034055710	East Ruston Stream : GB105034055670	GB105034050910	Smallburgh Watercourse GB105034050890	Ant: GB105034051330	Who?
				promotion of the "top 5" measures for phosphate reduction	soil layers in grassland fields	pesticides. In some cases, additional benefits for biodiversity.			Brumstead) and/or for which the agri census data shows a high proportion of general cropping (>10 holdings in the water body) (East Ruston, Ant upstream and Ant downstream)						
Specific catchments	Advice/Schemes : Livestock – Lowland grazing	Agriculture & Land Management	**A_DWPP_019**	Livestock farming measures for Lowland grazing farm type – promotion of the "top 5" measures for phosphate reduction.	Liaise with farmers within the high priority areas to push top 5 measures for phosphorus reductions on this farm type: 76 – Fence off rivers and streams from livestock; 35 – Reduce the length of the grazing day/grazing season; 61 – Store solid manure heaps on an impermeable base and collect effluent; 78 – Re-site gateways away from high-risk areas; 39 – Construct troughs with concrete base	Phosphates as primary, with some benefit for nitrates, sediment, pesticides. In some cases, additional benefits for biodiversity.	Advice delivery and schemes	CSF/NE Agri-Environment combination	Catchments where livestock farms are registered; however because grazing regimes changing also select water bodies where livestock farming is contributing >10% phosphates in the source apportionment and where livestock farms are grazing.	N	Y	Y	Y	N	NE and landowners
Specific catchments	Advice/Schemes : Arable – General cropping	Agriculture & Land Management	**A_DWPP_020**	Arable farming measures for General Cropping farm types – promotion of the "top 5" measures for sediment reduction	Liaise with farmers within the high priority areas to push top 5 measures for sediment reductions on this farm type: 4 – Establish cover crops in the autumn; 8 – Cultivate compacted tillage soils; 15 – Loosen compacted soil layers in grassland fields; 13 – Establish in-field grass buffer strips; and 9 – Cultivate and drill across the slope.	Sediments as primary, with some benefit for phosphates, nitrates, pesticides. In some cases, additional benefits for biodiversity.	Advice delivery and schemes	CSF/NE Agri-Environment combination	All general cropping holdings should eventually be targeted however the priorities set out here are for water bodies for which the agri census data shows a high proportion of general cropping (>10 holdings in the water body) (East Ruston, Ant upstream and Ant downstream)	Y	Y	N	N	Y	NE and landowners
Specific catchments	Advice/Schemes : Livestock – Lowland grazing	Agriculture & Land Management	**A_DWPP_021**	Livestock farming measures for Lowland grazing farm type - promotion of the "top 5" measures for sediment reduction.	Liaise with farmers within the high priority areas to push top 5 measures for sediment reductions on this farm type: 76 – Fence off rivers and streams from livestock; 61 – Store solid manure heaps on impermeable base and collect effluent; 35 – Reduce the length of the grazing day/grazing season; 78 – Re-site gateways away from high-risk areas; and 39 – Construct troughs with concrete base.	Sediments as primary, with some benefit for phosphates, nitrates, pesticides. In some cases, additional benefits for biodiversity.	Advice delivery and schemes	CSF/NE Agri-Environment combination	Catchments where livestock farms are registered and where active grazing takes place.	Y	N	N	N	Y	NE and landowners
Specific catchments	Investigation	Water Industry	**A_DWPP_022**	Water Company investigations to reduce phosphorus in discharges	EA and Water Company to investigate potential for reducing phosphorus in wastewater discharges in selected catchments. This could be approached either through improving existing operations or through new infrastructure, although consideration could also be given to catchment management approaches as an alternative, where suitable. There may be measures that water companies can voluntarily undertake downstream of assets (downstream of the final effluent sample point) that could mitigate further the effluent concentrations.	Phosphorus	Investigation/ regulatory mechanism	Water Company planning cycle/ NEP	Action (in the form of investigations) prioritised here in water bodies where >25% of phosphate load is attributed to STW.	N	N	N	N	Y	Environment Agency
Specific catchments	Regulatory	Agriculture & Land Management	**A_DWPP_023**	Unconsented farm discharges	Identify and remedy unconsented discharges from farms, for example specific farms with poor management practice e.g. Slurry pit/field corner management etc.	Phosphorus and sediment	Regulatory mechanism	EA pollution inspection procedure	Investigations in all agriculturally dominated catchments	N	Y	Y	N	N	Environment Agency
Specific catchments	Regulatory	Urban	**A_DWPP_024**	Unconsented urban discharges	Continue to identify and remedy unconsented discharges from the urban environment (for example misconnections) through the WFD and NIRS complaint process.	Phosphorus	Regulatory mechanism	EA pollution inspection procedure	Specific catchments where urban is responsible for significant (>25%) portion of the phosphate load, and/or intermittent sources have been identified in the SAGIS model	Y	N	N	N	N	Environment Agency
Specific catchments	Investigation	Agriculture & Land Management	**A_DWPP_025**	Adding to the evidence base	Address knowledge gap for sediment to improve evidence base for sediment: • Collate information to generate baseline of information of sediment pressures for the SSSI • Undertake mapping exercises to identify reaches that suffer from deposited sediment; • Identify any literature studies that quantify sediment movement • Commission assessments in water bodies that have data gaps or uncertainties	Sediment	Investigation/ regulatory mechanism	Commission of surveys, and data collection	Data collection in specific water bodies that have information gaps or uncertainties	Y	Y	Y	Y	Y	Natural England, Environment Agency

PART 2 – SUPPORTING EVIDENCE

4. Characteristics of the catchment

4.1. Area covered by DWPP

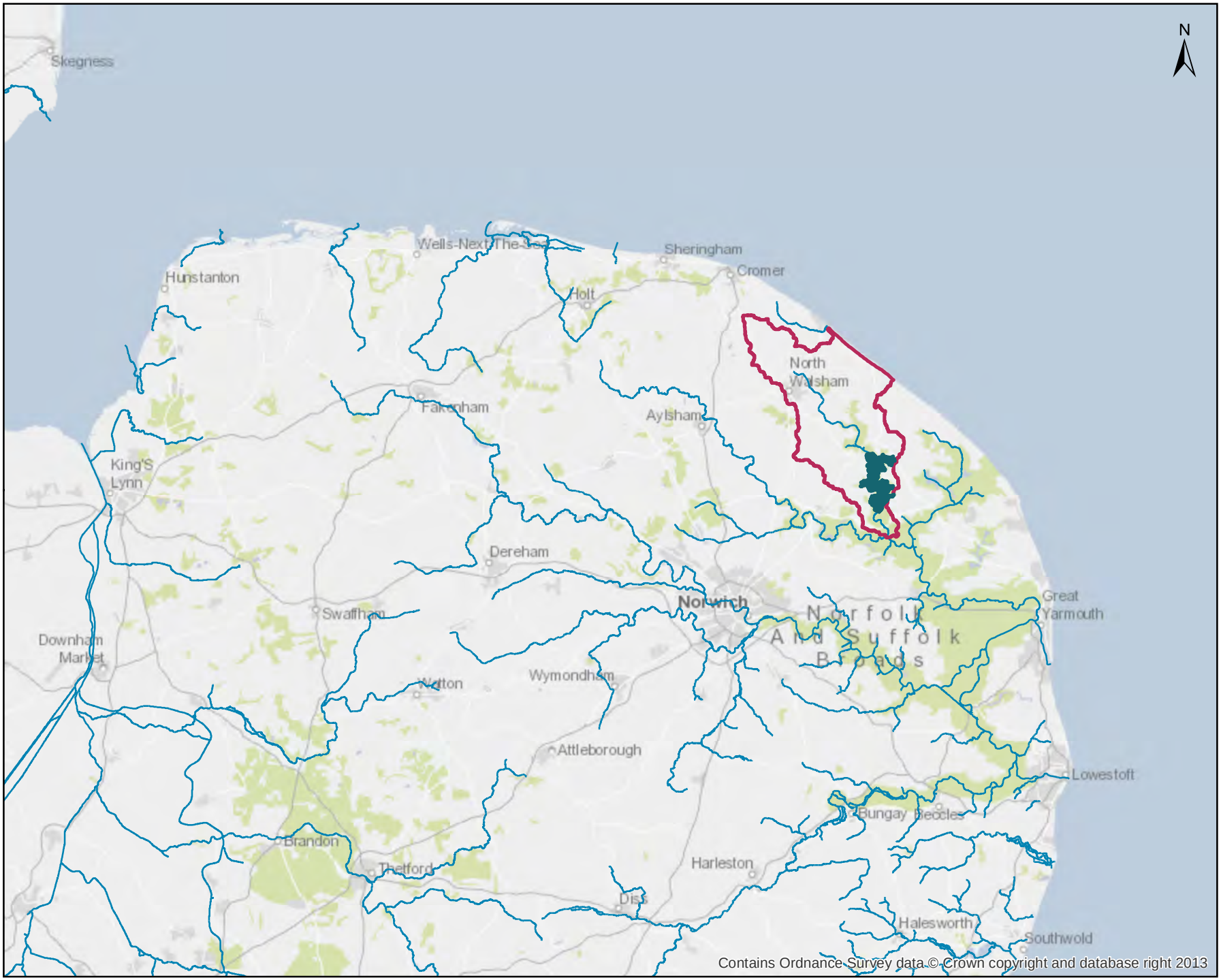
The Ant Broads and Marshes SSSI is located within the River Ant catchment in North Norfolk (Figure 4.1). The SSSI covers both banks of the River Ant extending approximately 5.5 km down the river from the southern edge of Stalham and finishing 2 km to the north of Ludham Bridge. The River Ant joins the River Bure near the remains of St Benet's Abbey. The site is also designated as a RAMSAR, SPA (Special Protection Area), SAC (Special Area of Conservation), and NNR (National Nature Reserve). The wider catchment also has a second SAC site, a further seven SSSIs, two NNRs, three LNR (Local Nature Reserves) and an AONB (Area of Outstanding Natural Beauty) (Figure 4.1). The habitats on the site include dykes, fen, reedbeds, carr woodland and open broads.

The surface water catchment of the Ant Broads and Marshes SSSI has an area of 156.8 km^2 (15,683 ha) which is subdivided into 5 Water Framework Directive (WFD) waterbodies (Table 4.1 and Figure 4.2). For this report the River Basin Management Plan (RBMP) Cycle 1 WFD water body boundaries have been used as the report study area and for more detailed analysis of the catchment. A list of water bodies contained within the Ant Broads and Marshes SSSI, and the SSSI units to which they correspond is provided in Table 4.1.

These catchments will change in 2016 for Cycle 2 and will affect the study area and water body catchments as shown in Figure 4.3 where the boundaries have changed and in some cases the water bodies have been simplified into larger catchments. It should be noted that the Cycle 2 catchments are already available for use under the OGL licence on the EA Geostore site.

Table 4.1: WFD Cycle 1 water bodies in the Ant Broads and Marshes SSSI catchment

EA WB ID	Name	Area (Ha)
GB105034050890	Smallburgh Watercourse	1614
GB105034050910	-	922
GB105034051330	Ant	4192
GB105034055670	East Ruston Stream	3701
GB105034055710	Ant	5254
	Total	**15683**



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.1: Ant Broads and Mashes catchment location

- Ant Broads and Marshes SSSI
- Ant Broads and Marshes Catchment
- Main Rivers

0 6 12 18 km

Scale (at A4): 1:500,000

Reference: 5120447	Drawn: JAM 21/05/2014
Checked: JHA 21/05/2014	Authorised: HG 21/05/2014

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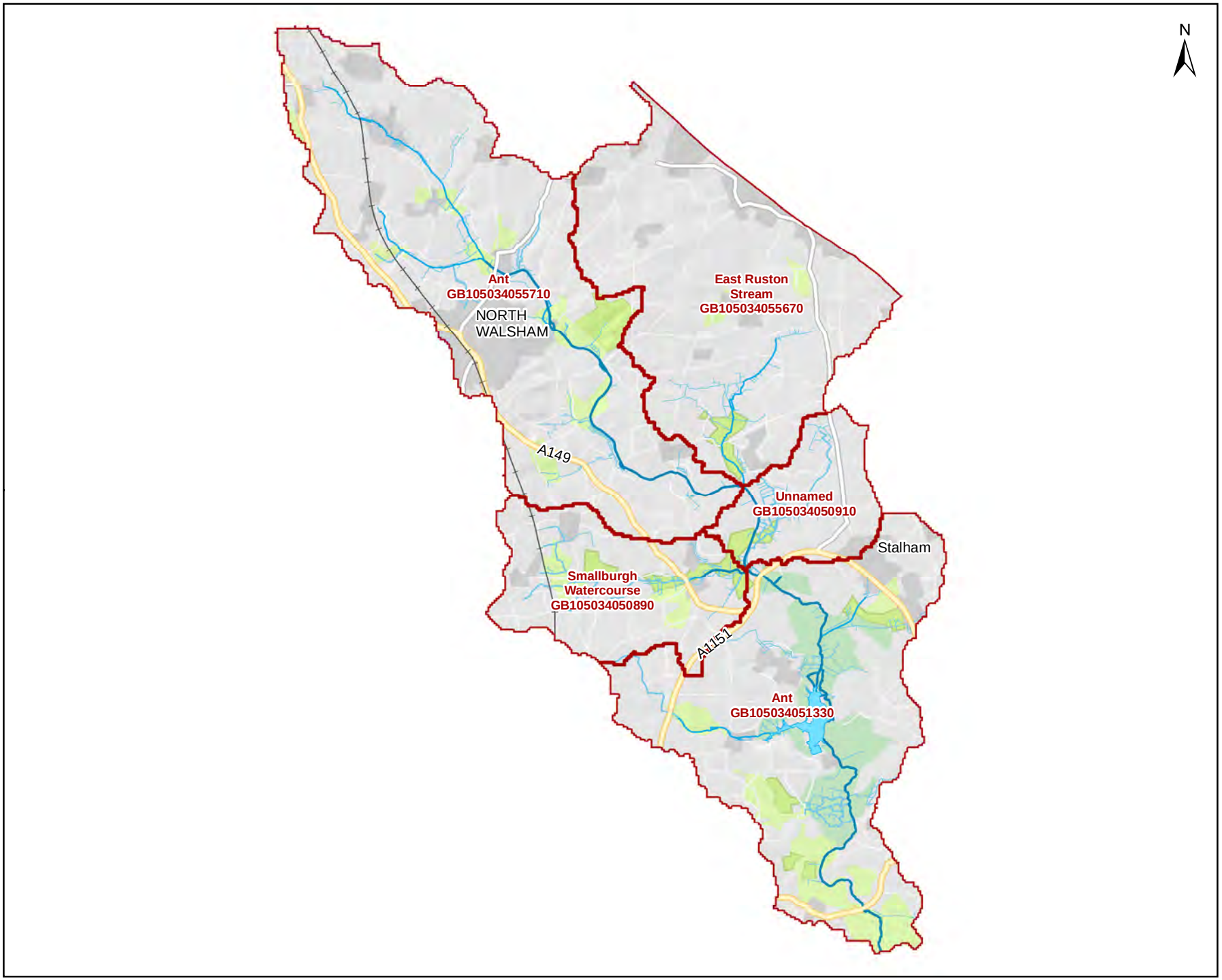

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.2: Ant Broads and Marshes SSSI catchment Water Framework Directive Cycle 1 water bodies

WFD Water bodies

0 1 2 3 km

Scale (at A4): 1:120,000

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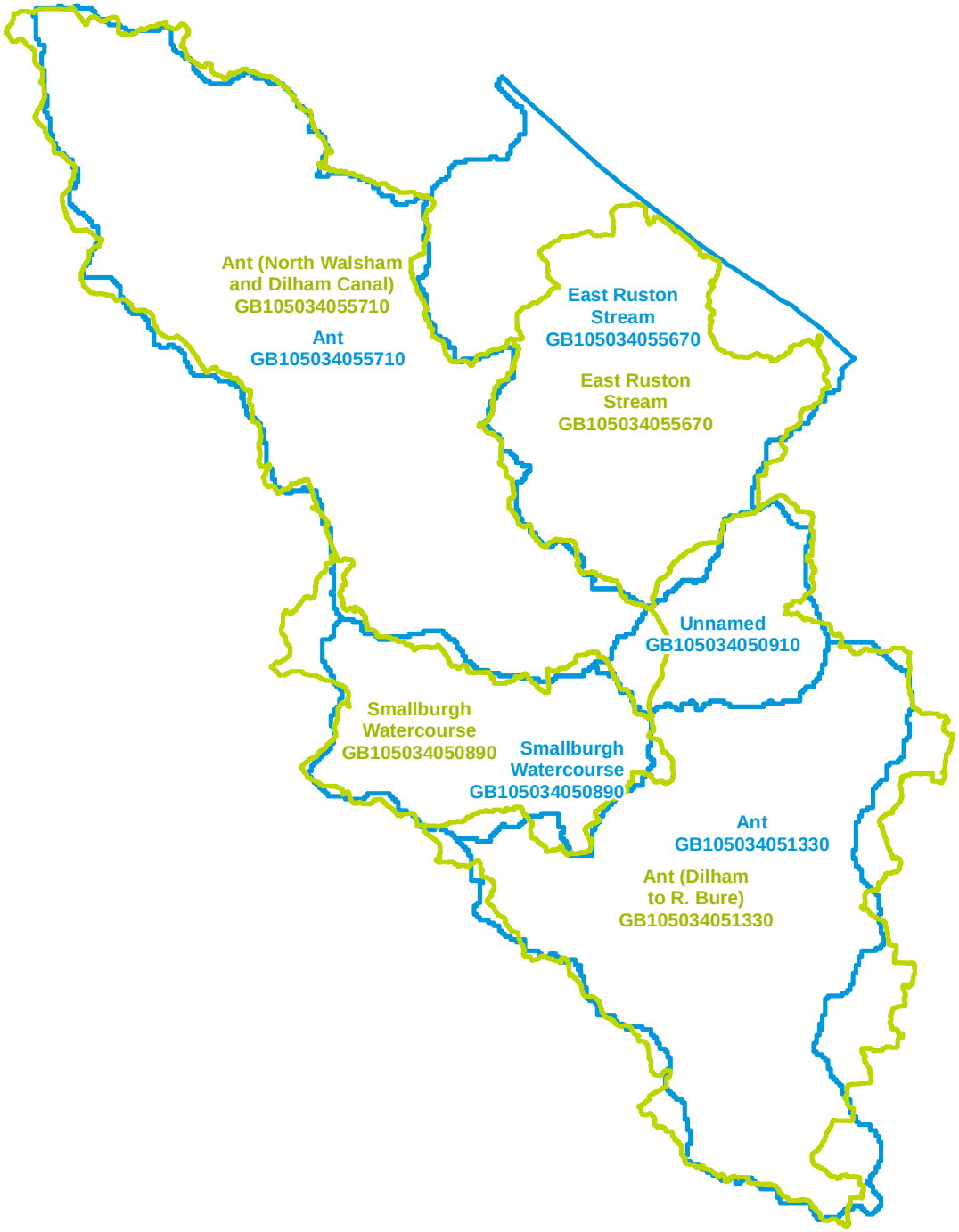
Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.3: RBMP Cycle 2 catchment changes



RBMP Cycle 2 WFD Water bodies

RBMP Cycle 1 WFD Water bodies

0 1 2 3 km

Scale (at A4): 1:120,000

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4.2. Climate

Figure 4.4 shows that the average mean monthly rainfall at an indicative East Anglian raingauge. It also shows mean monthly evaporation. Monthly rainfall is relatively constant throughout the year, with minima in spring, and maxima in autumn. The mean annual rainfall (1995–2011) is 643 mm.

Figure 4.4 also shows how the evapotranspiration in the catchment varies on a monthly basis and the balance between rainfall and evapotranspiration (the balance). The data shows that evapotranspiration exceeds rainfall for more than half the year, between March and September.

The low rainfall and high evapotranspiration rates dominate the climate. Rainfall falling between October and February is most likely to have the ability to generate runoff and mobilise catchment pollutants. Due to the easterly location of East Anglia, the low mean annual rainfall and the limited orographic controls on rainfall, there is a low frequency of intense daily rainfall events greater than 10mm/day that have the highest potential for mobilising diffuse pollutants. The annual diffuse pollution load in the catchment is therefore likely to be mobilised in a small number of high intensity rainstorm events, typically during the autumn and winter months.

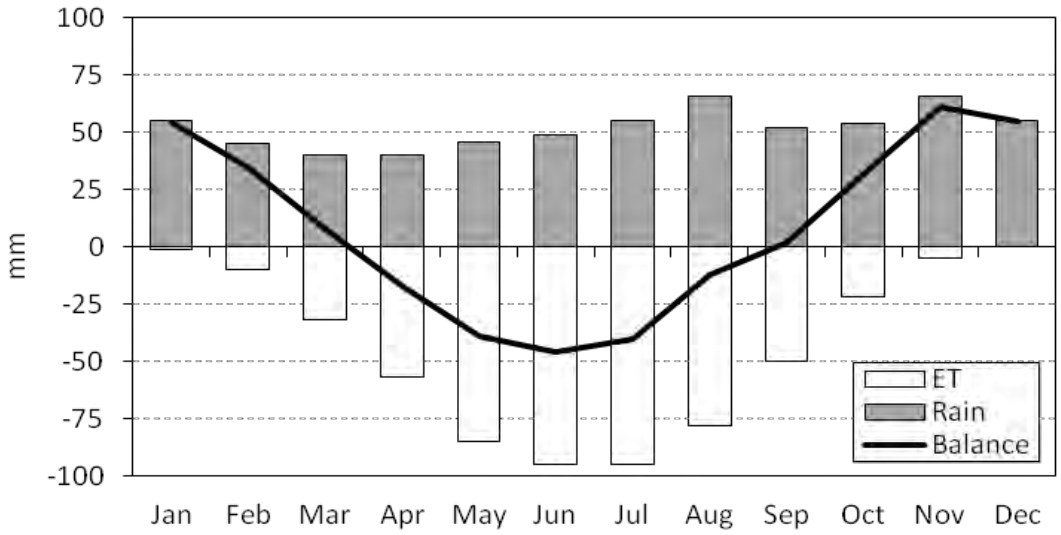


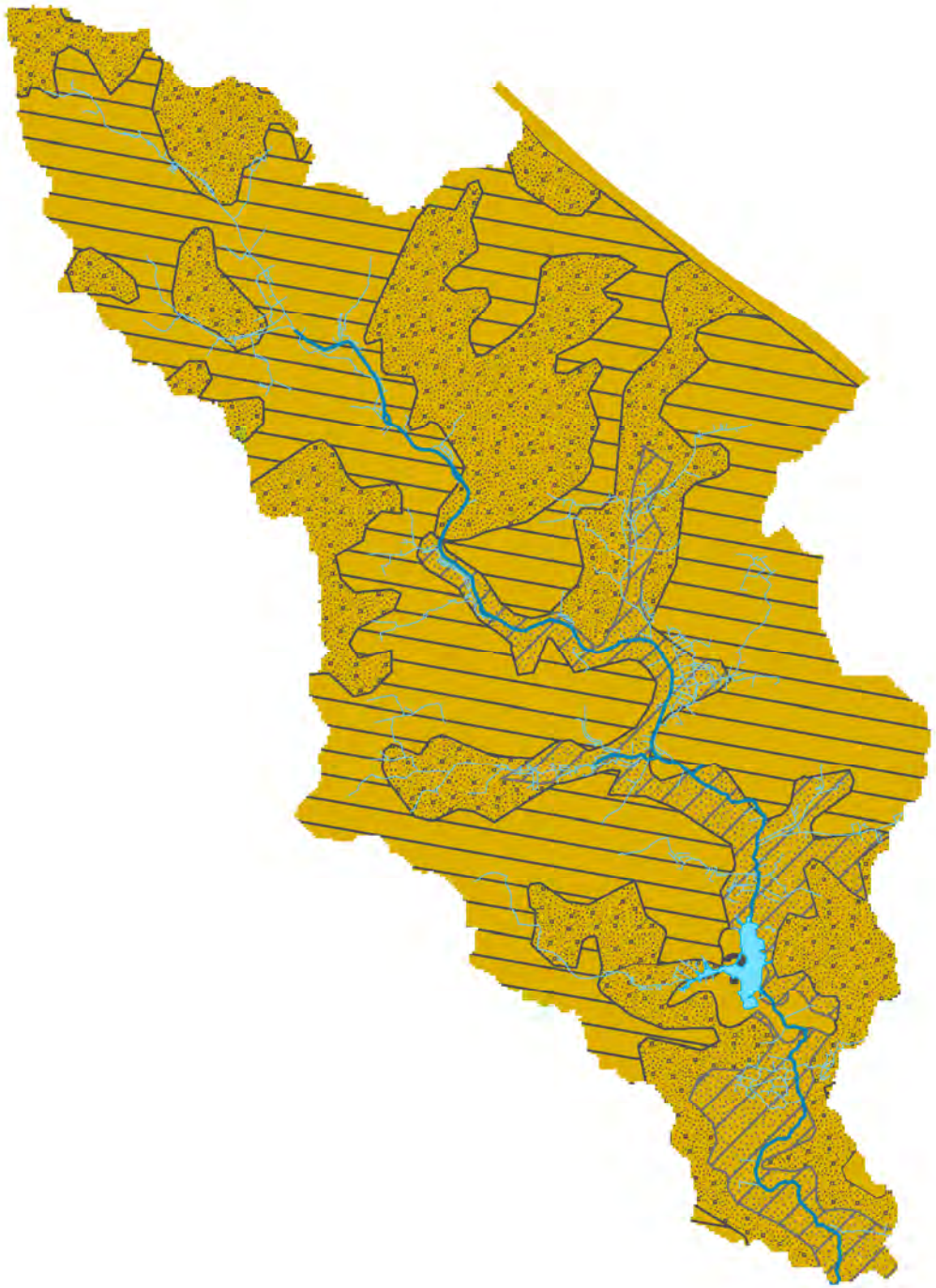
Figure 4.4: Long term average (1995–2011) monthly rainfall at Rocklands St Peters rain gauge in East Anglia compared against long term average potential evapotranspiration

4.3. Soils and geology

The majority of the Ant catchment is covered by brown silty-loam soils overlying shallow sandy subsoils (Wick 3 series). These soils are good arable farmland, are freely draining having coarse textures, large porosity and little retained water. Rainfall falling across the catchment (and any soluble diffuse pollutants it carries) has the potential flow freely through the soils.

The underlying geology is predominantly comprised of tertiary sands and clays of glacial origin (diamicton) (Figure 4.5). The catchment has a baseflow index of 0.86, which suggests that most of the water drains down through the soils to a groundwater compartment and, on average, only 14 percent of the water flows from the soils directly into the river system (Environment Agency, 2004).

Soils to the east are more slowly permeable, seasonally wet acid loamy and clayey soils. The marshes themselves and valley bottoms are covered by naturally wet fen peat soils. River floodplains in the north consist of loamy and sandy soils with naturally high groundwater and a peaty surface. At the very bottom of the catchment where the River Ant joins the River Bure there are loamy and clayey soils of coastal flats. In these locations, flashier responses to nutrient generation are expected due to the nature of the less permeable soils, although these are more limited in extent at the catchment scale.



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Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.5: Ant Broads and Marshes SSSI catchment geology

Lakes
Main Rivers
Watercourses

Superficial Geology

Clay, Silt and Sand
Diamicton
Sand and Gravel
Unknown Lithology

Bedrock Geology

Neogene to Quaternary Rocks (Undifferentiated) – Gravel, Sand, Silt and Clay

0 1 2 3 km

Scale (at A4): 1:120,000

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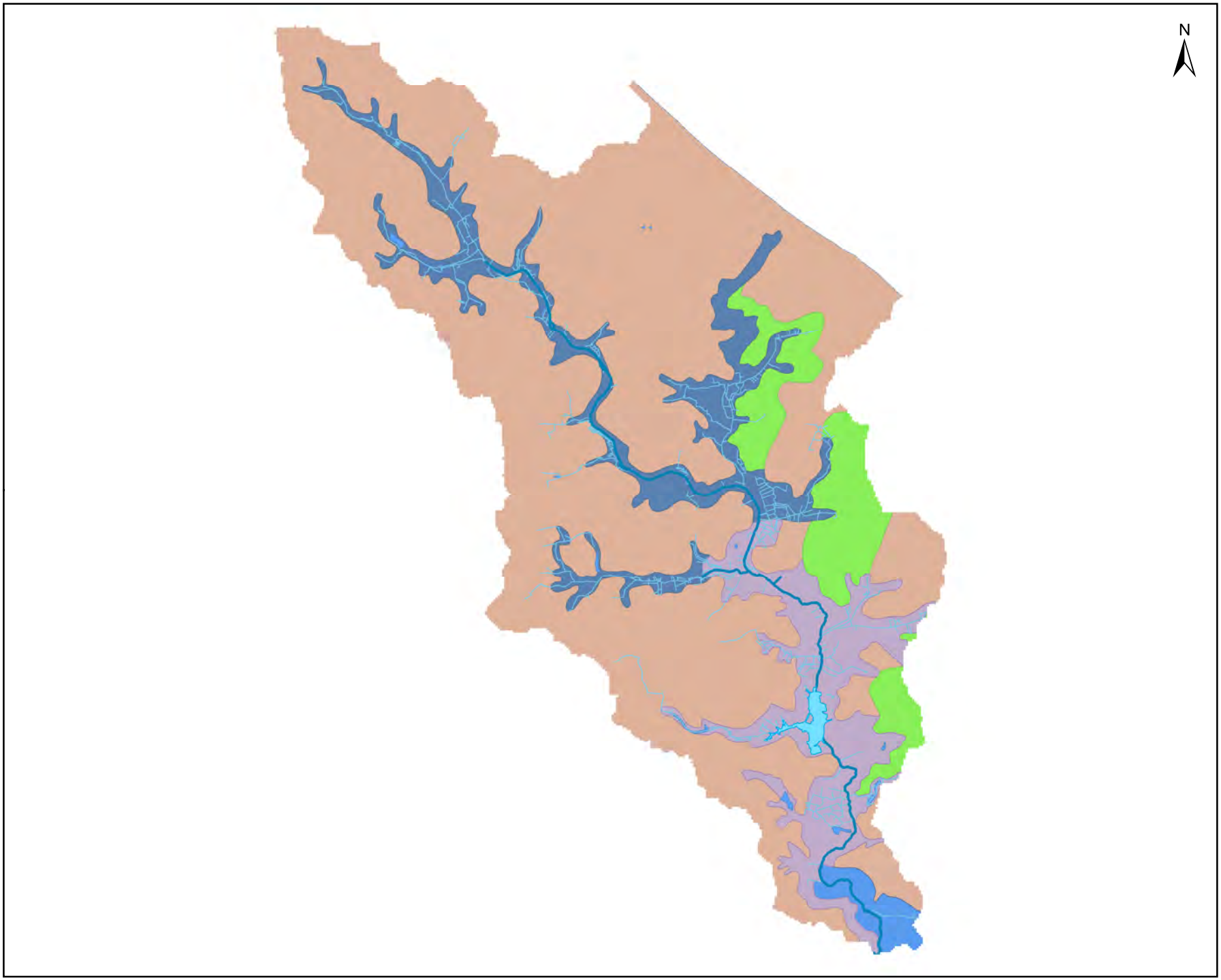

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.6: Ant Broads and Marshes SSSI catchment soils

Main Rivers
Watercourses

National Soil Map

Soil Condition

- Fen peat soils
- Freely draining slightly acid loamy soils
- Loamy and clayey soils of coastal flats with naturally high groundwater
- Loamy and sandy soils with naturally high groundwater and a peaty surface
- Slowly permeable seasonally wet acid loamy and clayey soils
- Sea
- Water

0 1 2 3 km

Scale (at A4): 1:120,000

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4.4. Landscape setting and topography

Elevations in the catchment range from 0 mAOD (sea level) at the bottom of the catchment, to a maximum of 62 mAOD in the northwest of the catchment (Figure 4.7).

Hill slopes in the catchment are typically very shallow (less than 3 degrees) in the bottom half of the catchment and around the broads. The steepest slopes in the catchment tend to be in the upper (northern) part of the catchment, where there are areas with slopes of up to 7 degrees (Figure 1–3). However, these areas are of limited extent and overall, the flatness of the land is likely to mean that the transportation of diffuse pollution in the Ant catchment will be limited. There are localised areas in the north of the catchment however, along the line of the main river and its tributaries where there is a risk of slope-generated runoff. The low river gradients are likely to allow rapid sedimentation of particulate nutrients once delivered to the river.

4.5. Catchment hydrology

The River Ant Broads and Marshes SSSI is within the Tidal Ant/Bure catchment that is 164 km^2 in extent and is drained by the River Ant (which enters from the north-west) and by the River Bure (which enters from the west). Water levels in low-lying areas adjacent to the main rivers within the Broads area are controlled by a large managed network of man-made drains. Pumping stations are required to discharge water from the drainage network in areas where the main rivers are embanked.

The River Ant begins at the end of the North Walsham and Dilham Canal (Figure 4.9) which itself starts at North Walsham and flows southeast to Dilham. The canal is joined by several smaller tributaries including the Hundred Stream in the northeast of the catchment and Fox's Beck/Bradfield Back in the northwest of the catchment.

At its downstream end the River Ant flows into Barton Broad. Barton Broad has an area of 57.6 km^2 (5760 ha). The main inflow into Barton Broad is from the River Ant. Smaller tributaries from Neatishead (Lime Kiln Dyke), Stalham (Stalham Dyke) and Sutton (Sutton Staithe) also contribute to flow. The River Ant continues from Barton Broad to join the River Bure near the remains of St Benet's Abbey.

Throughout the SSSI, water levels are dependent almost entirely on river levels and the quality of the water on site is related to varying degrees to the quality of the river water (EA, 2005b).

4.5.1. Barton Broad

In Barton Broad, within areas with an open connection with the river, water levels are controlled by fluctuations in the River Ant. Water levels in Barton Broad range between 0.15 to 0.8 m AOD and vary on individual tidal cycles. However, the influence of the tides is indirect, by the backing up of water and sources of water to the Broad are primarily controlled by inflows from the upstream catchment rather than tidal fluxes up the River Ant. Indeed, the narrow width of the river at Ludham Bridge acts as a restraint to strong tidal water flow that prevents serious saline water incursion, though this does occur from time to time.

Scatter plots of parameters found to be different in groundwater vs. surface water in the EA Review of Consents Stage 4 Report (alkalinity, calcium, magnesium, nitrate and iron) suggest a possible groundwater influence, i.e. that there may be direct groundwater upwelling into the Broad.

4.5.2. Crome's Broad

Water supply to Crome's Broad includes runoff from the local agricultural catchment (which may itself contain a groundwater component) and used to include inflows from the river, either from a sluice or through overtopping of the embankment. A series of internal sluices on the site are used to control water levels locally and currently they are kept closed (September 2006 site visit) to prevent poor quality water from the River Ant entering the broad. Hence the broad is dependent on groundwater and runoff input. Several wind pumps that are present on the site have become derelict though the area is still drained by the Water Management Alliance to the river. Groundwater upwellings are likely in the area to the north and northeast of Barton Broad, and possibly to a lesser extent to the east of Crome's Broad.

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.7: Ant Broads and Marshes SSSI catchment topography

Lakes
Main Rivers
Watercourses
Contours (10m intervals)

Elevation (mAOD)

- -1 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 90
- 91 - 100

0 1 2 3 km

Scale (at A4): 1:120,000

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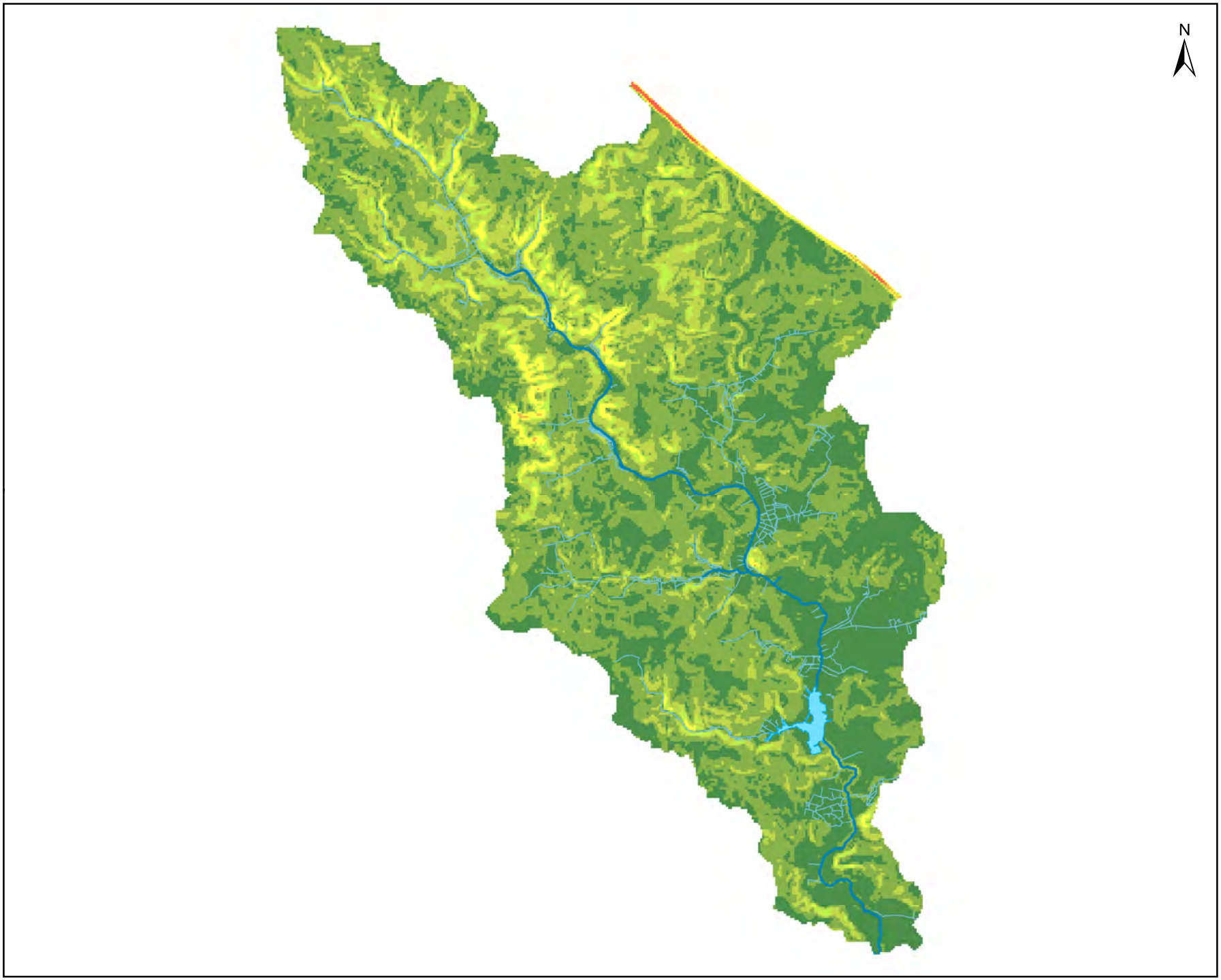

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.8: Ant Broads and Marshes SSSI catchment slope

Lakes
Main Rivers
Watercourses

Slope (degrees)

0
0 - 1
1 - 2
2 - 3
3 - 7
7 - 10
> 10

0 1 2 3 km

Scale (at A4): 1:120,000

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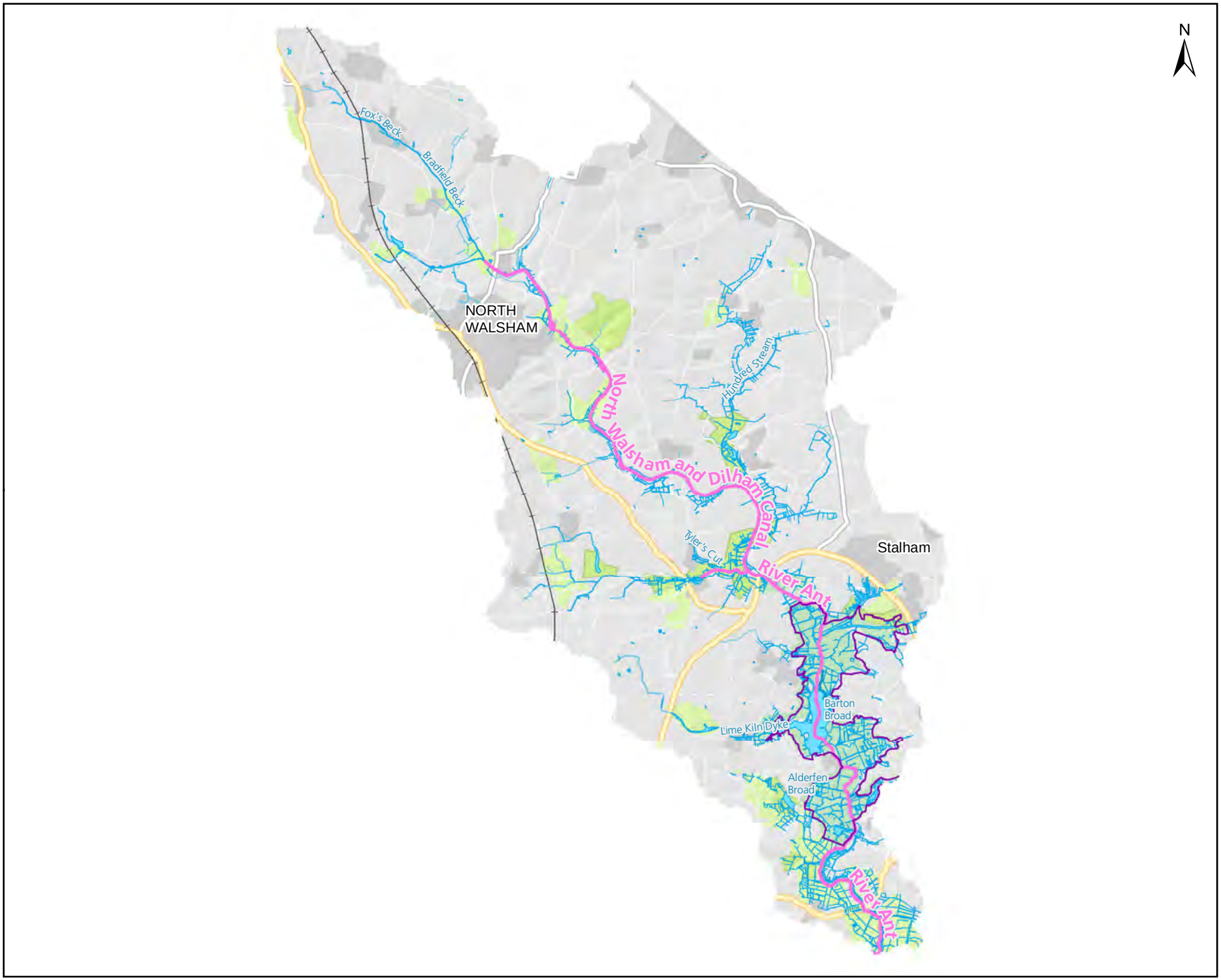
Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.9: Ant Broads and Marshes SSSI catchment Main Rivers



Ant Broads and Marshes SSSI
Main Rivers
Watercourses
Lakes

0 1 2 3 km

Scale (at A4): 1:120,000

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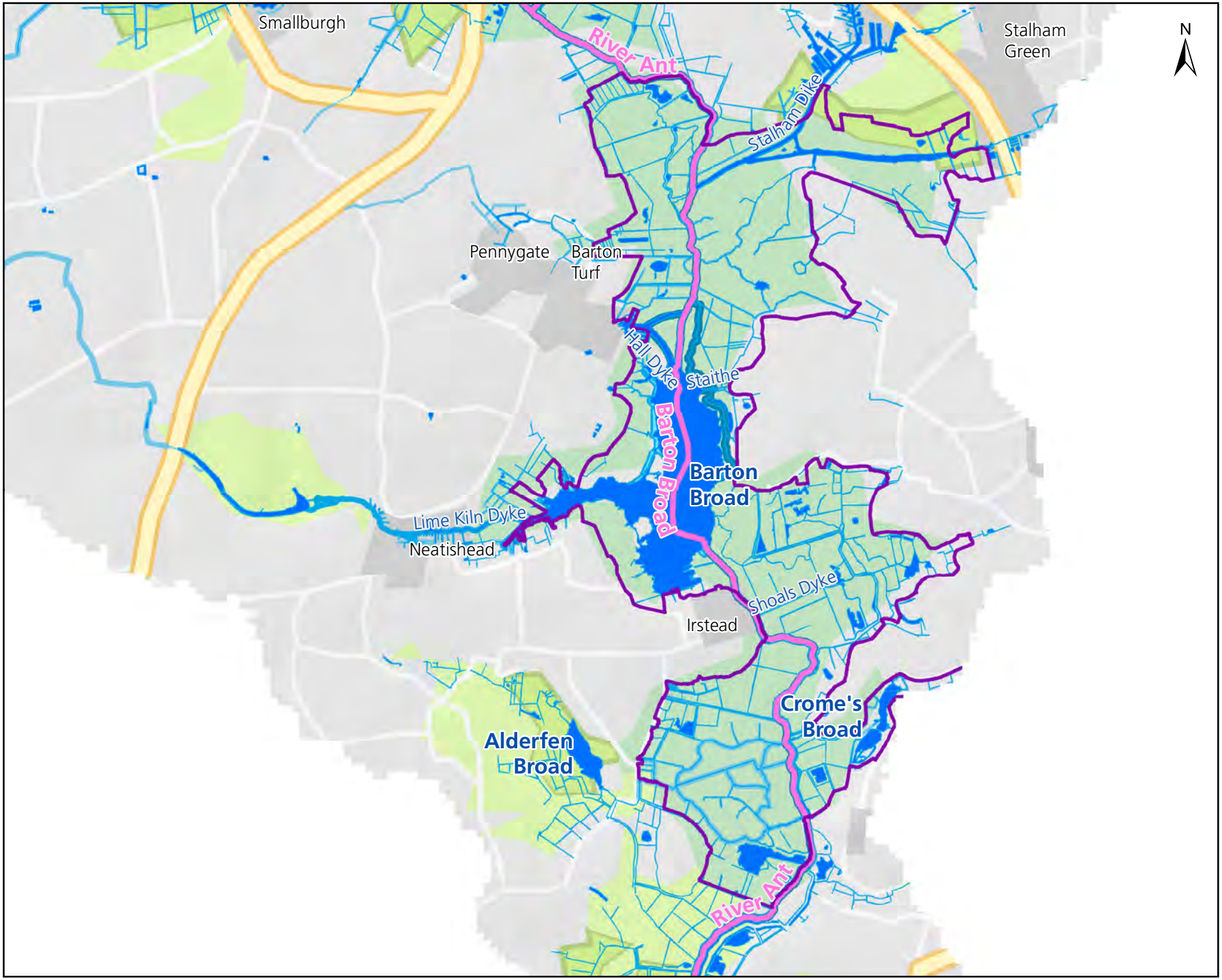

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.10: Ant Broads and Marshes SSSI Hydrological Detail

- Ant Broads and Marshes SSSI
- Main Rivers
- Watercourses
- Lakes

0 — 1 km

Scale (at A4): 1:35,000

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4.6. Land use

The dominant land use within the catchment is arable agriculture, in particular cereals, covering 78% of the catchment, with some areas of pasture in the river floodplain. The broads and marshes themselves make up only 5% of the catchment. Urban areas cover 4% of the catchment (Figure 4.11 CORINE Land Cover 2006 and Table 4.2.). Comparison with historic land use maps (Figure 4.12) indicates that the catchment has been arable since the post-war period. The most obvious changes include growth in the larger urban areas including North Walsham and Stalham, and a conversion of some of floodplain pastures to arable farming.

Table 4.2: CORINE land use statistics for the Ant Broads and Marshes SSSI catchment

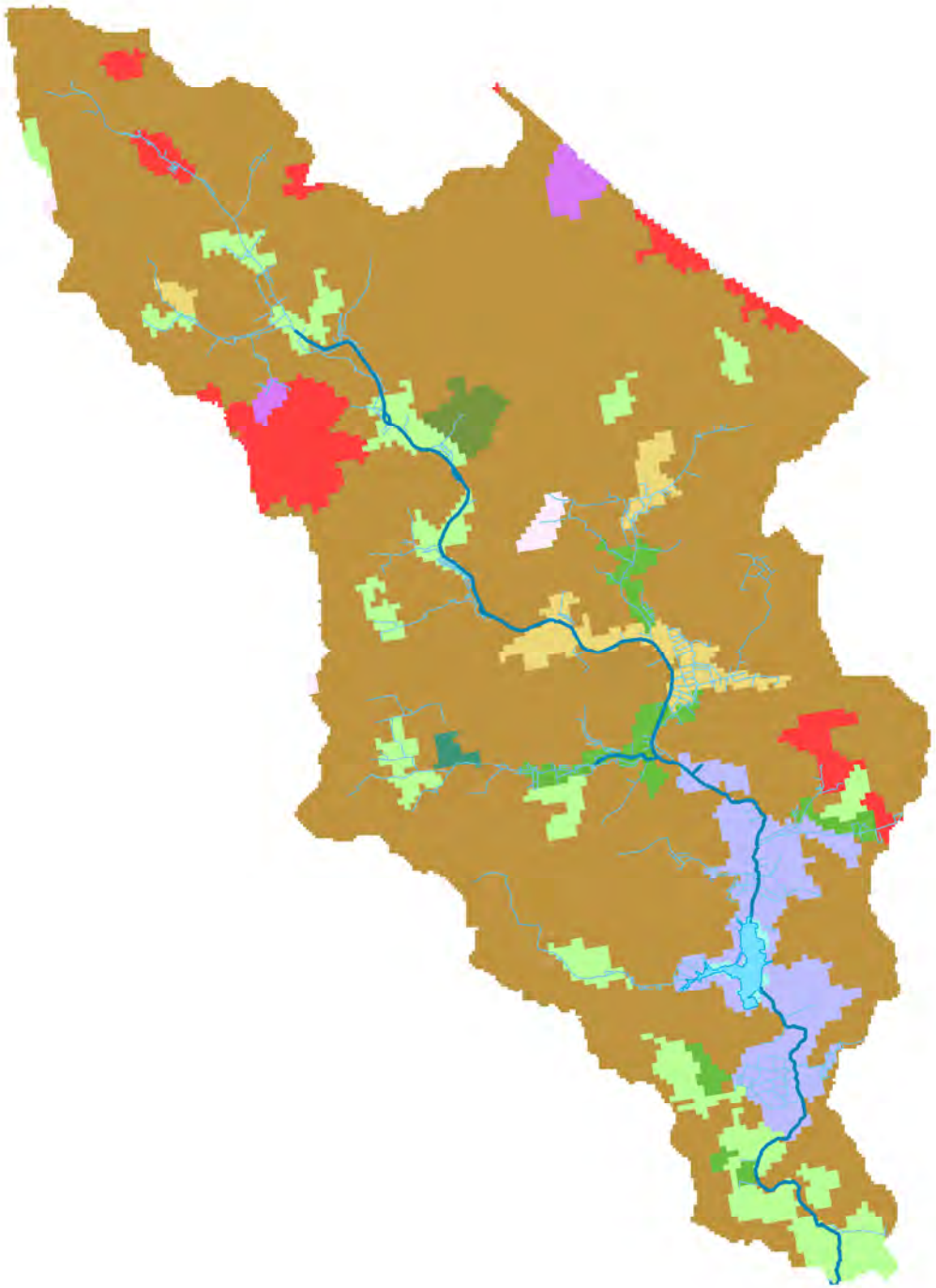
CORINE Land Cover Classification	Area (ha)	Area (%)
Non-irrigated arable land	12,148	78%
Pastures	1,068	7%
Inland marshes	745	5%
Discontinuous urban fabric	653	4%
Land principally occupied by agriculture	350	2%
Broad-leaved forest	289	2%
Coniferous forest	110	1%
Industrial or commercial units	109	1%
Water bodies	69	0%
Sport and leisure facilities	64	0%
Mixed forest	31	0%
Sea and ocean	16	0%
Total	15,652	100%

The high proportion arable farming reflects the excellent soil quality in the catchment. The majority of the catchment is classified by the Agricultural Land Classification (ALC) as Grade 3 (good or moderate quality), with significant areas of Grade 2 (very good quality) and Grade 1 (excellent quality) (Figure 4.13). Defra agricultural census data for 2010 shows that there are two main farm types in the catchment, general cropping (making up around 82% of the farms in the catchment) and lowland grazing (the remaining 18% of the farms). Table 4.3 and Figure 4.14 provide a further breakdown of the agricultural census data by WFD water body. Some data have been suppressed in line with standard practice for where there are fewer than five holdings within a water body catchment.

Figure 4.14 shows that three of the four water bodies (the Ant [North Walsham and Dilham Canal], the Ant [Dilham to R. Bure] and the East Runton Stream) show similar characteristics in terms of farming practices – mostly cereals (typically 40–60%), some other arable crops (typically 25–35%) and a smaller portion still of pasture, with a little woodland. An exception is the Smallburgh sub-catchment where a greater proportion of land (>50%) is dedicated to lowland grazing. Greater detail regarding the distribution of land use in the catchment is provided in an Environment Agency (2004) report that describes the results of field land use mapping as follows:

> *The cultivation of cereal and root crops dominates the land use throughout the Upper Ant catchment. Potato and sugar beet production are dominant in the headwater region above Swafield Bridge, while winter cereal cultivation was dominant in the lower region of the catchment between Honing Lock and Hunsett Mill. Permanent grassland was a minor land use, being largely concentrated in the riparian zone. Woodland and rough grazing accounted for only a small proportion of the surveyed area (4 per cent).*
>
> *Cattle, horses, pigs and sheep were distributed on areas of permanent grassland throughout the catchment, with a greater proportion of pig production in the headwater region above Swafield Bridge. Sheep production is concentrated in the lower region between Honing Lock and Hunsett Mill. Cattle are distributed throughout the catchment, with the highest density between Wayford Bridge and Honing Lock. Cattle and pigs are also distributed on potato and sugar beet fields, with direct grazing of fodder crops a common practice.*

Most of this description corresponds to the description given by Defra statistics. However, there are likely to be a small number of pig farms in the catchment headwaters and these data have probably been suppressed. Table 4.4 sets out livestock numbers in the catchment of the River Ant. The numbers are generally low reflecting the prevalence of arable farming in the catchment. However, the livestock data do indicate that there are likely to be a small number of significant poultry operations in the catchment that have been suppressed from the Defra list.



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.11: Current Land Cover (CORINE 2006)

Main Rivers
Watercourses

CORINE Land Cover 2006

- 112 - Discontinuous urban fabric
- 121 - Industrial or commercial units
- 124 - Airports
- 142 - Sport and leisure facilities
- 211 - Non-irrigated arable land
- 231 - Pastures
- 243 - Land principally occupied by agriculture, with significant areas of natural vegitation
- 311 - Broad-leaved forest
- 312 - Coniferous forest
- 313 - Mixed forest
- 324 - Transitional woodland-shrub
- 411 - Inland marshes
- 423 - Intertidal flats
- 512 - Water bodies
- 523 - Sea and ocean

0 1 2 3 km

Scale (at A4): 1:120,000

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CORINE Land Cover © European Environment Agency, 2014; Contains Ordnance Survey data © Crown copyright and database right 2014
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Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.12: Historic land cover for the Ant Broads and Marshes SSSI catchment

Main Rivers

Watercourses

The Land Utilisation Survey of Britain, 1933-1949 © Audrey N. Clark

- Rough grazing
- Urban
- Water
- Arable
- Suburban
- Grassland
- Woodland

0 1 2 3 km

Scale (at A4): 1:120,000

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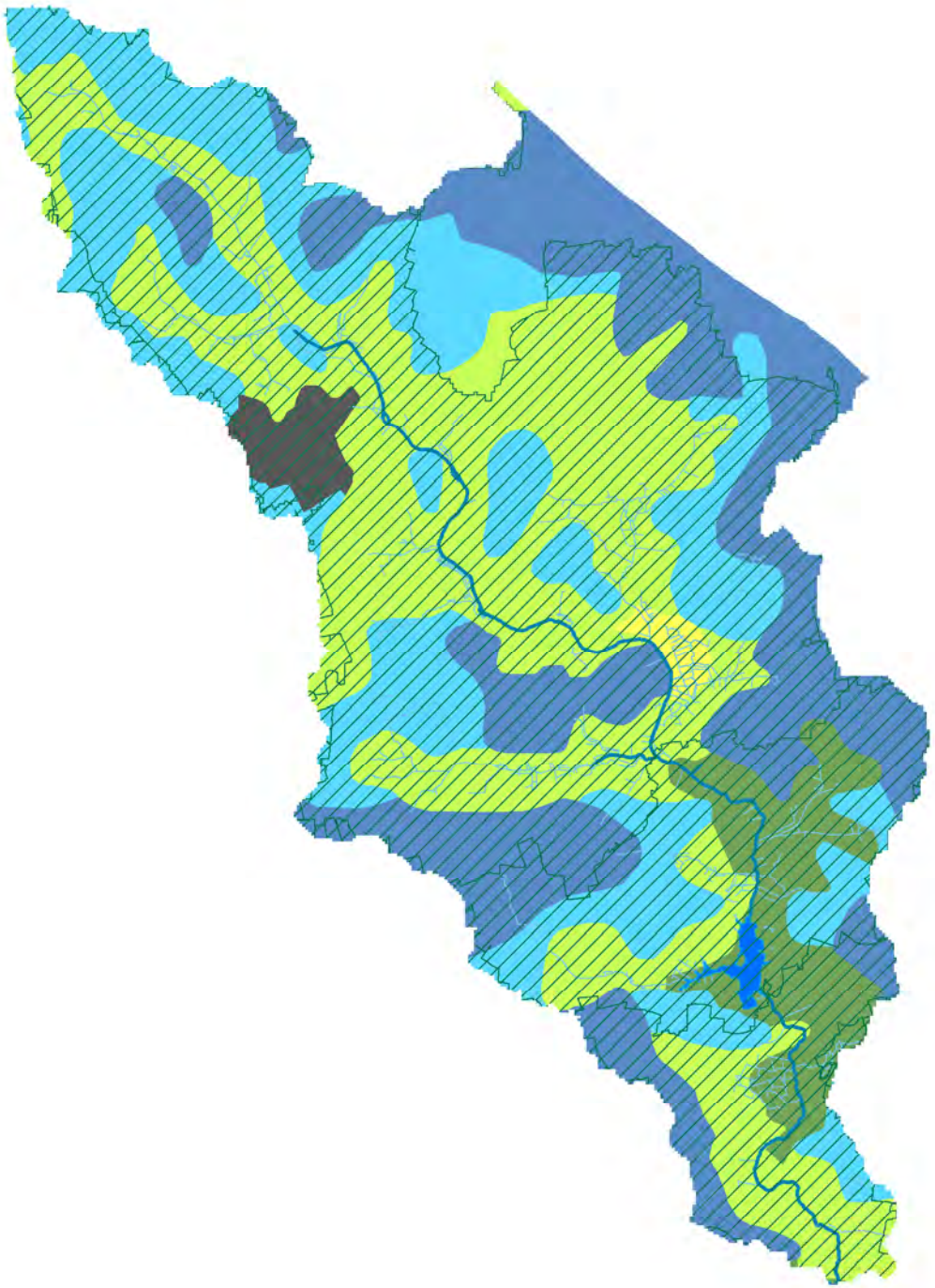
Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.13: Agricultural Land Classification



Nitrate Vulnerable Zones © Environment Agency
Lakes
Main Rivers
Watercourses

Agricultural Land Classification

Grade 1 Excellent
Grade 2 Very good
Grade 3 Good or Moderate
Grade 4 Poor
Non Agricultural
Urban

0 1 2 3 km

Scale (at A4): 1:120,000

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Table 4.3: Farming practices in the Ant Broads and Marshes SSSI catchment – individual water body catchments

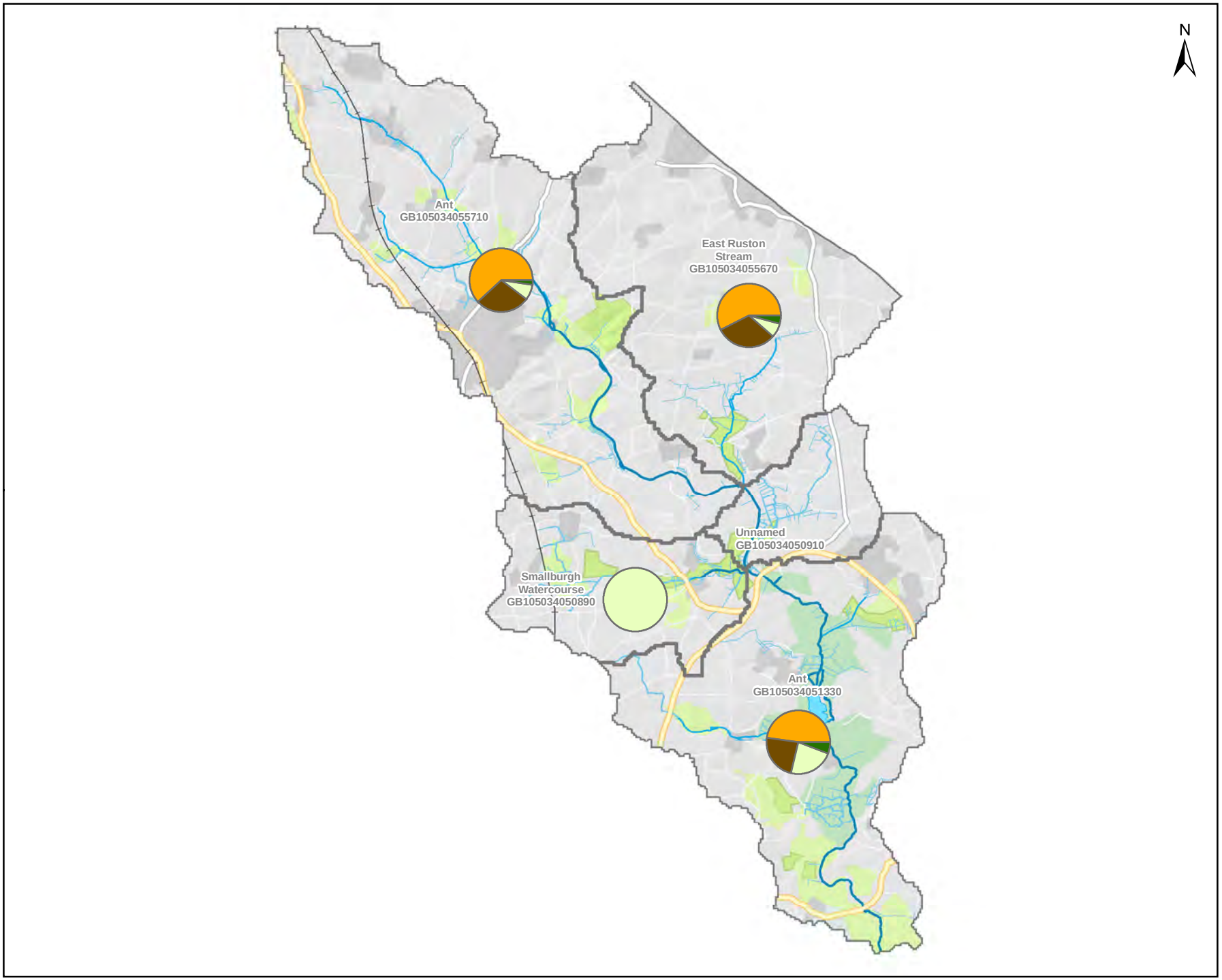
Robust Farm Type	Smallburgh Watercourse	Ant (Dilham to R. Bure)	East Ruston Stream	Ant (North Walsham and Dilham Canal)	TOTALS
Cereals	#	0	#	0	**0**
General Cropping	6	22	10	24	**62**
Horticulture	#	0	#	#	**0**
Specialist Pigs	#	0	0	0	**0**
Specialist Poultry	0	0	#	0	**0**
Dairy	#	0	#	#	**0**
Lowland Grazing	0	6	#	8	**14**
Mixed	0	#	0	0	**0**
Unclassified	#	#	0	#	**0**
TOTALS	**6**	**28**	**10**	**32**	**76**

 # indicates that the data have been suppressed to preserve the anonymity of farm holdings in areas where there are <5 individual farms of any given type. Brumstead is not represented as all data has been suppressed for this water body.

Table 4.4: Livestock numbers within the Ant Broads and Marshes SSSI catchment

Robust Farm Type	Smallburgh Watercourse	Ant (Dilham to R. Bure)	East Ruston Stream	Ant (North Walsham and Dilham Canal)	TOTALS
Cattle	710	668	#	516	**1,895**
Pigs	0	#	864	2,111	**2,975**
Sheep	#	915	#	605	**1,520**
Total Poultry*	#	108,138	#	464,778	**572,916**

 # = suppressed data (see Table 1-4). Brumstead is not represented as all data has been suppressed for this water body.



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.14: Agricultural Pressures

WFD Water bodies

Crops *supressed data (where there are less than 5 of a farm type per catchment) not represented in these charts

Cereals
Other Arable Crops
Pasture
Rough Grazing
Woodland

0 1 2 3 km

Scale (at A4): 1:120,000

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4.6.1. Current extent of land management schemes

A large proportion of the agricultural land in the Ant catchment is managed under environmental stewardship schemes (Figure 4.15). Entry Level Stewardship (ELS) schemes cover 38% of the catchment, Higher Level Stewardship (HLS) agreements 17%, with small areas (1%) of Organic Entry Level Stewardship (OELS); in total nearly 60% of the catchment is covered by environmental stewardship. The areas that are not covered by agreements are in the north of the catchment, around North Walsham and Bacton/Walcott.

Table 4.5 summarises the uptake incidence of stewardship options in the Ant catchment. Unfortunately some of the options relate to area measurements and some do not, hence it is not possible at this level to state how many hectares are covered by each option; what it does show however is the relative popularity of the different options currently being implemented and provides useful context to consider alongside the modelling outputs and can be used in future to help guide the application of measures. There are 168 different options in the catchment but the ones that are important for diffuse water pollution control are:

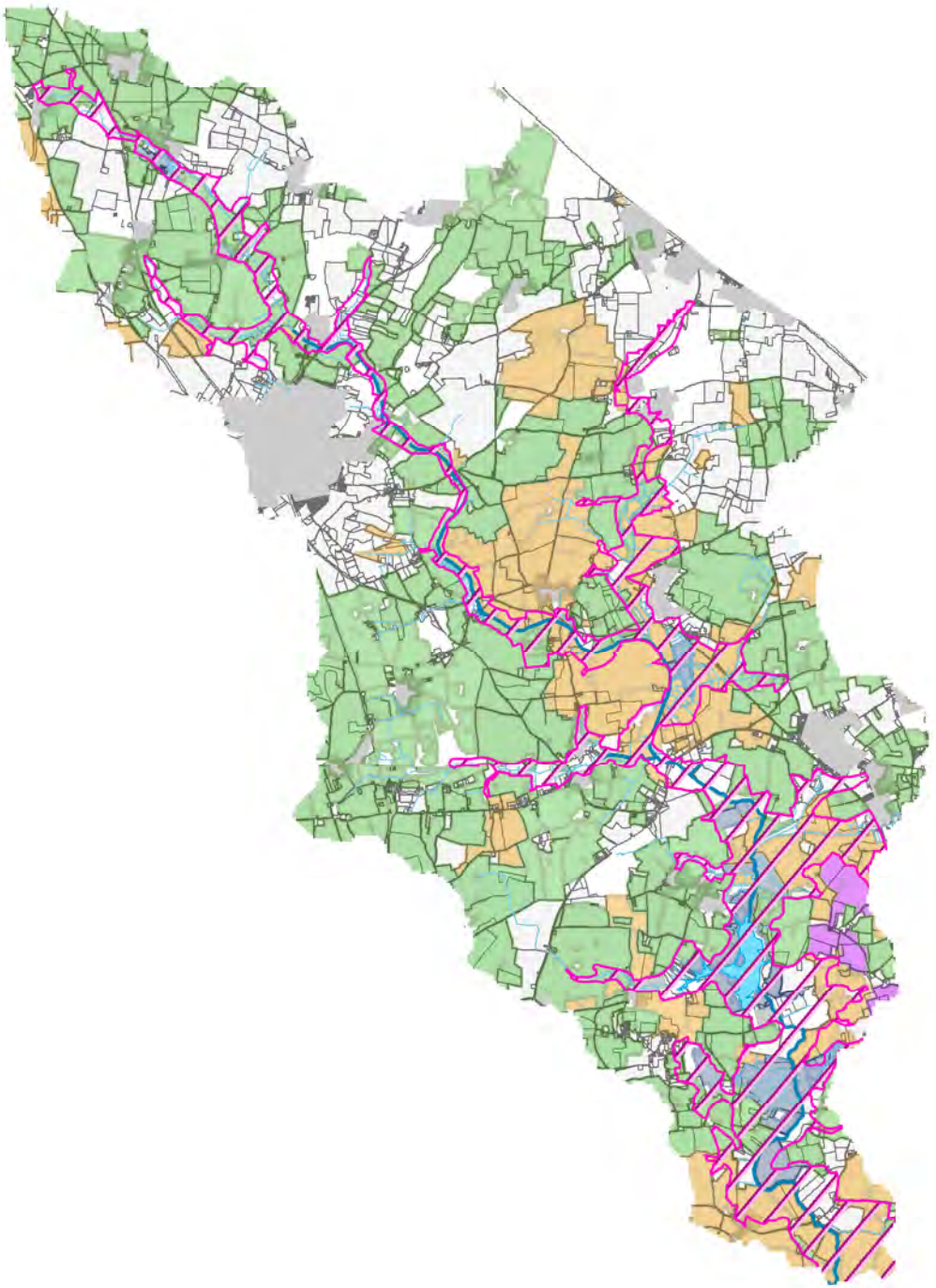
- 558 hectares (3.5% of the catchment) are under some fertiliser management option (e.g. HK3 – Permanent grassland with very low inputs or EK2 and EK3 – permanent grassland with low inputs);
- 169ha (1% of the catchment) of buffer strips cover areas of uncropped cultivated areas on arable land (EE1, 2 and 3, HE1 and 2, EF11 and 12, HJ/EJ55, HJ/EJ9, HF20, EE9) or grassland (EE5);
- Close to 9 km of livestock fencing has been installed across the catchment (FSH, FSH2010, FSB HF20,EJ11, FDS);
- 15 ha (0.1% of the catchment) of the catchment is covered by options using winter cover crops (EJ13) and overwintered stubble (HF6); and
- 41 ha (0.3% of the catchment) have been reverted from arable to grassland or heathland to prevent erosion and run-off (HJ3) or HO3.
- 1ha of infield wetlands/ponds have been created on arable land (EE8).

Whilst there are no specific phosphorus limits associated with any of the above options, a reduction in phosphorus losses is implicit for all of the above options. For example, the typical ratio of fertilisers and manures approximated as 20:10:10 N:P:K (Natural England, pers. comm.) and buffer strips can reduce phosphorus runoff by 10–20% depending on their width (Cuttle *et al*., 2007). However, it is important to note that the precise reductions in phosphorus loads associated with these measures are not fully understood nor have they been strategically considered by Natural England and its partners. This is currently being addressed through a study of the effectiveness of Catchment Sensitive Farming (CSF) measures across England and Wales (Environment Agency, pers. comm.).

Overall, the current uptake incidence of resource protection options within the River Ant catchment is very low. Although 60% of the catchment is covered by some form of agri-environment agreement, only 5% of the catchment is covered by resource protection options.

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.15: Land Management in the Ant Broads and Marshes SSSI catchment



Environmentally Sensitive Areas (ESA)
Lakes
Main Rivers
Watercourses

Stewardships

Entry Level Stewardship
Entry Level plus Higher Level Stewardship
Higher Level Stewardship
Organic Entry Level plus Higher Level Stewardship
Urban Areas
Land Registry Cadastral Parcels

0 1 2 3 km

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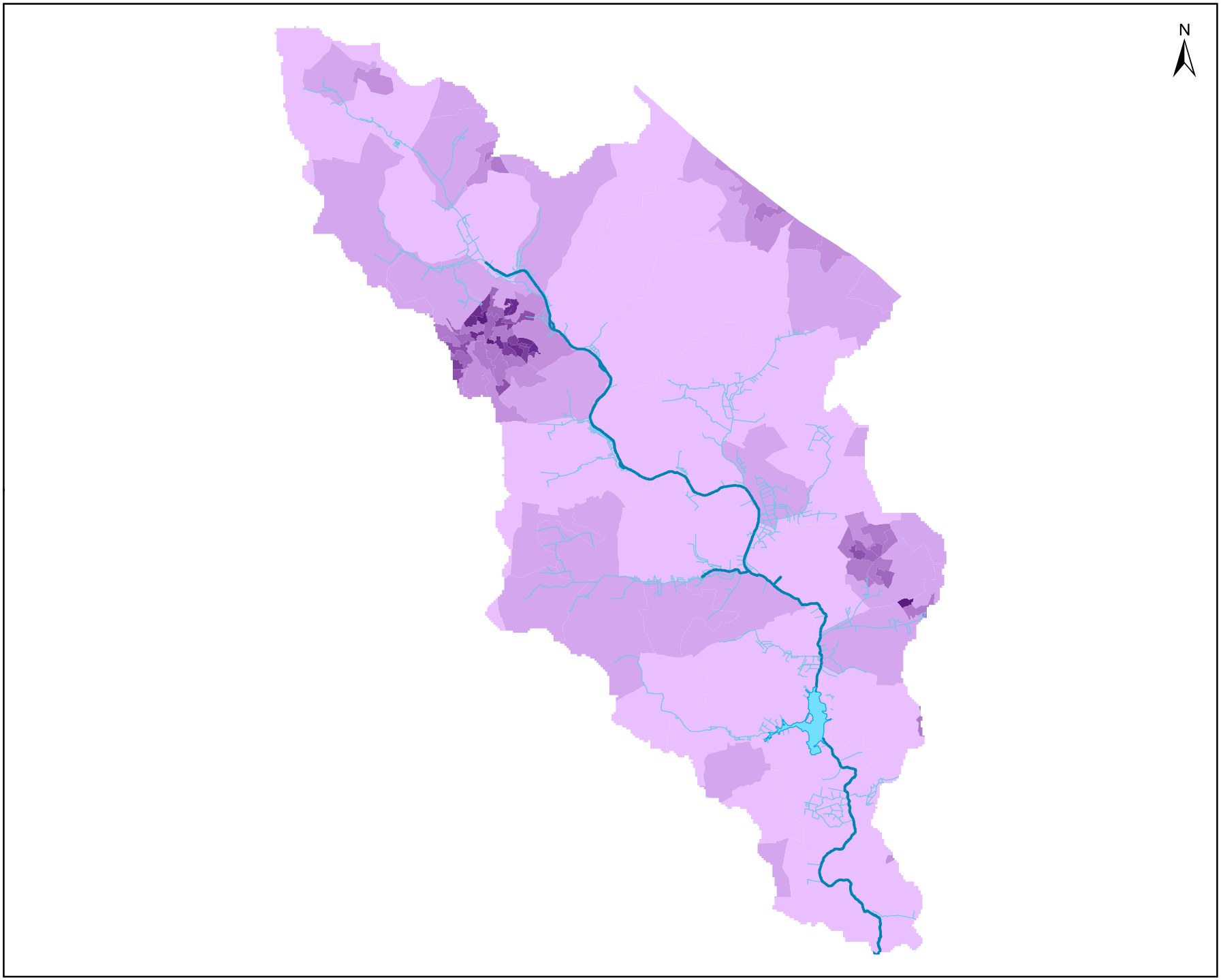
Table 4.5: Land management coverage in the Ant Broads and Marshes SSSI catchment

CODE	Description	Extent	Unit	Catch %	Type
EC24	Hedgerow tree buffer strips on cultivated land	0.06	ha	0.00%	Buffer
EC25	Hedgerow tree buffer strips on grassland	0.6	ha	0.00%	Buffer
EE1	2m buffer strips on cultivated land	9.67	ha	0.06%	Buffer
EE2	4m buffer strips on cultivated land	14.5	ha	0.09%	Buffer
EE3	6m buffer strips on cultivated land	29.22	ha	0.19%	Buffer
EE5	4m buffer strips on intensive grassland	0.38	ha	0.00%	Buffer
EE8	Buffering in-field ponds in arable land	0.73	ha	0.00%	Wetland
EE9	6m buffer strips on cultivated land next to a watercourse	3.78	ha	0.02%	Buffer
EF11	Uncropped, cultivated margins for rare plants on arable land	0.26	ha	0.00%	Buffer
EF13	Uncropped cultivated areas for ground-nesting birds – arable	1	ha	0.01%	Buffer
EF22	Extended overwintered stubbles	3	ha	0.02%	Land cover
EJ9	12m buffer strips for watercourses on cultivated land	2.93	ha	0.02%	Buffer
EK2	Permanent grassland with low inputs: outside SDA & ML	138.47	ha	0.88%	Low fertiliser
EK3	Permanent grassland with very low inputs: outside SDA & ML	322.38	ha	2.06%	Low fertiliser
FDS	Fencing supplement - difficult sites	439	m	n/a	Fencing
FSB	Sheep Fencing – newly restored boundary	2345	m	n/a	Fencing
FSB2010	Sheep Fencing – newly restored boundary	235	m	n/a	Fencing
FSH	Sheep Fencing	3656	m	n/a	Fencing
FSH2010	Sheep Fencing	2293	m	n/a	Fencing
HE1	2 m buffer strips on cultivated land	0.21	ha	0.00%	Buffer
HE10	Floristically enhanced grass margin	34.69	ha	0.22%	Buffer
HE2	4 m buffer strips on cultivated land	4.51	ha	0.03%	Buffer
HE3	6 m buffer strips on cultivated land	4.47	ha	0.03%	Buffer
HF14	Unharvested, fertiliser-free conservation headland	7.18	ha	0.05%	Low fertiliser
HF20	Cultivated fallow plots or margins for arable plants	3.23	ha	0.02%	Buffer
HF20NR	Cultivated fallow plots or margins for arable plants	0.57	ha	0.00%	Buffer
HF6	Overwintered stubble	11.87	ha	0.08%	Land cover
HJ3	Reversion to unfertilised grassland to prevent erosion/run-off	27.79	ha	0.18%	Reversion
HJ5	In-field grass areas to prevent erosion or run-off	0.5	ha	0.00%	Buffer
HJ6	Preventing erosion or run-off from intensively managed grassland	55.1	ha	0.35%	Buffer
HJ8	Nil fertiliser supplement	55.1	ha	0.35%	Low fertiliser
HJ9	12 m buffer strips for watercourses on cultivated land	2.49	ha	0.02%	Buffer
HK3	Permanent grassland with very low inputs	35.05	ha	0.22%	Low fertiliser
HK8	Creation of species-rich, semi-natural grassland	3.72	ha	0.02%	Reversion
HO4	Creation of lowland heathland from arable or improved grassland	9.29	ha	0.06%	Reversion
OE8	Buffering in-field ponds in rotational land	0.03	ha	0.00%	Wetland
OHE3	6 m buffer strips on rotational land	0.58	ha	0.00%	Buffer

4.7. Sources of sewage

4.7.1. Catchment population

Population pressures in the catchment of the Ant Broads and Mashes arise from the discharge of effluent from the existing built environment into the River Ant and its tributaries. The total catchment population is estimated to be around 24,845 people based on data from the 2011 census. As the catchment does not directly align with the Output Areas used by the census this population estimate has been derived using a weighted average based on area. The majority of the people in the catchment live in the towns of North Walsham and Stalham. Figure 4.16 shows the 2011 Census data for the population density, reflecting this spatial pattern within the catchment.



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.16: Ant Broads and Marshes SSSI catchment Census Population

Lakes
Main Rivers
Watercourses

Population Density (Persons/ha)

Quantile Ranges

0.0810 - 0.491
0.492 - 2.95
2.96 - 11.1
11.2 - 22.8
22.9 - 32.4
32.5 - 41.0
41.1 - 51.5
51.6 - 65.0
65.1 - 85.3

0 1 2 3 km

Scale (at A4): 1:120,000

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Table 4.6: Ant Broads and Marshes SSSI catchment census summary

Waterbody ID	Name	Persons always present	% of total catchment
GB105034051330	Ant	4,769	19%
GB105034055710	Ant	14,296	58%
GB105034055670	East Ruston Stream	2,977	12%
GB105034050890	Smallburgh Watercourse	1,468	6%
GB105034050910	Unnamed	1,337	5%
Total	-	**24,845**	**100%**

4.7.2. Waste Water Treatment Works

A total of eight waste water treatment works (WwTWs) discharge into the River Ant upstream of the SSSI. In combination, these WwTWs serve a population equivalent of 13,190 people. In addition, the North Walsham WwTW serving around 5,400 people no longer discharges into the catchment since it was diverted to the North Sea as part of a campaign to reduce phosphorus loads in the River Ant in the 1980s (Wade *et al.*, 2003).

Other details provided in the previous DWPP are as follows:

- Neatishead village applied for first time rural sewage and the south of the village has now been connected and the sewage goes to Belaugh on the Bure so out of the Ant catchment.
- Anglian Water have proposed to install mains sewer to the north part of Neatishead – see section 8.
- There have been concerns raised over surcharging manholes at Sutton Staithe – this is a long running issue which is being resolved through sealing of manholes and increasing the capacity within the sewer system.

As the tidal influence on most of the SSSI is indirect, by the backing up of water, downstream WwTWs are not included in this list considered. At the catchment scale, the largest WwTW in the SSSI catchment is Stalham STW serving 10,861 persons. There is a phosphate consent limit of 2mg/l on this discharge.

Table 4.7: Consented sewage treatment works discharges within the Ant Broads and Marshes SSSI catchment

Waterbody ID	Waterbody Name	WwTW label	Population equivalent	TP consent limit (mg/l)
GB105034051330	Ant	BARTON TU	30	
GB105034051330	Ant	NEATISHEAD	40	
GB105034051330	Ant	NEATISHEAD	40	
GB105034055670	East Ruston Stream	EAST RUST	51	
GB105034055710	Ant	TRUNCH–N	126	
GB105034055710	Ant	SOUTHREPPS	786	
GB105034051330	Ant	HORNING–K	1256	
GB105034051330	Ant	STALHAM STW	10861	2
		Total	**13190**	

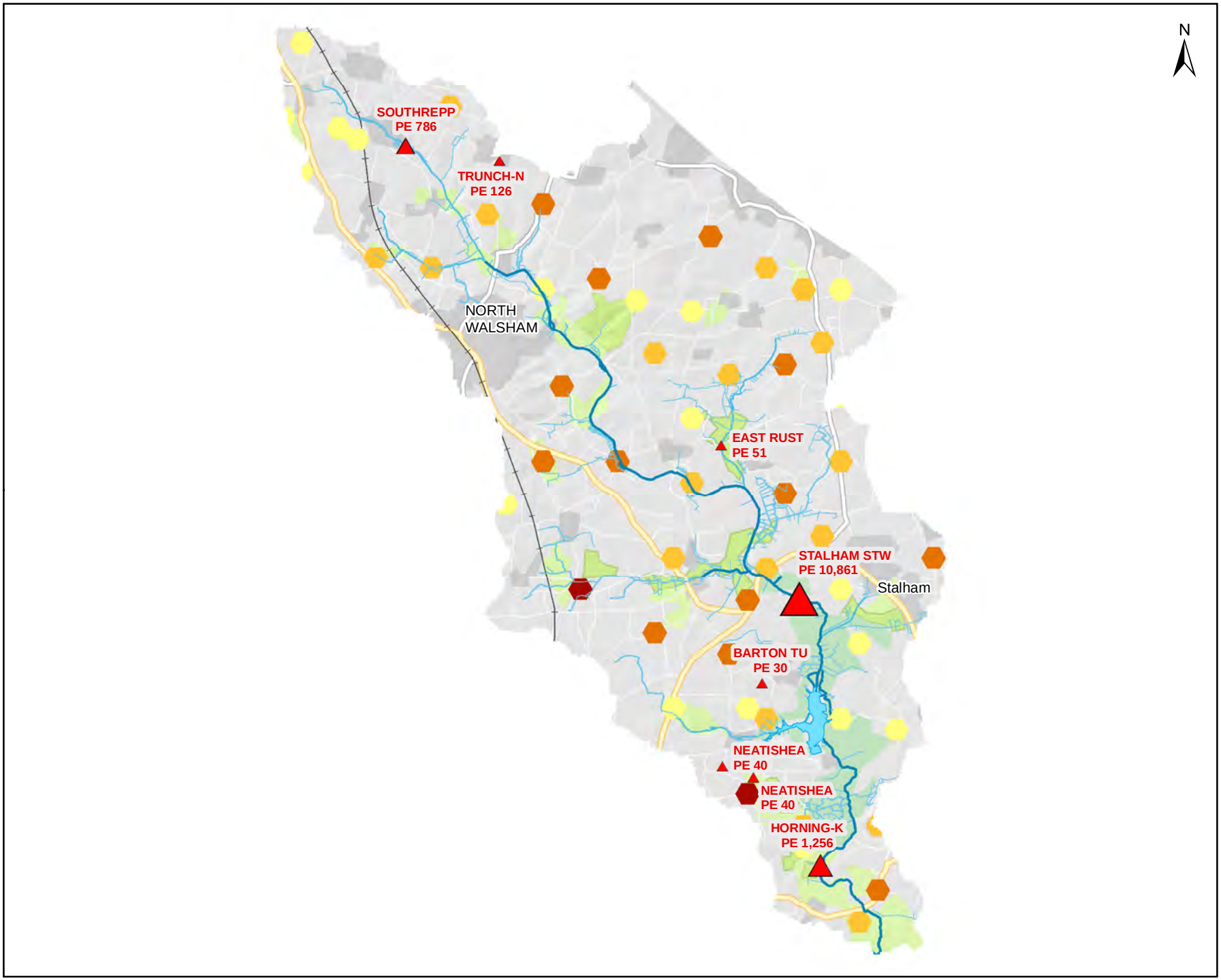
4.7.3. Septic tanks and soakaways

Other sources of sewage effluent would include small sewage treatment plants and any illegally connected or poorly maintained septic tanks.

Studies have estimated that there are between 973 (May *et al.,* 2011) and 1,305 (EA, 2009 National Properties Database) properties not served by mains sewerage in the River Ant catchment. Assuming an average occupancy of 2.3, the EA estimate is equal to a population of 3,002 (see Table 4.8). These estimates need to be taken with a degree of caution due to the large uncertainties in the underlying data and methodology used to derive them. Figure 4.17 shows the locations of wastewater treatment works and possible septic tank locations within the catchment.

Table 4.8: Estimate of population not connected to mains sewerage within the Ant Broads and Marshes SSSI catchment

Waterbody ID	Name	Properties not on mains sewerage	Population Equivalent	%
GB105034050890	Smallburgh Watercourse	236	543	18%
GB105034050910	Unnamed	95	219	7%
GB105034051330	Ant	378	869	29%
GB105034055670	East Ruston Stream	266	612	20%
GB105034055710	Ant	330	759	25%
Total		**1,305**	**3,002**	**100%**



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.17: Population Pressures

Wastewater Treatment Works

Population Equivalent

- 11 - 500
- 501 - 1000
- 1001 - 2500
- 5001 - 21333

- Lakes
- Main Rivers
- Watercourses

Possible septic tank locations and numbers (Nov 2009)

- 1 - 10
- 11 - 30
- 31 - 80
- 81 - 155

0 1 2 3 km

Scale (at A4): 1:120,000

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4.8. Conservation and ecology

4.8.1. Ant Broads and Marshes SSSI

The full SSSI citation can be found in Appendix A and on the website of Natural England[5].

The SSSI comprises an extensive valley complex of open fen, wet woodland and open water habitats. The notified features are as follows:

- Assemblages of breeding birds – Lowland open waters and their margins
- Invertebrate Assemblage
- Lowland ditch systems
- Population of Schedule 8 plant – *Liparis loeselii*, Fen Orchid
- Standing waters
- Vascular Plant Assemblage
- M24 – *Molinia caerula – Cirsium dissectum* fen-meadow
- M5 – *Carex rostrata – Sphagnum squarrosum* mire
- M9 – *Carex rostrata – Calliergon cuspidatum*/*giganteum* (*Calliergonella cuspidata/Calliergon giganteum*) mire
- S2 – *Cladium mariscus* swamp and sedge-beds
- S24 – *Phragmites australis – Peucedanum palustris* tall-herb fen
- S27 – *Carex rostrata – Potentilla palustris* swamp
- W2 – *Salix cinerea – Betula pubescens* – Phragmites australis woodland
- W5 – *Alnus glutinosa – Carex paniculata* woodland
- W6 – *Alnus glutinosa – Urtica dioica* woodland

4.8.2. The Broads SAC

The Ant Broads and Marshes form part of The Broads SAC. Information on the SAC can be found in Appendix B, and on the website of the JNCC[6]. The specific conservation objectives for SAC features are to maintain, in favourable condition:

- hard oligo-mesotrophic waters with benthic vegetation of Chara spp[†];
- natural eutrophic lakes with Magnopotamion or Hydrocharition – type vegetation[†];
- transition mires and quaking bogs[†];
- calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*[†];
- alkaline fens[7];
- alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae, Salicion albae*)[†];
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)[‡];
- habitats for the populations of Desmoulin's whorl snail (*Vertigo moulinsiana*)[†];
- habitats for the populations of Fen orchid (*Liparis loeselii*)[†];
- habitats for the populations of Ramshorn snail (*Anisus vorticulus*)[†]; and
- habitats for the populations of Otter (*Lutra lutra*)[8 ‡].

[†] *Annex I habitat/Annex II species that is a primary reason for SAC designation*
[‡] *Annex II species present as a qualifying feature but not a primary reason for SAC designation.*

[5] The SSSI citation can be found via the website of Natural England: http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1000501

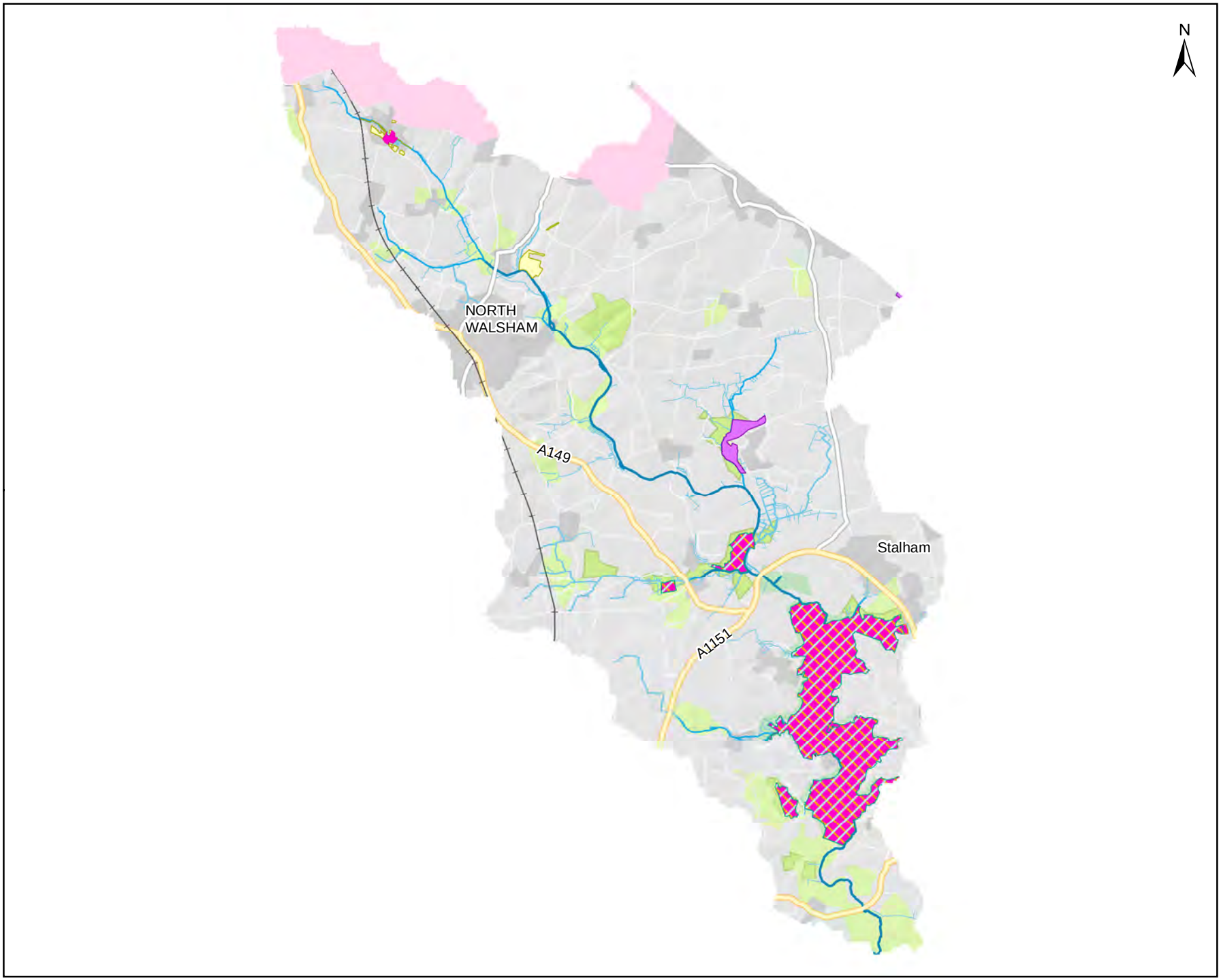
[6] The full description of the SAC can be found on the JNCC website: http://jncc.defra.gov.uk/ProtectedSites/SACselection/n2kforms/UK0013577.pdf

[7] Annex I habitat/Annex II species that is a primary reason for SAC designation

[8] Annex II species present as a qualifying feature but not a primary reason for SAC designation

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.18: Ant Broads and Marshes SSSI: catchment environmental designations



- Ramsar
- SPA
- SAC
- SSSI
- NNR
- LNR
- AONB

0 1 2 3 km

Scale (at A4): 1:120,000

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4.8.3. Broadland SPA and Ramsar Site

The Ant Broads and Marshes also forms part of The Broadland SPA and Ramsar site. Information on the SPA can be found in Appendix B, and on the website of the JNCC[9]. Information on the Ramsar site can be found in Appendix D, and on the website of the JNCC[10].

The Broadland SPA site is designated as during the breeding season it regularly supports:

- *Botaurus stellaris* (the Great Bittern)
- *Circus aeruginosus* (the Western Marsh-harrier)

In addition, over winter the area regularly supports:

- *Circus cyaneus*
- *Cygnus columbianus bewickii*
- *Cygnus cygnus*
- *Anas strepera*

The Broadland Ramsar site supports a number of rare species and habitats within its biogeographical zone context, including the following Habitats Directive Annex I features:

- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
- Calcium-rich fen dominated by great fen sedge (saw sedge).
- Alkaline fens Calcium-rich springwater-fed fens.
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion*
- *incanae, Salicion albae*) Alder woodland on floodplains,

And the Annex II species:

- *Vertigo moulinsiana* Desmoulin's whorl snail
- *Lutra lutra* Otter
- *Liparis loeselii* Fen orchid

The site supports the following species/populations occurring at levels of international importance with peak counts in winter:

- Tundra swan , *Cygnus columbianus bewickii*
- Eurasian wigeon , *Anas penelope*
- Gadwall , *Anas strepera strepera*
- Northern shoveler , *Anas clypeata*
- Pink-footed goose , *Anser brachyrhynchus*
- Greylag goose , *Anser anser anser*

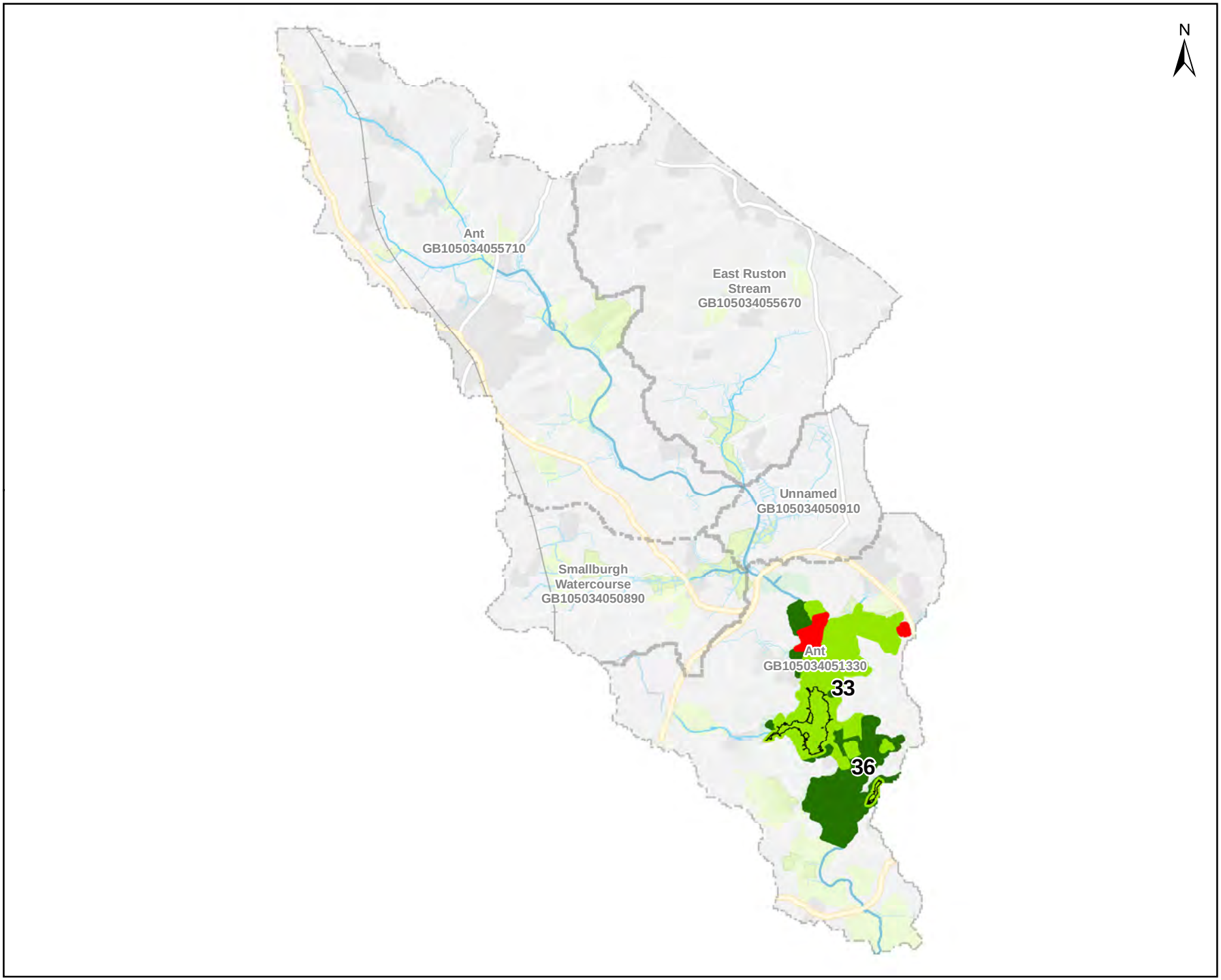
The site supports a range of other noteworthy flora and fauna set out in the citation.

4.9. Environmental targets for favourable condition

4.9.1. Overall SSSI condition assessment

The overall condition assessment results are provided in Figure 4.19 and Table 4.9.

[9] The full description of the SAC can be found on the JNCC website: http://jncc.defra.gov.uk/pdf/SPA/UK9009253.pdf
[10] The full description of the SAC can be found on the JNCC website: http://jncc.defra.gov.uk/pdf/RIS/UK11010.pdf



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 4.19: Ant Broads and Marshes SSSI catchment unit condition

Units in adverse condition due to Water Pollution – Agriculture / Run-off

SSSI Unit Condition

- Favourable
- Unfavourable Recovering
- Unfavourable Declining
- WFD Water bodies

0 1 2 3 km

Scale (at A4): 1:120,000

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Table 4.9: Ant Broads and Marshes SSSI unit condition assessment table

Unit	SSSI Unit ID	Area (ha)	Condition	Last assessment
1	1015916	10.40	Favourable	28 Jan 2010
2	1015917	30.60	Favourable	28 Jan 2010
3	1015926	25.30	Unfavourable Recovering	16 Sep 2013
4	1015918	18.30	Favourable	29 Jan 2010
5	1015927	121.8	Favourable	04 Feb 2010
6	1015928	16.60	Favourable	28 Jan 2010
7	1015919	0.60	Favourable	01 Feb 2010
8	1015929	36.00	Unfavourable Recovering	04 Feb 2010
9	1015930	5.30	Favourable	21 Jan 2010
10	1015931	123	Unfavourable Recovering	04 Feb 2010
11	1015932	35.80	Favourable	16 Sep 2013
12	1015933	7.40	Favourable	28 Jan 2010
13	1015920	2.60	Favourable	01 Feb 2010
16	1015935	7.90	Favourable	29 Jan 2010
17	1015936	9.80	Favourable	28 Jan 2010
18	1015937	8.40	Unfavourable Recovering	28 Jan 2010
19	1015938	0.40	Favourable	21 Jan 2010
20	1015939	2.00	Favourable	21 Jan 2010
21	1015940	5.70	Unfavourable Recovering	21 Jan 2010
22	1015941	27.70	Favourable	28 Jan 2010
23	1015921	12.00	Unfavourable Recovering	04 Feb 2010
24	1015922	24.00	Unfavourable Recovering	04 Feb 2010
25	1015923	17.00	Unfavourable Recovering	28 Jan 2010
26	1015942	68.10	Unfavourable Recovering	01 Feb 2010
27	1015924	16.40	Favourable	28 Jan 2010
28	1015943	2.00	Favourable	21 Jan 2010
29	1015915	1.70	Favourable	21 Jan 2010
30	1015944	3.10	Unfavourable Declining	21 Jan 2010
31	1015925	24.30	Unfavourable Declining	09 Feb 2010
32	1026036	0.10	Favourable	01 Feb 2010
33	**1028678**	**71.30**	**Unfavourable Recovering**	12 Nov 2010
34	1028679	0.40	Favourable	08 Mar 2010
35	1028680	1.30	Unfavourable Recovering	16 Sep 2013
36	**1028681**	**4.20**	**Unfavourable Recovering**	12 Nov 2010
37	1028682	4.00	Favourable	21 Jan 2010

4.9.2. What attributes contribute to the latest condition assessment?

Although a number of the 37 SSSI Units are currently in unfavourable condition, only two of the SSSI units are in adverse condition attributed to Diffuse Water Pollution. These are:

- Unit 33, Barton Broad (71.26 hectares)
- Unit 36, Crome's Broad (4.22 hectares)

Both these Units are located within the WFD waterbody 'Ant', within the ID GB10503405130. Summaries of Unit condition assessments are available via the website of Natural England[11].

[11] Summaries of Unit condition assessments are available via the website of Natural England:
http://www.sssi.naturalengland.org.uk/Special/sssi/reportAction.cfm?report=sdrt13&category=S&reference=1000501

5. What is the evidence?

5.1. Reasons cited for unfavourable condition

Barton Broad

In addition to the 2010 condition assessment[12], Barton Broad (Unit 33) was assessed as unfavourable during a condition assessment in July 2012 due to:

- Poor water quality (excess Total P)
- Excessive algal biomass (chlor a)
- Impoverished aquatic flora

Barton Broad has been monitored intensively since the early 1970s; at times this effort has been intensive in order to inform and support on-going restoration and management options (such as phosphorus stripping on the upstream STW). It has also been the subject of significant paleolimnological studies (e.g. Madgwick *et al*., 2011).

The collective evidence-base for Barton Broad, including condition assessments, paleolimnological studies and historical monitoring is consistent with the impact of eutrophication. Fossil diatoms, plant macrofossils, historic aquatic macrophyte records and anecdotal evidence suggest that the primary period for loss of aquatic macrophyte species and structural complexity, along with a switch towards a more algal-dominated community, occurred between approximately 1920 and 1950 (Madgwick *et al*., 2011). Despite the likelihood of multiple pressures, eutrophication is cited as a key driving force, from which the site is yet to make a stable recovery (Madgwick *et al*., 2011). The River Ant has been implicated as causal in terms of nutrient loading (see the summary of the condition assessment above), which undermines restoration measures which only focus on the lake itself.

Crome's Broad

Although an equivalent condition assessment is not available for Crome's Broad (Unit 36), it is reported as unfavourable recovering in the SSSI Unit condition summary. The summary reported that the Unit continues to benefit from mud pumping that has been carried out, and that the macrophyte diversity appears to be stable, particularly in the south basin. While this Unit is within the River Ant catchment, unlike Barton Broad, it is off-line and so not directly fed by the Ant itself. Nutrient pressures from the Ant are therefore less relevant for the management of this Unit.

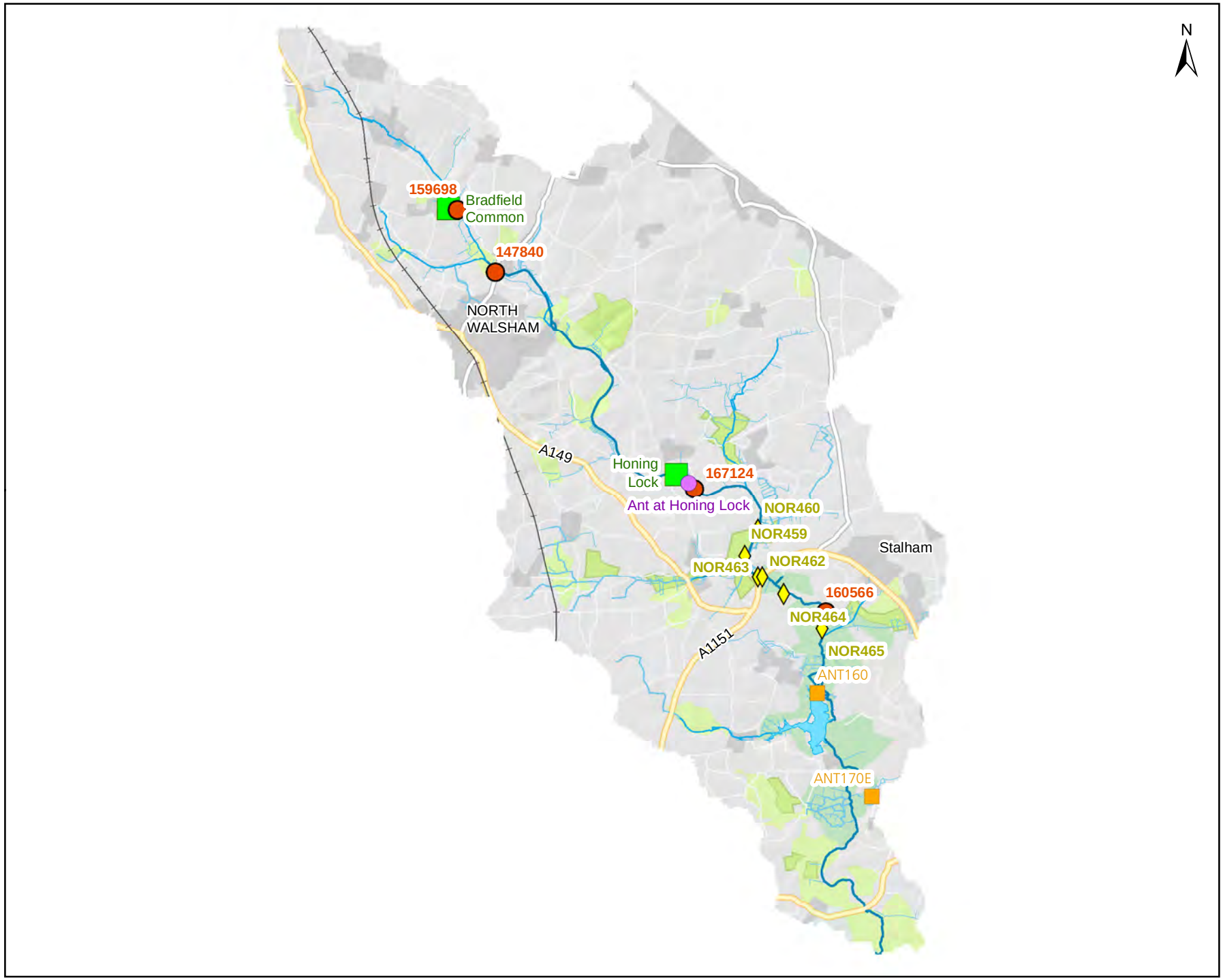
[12] The 2010 condition assessment is reported online at: http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1000501

5.2. SSSI water quality objective compliance

An assessment of compliance with the Ant Broads and Marshes SSSI's water quality objectives has been undertaken as part of this study. The assessment has used data collected in the catchment at the two Environment Agency sampling points in the River Ant catchment. Their location is shown in Figure 5.1 below. The two monitoring locations correspond with the two main features of interest, Barton Broad and Crome's Broad.

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 5.1: Ant Broads and Marshes SSSI catchment monitoring locations



Flow Monitoring

Water Quality Monitoring

Monitoring sites selected as most recent data collection date per SSSI Unit after 2010

Fish Monitoring Sites

Macrophyte Monitoring Sites

Macroinvertebrate Monitoring Sites

0 1 2 3 km

Scale (at A4): 1:120,000

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5.2.1. Phosphate

5.2.1.1. SSSI objective/targets

There are separate targets for Barton Broad and Crome's Broad reviewed below.

5.2.1.1.1. Barton Broad

Barton Broad is designated as a heavily modified lake under the WFD, and therefore must meet Good Ecological Potential (GEP) by 2027. Targets for total phosphorus and chlorophyll-*a* relevant to Natural England and to the Environment Agency are given in Table 5.1. They include the Water Framework Directive targets the Environment Agency are working towards, and the Natural England total phosphorus target for Special Area of Conservation (SAC) naturally eutrophic lakes. All the targets are based on an annual average for a 3-year period.

Table 5.1: Barton Broad phosphorus targets

Target	Owner	Total Phosphorus (µg/l)	Chlorophyll *a* (mg/l)
SAC (naturally eutrophic lakes)	*Natural England*	*50*	-
WFD High to Good	Environment Agency	44	9
WFD Good to Moderate	Environment Agency	59	20
WFD Moderate to Poor	Environment Agency	119	39
WFD Poor to Bad	Environment Agency	238	118

The targets are currently under review, as Natural England and the Environment Agency are currently working to deliver concentrations of total phosphorus and chlorophyll-*a* that are better than GEP (shown in italics in Table 2.1).

5.2.1.1.2. Crome's Broad

Crome's Broad is within the SAC, though the broad itself is not identified as one of the eutrophic lake features of the SAC. It has a target of 100 µg/l of Total Phosphorus, due to its baseline status as a lake supporting simple macrophyte communities and Special Protection Area (SPA) bird populations.

5.2.1.2. Data available for the Ant Broads and Marshes SSSI

Phosphorus data provided by the Environment Agency are reviewed in Table 5.2. This table indicates that there is a very good long-term water quality record for Barton Broad (EA sampling site: ANT160), with over 40 years of total phosphorus data. The record for Crome's Broad (EA sampling site: ANT170E) is shorter and is close to 10 years.

Table 5.2: Phosphorus data availability for the Ant Broads and Marshes SSSI catchment

Name	EA Sampling site ID	Start Date	End Date	No. samples for Phosphorus, total as P	No. samples for Orthophosphate, reactive as P
Barton Broad	ANT160	06/04/1981	15/01/2014	607	166
Crome's Broad	ANT170E	12/04/2006	16/12/2013	88	0

5.2.1.3. Long term orthophosphate trends

Figure 5.2 below shows annual average levels of Total Phosphorus level Barton Broad since 1980. There have been substantial declines in Total Phosphorus levels since 1980 following the introduction of tertiary treatment at Stalham STW and the diversion of effluent from North Walsham STW. A review of activities in the catchment is provided in Table 5.3. Since the late 1990s, total phosphorus levels in Barton Broad have been below 0.10 mg/l and in some years have approached the 0.05 mg/l target (Table 5.2). However, only in one year (2005) have levels ever dropped below the 0.05 mg/l target.

Table 5.3: A review of the main phosphorus mitigating activities in the Ant Broads catchment

Date	Description
1978	Experimental Phosphorus removal at Stalham STW
1980	Diversion of effluent from North Walsham STW
1983	Phosphorus removal from small STW discharging to River Ant
1996–2001	Sediment removal from Barton Broad
1997	Enhanced phosphorus removal at Stralham STW
1998	Phosphorus removal from factory discharging to River Ant
2004	Fish free enclosures established in four locations at Barton Broad

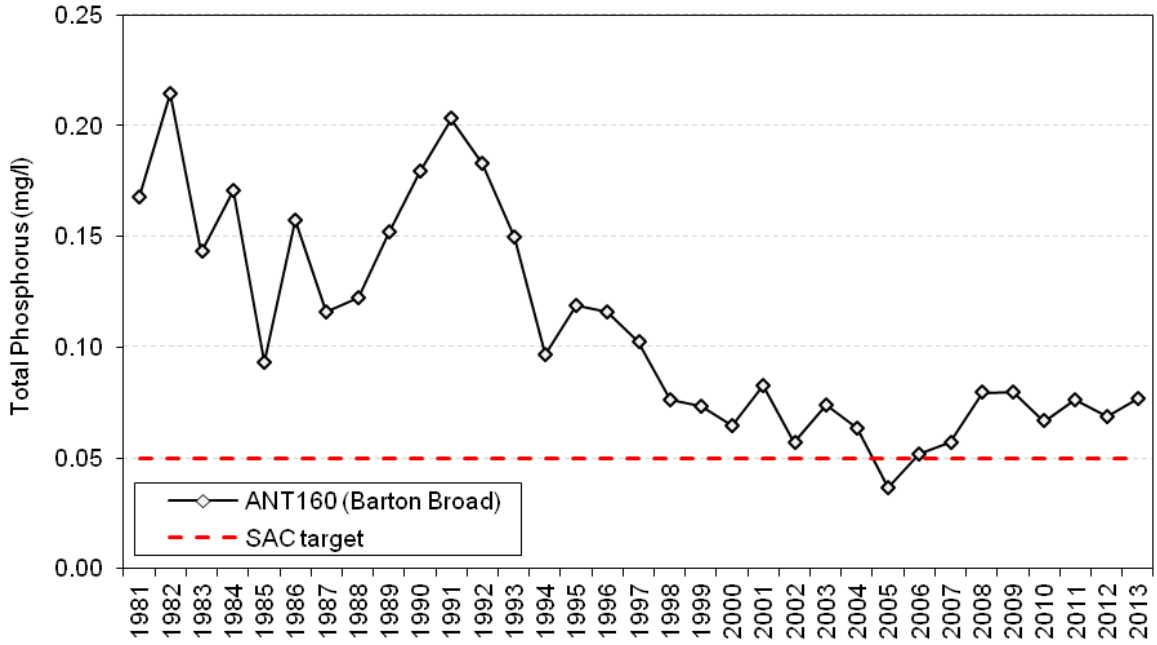


Figure 5.2: Barton Broad total phosphorus monitoring data (1980–2013)

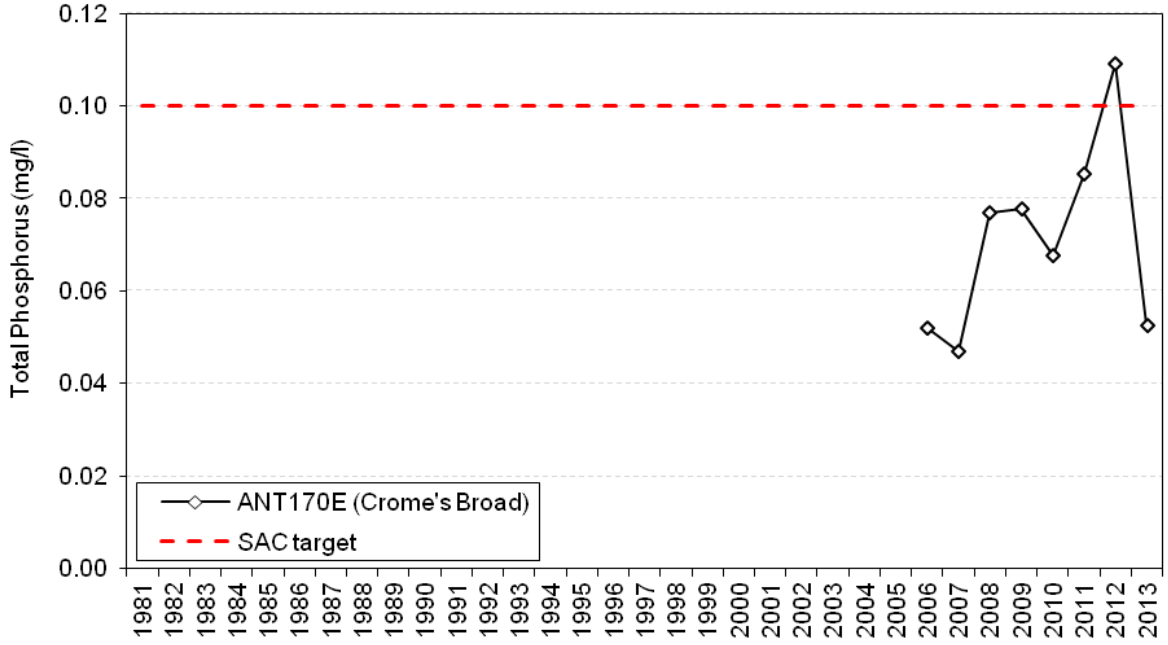


Figure 5.3: Crome's Broad phosphorus monitoring data (2007–2013)

5.2.1.4. Recent trends

Table 5.4 assesses the compliance of water quality in Barton Broad and Crome's Broad in more recent times, considering the years between 2006 and 2013. The table is colour coded relative to the phosphate targets. The key points to note from this are that during the period between 2010 and 2012 the data shows that the three year average total phosphorus level is 0.071 mg/l in Barton Broad, therefore failing the 0.05 mg/l target. In Crome's Broad, the three year average total phosphorus level (2010 to 2012) is 0.087mg/l, therefore passing the 0.1 mg/l target.

Table 5.4: Compliance with SSSI phosphate targets

WIMS ID	ANT160	ANT170E
Site name	Barton Broad	Crome's Broad
Target	0.05	0.10
2006	0.052	0.052
2007	0.057	0.047
2008	0.080	0.077
2009	0.080	0.078
2010	0.067	0.068
2011	0.077	0.085
2012	0.069	0.109
2013	0.077	0.053

A green shaded cell indicates the site has passed the target; orange that the site is within 10% of the target; and red that the site is greater than 10% of the target.

5.2.1.5. Seasonal trends

Figure 5.4 and Figure 5.5 show how total phosphorus levels vary seasonally in Barton Broad and Crome's Broad. The data show the period between 2010 and 2012.

There is a distinct seasonal trend in phosphorus levels in Barton Broad with the lowest levels in the winter and the highest levels in the summer (Figure 5.4). On average, phosphorus levels are above the 0.05 mg/l target between March and October. At other times of year they pass the 0.05 mg/l target. The seasonal trend could be indicative of internal loading in Barton Broad. An alternative possible explanation is that the location of the monitoring point is close to where the River Ant enters Barton Broad, and the trend may reflect the Ant river itself and a dominance of point sources.

In contrast, the seasonal pattern in Crome's Broad shows peak phosphorus levels during the winter months (Figure 5.5). **This seasonal trend is more closely associated with diffuse pollution.** Smaller peaks occur during the summer months when plant uptake is greater.

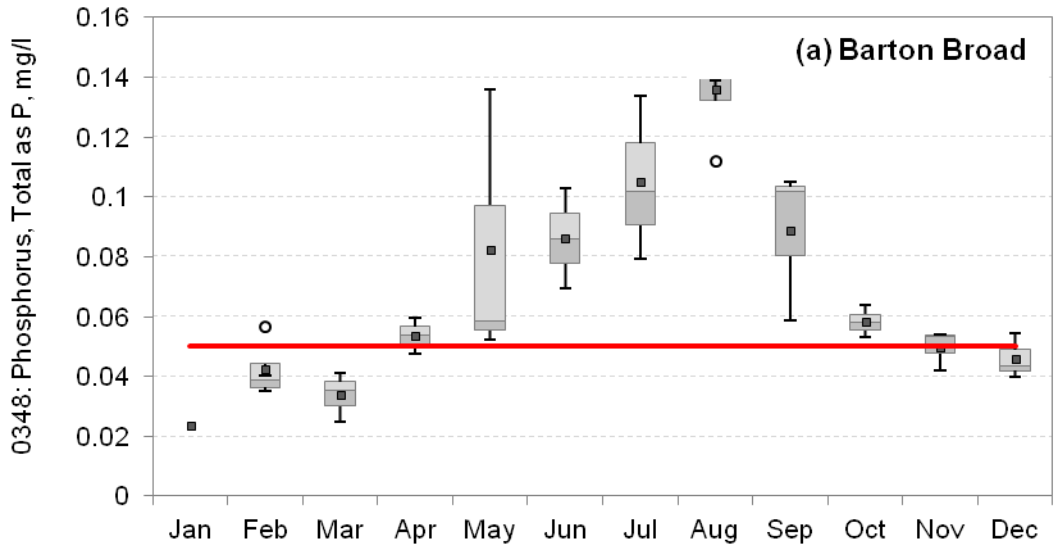


Figure 5.4: Seasonal phosphate trends in Barton Broad

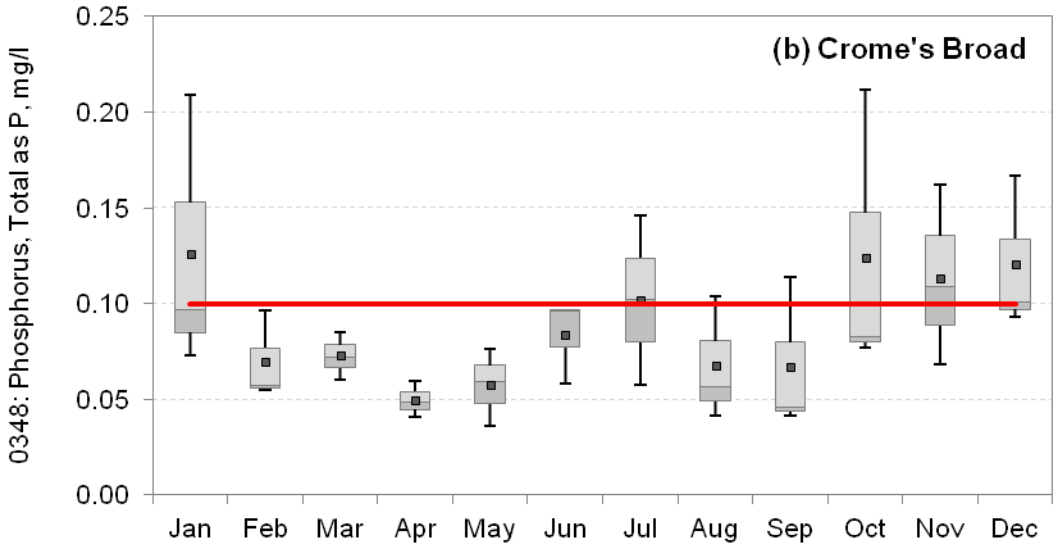


Figure 5.5: Seasonal phosphate trends in Crome's Broad

5.2.2. Suspended Solids and siltation

The Common Standards Monitoring guidance[13] for standing waters considers sediment as a relevant pressure. It includes two broad measures for condition assessment:

- Maintain natural sediment load; and
- Maintain natural and characteristic substrate.

Whilst there are no specific targets for sediment in the River Ant catchment, Barton Broad or Crome's Broad, there has been significant historical interest concerning the rate of sedimentation in Barton Broad, including the storage and subsequent release of phosphorus from sediments and their effects on ecological condition. Further details of these studies can be found in the developing Barton Broad Dossier (*Broads Review Project: Unpublished Draft Report by Natural England and the Broads Authority*).

In summary, coring has shown that TP concentrations decreased with increasing sediment depth. Suction dredging was undertaken between 1996 and 2001 to remove sediment bound phosphorus in Barton Broad. Immediately after dredging, the sediment phosphorus concentration was lowered to 50% of its original levels

[13] See: http://jncc.defra.gov.uk/pdf/CSM_standingwaters_Mar05.pdf

for a period of 5 years after dredging. However, recent data indicate that sediment dredging activities have had little long-term effect on sediment TP concentration or vertical profiles within the sediments of Barton Broad. Phosphorus levels in the surface sediment of the Broad rapidly increased after dredging, probably as a result of the deposition of algal rich material settling out coupled with inputs from the river.

5.3. Ecological objectives compliance

5.3.1. Barton Broad

A draft report currently being prepared by Natural England and the Broads Authority (*Barton Broad Dossier, and Broads Review Project: Unpublished Draft Report by Natural England and the Broads Authority*) provides a review of the current and historic character of the flora of Barton Broad.

Palaeolimnological investigations have identified three stages in the aquatic vegetation development of Barton Broad over the last 200 years. Prior to the late 1800s, macrophyte communities were diverse and included a multi-layered mosaic of short-stature submerged taxa. There is evidence of a shift to mild eutrophic conditions in the 1900s with a marked increase in planktonic diatoms post 1950s indicative of highly nutrient-rich waters.

Annual surveys since about 1980 have shown a general improvement since about 2003. Prior to this date, macrophytic vegetation had been absent, or effectively absent (<5% cover) from Barton Broad for the 20 preceding years. Since then there has been a general improvement, with especially high cover in the period 2005–2007 although this has not been sustained. Nevertheless there is a significant positive trend in cover over the 30 year period for which data are available and there has also been a long-term significant improvement in terms of species richness despite an apparent decline in the last few years.

The significant appearance of aquatic vegetation in Barton post-dates sediment removal by several years. It is also important to note that some of the historic species of the Broad are considered to be ill-adapted to survive the hydraulic stresses associated with current boat movements in Barton. Increased populations of herbivorous water birds and the indirect effects of fish on zooplanktivory may also limit the ability of macrophytes to establish permanently.

5.3.2. River Ant

In addition to the available baseline information for Barton Broad, the Environment Agency has a number of routine monitoring points for macrophyte, fish and macroinvertebrate communities on the River Ant. These sites are all upstream of Barton Broad and can therefore be considered representative of water quality pressures that are contributing to those evident in Barton Broad itself. These can be used to further assess the pressures within the catchment, and importantly, investigate the ecological impacts of water quality deterioration that may be linked to diffuse pollution.

5.3.2.1. Macrophyte and diatom community evidence

Macrophyte monitoring has been undertaken at four locations on the River Ant upstream of Barton Broad.

Figure 5.1 shows the location of Environment Agency macrophyte survey sites along the Ant that are relevant to this assessment. These locations (moving downstream) are:

- Common Road Bradfield (Site ID 159698 – surveyed August 2012);
- Upstream Swafield Bridge (Site ID 147840 – surveyed August 2007);
- Downstream Honing lock (Site ID 167124 – surveyed September 2013); and
- Upstream Hunsett Drainage Mill (Site ID 160566 – surveyed August 2013).

Macrophytes in the River Ant water body are not reported in terms of WFD ecological status in the Anglian River Basin Management Plan. However, macrophyte community biotic metrics calculated by the Environment Agency that are of direct relevance to this assessment include:

- Macrophyte Mean Trophic Rank (MTR; Holmes *et a*l., 1999). MTR describes plant community preferences to nutrients. Each contributing species has a Species Trophic Rank (STR) between 1 and 100. It has now been superseded by the River Macrophyte Nutrient Index for WFD classification (RMNI; LEAFPACS Protocol (UKTAG, 2009)), but this was not provided for all monitoring sites in the EA data request. Under MTR, plant communities with a score of 1 occur in very high nutrient levels while communities with a score of 100 occur in very low nutrient rivers; and
- River Macrophyte Nutrient Index (RMNI; LEAFPACS Protocol (UKTAG, 2009)). RMNI is designed to categorise a macrophyte communities preferences to nutrient levels. Scores range from 1 to 10 with scores of 1 representing plant communities with preference for very low levels of nutrients and 10 representing communities with a preference for much enriched conditions.

In summary:

- The reported MTR for the Ant macrophyte monitoring sites ranges from 30.7 to 42. A site with an MTR of less than 25 is considered to be very badly damaged by eutrophication (Holmes *et al*., 1999). With MTRs only slightly above this cut-off, the Ant macrophyte monitoring sites are therefore clearly showing strong signs of anthropogenic eutrophication; and
- RMNI (and associated expected scores) were only available for Common Road Bradfield and Upstream Swafield Bridge sites (the two most upstream). Scores reported were 7.33 and 7.82 respectively, indicating enriched conditions. In the context of the expected RMNI under reference conditions for these sites, the macrophyte communities were both classed as moderate status. This indicates significant deviation from reference conditions as a result of eutrophication pressure in the Ant.

5.3.2.2. Macroinvertebrate community evidence

The Environment Agency typically assesses four pressures using macroinvertebrate surveys and pressure metrics:

- Flow pressure metric (Lotic Invertebrate Flow Evaluation, LIFE, see Extence *et al*. 1999) – this metric indicates when flows are affecting the macroinvertebrate assemblage. It can be used to help determine when abstraction is affecting the ecology.
- Water quality pressure metrics (Number of Taxa; NTAXA, Average Score Per Taxon; ASPT, see UKTAG 2013) – These two metrics together can be used to determine the impacts of water quality pollution (particularly organic enrichment and toxic chemical pollution) on the ecology
- Sediment pressure metric (Proportion Sediment Index; PSI. See Extence *et al*. (2013) – this metric indicates when over-sedimentation is affecting the macroinvertebrate assemblage.

Figure 5.1 shows the location of macroinvertebrate survey sites along the Ant, whilst Figure 5.6 is an example of the pressure metric data over time, plotted with flow. This type of graphical analysis is called Hydro Ecological Validation (HEV) and is used by the Environment Agency to identify pressures within water bodies as part of WFD investigations. When LIFE, N–TAXA, ASPT and PSI scores are below WFD good cut-off, the general conclusion is that there is a pressure affecting the macroinvertebrate assemblage.

The HEV analysis requires some degree of expert judgement to ascertain whether the various pressures are present and constant, requiring an understanding of how the metrics interact with each other, and how morphology and American signal crayfish predation affects the outputs. Individual low metric scores within the data would not indicate a consistent pressure on the invertebrate community; poor morphology can lower LIFE scores whilst American signal crayfish predation can increase LIFE scores, but lower N–TAXA scores.

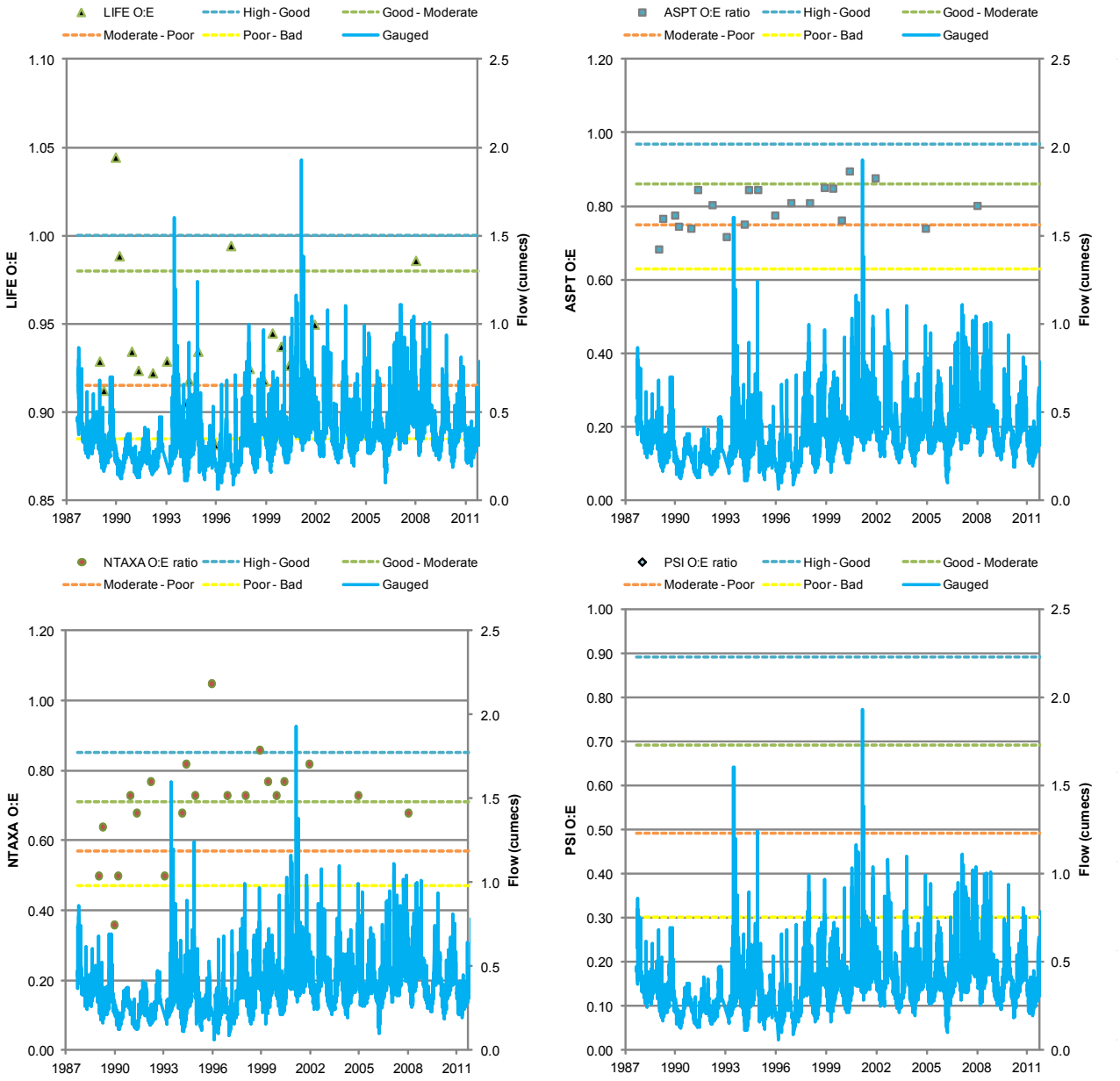


Figure 5.6: HEV plots at Bradfield Common along Fox's Beck
(Note that PSI data was not available in a suitable format to be included in this work)

Table 5.5 summarises the HEV analysis for all the macroinvertebrate sites on the Ant. The HEV analysis has been used to determine the WFD status using the four metrics over the recent past, last 6 years (2008–2013) rather than from 1990 when most of the data is available from. The status has been classified as High, Good or Moderate or less. A class of Moderate or less generally suggests that a pressure is affecting the macroinvertebrate assemblage.

Table 5.5: HEV analysis summary, showing the WFD status of the macroinvertebrates for each pressure metric

Watercourse	Site	Flow sensitivity (LIFE)	Water quality sensitivity (ASPT)	Water quality sensitivity (N–TAXAT)	Sedimentation sensitivity (PSI)	American signal crayfish predation?
Ant	Honing Lock	High	Good	High	-	No
Fox's Beck (Ant)	Bradfield Common	Moderate or less	Moderate or less	Moderate or less	-	No

The results show that the water quality (ASPT and N–TAXA) is either at Good or High in the middle Ant catchment at Honing lock, but Moderate or less upstream on Fox's Beck. PSI data for the HEV analysis was not available at the time of reporting. Flow pressure (LIFE) is small in the middle River Ant; however there is a pressure in the upper Ant. This is supported by the water resource flow compliance for the upper Ant water body showing that flows are non-compliant with the Environmental Flow Indicator (EFI). Therefore, flow could be reducing the dilution of diffuse pollutants in the lower Ant, compounding upon any diffuse pollution inputs.

American signal crayfish have not been observed along the River Ant to date and therefore are not believed to be affecting the metric scores. Based on the River Habitat Survey data (http://www.riverhabitatsurvey.org) for the river, both macroinvertebrate survey sites are heavily re-sectioned although instream habitat is comparable with other reaches along the Ant which are not or less re-sectioned.

In summary, the implication for the SSSI are that water quality and flow pressures metrics show little diffuse pollution or flow pressure issues in the middle Ant catchment. However, along Fox's Beck, there are both flow and water quality pressures present. Sediment pressure assessment is inconclusive due to the lack of PSI data.

5.3.2.3. Fish community evidence

Environment Agency fisheries monitoring data is used under the Fisheries Classification Scheme 2 (FCS2; UKTAG, 2008) to determine WFD status based on the fishery community survey. This is undertaken with reference to an expected community for the prevailing site environmental conditions. It therefore provides a useful additional tool in terms of supporting evidence for SSSI Unit condition. Unfortunately, community status was not provided in the Environment Agency data request.

Under the FCS2, fish species are categorised according their resilience to environmental disturbance (including diffuse pollution). Therefore, in broad terms the relative presence/absence within fishery monitoring sites on the Ant may be indicative of prevailing environmental pressures such as diffuse pollution.

Fisheries in the River Ant water body are not reported in terms of WFD ecological status in the Anglian River Basin Management Plan.

Figure 5.1 shows the locations of Environment Agency fisheries survey sites along the Ant that are relevant to this assessment. Due to the number of fisheries surveys available on the River Ant, this has been limited to all sites above Barton Broad (i.e. those above the tidal limit), excluding sites surveyed prior to 2000.

- D/S Tonnage Bridge (Site ID NOR460– surveyed August 2000);
- Broad Fen (Site ID NOR459– surveyed August 2000);
- U/S Wayford Bridge (Site ID NOR462– surveyed August 2000);
- D/S Wayford Bridge No 1 (Site ID NOR463– surveyed August 2000);
- D/S Wayford Bridge No 2 (Site ID NOR464– surveyed August 2000); and
- U/S Stalham Dyke (Site ID NOR 465– surveyed August 2000).

In summary:

- Only five fish species were recorded in total across all fisheries survey sites above. Although WFD status classifications were not provided to enable a comparison with reference conditions, such low species diversity indicates highly compromised fisheries;
- Of those species recorded (namely 3-spined stickleback *Gasterosteus aculeatus*, gudgeon *Gobio gobio*, perch *Perca fluviatilis*, pike *Esox lucius* and roach *Rutilus rutilus*), none were in the "low tolerance" to environmental disturbance category;
- 3-spined stickleback, gudgeon and pike were recorded in very low numbers across either one or two of the sites only. In total they were limited to less than 10 individuals;
- The two dominant species, roach and perch, both have a "high tolerance" to environmental disturbance. These are species that can withstand environmental pressures associated with eutrophication and diffuse water pollution (e.g. reduced oxygen levels); and

Overall, the fisheries communities above Barton Broad appear to be highly compromised, though it should be noted that this 2000 baseline is now somewhat outdated, and it may have improved since then. While diffuse water pollution may play a role in the comprised nature of the fishery community, it is unlikely to be the only or main factor.

5.3.3. **Cromes Broad**

No data have been identified describing the ecological condition of Crome's Broad.

6. Sources of pollution leading to water quality failure

6.1. Catchment sources of phosphorus

6.1.1. Tools available to Natural England and its partners

The tools available to Natural England to estimate the sources of phosphate in the catchment of the River Ant catchment are described in Table 3.1 below. This includes items that have been provided to the Natural England national diffuse water pollution team, are used by its regulatory partners in operational practice (Environment Agency or water companies) or have been funded by Defra specifically to support diffuse pollution planning at the catchment scale. The River Ant catchment has also been the subject of a series of historic source apportionment studies reported in the academic literature.

Table 6.1: Key evidence sources for phosphorus pressures

Name	Description
SEPARATE	SEctor Pollutant AppoRtionment for the AquaTic Environment. Outputs from a Defra-funded project (WQ0223) to develop a field tool kit for ecological targeting of agricultural diffuse pollution mitigation measures. For each WFD water body in England a spreadsheet contains the apportionment of phosphate, sediment and nitrogen
SAGIS	Water industry (Environment Agency and UKWIR) standard tool for source apportionment in lakes and rivers
FARMSCOPER	FARM SCale Optimisation of Pollutant Emission Reductions is a Defra-funded tool developed to help understand nutrient losses from different farm types and to identify the farm scale measures that are most likely to help reduce these losses.
Review of Consents	2000 agricultural census and export coefficients were used to provide a “best guess” as to the amount of phosphorus which could be exported from the catchment to the watercourses
Historic source apportionment studies	Johnes (1996), Environment Agency (2004)

6.1.2. Outputs for the Ant Broads and Marshes SSSI

6.1.2.1. Review of consents

The Review of Consents work for the Ant catchment concluded that 51% of phosphate comes from consented discharges and 49% from agricultural/background inputs.

6.1.2.2. SEPARATE

The results of the SEPARATE model in Figure 6.1 below show that diffuse water pollution from agriculture accounts for a significantly smaller proportion of the annual total phosphorus loads in the Ant catchment, with the remainder from non-diffuse sources. Sewage Treatment Works provide the single largest source and account for close to three quarters of the annual phosphate loads in the Ant catchment.

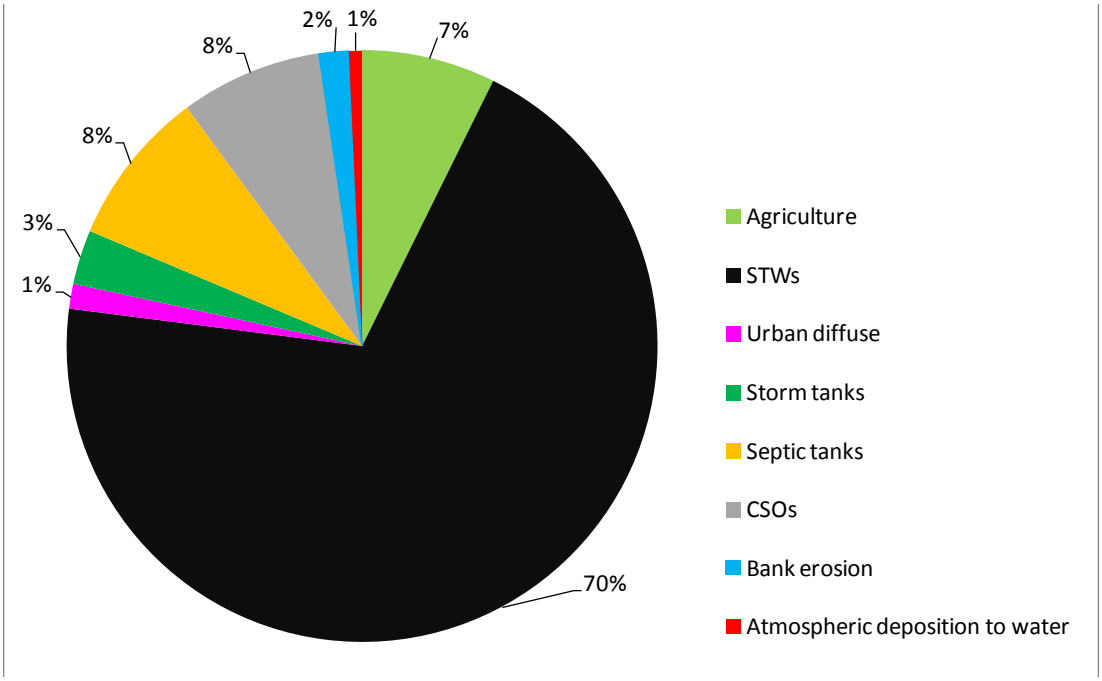


Figure 6.1: SEPARATE model outputs for sources of phosphate in the River Ant catchment

6.1.2.3. SAGIS

SAGIS provides greater detail on the source apportionment, providing an estimate of the breakdown of agricultural sources into arable and livestock categories and how phosphorus levels and the source apportionment vary along the course of a river.

Figure 6.2 summarises the SAGIS outputs as a map of the water bodies within the Ant catchment.

Figure 6.3 provides a picture board summarising the outputs from the SAGIS model for the River Ant catchment that includes (a) a catchment source apportionment, (b) the loads and apportionment associated with all WFD waterbodies in the catchment and (c) a longitudinal plot of concentrations and apportionment down the River Ant.

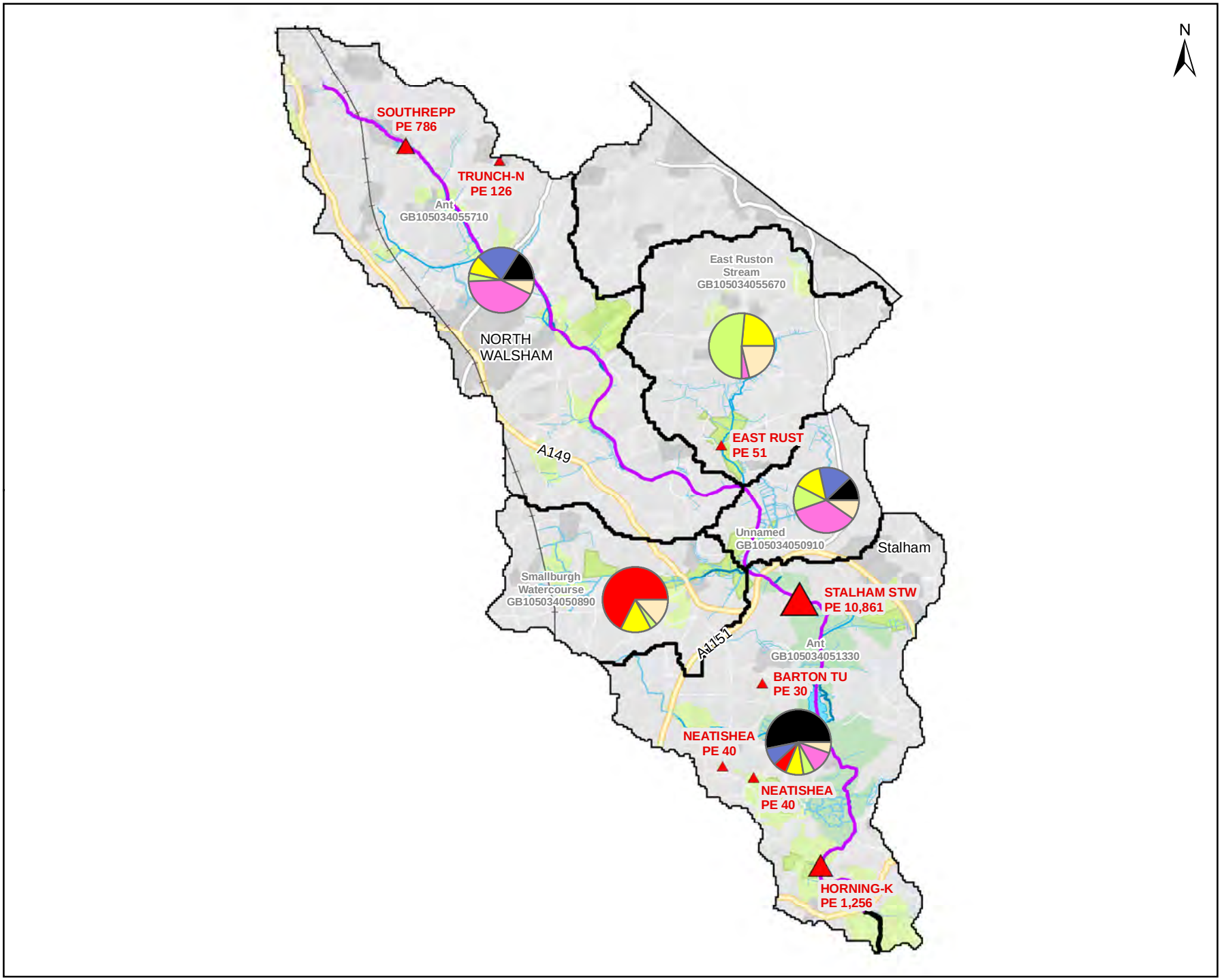
Results from SAGIS coincide with SEPARATE and suggest that, at the catchment scale, sewage treatment works are contributing the largest portion of the phosphorus within the catchment (Figure 6.3a). However, this varies considerably within different water bodies within the catchment. For example, the East Ruston Stream sub-catchment shows phosphorus contributions being almost entirely agricultural, and others where the importance of urban sources (Upper Ant sub-catchment) or industrial sources (Smallborough Watercourse sub-catchment) are high (Figure 6.3).

The largest phosphorus loads are associated with sewage treatment works located in the lower part of the catchment.

Figure 6.3c also shows how total phosphorus concentrations (y-axis) vary down the river system, from the river source at 0 km downstream (x-axis) to the end point of the river/area of interest, in this case some 30 km down the river from the source. The vertical broken lines represent individual river reaches joining the main River Ant. The total phosphate concentrations are represented by the top of the coloured area (in this case varying between approximately 0.02 and 0.12 mg/l along the river), and within these levels the relative contributions of phosphate from individual sources is represented by the different colours. The concentration of phosphate arising from the different sources is given by the height of each coloured section, not the cumulative height.

This longitudinal plot shows that in the uppermost ~15km, urban sources are an important contributor. At approximately 2 km and 19 km there are marked step changes in the overall phosphate levels related to inflows from Southrepps STW and Stalham STW. Downstream of Stalham STW, STW effluent discharges are the most important component of phosphate balance.

The SAGIS plots are useful as an overview of how dominant different sources are in different reaches and their area of influence in terms of distance downstream. Understanding this spatial detail within the source apportionment is key to the targeting and prioritisation of mitigation measures within the DWPP.



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 6.2: SAGIS outputs for the River Ant catchment

WFD Water bodies

Wastewater Treatment Works

Population Equivalent

- 11 - 500
- 501 - 1000
- 1001 - 2500
- 5001 - 21333

Chainge Plot Line

Phosphate source apportionment (Summary for each water body)

- STW
- Intermittent (CSOs, storm tanks)
- Industry
- Livestock
- Arable
- Highways
- Urban
- Septic Tanks

0 1 2 3 km

Scale (at A4): 1:120,000

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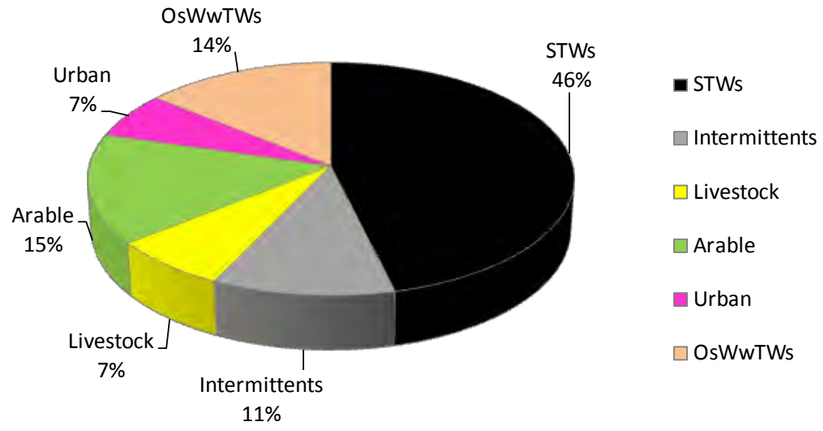
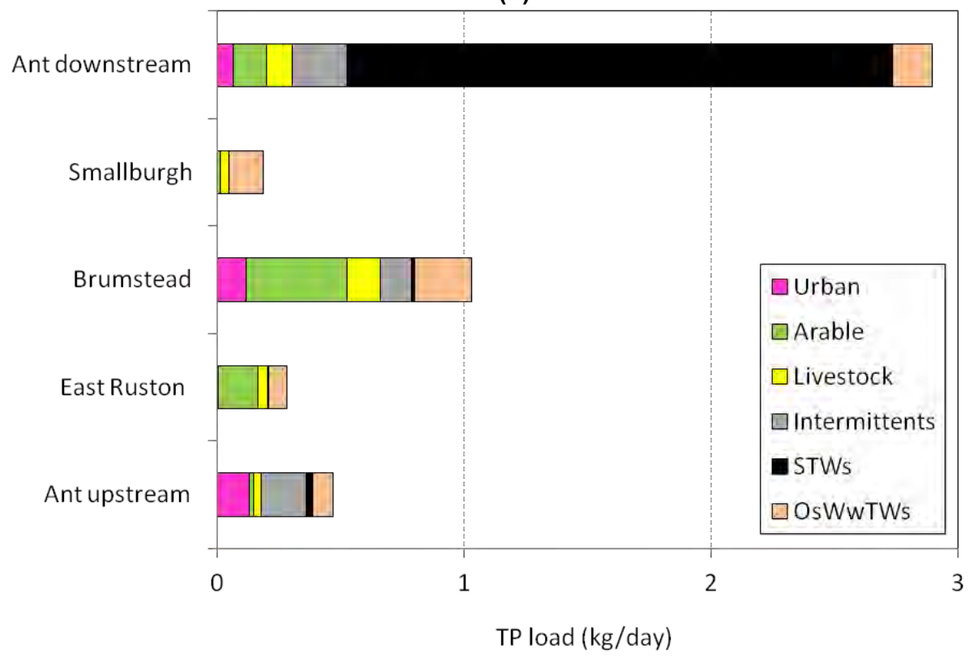
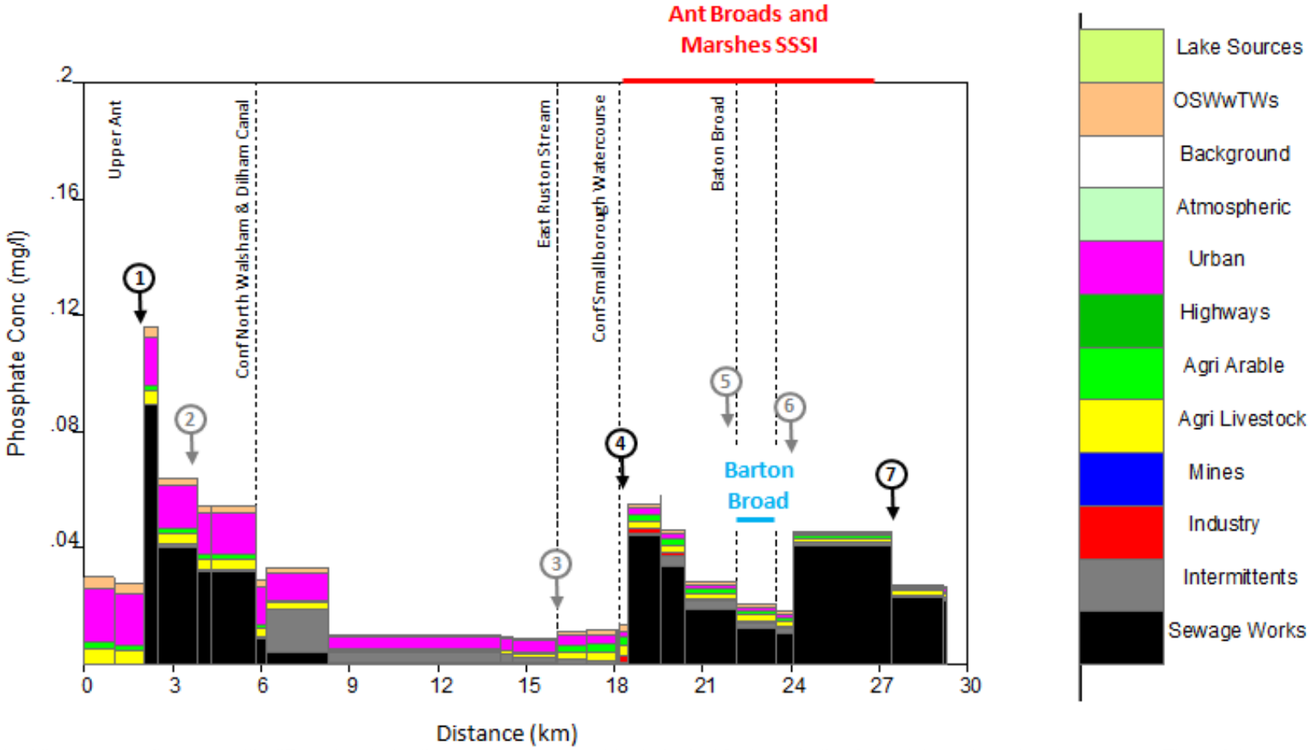
(a) Catchment source apportionment



(b)



(c) Source apportionment by WFD waterbody



(d) STW discharges shown in (c)

Transect label	STW Name	Population served	AMP5 phosphate consent (mg/l)
1	South Repp	786	-
2	Trunch N	126	-
3	East Ruston	61	-
4	Stalham	10,861	2
5	Barton	30	-
6	Neatishea	40	-
7	Horning	1256	-

The vertical dotted lines are confluences with different waterbodies or other important hydrological features in the Ant catchment moving downsream. These fatures are labelled. STW discharges are numbered based on the table below. STWs shown in black discharge straight into the River Ant. STWs labelled in grey discharge to watercourses that subsequnetly flow into the River

Figure 6.3: SAGIS outputs for the River Ant catchment

6.1.2.4. FARMSCOPER

The Defra-funded FARMSCOPER model is quickly becoming the industry preferred model for understanding the impact of farming activity on the water environment. Defra agricultural census data can be used to estimate the expected losses of phosphate from a range of 'typical' robust farm types for which Defra provide data. Table 3.7 below combines the information provided by Defra regarding the number of robust farm types in the Ant catchment with the estimated phosphate losses from each farm according to FARMSCOPER. Combining this information gives an estimate of the total phosphate loads that might be associated with each farm type in the catchment 'on average'.

Table 6.2: Farm types within the Ant catchment

FARMSCOPER farm type	No. of farms in Ant catchment	% of all farms	Estimated area (ha)	FARMSCOPER estimated Phosphate loss per farm (kg/ha/yr)	FARMSCOPER estimated Phosphate loss at catchment level (kg/yr)	FARMSCOPER estimated Phosphate loss at catchment level (%)
Mixed combinable	62	82%	12,416	0.1	1,242	70%
Lowland grazing	14	18%	2,726	0.2	545	30%
TOTALS	**76**	**100%**	**15,142**	-	**1,787**	**100**

Due to the high degree of suppressed data for the catchment, there are only two robust farm types that can be modelled for the Ant catchment. Catchment–scaled FARMSCOPER outputs indicate that for diffuse pollution, arable, mixed combinable farms contribute the most diffuse phosphate losses at a catchment level.

While the estimated phosphate loss of 1,787 kg/yr might sound large, it is relatively small when compared to the overall load.

6.2. Internal sources of phosphorus

A number of studies of Barton Broad have identified the potential importance of internal loads of phosphorus in Barton Broad. Sediment held within the Broad can act as either a sink or source for nutrients. The nutrient cycling is complex owing to a combination of sediment re-suspension and the relationship between the nutrients and the biological cycles occurring in the lake.

Incubation of individual cores taken from the deepest part of Barton Broad in February 2013 has identified potential phosphorus release rates of 2.33 mg/m^2/day following 6 to 8 days of hypoxic/anoxic conditions. These estimates have been scaled up to provide a view of the potential scale of annual internal loading of phosphorus due to internal sediment release with estimates ranging from153–456kg/yr based on the entire base of the lake contributing to the phosphorus load.

Figure 6.4 provides an updated evaluation of internal loading in Barton Broad relative to the catchment sources of phosphorus that are estimated by SAGIS compared to estimates of internal loading in Barton Broad. On an annual basis, internal loading can account for in the order of 10–20% of the phosphorus load. However, the timing of sediment release is important occurring mainly in summer when the main water quality failures in Barton Broad are registered (Section 3.2.1). It is also important to note that the precise source of stored sediment may also be linked to catchment inputs.

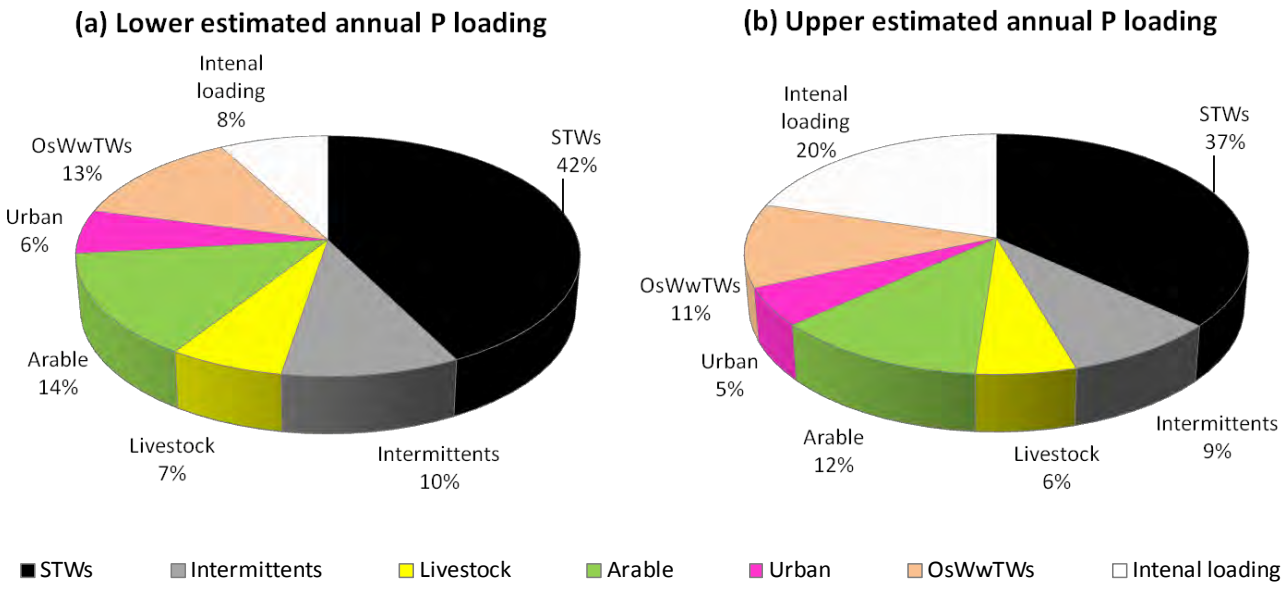


Figure 6.4 An evaluation of internal loading and catchment sources of phosphorus in Barton Broad

6.3. Sediment pressures

Information on sources of sediment in the catchment of the River Ant catchment is available from the sources available to Natural England and its partners.

Table 6.3: Data and models that inform of sediment pressures

Name	Description
SEPARATE	Outputs from a Defra-funded project (WQ0223) to develop a field tool kit for ecological targeting of agricultural diffuse pollution mitigation measures. For each WFD water body in England, a spreadsheet contains the apportionment of phosphate, sediment and nitrogen
FARMSCOPER	FARM SCale Optimisation of Pollutant Emission Reductions is a Defra-funded tool developed to help understand sediment losses from different farm types and to identify the farm scale measures that are most likely to help reduce these losses.
SCIMAP	SCIMAP is an approach to the generation of risk maps for diffuse pollution within catchments and helps to determine the most probable sources of sediment pollution, as well as connectivity (i.e. sediment transport)
Defra Erosion Risk Model	This model takes a risk mapping approach and uses data such as land cover, soil type and hill slope angle. It models erosion risk in a catchment on a 50m × 50m grid using CORINE Land Cover 2006, the National Soil Map and the Ordnance Survey Terrain 50 datasets. It does not attempt to model connectivity, it only shows areas which are likely to make sediment available for transportation.
Natural England studies	Natural England commissioned a sediment source tracing framework has been used to investigate the provenance of fine-grained bed sediment and associated organic matter in the River Ant.

6.3.1. Outputs for the River Ant

6.3.1.1. SEPARATE

The results of the SEPARATE model in Figure 6.5 below show that the majority of sediment in the River Ant is sourced from agriculture making up 60% of the estimated soil sediment in rivers. River bank erosion also contributes a large amount of sediment to the River Ant (ca. 40%). Urban and sewage treatment sources provide smaller sources of sediment on an annual basis.

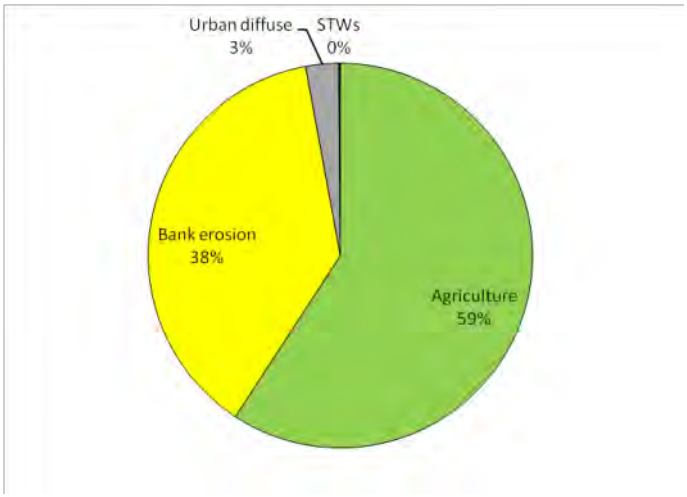


Figure 6.5: SEPARATE model outputs for sources of phosphate in the River Ant catchment

6.3.1.2. Natural England source tracing

Work commissioned under Natural England's sediment source tracing framework has been used to investigate the provenance of fine-grained bed sediment and associated organic matter in the River Ant. Representative samples of fine-grained sediment collected from the river channel bed were used to examine, as part of a reconnaissance survey, the contributions from cross sector sources, including grassland surface soils, arable surface soils, agricultural field drains, damaged road verges, channel banks/subsurface sources, urban street dust, farm yard manures/slurries, decaying instream vegetation and point source discharges (STWs and septic tanks) for human septic waste.

In the catchment as a whole, in the order of 60% of the sediment load in the catchment is estimated to arise from agricultural land with 20% from the erosion of river banks and a further 20% from urban sources such as street dust and road verges (see Table 6.4).

Table 6.4: Key evidence sources for sediment pressures

Source		North Walsham %	Hundred Stream %	Smallburgh %	Catchment median %	TOTAL %
Agriculture	Grassland surface soils	33	22	32	**29**	**60**
	Arable surface soils	20	6	18	**15**	
	Agricultural field drains	8	24	17	**16**	
Channel banks	Channel banks/subsurface sources	9	29	21	**20**	**20**
Urban	Urban street dust	21	7	5	**11**	**20**
	Damaged road verges	9	12	7	**9**	

6.3.1.3. FARMSCOPER

Table 3.7 below combines the information provided by Defra regarding the number of robust farm types in the Ant catchment (see Section 1.5) with the estimated sediment losses from each farm according to FARMSCOPER. Combining this information gives an estimate of the total sediment loads that might be associated with each farm type in the catchment 'on average'.

FARMSCOPER outputs indicate that arable farm types in the Ant catchment are associated with higher rates of sediment loss than grazing farms. When these farm-level contributions are aggregated up to the catchment level, the figures indicate that arable farms are likely to contribute the majority of sediment losses across the catchment.

Table 6.5: Apportionment of agricultural sediment sources in the Ant catchment according to FARMSCOPER

FARMSCOPER farm type		No. of farms in Ant catchment	% of all farms	Estimated area (ha)	FARMSCOPER estimated sediment loss per farm (kg/yr)	FARMSCOPER estimated sediment loss at catchment level (kg/yr)	FARMSCOPER estimated sediment loss at catchment level (%)
Arable	Roots combinable	62	82%	12,860	20.1	258,486	89%
Grazing	Lowland grazing	14	18%	2,823	11.7	33,029	11%
	TOTALS	**76**	**100%**	**15,683**	-	291,515	100%

6.3.1.4. SCIMAP

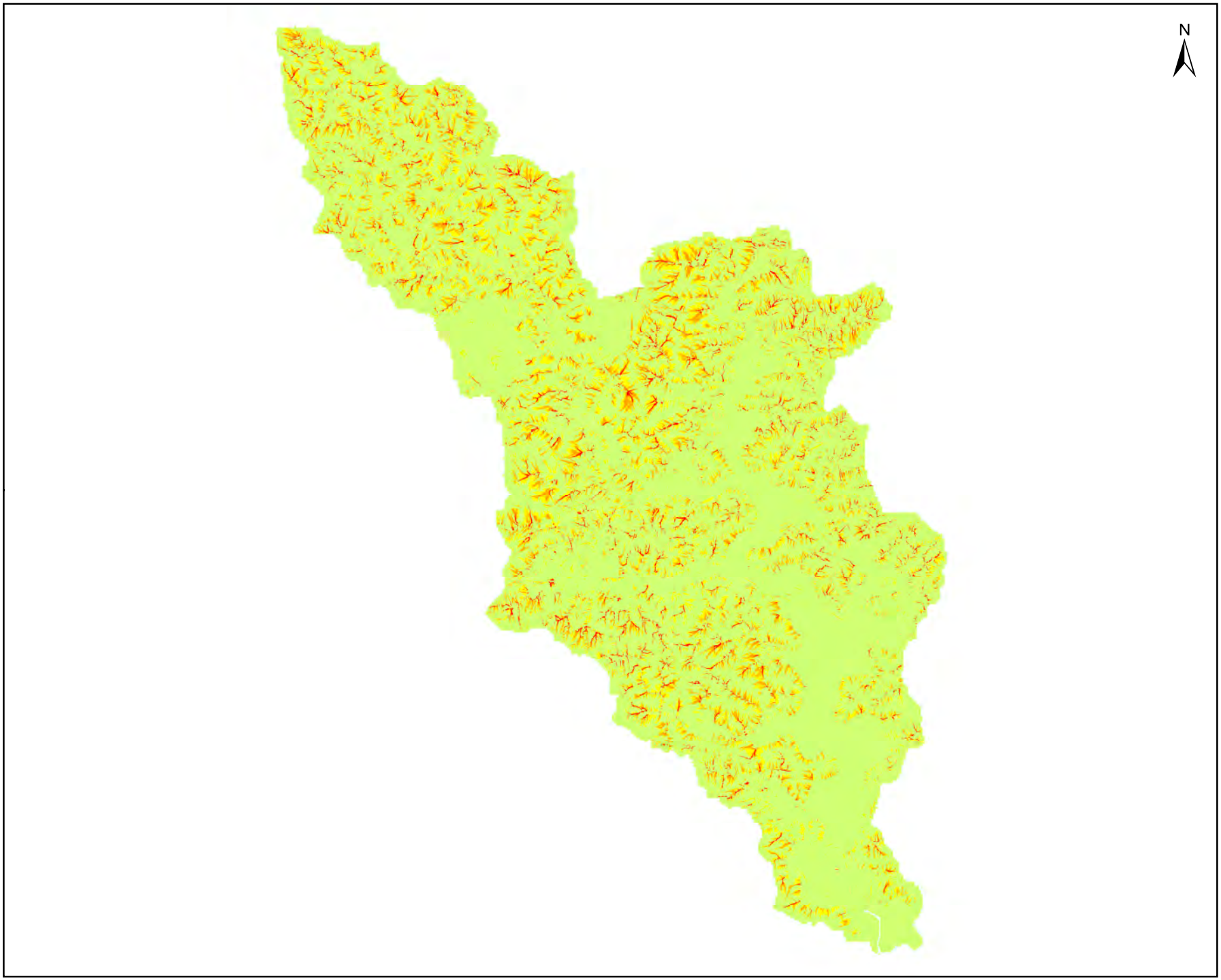
SCIMAP is a method that identifies locations in a catchment that are most at risk from soil loss based on a probabilistic/relative approach (SCIMAP, 2013). The basis of the analysis is the joint consideration of the probability of a unit of land producing a risk and then of that risk reaching the drainage network (Lane *et al*., 2006). Hydrologically well-connected and risky land uses should be the prime focus of management activities, and hence the result of SCIMAP is a method for determining where finite management resources should be best targeted to prevent erosion, which in turn will help reduce the release of adsorbed nutrients. SCIMAP uses a Land Cover Map 2007, a Digital Elevation Model (usually 5m × 5m LiDAR) and average annual rainfall as input data.

SCIMAP does not account for soil variability within a catchment, under the assumption that erosion risk is related mainly to land cover and that soil types within a catchment do not vary substantially. The SCIMAP output for the Ant catchment (Figure 6.6) shows that the risk from soil erosion is generally low across most of the catchment, with some slightly elevated areas of risk indicating increased risk from connectivity near to water courses. It is important to note that in SCIMAP, soil risk is mapped relative to the catchment as a whole; for example areas in red are the areas with the highest risk of soil loss in the catchment rather than being indicative of high risk themselves.

6.3.1.5. Defra Erosion Risk Model

Defra have proposed a national risk mapping approach based on land cover, soil type and hillslope angle. The Defra model was used to model erosion risk in the catchment on a 50m × 50m grid using CORINE Land Cover 2006, the National Soil Map and the Ordnance Survey Terrain 50 datasets (see Figure 6.7). Unlike SCIMAP, the Defra model does not attempt to model connectivity (i.e. sediment transport); it only shows areas which are likely to make sediment available for transportation.

Compared to other catchments in England and Wales, the Defra methodology indicates that erosion risk in the Ant catchment is generally low due to the shallow hill slopes present in the catchment. The areas of moderate to high risk predicted by the model are focused in upstream areas closest to the watercourses, on the steeper slopes around the watercourses where the land has been incised.



Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 6.6: SCIMAP outputs for the River Ant catchment

Erosion Risk In Catchment

Highest

Lowest

0 1 2 3 km

Scale (at A4): 1:120,000

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Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 6.7: Defra Erosion Risk Model outputs for the River Ant catchment

Lakes
Main Rivers
Watercourses

Soil Erosion Risk

Low
Moderate
High

0 1 2 3 km

Scale (at A4): 1:120,000

Reference: 5120447	Drawn: JAM 09/05/2014
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6.4. Flow pressures

Information on flow pressures within the catchment of the Ant has been covered by the investigations shown in Table 6.6. An assessment of flow is relevant to understand the degree of modification to the naturalised flow regime, the extent to which any diffuse pollution might be diluted, and the ability of the river to transported sediment.

Table 6.6: Key evidence sources for flow pressures

Name	Description
Environmental Flow Indicators (EFI)	EFIs have been developed to identify whether the flow regime within the catchment was at risk of not supporting WFD good ecological status/potential. The EFI assessment uses the outputs of the above
NEAC numerical groundwater model (run 6NEA568)	The North East Anglian Chalk Model (NEAC model) is the best available regional tool for flow compliance assessment, and is generally seen as more reliable than the nationally based Water Resource GIS

The Environmental Flow Indicators (EFIs) have been used to identify whether the flow regime within the catchment is at risk of not supporting WFD good ecological status/potential. The EFI 'product description' published in 2013 (Environment Agency 2013a) is summarised as follows:

- Compliance or non-compliance with the EFI helps to indicate where flow may or may not support good ecological status. Flows are either compliant or non-compliant (Band 1, Band 2 and Band 3). The band number reflects the departure of flows from a naturalised condition;
- EFIs are used to indicate where abstraction pressure may start to cause an undesirable effect on river habitats and species. They do not indicate where the environment is damaged from abstraction; and
- The EFI is not a target or objective for resolving unsustainable abstractions, it is an indicator of where water may need to be recovered. The decision to recover water in water bodies that are non-compliant with the EFIs should only occur when supported by additional evidence to provide ecological justification.

It should be noted that the Environment Agency's EFI compliance assessment methodology does not necessarily meet SSSI CSM requirements, and therefore is not a definitive SSSI assessment. However there is no SSSI CSM assessment available that assesses flow compliance.

Figure 6.8 shows the results of the WFD water resource flow compliance assessment, based on RBMP1 water body boundaries. These use Recent Actual flow scenarios derived from the Water Resource GIS (September 2009) and NEAC numerical groundwater model (model run 6NEA568), for comparison. The North East Anglian Chalk Model (NEAC model) is the best available regional tool for flow compliance assessment, and is generally seen as more reliable than the nationally based Water Resource GIS. The NEAC model outputs shows that all the waterbodies are compliant. However the Water Resource GIS model states that the Ant (upstream), East Ruston, and he unnamed water body are non-compliant with the EFI (Band 1).

Exemplar Diffuse Water Pollution Plan
Ant Broads and Marshes

Figure 6.8: Flow compliance in the Ant Broads and Marshes SSSI catchment

Lakes
Main Rivers
Watercourses

Recent Actual Q95 Flow Compliance

Water Resources GIS Sep-09 & North East Anglain Chalk Model Run 6NEA568

Compliant
Band 1
Band 2
Band 3

0 1 2 3 km

Scale (at A4): 1:120,000

Reference: 5120447	Drawn: JAM 09/05/2014
Checked: JHA 09/05/2014	Authorised: HG 09/05/2014

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6.5. Future pressures and trends

A number of factors can be identified that may influence current and future phosphorus and sediment pressures in the Ant catchment.

- **Population growth** is likely to increase population pressures in the catchment over the next few decades. The current main population centres within the catchment are North Walsham and Stalham. It is not currently known what the predicted population growth figures are.
- The future landscape for **technology to reduce P at point sources** is uncertain and not possible to specify at this stage, but it is likely that technological advances will enable more thorough removal of P prior to release into the environment over the next decades. For example, improvements in chemical dosing, tertiary treatment and evolving membrane technology is providing significant improvements in the quality of treatment works effluent.
- **Changes in agriculture** have occurred in the Ant catchment over the past two decades (Natural England, 2013). Although it is not possible to predict the future when it comes to agriculture in the catchment, it is assumed that as market forces change and other influences occur (such as water availability and climate change pressures) the agricultural practices within the catchment could change similarly in the future. This may alter the balance of both phosphorus and sediment sources in the catchment.
- By 2015 there will be **limits on the phosphate content of dishwasher detergents** and other cleaning products. It has been estimated that this will take 1mg/l off the effluent concentrations on works that do not have P stripping already in place. This may result in a reduction in population pressures in the catchment more generally.
- **Climate change** in the long run may result in changing patterns of rainfall and water availability. This will influence nutrient and sediment pressures in catchments by influencing agricultural practices (through soil conditions and availability of irrigation water), the mobilisation of diffuse and stored

6.6. Evidence gaps

In summary, available model outputs from SAGIS and SEPARATE suggest that whilst diffuse water pollution is a component of the phosphate balance of the River Ant catchment, the scale of these inputs is small relative to those from population pressures. It is worth noting that this is particularly the case towards the bottom end of the catchment where the main body of standing water interest is found in continuity with the Ant (namely Barton Broad). It is important to note that both models provide information regarding the impacts of point sources discharging at their fully licensed quantity and quality; in reality, the actual effluent quality from STWs may be significantly less than the fully licensed concentration.

Currently, the main evidence gap identified through this study relates to the need for aligning the findings of the Review of Consents process with outputs from some of the more recent industry standard tools available to Natural England and its partners. This may require some additional applications of the models to identify the specific Sewage Treatment Works that may be associated with the greatest loads.

The main action on NE arising from this element of the DWPP is to work closely with the Environment Agency to ensure that nutrient management priorities are built into consenting procedures in the catchment.

Different methods for mapping sediment sources within the catchment provide different results. However, with regards to Barton Broad, the main current evidence gap is to understand not the source of sediment itself but the source of the phosphorus within the sediment. All of the studies undertaken to date consider the sources of inorganic sediment. It is not currently known for example, whether phosphorus release during the summer is sustained by particulate phosphorus linked to inorganic particles eroded from arable fields or part of internal lake cycling during algal growth and dieback.

7. Current measures underway in the SSSI to address water pollution

Table 7.1 summarises existing measures being implemented within the Ant Broads and Marshes SSSI catchment as given in the previous DWPP for the SSSI.

A range of catchment measures have historically been undertaken to address water pollution to Barton Broad and the SSSI more generally. A chronology of these measures is provided in the table below reproduced from a draft report currently being prepared by Natural England and the Broads Authority (*Barton Broad Dossier – Broads Review Project: Unpublished Draft Report by Natural England and the Broads Authority*).

Date	Description
1978	Experimental Phosphorus removal at Stalham STW
1980	Diversion of effluent from North Walsham STW
1983	Phosphorus removal from small STW discharging to River Ant
1988	Barton Broad treated with Siltex to increase sediment consolidation
1996–2001	Sediment removal from Barton Broad
1997	Enhanced phosphorus removal at Stralham STW
1998	Phosphorus removal from factory discharging to River Ant
2004	Fish free enclosures established in four locations at Barton Broad

7.1. Point sources

As part of the Review of Consents process, 123 consents in the River Ant catchment were assessed. The majority were deemed to be trivial. However, 10 consents could not be shown not to cause an adverse impact on the interest features of the Ant Broads and Marshes SSSI alone or in combination and were taken forward for further consideration during Stage 4.

7.2. Sediment strategy

Barton Broad was treated with Siltex to increase sediment consolidation in 1988. P loading from the catchment was reduced (1980–1996) by about 90% following P stripping measures at major sewage treatment works in the catchment.

Sediment removal studies were conducted during 1996 and 2001 and included controlled comparisons between ‘dredged’ and ‘un-dredged’ sites as well as samples collected through time series following dredging activities from single sites.

However, it is believed that there is no current sediment monitoring programme for the catchment, and little available observed data.

7.3. Fisheries management

Bio-manipulation via fish removal was trialled at Barton Broad beginning in 2000 and these trials will be assessed elsewhere in this report. Various other in lake habitat enhancement activities have been conducted in recent years including installation of synthetic refugia (2001), island recreation (2003), installation of floating islands (2003), scrub control measures (ongoing), and macrophyte re-introduction (1984–1985).

7.4. Environmental Stewardship

More recent measures have included the promotion and implementation of the agri-environment measures that are reviewed in detail in Section 2.6.1. However, the current uptake incidence of resource protection

options within the River Ant catchment is very low. Although 60% of the catchment is covered by some form of agri-environment agreement, only 5% of the catchment is covered by resource protection options that may have a significant effect on diffuse water pollution sources to the SSSI.

7.5. Catchment Sensitive Farming

The CSF catchment is currently operating at 65% of its 75% target engagement, with 30,000ha having received advice on resource protection. To date, approx 275 farmers have received training and advice across the catchment.

Table 7.1 Measures in the old DWPP that are underway in the Ant Broads and Marshes SSSI to address water pollution

Measure and Pressure	Mechanism	Location	Evidence supporting the expected outcome *(positive or negative)*
Reduce sediment and Phosphate from agricultural land entering watercourses	CSF – Best-practice advocacy on soil-husbandry & soil management. Core delivery of farm 1:1 visits & workshops across 'priority' risk-assessed target list. Soil management planning visits, workshops, farm walks highlighting RP issues and mitigation, soil analysis. Soil husbandry and sediment reduction 1:1 visits now available	Ant Broads and Marshes has been selected as one of the priority areas 2010–11	Catchment Appraisal for Bure, Ant and Muckfleet. Inventory of effects associated with various methods available in Defra DWPA User Manual. To date, 613 1:1 farm visits on soil husbandry have taken place across the catchment. 500 stakeholders have attended events and workshops on this subject. The CSF catchment is currently operating at 65% of its 75% target engagement, with 30,000ha having received advice on resource protection. To date, approx 275 farmers have received training and advice across the catchment.
Reduce sediment and phosphate from agricultural land entering watercourses	CSF – Capital Grants Scheme for farm infrastructure improvements (re-concreting of yards, roofing of manure stores and gathering yards, relocation of gateways, watercourse fencing etc.)	The grant scheme has been in operation across the catchment since 2006. Ant Broads and Marshes has been selected as one of the priority areas 2010–11	Catchment Appraisal for Bure, Ant and Muckfleet. Inventory of effects associated with various methods available in Defra DWPA User Manual (Cuttle *et al.* 2009).
Reduce sediment and phosphate entering watercourses from agricultural land	Target nutrient pollution from agricultural runoff. Encouraging land owners to enter ELS/ HLS to take up RP Options (establish buffer strips, arable reversion to grassland etc.) to prevent agricultural nutrients/ sediment from entering watercourses	Land requiring resource protection.	Inventory of effects associated with various methods available in Defra DWPA User Manual (Cuttle *et al.* 2009)
Reduce phosphate from septic tanks and package treatment plants by installing first time rural sewage to rest of Neatishead	First Time Rural Sewage	Neatishead	Anglian Water appraisal identified problems with drainage –the installation of mains sewer has been agreed and is currently being proposed for 2013 onwards.
Liaise with Broads Authority as to location of houseboats that potentially discharge raw sewage into river. Reduce this pollution	Leaflet has been produced explaining rules and options for sewage disposal within the Broads.	Across whole of Broads	Low impact measure – awareness raising achieved through distribution of guidance leaflet to boat owners. Most boat owners spoken to said they were compliant.
Reduce phosphate pollution from boats	Green Blue Initiative (an innovative environmental awareness programme set up by the British Marine Federation and the Royal Yachting Association). Provides advisory posters and leaflets and promotes green boating practices.	Barton Broad	Low impact measure – awareness raising achieved through distribution of guidance leaflet to boat owners. Most boat owners spoken to said they were compliant. Green Blue on-line self assessment tool for use by businesses has been completed by 5 organisations to date.
Reduce bank erosion from boats	Enforcement of speed limit byelaws and encouragement of low wash hulls etc.	Barton Broad	Reduction in waves hitting banks should reduce boat wash and limit erosion
Reduce nutrients from septic tanks entering Alderfen Broad	Advisory visits being made to site by the Environment Agency. 140 letters sent, surveying area. Awaiting report	Alderfen Broad, then discharged out of the IDB pumps that lift the Alderfen overflow, enters the Ant near How Hill, which routinely	Expect to see reduction in nutrients. Effectiveness will need to be assessed through source apportionment study.

Measure and Pressure	Mechanism	Location	Evidence supporting the expected outcome *(positive or negative)*
		reverses flow on a flood tide and heads (upstream) to Barton Broad.	
Sediment removal (followed by biomanipulation which involves the temporary removal of selected fish species to increase the number of grazer zooplankton, particularly *Daphnia* species. This in turn effects a change in the ecosystem, in this case gaining clear water and plant re-growth.)	Sediment Management Strategy Barton Broad and Crome's Broad were mud pumped. In Barton Broad dredging took six years (1996–2001), removing over 305,000 m3 of sediment, equivalent to 160 Olympic size swimming pools. Suction dredging removed 50 tonnes of phosphorus from the sediment.	Barton Broad and Crome's Broad	Phosphorus concentration at 3 to 20 cm depth in the sediment remained significantly lower (approximately 50%) in the dredged areas for a period of five years after dredging. However, phosphorus levels of the surface sediment, at 1 cm depth, rapidly increased after dredging, to reach a similar concentration to that of the undredged surface sediment. This increase is probably a result of phosphorus rich algal material settling and reaching a state of re-equilibrium with the water. During the six-year dredging operation the average annual phosphorus concentration decreased each year. This encouraging trend is supported by longer clear water periods in the spring, with lower algal populations. Experiments showed 50% decrease in phosphorus release from the sediment after dredging. Therefore dredging has contributed towards lower phosphorus levels and fewer algae in the water (From Darkness to Light. The Restoration of Barton Broad, Broads Authority)
Reduce phosphate input to watercourses from package treatment plants	Leaflet produced explaining phosphate pollution and encouraging use of phosphate reduced/free detergents. Leaflet sent out to all existing package treatment plant owners and sent from Environment Agency consent department when new consent issued in the Broads area.	Broads catchments, including Ant	Feedback received from existing owners during initial send-out, some positive, saying they were changing detergent use. Difficult to evaluate effectiveness of project.

8. Diffuse Pollution actions needed to achieve favourable condition

8.1. FARMSCOPER

The diffuse pollution actions needed to achieve favourable condition have been identified using FARMSCOPER, a Defra-funded decision support tool that can be used to estimate the following:

- **losses** of agricultural pollutants (phosphate, nitrogen and sediment) from different robust farm types;
- **pathways** along which individual pollutants are lost from the 'typical' farm and their significance;
- **effectiveness** of different measures to reduce losses of from different 'robust farm types'; and
- **added value** of different measures with regards to biodiversity, water use and energy use.

The farm systems within the tool reflect management and environmental conditions of the main 'robust' farm types in England and Wales. The different farm types in a catchment can be identified in consultation with Defra. For example, there are only two main farm types in the River Ant catchment, general cropping and lowland grazing farms (see Section 1.4).

For each farm type, FARMSCOPER selects the individual measures that can reduce losses of agricultural pollutants for that farm type and assesses the effectiveness of the measure. The effectiveness of measures is expressed as a percentage reduction (established from literature reviews, field data and expert judgement). The tool contains over 100 mitigation methods, including many of those in the latest Defra Mitigation Method User Guide that cover the suite of measures included in agri-environment and CSF policy schemes.

An 'optimiser' function in FARMSCOPER allows the identification of the combination of measures that is capable of achieving the largest reductions in a given pollutant for a given farm type under typical or average conditions. This output represents the maximum potential reduction that agricultural measures could achieve if all the recommended measures were applied on a farm basis.

8.2. Approach/targeting measures

The maximum potential reduction that can be achieved required a large number of measures to be implemented. An example for the Ant catchment is given in Table 8.1 below that lists the number of options that are required to meet the maximum predicted reductions in agricultural pollutants in each robust farm type in the Ant catchment. In all cases, land advisers would need to pursue the implementation of more than 20 separate measures, and in some cases more than 40, to deliver the maximum benefit.

Table 8.1: FARMSCOPER Optimiser scenario: number of measures

Farm Type	Number of phosphate measures required on a farm for Optimiser scenario
Lowland grazing	42
Roots combinable	26

8.3. Approach

A more workable set of actions can be determined by selecting the top five most effective measures recommended by the optimiser run and assessing the likely reductions that can be achieved both individually and in-combination.

This approach identifies a more manageable subset of measures that can then be built into procedures for land management discussions in catchments between Natural England land management advisers and farmers as part of current or future environmental stewardship schemes.

A smaller number of mitigation measures are easier to discuss, provide a focus on the measures that really make a difference and in-combination may achieve a large proportion of the maximum reductions possible.

8.4. Results

Table 8.1 summarises the results of the FARMSCOPER assessment for the Ant catchment. For both the lowland grazing farm and the arable general cropping farm, using the top five measures approach will deliver the majority of predicted reductions in the losses of phosphorus. The measures are shown ranked according to their effectiveness (as determined by FARMSCOPER). In the Ant catchment there is very little difference in the effectiveness between different measures.

For lowland grazing farms, the top five measures summarised below would reduce phosphorus loses by 54% compared to a 64% reduction under the maximum optimiser scenario that would require the implementation of 42 options (see Table 8.1).

The measures are shown ranked according to their effectiveness (as determined by FARMSCOPER). The most effective measure for reducing phosphorus losses from lowland grazing farms in the Ant catchment is to fence off rivers and streams from livestock.

For general cropping farms, the top five measures summarised below would reduce phosphorus loses by 32% compared to a 40% reduction under the maximum optimiser scenario that would require the implementation of 26 options (see Table 8.1).

Figure 8.1: FARMSCOPER Assessment outputs for the River Ant catchment

Catchment specific information						FARMSCOPER outputs								
						Optimiser maximum		Top 5 Phosphorus measures				Top 5Sediment measures		
General class	Robust farm type	FARMSCOPER farm type	Commentary	No. in catchment	% of total	Max % reduction in P	Max % reduction in sediment	Top 5 measures (DWP manual ID number + title/name	% reduction (individual)	% reduction (in comb)		Top 5 measures (DWP manual ID number + title/name	% reduction (individual)	% reduction (in comb)
ARABLE	General cropping	Roots combinable (cropping with poultry manure)	This is a mainly arable farm that receives manure from a nearby poultry farm. The arable land is used for roots crops, combinable crops and vegetables	62	82	40	88	4 – Establish cover crops in the autumn	13	32		4 – Establish cover crops in the autumn	35	77
								8 – Cultivate compacted tillage soils	11			8 – Cultivate compacted tillage soils	24	
								9 – Cultivate and drill across the slope	7			13 – Establish in-field grass buffer strips	24	
								13 – Establish in-field grass buffer strips	10			15 – Loosen compacted soil layers in grassland fields	24	
								15 - Loosen compacted soil layers in grassland fields	11			106 – Plant areas of farm with wild bird seed/nectar flower mixtures	25	
LIVESTOCK	Lowland Grazing	Lowland grazing	The farm is a lowland beef and sheep farm. Land use is mainly grassland (two-thirds of which is cut for silage) and some arable land which is a mix of winter wheat, winter barley and forage maize.	14	18	64	52	76 – Fence off rivers and streams from livestock	39	54		8 – Cultivate compacted tillage soils	2	45
								35 – Reduce the length of the grazing day/grazing season	6			35 – Reduce the length of the grazing day/grazing season	9	
								61 – Store solid manure heaps on an impermeable base and collect effluent	9			39 – Construct troughs with concrete base	9	
								78 – Re-site gateways away from high-risk areas	3			78 – Re-site gateways away from high-risk areas	10	
								39 – Construct troughs with concrete base	2			106 – Plant areas of farm with wild bird seed/nectar flower mixtures	24	

8.4.1. Sediment reduction

Some of the measures identified by FARMSCOPER may potentially serve to reduce sediment as well as phosphate losses from farms in the Ant catchment. These are:

- Measure no.4 – Establish cover crops in autumn (to reduce sediment losses from all arable and pig farms)
- Measure no. 8 – Cultivate compacted tillage soils (will increase energy use)
- Measure no.13 – Establish in-field grass buffer strips (will increase biodiversity)
- Measure no.15 – Loosen compacted soil layers in grassland fields (will increase energy use)

The potential for reducing both phosphate and sediment losses from lowland grazing farms via application of common measures is lower for livestock and only the following measures are common:

- Measure no. 35 – Reduce the length of the grazing day/grazing season
- Measure no. 78 – Re-site gateways away from high-risk areas.

8.4.2. Wider benefits

The focus of this assessment has been on phosphates and sediment, however FARMSCOPER also provides outputs for other agricultural pollutants, see Table 8.2.

Table 8.3 and Table 8.4 present the potential reduction of the emission of nitrate, pesticides and greenhouse gases, and the effect of combinations of measures on biodiversity and energy use. The impact of agricultural measures on biodiversity and energy use is based on an arbitrary score that was assigned to each measure during the model development stage; the values were collated from existing literature on the impacts of the ELS scheme but are nothing more than indicators (the higher the value, the better). The added benefits (or negative ancillary impacts) are given for phosphorus and the sediment outputs only.

Table 8.2: Effectiveness of the Top 5 measures expressed as percent reduction for other pollutants

Robust Farm type	Methane (%)	Nitrous Oxide (%)	Ammonia (%)	Nitrate (%)	Pesticides (%)	Biodiversity*		Energy use*	
						P	Sed.	P	Sed.
Roots combinable	0	15	45	29	42	5	10	−13	−12
Lowland grazing	2	14	31	10	55	1	6	−3	−7

** No unit. The impact each measure may have on biodiversity and energy use is given an arbitrary score between 0 and 10, assigned on the basis of expert advice. The scores have to be interpreted as "the higher, the better".*

Table 8.3 Optimiser outputs presenting the maximum achievable reduction in pollutant emissions

Robust Farm type	Methane (%)	Nitrous Oxide (%)	Ammonia (%)	Nitrate (%)	Pesticides (%)	Biodiversity*		Energy use*	
						P	Sed.	P	Sed.
Roots combinable	0	18	47	31	55	31	−9	40	−12
Lowland grazing	2	21	37	18	61	51	53	−7	−6

** No unit. The impact each measure may have on biodiversity and energy use is given an arbitrary score between 0 and 10, assigned on the basis of expert advice. The scores have to be interpreted as "the higher, the better".*

Table 8.4 Effectiveness of the Top 5 measures expressed as percent reduction

Robust Farm type	Methane (%)	Nitrous Oxide (%)	Ammonia (%)	Nitrate (%)	Pesticides (%)	Biodiversity*		Energy use*	
						P	Sed.	P	Sed.
Roots combinable	0	15	45	29	42	5	10	−13	−12
Lowland grazing	2	14	31	10	55	1	6	−3	−7

** No unit. The impact each measure may have on biodiversity and energy use is given an arbitrary score between 0 and 10, assigned on the basis of expert advice. The scores have to be interpreted as "the higher, the better".*

Table 8.5 and Table 8.6 summarise common measures that FARSMCOPER recommends as part of a Top 5 combination and their individual effect on biodiversity and energy use.

Table 8.5 List of common measures and their impact on biodiversity and energy use in arable farms

Measure	Biodiversity	Energy use
4 – Establish cover crops in autumn	0.2	−3
8 – Cultivate compacted tillage soils	0	−5
9 – Cultivate and drill across the slope	0	0
13 – Establish in-field grass buffer strips	5	0
15 – Loosen compacted soil layers in grassland fields	0	−5

Table 8.6 List of common measures and their impact on biodiversity and energy use in livestock farms

Measure	Biodiversity	Energy use
35 – Reduce the length of the grazing day/grazing season	1	−3
39 – Construct troughs with a concrete base	0	0
61 – Store solid manure heaps on an impermeable base and collect effluent	0	0
76 – Fence off rivers and streams from livestock	0	0
78 – Re-site gateways away from high risk areas	0	0

8.5. Significance of diffuse pollution

It is important to note that the FARMSCOPER percentage reduction factors apply to individual farms, and the relationship between these reductions and in-river reductions is not linear. These data should not be used to 'scale up' to the catchment level directly.

The results of the catchment source apportionment indicate that diffuse pollution accounts for a relatively small proportion of the overall phosphate budget of the catchment and diffuse pollution measures are unlikely to result in large reductions in catchment phosphate concentrations.

This suggests that the large scale roll out of agricultural measures targeted at diffuse pollution control are unlikely to lead to a significant improvement in the quality of water flowing into and through the Ant Broads and Marshes SSSI.

Nevertheless, a number of measures to reduce diffuse pollution in the farm types present in the catchment have been identified as part of the diffuse water pollution planning process and are reviewed in sections below. The potential reductions are significant at the farm level but a low percentage for the catchment according to the source apportionment model outputs. The optimal strategy therefore is to ensure natural levels of sediment load and ensure agricultural contribution to phosphorus does not increase. This can be done through targeting advice and grants to enable uptake of the top measures in those farms that present greatest risk of sediment mobilisation.

A closer examination of the urban sources and non mains sewage discharges is also needed to ensure no deterioration and to look for ways to improve river water quality in the upper catchment.

9. Evidence on how far actions will get us to achieving favourable condition

Section 5.2 shows that the Total Phosphorus recorded in the catchment has significantly declined over time since 1980 following the introduction of tertiary treatment at Stalham STW and the diversion of effluent from North Walsham STW. The remaining sources of phosphorus are those which are difficult to 'fix', and so a greater amount of effort is needed to reduce them further.

Source apportionment investigations using industry standard tools (see Section 4) have shown that diffuse pollution sources are unlikely to be a significant source of phosphorus across the Ant catchment.

This suggests that the large scale roll out of agricultural measures targeted at diffuse pollution control are unlikely to lead to a significant improvement in the quality of water flowing into and through the Ant Broads and Marshes SSSI.

This DWPP sets out measures to help address phosphates and sediments from the diffuse sources identified within the SSSI catchment. At the scale of this assessment, it is generally not possible to understand the effectiveness of these measures on overall phosphate and sediment loads within the water courses; further modelling would be required in order to understand the expected outcomes. However, in the case of agricultural measures, the FARMSCOPER modelling that has been undertaken does provide some insight into how effective the suggested measures could be at reducing nutrient and sediment losses from an individual farm.

The FARMSCOPER outputs indicate which measures would best be applied in the agricultural sector to reduce phosphate and sediment losses at a farm level. The top five most effective measures for any given farm type and pressure (phosphate and sediment) have been selected and modelled separately. The outputs essentially give a percentage reduction in phosphate or sediment losses (the "savings" that could be made) from a particular farm type, and these reduction factors have been applied to the Agricultural Census data to understand, at an individual water body level, the potential for phosphate or sediment savings from applying measures on the type of farms (arable and livestock) within each water body. The magnitude of the potential phosphate and sediment savings are provided in Appendix E

It is important to note that these "savings" are relative to farm-level phosphate or sediment losses – they are not directly proportional to in-stream concentrations. Thus a similar reduction factor will probably not be seen for in-stream phosphate or sediment. However, the figures do give a useful indication of the potential for agricultural measures to help reduce phosphate or sediment mobilisation within the overall SSSI catchment.

The effectiveness of the top five most effective agricultural measures applied to all farms within each water body are presented in Table 9.1and Table 9.2 have been categorised as follows:

- **Low** = 0–25% reductions in farm scale phosphate or sediment losses
- **Moderate** = 26–60% reductions in farm scale phosphate or sediment losses
- **High** = 61%–100% reductions in farm scale phosphate or sediment losses

NB these "savings" are expressed as a percentage of the overall agricultural phosphate or sediment losses (as modelled by FARMSCOPER based on Agricultural Census Data), not as a percentage of the overall water body phosphate load (modelled in SAGIS). Furthermore, these percentage savings assume the top five measures are applied correctly on every farm in every water body, not just on the priority water bodies set out in the Action Plan.

Table 9.1 and Table 9.2 show that there is potential for reducing agricultural phosphate losses by applying measures at a farm level. The potential outcomes are slightly higher for the arable farming sector (the arable measures are generally more effective, and also there are more arable farms overall within the catchment compared with livestock farms). Table 9.2 indicates a higher potential for reducing sediment through applying top five measures to arable farms compared to livestock measures. It is also important to note that some measures serve to reduce both sediment and phosphate and these multiple benefits should be considered when implementing measures through the DWPP.

Table 9.1 Magnitude of theoretical effectives of Phosphate measures

Waterbody name	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Ant upstream	Moderate	Low	Low
East Ruston	Moderate	Moderate	Low
Brumstead	n/a	n/a	n/a
Smallburgh	Moderate	Moderate	Low
Ant downstream	Moderate	Low	Low

Due to data suppression, it was not possible to represent the Brumstead water body in the FARMSCOPER model.

Table 9.2 Magnitude of theoretical effectives of Sediment measures

Waterbody name	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Ant upstream	High	High	Low
East Ruston	High	High	Low
Brumstead	n/a	n/a	n/a
Smallburgh	High	High	Low
Ant downstream	High	High	Low

Due to data suppression, it was not possible to represent the Brumstead water body in the FARMSCOPER model.

10. Actions required on non-diffuse sources

Actions to control sewage, industrial and urban discharges would currently appear to provide a greater likelihood of success. Different models provide a different view of the precise magnitudes of each of these sources and further investigations may be required locally to identify the precise components of these sources. This investigation has used the standard outputs from the source apportionment tools available to NE and its regulatory partners and it is acknowledged that not all the sources may be quantified to a local level of detail.

The key point arising from the evidence, is that the degree of non-compliance with the phosphorus targets is not large. Given the relatively small contribution likely to be coming from diffuse (agricultural) sources, and the relatively large contribution from point sources, the most effective strategy to secure compliance would be modest further improvement to consented discharge.

It is also worth noting noted that further up the catchment non-agricultural diffuse component (urban and septic tanks) is a very significant contributor to load and it may be important to address to achieve WFD objectives in those sub catchments. However the impact is less critical in terms of the designated site objectives as the influence is not felt lower down in the catchment.

As the Review of Consents is not an ongoing process, the River Basin Management Planning process is the planning framework for delivering the necessary improvements for point source pollutants.

The main action on NE arising from this element of the DWPP is to work closely with the Environment Agency to ensure that nutrient management priorities are built into consenting procedures in the catchment.

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Appendices

The Appendices are as follows:

Appendix A Ant Broads and Marshes SSSI Citation

Appendix B Broadland SAC citation

Appendix C Broadland SPA citation

Appendix D Broadland Ramsar Citation

Appendix E FARMSCOPER outputs

Appendix F SAGIS Outputs

Appendix A Ant Broads and Marshes SSSI Citation

COUNTY: Norfolk SITE NAME: ANT BROADS & MARSHES

DISTRICT: North Norfolk

Status: Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981

Local Planning Authority: Broads Authority

National Grid Reference: TG 362 213 Area: 742.64 (ha) 1834.32 (ac)

Ordnance Survey Sheet 1:50,000: 134 1:10,000: TG 32 SW SE, TG 31 NE

Date Notified (Under 1949 Act):		Date of Last Revision:	
1954	Barton Broad	1968	– Barton Broad
	Sutton Broad	1974	– Sutton Broad
1971	Ant Marshes		– Ant Marshes

Date Notified (Under 1981 Act): 1989 Date of Last Revision: –

Other Information:
This is a composite site made up of the 3 former separate SSSIs known as Sutton Broad, Barton Broad and Ant Marshes. The site is listed in "A Nature Conservation Review" (Ratcliffe 1977) and is included within the Broads Environmentally Sensitive Area.

Reasons for Notification:
The flood-plain of the middle Ant valley, one of the 5 principal river valley systems constituting Broadland, supports one of the most extensive remaining areas of undeveloped primary fen habitats in Britain, and is considered to form the finest example of unpolluted valley fen in Western Europe. Nationally important stands of carr woodland are also present, principally in the vicinity of Barton Broad, and the wide range of wetland habitats has given rise to an associated fauna of exceptional interest.

In contrast with other Broadland river valleys, there are extensive areas of species-rich mixed fen communities that are still regularly cut for reed and sedge. Past management coupled with local hydrological and substrate variations has resulted in the development of the most diverse pattern of fen vegetation of all the Broadland valleys, and provides the only known sites for several plant communities and uncommon species that were once more widespread in Broadland. Further particularly distinctive features of the Ant Valley wetlands include the presence of numerous pools and turf ponds within the fen, plus a diversity of woodland types which exhibit similarities to those of the Bure Valley. The site also supports a wide range of breeding birds and insects including the majority of the broadland specialities.

Open Water and Marginal Swamp
The River Ant runs the length of the site and is extensively utilised by boat traffic. Closely associated with the river are three areas of open water created by the flooding of medieval peat-diggings, namely Sutton Broad, Cromes Broad and Barton Broad. Formerly, these areas supported a very rich flora and fauna, but nutrient enrichment over the last three decades has resulted in a marked deterioration in water quality and consequent disappearance of most aquatic plants. Algal blooms occur in summer, and the broads support only small amounts of aquatic macrophytes such as Yellow Water-Lily *Nuphar lutea* and White Water Lily *Nymphaea alba*.

Active measures are now being taken to reduce phosphate levels and restore a more diverse flora in Barton Broad. At the turn of the century, Sutton Broad was a large area of open water, but has now been reduced to a central navigable channel surrounded by a floating raft of fen vegetation. Crome's Broad, which lies in a small side-valley, is more isolated

from the river than the other three areas, and supports a less impoverished aquatic flora. Rigid Hornwort *Caratophyllum demersum* dominates, with small amounts of Water Starwort *Callitriche* spp present. Together with Barton Broad it attracts moderate numbers of wintering wildfowl, including Mallard, Teal, Wigeon, Shoveler, Pochard and Tufted Duck.

Area of Reedswamp dominated by Common Reed *Phragmites australis*, Lesser Reedmace *Typha angustifolia*, and more locally, Common Club-rush *Schoenoplectus lacustris*, occur around the margins of the Broads, providing a nesting habitat for wildfowl such as Gadwall, Pochard, Teal, Shoveler and Tufted Duck. Near Barton Broad, tussocks of Tussock-sedge *Carex paniculata* have gained a hold within areas of reedbed, depressing the vegetation and recreation swampy hollows between them. Here, a tall-fen vegetation has developed on the tops of tussocks, and this is prone to invasion by tree saplings with consequent development to swamp carr. Swamp vegetation also occurs in association with pools in the fen vegetation, locally dominated by Saw Sedge *Cladium mariscus* or Tufted Sedge *Carex elata*.

A network of species-rich dykes support an abundance of aquatic plants, including Frogbit *Hydrocharis morsus-ranae*, Water Violet *Hottonia palustris*, Spiked Water-milfoil *Myriophyllum spicatum* and the local Broadland species, Water Soldier *stratiotes aloides*.

Fen
Extensive areas of fen vegetation have developed on flat waterlogged floodplains on peat alongside the river, and show an outstanding range of variation, including plant communities almost wholly restricted to Broadland. These species-rich fens are principally dominated by Common Reed, and associates include Great Fen-sedge *Cladium mariscus*, Purple Small-reed *Calamagrostis canascens*, Yellow Loosestrife *Lysimachia vulgaris*, Purple Loosestrife *Lythrum salicaria*, Common Valerian *Valeriana officianalis*, Yellow Iris *Iris pseudacorus*, Water Dock *Rumex hydrolapathum*, and a large population of Milk Parsley *Peucedanum palustre*. Associated with these, is a diverse understorey of Blunt-flowered Rush *Juncus subnodulosus*, Marsh Cinquefoil *Potentilla palustris*, and Purple Moor-grass *Molinia caerulea*, together with a variety of herbs such as Marsh Bedstraw *Galium palustre*, Water Mint *Mentha aquatica* and occasional Marsh Helleborine *Epipactis palustris*.

Within this tall-fen community there is considerable variation, and several distinct vegetation types can be recognised. Fairly extensive areas are managed as commercial sedge-beds cut on a three to four year rotation so that Great Fen-sedge has attained prominence. Black Bog-rush *Schoenus nigricans* is an important component of the understorey throughout much of the cut areas, and in derelict mowing-marshes, woody species such as Bog-myrtle *Myrica gale*, have invaded the open fen. Ferns are especially abundant and include Royal Fern *Osmunda regalis*, the uncommon Marsh Fern *Thelypteris palustris* and populations of the nationally rare Crested Buckler-fern *Dryopteris cristata*. In contrast, wetter areas remain as unmown primary fen, often developed as a floating mat of vegetation which has colonised open water, as at Sutton Broad. Cyperus sedge *Carex pseudocyperus*, Greater Spearwort *Ranunculus lingua* and Slender Sedge *Carex lasiocarpa*, are all markedly more frequent here than in other fen areas, and particularly notable species include Greater Water Parsnip *Sium latifolium*, Cowbane *Cicuta virosa*, and Fibrous Tussock-sedge *Carex appropinquata*.

An interesting community occurs along the edge of the fens where they back onto the valley slopes of the adjoining upland. Here, Purple Moor-grass is generally dominant with frequent Meadow Thistle *Cirsium dissectum* and Heather *Calluna vulagaris*, Cross-leaved Heath *Erica tetralix*, Mat Grass *Nardus stricta* and Tormentil *Potentilla erecta*.

Small pools and stands of mire vegetation occur in shallow depressions as an intimate mosaic within the tall fen, and are largely associated with nineteenth century peat-diggings and turf ponds. Such areas are relatively isolated from the influence of nutrient-rich river

water and support a number of plant communities not found elsewhere in Broadland. The numerous permanent pools attest to the high water levels throughout the year, and support a diversity of aquatic plants including the local species: Lesser Water-plantain *Baldellia ranunculoides*, Fen Pondweed *Potamogeton coloratus*, Marsh St John's wort *Hypericum elodes* and three species of Bladderwort *Utricularia* spp. These pools, together with associated wetter areas of fen, are of exceptional interest for their aquatic coleoptera (water-beetles), and indeed the site is considered to be the most important in Britain for this group. The many rare relict fen species present are indicative of an undisturbed post-glacial history, and include *Agabus striolatus*, *Hydranea palustris* and *Hypdroporus scalesciarius*.

Hydroseral succession has resulted in the development of particularly species rich communities in old turf-ponds, characterised by Slender Sedge, Bottle Sedge *Carex rostrata* and the notable Lesser Tussock Sedge *Carex diandra* over a carpet of bryophytes such as the uncommon mosses *Cinclidium stygium* and *Scorpidium scorpiodes*. Other species present include Common Cotton-grass *Eriophorum angustifolium*, Bogbean *Meyanthes trifoliata*, Grass-of-Parnassus *Parnassia palustris*, Great Sundew *Drosera anglica*, Bogsedge *Carex limosa*, Early Marsh-orchid *Dactylorhiza incarnata*, Marsh Lousewort *Pedicularis palustris* and the notable Narrow-leaved Marsh-orchid *Dactylorhiza traunsteineri*. The nationally rare Fen Orchid *Liparis loeselii* also grows here at one of its few British stations.

The site is of national importance for its fenland invertebrate fauna, and a considerable number of rare or notable species have been recorded from several groups. There is a large population of the Swallow-tail Butterfly *Papilio machaon brittanica*, whose larvae feed on Milk-Parsley, and it is the only known site in Britain for *Trogus lapidator*, a wasp parasite on the Swallowtail. 45 species of moth considered rare or notable are present, including the only British localities for the Small Dotted Footman *Pelosia obtusa*, whose larvae depend on algae attached to Reed litter. The weevil, *Ceutorhynchus querceti* is one of several rare coleoptera in addition to the water-beetles, and a particularly large number of rare or notable Diptera (Trueflies) has been recorded.

Appendix B Broadland SAC Citation

NATURA 2000

STANDARD DATA FORM

FOR SPECIAL PROTECTION AREAS (SPA)
FOR SITES ELIGIBLE FOR IDENTIFICATION AS SITES OF COMMUNITY IMPORTANCE (SCI)
AND
FOR SPECIAL AREAS OF CONSERVATION (SAC)

1. Site identification:

1.1 Type K

1.2 Site code UK0013577

1.3 Compilation date 199601

1.4 Update 201102

1.5 Relationship with other Natura 2000 sites

U	K	9	0	0	9	2	5	3

1.6 Respondent(s) International Designations, JNCC, Peterborough

1.7 Site name **The Broads**

1.8 Site indication and designation classification dates

date site proposed as eligible as SCI	199601
date confirmed as SCI	200412
date site classified as SPA	
date site designated as SAC	200504

2. Site location:

2.1 Site centre location

longitude	**latitude**
01 36 13 E	52 44 07 N

2.2 Site area (ha) 5889.66

2.3 Site length (km)

2.5 Administrative region

NUTS code	Region name	% cover
UK403	Suffolk	3.27%
UK402	Norfolk	96.73%

2.6 Biogeographic region

Alpine	Atlantic	Boreal	Continental	Macaronesia	Mediterranean
	X				

3. Ecological information:

3.1 Annex I habitats

Habitat types present on the site and the site assessment for them:

Annex I habitat	% cover	Representativity	Relative surface	Conservation status	Global assessment
Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	2.98	A	A	A	**A**
Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation	4.96	A	B	A	**B**
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	0.99	B	C	A	**C**
Transition mires and quaking bogs	0.1	B	C	A	**B**
Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*	3.55	A	A	A	**A**
Alkaline fens	0.1	A	C	A	**B**
Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	12.96	A	B	A	**A**

3.2 Annex II species

	Population				Site assessment			
	Resident	Migratory						
Species name		Breed	Winter	Stage	Population	Conservation	Isolation	Global
Vertigo moulinsiana	Present	-	-	-	C	A	C	**A**
Triturus cristatus	Present	-	-	-	D			
Lutra lutra	23	-	-	-	C	A	C	**C**
Liparis loeselii	251-500	-	-	-	C	B	A	**B**
Anisus vorticulus	Rare	-	-	-	B	B	C	**B**

4. Site description

4.1 General site character

Habitat classes	% cover
Marine areas. Sea inlets	
Tidal rivers. Estuaries. Mud flats. Sand flats. Lagoons (including saltwork basins)	
Salt marshes. Salt pastures. Salt steppes	
Coastal sand dunes. Sand beaches. Machair	
Shingle. Sea cliffs. Islets	
Inland water bodies (standing water, running water)	16.0
Bogs. Marshes. Water fringed vegetation. Fens	19.0
Heath. Scrub. Maquis and garrigue. Phygrana	1.0
Dry grassland. Steppes	1.0
Humid grassland. Mesophile grassland	39.0
Alpine and sub-alpine grassland	
Improved grassland	
Other arable land	
Broad-leaved deciduous woodland	24.0
Coniferous woodland	
Evergreen woodland	
Mixed woodland	
Non-forest areas cultivated with woody plants (including orchards, groves, vineyards, dehesas)	
Inland rocks. Screes. Sands. Permanent snow and ice	
Other land (including towns, villages, roads, waste places, mines, industrial sites)	
Total habitat cover	**100%**

4.1 Other site characteristics

Soil & geology:

Alluvium, Basic, Clay, Nutrient-poor, Nutrient-rich, Peat

Geomorphology & landscape:

Floodplain, Lowland, Valley

4.2 Quality and importance

Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

- for which this is considered to be one of the best areas in the United Kingdom.

Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation

- for which this is considered to be one of the best areas in the United Kingdom.

Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)

- for which the area is considered to support a significant presence.

Transition mires and quaking bogs

- for which this is considered to be one of the best areas in the United Kingdom.

Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

- which is considered to be rare as its total extent in the United Kingdom is estimated to be less than 1000 hectares.
- for which this is considered to be one of the best areas in the United Kingdom.

Alkaline fens

- for which this is considered to be one of the best areas in the United Kingdom.

Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

- for which this is considered to be one of the best areas in the United Kingdom.

Vertigo moulinsiana

- for which this is considered to be one of the best areas in the United Kingdom.

Lutra lutra

- for which the area is considered to support a significant presence.

Liparis loeselii

- for which this is one of only three known outstanding localities in the United Kingdom.
- which is known from 15 or fewer 10 x 10 km squares in the United Kingdom.

Anisus vorticulus

- for which this is considered to be one of the best areas in the United Kingdom.

4.3 Vulnerability

The site has suffered from management neglect and natural succession during the 20th century. This is slowly being reversed through conservation and other management works undertaken by a number of bodies. Climate change is increasing saline intrusion into the site. The Environment Agency, Broads Authority and Natural England are working together to make the site more robust to such impacts. The site also suffers from eutrophication caused by release of nutrients from the sediment (historically deposited by sewage outfalls) and diffuse water pollution from a variety of sources. All main sewage works in the northern rivers are now phosphorus stripping and there is a programme of mud-pumping to remove the historic nutrient burden from lakes. Diffuse Water Pollution (DWP) Plans have been drawn up between the Environment Agency and Natural England to identify and address the problems of diffuse water pollution. Pressure from tourism and recreation is now being considered by the Broads Authority through the Broads Plan. Water Level Management Plans and Environmental Stewardship schemes are starting to raise water levels, revert arable areas back to grass and encourage sensitive management, particularly of the ditches, to address problems brought about by drainage in the past. Appropriate standards of flood defence are necessary for the wetland and works are currently proceeding under the Environment Agency's Broadland Flood Alleviation Project and Coastal Protection Strategy.

5. Site protection status and relation with CORINE biotopes:

5.1 Designation types at national and regional level

Code	% cover
UK01 (NNR)	35.7
UK04 (SSSI/ASSI)	100.0

Appendix C Broadland SPA Citation

NATURA 2000

STANDARD DATA FORM

FOR SPECIAL PROTECTION AREAS (SPA)
FOR SITES ELIGIBLE FOR IDENTIFICATION AS SITES OF COMMUNITY IMPORTANCE (SCI)
AND
FOR SPECIAL AREAS OF CONSERVATION (SAC)

1. Site identification:

1.1 Type J **1.2 Site code** UK9009253

1.3 Compilation date 199409 **1.4 Update** 199806

1.5 Relationship with other Natura 2000 sites

U	K	0	0	1	3	5	7	7

1.6 Respondent(s) International Designations, JNCC, Peterborough

1.7 Site name **Broadland**

1.8 Site indication and designation classification dates

date site proposed as eligible as SCI	
date confirmed as SCI	
date site classified as SPA	199409
date site designated as SAC	

2. Site location:

2.1 Site centre location

longitude	**latitude**
01 36 00 E	52 43 56 N

2.2 Site area (ha) 5462.4 **2.3 Site length (km)**

2.5 Administrative region

NUTS code	Region name	% cover
UK402	Norfolk	99.00%
UK403	Suffolk	1.00%

2.6 Biogeographic region

Alpine	Atlantic	Boreal	Continental	Macaronesia	Mediterranean
	X				

3. Ecological information:

3.1 Annex I habitats

Habitat types present on the site and the site assessment for them:

Annex I habitat	% cover	Representativity	Relative surface	Conservation status	Global assessment

3.2 Annex I birds and regularly occurring migratory birds not listed on Annex I

		Population				Site assessment			
		Resident	Migratory						
Code	Species name		Breed	Winter	Stage	Population	Conservation	Isolation	Global
A056	*Anas clypeata*			231 I		B		C	
A050	*Anas penelope*			10071 I		C		C	
A051	*Anas strepera*			240 I		B		C	
A021	*Botaurus stellaris*		>2 I			B		B	
A081	*Circus aeruginosus*		16 P			B		B	
A082	*Circus cyaneus*			22 I		B		C	
A037	*Cygnus columbianus bewickii*			>600 I		B		B	
A038	*Cygnus cygnus*			100 I		C		C	
A151	*Philomachus pugnax*			96 I		B		C	

4. Site description:

4.1 General site character

Habitat classes	% cover
Marine areas. Sea inlets	
Tidal rivers. Estuaries. Mud flats. Sand flats. Lagoons (including saltwork basins)	2.5
Salt marshes. Salt pastures. Salt steppes	
Coastal sand dunes. Sand beaches. Machair	
Shingle. Sea cliffs. Islets	
Inland water bodies (standing water, running water)	10.0
Bogs. Marshes. Water fringed vegetation. Fens	25.0
Heath. Scrub. Maquis and garrigue. Phygrana	13.0
Dry grassland. Steppes	
Humid grassland. Mesophile grassland	41.0
Alpine and sub-alpine grassland	
Improved grassland	
Other arable land	
Broad-leaved deciduous woodland	8.5
Coniferous woodland	
Evergreen woodland	
Mixed woodland	
Non-forest areas cultivated with woody plants (including orchards, groves, vineyards, dehesas)	
Inland rocks. Screes. Sands. Permanent snow and ice	
Other land (including towns, villages, roads, waste places, mines, industrial sites)	
Total habitat cover	**100%**

4.1 Other site characteristics

Soil & geology:

Basic, Clay, Nutrient-rich, Peat, Sedimentary

Geomorphology & landscape:

Floodplain, Lowland, Valley

4.2 Quality and importance

ARTICLE 4.1 QUALIFICATION (79/409/EEC)

During the breeding season the area regularly supports:

Botaurus stellaris (Europe - breeding)	at least 10% of the GB breeding population Three year mean 1996-1998

Circus aeruginosus	10.2% of the GB breeding population 5 year mean, 1987/8-1991/2
Over winter the area regularly supports:	
Circus cyaneus	2.9% of the GB population 5 year peak mean 1987/8-1991/2
Cygnus columbianus bewickii (Western Siberia/North-eastern & North-western Europe)	at least 8.2% of the GB population Count, as at 1996/7
Cygnus cygnus (Iceland/UK/Ireland)	1.8% of the GB population Count, as at 1996/7

ARTICLE 4.2 QUALIFICATION (79/409/EEC)	
Over winter the area regularly supports:	
Anas strepera (North-western Europe)	0.8% of the population 5 year peak mean, 1991/2-1995/6

4.3 Vulnerability

The site has suffered from management neglect and natural succession during this century. This is slowly being reversed via conservation and other management works undertaken through a number of bodies. Sea level rise and reduced summer flows in the river Bure brought about by abstraction are resulting in increasing saline intrusion into the site and generally drier summer conditions. The Environment Agency, Broads Authority and English Nature are proceeding with a project, to investigate options to remedy this situation. The site also suffers from eutrophication, brought through the build up of nutrients over a long period, primarily through sewage outfalls and, to a lesser degree, agriculture. Some of the sewage works are now stripping phosphorus and there is a programme of mud pumping to remove enriched material from lakes.

The region as a whole is a centre for tourism and recreation, however this pressure is now starting to be brought under control by the Broads Authority via the Broads Plan. Efficient drainage within much of the reclaimed parts of the wetland has reduced the wildlife value. Water Level Management Plans and the ESA scheme are starting to raise water levels, revert arable areas back to grass and encourage sensitive management, particularly of the ditches. Flood defence works are carried out in accordance with the Environmental Agency Broads Strategy.

5. Site protection status and relation with CORINE biotopes:

5.1 Designation types at national and regional level

Code	% cover
UK01 (NNR)	39.8
UK04 (SSSI/ASSI)	100.0

Appendix D Broadland Ramsar Citation

Information Sheet on Ramsar Wetlands (RIS)

Categories approved by Recommendation 4.7 (1990), as amended by Resolution VIII.13 of the 8th Conference of the Contracting Parties (2002) and Resolutions IX.1 Annex B, IX.6, IX.21 and IX. 22 of the 9th Conference of the Contracting Parties (2005).

Notes for compilers:

1. The RIS should be completed in accordance with the attached *Explanatory Notes and Guidelines for completing the Information Sheet on Ramsar Wetlands*. Compilers are strongly advised to read this guidance before filling in the RIS.

2. Further information and guidance in support of Ramsar site designations are provided in the *Strategic Framework for the future development of the List of Wetlands of International Importance* (Ramsar Wise Use Handbook 7, 2nd edition, as amended by COP9 Resolution IX.1 Annex B). A 3rd edition of the Handbook, incorporating these amendments, is in preparation and will be available in 2006.

3. Once completed, the RIS (and accompanying map(s)) should be submitted to the Ramsar Secretariat. Compilers should provide an electronic (MS Word) copy of the RIS and, where possible, digital copies of all maps.

1. Name and address of the compiler of this form:

FOR OFFICE USE ONLY.

DD MM YY

Designation date | Site Reference Number

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough
Cambridgeshire PE1 1JY
UK
Telephone/Fax: +44 (0)1733 – 562 626 / +44 (0)1733 – 555 948
Email: RIS@JNCC.gov.uk

2. Date this sheet was completed/updated:

Designated: 21 September 1994

3. Country:

UK (England)

4. Name of the Ramsar site:

Broadland

5. Designation of new Ramsar site or update of existing site:

This RIS is for: Updated information on an existing Ramsar site

6. For RIS updates only, changes to the site since its designation or earlier update:

a) Site boundary and area:

** Important note: If the boundary and/or area of the designated site is being restricted/reduced, the Contracting Party should have followed the procedures established by the Conference of the Parties in the Annex to COP9 Resolution IX.6 and provided a report in line with paragraph 28 of that Annex, prior to the submission of an updated RIS.

b) Describe briefly any major changes to the ecological character of the Ramsar site, including in the application of the Criteria, since the previous RIS for the site:

7. Map of site included:

Refer to Annex III of the *Explanatory Notes and Guidelines*, for detailed guidance on provision of suitable maps, including digital maps.

a) A map of the site, with clearly delineated boundaries, is included as:

i) **hard copy** (required for inclusion of site in the Ramsar List): *yes* ✓ -or- *no* □;
ii**) an electronic format** (e.g. a JPEG or ArcView image) Yes
iii) **a GIS file providing geo-referenced site boundary vectors and attribute tables** *yes* ✓ -or- *no* □;

b) Describe briefly the type of boundary delineation applied:

e.g. the boundary is the same as an existing protected area (nature reserve, national park etc.), or follows a catchment boundary, or follows a geopolitical boundary such as a local government jurisdiction, follows physical boundaries such as roads, follows the shoreline of a waterbody, etc.

The site boundary is the same as, or falls within, an existing protected area.

For precise boundary details, please refer to paper map provided at designation

8. Geographical coordinates (latitude/longitude):

52 43 56 N 01 36 00 E

9. General location:

Include in which part of the country and which large administrative region(s), and the location of the nearest large town.

Nearest town/city: Great Yarmouth

Located in eastern Norfolk, part of East Anglia.

Administrative region: Norfolk; Suffolk

10. Elevation (average and/or max. & min.) (metres): 11. Area (hectares): 5488.61

Min. -2
Max. 4
Mean 1

12. General overview of the site:

Provide a short paragraph giving a summary description of the principal ecological characteristics and importance of the wetland.

Broadland is a low-lying wetland complex straddling the boundaries between east Norfolk and northern Suffolk. The area includes the river valley systems of the Bure, Yare and Waveney and their major tributaries. The open distinctive landscape comprises a complex and interlinked mosaic of wetland habitats including open water, reedbeds, carr woodland, grazing marsh and fen meadow. The region is important for recreation, tourism, agriculture and wildlife.

13. Ramsar Criteria:

Circle or underline each Criterion applied to the designation of the Ramsar site. See Annex II of the *Explanatory Notes and Guidelines* for the Criteria and guidelines for their application (adopted by Resolution VII.11).

2, 6

14. Justification for the application of each Criterion listed in 13 above:

Provide justification for each Criterion in turn, clearly identifying to which Criterion the justification applies (see Annex II for guidance on acceptable forms of justification).

Ramsar criterion 2

The site supports a number of rare species and habitats within the biogeographical zone context, including the following Habitats Directive Annex I features:

H7210	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*	Calcium-rich fen dominated by great fen sedge (saw sedge).
H7230	Alkaline fens	Calcium-rich springwater-fed fens.
H91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	Alder woodland on floodplains,
and the Annex II species		
S1016	*Vertigo moulinsiana*	Desmoulin`s whorl snail
S1355	*Lutra lutra*	Otter
S1903	*Liparis loeselii*	Fen orchid.

The site supports outstanding assemblages of rare plants and invertebrates including nine British Red Data Book plants and 136 British Red Data Book invertebrates.

Ramsar criterion 6 – species/populations occurring at levels of international importance.

Qualifying Species/populations (as identified at designation):

Species with peak counts in winter:

Tundra swan , *Cygnus columbianus bewickii*, NW Europe	196 individuals, representing an average of 2.4% of the GB population (5 year peak mean 1998/9-2002/3)
Eurasian wigeon , *Anas penelope*, NW Europe	6769 individuals, representing an average of 1.6% of the GB population (5 year peak mean 1998/9-2002/3)
Gadwall , *Anas strepera strepera*, NW Europe	545 individuals, representing an average of 3.1% of the GB population (5 year peak mean 1998/9-2002/3)
Northern shoveler , *Anas clypeata*, NW & C Europe	247 individuals, representing an average of 1.6% of the GB population (5 year peak mean 1998/9-2002/3)

Species/populations identified subsequent to designation for possible future consideration under criterion 6.

Species with peak counts in winter:

Pink-footed goose , *Anser brachyrhynchus*, Greenland, Iceland/UK	4263 individuals, representing an average of 1.7% of the population (5 year peak mean 1998/9-2002/3)
Greylag goose , *Anser anser anser*, Iceland/UK, Ireland	1007 individuals, representing an average of 1.1% of the population (Source period not collated)

Contemporary data and information on waterbird trends at this site and their regional (sub-national) and national contexts can be found in the Wetland Bird Survey report, which is updated annually. See www.bto.org/survey/webs/webs-alerts-index.htm.

15. Biogeography (required when Criteria 1 and/or 3 and /or certain applications of Criterion 2 are applied to the designation):

Name the relevant biogeographic region that includes the Ramsar site, and identify the biogeographic regionalisation system that has been applied.

a) biogeographic region:

Atlantic

b) biogeographic regionalisation scheme (include reference citation):

Council Directive 92/43/EEC

16. Physical features of the site:

Describe, as appropriate, the geology, geomorphology; origins - natural or artificial; hydrology; soil type; water quality; water depth, water permanence; fluctuations in water level; tidal variations; downstream area; general climate, etc.

Soil & geology	acidic, basic, neutral, clay, alluvium, peat, nutrient-rich, sedimentary
Geomorphology and landscape	lowland, valley, floodplain
Nutrient status	eutrophic, highly eutrophic, mesotrophic, oligotrophic
pH	acidic, alkaline, circumneutral
Salinity	brackish / mixosaline, fresh
Soil	mainly mineral, mainly organic
Water permanence	usually permanent, usually seasonal / intermittent
Summary of main climatic features	Annual averages (Lowestoft, 1971–2000) (www.metoffice.com/climate/uk/averages/19712000/sites/lowestoft.html) Max. daily temperature: 13.0° C Min. daily temperature: 7.0° C Days of air frost: 27.8 Rainfall: 576.3 mm Hrs. of sunshine: 1535.5

General description of the Physical Features:

Broadland is a low-lying wetland complex in eastern England. The Broads are a series of flooded medieval peat cuttings within the floodplains of five principal river systems. The area includes the river valley systems of the Bure, Yare and Waveney and their major tributaries. The distinctive open landscape comprises a complex and interlinked mosaic of wetland habitats including open water, reedbeds, carr woodland, grazing marsh and fen meadow, forming one of the finest marshland complexes in the UK. The differing types of management of the vegetation for reed, sedge and marsh hay, coupled with variations in hydrology and substrate, support an extremely diverse range of plant communities.

17. Physical features of the catchment area:

Describe the surface area, general geology and geomorphological features, general soil types, general land use, and climate (including climate type).

Broadland is a low-lying wetland complex in eastern England. The Broads are a series of flooded medieval peat cuttings within the floodplains of five principal river systems. The area includes the river valley systems of the Bure, Yare and Waveney and their major tributaries. The distinctive open landscape comprises a complex and interlinked mosaic of wetland habitats including open water, reedbeds, carr woodland, grazing marsh and fen meadow, forming one of the finest marshland complexes in the UK.

18. Hydrological values:

Describe the functions and values of the wetland in groundwater recharge, flood control, sediment trapping, shoreline stabilization, etc.

Recharge and discharge of groundwater, Flood water storage / desynchronisation of flood peaks, Maintenance of water quality (removal of nutrients)

19. Wetland types:

Inland wetland

Code	Name	% Area
U	Peatlands (including peat bogs swamps, fens)	30
Tp	Freshwater marshes / pools: permanent	30
W	Shrub-dominated wetlands	15
Xf	Freshwater, tree-dominated wetlands	10
O	Freshwater lakes: permanent	10
Q	Saline / brackish lakes: permanent	3
M	Rivers / streams / creeks: permanent	2

20. General ecological features:

Provide further description, as appropriate, of the main habitats, vegetation types, plant and animal communities present in the Ramsar site, and the ecosystem services of the site and the benefits derived from them.

The peatland areas of this site support: alder woodland on the floodplain dominated by *Alnus glutinosa* and the *Betula-Dryopteris cristata* community; mixed tall-herb fen typical of calcareous conditions are dominated by *Phragmites australis* and *Cladium mariscus*. The very wet mires are dominated by *Carex* spp. and *Juncus* spp., and spring-fed fens with *Schoenus nigricans*, *Carex dioica* and *Pinguicula nigricans*. Open waters are mostly highly eutrophic; however, some plant-rich mesotrophic and eutrophic examples remain, dominated by *Chara* sp., *Najas marina* and *Ceratophyllum demersum*. The ditch systems within the drained grasslands support Magnopotamion and Hydrocharition vegetation, often with *Stratiotes aloides*.

Ecosystem services

21. Noteworthy flora:

Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in **12**. Justification for the application of the Criteria) indicating, e.g. which species/communities are unique, rare, endangered or biogeographically important, etc. *Do not include here taxonomic lists of species present – these may be supplied as supplementary information to the RIS.*

Nationally important species occurring on the site.

Higher Plants.

Nationally Rare:

S1903 *Liparis loeselii* Fen orchid.

S1831 *Luronium natans* Floating water-plantain.

Najas marina, Potamogeton acutifolius, Dryopteris cristata

Nationally Scarce: *Althaea officinalis, Dactylorhiza traunsteineri, Potamogeton compressus, Potamogeton trichoides, Pyrola rotundifolia, Sonchus palustris, Cicuta virosa, Carex appropinquata, Thelypteris palustris, Lathyrus palustris, Potamogeton coloratus, Sium latifolium, Stratiotes aloides, Myriophyllum verticillatum.*

Lower Plants.

Nationally Rare: *Chara intermedia, Nitellopsis obtusa, Chara connivens, Chara intermedia* and *Cinclodium stygium*

Nationally scarce: *Chara curta, Drepanocladus vernicosus, Chara pendunculata, Campylium elodes, Chara aspera, Ricciocarpus natans, Tolypella glomerata*.

22. Noteworthy fauna:

Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in **12**. Justification for the application of the Criteria) indicating, e.g. which species/communities are unique, rare, endangered or biogeographically important, etc., including count data. *Do not include here taxonomic lists of species present – these may be supplied as supplementary information to the RIS.*

Birds

Species currently occurring at levels of national importance:

Species regularly supported during the breeding season:

Eurasian marsh harrier , *Circus aeruginosus*, Europe	16 pairs, representing an average of 10.5% of the GB population (5 year mean 1987/8-1991/2)

Species with peak counts in spring/autumn:

Common coot , *Fulica atra atra*, NW Europe	3112 individuals, representing an average of 1.7% of the GB population (5 year peak mean 1998/9-2002/3)

Species with peak counts in winter:

Great cormorant , *Phalacrocorax carbo carbo*, NW Europe	273 individuals, representing an average of 1.1% of the GB population (5 year peak mean 1998/9-2002/3)
Great bittern , *Botaurus stellaris stellaris*, W Europe, NW Africa	2 individuals, representing an average of 2% of the GB population (5 year peak mean 1998/9-2002/3)
Bean goose , *Anser fabalis fabalis*, NW Europe - wintering	238 individuals, representing an average of 59.5% of the GB population (5 year peak mean for 1996/7-2000/01)
Greater white-fronted goose , *Anser albifrons albifrons*, NW Europe	351 individuals, representing an average of 6% of the GB population (Source period not collated)
Eurasian teal , *Anas crecca*, NW Europe	2934 individuals, representing an average of 1.5% of the GB population (5 year peak mean 1998/9-2002/3)
Common pochard , *Aythya ferina*, NE & NW Europe	800 individuals, representing an average of 1.3% of the GB population (5 year peak mean 1998/9-2002/3)
Smew , *Mergellus albellus*, NW & C Europe	10 individuals, representing an average of 2.7% of the GB population (5 year peak mean 1998/9-2002/3)
Hen harrier, *Circus cyaneus*, Europe	22 individuals, representing an average of 2.9% of the GB population (5 year peak mean 1987/8-1991/2)
Water rail , *Rallus aquaticus*, Europe	23 individuals, representing an average of 5.1% of the GB population (5 year peak mean 1998/9-2002/3)
Ruff , *Philomachus pugnax*, Europe/W Africa	82 individuals, representing an average of 11.7% of the GB population (5 year peak mean 1998/9-2002/3)

Species Information

Species occurring at levels of international importance.

Invertebrates.

S1016 *Vertigo moulinsiana* Desmoulin`s whorl snail

Assemblage.

This site supports a diverse assemblage of invertebrates including:
Aeshna isosceles, Papilio machaon britannicus.
136 British Red Data Book invertebrate species have been recorded on the site.

Nationally important species occurring on the site.

Mammals.

S1355 *Lutra lutra* Otter

23. Social and cultural values:

Describe if the site has any general social and/or cultural values e.g. fisheries production, forestry, religious importance, archaeological sites, social relations with the wetland, etc. Distinguish between historical/archaeological/religious significance and current socio-economic values.

Aesthetic
Aquatic vegetation (e.g. reeds, willows, seaweed)
Archaeological/historical site
Environmental education/ interpretation
Fisheries production
Forestry production
Livestock grazing
Non-consumptive recreation
Scientific research
Sport fishing
Sport hunting
Tourism
Transportation/navigation

b) Is the site considered of international importance for holding, in addition to relevant ecological values, examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning? No

If Yes, describe this importance under one or more of the following categories:

i) sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland:

ii) sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland:

iii) sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples:

iv) sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland:

24. Land tenure/ownership:

Ownership category	On-site	Off-site
Non-governmental organisation (NGO)	+	
Local authority, municipality etc.	+	
National/Crown Estate	+	

Private	+	+

25. Current land (including water) use:

Activity	On-site	Off-site
Nature conservation	+	+
Tourism	+	+
Recreation	+	+
Current scientific research	+	+
Collection of non-timber natural products: commercial	+	
Commercial forestry	+	+
Cutting/coppicing for firewood/fuel	+	+
Cutting of vegetation (small-scale/subsistence)	+	+
Fishing: commercial	+	+
Fishing: recreational/sport	+	+
Permanent arable agriculture		+
Rough or shifting grazing	+	+
Permanent pastoral agriculture	+	+
Hay meadows	+	+
Hunting: recreational/sport	+	+
Sewage treatment/disposal		+
Flood control	+	+
Irrigation (incl. agricultural water supply)		+
Mineral exploration (excl. hydrocarbons)		+
Transport route		+
Domestic water supply		+
Urban development		+
Non-urbanised settlements		+

26. Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects:

Explanation of reporting category:

1. *Those factors that are still operating, but it is unclear if they are under control, as there is a lag in showing the management or regulatory regime to be successful.*
2. *Those factors that are not currently being managed, or where the regulatory regime appears to have been ineffective so far.*

NA = Not Applicable because no factors have been reported.

Adverse Factor Category	Reporting Category	Description of the problem (Newly reported Factors only)	On-Site	Off-Site	Major Impact?
No factors reported	NA				

For category 2 factors only. What measures have been taken / are planned / regulatory processes invoked, to mitigate the effect of these factors?
Is the site subject to adverse ecological change? NO

27. Conservation measures taken:

List national category and legal status of protected areas, including boundary relationships with the Ramsar site; management practices; whether an officially approved management plan exists and whether it is being implemented.

Conservation measure	On-site	Off-site
Site/ Area of Special Scientific Interest (SSSI/ASSI)	+	
National Nature Reserve (NNR)	+	
Special Protection Area (SPA)	+	
Land owned by a non-governmental organisation for nature conservation	+	+
Management agreement	+	+
Site management statement/plan implemented	+	
Other	+	+
Environmentally Sensitive Area (ESA)	+	+
Special Area of Conservation (SAC)	+	

b) Describe any other current management practices:
The management of Ramsar sites in the UK is determined by either a formal management plan or through other management planning processes, and is overseen by the relevant statutory conservation agency. Details of the precise management practises are given in these documents.

28. Conservation measures proposed but not yet implemented:

e.g. management plan in preparation; official proposal as a legally protected area, etc.

No information available

29. Current scientific research and facilities:

e.g. details of current research projects, including biodiversity monitoring; existence of a field research station, etc.

Contemporary.

Flora.
The entire site has had a vegetation survey, primarily fen, wet woodland and open water areas, lakes plus ditch systems, and this is now on GIS.
Monitoring is undertaken on the site, particularly freshwater and fen habitats.

Completed.

Fauna.
Wintering and breeding bird survey of all drained marshland area completed, results on a GIS.
Some species survey and monitoring, e.g. *Liparis loeselii*, *Luronium natans* and a number of molluscs.

30. Current communications, education and public awareness (CEPA) activities related to or benefiting the site:

e.g. visitor centre, observation hides and nature trails, information booklets, facilities for school visits, etc.

Many nature trails and footpaths with information boards and leaflets plus five visitor centres at Ranworth, Hickling, Strumpshaw, How Hill and Carlton Colville.

31. Current recreation and tourism:

State if the wetland is used for recreation/tourism; indicate type(s) and their frequency/intensity.

Activities.

The area attracts large numbers of tourists predominantly during the summer, many of which are water-borne. The river and broads (lakes) both within and adjacent to the site carry large numbers of power and sail craft which results in large-scale erosion and loss of fringing reedswamp. Speed limits have been imposed, however boat numbers remains too high.

Facilities provided.

Land-based recreation within the site is well managed, directing people to facilities where boardwalks are provided.

Seasonality.

All year.

32. Jurisdiction:

Include territorial, e.g. state/region, and functional/sectoral, e.g. Dept. of Agriculture/Dept. of Environment, etc.

Head, Natura 2000 and Ramsar Team, Department for Environment, Food and Rural Affairs, European Wildlife Division, Zone 1/07, Temple Quay House, 2 The Square, Temple Quay, Bristol, BS1 6EB

33. Management authority:

Provide the name and address of the local office(s) of the agency(ies) or organisation(s) directly responsible for managing the wetland. Wherever possible provide also the title and/or name of the person or persons in this office with responsibility for the wetland.

Site Designations Manager, English Nature, Sites and Surveillance Team, Northminster House, Northminster Road, Peterborough, PE1 1UA, UK

34. Bibliographical references:

Scientific/technical references only. If biogeographic regionalisation scheme applied (see **15** above), list full reference citation for the scheme.

Site-relevant references

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Wiggington, M (1999) *British Red Data Books. 1. Vascular plants*. 3rd edn. Joint Nature Conservation Committee, Peterborough

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Please return to: **Ramsar Secretariat, Rue Mauverney 28, CH-1196 Gland, Switzerland**
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Appendix E FARMSCOPER outputs

The magnitude of the potential sediment **losses** are shown in the table below.

NB These relate to farms only.

	the F'SCOPER modelled total Sedt loss from all farms within that water body (according to Ag Census)	Which water bodies are losing the most Sedt from Agri sources	the F'SCOPER modelled total Sedt loss from arable farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt loss from livestock farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all Arable farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all Livestock farms within that water body (according to Ag Census)	Rank of the Sedt savings that could be made in each water body (highest first)
Waterbody name	**FARMSCOPER & Ag census modelled Sedt loss from Agriculture in WB (Kg/yr)**	**Rank Loss**	**FARMSCOPER & Ag census modelled Sedt loss from ARABLE (Kg/yr)**	**FARMSCOPER & Ag census modelled Sedt loss from LIVESTOCK (Kg/yr)**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) in water body**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) from ARABLE in water body**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) from LIVESTOCK in water body**	**Rank Magnitude of Sedt savings to be made from applying top 5 measures in water body**
Ant upstream	96376	1	86952	9424	71759	66953	4806	1
East Ruston	36230	3	36230	0	27897	27897	0	3
Brumstead	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Smallburgh	21738	4	21738	0	16738	16738	0	4
Ant downstream	86774	2	79706	7068	64978	61374	3605	2

The magnitude of potential phosphate **savings** are provided in the table below.

NB These relate to farms only.

	i.e. How much do we think P loss could be reduced by by applying ARABLE and LIVESTOCK top5 measures at every farm in each water body	i.e. Magnitude of potential outcome	i.e. How much do we think P loss could be reduced by by applying ARABLE top5 measures at every ARABLE farm in each water body	i.e. Magnitude of potential outcome	i.e. How much do we think P loss could be reduced by by applying LIVESTOCK top5 measures at every LIVESTOCK farm in each water body	i.e. Magnitude of potential outcome
Waterbody name	**P saved by applying "top 5" measures to all ARABLE AND LIVESTOCK farms in waterbody, expressed as a % of F'SCOPER modelled P loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of all Agri measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**	**P saved by applying "top 5" measures to all ARABLE farms in waterbody, expressed as a % of F'SCOPER modelled P loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of ARABLE measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**	**P saved by applying "top 5" measures to all LIVESTOCK farms in waterbody, expressed as a % of F'SCOPER modelled P loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of LIVESTOCK measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**
Ant upstream	41%	Moderate	18%	Low	23%	Low
East Ruston	32%	Moderate	32%	Moderate	0%	Low
Brumstead	n/a	n/a	n/a	n/a	n/a	n/a
Smallburgh	32%	Moderate	32%	Moderate	0%	Low
Ant downstream	40%	Moderate	20%	Low	20%	Low

The magnitude of the potential sediment losses are shown in the table below.

NB These relate to farms only.

	the F'SCOPER modelled total Sedt loss from all farms within that water body (according to Ag Census)	Which water bodies are losing the most Sedt from Agri sources	the F'SCOPER modelled total Sedt loss from arable farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt loss from livestock farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all Arable farms within that water body (according to Ag Census)	the F'SCOPER modelled total Sedt that could be saved by applying "top 5" measures to all Livestock farms within that water body (according to Ag Census)	Rank of the Sedt savings that could be made in each water body (highest first)
Waterbody name	**FARMSCOPER & Ag census modelled Sedt loss from Agriculture in WB (Kg/yr)**	**Rank Loss**	**FARMSCOPER & Ag census modelled Sedt loss from ARABLE (Kg/yr)**	**FARMSCOPER & Ag census modelled Sedt loss from LIVESTOCK (Kg/yr)**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) in water body**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) from ARABLE in water body**	**FARMSCOPER & Ag Census modelled Sedt savings that could be made (Kg/yr) from LIVESTOCK in water body**	**Rank Magnitude of Sedt savings to be made from applying top 5 measures in water body**
Ant upstream	96376	1	86952	9424	71759	66953	4806	1
East Ruston	36230	3	36230	0	27897	27897	0	3
Brumstead	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Smallburgh	21738	4	21738	0	16738	16738	0	4
Ant downstream	86774	2	79706	7068	64978	61374	3605	2

The magnitude of potential sediment **savings** are provided in the table below.

NB These relate to farms only.

	i.e. How much do we think Sedt loss could be reduced by by applying ARABLE and LIVESTOCK top5 measures at every farm in each water body	i.e. Magnitude of potential outcome	i.e. How much do we think Sedt loss could be reduced by by applying ARABLE top5 measures at every ARABLE farm in each water body	i.e. Magnitude of potential outcome	i.e. How much do we think Sedt loss could be reduced by by applying LIVESTOCK top5 measures at every LIVESTOCK farm in each water body	i.e. Magnitude of potential outcome
Waterbody name	**Sedt saved by applying "top 5" measures to all ARABLE AND LIVESTOCK farms in waterbody, expressed as a % of F'SCOPER modelled Sedt loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of all Agri measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**	**Sedt saved by applying "top 5" measures to all ARABLE farms in waterbody, expressed as a % of F'SCOPER modelled Sedt loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of ARABLE measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**	**Sedt saved by applying "top 5" measures to all LIVESTOCK farms in waterbody, expressed as a % of F'SCOPER modelled Sedt loss from Agriculture in the WB**	**Magnitude of theoretical effectiveness of LIVESTOCK measures (Low = 0-25%; Moderate = 26-60%; High = 61-100%)**
Ant upstream	74%	High	69%	High	5%	Low
East Ruston	77%	High	77%	High	0%	Low
Brumstead	n/a	n/a	n/a	n/a	n/a	n/a
Smallburgh	77%	High	77%	High	0%	Low
Ant downstream	75%	High	71%	High	4%	Low

Appendix F SAGIS outputs

Different water bodies show different pressures. The table below shows the phosphate loading of each water body.

WB_ID	Waterbody name	PO4 Load (Kg/yr)	Rank PO4 Load	STW load as % overall	Intermittent load as % overall load	Livestock load as % overall load	Arable load as % overall load	Urban load as % overall load	OsWwTS Load as % overall load	Is water body in top 3 for size (Q95)?	Is water body in top 3 for P load?	Is STW contributing >25% of total water body P load?	Is intermittent contributing >25% of total water body P load?	Is livestock contributing >25% of total water body P load?	Is arable contributing >25% of total water body P load?	Is urban contributing >25% of total water body P load?	Is OsWwTS contributing >25% of total water body P load?
GB105034055710	Ant upstream	171.6	3	5%	39%	6%	4%	27%	18%	Y	Y		Y			Y	
GB105034055670	East Ruston	103.2	4	0%	1%	15%	57%	1%	26%						Y		Y
GB105034050910	Brumstead	375.8	2	2%	12%	13%	40%	11%	22%	Y	Y				Y		
GB105034050890	Smallburgh	67.5	5	0%	0%	20%	6%	0%	74%								Y
GB105034051330	Ant downstream	1056.3	1	76%	8%	4%	5%	2%	6%	Y	Y	Y					

The magnitude of the potential phosphate losses are shown in the table below.

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