Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS001a

River Wensum SSSI - Exemplar Diffuse Water Pollution Plan and Action Plan

River Wensum 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 sites, 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 River Wensum SSSI. This work will also be used to help develop and implement DWP plans for other Natura 2000 sites.

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River Wensum SSSI

Exemplar Diffuse Water Pollution Plan &
Action Plan

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Plan Design Enable

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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 siltation) on the River Wensum Site of Special Scientific Interest (SSSI).

The SSSI units covered by this plan include units 45–55 (90.56 ha), which cover both riverine and floodplain units. The site includes the River Wensum from its headwaters in Whissonsett (Unit 45) to Hellesdon Mill on the outskirts of Norwich (Unit 54), together with parts of two tributaries, the River Tat (Unit 46) and the Langor Drain (Unit 55). It does not include other major tributaries such as the Wendling Beck.

The focus of this plan is on improving the condition of the riverine units 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 Plan 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	River Wensum SSSI Responsible Officer	Hannah Wallace
	Catchment Sensitive Farming River Basin co-ordinator body	Victoria Fradley
	Catchment Sensitive Farming Officer	
	Lead for the DWPP	Philippa Wilmott
Environment Agency	Senior Environment Officer, Environment Management Team	
	River Wensum SSSI Responsible Officer	Hannah Wallace

PART 1: SUMMARY OF EVIDENCE & ACTION PLAN

2. Summary of evidence for DWPP Actions on the River Wensum SSSI

2.1. What is the scale of the problem?

The compliance of water quality in the River Wensum relative to the current phosphate targets has been assessed (see Section 5.2). Available data show that the annual average orthophosphate levels between 2007 and 2013 were higher than the target at most of monitored sites (0.06 or 0.10 mg/l depending on location). Throughout this period average annual phosphate levels remained relatively constant. However in 2013 four of the seven sites were within or very close to the phosphate target. Set against the revised 2014 CSM targets (generally 0.05 mg/l (see Section 5.2.1)) the historic data shows that all locations on the River Wensum would fail the new annual target for most of the time: only one site on the River Wensum would pass the new targets in one year (2013). Most of the river also fails the new seasonal phosphate target with only a few exceptions.

Due to this non-compliance, this Diffuse Water Pollution plan focuses on identifying measures to address and reduce phosphate losses from the catchment.

The Source Apportionment GIS (SAGIS[1]) model has been used to understand the phosphate levels in the water bodies in the SSSI catchment. In Table 2.1 the model has provided estimated P loads for the exit point of each WFD water body catchment and ranks the data, with water bodies listed in order from upstream to downstream. It should be noted that in the version of SAGIS used for this Plan, the model does not include the Foulsham Tributary water body, however it does include the outputs of the Foulsham Sewage Treatment Works as entering the water body of Wensum, upstream of Norwich.

An important point to remember some of the driving force for this loading will be the size of the water body, in terms of flow and catchment area; to contextualise this; Q95 is given and similarly ranked with largest first.

In some cases, this shows that some of the larger water bodies do not necessarily have similarly high loads (e.g. Wensum 1 and 2), but some do (e.g. Wensum upstream of Norwich). These data provide an idea of the water bodies that could be prioritised for action.

The water bodies contributing the most phosphate load, excluding the “Wensum, upstream of Norwich” water body are: Wendling Beck; Tud; Blackwater Drain (downstream); Tat; and Blackwater Drain (mid).

Table 2.1 SAGIS outputs for Q95 and phosphate load in SSSI and SSSI contributing water bodies

WB_ID	Waterbody name	Q95	Rank Q95	PO4 Load (g/day)	Rank PO4 Load
GB105034051080	Tributary of Wensum	2.02	13	181	15
GB105034051100	Wensum upstream 1	6.85	5	1047	10
GB105034051110	Wensum upstream 2	7.73	3	1057	9
GB105034055870	Tat 1	3.60	9	137	17
GB105034051130	East Rudham Stream	2.01	14	192	14
GB105034051140	Tat 2	14.36	2	1403	7
GB105034055860	Little Ryburgh Tributary	0.57	18	115	18
GB105034051020	Wendling Beck	6.98	4	7579	2
GB105034051050	Blackwater	2.27	12	1770	5
GB105034051010	Penny Spot Beck	1.14	16	616	11
GB105034051090	Tributary of Blackwater Drain 1	1.18	15	467	13
GB105034051120	Blackwater Drain upstream	2.84	10	1199	8
GB105034051030	Blackwater Drain mid	4.36	8	1738	6
GB105034051060	Tributary of Blackwater Drain 2	1.00	17	593	12
GB105034051040	Blackwater Drain downstream	5.71	7	2382	4
GB105034051070	Swannington Beck	2.29	11	164	16
GB105034051000	Tud	5.83	6	3114	3
GB105034055881	Wensum, upstream of Norwich	50.02	1	22221	1

[1] *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.*

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 exporting the higher loads, and yellow and green indicating lower loads.

2.2. Where is the phosphate coming from?

The SAGIS model gives an indication of the apportionment of phosphate sources in the catchment. At the whole catchment level, Figure 2.1 below shows the source apportionment at the catchment outflow/downstream end of the SSSI (Norwich) i.e. it represents the **combined effects** of all sources in the catchment. It shows that agriculture as a whole (arable and livestock combined) is the largest contributor, followed by Sewage Treatment Works (STW) with a 33% contribution. Splitting agriculture shows that Arable farming contributes less than STWs, closely followed by Livestock farming. Urban sources are also significant.

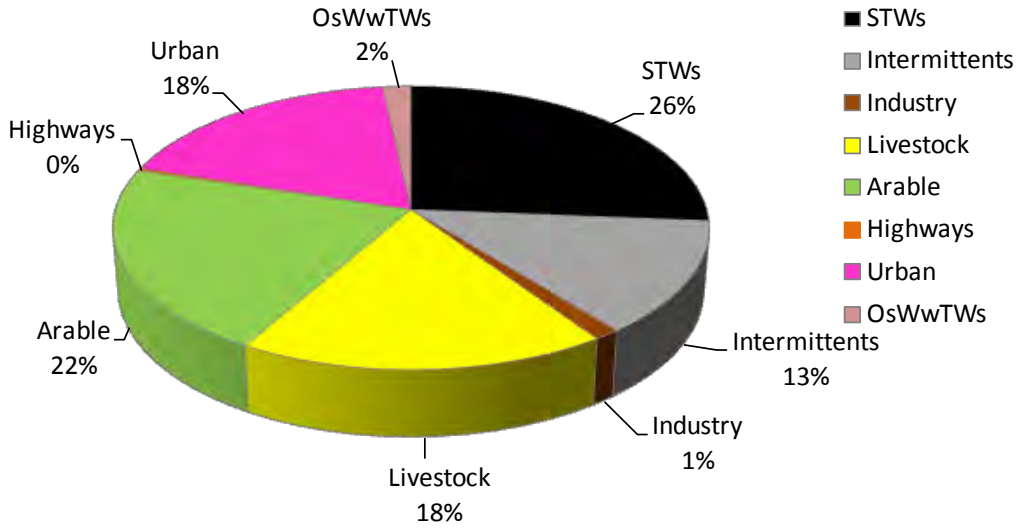


Figure 2.1 Overall catchment source apportionment

(Derived from SAGIS data. Note that the Foulsham Tributary water body is not included in the SAGIS model.)

Figure 2.2 overleaf shows a longitudinal profile along the main River Wensum water body showing the sources potentially responsible for phosphates in different river reaches. Figure 2.2 is a chainage plot showing how phosphate concentrations in the river change in a downstream direction. Confluences with different WFD waterbodies and STW inflows are labelled to show how different phosphate inflows entering the river affect concentrations down the River Wensum SSSI. So, this figure shows the **combined effects** of loads exported from different WFD waterbodies, its effects on concentrations, and how they vary downstream. 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 on with numbers. The plot shows clear step changes in concentrations where the largest STWs in the catchment flow into the River (e.g. Fakenham STW - marker 3 - and the inflow of the Blackwater and Wandling Beck that includes Dereham STW - marker 6). The plot also shows how important agricultural sources are throughout the entire length of the river. The overall effect are concentrations that exceed the FCT downstream of Fakenham.

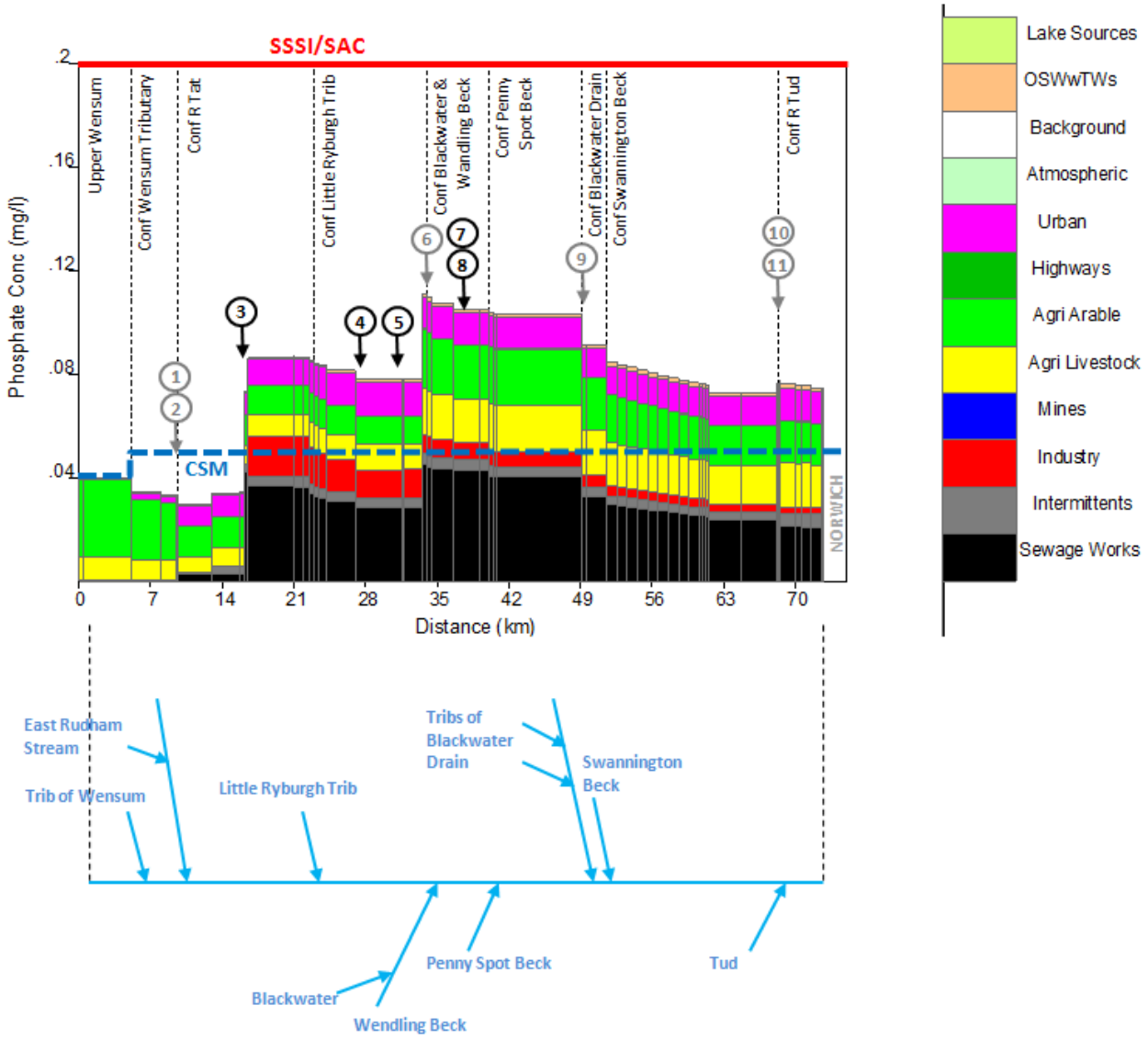


Figure 2.2 SAGIS longitudinal phosphate cumulative source apportionment profile for the main River Wensum

The blue dashed line represents the 2014 CSM thresholds for phosphate (mg/l). The vertical dotted lines are confluences with different waterbodies or other important hydrological features in the catchment moving downsream. STW discharges are numbered[2] – see footnote. *STWs shown in black discharge straight into the River Wensum. STWs labelled in grey discharge to watercourses that subsequently flow into the River Wensum.*

[2] **STW marked as follows**: 1 (East Rudham); 2 (Sculthorpe); 3 (Fakenham) 4 (Foulsham); 5 (North Elmham); 6 (Dereham); 7 (Swanton Morley); 8 (Bylaugh); 9 (Reepham); 10 (Mattishall); and 11 (Hockering).

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

Different water bodies show different pressures. The Wendling Beck for instance shows the highest phosphate load of all SSSI contributing water bodies; the highest proportion of which is likely to be coming from sewage treatment works. The Tud shows the next highest phosphate loading but has a higher proportion of source attributed to livestock, arable and urban sources.

The model outputs however highlight the overall influence of activities in the valley of the River Wensum itself, that is described as the Wensum upstream of Norwich waterbody.

The data presented in Figure 2.3 has been interrogated carefully to identify priorities for action in each WFD waterbody; the data are shown in Appendix D, and the key decisions on priorities set out in Table 2.2. The focus of this DWPP has been on the four main sources of phosphate within the catchment; STW; arable farming; livestock farming; and urban.

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

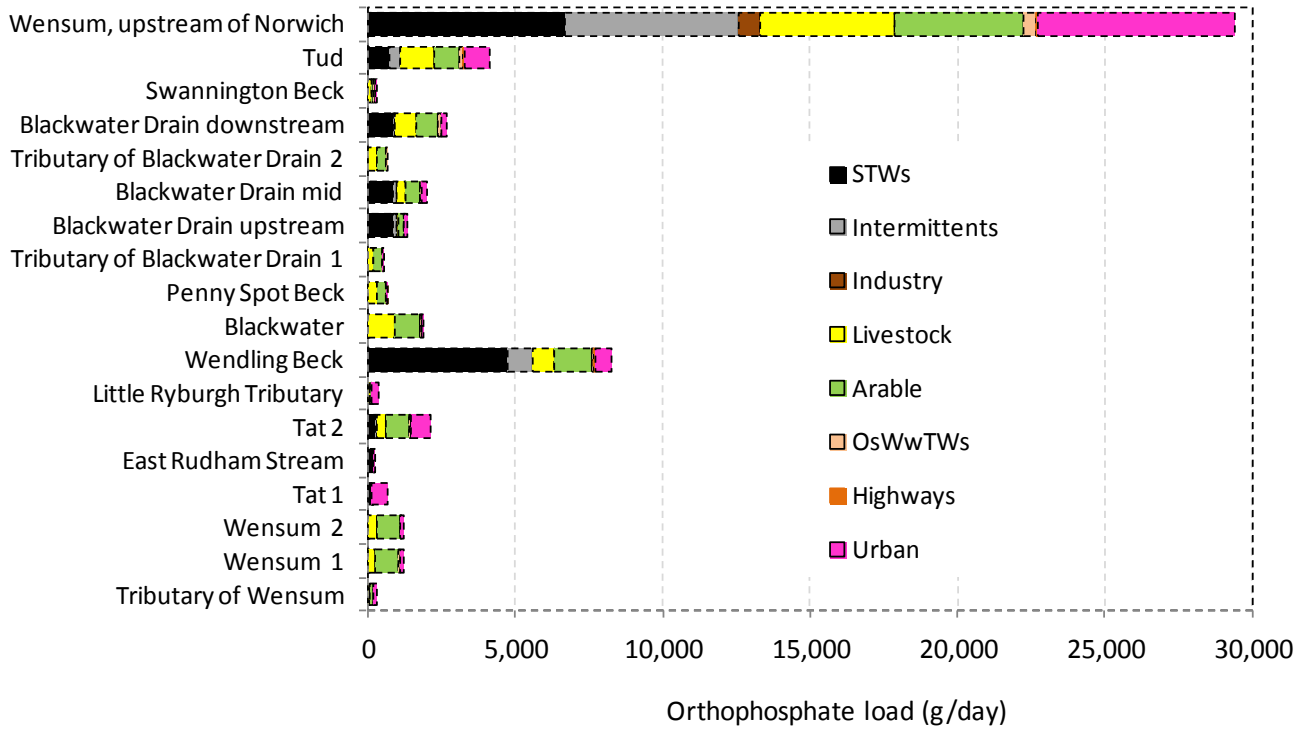


Figure 2.3 River Wensum SSSI-contributing water body source apportionment

(Data derived from SAGIS. The figure shows the load generated from each individual water body, not cumulatively. The Foulsham Tributary water body is not represented within the SAGIS model and so no data are available.)

Table 2.2 Decision matrix and prioritisation for DWPP Actions

Waterbody name	Waterbody ID	Is water body within highest rank (1–5) for P load?	Is STW 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?	Priorities PRIORITY 1 = water body is within highest rank (1–5) for overall load; PRIORITY 2 = outside of highest rank	Additional priorities (i.e. sector also shown in source apportionment)
Tributary of Wensum	GB105034051080				Y (41%)	Y (37%)	PRIORITY 2 action: Target arable and urban	Livestock
Wensum 1	GB105034051100				Y (66%)		**PRIORITY 2 action:** Target arable farming	Urban and livestock
Wensum 2	GB105034051110				Y (61%)		**PRIORITY 2 action:** Target arable farming	Urban and livestock
Tat 1	GB105034055870					Y (79%)	PRIORITY 2 action: Target Urban	n/a
East Rudham Stream	GB105034051130		Y (76%)				PRIORTY 2 action: Target STW	n/a
Tat 2	GB105034051140				Y (38%)	Y (33%)	**PRIORITY 1 action**: Target arable and urban	Livestock
Little Ryburgh Tributary	GB105034055860					Y (64%)	PRIORITY 2 action: Target urban sources	n/a
Wendling Beck	GB105034051020	Y	Y (57%)				**PRIORITY 1 action**: Target STW	Arable, livestock, intermittent and urban
Blackwater	GB105034051050	Y		Y (49%)	Y (50%)		**PRIORITY 1 action**: Target arable and livestock	n/a
Penny Spot Beck	GB105034051010			Y (42%)	Y (52%)		PRIORITY 2 action: Target arable and livestock	n/a
Tributary of Blackwater Drain 1	GB105034051090			Y (33%)	Y (52%)		PRIORITY 2 action: Target arable and livestock	n/a
Blackwater Drain upstream	GB105034051120		Y (64%)				PRIORITY 2 action: Target STW	Arable, livestock and urban
Blackwater Drain mid	GB105034051030		Y (43%)				PRIORITY 2 action: Target STW	Arable, livestock and urban
Tributary of Blackwater Drain 2	GB105034051060			Y (51%)	Y (46%)		PRIORITY 2 action: Target arable and livestock	n/a
Blackwater Drain downstream	GB105034051040	Y	Y (32%)	Y (26%)	Y (29%)		**PRIORITY 1 action:** Target STW, arable and livestock	urban
Swannington Beck	GB105034051070			Y (43%)	Y (29%)		PRIORITY 2 action: Target livestock.	n/a
Tud	GB105034051000	Y		Y (28%)			**PRIORITY 1 action**: Target livestock	Arable and urban
Wensum, upstream of Norwich	GB105034055881	Y	(23%)	(16%)	(15%)	(23%)	**PRIORITY 1 action**: Target Arable, livestock, urban	Intermittent

2.3. What can be done?

The priorities set out in Table 2.2 have been used to drive the measures in the Action Plan. Where the evidence identifies STW as a priority for action, this has been identified as a measure within the DWPP but for action by other parties (as STW is a point source). Where the evidence points towards agriculture being a key issue, specific measures have been identified that should be targeted to the farms within each water body, related to the farm types within certain SSSI contributing water bodies.

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

2.4. How effective might the measures be?

In terms of the effectiveness of agricultural measures, the FARMSCOPER tool has been used to understand the potential phosphate losses from the farms within the individual SSSI-contributing water body catchments.

Based on the FARMSCOPER outputs, and using the Agricultural Census data provided by Defra, this assessment shows that the highest risk (rank 1–5) of farm-level phosphate loss occurs in the Wensum upstream of Norwich, Tud, Wendling Beck, Blackwater Drain (downstream) and the Foulsham Tributary. This is broadly in line with the priorities set out by the source apportionment (Figure 2.3). The magnitude of the potential phosphate *losses* are provided in Appendix C.

The FARMSCOPER outputs indicate which measures would best be applied in the agricultural sector to reduce phosphate losses at a farm level. The top 5 most effective measures for any given farm type have been selected and modelled, see Table 2.3 (and Table 8.3). The outputs essentially give a percentage reduction in phosphate losses ("savings" that could be made) from a 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 savings from applying measures on the type of farms (arable and livestock) within each water body. The magnitude of the potential phosphate *savings* are provided in Appendix C.

Table 2.3 The top 5 FARMSCOPER measures for the farm types in the Wensum catchment

FARMSCOPER farm type	Top 5 measures (DWP manual ID number + title/name
Roots combinable (cropping with poultry manure)	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 soil layers in grassland fields
Mixed combinable (with pig manure)	8 – Cultivate compacted tillage soils
	9 – Cultivate and drill across the slope
	13 – Establish in-field grass buffer strips
	15 – Loosen compacted soil layers in grassland fields
	106 – Plant areas of farm with wild bird seed/nectar flower mixtures
Lowland grazing	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
Mixed Livestock	35 – Reduce the length of the grazing day/grazing season
	60 – Site solid manure heaps away from watercourses/field drains
	61 – Store solid manure heaps on an impermeable base and collect effluent
	62 – Cover solid manure stores with sheeting
	68 – Do not apply manure to high risk areas
Outdoor pigs	8 – Cultivate compacted tillage soils
	13 – Establish in-field grass buffer strips
	15 – Loosen compacted soil layers in grassland fields
	78 – Re-site gateways away from high-risk areas
	106 – Plant areas of farm with wild bird seed/nectar flower mixtures
Specialist poultry	34 – Adopt phase feeding of livestock
	38 – Move feeders at regular intervals
	78 – Re-site gateways away from high-risk areas
	106 – Plant areas of farm with wild bird seed/nectar flower mixtures
	332 – Reduce dietary N and P intakes: Pigs and Poultry

It is important to note that these “savings” are relative to farm-level phosphate losses and are not directly proportional to in-stream phosphate concentrations; so a similar level of phosphate reduction will not be seen in-stream. However, the figures do give a useful indication of the ***potential*** for agricultural measures to help reduce phosphate mobilisation within the catchment.

The effectiveness of the top 5 most effective agricultural measures applied to all farms within each water body are shown in Table 2.4, and have been categorised as follows:

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

It should be noted that these phosphate savings are expressed as a percentage of the overall agricultural phosphate losses, not of the overall water body phosphate load. Furthermore, these percentage savings assume the top 5 measures are applied correctly on every farm in every water body, not just on the priority water bodies set out in the action plan. This shows that the potential for reductions in either the arable or livestock sector in isolation is generally low, but combined action in each water body (aside from the Little Ryburgh Tributary) could result in moderate savings of farm-scale phosphate losses within the water body catchment.

In summary, it is thought that moderate reductions coupled with improvements at selected STWs may achieve compliance.

Table 2.4 Magnitude of theoretical effectives of measures

Waterbody name	Waterbody ID	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Wensum 2	GB105034051110	Moderate	Moderate	Low
Tat 2	GB105034051140	Moderate	Low	Low
Little Ryburgh Tributary	GB105034055860	Low	Low	Low
Wendling Beck	GB105034051020	Moderate	Low	Low
Blackwater	GB105034051050	Moderate	Moderate	Low
Blackwater Drain downstream	GB105034051040	Moderate	Low	Low
Swannington Beck	GB105034051070	Moderate	Low	Moderate
Tud	GB105034051000	Moderate	Low	Low
Wensum, upstream of Norwich	GB105034055881	Moderate	Low	Low
Foulsham Tributary	GB105034055850	Moderate	Low	Moderate

3. Action Plan

Table 3.1 The Diffuse Water Pollution Plan Action Plan for the River Wensum 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	Who?
SSSI catchment	Investigation	Agriculture & Land Management	**W_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	Evidence investigation & site specific action plan	Natural England - Review of CSF and Agri Environment	All sub-catchments that are under Environmental Stewardship with a particular focus on those that are eligible for Higher Level Stewardship. All sub-catchments currently have a degree of ELS uptake, whereas HLS uptake is more common in the middle section of the overall SSSI catchment	Natural England
Specific catchments	Scheme	Agriculture & Land Management	**W_DWPP_002**	Re-focused agri-environment priorities	Use the outputs W_DWPP_001 (review of existing agri-environment implementation) to implement advice and schemes that are more targeted to phosphate reduction in areas where there is an issue (based on evidence) or higher risk (based on available evidence).	Phosphorus	Scheme	Existing NE Agri-Environment	Water body selection for this measure is dependent on the outcomes of the Agri-environment review (W_DWPP_001)	Natural England
SSSI catchment	Advice	Agriculture & Land Management	**W_DWPP_003**	DWPP re-focus communication	Following review of Agri-environment implementation and ECSFDI reviews (W_DWPP_001 and W_DWPP_009) communicate any catchment priority changes to land managers and stakeholders, including NE, EA, NFU, CLA, Agronomists etc.	All	Advice	Existing communications routes, farm shows; CSF visits; NE catchment officers, local websites etc.	Communication should be SSSI catchment-wide.	Natural England
SSSI catchment	Regulatory	Agriculture & Land Management	**W_DWPP_004**	NVZ inspections	Higher rate of NVZ inspections to promote better nutrient management planning in high risk sub-catchments or where there is suspected issues with management practices or seasonal high risk activities.	Nitrates primarily but some benefit for phosphorus and sediment through advice and culture change	Monitoring outcomes and compliance	Existing EA mechanism for inspections	All sub-catchments that are within the NVZ boundary (NB: those marked with an N are water bodies that fall outside the NVZ)	Environment Agency
SSSI catchment	Regulatory	Agriculture & Land Management	**W_DWPP_005**	Agri Environment inspections	Higher rate of Agri-environment inspections following scheme implementation. This would be focused in target areas where measures being implemented for resource protection are highly site-specific and seasonal.	Phosphorus	Monitoring outcomes and compliance	CSF follow up visits	All sub-catchments in the SSSI catchment with the exception of urban dominated catchments (as defined in the CORINE land mapping)	Natural England/Rural Payments Agency
SSSI catchment	Investigation	Agriculture & Land Management	**W_DWPP_006**	Investigation into the feasibility of catchment scale agri-environment schemes	Investigation into the feasibility and land owner/land manager appetite for catchment scale agri-environment schemes, whereby farmers of a specific farm type all sign up to a certain level of measures and all have to comply in order for payments to be received. This would represent a collective sign-up, such that all signees must implement measures. The idea of this is so that action is wide-spread and simultaneous instead of piecemeal, and thus the outcomes may be easier to monitor.	Phosphates, sediment, nitrates, pesticides	Evidence investigation & site specific action plan	ECSFDI/NE Agri-Environment combination and consideration of using DTC/Rivers Trusts and Agronomists for support	All sub-catchments in the SSSI catchment that are under Environmental Stewardship of some description, with the exception of urban dominated catchments	Natural England, Rivers Trusts, possibly Water Company
Specific catchments	Scheme	Agriculture & Land Management	**W_DWPP_007**	Pilot study into catchment scale agri-environment schemes	Following on from W_DWPP_006, trial a pilot catchment-scale agri environment scheme, monitor implementation outcomes. Use this as an education site where interested farmers and landowners can come and see what the measures might entail.	Phosphorus	Pilot scheme	NE local project	TBC (dependent on outcomes of above task) (W_DWPP_006)	Natural England, Rivers Trusts, possibly Water Company
SSSI catchment	Scheme	Agriculture & Land Management	**W_DWPP_008**	Promotion of best practice	Promote best practice through existing advice visits, and assurance schemes – e.g. Red Tractor	Phosphates, sediment, pesticides, nitrates	Assurance scheme	TBC	TBC	Natural England, NFU, CLA, CFE
SSSI catchment	Investigation	Agriculture & Land Management	**W_DWPP_009**	Re-focus of the England Catchment Sensitive Farming Delivery Initiative programme activities within the SSSI catchment	This programme should be re-appraised within the catchment so that it is specifically targeted to locations where the phosphate pressure (identified in the data) or risk (from high-risk activities) is greatest. This could include specific farm types, locations, or locations that are known to be poorly managed, or a combination thereof.	Phosphates	Evidence investigation	ECSFDI	All water bodies within the SSSI catchment that have a strong agricultural pressure should be re-appraised. These water bodies have been identified using SAGIS data and selected because >25% of the phosphate load is estimated to be coming from agricultural sources.	Natural England, Defra
SSSI catchment	Advice and Scheme	Agriculture & Land Management	**W_DWPP_010**	Phosphate targeted ECSFDI Implementation	Following on from the appraisal of ECSFDI (W_DWPP_010) pursue a refocused programme of advice and schemes under ECSFDI and NE Agri-advisors to target specific areas within the catchment, delivering targeted advice and capital grants for phosphate-reducing land management practices and infrastructure.	Phosphorus	Advice and Scheme	ECSFDI	TBC (dependent on outcomes of above task)	Natural England, Defra
SSSI catchment	Investigation	Rural	**W_DWPP_011**	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 catchment shows elevated phosphate levels coincident with high risk from septic tanks (location and distance to source assessment) and a higher source apportionment attributable to OSWwTSs.	Phosphorus	Evidence investigation	?	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.	Environment Agency/Natural England
Specific catchments	Advice	Rural	**W_DWPP_012**	Action on poor septic tank management/mis connections	Dependent on the outcomes of W_DWPP_011 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. Alongside this, undertake a communications campaign on good practice management for septic tanks.	Phosphorus	Advice/ Regulatory	EA	Catchments selected here have an estimated >200 people not served by mains sewerage (the Tud, Wendling Beck, Swannington Beck, Tributary of Blackwater Drain, Foulsham Tributary and Wensum US Norwich). Further catchment should be added depending on the outcomes of related action	Environment Agency

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	Who?
									(W_DWPP_011)	
SSSI catchment	Investigation	Rural	**W_DWPP_013**	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	All sub-catchments within the SSSI catchment should be subject to risk mapping as this isn't just related to urban or rurally dominated areas and is specific to road network, land use, slope and existing mitigation.	Environment Agency/Natural England
Specific catchments	Scheme	Rural	**W_DWPP_014**	Road run-off pathway disruption techniques	Depending on the outcomes of W_DWPP_013 (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	TBC (dependent on outcomes of related task W_DWPP_013)	EA, Local Authority, Highways Agency
Specific catchments	Investigation	Urban	**W_DWPP_015**	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 appropriate	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.	Natural England (driving), Environment Agency and Local Authorities/ Councils etc
SSSI catchment	Policy review	Agriculture & Land Management	**W_DWPP_016**	Review of phosphate-reducing measures available through HLS and ELS	Undertake a policy review and understand the further scope for targeting towards resource protection and re-targeting of HLS priorities and measures if required	Phosphates as primary, with some benefit for nitrates, sediment, pesticides. In some cases, additional benefits for biodiversity.	Evidence investigation	Defra and Natural England	TBC	Natural England, Defra, Environment Agency
SSSI catchment	Advice	Agriculture & Land Management	**W_DWPP_017**	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 as primary focus, with some benefit for nitrates, sediment, 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	Natural England
Specific catchments	Schemes	Agriculture & Land Management	**W_DWPP_018**	Engagement with Catchment Based Approach Partners to maximise wider benefits	Working with the Rivers Trusts 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 as primary, with some benefit for nitrates, sediment, pesticides. In some cases, additional benefits for biodiversity.	Advice and Scheme	Catchment Based Approach	TBC	Natural England and Rivers Trusts/ Broads Authority
SSSI catchment	Advice	Agriculture & Land Management	**W_DWPP_019**	Strategy/ 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 as primary, with some benefit for nitrates, sediment, 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.	Natural England
SSSI catchment	Advice	Agriculture & Land Management	**W_DWPP_020**	Delivery of more evidence-based advice to farmers	Work closely with farmers to demonstrate the evidence base and preferred options for mitigation, guiding farmers to more appropriate land management measures. This is aimed at promoting a culture change whereby farmers learn about the evidence base and what can be done about it, which could help promote ownership of the problem and a culture of trust.	Sediment and phosphate	Advice delivery	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	Natural England with support from NFU/CLA / Agronomists
SSSI catchment	Advice	Agriculture & Land Management	**W_DWPP_021**	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	Natural England
SSSI catchment	Monitoring outcomes	Agriculture & Land Management	**W_DWPP_022**	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 future iterations of the action plan	All catchments	Natural England
SSSI catchment	Investigation	Agriculture & Land Management	**W_DWPP_023**	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	Priority catchments marked here include those where arable or livestock are contributing >25% of phosphate load within the catchment	Natural England Environment Agency
Specific catchments	Advice / Schemes: Arable – General cropping	Agriculture & Land Management	**W_DWPP_024**	Arable farming measures for General Cropping farm types - promotion of the	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 soil layers in grassland fields	Phosphates as primary, with some benefit for nitrates, sediment, pesticides. In some cases,	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 and/or for which	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	Who?
				"top 5" measures		additional benefits for biodiversity.			the agri census data shows a high proportion of general cropping (>10 holdings in the water body)	
Specific catchments	Advice / Schemes	Agriculture & Land Management	**W_DWPP_025**	Arable farming measures for Cereals farm types – promotion of the "top 5" measures	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 soil layers in grassland fields; 106 – Plant areas of farm with wild bird seed/nectar flower mixtures	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	All cereal holdings should eventually be targeted however the priorities set out here are for Prioritise implementation in water bodies that show >25% of phosphate load from arable sector and/or for which the agri census data shows a high proportion (>10 holdings) of cereal holdings within the water body.	NE and landowners
Specific catchments	Advice / Schemes: Livestock – Lowland grazing	Agriculture & Land Management	**W_DWPP_026**	Livestock farming measures for Lowland grazing farm type – promotion of the "top 5" measures.	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	All livestock farms should eventually be targeted, however the priorities set here are for water bodies that show >25% of phosphate load from livestock and/or for which the agri census data shows a high number of lowland grazing farms (>10 holdings in water body)	NE and landowners
Specific catchments	Advice / Schemes: Livestock – Mixed grazing	Agriculture & Land Management	**W_DWPP_027**	Livestock farming measures for Mixed grazing farm type – promotion of the "top 5" measures.	Liaise with farmers within the high priority areas to push top 5 measures for phosphorus reductions on this farm type: 35 – Reduce the length of the grazing day/grazing season; 60 – Site solid manure heaps away from watercourses/field drains; 61 – Store solid manure heaps on an impermeable base and collect effluent; 62 – Cover solid manure stores with sheeting; 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	All livestock farms should eventually be targeted, however the priorities set here are for water bodies that show >25% of phosphate load from livestock and/or for which the agri census data shows a high number of mixed grazing farms (>10 holdings in water body)	NE and landowners
Specific catchments	Advice / Schemes: Specialist farming – Specialist pigs	Agriculture & Land Management	**W_DWPP_028**	Specialist pig farming measures – promotion of the "top 5" measures:	Liaise with farmers within the high priority areas to push top 5 measures for phosphorus reductions on this farm type: 8 – Cultivate compacted tillage soils; 13 – Establish in–field grass buffer strips; 15 – Loosen compacted soil layers in grassland fields; 78 – Re-site gateways away from high-risk areas; 106 – Plant areas of farm with wild bird seed/nectar flower mixtures	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	Prioritise sub-catchments with pig farms (Tud, Wendling Beck and Tat, confirmed by agri-census statistics) as a starter but investigate the degree of suppressed data in the Little Ryburgh and Swannington sub-catchments as these may also contain pig farms	NE and landowners
Specific catchments	Advice / Schemes: Specialist farming – Specialist poultry	Agriculture & Land Management	**W_DWPP_029**	Specialist poultry farming measures - promotion of the "top 5" measures:	Liaise with farmers within the high priority areas to push top 5 measures for phosphorus reductions on this farm type: 34 – Adopt phase feeding of livestock; 38 – Move feeders at regular intervals; 78 – Re–site gateways away from high-risk areas; 106 – Plant areas of farm with wild bird seed/nectar flower mixtures; 332 – Reduce dietary N and P intakes: Pigs and Poultry	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	Target licensed poultry farms within the catchment - Tud, Wensum (to Tatter ford) and Wensum US Norwich as a starter but also investigate the degree of suppressed data in Little Ryburgh and Tat catchments.	NE and landowners
Specific catchments	Investigation	Water Industry	**W_DWPP_030**	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.	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. However, a catchment wide investigation should be undertaken on the current phosphate consent, level of treatment and potential for improvements.	NE and landowners
Specific catchments	Investigation /regulatory mechanism	Agriculture & Land Management	**W_DWPP_032**	Unconsented farm discharges	Identify unconsented discharges from farms, for example specific farms with poor management practice e.g. Slurry pit/field corner management etc. If the issue is significant then identify appropriate ways to tackle the issue.	Phosphorus	Investigation / regulatory mechanism	EA pollution inspection procedure	Investigations in all agriculturally dominated catchments e.g. walkover surveys	Environment Agency
Specific catchments	Investigation /regulatory mechanism	Urban	**W_DWPP_033**	Unconsented urban discharges	Identify and remedy unconsented discharges from the urban environment, for example e.g. misconnections etc	Phosphorus	Investigation / regulatory mechanism	EA pollution inspection procedure	Specific catchments where urban is responsible for significant (>25%) portion of the phosphate load, and/or intermittents sources have been identified in the SAGIS model. Can use walkover surveys, dye/tracer studies to identify misconnections.	Environment Agency
Specific catchments	Investigation /regulatory mechanism	Industry	**W_DWPP_034**	Unconsented industrial discharges	Identify and remedy unconsented industrial discharges for example from small industrial estates or industrial areas	Phosphorus	Investigation / regulatory mechanism	EA pollution inspection procedure	Specific catchments where land use data (CORINE) shows industrial land use. Tat, Blackwater (Wendling Beck) Tud.	Environment Agency
Specific catchments	Investigation	Agriculture & Land Management	**W_DWPP_035**	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	Natural England, Environment Agency

PART 2 – SUPPORTING EVIDENCE

4. Characteristics of the catchment

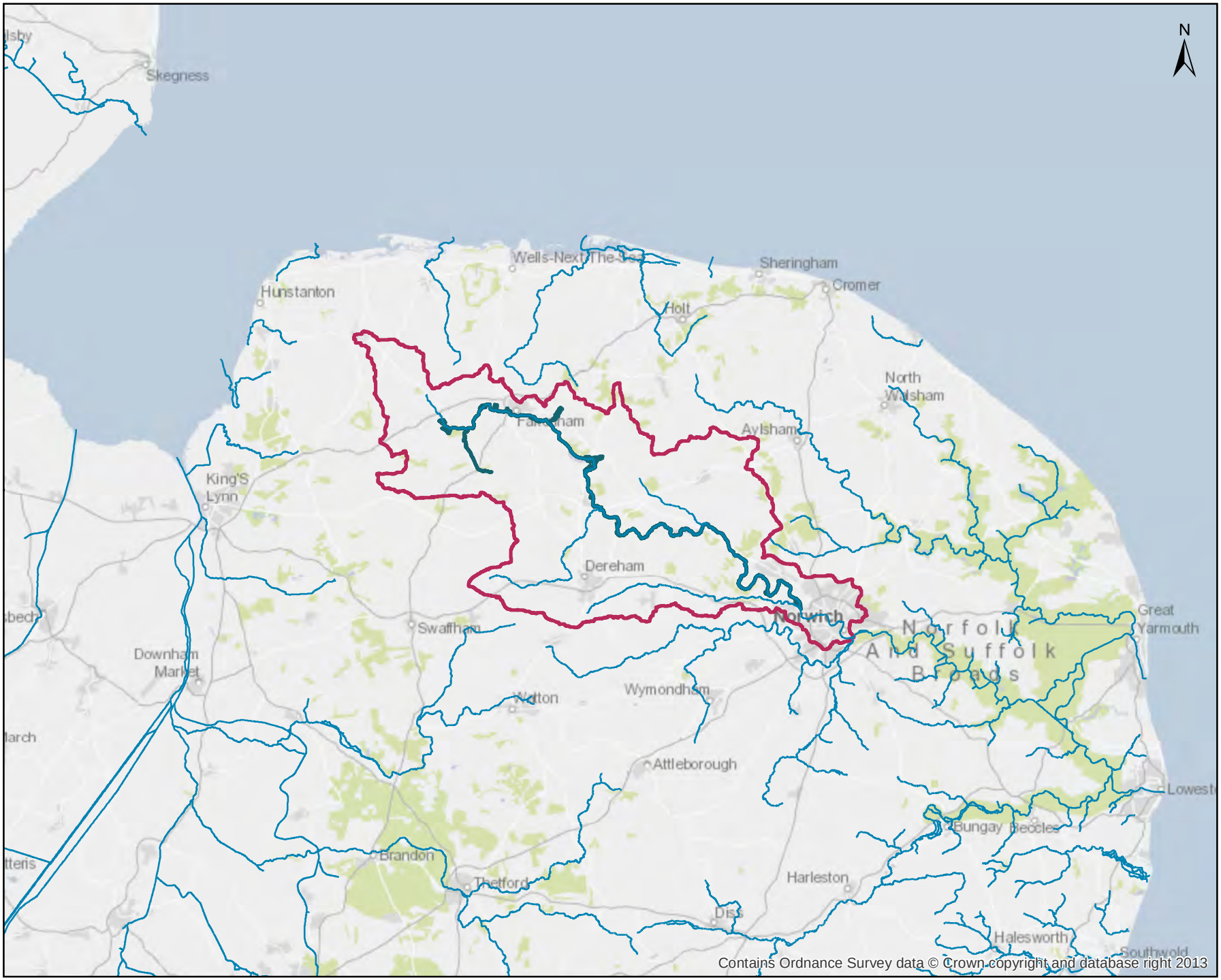
4.1. Area covered by DWPP

The River Wensum rises close to the village of Whissonsett, near Fakenham in North Norfolk at an altitude of 50 m above sea level. The river flows 73 km, for the most part in a south-easterly direction, to the tidal limit at New Mills in Norwich (Figure 4.1), with a catchment area of 685 km^2 (68493 ha). The general location of the River Wensum SSSI catchment is shown in Figure 4.1.

The SSSI units covered by this plan include units 45–55 (90.56ha), which cover both riverine and floodplain units. The site includes the River Wensum from its headwaters in Whissonsett (Unit 45) to Hellesdon Mill on the outskirts of Norwich (Unit 54), together with parts of two tributaries, the River Tat (Unit 46) and the Langor Drain (Unit 55). The SSSI does not include other major tributaries such as the Wendling Beck, however this Plan does, as the tributary is part of the catchment.

The catchment is primarily rural, with the principal land use in its shallow valley being managed grassland. Other than Fakenham, Taverham, and Dereham (the latter on the Wendling Beck) there are few urban areas that influence the river.

The catchment is reasonably flat, with elevations ranging from 0 mAOD at the tidal limit of the river, to a maximum of 98 mAOD (Figure 4.2). Hill slopes in the catchment are generally very shallow, with the majority of slopes not exceeding 1 degree (Figure 4.3). The steeper slopes in the catchment tend to be within 500 m of a watercourse where the land has been incised (Figure 4.3).



Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.1: River Wensum catchment location

- Main Rivers
- River Wensum SSSI
- River Wensum Catchment

0 6 12 18 km

Scale (at A4): 1:500,000

Reference: 5120447	Drawn: JAM 21/05/2014
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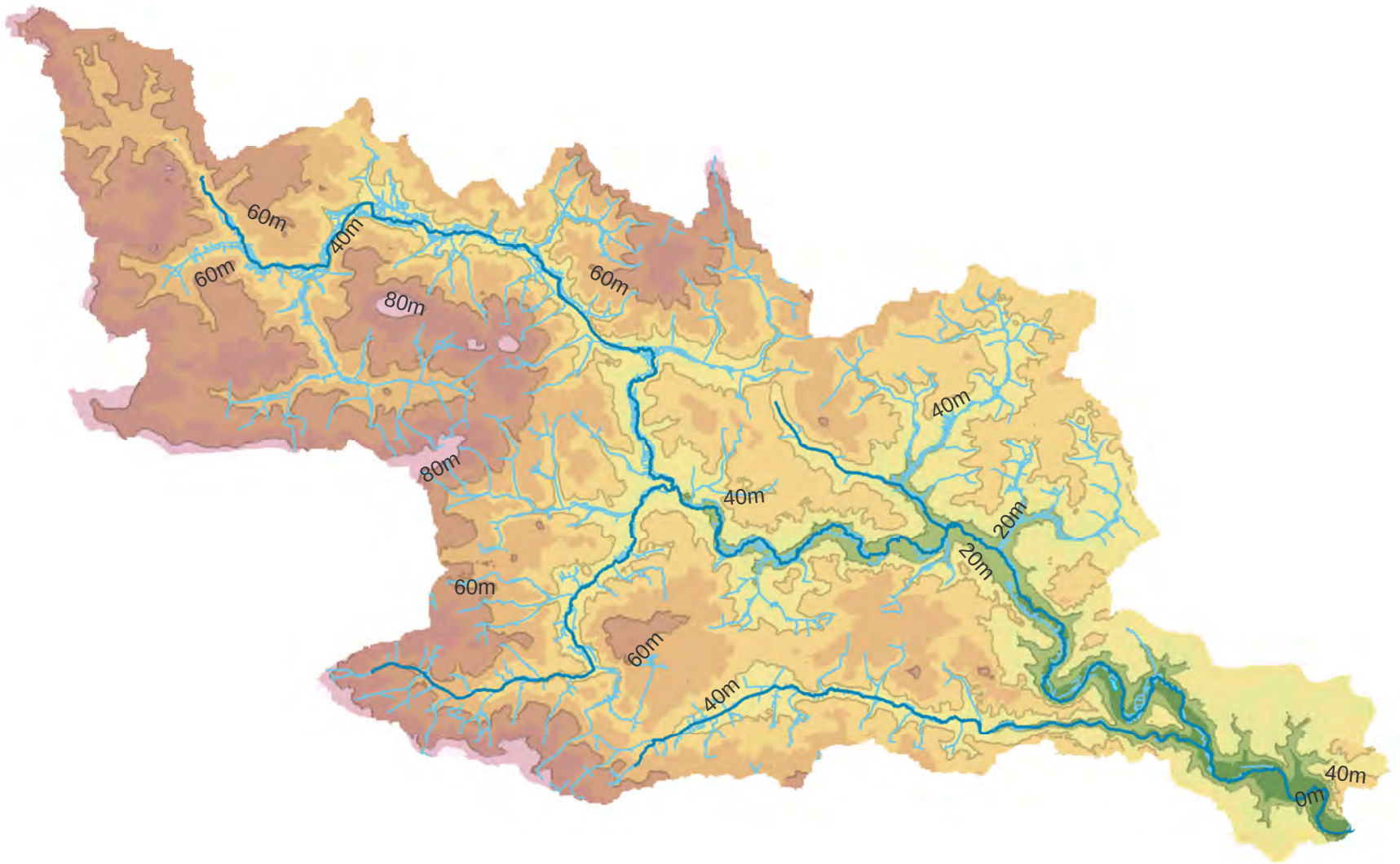
Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.2: River Wensum SSSI catchment topography



Lakes
Main Rivers
Watercourses
Contours (20m intervals)

Elevation (mAOD)

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

0 2 4 6 km

Scale (at A4): 1:222,000

Reference: 5120447	Drawn: JAM 09/05/2014
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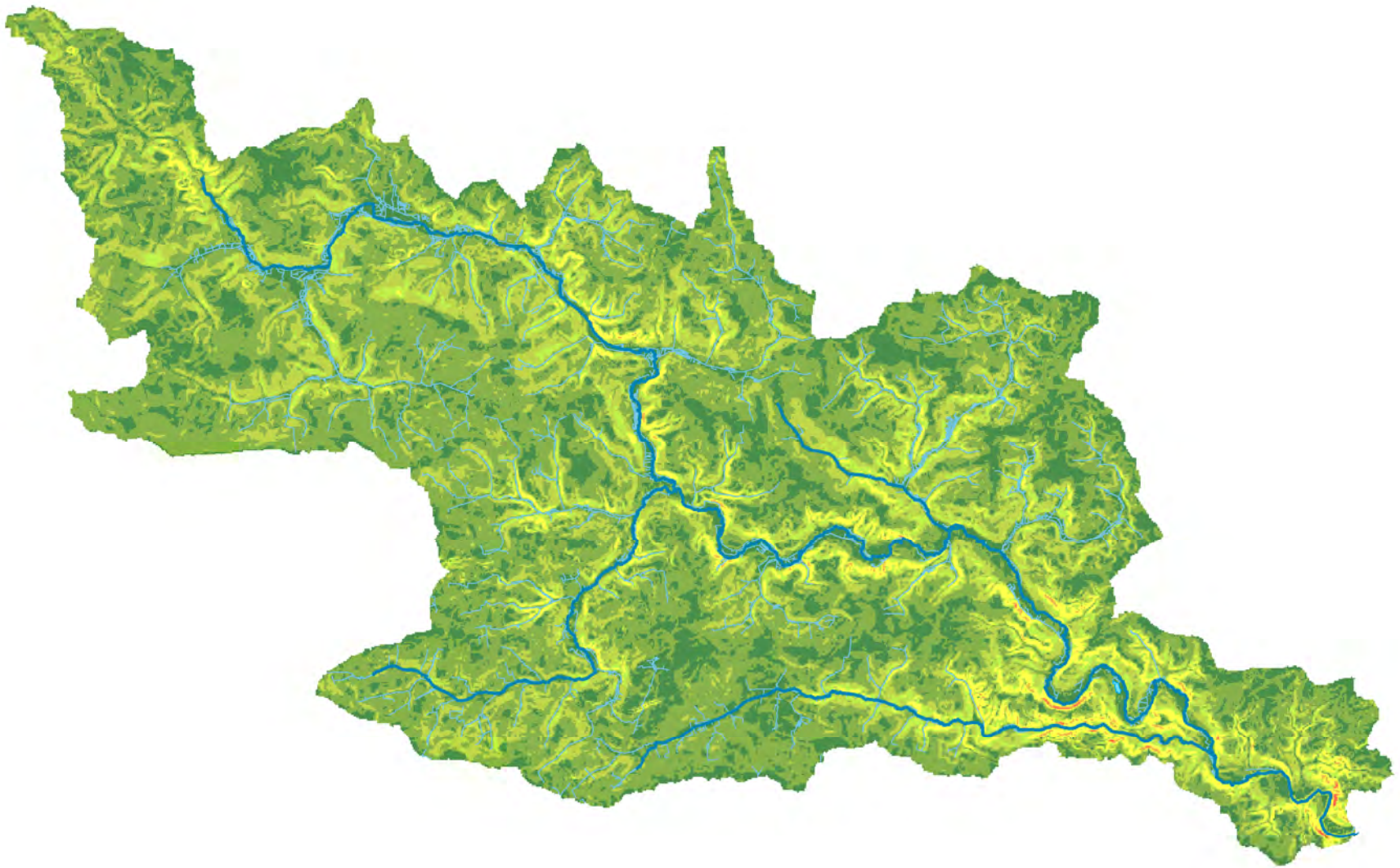
Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.3: River Wensum Slope



Lakes
Main Rivers
Watercourses

Slope (degrees)

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

0 2 4 6 km

Scale (at A4): 1:222,000

Reference: 5120447	Drawn: JAM 09/05/2014
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4.2. Climate

There are three operational Environment Agency rainfall gauges in the Wensum area: East Wretham (TL927909); Rockland St Peter (TL985976); and Carbrooke (TL941026).

To determine the most representative gauge to use to understand rainfall patterns within the catchment, analysis was undertaken of online mapped long term average rainfall patterns derived by the Met Office and shown on the National River Flow Archives website[3]. These show that each rain gauge is broadly representative of rainfall patterns within the catchment, with variances likely to be up to 50 mm per year, less than 10% of long term annual average rainfall. The Rockland St Peter gauge has been used to provide a conceptual understanding of rainfall patterns within the Wensum catchment.

Figure 4.4 shows that the average mean monthly rainfall at the rain gauge is quite steady throughout the year, with rainfall typically being lowest in spring, and higher throughout other times of the year. The mean annual rainfall (1995–2011) recorded at the rain gauge is 643 mm, although Figure 4.5 shows that intra-annual total rainfall varies greatly. The mean annual range covers the period for complete annual rainfall data is available at the gauge.

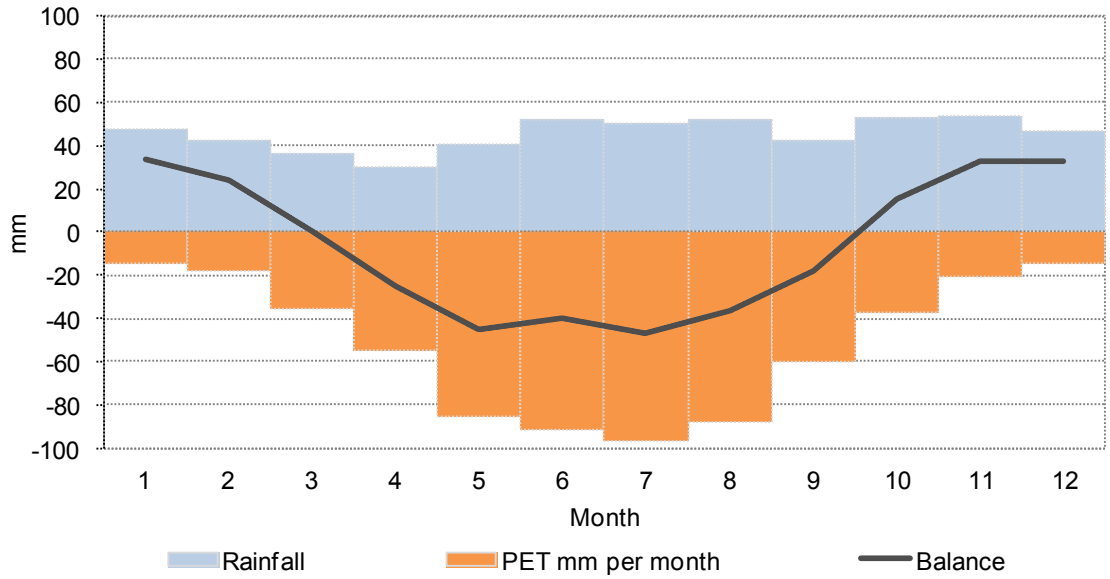


Figure 4.4 Long term average (1995–2011) monthly rainfall at Rocklands St Peters rain gauge compared against long term average potential evapotranspiration, with the balance

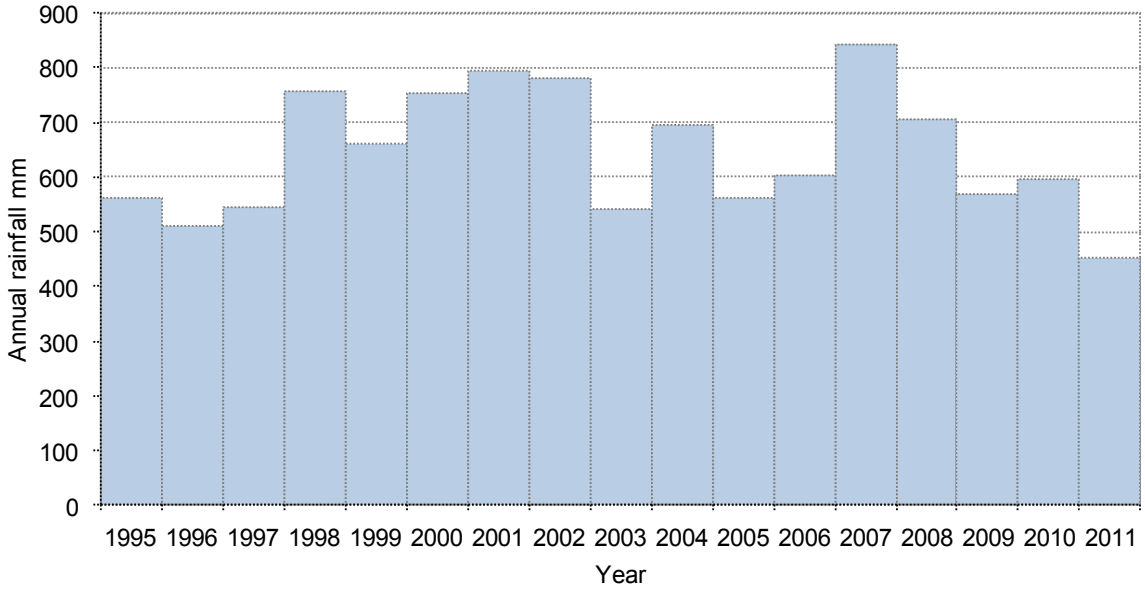


Figure 4.5 Total annual rainfall at Rocklands St Peters rain gauge

[3] The River Flow Archives website can be found here: http://www.ceh.ac.uk/data/nrfa/data/spatialdata.html?33049

Average monthly evapo-transpiration rates for Met Office Rainfall and Evaporation Calculation System (MORECS) grid square 130, which the Wensum catchment is part of, is shown in Table 4.1. MORECS is a water balance model which calculates evapo-transpiration using the Penman–Monteith equation. Outputs are provided in grid squares covering Great Britain and Northern Ireland. The data shows that actual evapo-transpiration rates are equal to, or close to potential rates between January to June, and October to December, whilst between May to September the gap widens increasing the likelihood that abstracted water is used for irrigation under arable cover within the catchment.

Table 4.1 Average monthly evapo-transpiration for MORECS square 130 for the period 1961–1998

Month	Potential evapo-transpiration (mm/month)	Actual evapo-transpiration (grass) (mm/month)
January	14.72	14.72
February	18.00	17.99
March	35.47	35.35
April	54.86	54.51
May	85.90	82.89
June	91.74	74.59
July	96.60	67.87
August	88.45	54.78
September	59.92	43.38
October	37.33	32.65
November	21.10	20.30
December	14.19	14.14
Annual total	**618**	**513**

4.3. Geology and hydrology

The Wensum is one of the best examples in the UK of a naturally enriched calcareous lowland river. The upper reaches of the river are fed by chalk springs and drainage from calcareous soils, and support chalk stream vegetation communities. In the downstream reaches the river flows predominantly over boulder clay and gravels and the vegetation communities in this reach reflect the change in substrate and slower flow conditions. The geology of the catchment is provided in Figure 4.6.

The catchment is underlain by the cretaceous White Chalk subgroup, which is exposed along a wide front running roughly diagonally from Hampshire to Norfolk and Lincolnshire. However, as one travels from Hampshire to Norfolk, the influence of the chalk on the land surface becomes increasingly masked by glacial and fluvio-glacial silts, sands, gravels and boulder clays, with the Wensum catchment being largely covered by boulder clay.

This cover increases runoff during wetter periods and reduces the base flow contribution during drier periods, making the River Wensum flashier than typical chalk streams such as the Hampshire River Avon, River Test and River Frome. The drift deposits leads to a high density drainage network along the Wensum, comparable with flashy lowland catchments.

The Base Flow Index (BFI) for the Wensum at Costessy Mill gauge is 0.75 (National Rivers Flow Archive gauge #34004 – www.ceh.ac.uk/data/nrfa), inferring that three quarters of the flow in the river comes from baseflow, on average. This is substantially lower than in typical chalk streams; > 0.90 BFI, although still means that the Wensum is a baseflow dominant catchment. Despite this the river has limited winterbournes due to a number of secondary aquifers along the river which overlay the drift deposits and keep the river flowing during low flow periods.

4.3.1. River Wensum SSSI water bodies

The River Wensum SSSI encompasses several main rivers, a summary of which is set out in Figure 4.7. In addition to this, the SSSI is comprised of many separate water bodies a defined under the Water Framework Directive and these are presented in Figure 4.8.

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. These catchments will change in 2016 for Cycle 2 and will affect the study area and water body catchments as shown in Figure 4.9 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.

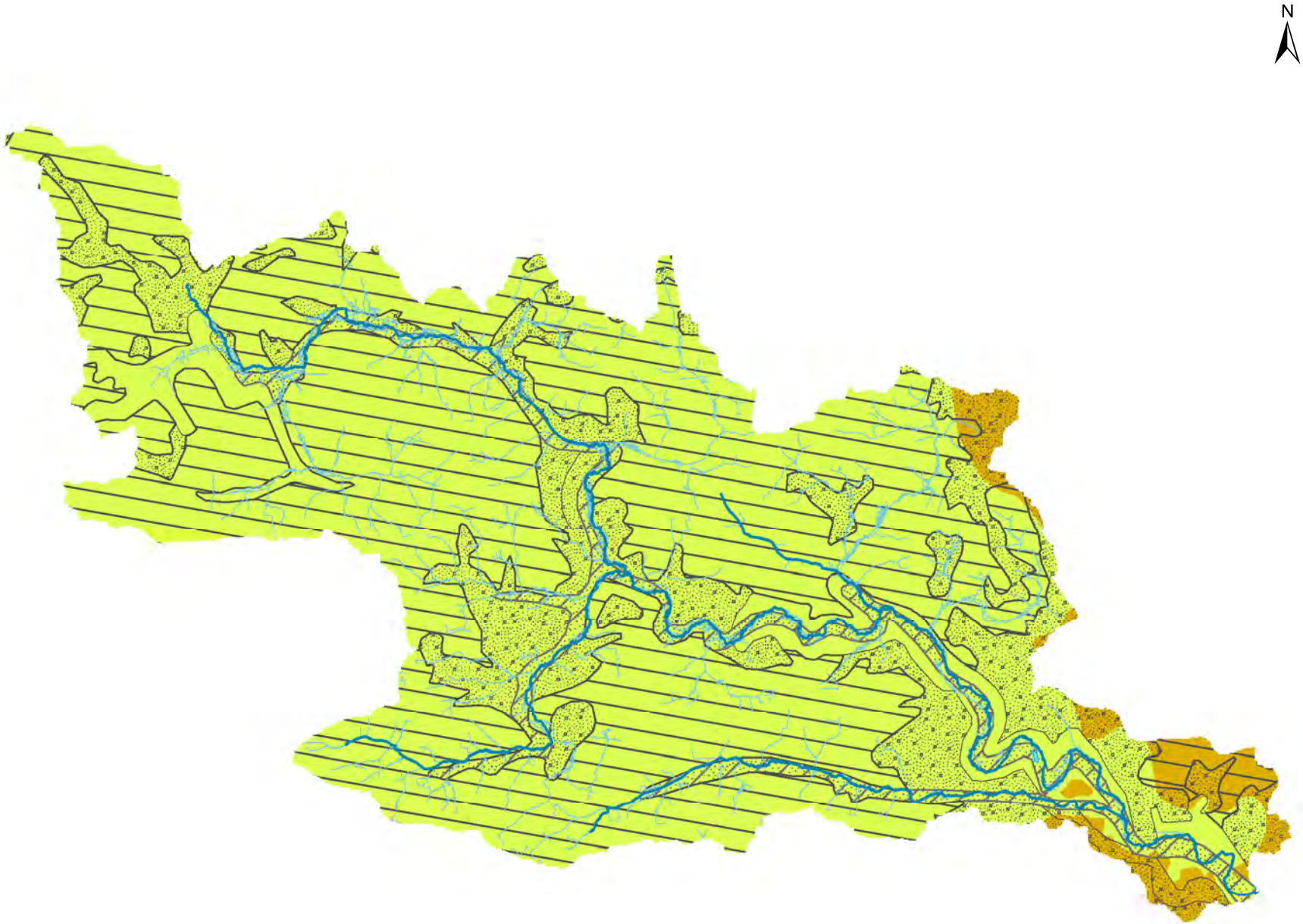
A list of water bodies contained within the River Wensum SSSI, and the SSSI units to which they correspond is provided in Table 4.2.

Table 4.2 WFD water bodies in the River Wensum SSSI

Water body code (EA WB ID)	Water body name	Water body catchment area (ha)	SSSI River Unit
GB105034051000	Tud	7417	
GB105034051010	Penny Spot Beck	1629	
GB105034051020	Wendling Beck	7012	
GB105034051030	Blackwater Drain	69	
GB105034051040	Blackwater Drain	592	
GB105034051050	Blackwater	3262	
GB105034051060	Tributary of Blackwater Drain	1367	
GB105034051070	Swannington Beck	2916	
GB105034051080	Tributary of Wensum	2502	
GB105034051090	Tributary of Blackwater Drain	1455	
GB105034051100	Wensum	2751	45
GB105034051110	Wensum	1110	45
GB105034051120	Blackwater Drain	3185	
GB105034051130	East Rudham Stream	2094	
GB105034051140	Tat	802	45, 46, 47
GB105034055850	Foulsham Tributary	3295	
GB105034055860	Little Ryburgh Tributary	1570	55
GB105034055870	Tat	4286	
GB105034055881	Wensum US Norwich	17730	47–55
GB105034055882	Wensum DS Norwich	3449	
	Total	**68493**	

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.6: River Wensum catchment geology



Lakes
Main Rivers
Watercourses

Superficial Geology

Clay, Silt and Sand
Diamicton
Sand and Gravel

Bedrock Geology

Neogene to Quaternary Rocks (Undifferentiated) – Gravel, Sand, Silt and Clay
White Chalk Subgroup - Chalk

0 2 4 6 km

Scale (at A4): 1:222,000

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

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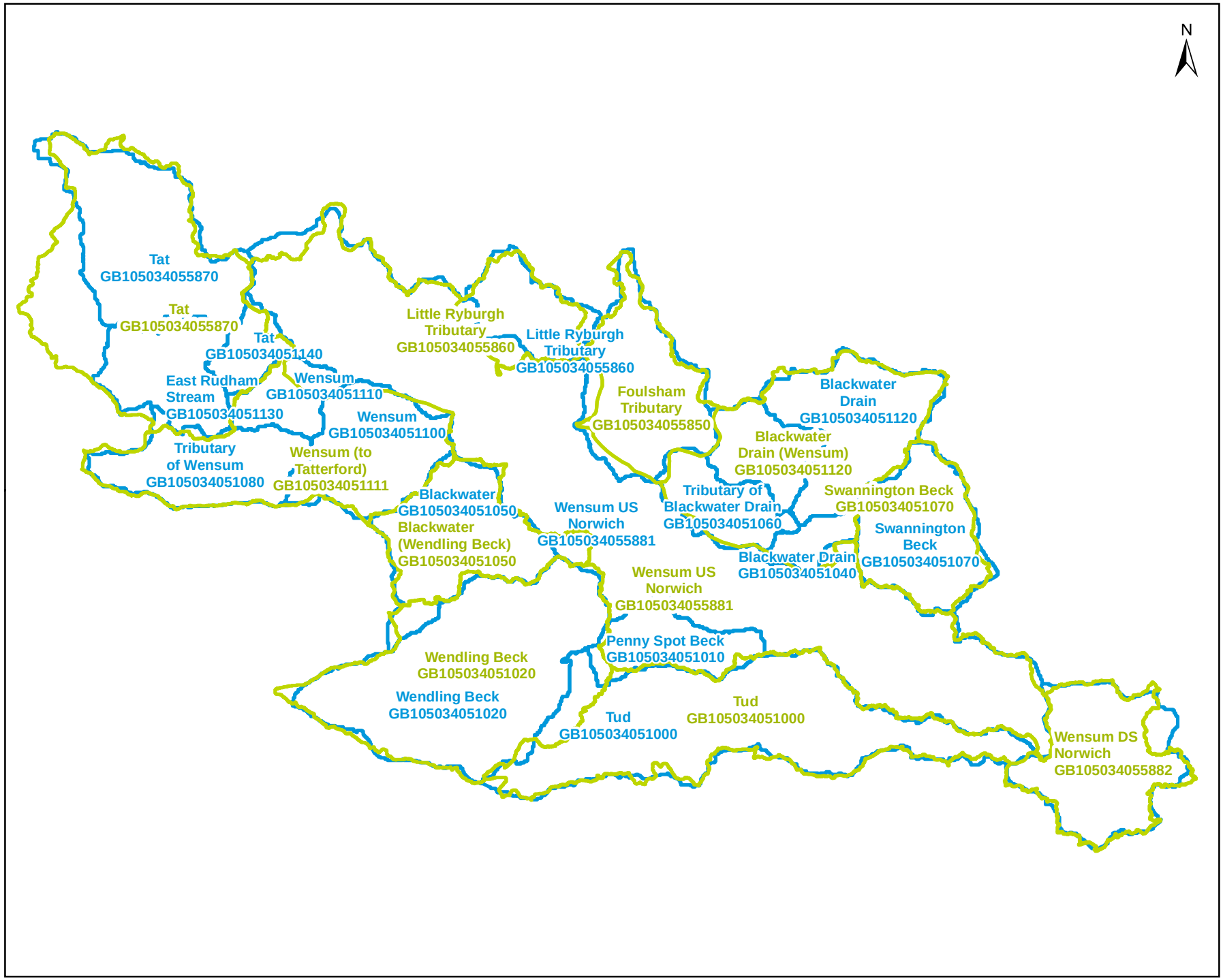
Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.9: RBMP cycle catchment changes



RBMP Cycle 2 WFD Water bodies

RBMP Cycle 1 WFD Water bodies

0 2 4 6 km

Scale (at A4): 1:222,000

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River Wensum SSSI

Figure 4.8: River Wensum SSSI Water Framework Directive water bodies

WFD Water bodies

0 2 4 6 km

Scale (at A4): 1:222,000

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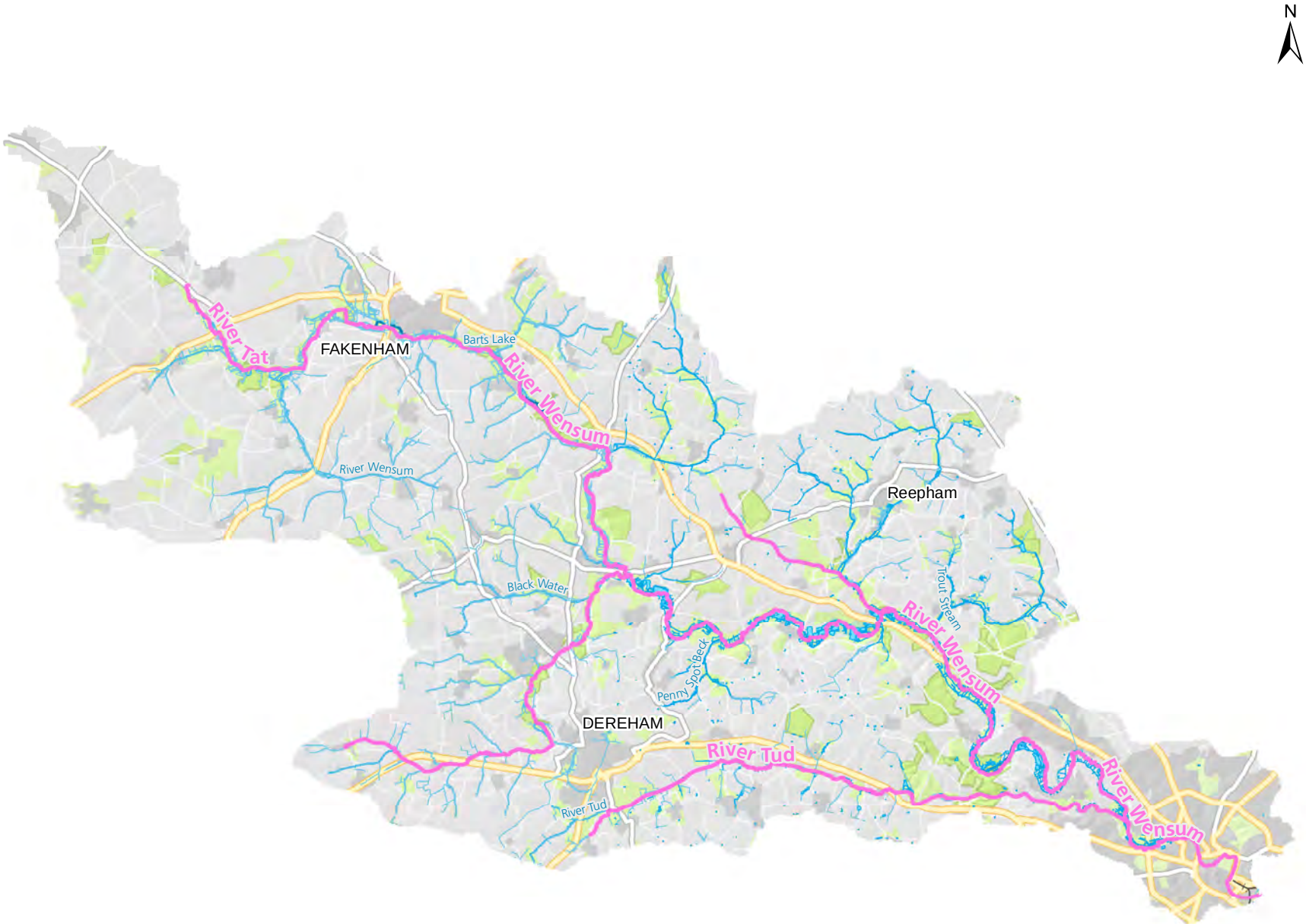
Figure 4.7: River Wensum SSSI Main Rivers



Main Rivers

Watercourses

Lakes

0 2 4 6 km

Scale (at A4): 1:222,000

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4.3.2. Hydrological modifications in the SSSI

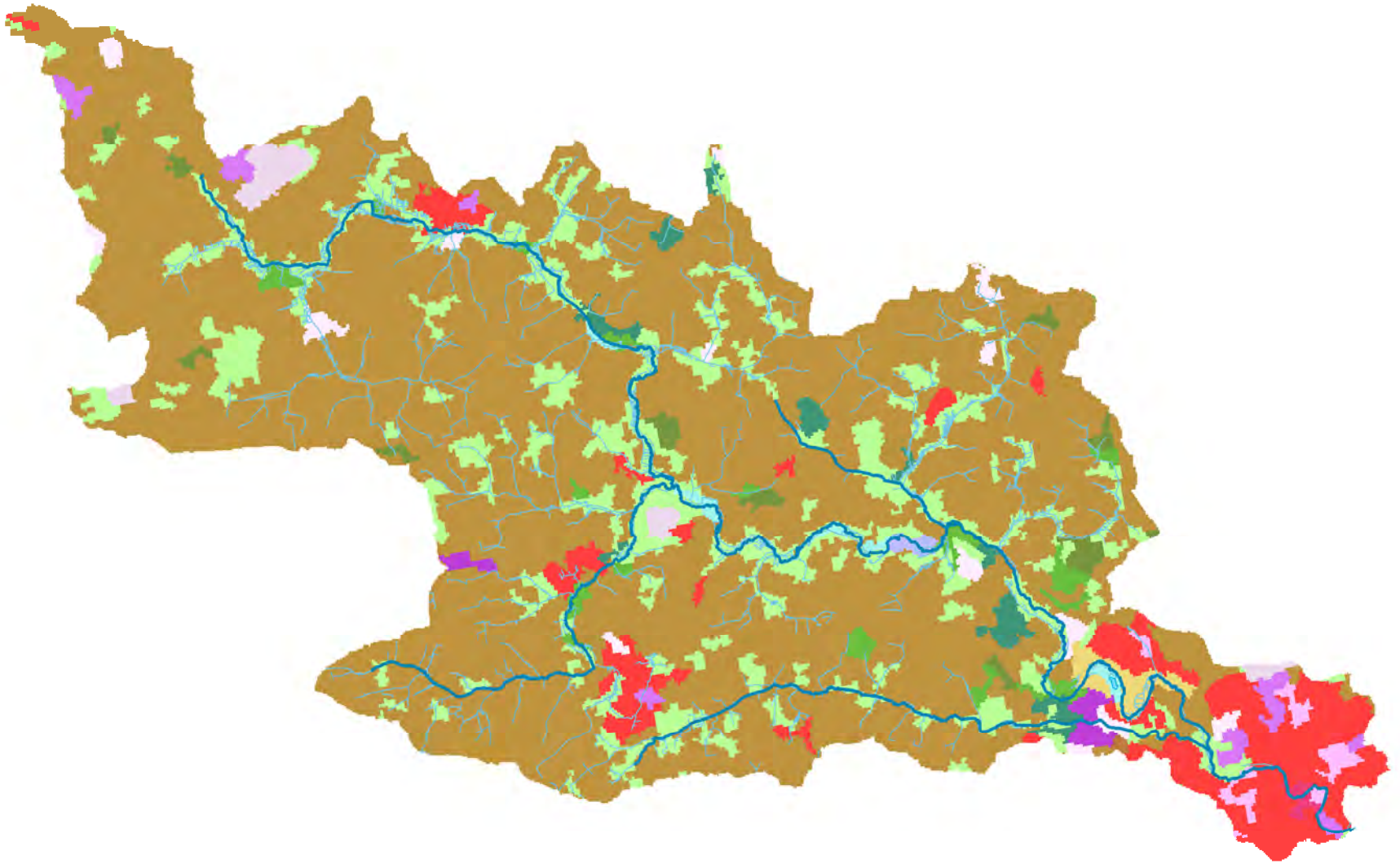
Despite the majority of the Wensum floodplain remaining relatively natural and managed for grazing, the drainage of the catchment has been substantially altered over time by channel simplification, floodplain drainage and the presence of mills and their associated structures. This has resulted in sections with slower flowing deeper water above the mills and shallow faster-flowing sections below them. In some reaches the river has been widened and lined with embankments to provide a higher flow to power the mills. This has resulted in the elevation of water levels in the river above the surrounding floodplain.

The floodplain mostly comprises managed grassland with areas of fen, wet grassland, wet woodland and reedbed and has been drained for farming in these areas by a series of Internal Drainage Board Main Drains running parallel to the river, which rejoin the main channel below each impoundment. The mill structures exert a disproportionate impact on the river, with over two thirds of its length impounded, so that in many cases the Wensum behaves more like a series of linear lakes than free-flowing river. A further complexity of impounded reaches is that it is no longer possible to drain the land directly into the river, and a secondary drainage system has been developed on the floodplain on either side of the river, draining back into the river immediately below the mill structures.

Land drainage and flood defence in larger drainage systems are managed by the Norfolk Rivers Internal Drainage Board (IDB), whilst individual landowners manage smaller drains. The Environment Agency is the Operating Authority for the River Tat and the River Wensum below its confluence with the Tat.

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.11: CORINE Land Cover Map



N

Main Rivers
Watercourses

CORINE Land Cover 2006

- 111 - Continuous urban fabris
- 112 - Discontinuous urban fabric
- 121 - Industrial or commercial units
- 124 - Airports
- 131 - Mineral extraction sites
- 132 - Dump sites
- 141 - Green urban areas
- 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
- 322 - Moors and heathland
- 324 - Transitional woodland-shrub
- 411 - Inland marshes
- 512 - Water bodies

0 2 4 6 km

Scale (at A4): 1:222,000

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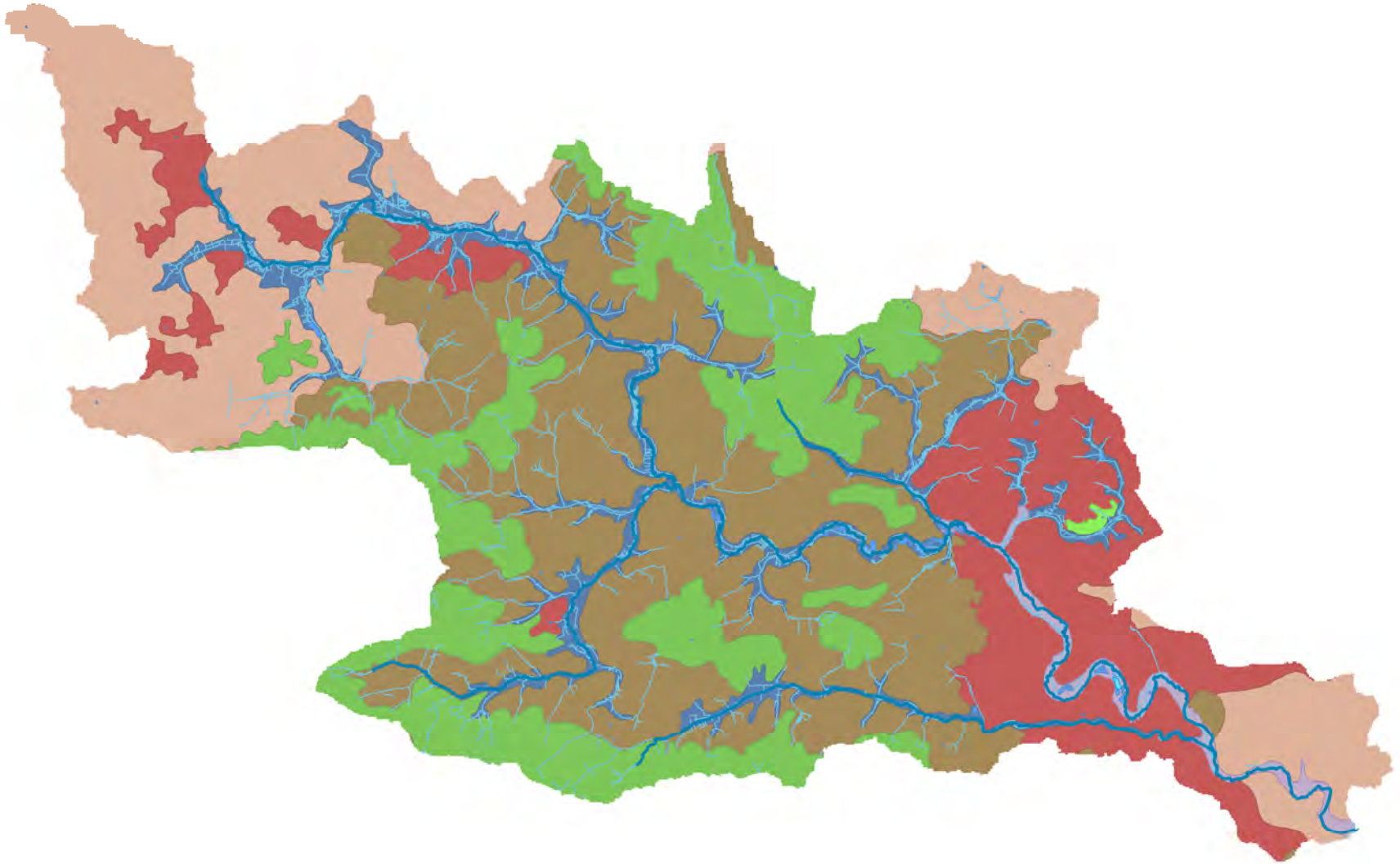
River Wensum SSSI

Figure 4.10: Wensum SSSI catchment soils map



Main Rivers
Watercourses

National Soil Map

Soil Condition

- Fen peat soils
- Freely draining slightly acid loamy soils
- Freely draining slightly acid sandy soils
- Loamy and sandy soils with naturally high groundwater and a peaty surface
- Naturally wet very acid sandy and loamy soils
- Shallow lime-rich soils over chalk or limestone
- Slightly acid loamy and clayey soils with impeded drainage
- Slowly permeable seasonally wet acid loamy and clayey soils
- Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
- Sea
- Water

0 2 4 6 km

Scale (at A4): 1:222,000

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Table 4.3 CORINE land use statistics for the River Wensum SSSI catchment

CORINE ID & Description	Area in catchment (ha)	% of catchment area
Continuous urban fabric	104	0%
Discontinuous urban fabric	4,363	6%
Industrial or commercial units	602	1%
Airports	626	1%
Mineral extraction sites	305	0%
Dump sites	29	0%
Green urban areas	377	1%
Sport and leisure facilities	806	1%
Non-irrigated arable land	48,527	71%
Pastures	9,552	14%
Land principally occupied by agriculture	412	1%
Broad-leaved forest	976	1%
Coniferous forest	676	1%
Mixed forest	791	1%
Inland marshes	106	0%
Water bodies	240	0%
TOTALS	**68,493**	**100%**

Agricultural Land Classification (ALC) data, shows that the majority of the catchment is classified Grade 3, which is “good or moderate” quality, with some areas of Grade 2, “very good” quality. The floodplains of the major river valleys are generally classified as Grade 4 (poor). The Defra data also provides a breakdown of the livestock category, and these data are given in Table 4.5. Poultry are the most numerous animal farmed within the catchment, although the number of poultry farms is low at 21 (Table 4.4) and this is because each farm typically has more animals compared with for example a dairy farm. Similarly with pig farming – the number of farms is reasonably low (17) but the number of animals is high. One point to note with both these categories, is the extent to which data is suppressed in the dataset, which could indicate an underestimate of the number of farms of that type within the water body (if there are fewer than five holdings within a water body, Defra suppresses the data for confidentiality reasons).

The agricultural practices within the catchment have been further examined using Agricultural Census data supplied by Defra. This sets out the farming practices in operation within any water body catchment and is a useful indication of the various activities, and therefore risks, arising from farming practices within the SSSI catchment. At the catchment scale, arable farming dominates, with general cropping comprising 36% of the farms and cereal farming comprising 29% of farms. The remaining farms are used for livestock (with a small percentage being mixed livestock and arable). These data are presented in Figure 4.12.

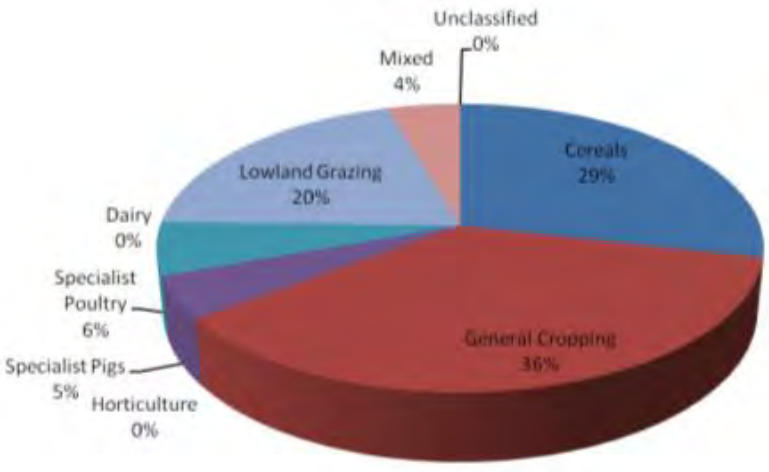


Figure 4.12 Wensum catchment-scale farming practices

Percentage values present the number of farms in the farm category as a proportion of the total farms in the catchment.

The agricultural census data has been further broken down at the water body scale and is presented in Figure 4.14, as well as in Table 4.4. Some data have been suppressed in line with standard practice for

where there are fewer than five holdings within a water body catchment (the extent of suppression is indicated in Table 4.4).

The Defra data also provides a breakdown of the livestock category, and these data are given in

Table 4.5. Poultry are the most numerous animal farmed within the catchment, although the number of poultry farms is low at 21 (Table 4.4) and this is because each farm typically has more animals compared with for example a dairy farm. Similarly with pig farming – the number of farms is reasonably low (17) but the number of animals is high. One point to note with both these categories, is the extent to which data is suppressed in the dataset, which could indicate an underestimate of the number of farms of that type within the water body (as mentioned previously, if there are fewer than five holdings within a water body, the data is suppressed for confidentiality reasons).

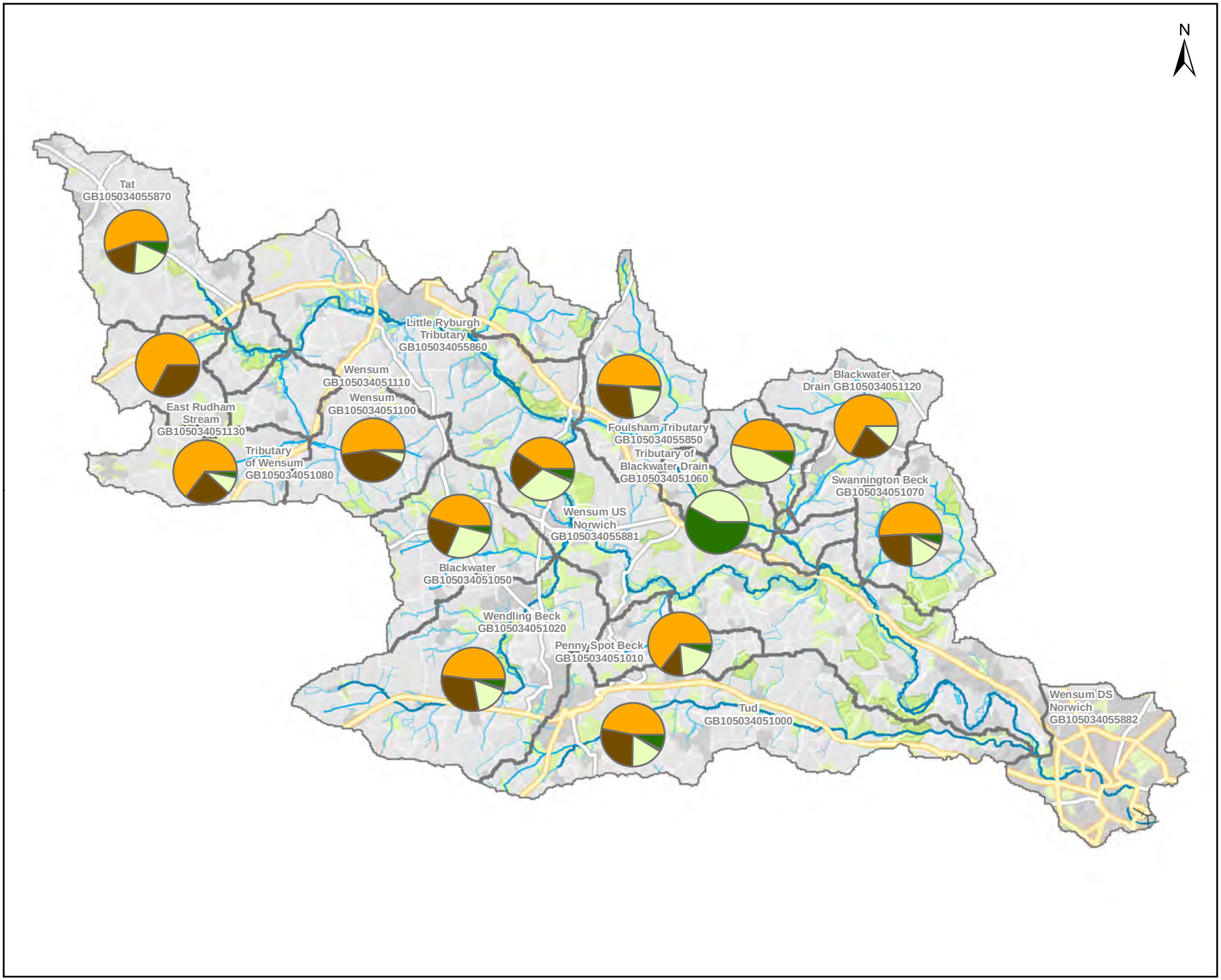
4.3.3. Current extent of land management schemes

Data on the extent of land management within the SSSI catchment has been obtained from Natural England (data request dated May 2013) and is presented in

Table 4.6. To reflect the rural nature of the catchment, the majority of the land area, outside of the urban areas, is under Natural England's Environmental Stewardship Schemes. Most of the catchment is covered by Entry Level Stewardship (ELS), with some areas also being managed through Higher Level Stewardship (HLS). There are also some minor areas under Organic Entry Level Stewardship schemes (OELS) and Organic Higher Level Stewardship (OHLS). The entire river channel is also in an ESA (Environmentally Sensitive Area).

Table 4.6 shows of each stewardship scheme, per water body.

The catchment has seen little land use change, the historical maps (Figure 4.16) shows it has remained predominantly arable with the biggest change being a growth in urban areas including Norwich, Dereham and Fakenham.



Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

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 2 4 6 km

Scale (at A4): 1:222,000

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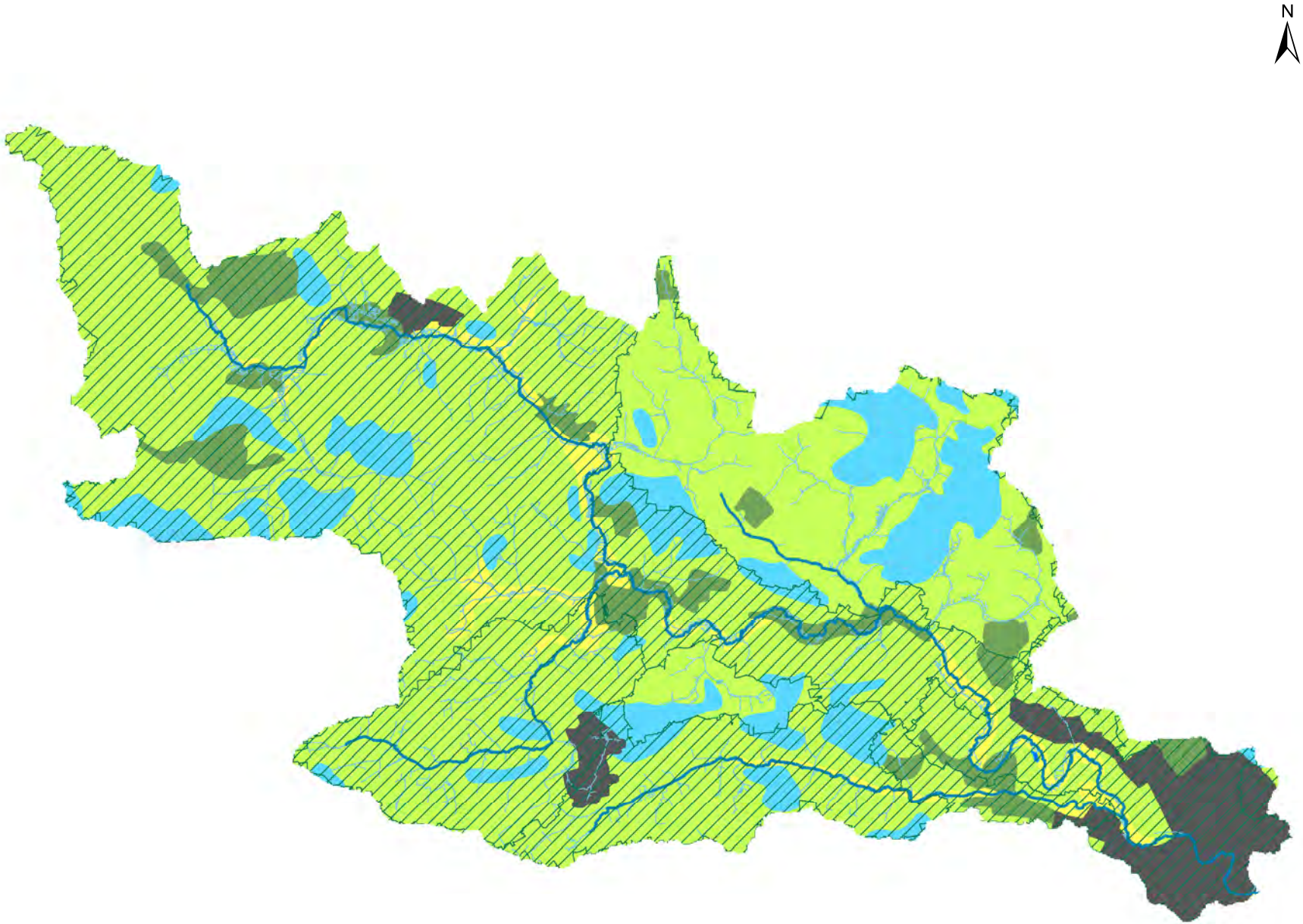
Figure 4.13: Agricultural Land Classification



Nitrate Vulnerable Zones © Environment Agency
Lakes
Main Rivers
Watercourses

Agricultural Land Classification

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

0 2 4 6 km

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Table 4.4 Farming practices in the River Wensum SSSI – individual water body catchments

Water body ID and name	GB1050340 51000	GB1050340 51020	GB105034051 050	GB105034051 070	GB105034051 111	GB105034051 120	GB1050340 55850	GB105034055 860	GB105034 055870	GB1050340 55882	GB1050340 55881	
Robust Farm Type	**Tud**	**Wendling Beck**	**Blackwater (Wendling Beck)**	**Swannington Beck**	**Wensum (to Tatterford)**	**Blackwater Drain (Wensum)**	**Foulsham Tributary**	**Little Ryburgh Tributary**	**Tat**	**Wensum DS Norwich**	**Wensum US Norwich**	**TOTALS**
Cereals	21	17	11	0	5	9	8	#	0	0	30	**101**
General Cropping	20	16	7	10	7	14	0	0	16	0	38	**128**
Horticulture	0	0	0	#	0	0	#	#	#	#	0	**0**
Specialist Pigs	5	5	0	#	0	0	0	#	7	#	0	**17**
Specialist Poultry	6	0	0	0	7	0	0	#	#	0	8	**21**
Dairy	#	0	0	#	#	#	#	#	#	#	0	**0**
Lowland Grazing	14	7	0	7	0	8	8	0	0	#	27	**71**
Mixed	8	0	0	0	0	0	0	0	0	#	8	**16**
Unclassified	0	#	#	#	#	#	0	#	#	#	0	**0**
Total Farms	***74***	***45***	***18***	***17***	***19***	***31***	***16***	***0***	***23***	***0***	***111***	***354***

 # 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

Table 4.5 Livestock numbers within the River Wensum SSSI catchment

Water body ID and name	GB105034 051000	GB1050340 51020	GB105034051 050	GB105034051 070	GB105034051 111	GB105034051 120	GB1050340 55850	GB105034055 860	GB105034 055870	GB1050340 55882	GB1050340 55881	
Robust Farm Type	**Tud**	**Wendling Beck**	**Blackwater (Wendling Beck)**	**Swannington Beck**	**Wensum (to Tatterford)**	**Blackwater Drain (Wensum)**	**Foulsham Tributary**	**Little Ryburgh Tributary**	**Tat**	**Wensum DS Norwich**	**Wensum US Norwich**	**TOTALS**
Cattle	1,685	935	979	456	#	971	284	#	#	2,667	0	7,976
Pigs	7,250	5,398	#	0	8,787	#	8,794	0	24,226	#	0	54,455
Sheep	370	1,657	#	1,307	2,007	#	#	#	#	2,094	0	7,434
Total Poultry*	123,459	63,158	199,866	#	1,068,305	#	88,215	0	165	482,869	#	2,026,037

 # 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

Table 4.6 Land management coverage in the River Wensum catchment

Waterbody name	Waterbody name	ELS (ha)	HLS (ha)	ELS + HLS (ha)	OEL + HLS (ha)	OEL (ha)	None (ha)
Blackwater (Wendling Beck)	GB105034051020	1217	9	1111			823
Blackwater Drain (Wensum)	GB105034051120	2626	25	1339	398	167	1952
Foulsham Tributary	GB105034055850	908		887	122		1050
Little Ryburgh Tributary	GB105034055860	745	6	404	23	167	467
Swannington Beck	GB105034051070	1006	21	220			1650
Tat	GB105034055870	3798	55	1389	1124	285	2139
Tud	GB105034051000	2052	9	1641		31	3283
Wendling Beck	GB105034051020	3581	16	1784			2560
Wensum (to Tatterford)	GB105034051111	4396		741			825
Wensum DS Norwich	GB105034055882	28	60	56			3106
Wensum US Norwich	GB105034055881	6707	119	5102	302	11	6683
Grand Total		**27065**	**320**	**14676**	**1969**	**661**	**24540**

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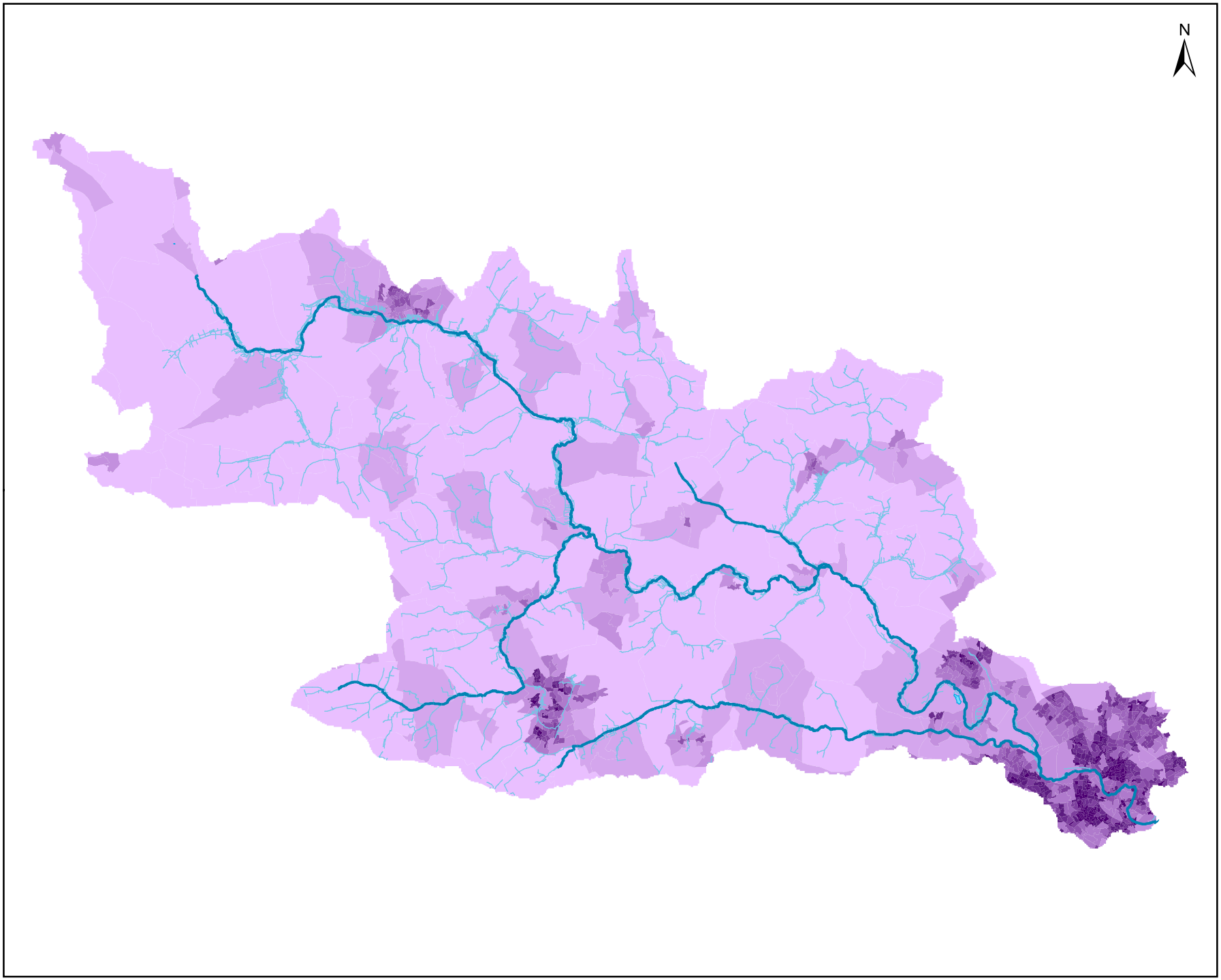
River Wensum SSSI

Figure 4.17 River Wensum Census Population



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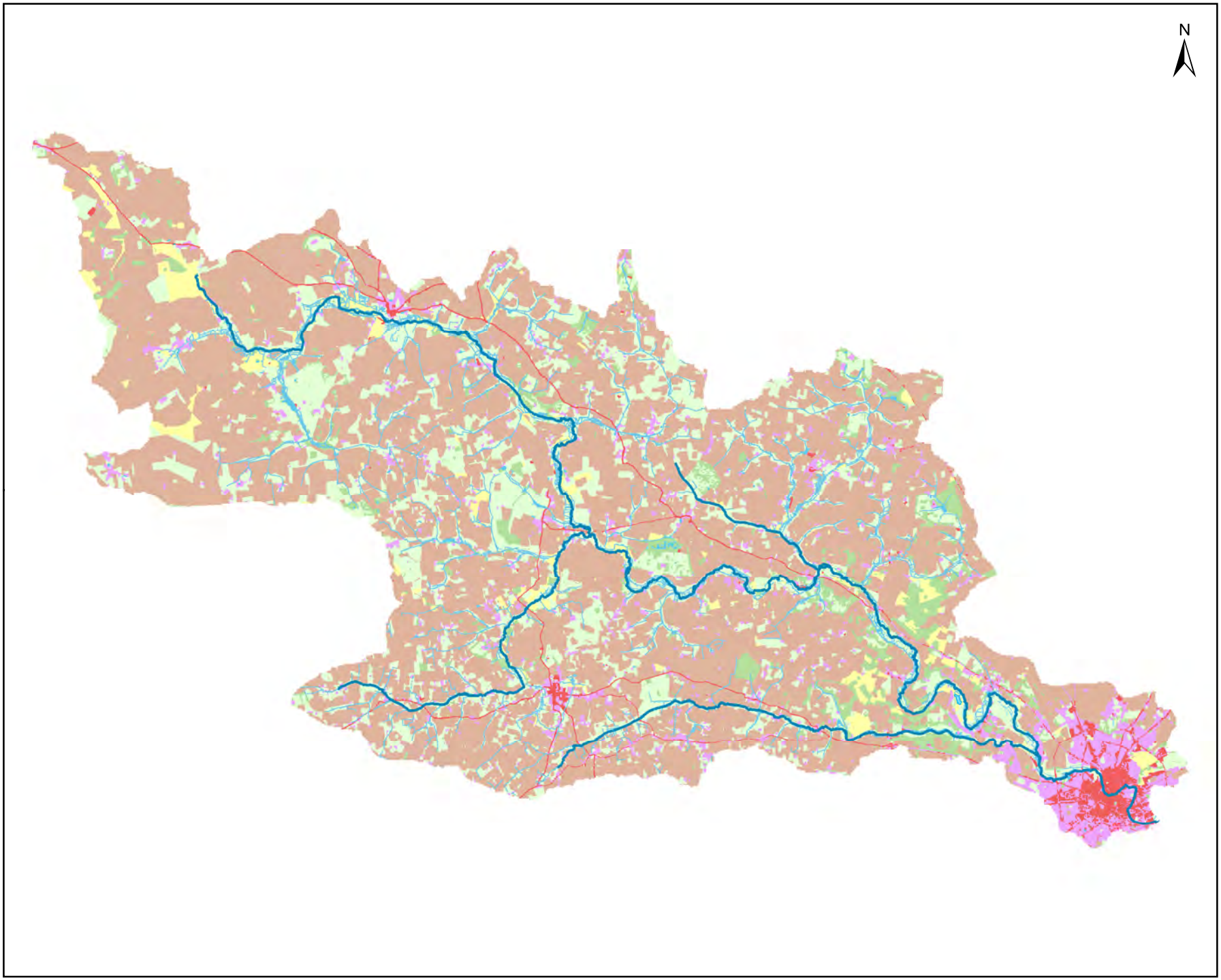

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.16: Historic land cover map for the River Wensum catchment

Main Rivers

Watercourses

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

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

0 2 4 6 km

Scale (at A4): 1:222,000

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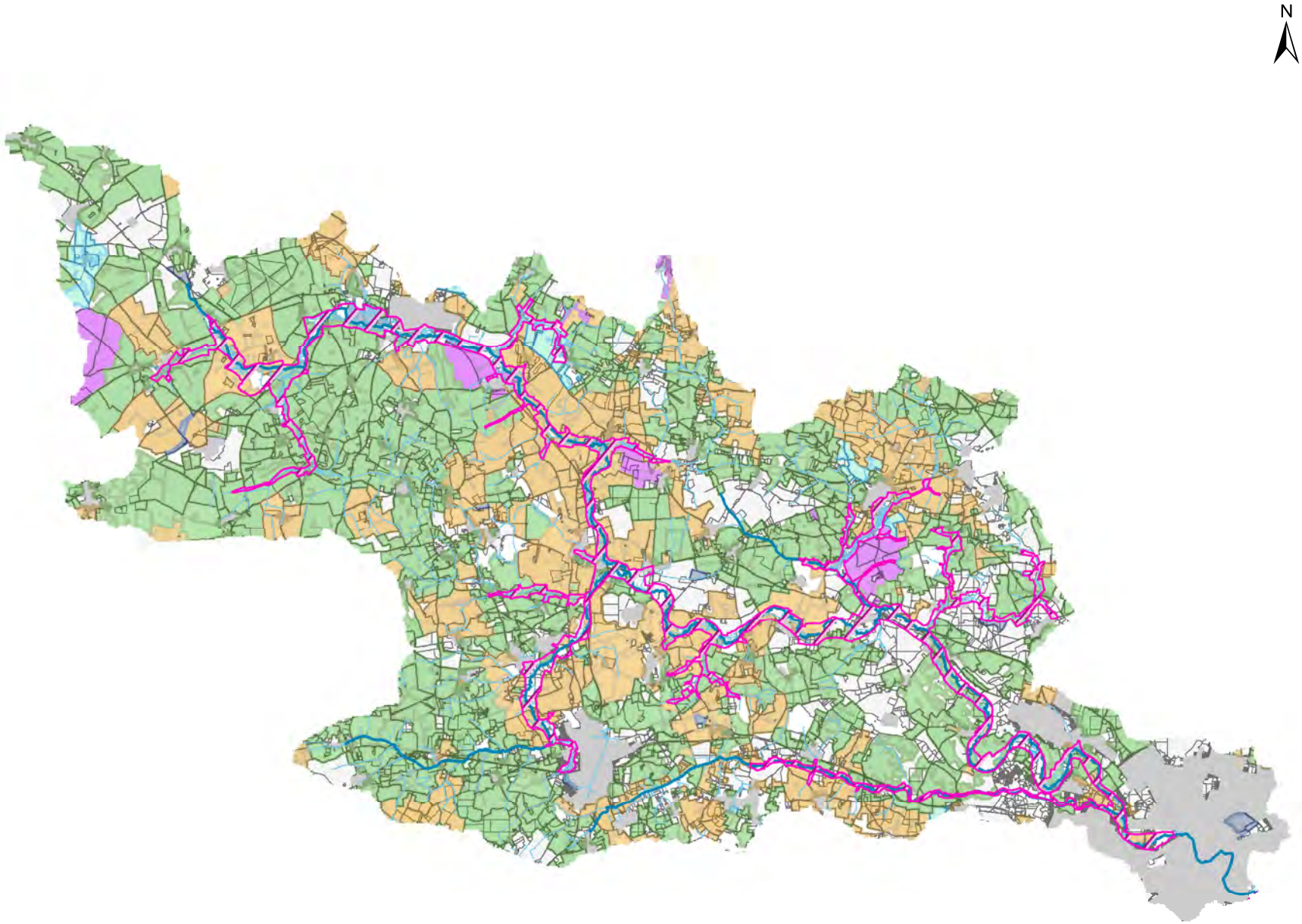
Figure 4.15: Land Management in the River Wensum catchment



- Environmentally Sensitive Areas (ESA)
- Lakes
- Main Rivers
- Watercourses

Stewardships

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

0 2 4 6 km

Scale (at A4): 1:222,000

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4.4. Sources of sewage

4.4.1. Catchment population

Population pressures in the catchment arise from the discharge of effluent from the existing built environment into the Wensum and its tributaries. The total catchment population is estimated to be around 211,306 people based on data from 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. Of this total, 133,945 people live in Norwich and the surrounding towns at the bottom of the catchment. Other large towns within the catchment include Dereham, Fakenham and Reepham. Figure 4.17 and Figure 4.18 reflect this spatial pattern of population density within the catchment and the figures are given in Table 4.7.

Table 4.7 River Wensum SSSI catchment census summary

Water body ID	Name	Persons always present	% of total catchment
GB105034051000	Tud	21,152	10.0%
GB105034051010	Penny Spot Beck	997	0.5%
GB105034051020	Wendling Beck	15,919	7.5%
GB105034051030	Blackwater Drain	15	0.0%
GB105034051040	Blackwater Drain	260	0.1%
GB105034051050	Blackwater	1,310	0.6%
GB105034051060	Tributary of Blackwater Drain	796	0.4%
GB105034051070	Swannington Beck	1,447	0.7%
GB105034051080	Tributary of Wensum	1,064	0.5%
GB105034051090	Tributary of Blackwater Drain	690	0.3%
GB105034051100	Wensum	1,188	0.6%
GB105034051110	Wensum	304	0.1%
GB105034051120	Blackwater Drain	3,490	1.7%
GB105034051130	East Rudham Stream	522	0.2%
GB105034051140	Tat	264	0.1%
GB105034055850	Foulsham Tributary	1,759	0.8%
GB105034055860	Little Ryburgh Tributary	501	0.2%
GB105034055870	Tat	1,512	0.7%
GB105034055881	Wensum US Norwich	34,991	16.6%
GB105034055882	Wensum DS Norwich	123,126	58.3%
Total	**-**	**211,306**	**100%**

4.4.2. Consented Discharges

Treated sewage discharges were taken through to the stage 4 assessment under the Environment Agency's Review of Consents under Regulation 50 of the Conservation (Natural Habitats &c.) Regulations 1994. The objective of this Review was to confirm whether adverse effect on integrity could be attributed to any of the licences, either 'alone' or 'in combination'. Several of these consents have been modified to reduce the phosphate concentrations through the Review of Consents process. Phosphate stripping was put in place for Fakenham and Dereham sewage treatment works during AMP3, and further phosphate stripping is being instigated under AMP5 and delivered by 2014.

In addition, a number of industrial processes have required Environmental Permitting, and in order to satisfy the requirements of this permitting system, businesses have been required to put in place phosphate stripping.

4.4.3. Sewage treatment Works

There are 20 waste water treatment works (WwTWs) within the catchment with a total population equivalent of 57,089 people (see Table 4.8). Norwich and surrounding towns are served by Whitlingham STW which lies outside of the catchment, downstream of the confluence with the River Yare.

Table 4.8 Consented sewage treatment works discharges within the River Wensum SSSI catchment

Name	EQS	Population equivalent
BEESTON–B	120	290
BRISLEY H	120	18
Bylaugh STW	120	3,489
DEREHAM STW	120	21,333
East Rudham STW	120	561
ELSING–CH	120	23
ELSING–HE	120	23
FAKENHAM STW	120	16,069
Foulsham STW	120	1,275
GATELEY–C	120	11
HOCKERING	120	620
HORNINGTO	120	12
Mattishall STW	120	3,487
North Elmham STW	120	1,322
Reepham(Norfolk) STW	120	6,391
Sculthorpe STW	120	1,194
SOUTH RAY	120	109
STIBBARD–	120	216
Swanton Morley STW	120	612
WENDLING–	120	34
Total		**57,089**

4.4.4. Septic tanks and soakaways

Other sources of sewage effluent would be small package sewage treatment plants and any illegally connected septic tanks. The impact of discharges from septic tanks is not known and a study should be undertaken to confirm the number of properties which are not connected to mains sewers, and an estimate of the non-consented population across the whole catchment.

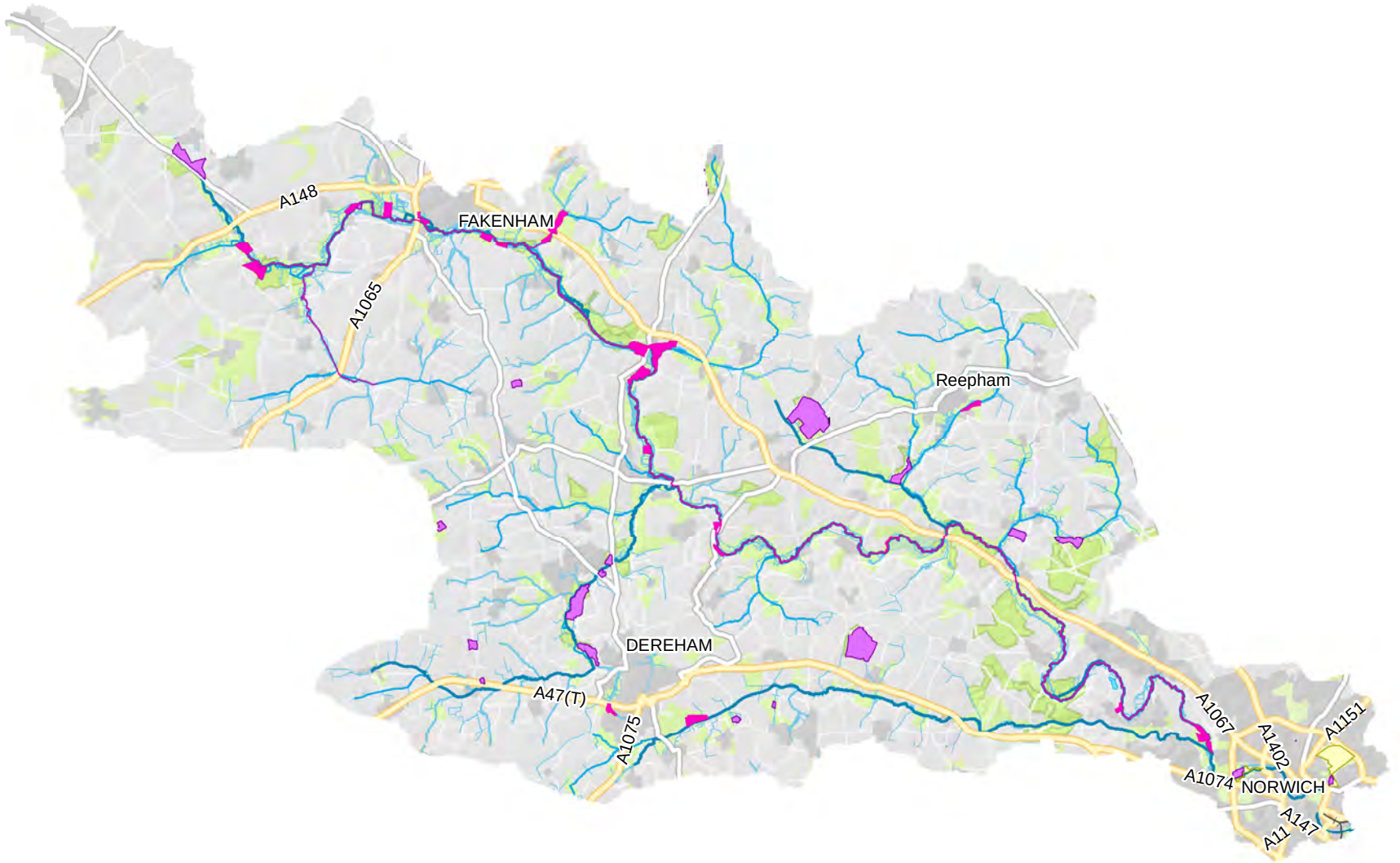
It is estimated that there are approximately 1,863 properties within the catchment that are not connected to mains sewerage (Table 4.9) and are instead served by septic tanks or small package treatment works. Assuming an average occupancy of 2.3 this is equal to a population of 4,285. These estimates 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 4.18 shows the location of WwTWs and possible septic tank locations within the catchment.

Table 4.9 Estimate of population not connected to mains sewerage within the SSSI catchment

Waterbody ID	Name	Properties not on mains sewerage	Population Equivalent	Population Equivalent %
GB105034051000	Tud	407	936	22%
GB105034051010	Penny Spot Beck	57	131	3%
GB105034051020	Wendling Beck	237	545	13%
GB105034051030	Blackwater Drain	0	0	0%
GB105034051040	Blackwater Drain	45	104	2%
GB105034051050	Blackwater	49	113	3%
GB105034051060	Tributary of Blackwater Drain	17	39	1%
GB105034051070	Swannington Beck	152	350	8%
GB105034051080	Tributary of Wensum	26	60	1%
GB105034051090	Tributary of Blackwater Drain	90	207	5%
GB105034051100	Wensum	45	104	2%
GB105034051110	Wensum	19	44	1%
GB105034051120	Blackwater Drain	70	161	4%
GB105034051130	East Rudham Stream	15	35	1%
GB105034051140	Tat	14	32	1%
GB105034055850	Foulsham Tributary	90	207	5%
GB105034055860	Little Ryburgh Tributary	28	64	2%
GB105034055870	Tat	30	69	2%
GB105034055881	Wensum US Norwich	472	1086	25%
GB105034055882	Wensum DS Norwich	0	0	0%
Total		**1863**	**4285**	**100%**

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.19: River Wensum catchment environmental designations



SAC
SSSI
NNR
LNR

0 2 4 6 km

Scale (at A4): 1:222,000

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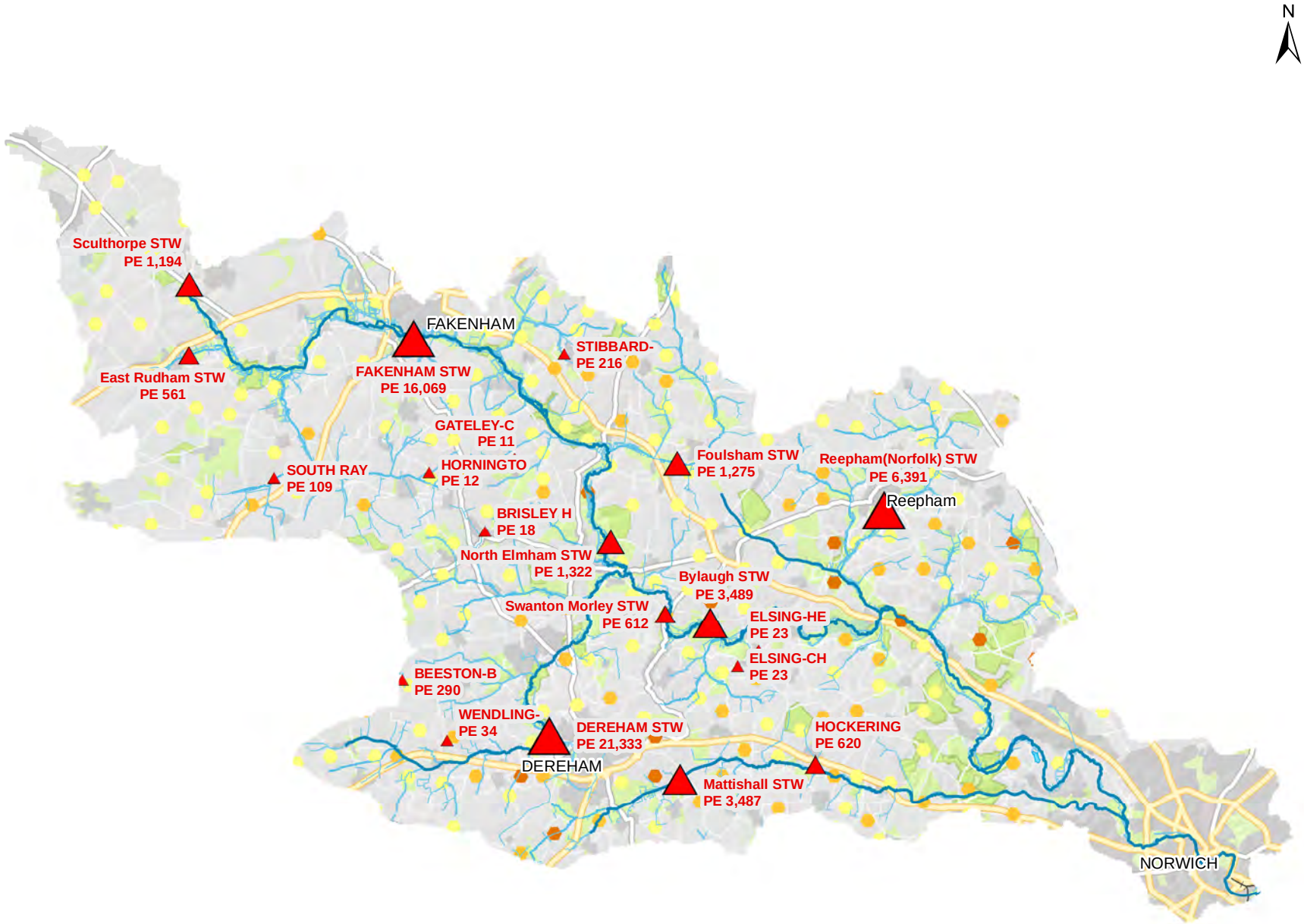
River Wensum SSSI

Figure 4.18: Population Pressures



Wastewater Treatment Works

Population Equivalent

- 11 - 500
- 501 - 1000
- 1001 - 2500
- 2501 - 5000
- 5001 - 21333

- Lakes
- Main Rivers
- Watercourses

Possible septic tank locations and numbers (Nov 2009)

- 1 - 10
- 11 - 30
- 31 - 80

0 2 4 6 km

Scale (at A4): 1:222,000

Reference: 5120447	Drawn: JAM 09/05/2014
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4.5. Conservation and ecology

4.5.1. River Wensum SSSI

Both the River Wensum and its wider catchment are considered high value in terms of conservation and ecology. The main River Wensum is designated as a Special Area of Conservation (SAC) in addition to being a Site of Special Scientific Interest (SSSI). Furthermore, the wider River Wensum catchment that serves the SSSI River has a total of 2 SACs, 23 SSSIs, 2 National Nature Reserves (NNR) and 2 Local Nature Reserves (LNR). These sites are presented in Figure 4.19 . In summary however, the Wensum has been selected as a SSSI as one of a national series of rivers of special interest as an example of an enriched, calcareous lowland river. With a total of over 100 species of plants, a rich invertebrate fauna and a relatively natural corridor, it is probably the best whole river example of its type in terms of nature conservation, although short stretches of other similar rivers may show a slightly greater diversity of species.

Full details of the designated features are summarised in Natural England's conservation objectives and favourable condition tables for the SSSI (Natural England, September 2008). The full citation for the SSSI can be found in Appendix A and on the Natural England website[4].

SSSI units covered by this DWP Plan include units 45–55 (90.56 ha). This includes the River Wensum from its headwaters in Whissonsett (Unit 45) to Hellesdon Mill on the outskirts of Norwich (Unit 54), together with parts of two tributaries, the River Tat (Unit 46) and the Langor Drain (Unit 55). It does not include other major tributaries such as the Wendling Beck, however this Plan does, as it is part of the Wensum catchment.

Chalk rivers such as the River Wensum are characterised by a high base flow from underlying aquifers with very low nutrient levels and very low turbidity. Diffuse pollution impacts the site through changes to the chemical environment within the water, but also by increasing turbidity, deposition of silt and changes to the physical nature of substrates. There are a number of key species in the SSSI citation that are particularly susceptible to these impact pathways, for example:

- species that rely on exposed gravels for breeding and structural habitat (e.g. brown trout, chub, barbel, lesser-water parsnip *Berula erecta*, brook water-crowfoot *Ranunculus penicillatus*, *Amphinemura standfussi* (a stonefly) and white-clawed crayfish); and
- species that are particularly sensitive to changes in water quality (e.g. brown trout, bullhead, European eel, white-clawed crayfish, and brook water-crowfoot).

The Environment Agency WFD fish classification scheme identifies brown trout, lamprey and bullhead as species which have a low tolerance to environmental disturbance including diffuse pollution.

4.5.2. River Wensum SAC

The full extent of the River Wensum SSSI is also designated as an SAC (see Appendix B) on account of supporting a number of Habitats Directive Annex I habitats and Annex II species. The specific Conservation Objectives for the SAC features are to:

- maintain in favourable condition, the watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation[5]; and
- maintain in favourable condition, the habitats for the populations of[6]:
  - white-clawed crayfish (*Austropotamobius pallipes)*;
  - bullhead (*Cottus gobio*);
  - brook lamprey (*Lampetra planeri*); and
  - Desmoulin's whorl snail (*Vertigo moulinsiana*).

The reproductive cycles and habitat requirements of the SAC features make them particularly sensitive to sedimentation and water quality impacts. For example:

- bullhead require clean gravels for spawning and refuge;
- brook lamprey require a diverse range of substratum throughout their lifecycle;

4 See: http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1006328

5 Annex I habitat/Annex II species that is a primary reason for SAC designation

6 Annex II species present as a qualifying feature but not a primary reason for SAC designation.

- the *Ranunculion fluitantis/Callitricho-Batrachion* community requires clean gravels and can be displaced by negative indicators such as fennel pondweed *Potamogeton pectinatus* with increasing nutrient inputs;
- white-clawed crayfish require well oxygenated water and are sensitive to deterioration in water quality; and
- Desmoulin's whorl snail are sensitive to eutrophication both directly through intolerance of poor water quality, and indirectly as it can affect the community structure of riparian habitats on which they depend.

4.6. Environmental targets for favourable condition

4.6.1. Overall SSSI condition assessment

The overall condition assessment results[7] are provided in Figure 4.20. The catchment consists of 20 WFD water bodies, listed previously in Table 4.2 alongside the SSSI River units to which they correspond. The River Wensum SSSI covers an area of 309 ha, broken down into 55 units of which 6 are considered to be in Favourable Condition; 37 have been assessed as Unfavourable Recovering; and 12 have been assigned as Unfavourable No Change.

Natural England assessed the condition of SSSI unit 45 as unfavourable recovering in February 2013. All other SSSI river units (units 46–55) are in unfavourable condition, and have an adverse condition reason of Water Pollution – Agriculture/Run-Off.

4.6.2. What attributes are contributing to the latest condition assessment?

Condition assessment tables for the individual SSSI River units included in this plan are summarised in Table 4.10. Table 4.10 should be read in combination with Figure 4.20, which shows the spatial location of the SSSI units. Although the condition assessments predate the new guidance (and therefore the use of specific biotic metrics in the assessment), these have been included to help provide a baseline for the assessment of current pressures within the River Wensum. All units fail to achieve favourable condition as a result of a diverse range of pressures including water quality, substrate, channel morphology, macrophyte community and alien species. Those attributes relating to water quality and sedimentation specifically (those directly affected by diffuse water pollution) are characterised and explored in greater depth in Section 6.

7 Information on how favourable condition is assessed can be found here: http://jncc.defra.gov.uk/pdf/CSM_rivers_jan_14.pdf

Table 4.10 Condition Assessment attributes for river SSSI units on the River Wensum SSSI/SAC (from River Wensum SSSI Unit Condition Assessments, Natural England (2010)

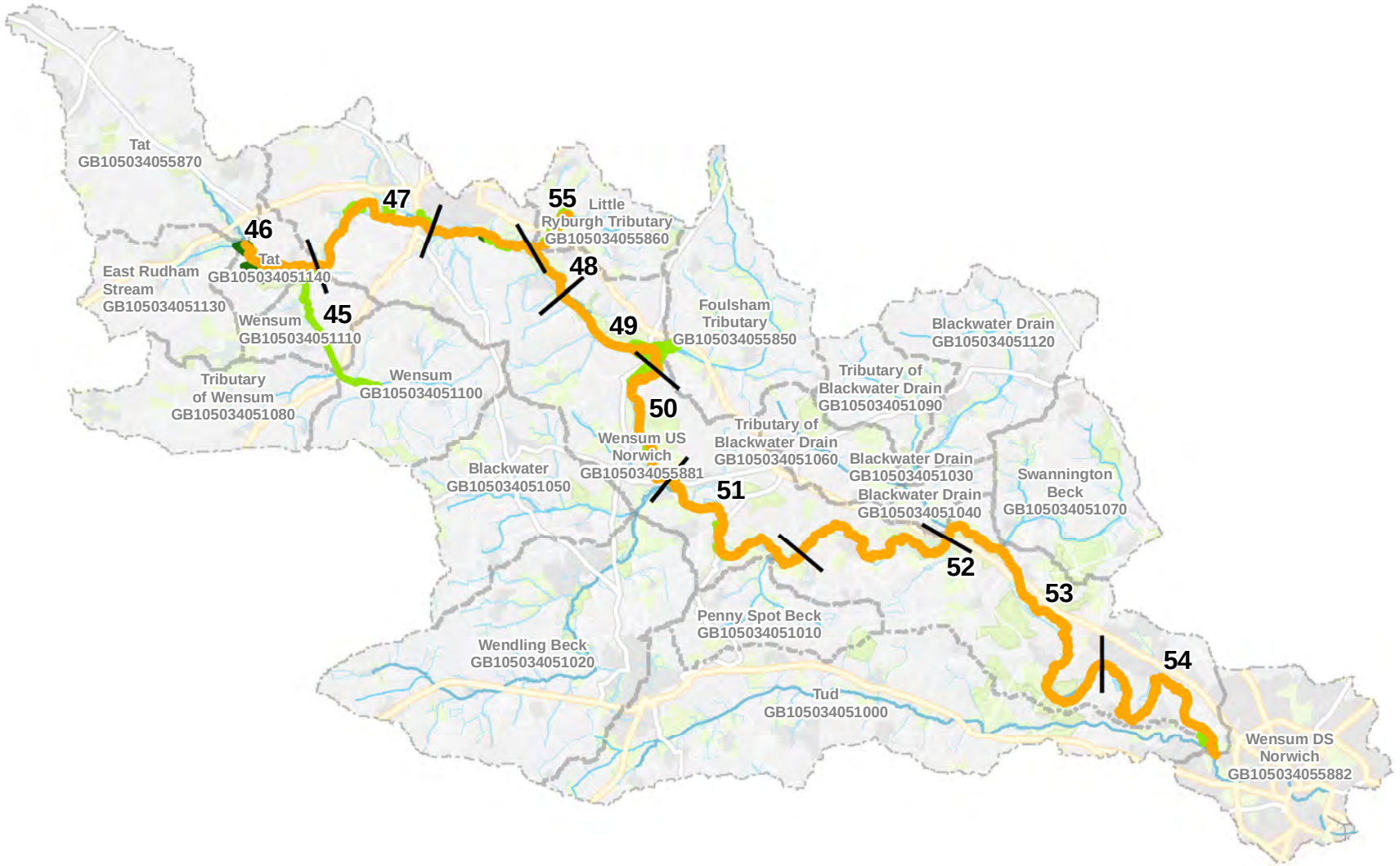
Note: with the exception of Unit 55, SSSI Units move downstream with increasing Unit number. Unit 55 is a small

	SSSI Unit										
Attribute	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**
Overall Status	×	×	×	×	×	×	×	×	×	×	×
Habitat Extent (no loss)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Habitat Functioning – water flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Habitat Functioning – water quality (general assessments biological GQA class)	*n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Habitat Functioning – water quality (general assessments chemical GQA class)	*n/a*	×	×	×	×	×	×	×	✓	×	*n/a*
Habitat Functioning – water quality (general assessments un-ionised ammonia)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Habitat Functioning – water quality *(suspended solids)*	×	×	×	×	×	×	×	×	×	×	✓
Habitat Functioning – water quality *(Total Reactive Phosphorus)*	×	×	×	×	×	×	×	×	×	×	×
Habitat Structure– substrate *(siltation)*	×	✓	×	×	×	×	×	×	×	×	×
Habitat Structure– channel and banks *(channel form)*	×	✓	✓	✓	*n/a*	✓	✓	*n/a*	✓	×	×
Habitat Structure– channel and banks *(bank and riparian zone vegetation)*	✓	✓	×	×	×	×	×	✓	×	×	✓
Plant Community –species composition and abundance	×	×	×	×	×	×	×	✓	×	✓	×
Plant Community –reproduction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Plant Community Negative Indicators– native species	✓	✓	×	×	✓	×	✓	×	×	×	✓
Negative Indicators– alien/introduced species	✓	×	×	✓	✓	✓	×	×	×	×	×
Negative Indicators– fish introductions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Negative Indicators– in-stream barriers	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
	SAC Species Records (from Condition Assessment Tables)										
White-clawed crayfish	?	*p*	*p*	*p*	*p*	*p*	?*	*p* *	*p* *	*p* *	?
Bullhead	*p*	?	?	?	?	?	?	?	?	?	?
Brook lamprey	?	?	?	?	?	?	?	?	?	?	?
Desmoulin's whorl snail	?	?	*p*	*p*	*p*	?	?	?	*p*	*p*	?

tributary, it's confluence with the Wensum is between Unit 48 and 49.
✓= favourable × = unfavourable n/a= not assessed/supporting data not available
*p= confirmed present ?=not confirmed *=signal crayfish recorded*

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 4.20: River Wensum SSSI unit condition



SSSI Unit Boundaries

SSSI Unit Condition

Favourable

0 2 4 6 km

Scale (at A4): 1:222,000

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5. What's the evidence?

5.1. Reasons cited for unfavourable condition

Natural England's ENSIS database attributes the unfavourable condition within the River Wensum SSSI to:

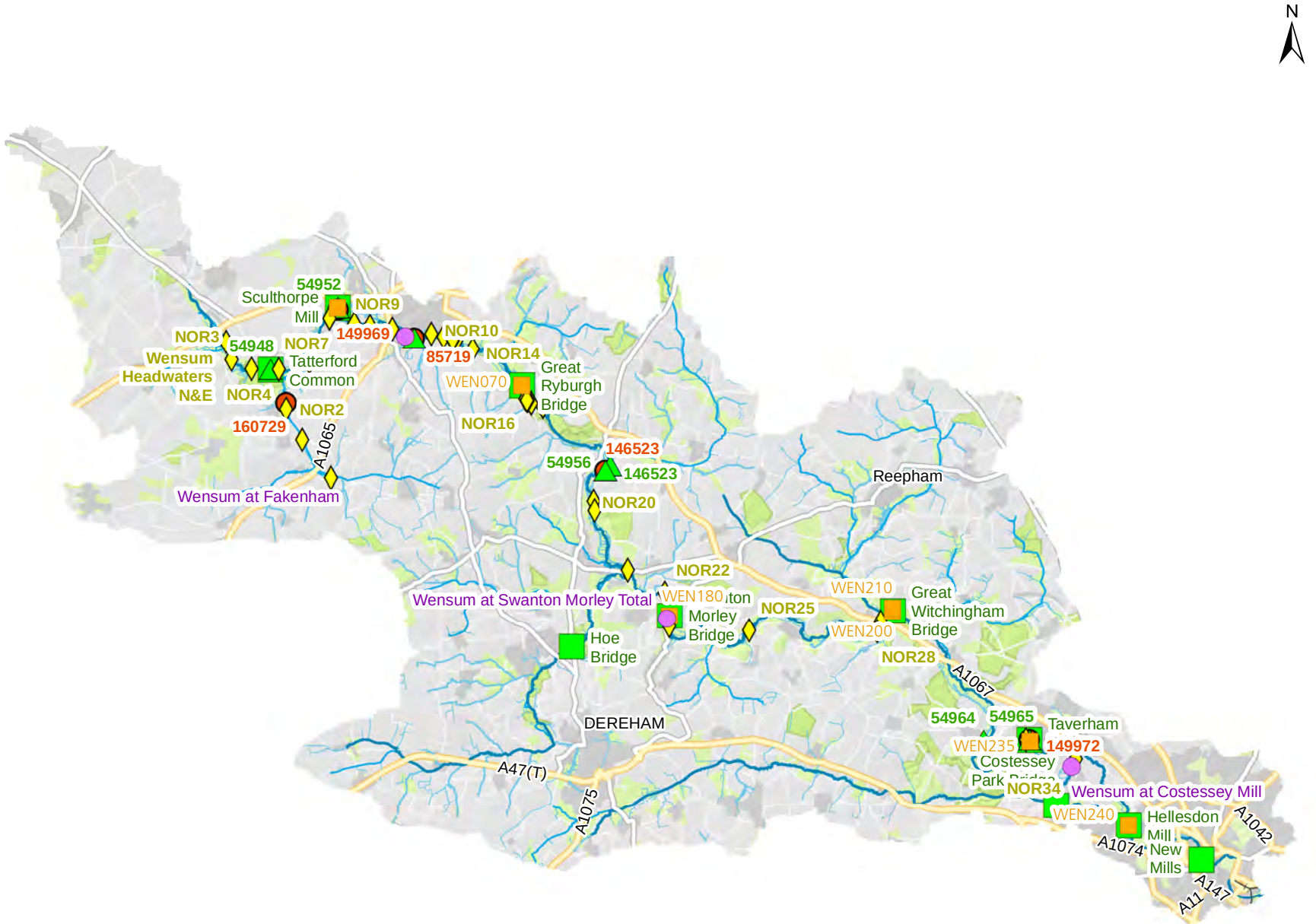
- Inappropriate Water Levels;
- Inappropriate Weirs and Dams and Other structures;
- Invasive Freshwater Species;
- Siltation;
- Water Abstraction;
- Water pollution (Agricultural run-off); and
- Water pollution (discharges).

5.2. SSSI water quality objective compliance

An assessment of compliance with SSSI water quality objectives has been undertaken as part of this study, using data sourced from the Environment Agency. The location of monitoring points from which data has been used is provided in Figure 5.1.

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 5.1: River Wensum SSSI monitoring locations



Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 5.1: River Wensum SSSI monitoring locations

- Flow Monitoring
- Water Quality Monitoring

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

- Fish Monitoring Sites
- Diatom Monitoring Sites
- Macrophyte Monitoring Sites
- Macroinvertebrate Monitoring Sites

0 2 4 6 km

Scale (at A4): 1:222,000

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5.2.1. Phosphate

Natural England has set Total Reactive Phosphorus (TRP) targets for the River Wensum. The current targets are shown in Table 5.1 below and vary in different reaches of the river. All the targets are based on an annual average of monthly data collected over a 3-year period.

New CSM guidance issued in 2014 has proposed some changes to phosphate targets in rivers (REFERNECE). For the River Wensum, where mean annual phosphate concentration targets were previously 0.06 or 0.10 mg/l they will generally be reduced to 0.05 mg/l (see Section 5.2.1).

The Environment Agency do not measure total reactive phosphorus but instead measure orthophosphate to estimate dissolved and soluble phosphate levels in rivers and this determinand can be used to assess the compliance of the river to the phosphate targets.

Table 5.1 River Wensum phosphorus targets

Location	Total Reactive Phosphorus target (mg/l)	
	Current	2014 CSM review
From upstream limits to Sculthorpe	0.04	0.04
Sculthorpe to Taverham Bridge (mid-catchment)	0.06	0.05
Taverham Bridge to the downstream limit of the SSSI	0.10	0.05

5.2.1.1. Data available for the River Wensum

There are seven sampling points in the River Wensum catchment for which phosphorus data were available. These data are summarised in the Table 5.2 showing the data extends back to the late 1980s for most of these seven sites. **This table indicates that there is a very good long-term water quality record for the catchment, with nearly 25 years of phosphate data.**

Table 5.2 Phosphorus data availability for the Wensum 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
R. Wensum Sculthorpe Mill	WEN040	15/03/1989	23/01/2014	522	606
R. Wensum Great Ryburgh Bridge	WEN070	15/03/1989	14/01/2014	218	305
R. Wensum Swanton Morley Bridge	WEN180	16/03/1989	30/01/2014	496	607
R. Wensum Great Witchingham Bridge	WEN200	16/03/1989	30/01/2014	423	594
Blackwater Drain Gt. Witchingham (R. Wensum)	WEN210	16/03/1989	17/01/2014	138	302
R. Wensum Taverham Bridge	WEN235	16/03/1989	02/01/2014	237	290
R. Wensum Hellesdon Mill	WEN240	23/08/1983	06/01/2014	152	285

5.2.1.2. Long term orthophosphate trends

Continuous orthophosphate data for all sites is available from 1989 onward and this is represented in Figure 5.2 as annual average orthophosphate levels for the main sites in the catchment. This demonstrates that there has been a dramatic improvement in orthophosphate levels in the River Wensum since the 1990s.

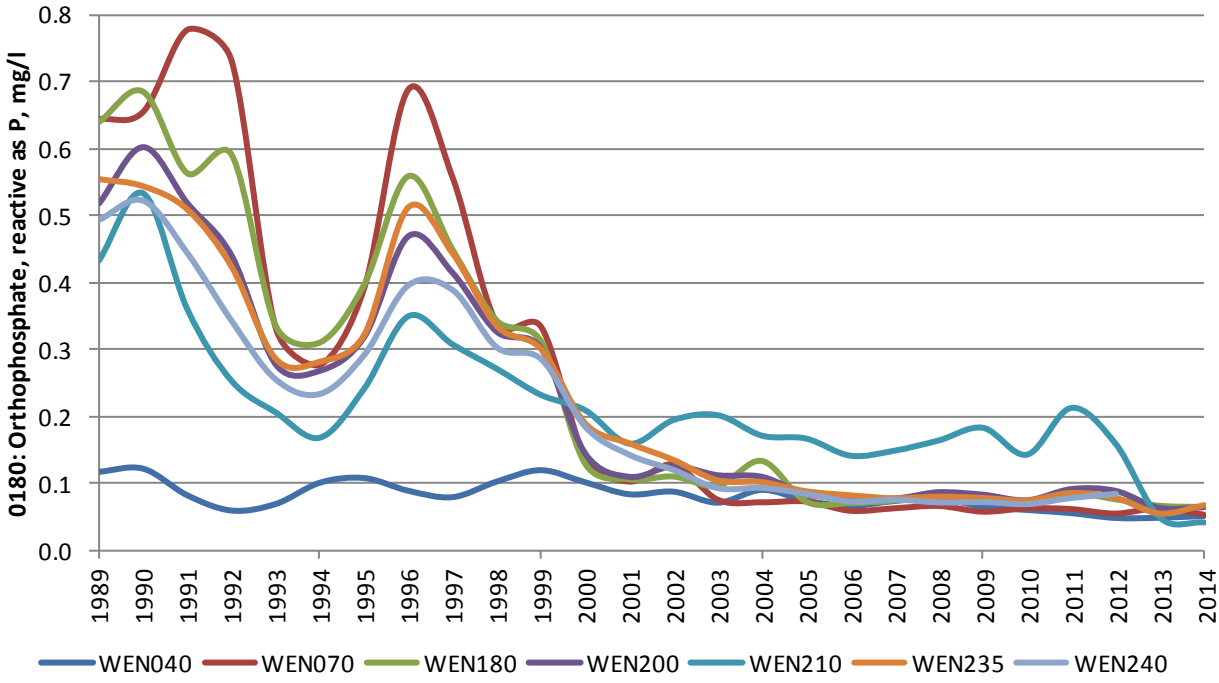


Figure 5.2 River Wensum orthophosphate monitoring data (1989–2014)

The sample point ID numbers increase down the catchment i.e. WEN040 is upstream of WEN070 and so forth. The chart clearly shows a long term reduction in Phosphate levels occurring from 2000 which is most likely to be linked to phosphorus stripping at sewage treatment works. Site WEN040, which is at the top of the catchment, does not have the same level phosphate as the downstream sites during the 1990s. During the 2000s site WEN210 (a sample point on a tributary to the Wensum) has approximately double the phosphate levels recorded at the other sites, this continues until 2013 when levels rapidly decrease to be in-line with the rest of the catchment. **Figure 5.3 shows the data from 2000 onward indicating a continual gradual improvement in orthophosphate levels in the River Wensum**.

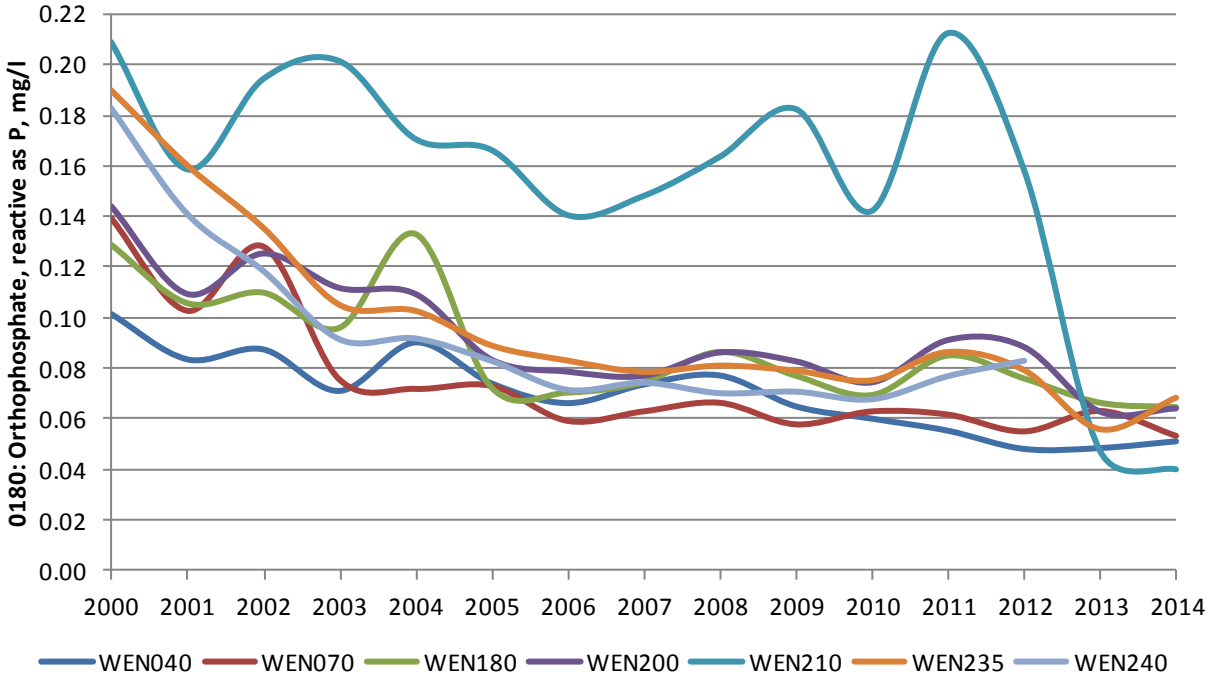


Figure 5.3 River Wensum orthophosphate monitoring data (2000–2014)

5.2.1.3. Orthophosphate compliance

Figure 5.4 and Table 5.3 assess the compliance of water quality in the River Wensum relative to the current phosphate targets. These show the annual average orthophosphate levels in the River Wensum between

2007 and 2013. The table is colour coded relative to compliance with the phosphate targets shown in section 5.2. This shows that between 2007–2012 orthophosphate levels at most of the sites in the River Wensum were greater than the target threshold. Throughout this period mean annual phosphate levels remained relatively constant. However in 2013 four of the seven sites were within or very close to the phosphate target.

Table 5.4 shows that 2014 onwards, the CSM phosphate targets for the River Wensum will change; where mean annual phosphate concentration targets were previously 0.06 or 0.10mg/l they will generally be reduced to 0.05 mg/l (see Section 5.2.1). Table 5.4 shows what compliance in the River Wensum would look like if historic data were compared to the new 2014 CSM targets. This shows that all locations on the River Wensum would fail the CSM target for most of the time; only one site on the River Wensum (WEN201) would pass the new targets in one year (2013).

Table 5.5 shows the seasonal compliance assessment for the River Wensum. There are no seasonal targets for lakes currently or in the future. It can be seen that most of the river also fails the seasonal phosphate target with some exceptions in 2009 and 2012 in the upper reaches of the river (WEN070) and downstream (WEN210) in 2013.

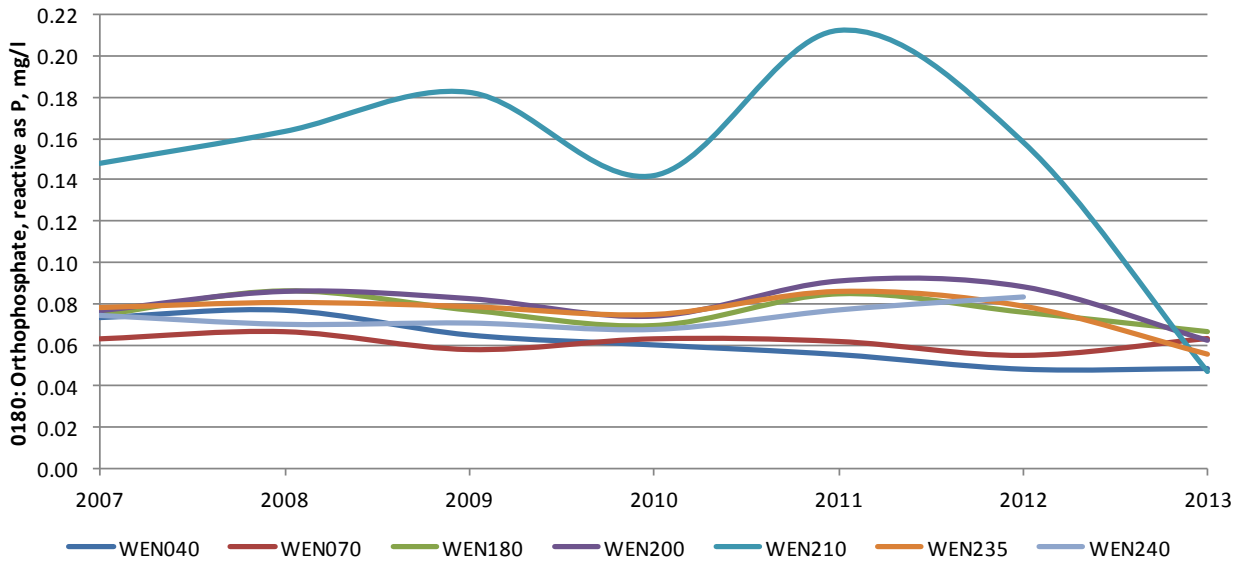


Figure 5.4 River Wensum orthophosphate monitoring data (2007–2014)

Annual averages of Orthophosphate, reactive as P, mg/l

Table 5.3 Compliance with current SSSI phosphate targets

	WEN040	WEN070	WEN180	WEN200	WEN210	WEN235	WEN240
Target	**0.04 mg/l**	**0.06 mg/l**	**0.06 mg/l**	**0.06 mg/l**	**0.06 mg/l**	**0.06 mg/l**	**0.10 mg/l**
2007	0.073	0.063	0.074	0.077	0.148	0.078	0.074
2008	0.077	0.066	0.086	0.086	0.163	0.081	0.070
2009	0.065	0.058	0.077	0.083	0.182	0.079	0.071
2010	0.060	0.063	0.069	0.074	0.142	0.075	0.068
2011	0.055	0.061	0.085	0.091	0.212	0.086	0.077
2012	0.048	0.055	0.076	0.088	0.158	0.079	0.083
2013	0.048	0.063	0.066	0.062	0.047	0.056	n/a

Green 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.

Table 5.4 Compliance with (2014 CSM targets review) SSSI phosphate targets

	WEN040	WEN070	WEN180	WEN200	WEN210	WEN235	WEN240
Target	**0.04 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**
2007	0.073	0.063	0.074	0.077	0.148	0.078	0.074
2008	0.077	0.066	0.086	0.086	0.163	0.081	0.070
2009	0.065	0.058	0.077	0.083	0.182	0.079	0.071
2010	0.060	0.063	0.069	0.074	0.142	0.075	0.068
2011	0.055	0.061	0.085	0.091	0.212	0.086	0.077
2012	0.048	0.055	0.076	0.088	0.158	0.079	0.083
2013	0.048	0.063	0.066	0.062	0.047	0.056	n/a

Green 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.

Table 5.5 Compliance with seasonal (April to September) with SSSI phosphate targets

	WEN040	WEN070	WEN180	WEN200	WEN210	WEN235	WEN240
Target	**0.04 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**	**0.05 mg/l**
2007	0.069	0.059	0.065	0.064	0.152	0.064	0.063
2008	0.082	0.058	0.089	0.081	0.205	0.072	0.060
2009	0.068	0.044	0.069	0.071	0.184	0.066	0.058
2010	0.063	0.063	0.069	0.072	0.169	0.068	0.060
2011	0.052	0.053	0.078	0.082	0.225	0.077	0.063
2012	0.041	0.041	0.075	0.081	0.170	0.075	0.082
2013	0.043	0.065	0.066	0.059	0.049	0.054	n/a

Green 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.

5.2.1.4. Seasonal trends in orthophosphate

Figure 5.5 shows how orthophosphate levels vary seasonally in the river. The data shown cover the period 2010–2012. The figure has been split to show WEN210 in the top chart and all the other sites in the bottom as they show a different pattern and scale of variation.

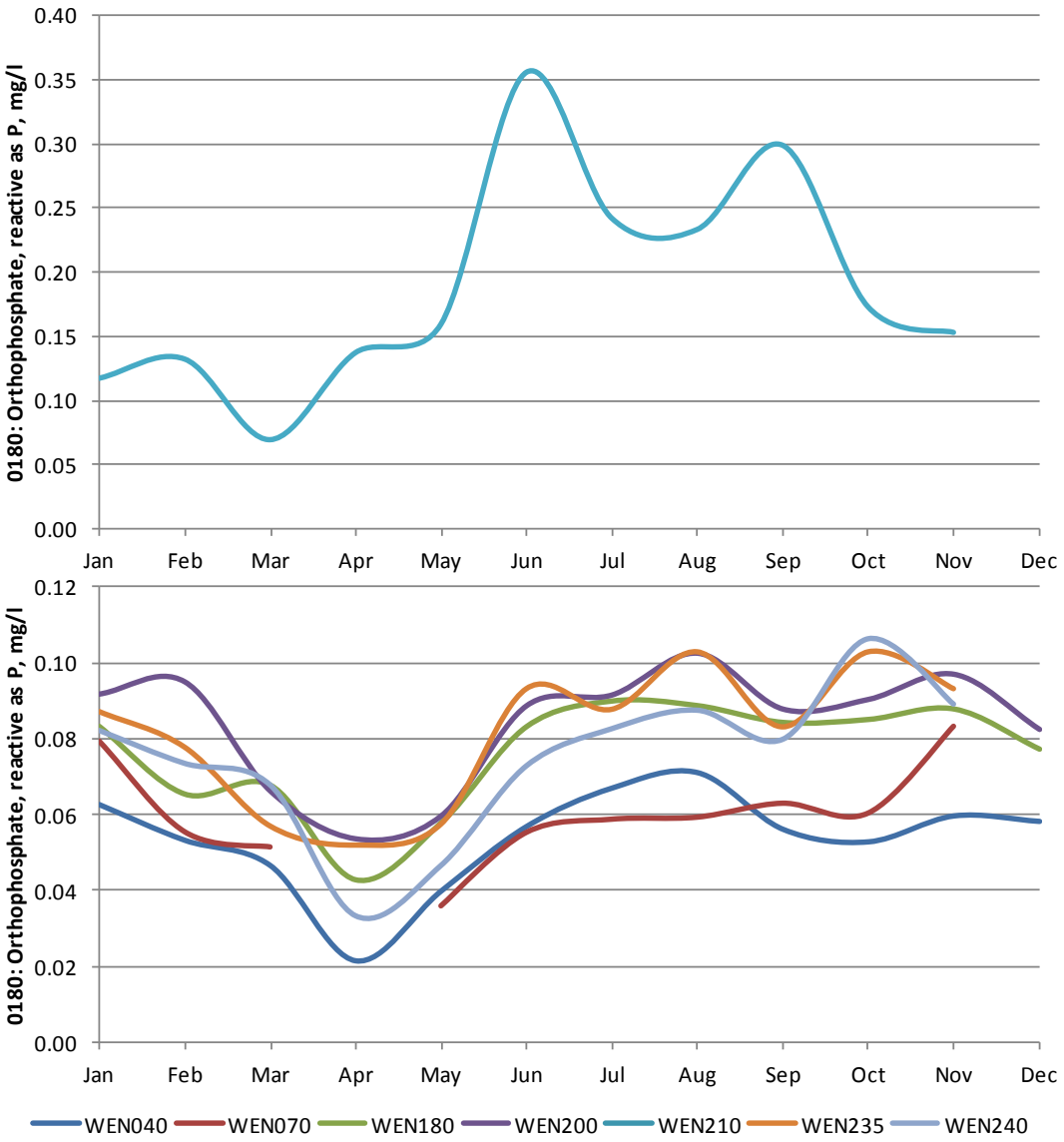


Figure 5.5 Seasonal trends in orthophosphate

In general the lowest orthophosphate levels are recorded in the spring months (March–May) and thereafter they increase during the summer with peaks in mid to late summer (July–August) and autumn (October–November). This pattern is a useful indication of the sources of phosphate in the Wensum catchment, as elevated phosphate levels in summer, when river flows are lowest, typically represent effects of point sources whereas autumn peaks are commonly associated with the flushing of diffuse phosphate sources.

5.2.2. Suspended Solids/siltation

5.2.2.1. Wensum Targets

The favourable condition tables for the River Wensum SSSI identify a target of 10 mg/l as suitable for most rivers. However, silt input is from run-off is highly variable, and routine sampling programmes may miss short peaks of high silt loading. The favourable condition table for water quality from Natural England used to include a target for suspended solids, as set out in Table 5.6. Note that the conditions assessment has moved away from a concentration target, so this information is for reference only.

Table 5.6 Former suspended solid targets

Feature	Target
Bullhead	25 mg/l
Brook Lamprey	25 mg/l
White-clawed crayfish	25 mg/l

The assessment has used water quality data from the Environment Agency for the period 2010–2012. This is an update of the information contained in the previous DWP Plan and the condition assessment that used data for the period 2007–2009. All locations covered by Environment Agency monitoring meet both the general river target of 10 mg/l and the feature-specific target of 25 mg/l.

5.2.2.2. Suspended solids compliance

Figure 5.6 shows the annual averages for suspended sediment over the period 1998 to 2013, and shows that **the values have remained relatively consistent for the catchment over this period, well below the former target of 25 mg/l.**

The Geomorphological Appraisal of the River Wensum SAC confirmed silt ingress to the river from the wider catchment as a significant issue that needed to be resolved in order for the river units to attain favourable condition. The appraisal included the assessment of continuous turbidity data from the Anglian Water Services abstraction at Costessey, but also involved collection of turbidity data from rainfall events. The appraisal concluded that headwater reaches of tributaries were vulnerable to silt ingress and that the majority of silt ingress to the Wensum occurred in the upper reaches of tributaries.

River units on the River Wensum are therefore considered to be in unfavourable condition in relation to turbidity.

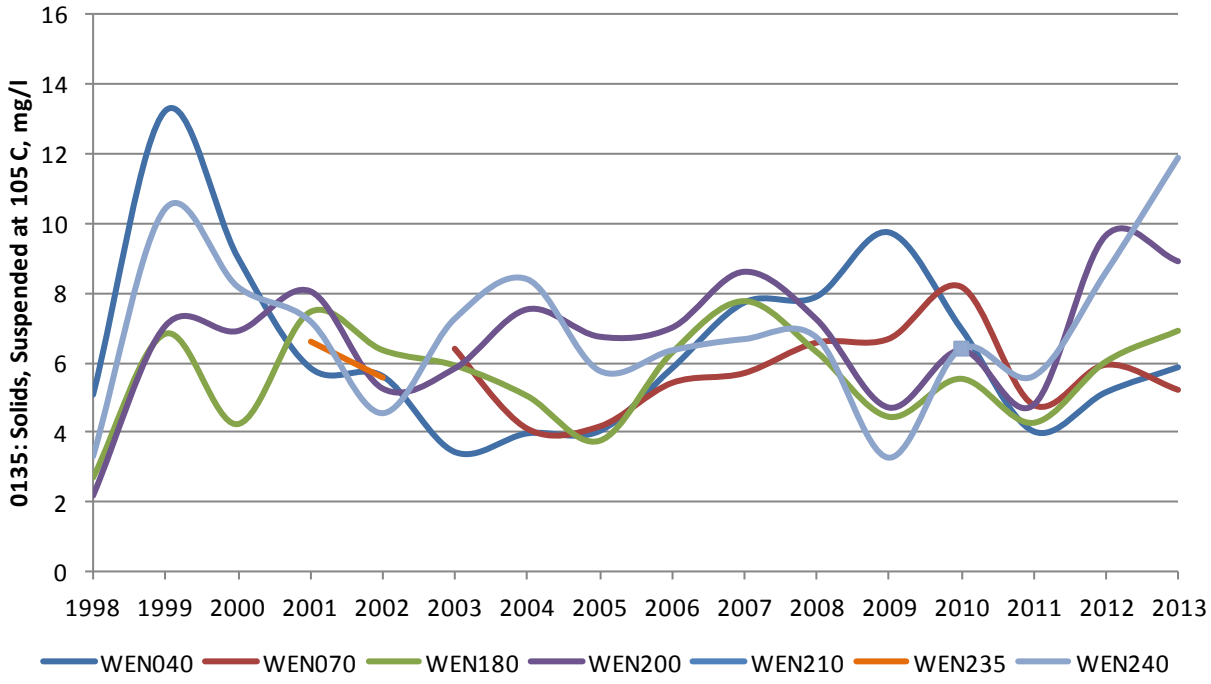


Figure 5.6 Suspended solids monitoring data (1998–2013)

Figure 5.7 shows the monthly averages for suspended solids over the period 2010–2012. The chart shows that every site experiences a peak in suspended solids concentration during the month of March. Average suspended solid concentrations then tend to be at their lowest during the spring and summer months of April to September, before rising again over the winter months. **Throughout the year however the values remain well within the target levels identified (**Table 5.6**).**

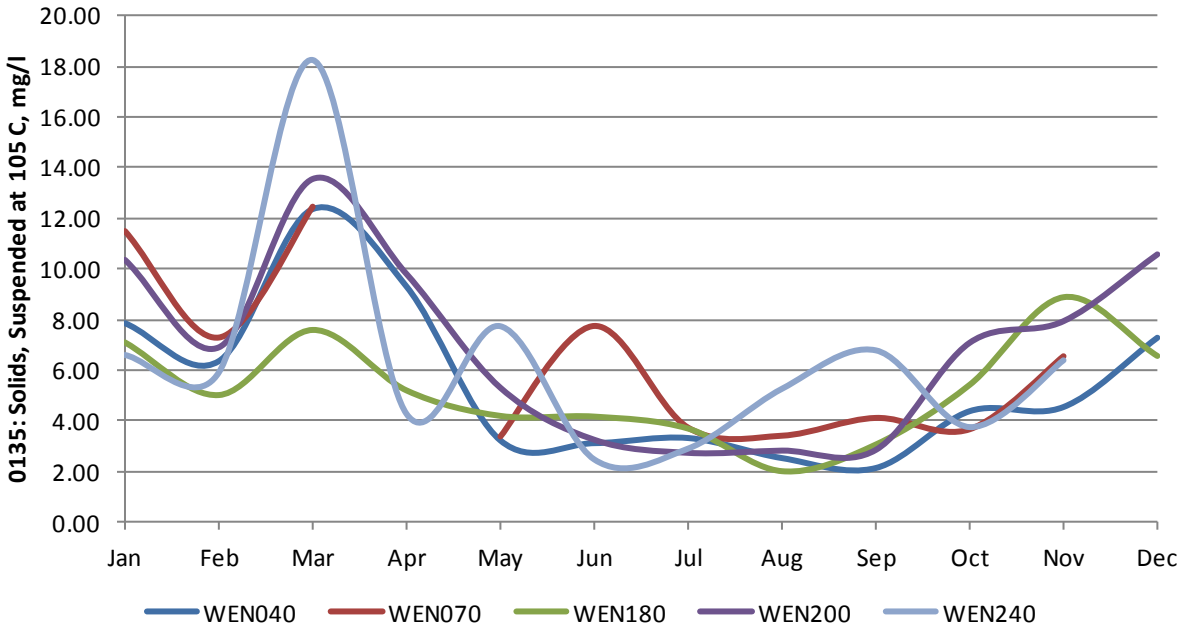


Figure 5.7 Seasonal trends in suspended sediment

5.3. Additional ecological evidence of impact

5.3.1. Macrophyte and diatom community evidence

The SSSI citation states that the River Wensum supports "over 100 species of plants". Macrophyte and diatom sampling data from routine Environment Agency monitoring can be used to indicate pressures within the catchment, including those associated with diffuse water pollution (such as eutrophication).

Figure 5.1 shows the location of Environment Agency macrophyte and diatom survey sites along the River Wensum that have been surveyed since 2010. The most recent WFD status assessment for macrophytes in the River Wensum U/S Norwich water body (GB105034055881) was undertaken in 2011 (Natural England, 2014), and reported moderate status (i.e. significant deviation from reference conditions).

Table 5.7 presents the most recent biotic metrics and scores available by SSSI unit, limited to surveys undertaken since 2010 (i.e. those more likely to be representative of recent conditions). This is provided alongside species records for *Ranunculus* sp, as a broad indicator of the *Ranunculus* community for which the SAC is partly designated. In summary:

- Macrophyte biotic metrics indicate a community impacted by eutrophication.
- The SSSI is expected to be naturally eutrophic; however, the River Macrophyte Nutrient Index (RMNI) is shown to be higher than expected for this river type, given rise to the WFD status failures reported. This indicates damage associated with anthropogenic eutrophication. Diffuse pollution may be contributing to this.
- Mean Flow Ranking (MFR) indicates relatively low flow velocities, which may be linked to reported abstraction issues but more likely the natural community expected for this lowland system.
- TDI supports observations from Mean Trophic Rank (MTR), and is indicative of eutrophication, although this cannot be compared to expected conditions for the river type as these have not been provided.
- River % Motile Taxa indicates that sedimentation increases moving downstream, as would be expected. Sedimentation pressures may be linked to diffuse pollution, particularly in lower reaches.

Table 5.7 Macrophyte and diatom community evidence compared with the relevant Natural England condition assessment attributes for river SSSI units on the River Wensum SSSI/SAC

Attribute	SSSI Unit										
	45	46	47	48	49	50	51	52	53	54	55
	EA Routine Monitoring Data (Scores)										
Macrophyte RMNI WFD Status	Moderate	*n/a*	Good	Moderate	*n/a*	Moderate	*n/a*	*n/a*	*n/a*	Moderate	*n/a*
Macrophyte RMNI	8.36	*n/a*	7.83	8.2	*n/a*	8.06	*n/a*	*n/a*	*n/a*	8.11	*n/a*
Ranunculus sp.	×	*n/a*	✓	✓	*n/a*	✓	*n/a*	*n/a*	*n/a*	✓	*n/a*
Macrophyte Mean Flow Rank (MFR)	*1.5*	*n/a*	*2*	*1.88*	*n/a*	*2.1*	*n/a*	*n/a*	*n/a*	*1.96*	*n/a*
River Trophic Diatom Index (TDI4)	*n/a*	51.35	*n/a*	*74.83*	63.16	*n/a*	*n/a*	*n/a*	64.78	*67.04*	*n/a*
River % Motile Diatom Taxa	*n/a*	*21*	*17*	*30*	21	*n/a*	*n/a*	*n/a*	42	*69*	*n/a*
	SSSI Status of Related Attributes										
Habitat Functioning – water quality (general assessments chemical GQA class)	*n/a*	×	×	×	×	×	×	×	✓	×	*n/a*
Habitat Functioning – water quality (general assessments un-ionised ammonia)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Habitat Functioning – water quality *(Total Reactive Phosphorus)*	×	×	×	×	×	×	×	×	×	×	×
Habitat Structure– channel and banks *(bank and riparian zone vegetation)*	✓	✓	×	×	×	×	×	✓	×	×	✓
Plant Community – species composition and abundance	×	×	×	×	×	×	×	✓	×	✓	×
Plant Community – reproduction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Plant Community Negative Indicators– native species	✓	✓	×	×	✓	×	✓	×	×	×	✓
Negative Indicators– alien/introduced species	✓	×	×	✓	✓	✓	×	×	×	×	×

5.3.2. Macroinvertebrate community evidence

The SSSI citation states that the River Wensum supports “a rich invertebrate fauna”. Macroinvertebrate sampling data in rivers can be used to understand how the ecology (macroinvertebrates in this case) responds to environmental variables and pressures within catchments, including diffuse water pollution.

The abundance and diversity of macroinvertebrate communities sampled are scored with pressure metric tools, comparing what was sampled against what would be expected to be there without pressures. The observed versus expected ratio is used to define a WFD status class (from High to Bad) for each pressure metric. Consequently, this allows the type and locations of catchment measure to be prioritised where the ecology is affected by environmental pressures.

The most recent WFD status assessment for macroinvertebrates in the River Wensum U/S Norwich waterbody (GB105034055881) was undertaken in 2012 (Natural England, 2014), and reported high status (i.e. no deterioration from reference conditions).

Figure 5.1 shows the location of macroinvertebrate survey sites along the Wensum, whilst Figure 5.8 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.

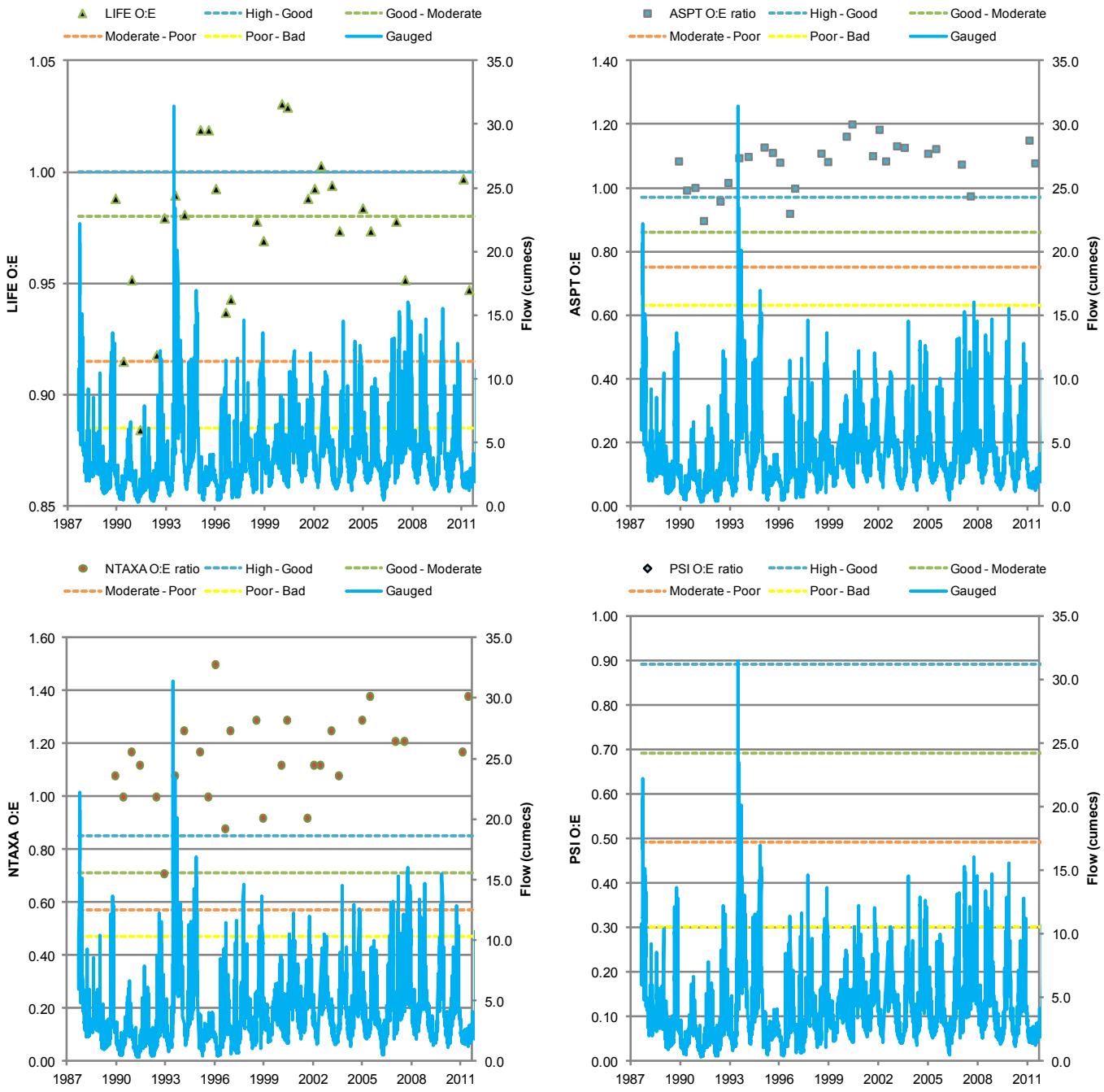


Figure 5.8 HEV plots at the Helleson Mill survey site

(Note that Psi data was taken from AMEC (2012) as was not available in raw format for this project)

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.

Table 5.8 summarises the HEV analysis for all the macroinvertebrate sites on the Wensum. 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 5.8 HEV analysis summary, showing the WFD status of the macroinvertebrates for each pressure metric

Water course	Site	Flow sensitivity (LIFE)	Water quality sensitivity (ASPT)	Water quality sensitivity (N–TAXA)	Sedimentation sensitivity (PSi)	Is it apparent that American signal crayfish predation is affecting the metric scores?
Wensum	Hellesdon Mill	Moderate or less	High	High	Moderate or less	No
Wensum	New Mill	High	High	High	-	No
Wensum	Great Ryburgh Bridge	High	High	High	-	No
Wensum	Swanton Moreley Bridge	? crayfish predation.	High	High	-	Yes – post 2006
Wensum	Tavernham Bridge	High	High	High	High	No
Wensum	Great Winchingham Bridge	High	High	High	-	No
Wensum	Sculthorpe Mill	Good	High	High	-	No
Tud	Berry's Bridge Honingham	High	High	High	-	No
Tat	Tatterford Common	High	High	High	-	No
Tud	Costessey Park Bridge	High	High	Good	-	No
Whitewater	Hoe Bridge	High	High	High	-	No

The results show that the water quality (ASPT and N–TAXA) is either at Good or High across the Wensum catchment. Psi data for the HEV analysis was not available at the time of reporting although it was possible to infer the Psi scores from the Psi analysis undertaken by AMEC (2012) at two sites. This suggested that over-sedimentation is a pressure in the lower Wensum (Hellesdon Mill), although this could be attributed to impoundments rather than the transfer of sediment from the land to the river.

Flow pressures (LIFE) are also suggested to be small along most of the River Wensum; however there is a pressure in the lower Wensum (Hellesdon Mill). This is supported by ongoing Environment Agency RSA investigations, and the water resource flow compliance for the lower Wensum 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 Wensum, compounding upon any diffuse pollution inputs.

American signal crayfish are clustered throughout the River Wensum catchment, and have been observed at the New Mill and Great Wichingham survey sites although at present, noticeable predation of macroinvertebrates is only occurring at a single survey site; Swanton Moreley Bridge, making the results at this site difficult to interpret although prior to signal crayfish presence, there was no indication of water quality pressures at the site.

Where the WFD status is below the Good cut-off, the morphology of the survey site was assessed further to determine if this could be lowering the survey scores. The Hellesdon Mill site is within a heavily resectioned and impounded reach, however the survey site itself does have good instream habitat and is free flowing suggesting that site specific morphology is not a major pressure despite the reach scale modifications (see Entec (2009) for more information). The morphology of the other sites is also assessed in Entec (2009) and can be also be interpreted from River Habitat Survey data (http://www.riverhabitatsurvey.org).

The results of the HEV analysis are also mapped against relevant Natural England condition assessment attributes in Table 5.9. The comparison supports the previous biological GQA assessment (the general quality classification scheme that pre-dated the WFD classification), and also suggests that despite the recorded 'unfavourable status' of water quality chemical standards in the River Wensum, the macroinvertebrate assemblage is healthy; generally at High status under WFD.

In summary:

- Water quality pressures metrics show little diffuse pollution impact in the Wensum catchment
- Flow sensitive metric suggests flow and abstraction pressures present in the lower Wensum. This could compound any diffuse pollutants through reduction in dilution.

- Sediment pressure assessment is inconclusive due to the lack of Psi data, and morphological factors that could be confounding the analysis such as weirs and mills.

Table 5.9 Macroinvertebrate community evidence compared with the relevant Natural England condition assessment attributes for river SSSI units on the River Wensum SSSI/SAC

Attribute	SSSI Unit										
	45	46	47	48	49	50	51	52	53	54	55
	EA Monitoring Data (WFD Status)										
ASPT and N–TAXA WFD status	High	High	High	High	High	High	High	High	High	High	High
	SSSI Status of Related Attributes										
Habitat Functioning – water quality (general assessments biological GQA class)	*n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Habitat Functioning – water quality (general assessments chemical GQA class)	*n/a*	×	×	×	×	×	×	×	✓	×	*n/a*
Habitat Functioning – water quality (general assessments un-ionised ammonia)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Habitat Functioning – water quality *(Total Reactive Phosphorus)*	×	×	×	×	×	×	×	×	×	×	×

5.3.3. Fish community evidence

The SSSI citation states that the River Wensum supports a “good mixed fishery”, with brown trout forming the major component in the upper reaches and chub, pike, eel and barbell dominating the mid to lower reaches. The SAC also cites bullhead and brook lamprey as Annex II species present as qualifying features.

Environment Agency fisheries monitoring data is used under the Fisheries Classification Scheme 2 (FCS2; UKTAG, 2008b) 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 data request.

Under the FSC2 bullhead, brook lamprey and brown trout are all considered to have low tolerance to environmental disturbance (including diffuse pollution). Therefore in broad terms their relative presence/absence within SSSI units may be indicative of prevailing environmental pressures such as diffuse pollution.

The most recent WFD status assessment for fish in the River Wensum U/S Norwich water body (GB105034055881) was undertaken in 2012 (Natural England, 2014), and reported good status (i.e. slight deterioration from reference conditions). Figure 5.1 shows the location of Environment Agency fisheries survey sites along the Wensum that have been surveyed since 2010.

Table 5.10 presents the most recent Unit survey species diversity, as well as presence absence for key species.

In summary:

- Species diversity is lowest in the headwater Units, but all three key species are present.
- Key species are present throughout the SSSI.
- Although this analysis does not consider populations relative to expected conditions, this is a broad indication that conditions within each Unit are capable of supporting these species.

Table 5.10 Fish species diversity and key species evidence compared with the relevant Natural England condition assessment attributes for river SSSI units on the River Wensum SSSI/SAC

Attribute	SSSI Unit										
	45	46	47	48	49	50	51	52	53	54	55
	EA Monitoring Data (Presence/Absence)										
Species diversity (total species)	7	6	11	14	14	13	13	14	14	14	n/a
Brook lamprey	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	n/a
Bullhead	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	n/a
Brown trout	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	n/a
	SSSI Status of Related Attributes										
Habitat Functioning - water flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Habitat Functioning – water quality (general assessments biological GQA class)	*n/a*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Habitat Functioning – water quality (general assessments chemical GQA class)	*n/a*	×	×	×	×	×	×	×	✓	×	*n/a*
Habitat Functioning – water quality (general assessments un-ionised ammonia)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Habitat Functioning – water quality *(suspended solids)*	×	×	×	×	×	×	×	×	×	×	✓
Habitat Functioning – water quality *(Total Reactive Phosphorus)*	×	×	×	×	×	×	×	×	×	×	×
Habitat Structure– substrate *(siltation)*	×	✓	×	×	×	×	×	×	×	×	×

5.4. Additional evidence requirements

5.4.1. Additional water quality evidence requirements

Any evidence gaps with regards to phosphorus dynamics in the catchment of the River Wensum are expected to be filled by the Demonstration Test Catchment (DTC) project that is collecting large volumes of water quality data using state-of-the-art equipment following a multi-million pound investment by Defra. This project is due for completion in 2015 when data and information obtained will become publically available and should be incorporated within this plan. For example, the high resolution monitoring will help to understand the times of year and climatic conditions that are associated with the greatest deterioration of water quality conditions in the river and how long they last, This information will be helpful to design mitigation strategies and understand the nature of ecological impacts on the river.

5.4.2. Additional ecological evidence requirements

From an ecology perspective, the confounding influence of habitat pressure could be more directly assessed by including detailed RHS data in the additional evidence. WFD status classifications for diatoms and fish would also help determine whether site specific observations are indicative of deterioration, or are expected for the river type. This could not be assessed with the information available.

The monitoring network itself is fairly extensive– there are no specific recommendations in terms of new sites, only for continuation of those sites routinely monitored at present. **The PSI metric is also key in assessments** of this nature, not least because it is indicative of sedimentation (which can be associated with diffuse pollution), but because it is specified explicitly to form part of the condition assessment under the new CSM guidance (JNCC, 2014).

6. Sources of pollution leading to water quality failure

6.1. Phosphate pressures

6.1.1. Tools available to Natural England and its partners

The tools that are available to Natural England to estimate the sources of phosphate in the catchment of the River Wensum are summarised in Table 6.1. The tools described are those that are either used by Natural England's regulatory partners (such as the Environment Agency or water companies) or that have been developed by Defra specifically to support diffuse pollution planning at the catchment scale.

These tools are very useful, but should be used with care. As the tools are models, there may be some differences in the outputs due to differences in input data, spatial coverage and configuration.

Table 6.1 Key evidence tools to identify sources of 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.

6.1.2. Outputs for the River Wensum

6.1.2.1. SEPARATE

The results of the SEPARATE model in Figure 6.1 show that diffuse water pollution from agriculture accounts for approximately one third of the annual total phosphorus loads in the Wensum catchment, with the remainder from non-diffuse sources. Sewage Treatment Works provide the single largest source and account for close to half of the annual phosphate loads in the Wensum catchment.

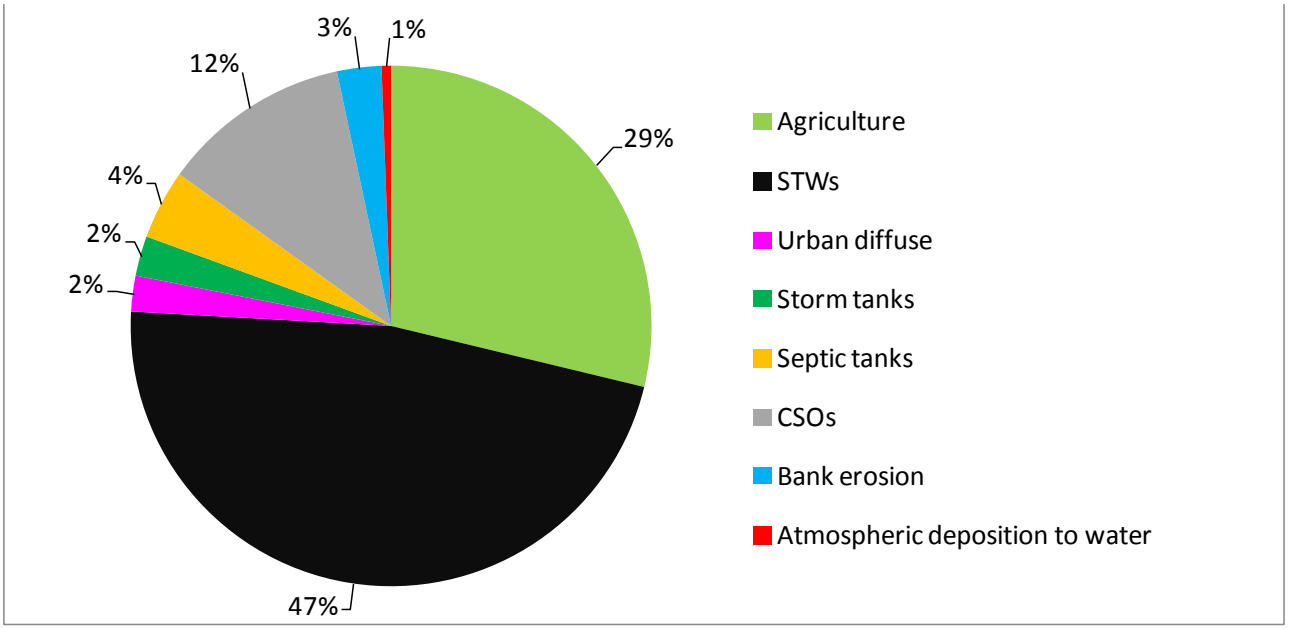


Figure 6.1 SEPARATE model outputs for sources of phosphate in the River Wensum catchment

6.1.2.2. SAGIS

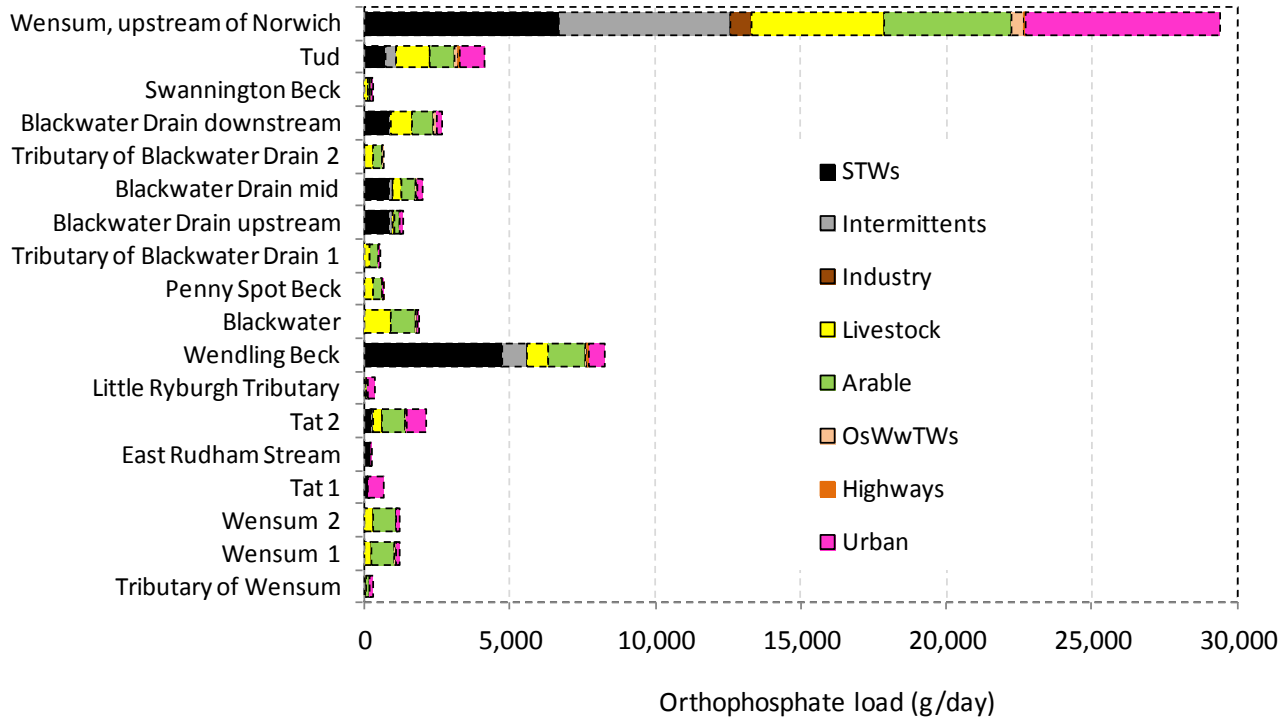


Figure 6.2 shows the SAGIS phosphate apportionment for each WFD waterbody within the Wensum catchment. Although the overall source apportionment shows that sewage treatment works are contributing a significant portion of the phosphate overall within the catchment (Figure 6.1) this varies considerably within different water bodies within the Wensum catchment, with some catchments showing phosphate contributions being almost entirely agricultural, and others being heavily dominated by sewage treatment works or other urban influences.

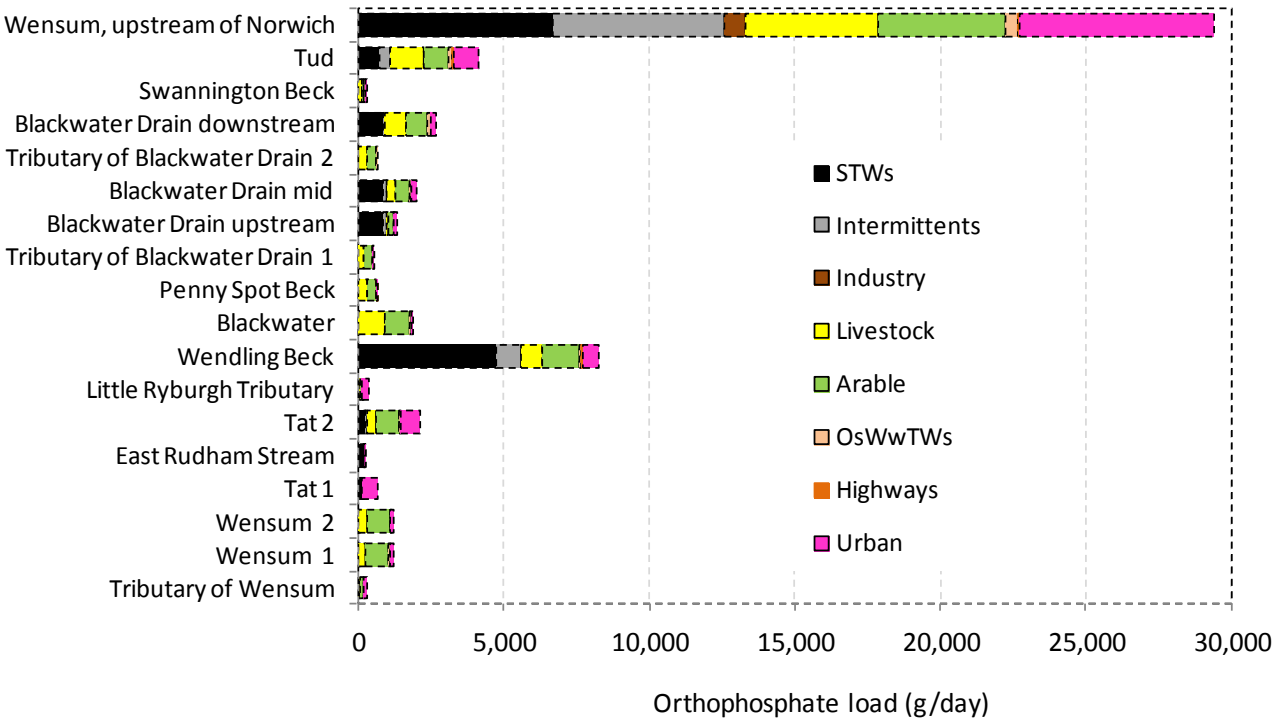


Figure 6.2 Source apportionment in the River Wensum catchment water bodies
Data are derived from SAGIS and relate to the load generated within each individual water body. Note that the pie charts are placed for visibility: the data relates to the exit point of the water body.

Figure 6.3 shows the SAGIS simulated data for the in-river phosphate concentrations (y-axis) longitudinally through the river system, from the river source at 0 km downstream (x-axis) to the bottom of the SSSI at Norwich. It is a chainage plot showing how phosphate concentrations in the river change in a downstream direction. Confluences with different WFD waterbodies and STW inflows are labelled to show how different phosphate inflows entering the river affect concentrations down the River Wensum SSSI. So, this figure shows the **combined effects** of loads from different WFD waterbodies, its effects on concentrations and how they vary downstream. The vertical broken lines represent individual river reaches joining the main River Wensum. The total phosphate concentrations are represented by the top of the coloured area (in this case varying between approximately 0.04 and 0.10 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 ~15 km, the main contributor of phosphate is arable farming, with a smaller amount being contributed from livestock farming. At approximately 15km, there is a marked step change in the overall phosphate levels and the source apportionment changes abruptly, with increased contributions from urban, industry and sewage treatment works, demonstrating the contributions from an urban area. This pattern of apportionment continues downstream, with increasing contributions from arable and livestock farming in the middle of the catchment downstream.

Figure 6.4 shows the catchment source apportionment at the outflow/downstream end of the SSSI (Norwich) i.e. it represents the **combined effects** of all sources in the catchment. It shows that agriculture as a whole (arable and livestock combined) is the largest contributor, followed by Sewage Treatment Works (STW) with a 33% contribution. Splitting agriculture shows that Arable farming contributes less than STWs, closely followed by Livestock farming. Urban sources are also significant.

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.

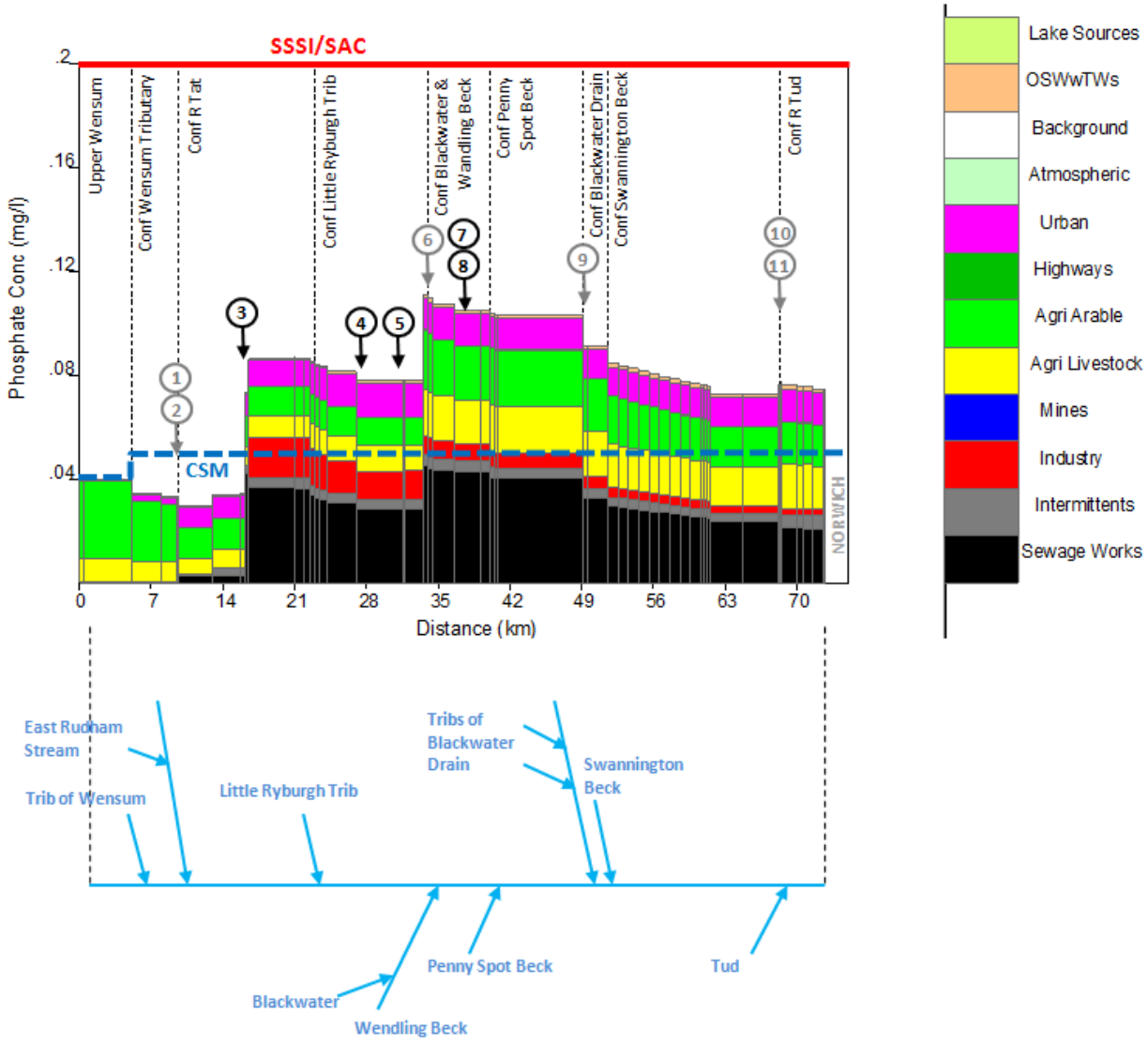


Figure 6.3 SAGIS Longitudinal cumulative phosphate source apportionment profile for the River Wensum

The blue dashed line represents the 2014 CSM thresholds for phosphate (mg/l). The vertical dotted lines are confluences with different waterbodies or other important hydrological features in the catchment moving downstream. STW discharges are numbered[8] – see footnote. *STWs shown in black discharge straight into the River Wensum. STWs labelled in grey discharge to watercourses that subsequently flow into the River Wensum.*

[8] **STW marked as follows**: 1 (East Rudham); 2 (Sculthorpe); 3 (Fakenham) 4 (Foulsham); 5 (North Elmham); 6 (Dereham); 7 (Swanton Morley); 8 (Bylaugh); 9 (Reepham); 10 (Mattishall); and 11(Hockering).

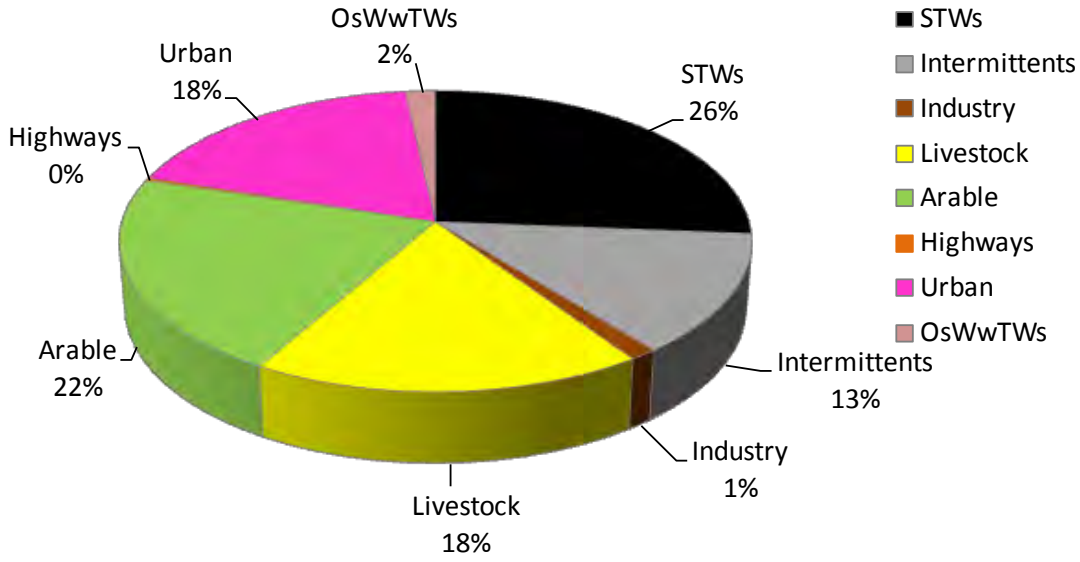


Figure 6.4 Overall catchment source apportionment
(Derived from SAGIS)

6.1.2.3. 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 6.2 combines the information provided by Defra regarding the number of robust farm types in the Wensum catchment (see Table 4.4) 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'.

FARMSCOPER outputs scaled to the catchment scale indicate that lowland grazing contributes the most phosphate losses at a catchment level, followed by roots combinable and mixed combinable (although the numbers are roughly of the same magnitude). Overall, arable (mixed combinable + roots combinable) and livestock farm types (mixed livestock + lowland grazing) when combined provided similar catchment scale phosphate contributions.

Table 6.2 Phosphate loss for FARMSCOPER farm types within the Wensum catchment

Type	FARM-SCOPER farm type	No. of farms in Wensum catchment	% of all farms	Estimated area (ha)	FARM-SCOPER estimated Phosphate loss per farm (kg/yr)	FARM-SCOPER estimated Phosphate loss at catchment level (kg/yr)	FARM-SCOPER estimated Phosphate loss at catchment level (%)	By sector
Arable	Mixed combinable	101	29%	19,753	0.1	1,975	22%	38
	Roots combinable	128	36%	25,033	0.06	1,502	16%	
Grazing	Mixed Livestock	16	5%	3,129	0.3	939	10%	40
	Lowland grazing	71	20%	13,886	0.2	2,777	30%	
Specialist	Outdoor pigs	17	5%	3,325	0.23	765	8%	21
	Specialist poultry	21	6%	4,107	0.28	1,150	13%	
	TOTALS	**354**	**100%**	**69,232**	-	**9,108**	**100**	**100**

6.1.3. Summary and Evidence gaps

In summary, the FARMSCOPER model outputs suggests that, of the farm types present in the Wensum catchment, those associated with the highest risk of phosphate loss are 'Lowland grazing farms', which comprise 20% of all farms in eh catchment.

The outputs from the SAGIS and SEPARATE models indicate that whilst diffuse water pollution is a component of the phosphate balance to the River Wensum SSSI catchment, population pressures are a more dominant component, i.e. point source pollutant sources have a greater significance.

Therefore while action to minimise diffuse phosphate loss will contribute to reducing the pollution of the Wensum SSSI, additional measures to reduce point source pollutants are also necessary to make a significant impact.

6.2. Sediment pressures

Understanding where sediment is coming from is essential to help target mitigation measures in a catchment.

A key source of diffuse pollution is the release of nutrients adsorbed to soil or sediment particles, which are eroded from land parcels into water bodies, such as the River Wensum. Therefore assessing where sediment pollution occurs can also indicate the source of diffuse nutrient pollution.

6.2.1. Tools available to Natural England and its partners

Information on sources of sediment in the catchment of the River Wensum is covered by a number of investigations summarised in Table 6.3.

Table 6.3 Key evidence sources for sediment 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
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.
Wensum Alliance	The Wensum Alliance has used spectroscopy to show how sources of sediment in the Blackwater (a tributary of the Wensum) change during individual storm events.

6.2.2. Outputs for the River Wensum

6.2.2.1. SEPARATE

The results of the SEPARATE model in Figure 6.5 show that the majority of sediment in the River Wensum is sourced from agriculture. Erosion from banks contributes about a quarter of the annual sediment budget of the River Wensum. Urban and sewage treatment sources provide smaller sources of sediment on an annual basis.

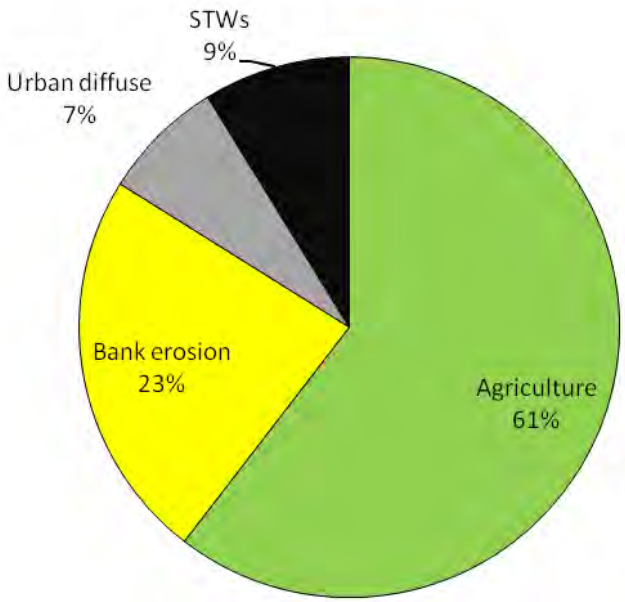


Figure 6.5 SEPARATE model outputs for sources of sediment in the River Wensum catchment

6.2.2.2. The Wensum Alliance

Studies undertaken by UEA[9] have considered the apportionment of sediment in the Blackwater sub-catchment over shorter timescales. A sample of the results is shown in Figure 6.6. The Wensum Alliance study is showing that material from bank erosion dominates during low flow conditions and that agricultural sources (topsoil and field drains) become dominant when rainfall events pass through the catchment generating surface runoff.

Estimating where the main sources are within the catchment can be evaluated using the methods set out below. Each method has distinct advantages and disadvantages.

[9] Information on these studies can be found at:

www.wensumalliance.org.uk/presentations/04jul13_year4_conference/Wensum2013_Richard.pdf

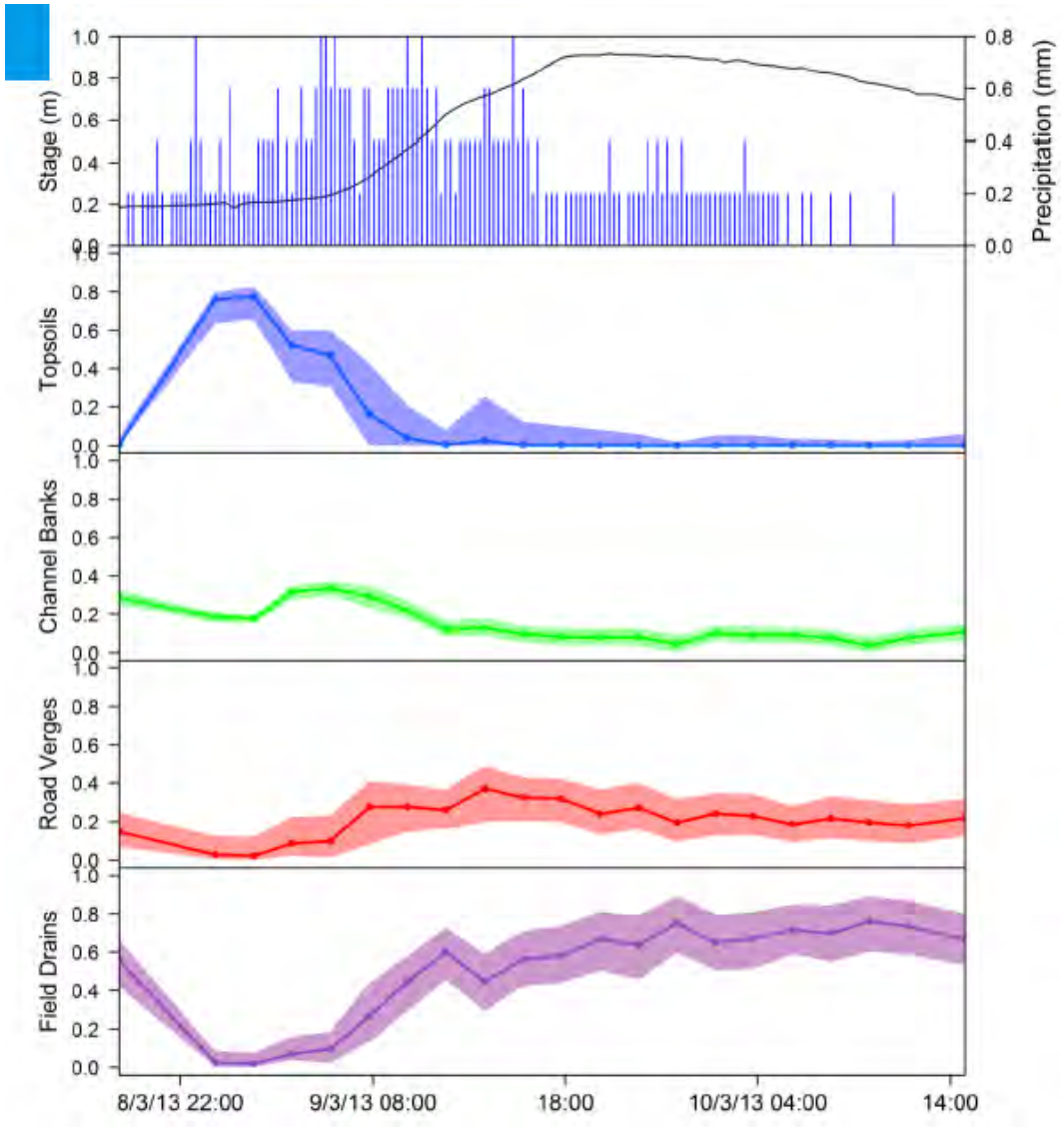


Figure 6.6 Sample results for sediment under the Wensum Alliance project

6.2.2.3. FARMSCOPER

Table 3.7 combines the information provided by Defra regarding the number of robust farm types in the Wensum 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'.

The farm types of arable, and specialist outdoor pigs have the highest losses of sediment (kg/yr) in the Wensum catchment. When these farm-level contributions are aggregated up to the catchment level, the figures indicate that the highest losses of sediment across the catchment are roots combinable and mixed combinable that contribute over three quarters of the diffuse sediment load in the river and that they contribute up to five times as much sediment than lowland grazing.

Table 6.4 Sediment loss for FARMSCOPER farm types within the Wensum catchment

FARM-SCOPER farm type		No. of farms in Wensum catchment	% of all farms	Estimated area (ha)	FARM-SCOPER estimated sediment loss per farm (kg/yr)	FARM-SCOPER estimated sediment loss at catchment level (kg/yr)	FARM-SCOPER estimated sediment loss at catchment level (%)	By sector
Arable	Mixed combinable	101	29%	19,753	21.4	422,706	35%	77
	Roots combinable	128	36%	25,033	20.1	503,164	42%	
Grazing	Mixed Livestock	16	5%	3,129	14.3	44,747	4%	17
	Lowland grazing	71	20%	13,886	11.7	162,461	13%	
Specialist	Outdoor pigs	17	5%	3,325	22.3	74,141	6%	6
	Specialist poultry	21	6%	4,107	0	0	0%	
	TOTALS	**354**	**100%**	**69,232**	-	1,207,218	100%	100

6.2.2.4. SCIMAP

SCIMAP is an approach to the generation of risk maps for diffuse pollution within catchments. SCIMAP aims to determine where within a catchment is the most probable source of diffuse pollution and is 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 to produce:

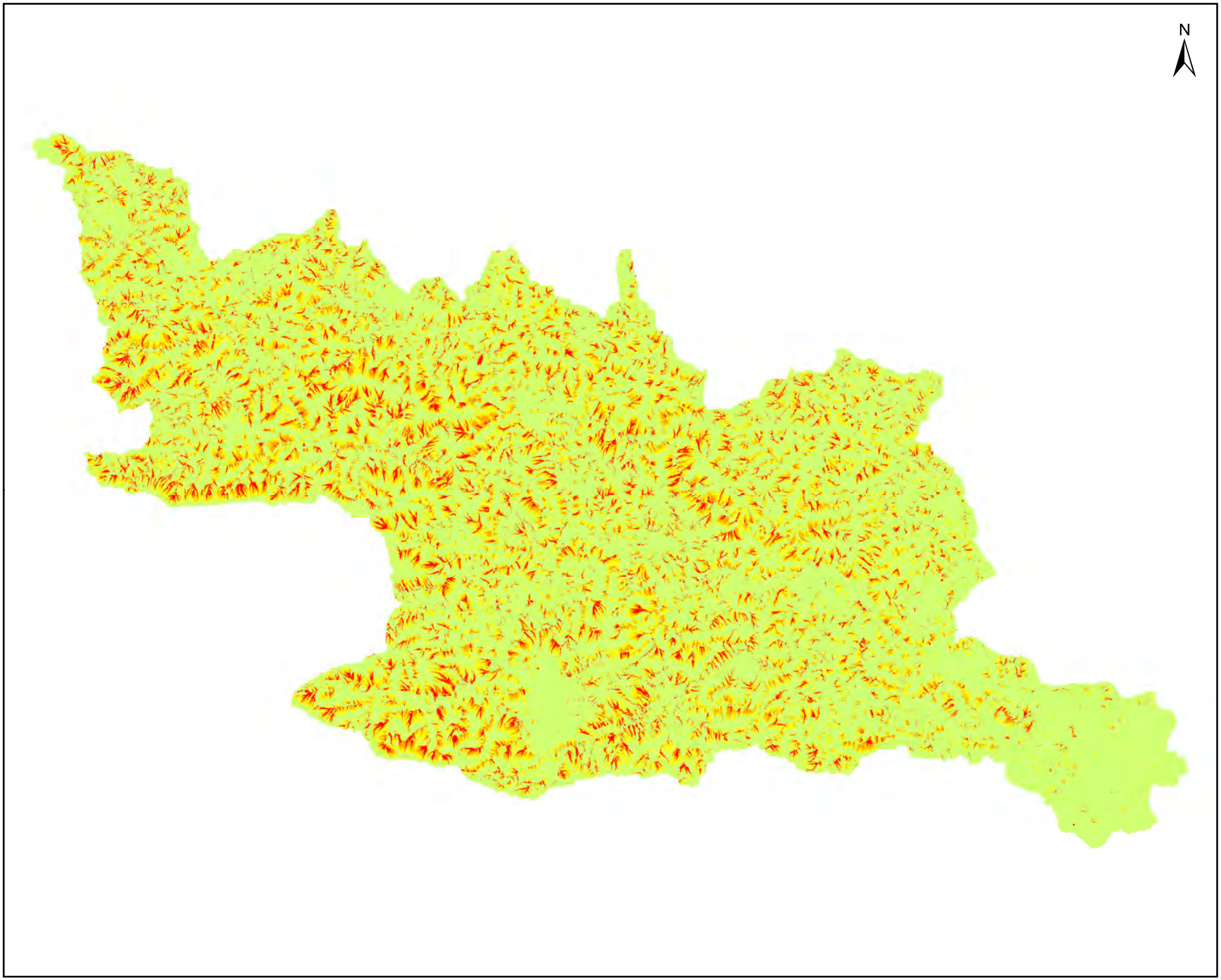
- **Point Erosion Risk** – the risk of erosion is a function of rainfall intensity, slope, upstream contributing area and land management type
- **Connectivity Risk** – This is a function of slope and proximity to a watercourse. The steeper the slope and closer the source to a watercourse, the greater the risk
- **Accumulated Erosion Risk** – A combination of point erosion and connectivity risk showing high risk where point erosion risk is well connected to a watercourse.
- **Sediment Load** – The accumulated erosion risk within a watercourse.
- **Sediment Concentration** – The accumulated erosion risk within a watercourse, diluted based on the upstream catchment area.

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. This assumption may not be valid for the River Wensum catchment, which exhibits a mixture of loamy/clayey, peaty and sandy soils. More importantly, the connectivity model used by SCIMAP assumes that sediment transport is completely driven by overland flow resulting from rainfall and that the flow accretion can be reliably predicted based on upstream catchment area alone. As discussed previously, the Wensum is a northern chalk river, with the majority of its flow being groundwater fed. The variability in the thickness of geological drift across the catchment means that flow accretion is non-uniform both in-channel and across land draining into the main watercourses. Due to these issues the predictions made by SCIMAP are less reliable and therefore less useful in catchments such as the Wensum, but still indicate where relative risk of event driven erosion and transport likely to be greatest.

The SCIMAP output (Figure 6.7) 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 and steep slopes near to water courses. However the whole catchment map shows localised areas of moderate risk widely scattered through catchment.

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 6.7: SCIMAP outputs for the River Wensum SSSI catchment



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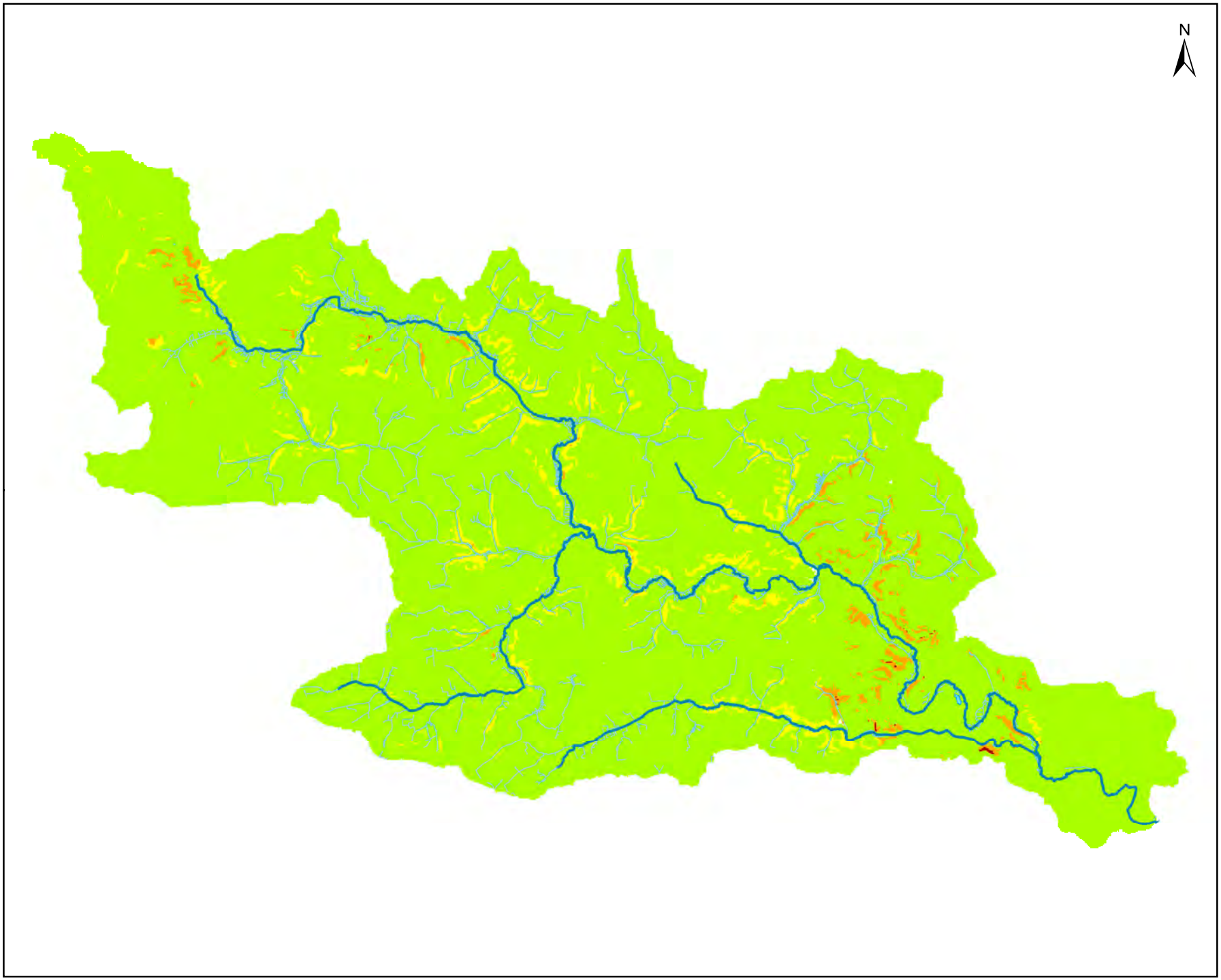
6.2.2.5. Defra Erosion Risk Model

Defra (2005) have proposed a 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 6.8). 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 Wensum catchment is generally low. The higher risk areas are estimated to be close to the watercourses. The Defra model classifies the majority of the catchment as having a low risk of erosion due to the shallow hill slopes present in the catchment. The areas of moderate to high risk predicted by the model are focused on the steeper slopes around the watercourses where the land has been incised. The areas with the highest level of risk are found at the bottom end of the catchment (upstream of Norwich) and around the source of the River Tat, where the soil texture is sandy.



Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 6.8: Defra Erosion Risk Model outputs for the River Wensum SSSI catchment

Lakes
Main Rivers
Watercourses

Soil Erosion Risk

Low
Moderate
High
Very High

0 2 4 6 km

Scale (at A4): 1:222,000

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6.2.3. Evidence gaps

Currently, the main evidence gap identified through this study is the description of the methods and assumptions that underpin the SEPARATE model. In addition, the Demonstration Test Catchment (DTC) project is investigating sediment source apportionment in the Wensum catchment in greater detail. This project is due for completion in 2015 when data and information obtained will become publically available.

However, there is limited evidence that the River Wensum suffers from significant sedimentation based on water quality monitoring data that gives mean suspended solids concentrations of less than 10 mg/l throughout the whole catchment. This may be related to the scale of impoundment along the length of the river that acts as an on-line sediment trap, limiting the mobility of sediment in the river.

6.3. Flow pressures

6.3.1. Investigations

Information on flow pressures within the catchment of the River Wensum has been covered by the investigations shown in Table 6.5. 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 6.5 Key evidence sources for flow pressures

Name	Description
CSM Condition Assessment	Conditions assessment of each SSI unit by Natural England. Last performed in 2010.
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

6.3.2. CSM flow compliance assessment

The Natural England CSM flow compliance assessment for river SSSIs[10] comprises an assessment the degree to which the flow exceeds permitted targets of deviation beyond the naturalised flow regime. The 2010 CSM Condition Assessment of the River Wensum report set out the following text with regard to flow targets for all the river units (units 45 to 55). Natural England concluded that all the river units, met the flow targets with the exception of Unit 54:

> The River Wensum SAC was used as a pilot for the RAM methodology in 2002, and this report indicated that the river was grossly over abstracted in its lower reaches. The level of concern was of a scale that an interim agreement was reached between English Nature and the Environment Agency for the period up until the conclusion of the Review of Consents. This policy included:
>
> - Closure of the catchment to new abstraction
> - Aggressive claw back as licenses are renewed.
> - The inclusion of a cessation clause if aquifer levels reach a critical threshold.
>
> The hydrology of the river was further investigated during AMP4, and the subsequent report highlighted the fact that the river was grossly over-abstracted in its lower reaches.
>
> By the time that the Broadland Catchment Abstraction Management Strategy had been developed the more precautionary Habitats Directive Ecological Flow objectives had been developed to supersede the RAM methodology on SAC Rivers. The HDERF flow targets agreed through the CAMS process were adopted as the flow targets for the River Wensum SSSI, and were subsequently adopted within the Review of Consents process.
>
> The Appendix 21 and subsequent modelling for the Environment Agency Regulation 50 Review of Consents for the River Wensum SAC has concluded that in relation to the Fakenham and Swanton Morley gauging stations, although the river is 'over-licensed' at the present time, it is not 'over-

[10] See the 2014 CSM guidance for rivers here: http://jncc.defra.gov.uk/pdf/CSM_rivers_jan_14.pdf

abstracted' and that this could be addressed through a policy of 'claw back' implemented as licenses come up for renewal.

However, the Appendix 21 and subsequent modelling of the riverine European interest features at the Hellesdon Assessment Point, located at the bottom of the catchment are at 'high risk' from current levels of abstraction.

Although this unit is in favourable condition in relation to water resources, and flow criteria, the abstraction in the catchment as a whole has a cumulative impact with regard to the flow regime between Costessey and Hellesdon, and the Review of Consents solution may require sustainability reductions within the catchment as a whole.

Natural England concluded that the river Units, 45 to 55, met the flow targets with the exception of Unit 54.

6.3.3. Environmental Flow Indicators

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.
- 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.

Figure 6.9 and Table 6.6 show 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.

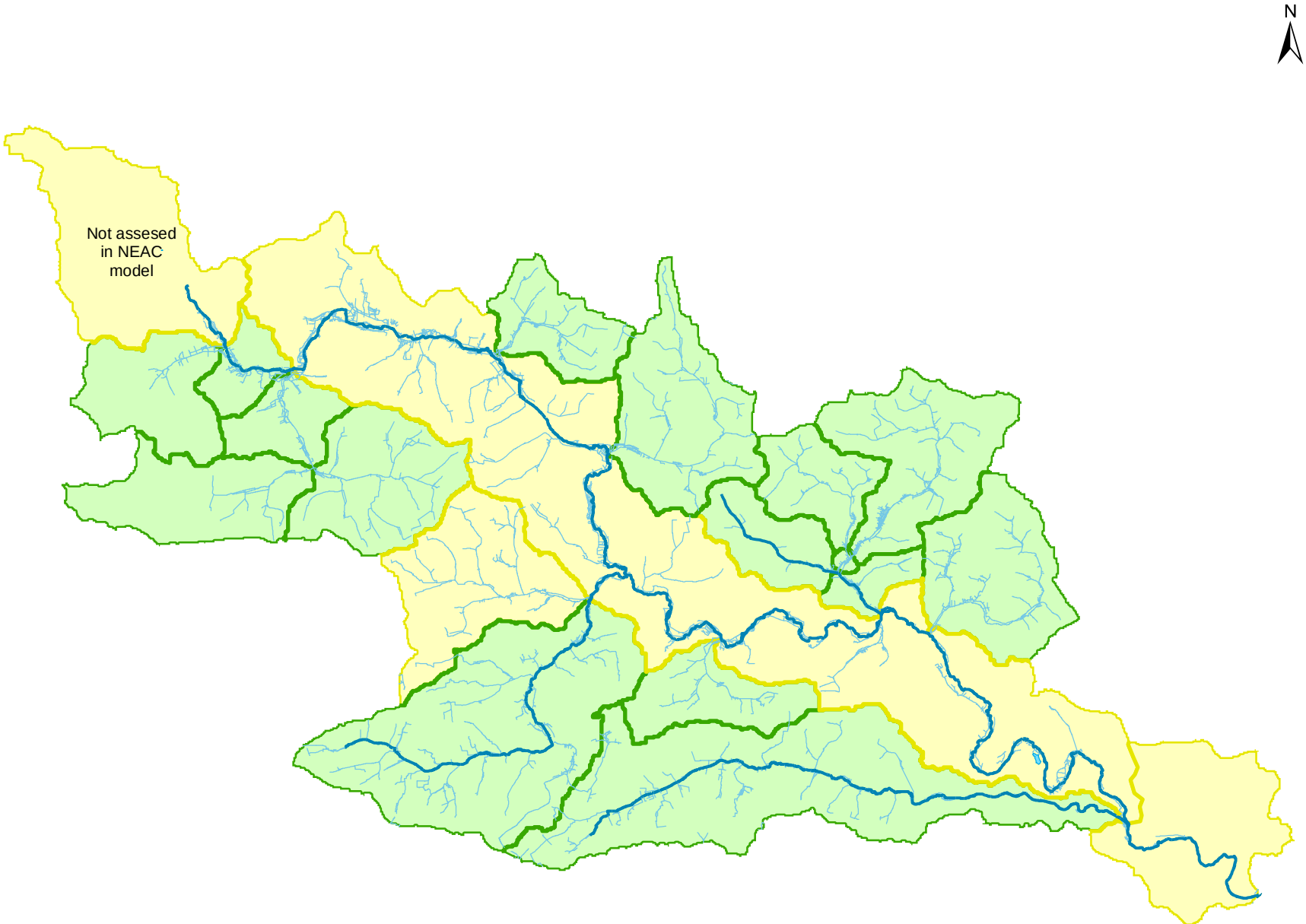
Both the Water Resource GIS and NEAC model show that the main stem of the River Wensum and Wendling Beck are non-compliant with the EFI (Band 1). The River Tat in the upper catchment is also non-compliant with the EFI in the Water Resource GIS, but was not assessed in the NEAC model as the flows are too small to undertake the assessment with confidence.

The compliance assessment therefore suggests that the main stem of the River Wensum, Wendling Beck and the River Tat have a degree of abstraction pressure which "may start to cause an undesirable effect on river habitats and species". Whilst the non-compliance of the "Wensum US Norwich" water body (GB105034055881) suggests that a large length of the main river is affected by abstraction. In reality, the abstraction pressures are focussed in the lower reaches close to Norwich (although the entire water body receives the Band 1 non-compliance status) around Cotessey Mill. This is supported by the HEV assessment (Figure 5.8) showing that flow sensitivity pressure metric is only below the WFD Good cut-off downstream of Cotessey Mill. Upstream, the LIFE scores suggest a Good or High status flow pressure. The Environment Agency is currently investigating abstraction pressures around Cotessey Mill as part of the Restoring Sustainable Abstraction (RSA) programme.

The compliance flow assessment and HEV LIFE metric results are mapped against the relevant SSSI unit assessment attributes in Table 6.7. This takes into consideration that the abstraction pressure in the River Wensum is greatest downstream of Cottessy Mill rather than along the whole of water body GB105034055881. It shows that abstraction pressures are focussed in the lower units 54 and 55, which could potentially aggravate diffuse pollution issues through a reduction in pollutant dilution.

Exemplar Diffuse Water Pollution Plan
River Wensum SSSI

Figure 6.9: Flow compliance in the River Wensum 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 2 4 6 km

Scale (at A4): 1:222,000

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Table 6.6 WFD (RBMP cycle 1) water resource flow compliance assessment for the River Wensum SSSI catchment water bodies

Waterbody ID	Waterbody Name	Water Resource GIS compliance assessment	NEAC compliance assessment
GB105034051000	Tud	Compliant	Compliant
GB105034051020	Wendling Beck	Compliant	Compliant
GB105034051050	Blackwater (Wendling Beck)	Band1	Band1
GB105034051070	Swannington Beck	Compliant	Compliant
GB105034051110	Wensum	Compliant	Compliant
GB105034051120	Blackwater Drain (Wensum)	Compliant	Compliant
GB105034055850	Foulsham Tributary	Compliant	Compliant
GB105034055860	Little Ryburgh Tributary	Compliant	Band1
GB105034055870	Tat	Band1	-
GB105034055881	Wensum US Norwich	Band1	Band1
GB105034055882	Wensum DS Norwich	Band1	Band1
GB105034051010	Penny Spot Beck	Compliant	Compliant
GB105034051030	Blackwater Drain	Compliant	Compliant
GB105034051040	Blackwater Drain	Compliant	Compliant
GB105034051060	Tributary of Blackwater Drain	Compliant	Compliant
GB105034051080	Tributary of Wensum	Compliant	Compliant
GB105034051090	Tributary of Blackwater Drain	Compliant	Compliant
GB105034051100	Wensum	Compliant	Compliant
GB105034051130	East Rudham Stream	Compliant	Compliant
GB105034051140	Tat	Compliant	Compliant

Table 6.7 Water resource pressure evidence compared with the relevant Natural England condition assessment attributes for river SSSI units on the River Wensum SSSI/SAC

	SSSI Unit										
Attribute	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**
	Status										
Habitat Functioning – water flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
EFI compliance assessment	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Band 1	Band 1
Macroinvertebrate flow sensitivity status	Good	Good	Good	-	Good	-	Good	Good	Good	Moderate or less	Moderate or less

6.4. Sources of isoproturon (agricultural herbicide)

The River Wensum has failed drinking water targets for this chemical. Isoproturon is an agricultural herbicide used mainly against black-grass on over half the cereal acreage. It was withdrawn from use in June 2009. It is measured in the Wensum at Sweetbriar Road Bridge, Norwich, about 8 times a month. The set limit is 0.01 ug/l.

The Rural Payments Agency suspect that there has been a significant amount of Isoproturon used, after approval lapsed on 30 June 2009, because large amounts were purchased in the autumn of 2008 and the subsequent wet weather conditions precluded its use during that season. As a result, farmers and growers will have been tempted to use the product already in store during the autumn of 2009 rather than incur significant expenditure on alternative products combined with the costly disposal of the unapproved product. The water quality should improve once this product is no longer in use.

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

Table 7.1 lists existing measures being implemented within the Wensum SSSI catchment, as presented in the first Diffuse water Pollution Plan for the site.

Table 7.1 Measures in the old DWPP that are underway in the Wensum SSSI to address water pollution

Measure and pressure	Mechanism	Location	Evidence supporting the expected outcome *(positive or negative)*
Reduce sediment and phosphate, together with nutrients and pesticides from entering watercourses from agricultural land	England Catchment Sensitive Farming Delivery Initiative until March 2011.	Agricultural land within specific target areas of the Wensum priority area	Catchment Appraisal for Wensum. The River Wensum was one of the four initial pilots for the concept of Catchment Sensitive Farming, and since its inception, this has allowed the RDS and later, Natural England to engage with the farming community with regard to diffuse pollution, to encourage the adoption of farming practices that will reduce the risk of diffuse pollution from agricultural sources. One of the targets of ELS has been to assist in reduction of diffuse pollution on high risk fields. Resource protection has been taken forward through HLS. In the Wensum catchment, 4050 ha has been covered by ES resource protection options, whilst 62760 metres of other options have also been adopted. (See attached sheet).
Reduce sediment runoff through poaching by options to reduce livestock density	HLS		Poaching is not a widespread issue in the Wensum catchment. However, where it is present, it should be managed through ensuring that stock densities are appropriate, rather than fencing stock off from the river completely. Inventory of effects associated with various methods available in Defra DWPA User Manual (Cuttle *et al*. 2009). Use of HLS options needs to be targeted across catchment
Reduce sediment runoff and P inputs – e.g. siltation traps and infrastructure	HLS special project	This is an approach which might be appropriate in localised circumstances	Inventory of effects associated with various methods available in Defra DWPA User Manual (Cuttle *et al*. 2009). Use of HLS options needs to be targeted in particular within Units 5, 6, 7 and 8,
Events and actions to encourage and educate farmers to improve their land management and reduce DWP. Examples include farm events, farm walks, publicity etc.	Campaign for the Farmed Environment voluntary measures (direct and influencing ELS/HLS) Elizabeth Ranelegh is the catchment officer. When working for FWAG a couple of years ago she made farm visits aimed at improvement of RP options. She liaises with Alex Nichols to deliver FEPs in the area.	Whole catchment	
Buffer strips & all other mitigation measures/agri-env options – some labelled RP options, others not.	ELS/HLS/CSS/ CFE	Farm holdings along watercourses	Inventory of effects associated with various methods available in Defra DWPA User Manual (Cuttle *et al*. 2009).
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.	Whole catchment	Feedback received from existing owners during initial send-out, some positive, saying they were changing detergent use.
EA regulatory action (Note: no data has been provided on the extent of deployment of these measures in the catchment)	Includes: - Cross compliance inspection visits to targeted farms. - Advice and enforcement following pollution incidents. - Targeted NVZ inspections and workshops. - Inspection of GW Authorisations (now EPR permits). - Advice and approvals through the Water Resources (Silage, Slurry and Agricultural Fuel Oil) Regulations 2010 (SSAFO). - Regulation of sewage sludge imports.	Across the whole of the catchment, but primarily targeting identified WFD stretches and groundwater source zones with elevated levels of nitrate	These actions will contribute to the prevention of deterioration in water quality and in some cases deliver an improvement to the current status. Further improvements will be delivered by recently completed AMP schemes and CSF advice
Reduce siltation in river	River Wensum Restoration Strategy	River channel	Through restoration of the river channel e.g. removal/reduction of mill structures, raising of bed levels, narrowing of the channel etc. This will lead to a more naturalised channel, which is better able to maintain a clean gravel bed.

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 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 FARMSCOPER outputs may include a large number of measures that may be difficult to promote locally as it often requires many measures to be implemented on each farm. An example for the Wensum catchment is given in Table 8.1 which lists the number of options that are required to meet the maximum predicted reductions in agricultural pollutants in each robust farm type in the 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	Number of sediment measures required on a farm for Optimiser scenario
Lowland	42	25
Mixed combinable	28	21
Mixed livestock	48	24
Outdoor pigs	36	20
Roots combinable	26	22
Special poultry	20	/

A more workable set of actions can be determined by selecting the Top 5 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.

8.3. Results

Table 8.2 summarises the results of the FARMSCOPER assessment for the Wensum catchment. For both the lowland grazing farm and the arable general cropping farm, application of the top 5 measures approach will deliver the majority of predicted reductions in the losses of phosphorus.

Some measures serve to reduce both phosphorus and sediment and can be applied to **all** arable and pig farm types within the River Wensum catchment. These are:

- 8 – Cultivate compacted tillage soils (will increase energy use)
- 13 – Establish in-field grass buffer strips (will increase biodiversity)
- 15 – Loosen compacted soil layers in grassland fields (will increase energy use)

Other mitigation methods set out in the Top 5 scenarios are often common to pollutant/farm type in various combinations. These are:

- 106 – Plant areas of farm with wild bird seed/nectar flower mixtures (to reduce Phosphorus and sediment losses from cereal farms)
- 4 – Establish cover crops in autumn (to reduce sediment losses from all arable and pig farms)
- 78 – Re-site gateways away from high-risk areas (to reduce phosphorus losses from pig farms)
- 9 – Cultivate and drill across the slope (to reduce phosphorus losses from arable farms generally and sediment from cereal farms)

Table 8.2 FARMSCOPER Assessment outputs for the River Wensum Catchmen

	Catchment specific information					FARMSCOPER outputs							
						Maximum achievable		Top 5 Phosphorus measures			Top 5 Sediment 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	128	36	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	
	Cereals	Mixed combinable (with pig manure)	Arable farm with a lot of winter cereals, but some spring cereals and legumes grown in rotation. It receives FYM and/or slurry from a nearby indoor pig farm.	101	29	41	88	8 – Cultivate compacted tillage soils	12	34	4 – Establish cover crops in the autumn	16	70
								9 – Cultivate and drill across the slope	7		8 – Cultivate compacted tillage soils	25	
								13 – Establish in-field grass buffer strips	10		13 – Establish in-field grass buffer strips	25	
								15 – Loosen compacted soil layers in grassland fields	12		15 – Loosen compacted soil layers in grassland fields	25	
								106 – Plant areas of farm with wild bird seed/nectar flower mixtures	10		9 – Cultivate and drill across the slope	19	
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.	71	20	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	
	Mixed	Mixed Livestock	This farm is not dominated by any particular system, with a mixture of livestock and a reasonable area of arable land. There is a small dairy herd as well as some beef cows and followers; a small flock of sheep and a small indoor pig unit	16	5	65	68	35 – Reduce the length of the grazing day/grazing season	4	26	8 – Cultivate compacted tillage soils	12	51
								60 – Site solid manure heaps away from watercourses/field drains	3		13 – Establish in-field grass buffer strips	12	
								61 – Store solid manure heaps on an impermeable base and collect effluent	17		15 – Loosen compacted soil layers in grassland fields	12	
								62 – Cover solid manure stores with sheeting	3		106 – Plant areas of farm with wild bird seed/nectar flower mixtures	26	
								68 – Do not apply manure to high risk areas	**		78 – Re-site gateways away from high-risk areas	10	
SPECIALIST	Specialist pigs	Outdoor pigs	-	17	5	59	87	8 – Cultivate compacted tillage soils	21	50	8 – Cultivate compacted tillage soils	25	49
								13 – Establish in-field grass buffer strips	10		9 – Cultivate and drill across the slope	18	
								15 – Loosen compacted soil layers in grassland fields	21		13 – Establish in-field grass buffer strips	25	
								78 – Re-site gateways away from high-risk areas	8		15 – Loosen compacted soil layers in grassland fields	25	
								106 – Plant areas of farm with wild bird seed/nectar flower mixtures	10		106 – Plant areas of farm with wild bird seed/nectar flower mixtures	25	
	Specialist poultry	Specialist poultry	-	21	6	37	-	34 – Adopt phase feeding of livestock	2	36	Not applicable		
								38 – Move feeders at regular intervals	10				
								78 – Re-site gateways away from high-risk areas	10				
								106 – Plant areas of farm with wild bird seed/nectar flower mixtures	10				
								332 – Reduce dietary N and P intakes: Pigs and Poultry	10				

8.4. Wider benefits of the Top 5 measures

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

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 collate 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 8.5 to Table 8.7 summarise common measures that FARMSCOPER recommends as part of a Top 5 combination and their individual effect on biodiversity and energy use.

Table 8.3 Effectiveness of the Top 5 measures expressed as percent reduction

Robust Farm type	Methane (% reduction)	Nitrous Oxide (%)	Ammonia (%)	Nitrate (%)	Pesticides (%)	Biodiversity*		Energy use*	
						P	Sed.	P	Sed.
Mixed combinable	0	20	46	20	48	10	5	−10	−13
Roots combinable	0	15	45	29	42	5	10	−13	−12
Mixed Livestock	2	11	12	19	50	1	10	−3	−10
Lowland grazing	2	14	31	10	55	1	6	−3	−7
Outdoor pigs	4	10	14	12	51	10	13	−10	−9
Specialist poultry	4	4	/	13	/	5	-	0	-

** 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 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.
Mixed combinable	0	21	47	22	57	51	40	−8	−3
Roots combinable	0	18	47	31	55	31	−9	40	−12
Mixed Livestock	3	23	/	27	58	53	53	−5	−7
Lowland grazing	2	21	37	18	61	51	53	−7	−6
Outdoor pigs	4	13	16	14	57	54	50	−8	−8
Specialist poultry	4	4	/	13	0	37	-	0	-

** 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 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.
Mixed combinable	0	20	46	20	48	10	5	−10	−13
Roots combinable	0	15	45	29	42	5	10	−13	−12
Mixed Livestock	2	11	12	19	50	1	10	−3	−10
Lowland grazing	2	14	31	10	55	1	6	−3	−7
Outdoor pigs	4	10	14	12	51	10	13	−10	−9
Specialist poultry	4	4	/	13	/	5	-	0	-

** 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 8.6 List of common measures and their impact on diversity and energy use in arable and pig farming

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
78 – Re-site gateways away from high risk areas	0	0
106 – Plant areas of farm with wild bird seed/nectar flower mixtures	5	−0.2

Table 8.7 List of common measures and their impact on diversity and energy use in arable and pig farming

Measure	Biodiversity	Energy use
8 – Cultivate compacted tillage soils	0	−5
13 – Establish in-field grass buffer strips	5	0
15 – Loosen compacted soil layers in grassland fields	0	−5
35 – Reduce the length of the grazing day/grazing season	1	−3
39 – Construct troughs with a concrete base	0	0
60 – Site solid manure heaps away from watercourses/field drains	0	0
61 – Store solid manure heaps on an impermeable base and collect effluent	0	0
62 – Cover solid manure stores with sheeting	0	0
76 – Fence off rivers and streams from livestock	0	0
78 – Re-site gateways away from high risk areas	0	0
106 – Plant areas of farm with wild bird seed/nectar flower mixtures	5	−0.2

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 SAGIS model gives an indication of phosphate loadings at catchment level. The results, shown in Figure 6.4, show that Sewage Treatment Works (STW) dominate the phosphate load overall, with the next biggest inputs coming from arable farming, livestock farming, followed by urban sources. These results indicate that diffuse pollution accounts do not count for all the phosphate export of the catchment and diffuse pollution measures alone are unlikely to result in large reductions in catchment phosphate concentrations.

Nevertheless, the FARMSCOPER model has demonstrated that respectable percentage reductions can be achieved by applying the top 5 measures. Therefore 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. 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 catchment.

9. Evidence on how far actions will help achieve favourable condition

It is generally not possible to understand the effectiveness of the measures set out in the DWPP as a whole, as this greatly depends on the extent to which measures are uptaken and deployed. It is also not possible to understand the effectiveness of advisory measures, although this can be tracked using engagement rates similar to CSF.

In terms of the effectiveness of agricultural measures, the FARMSCOPER tool has been used to understand the potential phosphate losses from the farms within the individual SSSI-contributing water body catchments. Based on the FARMSCOPER outputs, and using the Agricultural Census data provided by Defra, this assessment shows that the highest risk of farm-level phosphate loss occurs in the Wensum upstream of Norwich, Tud, Wendling Beck, Blackwater Drain (downstream) and the Foulsham Tributary. This is broadly in line with the priorities set out by the source apportionment (Figure 2.3). The magnitude of the potential phosphate *losses* are provided in Appendix C.

The FARMSCOPER outputs indicate which measures would best be applied in the agricultural sector to reduce phosphate losses at a farm level. The top 5 most effective measures for any given farm type have been selected and modelled. The outputs essentially give a percentage reduction in phosphate losses ("savings" that could be made) from a 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 savings from applying measures on the type of farms (arable and livestock) within each water body. The magnitude of the potential phosphate *savings* are provided in Appendix C.

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

The effectiveness of the top 5 most effective agricultural measures applied to all farms within each water body are shown in Table 9.1, and have been categorised as follows:

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

It should be noted that these phosphate savings are expressed as a percentage of the overall agricultural phosphate losses, not of the overall water body phosphate load. Furthermore, these percentage savings assume the top 5 measures are applied correctly on every farm in every water body, not just on the priority water bodies set out in the action plan. This shows that the potential for reductions in either the arable or livestock sector in isolation is generally low, but combined action in each water body (aside from the Little Ryburgh Tributary) could result in moderate savings of farm-scale phosphate losses within the water body catchment.

In summary, it is thought that moderate reductions coupled with improvements at selected STWs may achieve compliance.

Table 9.1 Magnitude of theoretical effectives of FARMSCOPER measures

Waterbody name	Waterbody ID	Magnitude of theoretical effectiveness of all Agri measures combined	Magnitude of theoretical effectiveness of ARABLE measures	Magnitude of theoretical effectiveness of LIVESTOCK measures
Wensum 2	GB105034051110	Moderate	Moderate	Low
Tat 2	GB105034051140	Moderate	Low	Low
Little Ryburgh Tributary	GB105034055860	Low	Low	Low
Wendling Beck	GB105034051050	Moderate	Low	Low
Blackwater	GB105034051050	Moderate	Moderate	Low
Blackwater Drain downstream	GB105034051040	Moderate	Low	Low
Swannington Beck	GB105034051070	Moderate	Low	Moderate
Tud	GB105034051000	Moderate	Low	Low
Wensum, upstream of Norwich	GB105034055881	Moderate	Low	Low
Foulsham Tributary	GB105034055850	Moderate	Low	Moderate

10. Actions required on non-diffuse sources

Actions to control sewage and urban discharges would appear to provide a likelihood of success with regard to reducing phosphorus inputs into the catchment. 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.

Given the balance of contributions likely to be coming from diffuse (agricultural) sources and from point sources, the most effective strategy to secure compliance would be modest further improvement to consented discharge.

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.

References

AMEC (2012) Wensum – In River Needs further review of macroinvertebrate data and hydroecology targets. Report to the Environment Agency.

Boon, P.J., Holmes, N.T.H., Maitland, P.S. and Fozzard, I.R. (2002). Developing a new version of SERCON (System for Evaluating Rivers for Conservation). *Aquatic Conservation: Marine and Freshwater Ecosystems* **12**(4), 439–455.

Cuttle, S.P., C.J.A. Macleod, D.R. Chadwick, D. Scholefield, P.M. Haygarth, P. Newell-Price, D. Harris, M.A. Shepherd, B.J. Chambers, and R. Humphrey (2007) "*An Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA): User manual ES0203."* Defra, London

Defra (2005). *Controlling soil erosion: a manual for the assessment and management of agricultural land at risk of water erosion in lowland England*. Revised September 2005. Department for Environment, Food and Rural Affairs, London.

Entec (2009) Habitats Directive Review of Consents – Stage 4 River Wensum – Flow Evaluations Using Macroinvertebrate Communities

Environment Agency (2002). *Resource Assessment and Management Framework*. Report and User Manual (Version 3), W6–066M. Environment Agency, Bristol.

Environment Agency (2013a) Environmental Flow Indicator Product Description. http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_7935_811630.pdf

Extence, C.A., Balbi, D.M. and Chadd, R.P. (1999) River flow indexing using British benthic macroinvertebrates: A framework for setting hydroecological objectives. *Regulated Rivers Research and Management*, 15, 543–574.

Extence, C.P., Chadd, R., England, J., Dunbar, M.J., Wood, P., Taylor, E. (2013) The Assessment of Fine Sediment Accumulation in Rivers Using Macro-Invertebrate Community Response. *River Research and Applications*, 29, 17–55.

Joint Nature Conservation Committee (2014). Common Standards Monitoring Guidance for Rivers. Version January 2014. ISSN 1743–8160 (online). Available at http://jncc.defra.gov.uk/pdf/CSM_rivers_jan_14.pdf

Kelly, M.G., Adams, C., Graves, A.C., Jamieson, J., Krokowski, J., Lycett, E., Murray-Bligh, J., Pritchard, S. and Wilkins, C. (2001) *The Trophic Diatom Index: A User's Manual. Revised Edition*. Environment Agency R&D Technical Report E2/TR2. Bristol: Environment Agency. Available at http://botany.natur.cuni.cz/neustupa/trophic-diatom-index.pdf

Lane SN, Brookes CJ, Heathwaite AL, Reaney S. (2006). Surveillant science: challenges for the management of rural environments emerging from the new generation diffuse pollution models. *Journal of Agricultural Economics*, 57(2), 239–257

Natural England (2010). *River Wensum SSSI Unit Condition Assessments* March 2010.

Natural England (2014). WFD Biological Quality Element status for River Wensum U/S Norwich waterbody (GB105034055881). Atkins Ref: \\wsatkins.com\project\GBEMC\Water\Project\WENV\Project\5128377 NE Exemplar DWPPs\50_Data&reports in\DI045_EA Data provision_River Wensum.docx

SCIMAP (2013). http://www.scimap.org.uk/scimap-overview/

Sear, D.A., Newson, M., Old, J.C. and Hill., C. (2006). Geomorphological appraisal of the River Wensum Special Area of Conservation. English Nature Research Reports, No 685. Available at http://publications.naturalengland.org.uk/publication/80078.

UKTAG (2013) Final recommendations on new and updated biological standards. Available at http://www.wfduk.org/stakeholders/final-recommendations-new-and-updated-biological-standards-0

UKTAG, 2008a, UKTAG River assessment methods: macrophytes and phytobenthos: phytobenthos–Diatom Assessment for River Ecological Status (DARES). Available at http://www.wfduk.org/resources%20/river-phytobenthos

UKTAG, 2008b, UKTAG Rivers assessment method fish fauna (Fisheries Classification Scheme 2 (FCS2)). Available at http://www.wfduk.org/resources%20/river-fish

UKTAG, 2009. UKTAG River assessment methods: macrophytes and phytobenthos: macrophytes (River LEAFPACS). Available at http://www.wfduk.org/resources%20/river-macrophytes

Appendices

The Appendices are as follows:

Appendix A River Wensum SSSI Citation

Appendix B River Wensum SAC citation

Appendix C FARMSCOPER outputs

Appendix D SAGIS Outputs

Appendix A River Wensum SSSI Citation

Date of Notification: 4 February 1993

COUNTY: Norfolk SITE NAME: RIVER WENSUM

Status: Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981, section 17 of the Water Resources Act 1991, Section 4 of the Water Industry Act 1991 and Section 13 of the Land Drainage Act 1991.

National Rivers Authority Region: Anglian

International Drainage Board: River Wensum

Water Company: Anglian Water Plc

Local Planning Authorities: North Norfolk District Council, Norfolk County Council, Kings Lynn & West Norfolk District Council, South Norfolk District Council, Breckland District Council, Broadland District Council

National Grid Reference: TF 942246 to TG 250078

Length of River SSSI: Approx 71km Area: 393.31 (ha) 971.9 (ac)

Ordnance Survey Sheet 1:50,000: 132 133 134 1:10,000: TF 82 SE NE NW, TF 93 SE, TF 92 SE NE NW, TF 83 SE, TG 01 NE NW, TG 02 SW, TG 11 SE SW NW

Date of Notification (under 1981 Act): 1993

Other Information:
New site.

Description and Reasons for Notification:
Key features
The Wensum has been selected as one of a national series of rivers of special interest as an example of an enriched, calcareous lowland river. With a total of over 100 species of plants, a rich invertebrate fauna and a relatively natural corridor, it is probably the best whole river of its type in nature conservation terms, although short stretches of other similar rivers may show a slightly greater diversity of species.

The upper reaches are fed by springs that rise from the chalk and by run-off from calcareous soils rich in plant nutrients. This gives rise to dense beds of submerged and emergent vegetation characteristic of a chalk stream. Lower down, the chalk is overlain with boulder clay and river gravels, resulting in aquatic plant communities more typical of a slow-flowing river on mixed substrate. Diversity of plant species is further enhanced by mills and weirs; upstream the river slows to produce characteristic deep water plant communities, whilst below the barriers they are replaced by species tolerant of swirling and turbulent water.

Unusually for a lowland river in England, much of the adjacent land is still traditionally managed for hay crops and by grazing, giving a wide spectrum of grassland habitats some of which are seasonally inundated. The mosaic of meadow and marsh habitats, including one of the most extensive reedbeds in the country outside the Broads, provide niches for a wide variety of specialised plants and animals.

The River itself supports an abundant and diverse invertebrate fauna including the native freshwater crayfish *Austropotamobius pallipes* as well as a good mixed fishery. Brown trout *Salmo trutta fario* form the major component of the fish community of the upper

Wensum, whilst the middle and lower reaches are dominated by chub *Leuciscus cephalus*, pike *Esox lucius*, eel *Anguilla anguilla* and barbel *Barbus barbus*. Kingfisher *Alcedo attthis* and little grebe *Tachybaptus ruficollis* breed along the River, whilst the adjacent wetlands have good populations of reed warblers *Acrocephalus scirpaceus*, sedge warblers *Acrocephalus schoenobaenus* and barn owls *Tyto alba*.

Flora

In the upper reaches on gravel substrates lesser water-parsnip *Berula erecta* and the brook water-crowfoot *Ranunculus penicillatus* form a large component of the flora. Where silt has been deposited, spiked water milfoil *Myriophyllum spicatum*, blue water-speedwell *Veronica anagalis-aquatica*, opposite leaved pondweed *Groenlandia densa*, willow moss *Fontinalis antipyretica* and the nationally rare short-leaved starwort *Callitriche truncata* occur.

The middle and lower stretches of the river are characterised by rich lowland plant communities. The dominants are yellow water-lily *Nuphar lutea*, flowering rush *Butomus umbellatus*, fennel pondweed *Potamogeton pectinatus*, perfoliate pondweed *Potamogeton perfoliatus*, arrowhead *Sagittaria sagittifolia* and unbranched bur-reed *Sparganium erectum*. Variations in the aquatic plant community reflect the alternation of fast-flowing shallows with deep slow-moving water. Other species with widespread distribution along the Wensum include rigid hornwort *Ceratophyllum demersum*, spiked water-milfoil *Myriophyllum spicatum*, fan-leaved water-crowfoot *Ranunculus circinatus*, branched bur-reed *Sparganium erectum*, common club-rush *Scirpus lacustris*, horned pondweed *Zannichellia palustris* and the nationally scarce river water-dropwort *Oenanthe fluviatilis*.

The marginal and bankside communities are typical of lowland rivers. Often there are dense and continuous stands of reeds or sedges. Reed sweet-grass *Glyceria maxima* is dominant in the lower reaches. Elsewhere stands of reed canary-grass *Phalaris arundinacea*, greater pond-sedge *Carex riparia*, reedmace *Typha latifolia* and common reed *Phragmites australis* are widespread. Where edges are not dominated by tall emergents, stragling or low-growing herbs such as fool's water-cress *Apium nodiflorum*, water-mint *Mentha aquatica*, water forget-me-not *Myosotis scorpioides* and brooklime *Veronica becaabunga* occur.

Of the semi-natural habitats associated with the River, the most frequently occurring are acidic or neutral unimproved wet grasslands. The flora of these grasslands is typified at Helhoughton and Turf Common by bogbean *Menyanthes trifoliata*, marsh marigold *Caltha palustris*, yellow rattle *Rhinanthus minor*, ragged robin *Lychnis flos-cuculi*, southern marsh orchid *Dactylorhiza praetermissa*, common spotted orchid *Dactylorhiza fuchsii*, water mint *Mentha aquatica* and yellow iris *Iris pseudacorus*.

Elsewhere the land is seasonally inundated so that grazing is restricted; extensive areas of reedbed and tall mixed fen communities have developed which provide valuable breeding and hunting grounds for birds such as the barn owl *Tyto alba* and hen harrier *Circus cyaneus*. Examples include Guist Common which is reed dominated; Goggs Mill Reserve near Fakenham which has a mixed fen community with species such as meadowsweet *Filipendula ulmaria*, angelica *Angelica sylvestris* and meadow rue *Thalictrum flavum*, and Sculthorpe Moor, which although gradually being invaded by willow *Salix* spp. scrub has a fen community of saw sedge *Cladium mariscus* and black bog-rush *Schoenus nigricans*. Although there are several areas of alder swamp interspersed with the above communities, Guist Carr forms the main example of wet woodland within the SSSI.

All of the habitats within the SSSI are intrinsically linked to and dependent on the River for their continued existence. Appropriately, in times of drought, these adjacent wetlands have a vital role in buffering the river against low flows; in wetter periods they absorb river flood waters and become swamp-like in nature.

Two tributaries have been included in the SSSI, the Tat and the Langor Drain. They are both major flow contributors to the main river; historically, the Tat may have been the

original Wensum. The Langor valley comprises an extensive area of semi-natural habitat which is dominated by fen vegetation. The specific composition ranges from almost exclusively reed to a mixture of meadowsweet and sedge species. Parts of Little Ryburgh Common are grazed, having bittersweet *Solanum dulcamara,* branched bur-reed *Sparganium erectum,* water cress *Rorippa nasturtium-aquaticum,* greater tussock sedge *Carex paniculata,* lesser water parsnip *Berula erecta,* water mint *Mentha aquatica,* and marsh marigold *Caltha palustris* as elements in their flora. The vegetation of the drier areas of Little Ryburgh Common includes bracken *Pteridium aquilinum,* honeysuckle *Lonicera periclymenum,* field scabious *Knautia arvensis,* harebell *Campanula rotundifolia* and soft rush *Juncus effusus*.

Invertebrates

The Wensum has an abundant and diverse mollusc fauna which includes the nationally rare, small snail *Vertigo moulinsiana,* which is associated with aquatic vegetation at the river edge. Two other aquatic molluscs which occur, *Valvata piscinalis* and *Gyraulus albus,* have a localised distribution in England. Water beetles are well represented; *Brychnus elevatus,* of localised distribution in England, is found in deep slow-flowing sections of the river. The mayflies *Ephemerella ignita, Caenis luctuosa, Centroptilium luteolum* and *Centroptilium pennulatum* are also of local distribution. There is a species of stonefly, *Amphinemura standfussi,* more usually associated with upland rivers. The flatworm *Crenobia alpina* is of note, being a relict in southern England where it is confined to cold-water springs.

Appendix B River Wensum 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 B **1.2 Site code** UK0012647

1.3 Compilation date 200103 **1.4 Update**

1.5 Relationship with other Natura 2000 sites

1.6 Respondent(s) International Designations, JNCC, Peterborough

1.7 Site name **River Wensum**

1.8 Site indication and designation classification dates

date site proposed as eligible as SCI	200103
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**
00 59 38 E	52 43 04 N

2.2 Site area (ha) 381.74 **2.3 Site length (km)**

2.5 Administrative region

NUTS code	Region name	% cover
UK402	Norfolk	100.00%

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
Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation	20	B	C	B	**B**
Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*	0.5	D			
Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	0.5	D			

3.2 Annex II species

	Population				Site assessment			
	Resident	Migratory						
Species name		Breed	Winter	Stage	Population	Conservation	Isolation	Global
Vertigo moulinsiana	Common	-	-	-	C	B	C	**C**
Austropotamobius pallipes	Common	-	-	-	C	B	B	**B**
Lampetra planeri	Common	-	-	-	C	B	C	**C**
Cottus gobio	Common	-	-	-	C	B	C	**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)	
Salt marshes. Salt pastures. Salt steppes	
Coastal sand dunes. Sand beaches. Machair	
Shingle. Sea cliffs. Islets	
Inland water bodies (standing water, running water)	42.0
Bogs. Marshes. Water fringed vegetation. Fens	12.0
Heath. Scrub. Maquis and garrigue. Phygrana	
Dry grassland. Steppes	
Humid grassland. Mesophile grassland	40.0
Alpine and sub-alpine grassland	
Improved grassland	
Other arable land	
Broad-leaved deciduous woodland	6.0
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, Neutral, Nutrient-rich, Peat, Sand, Sedimentary

Geomorphology & landscape:

Floodplain, Lowland, Valley

4.2 Quality and importance

Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

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

Vertigo moulinsiana

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

Austropotamobius pallipes

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

Lampetra planeri

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

Cottus gobio

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

4.3 Vulnerability

A stepped profile, with alternating fast- and slow-moving reaches, was imposed on the river with the construction of water-mills. Habitat diversity has been reduced by the modification of the channel form. The input of silt and agricultural chemicals as a result of arable farming practices are a concern and the reversion of arable fields to low-input grassland should be encouraged. A strategy should be devised for silt management in the river and catchment to minimise disturbance to the channel and bankside. Further development on the flood plain might alter the flow regime of the river.
More detailed studies on groundwater resources should be carried out so as to determine suitable flow objectives to ensure that the river's ecology is not threatened by water abstraction. At adjacent sewage treatment works, phosphorous removal will be a statutory requirement by 2004. However, a holistic strategy is needed to identify further mechanisms for the control of eutrophication.
Any increase in the distribution of *Pacifastacus leniusculus* within the catchment would threaten the long-term viability of *Austropotamobius pallipes*. Populations of *Lampetra planeri* and *Cottus gobio* are dependent on the maintenance of riffle habitats and might also be vulnerable to the introduction of non-native fish species. Populations of *Vertigo moulinsiana* are susceptible to interference with the emergent bank-side vegetation in which they occur.

5. Site protection status and relation with CORINE biotopes:

5.1 Designation types at national and regional level

Code	% cover
UK04 (SSSI/ASSI)	100.0

Appendix C FARMSCOPER outputs

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

WB_ID	Waterbody name	Modelled total P loss from all farms within that water body (according to Ag Census) (kg P/yr)	Water bodies losing the most P from Agri sources (Rank 1–10)	Modelled total P loss from ARABLE within that water body (kg P/yr)	Modelled total P loss from LIVESTOCK farms within that water body (kg P/yr)	Modelled total P that could be saved by applying "Top 5" measures to all farms within that water body (kg P/yr)	Modelled total P that could be saved by applying "top 5" measures to all ARABLE farms within that water body (kg P/yr)	Modelled total P that could be saved by applying "top 5" measures to all LIVESTOCK farms within that water body (kg P/yr)	Ranked magnitude of P savings to be made from applying top 5 measures in water body (where 1 is highest)
GB105034051080	Tributary of Wensum								
GB105034051100	Wensum upstream 1								
GB105034051110	Wensum upstream 2	132	9	130	1.96	44	43	1	9
GB105034055870	Tat 1								
GB105034051130	East Rudham Stream								
GB105034051140	Tat 2	251	7	160	91	97	51	46	7
GB105034055860	Little Ryburgh Tributary	0	10			0			10
GB105034051020	Wendling Beck	583	3	364	219	236	121	116	3
GB105034051050	Blackwater	202	8	202	0	67	67	0	8
GB105034051010	Penny Spot Beck								
GB105034051090	Tributary of Blackwater Drain 1								
GB105034051120	Blackwater Drain upstream								
GB105034051030	Blackwater Drain mid								
GB105034051060	Tributary of Blackwater Drain 2								
GB105034051040	Blackwater Drain downstream	424	4	248	176	177	82	95	4
GB105034051070	Swannington Beck	254	6	100	154	115	32	83	6
GB105034051000	Tud	1219	2	452	766.68	451	150	301	2
GB105034055881	Wensum, upstream of Norwich	1728	1	740	988.24	667	244	423	1
GB105034055850	Foulsham Tributary	272	5	96	176	128	33	95	5

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

WB_ID	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%)
GB105034051080	Tributary of Wensum						
GB105034051100	Wensum upstream 1						
GB105034051110	Wensum upstream 2	33%	Moderate	32%	Moderate	1%	Low
GB105034055870	Tat 1						
GB105034051130	East Rudham Stream						
GB105034051140	Tat 2	39%	Moderate	20%	Low	18%	Low
GB105034055860	Little Ryburgh Tributary						
GB105034051020	Wendling Beck	41%	Moderate	21%	Low	20%	Low
GB105034051050	Blackwater	33%	Moderate	33%	Moderate	0%	Low
GB105034051010	Penny Spot Beck						
GB105034051090	Tributary of Blackwater Drain 1						
GB105034051120	Blackwater Drain upstream						
GB105034051030	Blackwater Drain mid						
GB105034051060	Tributary of Blackwater Drain 2						
GB105034051040	Blackwater Drain downstream	42%	Moderate	19%	Low	22%	Low
GB105034051070	Swannington Beck	45%	Moderate	13%	Low	33%	Moderate
GB105034051000	Tud	37%	Moderate	12%	Low	25%	Low
GB105034055881	Wensum, main	39%	Moderate	14%	Low	25%	Low
GB105034055850	Foulsham Tributary	47%	Moderate	12%	Low	35%	Moderate

Appendix D 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 (g/day)	Rank PO4 Load	STW load as % overall	Livestock load as % overall load	Arable load as % overall load	Urban load as % overall load	Is water body ranked high (1–5) for size (Q95)?	Is water body ranked high (1–5) (excl Wensum overall) for P load?	Is STW 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?
GB105034051080	Tributary of Wensum	297	16	0%	19%	41%	37%					Y	Y
GB105034051100	Wensum upstream 1	1183	10	0%	22%	66%	10%	Y				Y	
GB105034051110	Wensum upstream 2	1217	9	0%	23%	64%	11%	Y				Y	
GB105034055870	Tat 1	662	11	15%	1%	1%	79%						Y
GB105034051130	East Rudham Stream	199	18	76%	4%	9%	3%			Y			
GB105034051140	Tat 2	2140	5	11%	14%	38%	33%	Y	Y			Y	Y
GB105034055860	Little Ryburgh Tributary	338	15	0%	21%	13%	64%						Y
GB105034051020	Wendling Beck	8279	2	57%	8%	16%	7%	Y	Y	Y			
GB105034051050	Blackwater	1789	7	0%	49%	50%	0%				Y	Y	
GB105034051010	Penny Spot Beck	657	12	0%	42%	52%	4%				Y	Y	
GB105034051090	Tributary of Blackwater Drain 1	552	14	0%	33%	52%	11%				Y	Y	
GB105034051120	Blackwater Drain upstream	1357	8	64%	7%	11%	10%			Y			
GB105034051030	Blackwater Drain mid	2002	6	43%	16%	24%	10%			Y			
GB105034051060	Tributary of Blackwater Drain 2	609	13	0%	51%	46%	0%				Y	Y	
GB105034051040	Blackwater Drain downstream	2666	4	32%	26%	29%	8%		Y	Y	Y	Y	
GB105034051070	Swannington Beck	228	17	0%	43%	29%	0%				Y	Y	
GB105034051000	Tud	4142	3	17%	28%	21%	21%		Y		Y		
GB105034055881	Wensum, upstream of Norwich	29384	1	23%	16%	15%	23%	Y	Y				

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