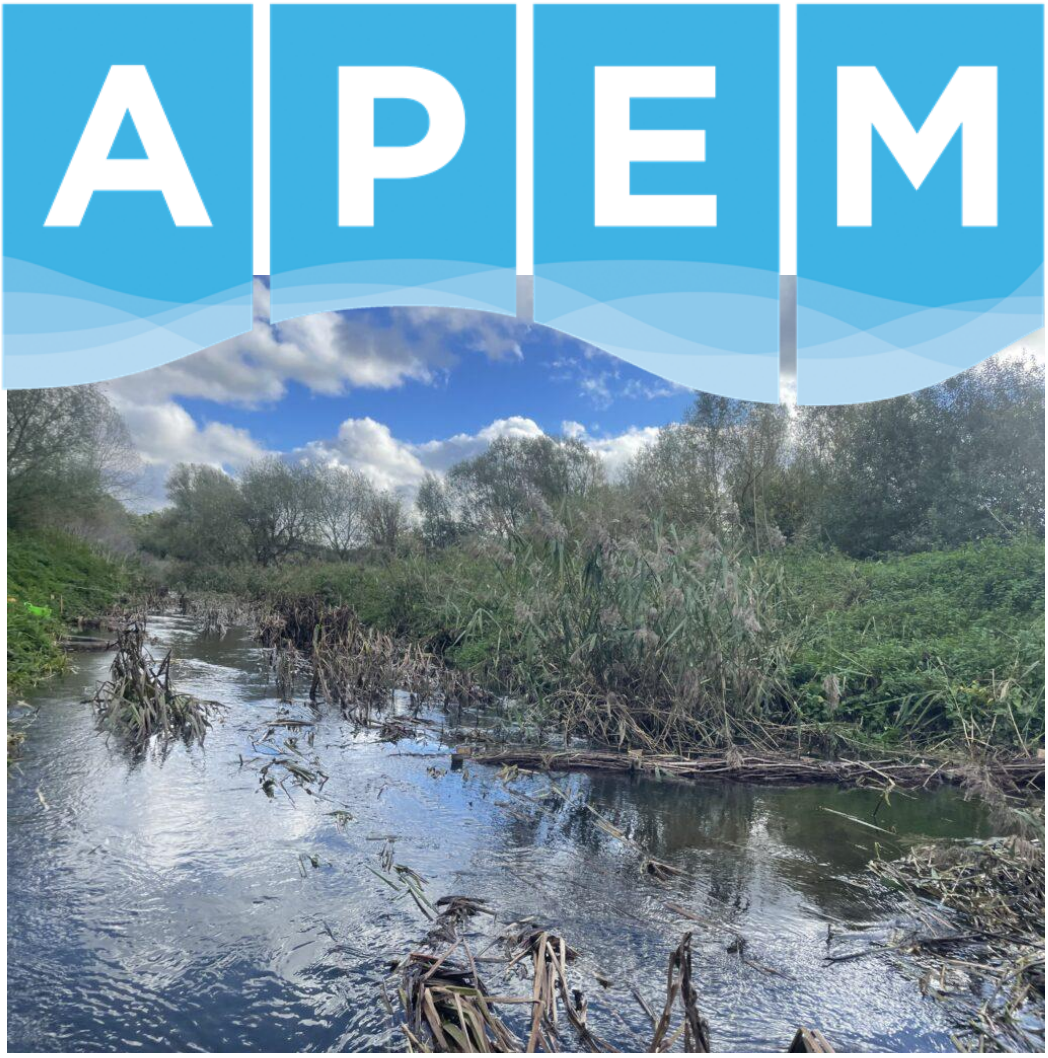

River Lark Catchment Optimisation

Anglian Water Services Ltd

April 2022

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1. Executive summary

The River Lark catchment comprises of 12 surface water bodies under the EU Water Framework Directive (WFD). None of these water bodies achieve Good status under the current WFD classification. The River Lark Pollution Review and Action Plan identified the primary concerns within the catchment contributing to the WFD classification status: physical modification; low flow; invasive non-native species (INNS); and point-source and diffuse pollution. The aim of this project was to identify four priority water bodies to focus on for initial catchment improvements, undertake a natural capital baseline assessment and find locations for the undertaking of catchment measures.

APEM's Optimisation Assessment Tool (OAT) identified four water bodies that should be prioritised: Lark (Abbey Gardens to Mildenhall); Tuddenham Stream; Cavenham Steam; and Lark (Hawstead to Abbey Gardens). A natural capital baseline assessment was carried out for the four water bodies. It found that a total of £21,717,943 of benefit was provided by the four water bodies in total. Highest areas of natural capital density largely surrounded wooded areas as well as recreational sites, whereas areas of low natural capital density were within urbanised centres.

Catchment measures were then determined within the four chosen water bodies – these included land use change, channel modification, and riparian improvement measures. Forty-four georeferenced locations were identified for 15 catchment measures.

Recommended next steps include completing walkover surveys at specified locations to determine their suitability measure deployment, working with landowners to expand dense natural capital out to areas where it may be lacking, and then re-running a natural capital assessment once catchment restoration has been completed.

2. Background

2.1 Project background

The River Lark stretches 57 km from its chalk spring headwaters in Suffolk to its confluence with the River Great Ouse in Cambridgeshire. Its tributaries include the River Linnet, Culford Stream, Cavenham Stream, Tuddenham Stream and the River Kennet (EA, Lark Operational Catchment, 2022). Historically, the Lark was used for navigation through to the River Ouse and the ocean beyond. Navigation on the river had been continuously improved from 1621 (St Edmundsbury, 2016); however, the waterway was officially abandoned in 1888 and today only 16km of the river is navigable (Inland Waterways Association, 2022). As one of only 200 chalk rivers globally, the Lark possesses ecologically and hydrologically important habitat.

In April 2021, the River Lark Pollution Review and Action Plan was published. This action plan highlighted the key pressures to the catchment to be: physical modifications, low flows, point source discharges, diffuse pollution, and invasive species; as well as highlighting proposed and ongoing solutions to these issues across the catchment (Brighty, et al., 2021). Currently, none of the Lark's twelve surface water bodies achieve good ecological or chemical status (Figure 1); however, there is substantial catchment-wide investment planned under the AMP7 WINEP programme between 2020 and 2024 which aims to improve the Lark by targeting the key pressures across the catchment (Brighty, et al., 2021). Solutions to improve the Lark detailed in the action plan include enhanced monitoring and data collection; engage with landowners to promote sustainable water sensitive farming practices; and the identification and delivery of river restoration projects (Brighty, et al., 2021).

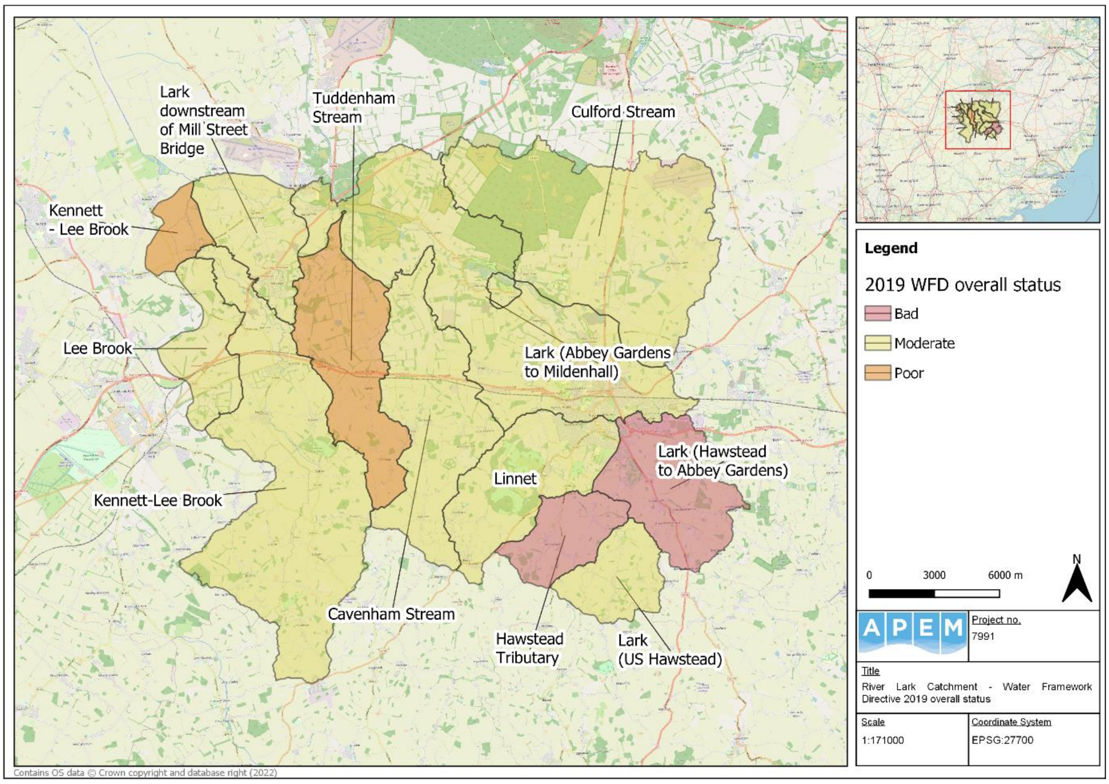


Figure 1 River Lark catchment

Table 1 Lark catchment water bodies and reasons for not achieving good (RNAG) status

Waterbody ID	Water body name	2019 WFD RNAG
GB105033043051	Lark (Abbey Gardens to Mildenhall)	Physical modification, groundwater abstraction, sewage discharge (continuous), groundwater abstraction, surface water abstraction, and trade/industry discharge.
GB105033043000	Cavenham Stream	Groundwater and surface water abstraction.
GB105033043010	Tuddenham Stream	Physical modification, sewage discharge (continuous), groundwater abstraction, surface water abstraction, and land drainage.
GB105033042940	Lark (Hawstead to Abbey Gardens)	Groundwater abstraction, sewage discharge (continuous), North American signal crayfish, natural conditions, land drainage, urbanisation, flood protection - structures, poor livestock management, and low flow (not drought).
GB105033043030	Culford Stream	Physical modification - flood protection, other (local and central government and recreation).
GB105033042930	Hawstead Tributary	Poor soil management, drought, sewage discharge (continuous), physical modification - land drainage.
GB105033043020	Kennett - Lee Brook	Poor soil management, physical modification - land drainage, flow - groundwater abstraction (agriculture and rural land management and water industry), North American signal crayfish
GB105033042990	Kennett-Lee Brook	Poor nutrient management (agriculture), sewage discharge (water industry) physical modification - barriers, flow - groundwater abstraction, North American signal crayfish
GB105033042920	Lark (HS Hawstead)	Sewage discharge (continuous), physical modification - land drainage (agriculture), North American signal crayfish
GB105033043052	Lark downstream of Mill Street Bridge	Sewage discharge (continuous), physical modification (urban and transport, local and central government)
GB105033042970	Lee Brook	Sewage discharge (continuous), flow - groundwater abstraction
GB105033042950	Linnet	Sewage discharge (continuous), Physical modification (local and central government, agriculture and rural land management, urban and transport, flood protection, urbanisation), flow water abstraction, groundwater abstraction (agriculture and water industry), North American signal crayfish

2.2 Project objective

This project aimed to identify four priority water bodies within the Lark Catchment using OAT and determine catchment measures that address the primary concerns identified in the River Lark Pollution Review and Action Plan. However, it is important to note that it was not within the scope of this project to assess the issue of point-source pollution as there are other mechanisms in which this issue is addressed. Additionally, it was not within the scope to create a bespoke plan at each water body – but rather, a list of measures that may be incorporated within the water body in question, with some geographical examples given. Additionally, a natural capital perspective was taken to quantify the benefit of implementation of said catchment measures using APEM's COVER+® tool, with the objective of aiding decision-making and providing further evidence of the value of catchment restoration.

3. Catchment prioritisation

3.1 OAT methodology

All Lark catchment water bodies were assessed in OAT to determine the top four for recommendation for catchment intervention. Twenty metrics were used to assess the water bodies, as detailed in Table 2. All are derived from publicly available datasets, except number of properties at risk of flooding (in which a Freedom of Information request was made to the Environment Agency). Metrics not included for analysis were invertebrate and macrophyte presence. These were identified as a means to determine flow within the water bodies; however, the data sampling locations were not evenly spread throughout the Lark catchment, so were not included.

Table 2 OAT metrics

Metric	Description	Source
WFD status	The WFD Overall status and Ecological status were incorporated into OAT as a proxy for water quality of the water body. A higher score indicates low quality and higher prioritisation.	EA Catchment Data Explorer
Flood Zone	The EA Flood Map for Planning (Rivers and Sea) Flood Zones 2 and 3 were included into OAT as a metric for how at risk the area was to flooding. Areas within Flood Zone 2 are estimated to have a 1 in 1000 (0.1%) chance of flooding each year. Areas within Flood Zone 3 are estimated to have a 1 in 100 (1%) chance of flooding from rivers and 1 in 200 (0.5%) chance of flooding from the sea each year. A higher score indicates a higher risk of flooding and higher prioritisation.	EA Flood Map Planning (Rivers and Sea) – Flood Zone 2 and EA Flood Map for Planning (Rivers and Sea) – Flood Zone 3
Properties at risk of flooding	An FOI request was made (on 21 February 2022) to the EA to obtain number of properties at risk of flooding. These are properties that are located within Flood Zone 2. A higher score indicates more properties at risk of flooding and higher prioritisation.	EA FOI request
Population	Population within the water body was determined using population density of the local authority and taking a proportional approach based on the water body size. This was used to approximate pollution to the water body. A higher score indicates a higher population and higher prioritisation.	ONS 2020
Diffuse pollution	The proportion of arable land was used as a proxy for diffuse pollution as it is understood that farming practices contribute to diffuse pollution (EA, 2019).	Copernicus CORINE land cover (2018)

Metric	Description	Source
	The Copernicus CORINE land cover shapefile was used to determine the proportion of arable land within each water body catchment. A higher score indicates a higher percentage of arable land and higher prioritisation.	
Invasive species	Density of riparian and freshwater INNS were included as a proxy for the catchment habitat quality. INNS data were downloaded from the National Biodiversity Network (NBN) for the following species lists: Wildlife and Countryside Act (Schedule 9), WFD UK Technical Advisory Group, and Alien Species of Union Concern. A higher score indicates a higher density of invasive species and higher prioritisation.	NBN Atlas open-source data
Protected species	Density of riparian and freshwater protected species was included as a proxy for the catchment habitat quality. Protected species data was downloaded from the NBN for the following species lists: Wildlife and Countryside Act (Schedules 5 and 8), Habitats Directive (Annex 2), and Natural Environment Research Council (Schedule 41). Protected species were categorised based on their status on the International Union for Conservation of Nature (IUCN) red list. Species that were critically endangered were scored higher than those considered of least concern. An overall protected species score was given by multiplying the density of least concern, endangered and critically endangered. A higher score indicates better quality habitat and higher prioritisation.	NBN Atlas open-source data IUCN Red List
Designated sites	Level of site designation (local, national, international) within the water body catchment, if applicable, was used to determine the importance of the habitat. A higher score indicates a higher site designation and higher prioritisation.	NE Local Nature Reserves, NE National Nature Reserves, NE Special Areas of Conservation, and NE Special Protection Areas NE Sites of Special Scientific Interest
Climate change vulnerability	The proportion of the water body considered to be climate change vulnerable was used to determine the importance of intervention. This was broken up by high, medium and low vulnerability – in which a score was applied to area of low vulnerability, a sperate score of area of medium vulnerability and third score for area of high vulnerability within the water body catchment. A higher score indicates a higher climate change vulnerable area and higher prioritisation.	NE National Biodiversity Climate Change Vulnerability Assessment
Safeguard zones - groundwater	Safeguard groundwater drinking zone was used to increase the significance of the water body catchment due to providing drinking water. A higher score indicates a higher proportion of safeguard zone within the water body catchment and a higher prioritisation.	Drinking Water Safeguard Zones (Groundwater)

Metric	Description	Source
Greenspace	The proportion of greenspace was used to determine level of public engagement with the water body catchment. A higher score indicates a higher proportion of greenspace and higher prioritisation.	OS Greenspace and proposed greenspace by River Lark Catchment Partnership.

Each metric was scored individually and then multiplied together to obtain an overall score for each water body – whereby a higher score indicates prioritisation. The metrics were categorised and scored differently based on how heavily each metric should be weighted (and therefore considered more important). For instance, it was noted that diffuse pollution was an issue of high importance in the Lark catchment; therefore, the diffuse pollution metric was given the highest weighting.

An impact level was also assigned to each score based on the category. The impact is defined by how severely that metric is scored – a higher score for a metric means it will contribute a larger impact to the overall score for the water body. Impact levels are categorised by the number of bins (groupings) the data has. For instance, Table 3 shows an example of the scoring for diffuse pollution and score impact. This metric contains 5 bins with the impact ranging from low to very high. Other metrics contain 4 bins, which are defined by the data quartiles and range from low to high. In the case of diffuse pollution, an additional bin was added to further separate the data and provide more detailed results. For more information about how each metric was scored see Appendix 1 .

Table 3 Diffuse pollution scoring

Diffuse pollution (proportion of arable land)	Score	Impact
<40%	1	Low
40-55%	2	Low-Moderate
55-70%	3	Moderate-High
70-85%	4	High
>85%	5	Very high

In order to prevent the largest water bodies from automatically scoring highest, a proportional approach was taken. For instance, the protected species metric was scored by the density of species found (i.e. number of species divided by area of water body) rather than simply the number of species. This removes the chance of skewing the results towards the larger water bodies that may contain higher species numbers due to its size.

3.2 OAT results

The scores quantified by OAT were fairly evenly distributed throughout the Lark catchment (Table 4), with the lowest score held by Kennett-Lee Brook and highest score held by Lark (Abbey Gardens to Mildenhall). The top four scoring water bodies were determined to be the priority water bodies for catchment intervention, these include: Lark (Abbey Gardens to Mildenhall), Tuddenham Stream, Cavenham Stream and Lark (Hawstead to Abbey Gardens). The respective scores for each were 218, 167,132 and 96.

A variety of values distinguish these four areas from the rest of the catchment, for example these areas have particularly high designated site and protected species scores which contribute towards their high overall scores – among other things. Many areas scored highly in diffuse pollution score including Cavenham stream, Tuddenham stream, and Lark (Hawstead to Abbey Gardens). The high 2019 WFD score for Tuddenham stream should also be noted.

Table 4 OAT results

Water body	Overall score
Lark (Abbey Gardens to Mildenhall)	218
Tuddenham Stream	167
Cavenham Stream	132
Lark (Hawstead to Abbey Gardens)	96
Kennett - Lee Brook	86
Lark downstream of Mill Street Bridge	75
Culford Stream	63
Hawstead Tributary	53
Lark (US Hawstead)	53
Lee Brook	25
Kennett-Lee Brook	22
Linnet	21

3.2.1 Lark (Abbey Gardens to Mildenhall) (GB105033043051)

Lark (Abbey Gardens to Mildenhall) scored the highest of all water bodies within the Lark catchment. Table 5 details the scoring for each metric within Lark (Abbey Gardens to Mildenhall) and Figure 2 depicts a radar plot of the metric scores. Of the 20 metrics, six were considered to be of high impact, four high-moderate impact, five moderate impact, and five of low impact. The primary metrics that caused Lark (Abbey Gardens to Mildenhall) to have the highest score are number of properties at risk of flooding, population, protected species, designated sites and climate change vulnerability.

Table 5 Lark (Abbey Gardens to Mildenhall) OAT scores

Metric	Lark (Abbey Gardens to Mildenhall)	Impact
WFD Overall Score	1.5	Low
WFD Ecological Status Score	1.5	Low
Flood Zone 2 Risk Score	1.15	Moderate
Flood Zone 3 Risk Score	1.2	Moderate
Properties at Risk Score	1.25	High
Population Score	1.25	High
Diffuse Pollution Score	3	Moderate-High
Protected Species Score	1.66	High

Metric	Lark (Abbey Gardens to Mildenhall)	Impact
INNS Score	1.4	Moderate-High
Designated Site Score	1.2	High
Local Nature Reserve Score	1.1	Low
National Nature Reserve Score	1.15	Low
SPA Score	1.25	High
SAC Score	1.15	Low
SSSI Score	1.3	Moderate
Climate Change Vulnerability - Low Risk Score	1.15	Moderate-High
Climate Change Vulnerability - Medium Risk Score	1.2	Moderate-High
Climate Change Vulnerability - High Risk Score	1.3	High
Safeguard Zone (Groundwater) Score	1.15	Moderate
Greenspace Score	1.15	Moderate

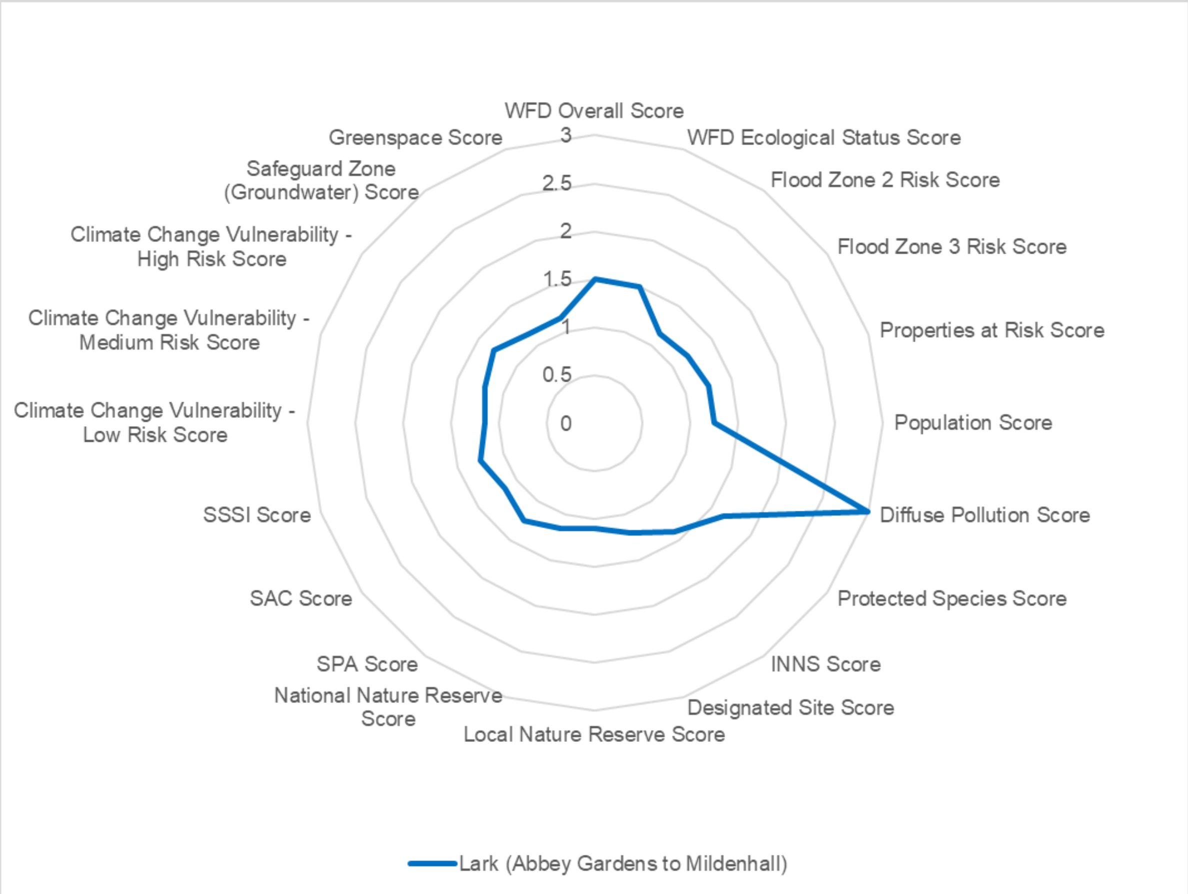


Figure 2 Lark (Abbey Gardens to Mildenhall) radar plot showing the scores for each metric

The number of properties at risk of flooding was 272 – the second highest in the Lark catchment (following Linnet). The population within Lark (Abbey Gardens to Mildenhall) was anticipated to be approximately 15,000 people, which was the highest in the Lark catchment. There were eight protected species observed within the water body (Table 6) – six of which were least concern, one endangered, and one critically endangered according to the IUCN Red List (2021). The number of INNS recorded within the catchment were 13 (Table 7), which was the highest number within the Lark catchment. Additionally several SSSIs are within the water body boundary, these include: Brechland Farmland; Breckland Forest; Cavenham - Icklingham Heaths; Cherry Hill and The Gallops, Barton Mills; Deadman's Grave, Icklingham; How Hill Track; Lackford Lakes; The Glen Chalk Caves, Bury St Edmunds; and West Stow Heath.

Table 6 Protected species within Lark (Abbey Gardens to Mildenhall)

Scientific name	Common name	IUCN status
Anguilla anguilla	European Eel	Critically Endangered
Arvicola amphibius	European Water Vole	Endangered
Bufo bufo	Common Toad	Least Concern
Cottus gobio	Bullhead	Least Concern
Lampetra planeri	Brook Lamprey	Least Concern
Lutra lutra	European Otter	Least Concern
Oenanthe fistulosa	Tubular Water-dropwort	Least Concern
Salmo trutta	Brown/Sea Trout	Least Concern

Table 7 INNS recorded in the Lark (Abbey Gardens to Mildenhall) water body

Scientific name	Common name
Cyprinus carpio	Common Carp
Elodea canadensis	Canadian Waterweed
Elodea nuttallii	Nuttall's Waterweed
Fallopia japonica	Japanese Knotweed
Ferrissia (Petancyclus) wautieri	Wautier's Limpet
Heracleum mantegazzianum	Giant Hogweed
Impatiens glandulifera	Himalayan Balsam
Lemna minuta	Least Duckweed
Pacifastacus leniusculus	Signal Crayfish
Physella acuta	(blank)
Potamopyrgus antipodarum	Jenkins' Spire Snail
Robinia pseudoacacia	False-acacia
Sander lucioperca	Zander

3.2.2 Tuddenham Stream (GB105033043010)

Tuddenham Stream scored second highest in the Lark catchment. Table 8 details the scores for each metric within Tuddenham Stream and Figure 3 illustrates the metric scores using a radar diagram. Of the 20 metrics, one was considered to be very high impact, two high impact, two moderate-high impact, five moderate impact, one low-moderate impact and the remaining nine metrics either low or very low impact. The primary metrics that led Tuddenham Stream to score highly were population, diffuse pollution, and designated sites.

The estimated population within Tuddenham Stream was approximately 6,000 people, which is the fifth highest within the Lark catchment. Approximately 84% of the water body area is arable land – the fifth highest. There are also many internationally designated sites within the water body, including Breckland Farmland SSSI; Cavenham - Icklingham Heaths SSSI; Cherry Hill and The Gallops SSSI, and Barton Mills SSSI.

Table 8 Tuddenham Stream OAT scores

Metric	Tuddenham Stream	Impact
WFD Overall Score	2	Moderate
WFD Ecological Status Score	2	Moderate
Flood Zone 2 Risk Score	1	Very Low
Flood Zone 3 Risk Score	1	Very Low
Properties at Risk Score	1.15	Low
Population Score	1.2	Moderate-High
Diffuse Pollution Score	5	Very High
Protected Species Score	1.63	Moderate
INNS Score	1.2	Low
Designated Site Score	1.2	High
Local Nature Reserve Score	1	Very Low
National Nature Reserve Score	1	Very Low
SPA Score	1.2	Moderate
SAC Score	1	Very Low
SSSI Score	1.3	Moderate
Climate Change Vulnerability - Low Risk Score	1.15	Moderate-High
Climate Change Vulnerability - Medium Risk Score	1.15	Low-Moderate
Climate Change Vulnerability - High Risk Score	1.3	High
Safeguard Zone (Groundwater) Score	1	Very Low
Greenspace Score	1	Very Low

Figure 3 Tuddenham Stream radar plot showing the scores for each metric

3.2.3 Cavenham Stream (GB105033043000)

Cavenham Stream scored the third highest of the water bodies in the Lark catchment. Table 9 details the scores for each metric. Of the 20 metrics, one was considered of very high impact, one of high impact, three moderate-high impact, four moderate impact, two low-moderate and the remaining nine metrics low or very low. The noteworthy metrics that caused Cavenham Stream to result in being a water body for prioritisation are population, diffuse pollution, designated sites, and climate change vulnerability.

The population within Cavenham Stream was estimated to be approximately 7,400 people, which is the fourth highest within the Lark catchment. Cavenham Stream has the third highest proportion of arable land at around 87%. Two internationally recognised sites are also found within the water body: Black Ditches, Cavenham SSSI and Breckland Farmland SSSI.

Table 9 Cavenham Stream OAT scores

Metric	Cavenham Stream	Impact
WFD Overall Score	1.5	Low
WFD Ecological Status Score	2	Moderate
Flood Zone 2 Risk Score	1	Very Low
Flood Zone 3 Risk Score	1	Very Low
Properties at Risk Score	1.2	Moderate
Population Score	1.2	Moderate-High
Diffuse Pollution Score	5	Very High
Protected Species Score	1.5	Moderate
INNS Score	1.3	Low-Moderate
Designated Site Score	1.2	High
Local Nature Reserve Score	1	Very Low
National Nature Reserve Score	1	Very Low
SPA Score	1.2	Moderate
SAC Score	1	Very Low
SSSI Score	1.2	Low
Climate Change Vulnerability - Low Risk Score	1.15	Moderate-High
Climate Change Vulnerability - Medium Risk Score	1.15	Low-Moderate
Climate Change Vulnerability - High Risk Score	1.25	Moderate-High
Safeguard Zone (Groundwater) Score	1.1	Low
Greenspace Score	1	Very Low

Figure 4 Cavenham Stream radar plot showing the scores for each metric

3.2.4 Lark (Hawstead to Abbey Gardens) (GB105033042940)

Lark (Hawstead to Abbey Gardens) scored as the fourth highest water body for prioritisation in the Lark catchment. Table 10 details the scores for each metric within Lark (Hawstead to Abbey Gardens) and Figure 5 shows the metric scores in a radar plot. Of the 20 metrics, two were considered to be high impact, three moderate-high impact, four moderate impact, two low-moderate impact and the remining nine metrics either low or very low impact. The primary reasons that caused this result were the WFD 2019 status, diffuse pollution, INNS and climate change vulnerability.

The 2019 WFD overall status for Lark (Hawstead to Abbey Gardens) was 'bad'. Approximately 85% of the water body is arable land, which is the fourth highest in the Lark catchment. There were four species of INNS recorded within the water body: Signal crayfish (*Pacifastacus leniusculus),* Jenkin's spire snail (*Potamopyrgus antipodarum*), Canadian waterweed (*Elodea canadensis*), and Common Carp (*Cyprinus carpio*).

Table 10 Lark (Hawstead to Abbey Gardens)

Metric	Lark (Hawstead to Abbey Gardens)	Impact
WFD Overall Score	2.5	High
WFD Ecological Status Score	1.5	Low
Flood Zone 2 Risk Score	1	Very Low
Flood Zone 3 Risk Score	1	Very Low
Properties at Risk Score	1.2	Moderate
Population Score	1.15	Low-Moderate
Diffuse Pollution Score	4	High
Protected Species Score	1.38	Moderate
INNS Score	1.4	Moderate-High
Designated Site Score	1.15	Moderate
Local Nature Reserve Score	1.1	Low
National Nature Reserve Score	1	Very Low
SPA Score	1	Very Low
SAC Score	1	Very Low
SSSI Score	1.0	Very Low
Climate Change Vulnerability - Low Risk Score	1.1	Low-Moderate
Climate Change Vulnerability - Medium Risk Score	1.2	Moderate-High
Climate Change Vulnerability - High Risk Score	1.25	Moderate-High
Safeguard Zone (Groundwater) Score	1	Very Low
Greenspace Score	1.15	Moderate

Figure 5 Lark (Hawstead to Abbey Gardens) radar plot showing the scores for each metric

3.3 OAT limitations

A bespoke version of OAT was built to include relevant datasets identified by stakeholders. As such it is important to note the limitations that exist when building/using tools to determine outcomes.

As mentioned, metrics were scored and weighted based on their importance. It was noted that this risks the event of creating a tool that provides values that would be expected rather than letting the data speak for themselves. However, weightings were still incorporated – with all discussed and approved by Anglian Water Services.

Macrophyte and invertebrate data were identified by stakeholders as important to incorporate into the tool as a proxy for flow. However, due to the limited data available on the EA Catchment Explorer, these data were not included for assessment within OAT. This is because the macrophyte and invertebrate samples were not adequately distributed between the water bodies. Therefore, the inclusion of these data would cause the results to be skewed towards the water bodies that contained samples and away from water bodies that lacked samples. However, the 2019 WFD ecological status was incorporated which does take into account macrophyte and invertebrate presence.

4. Ecosystem services quantification using COVER+®

4.1 Ecosystem services & COVER+®

4.1.1 Natural capital and ecosystem services

Natural Capital is defined by the UK Government's 25-Year Environment Plan as:

'the elements of nature that either directly or indirectly provide value to people'.

Natural capital assets are the stocks of renewable and non-renewable natural resources and the natural processes that underpin them. For example, soils, forests, farmland, rivers, minerals and oceans. The benefits we obtain from these natural capital assets are referred to as ecosystem services. These can often be obvious such as clean water, timber, food and opportunities for recreation. However, these services can also be indirect and 'invisible' such as pollinator services or a sense of well-being.

Ecosystem services are categorised into four main groups: provisioning, regulating, cultural and supporting. Provisioning services are those which provide tangible outputs, such as timber and food. Regulatory services provide a regulating function to an ecosystem process, such as carbon sequestration and water purification. Cultural services relate to a society's sense of well-being and connection, such as recreation and physical health. Lastly, supporting services are determined to be those which underpin all the services such as nutrient cycling. Generally supporting services are not included in natural capital assessments in order to prevent double counting.

4.1.2 COVER+®

COVER+® was created by APEM in 2021 and calculates values for ecosystems services in a quantitative way that, where possible, are monetised. The tool integrates methods that are well-tested and credible, such as the EA's Enabling a Natural Capital Approach (ENCA).

Primary inputs are derived from GIS spatial interrogation using datasets such as CORINE land cover. The tool pulls all these approaches together in a transparent and robust way; facilitating spatial representation of natural capital outputs to support better decision making and stakeholder engagement.

Cover+® can provide quantification for the following ecosystem services shown in Table 11.

Table 11 COVER+® Ecosystem services assessed and approaches utilised

Ecosystem service type	Ecosystem service	Approach	Output
Provisioning	Agriculture	Follows EA NCRAT. Yield of wheat, dairy and meat provided by agricultural land is multiplied by gross margin (John Nix Pocketbook for Farm Management, 2022).	£ / year
	Timber	Follows EA NCRAT. This service recognises that the value of standing wood at least equates to the cost of timber – whether or not the wood is actually used for timber production. To measure value of woodland, the total volume of timber harvested in the UK (ONS, 2020) is divided by the total area of UK woodland (Forest Research, 2018), which gives volume timber removals per hectare of woodland. This is then applied to the price of standing woodland (Forest Research, 2021).	£ / year
	Water regulation – pumping water supply	This service is measured at the local authority level, then made proportional by the percent area each water body is within the local authority. ONS provides population density per local authority, this was used to approximate the number of people living within the water body area. Then it was assumed that each person uses approximately 142 l/day of water, which corresponds to a price of £20 /year/person (Energy Savings Trust, 2013).	£ / year
Regulating	Air Purification	Follows EA NCRAT. Measures the removal rate of PM2.5, SO2, NO2 and O3. The removal rate from each habitat type for each pollutant is multiplied by value of removal (Jones, et al., 2017).	£ / year
	Carbon Sequestrati on	Follows EA NCRAT. Carbon sequestration rates for habitats (Christie, et al., 2011) are multiplied by Business, Energy & Industrial Strategy (BEIS) non-traded price of carbon (BEIS, 2021).	£ / year
	Water quality/purifi cation	Follows EA NCRAT. Operational catchment information is found for each site within surface waterbodies (EA, 2021), then a monetary value provided by the National Water Environment Benefits Survey (NWEBS) is multiplied by the km of 'Good' and 'High' status water bodies (EA, 2013).	£ / year
	Flood risk	Follows EA NCRAT. Values are quantified by estimating the amount of stored water that does not enter a river or sewer system and the costs saved from flooding damages (JBA Consulting, 2016).	£ / year
Cultural	Recreation	The Outdoor Recreation Valuation Tool (ORVal) provides number of visitors/year and welfare value associated with visits based on travel costs (Unitversity of Exeter, 2022).	# Visits / year £ / year
	Physical health	According to White et al., 43% of visits to greenspaces are estimated to involve at least 30 minutes of exercise (2016). The number of recreational visits from ORVal was multiplied by quality-adjusted-life-years (QALYs) gained from physical activity (National Institute for Health and Care Excellence, 2018), then multiplied by the cost effectiveness threshold of a QALY (Claxton, et al., 2015).	# Visits / year £ / year

4.2 Habitat extent

4.2.1 Lark (Abbey Gardens to Mildenhall) (GB105033043051)

Lark (Abbey Gardens to Mildenhall) is the largest water body within the Lark catchment with a total area of approximately 8,700 ha. The river stretches 22 km in length, categorised at a moderate ecological status, and passes through both rural and highly urban habitat (EA, Lark (Abbey Gardens to Mildenhall), 2022). Both Cavenham and Tuddenham tributaries join the Lark along this stretch of the river. Lark (Abbey Gardens to Mildenhall) habitat extent is primarily arable land (68%), followed by urban (14.4%), woodland (12.4%), pasture (2%) and lakes (1%).

Table 12 Lark (Abbey Gardens to Mildenhall) habitat extent

Broad habitat	Detailed habitat	Area (ha)	Area (%)
Enclosed Farmland - Arable land	Non-irrigated arable land	4,422.3	51%
	Land principally occupied by agriculture	1,442.2	17%
Enclosed Farmland - Grassland (pasture)	Pastures	158.3	2%
Freshwater/floodplains - Lakes	Water bodies	86.3	1%
Urban - Green space	Green urban areas	30.5	0.4%
	Sport and leisure facilities	293.5	3%
Urban - Other	Discontinuous urban fabric	797.7	9%
	Industrial or commercial units	317.0	4%
	Mineral extraction sites	35.8	0.4%
	Construction sites	70.1	1%
Woodland - Broadleaved, mixed & yew	Broad-leaved forest	164.4	2%
	Transitional woodland-shrub	35.3	0.4%
Woodland - Coniferous	Coniferous forest	848.3	10%
	TOTAL	8,701.5	100%

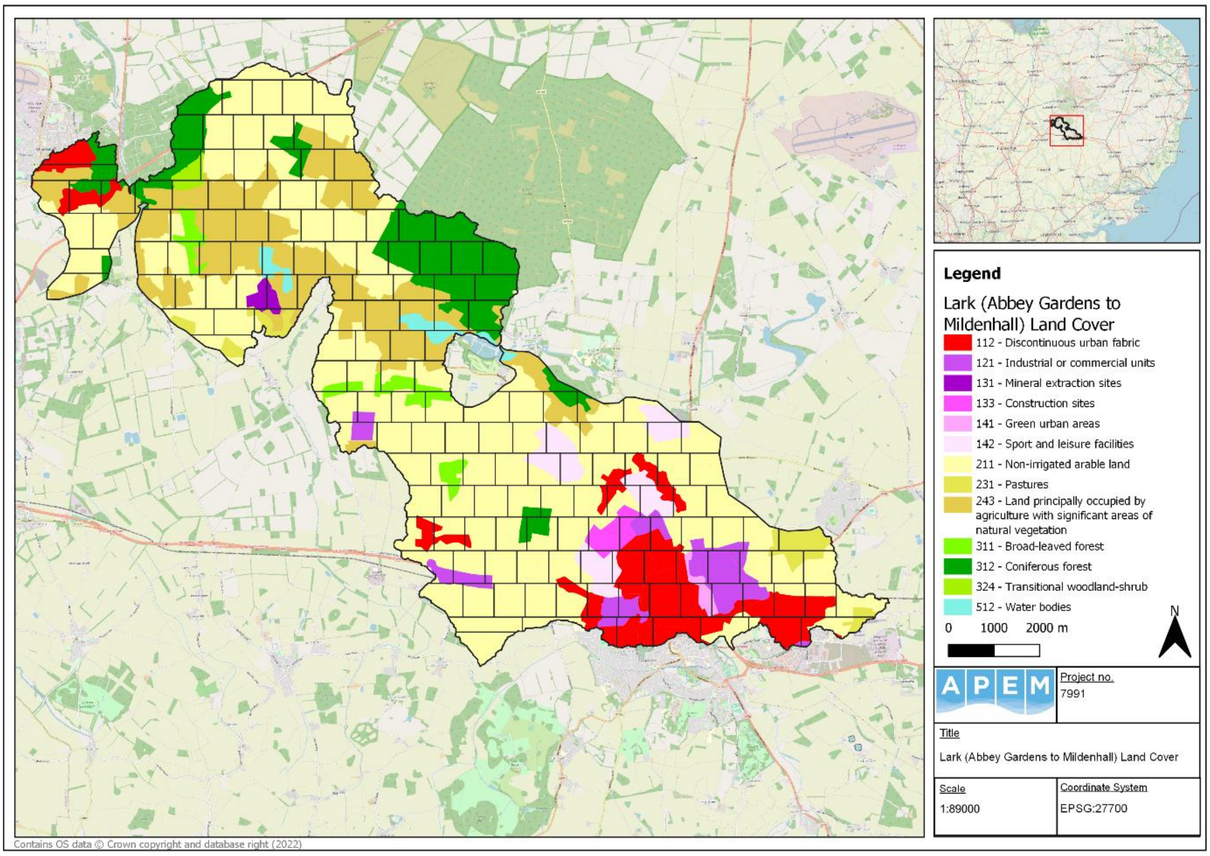


Figure 6 Lark (Abbey Gardens to Mildenhall) habitat extent divided into 0.5 km² parcels

4.2.2 Tuddenham Stream (GB105033043010)

Tuddenham stream is a 3.7 km rural tributary which joins the river Lark shortly upstream of Mildenhall. This stream has poor ecological status (EA, Tuddenham Stream, 2022). It is made up primarily by arable land (87%), pastureland (9%), woodland (4%), and urban (0.3%).

Table 13 Tuddenham Stream habitat extent

Broad habitat	Detailed habitat	Area (ha)	Area (%)
Enclosed Farmland - Arable land	Non-irrigated arable land	2,963.1	84%
	Land principally occupied by agriculture	113.1	3%
Enclosed Farmland - Grassland (pasture)	Pastures	319.1	9%
Urban - Other	Discontinuous urban fabric	11.7	0.3%
Woodland - Broadleaved, mixed & yew	Broad-leaved forest	15.1	0.4%
	Mixed forest	108.0	3%
Woodland - Coniferous	Coniferous forest	17.2	0.5%
	TOTAL	3,547.2	100%

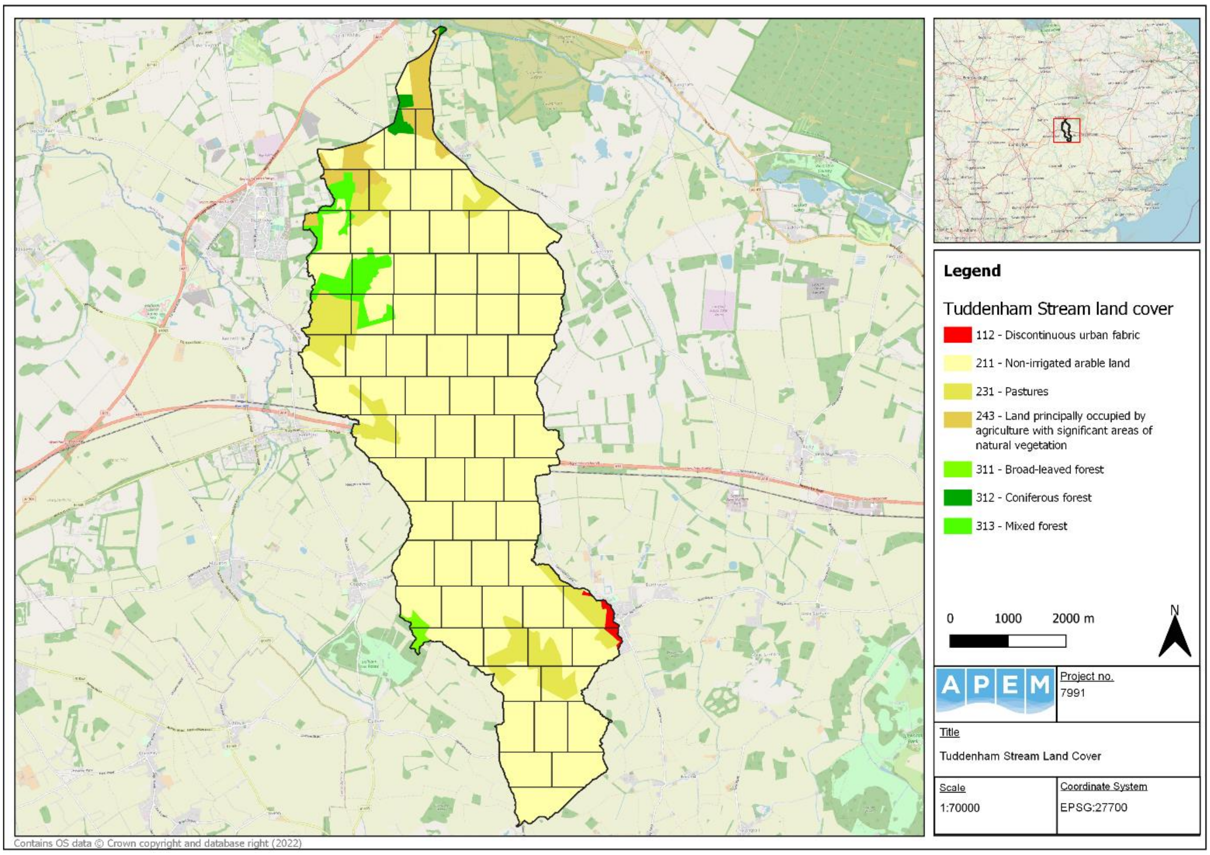


Figure 7 Tuddenham Stream habitat extent divided into 0.5 km² parcels

4.2.3 Cavenham Stream (GB105033043000)

Cavenham stream is a 19 km rural tributary of the Lark with good ecological status that confluences between Bury St Edmunds and Mildenhall (EA, Cavenham Stream, 2022). The majority of habitat in within Cavenham Stream is arable (91%) – the highest in the Lark catchment – followed by pastureland (4%), urban (3%), and woodland (2%).

Table 14 Cavenham Stream habitat extent

Broad habitat	Detailed habitat	Area (ha)	Area (%)
Enclosed Farmland - Arable land	Non-irrigated arable land	3,766.4	87%
	Complex cultivation patterns	3.6	0.1%
	Land principally occupied by agriculture	158.9	4%
Enclosed Farmland - Grassland (pasture)	Pastures	160.9	4%
Urban - Green space	Sport and leisure facilities	85.5	2%
Urban - Other	Discontinuous urban fabric	52.8	1%
	Industrial or commercial units	0.6	0.01%
Woodland - Broadleaved, mixed & yew	Broad-leaved forest	85.6	2%
	TOTAL	4,314.4	100%

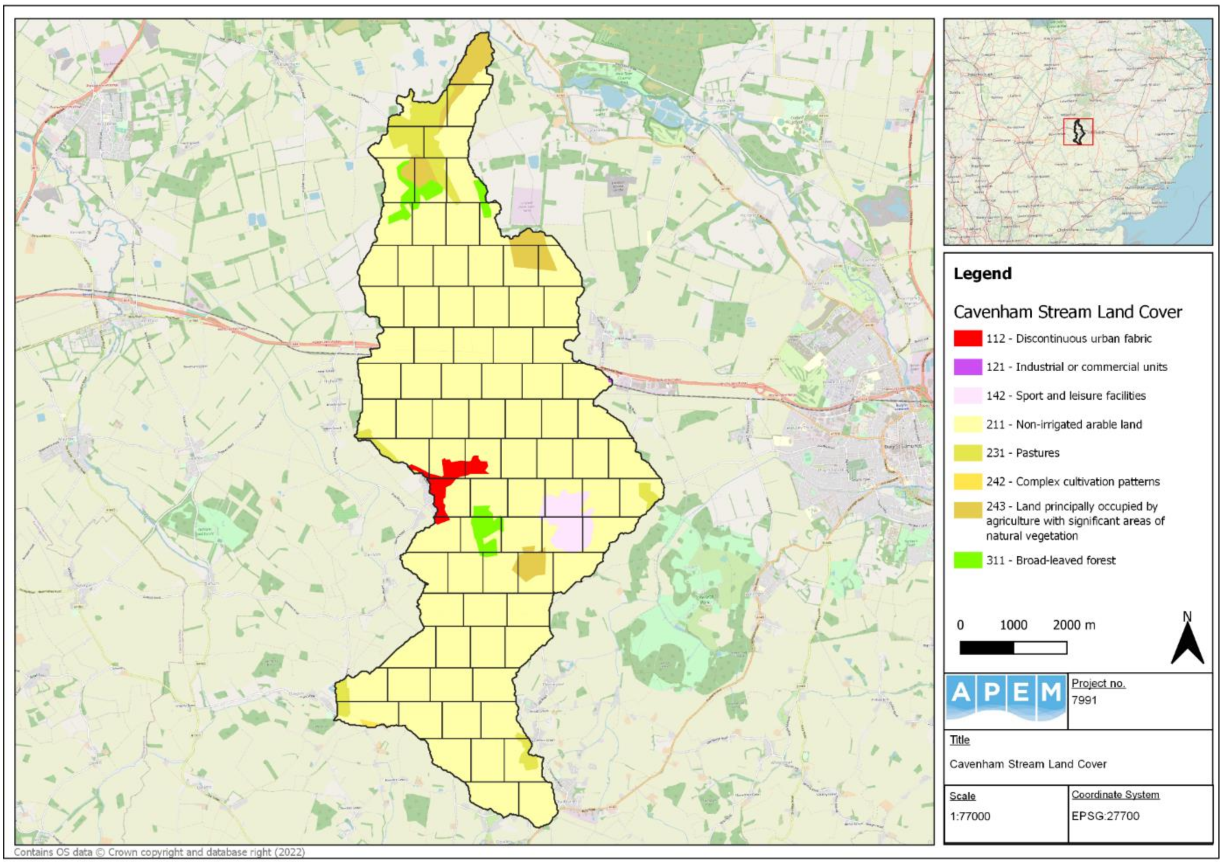


Figure 8 Cavenham Stream habitat extent divided into 0.5 km² parcels

4.2.4 Lark (Hawstead to Abbey Gardens) (GB105033042940)

The River Lark between Hawstead to Abbey Gardens is a rural 6.6 km section of the Lark, though does run near the A134 for a considerable period. This section of the Lark is categorised as having bad ecological status (EA, Lark (Hawstead to Abbey Gardens), 2022). The habitat extent of the water body includes 85% arable land, 12% urban, 2% woodland and 1% pastureland.

Table 15 Lark (Hawstead to Abbey Gardens) habitat extent

Broad habitat	Detailed habitat	Area (ha)	Area (%)
Enclosed Farmland - Arable land	Non-irrigated arable land	2,474.2	85%
Enclosed Farmland - Grassland (pasture)	Pastures	26.2	1%
Urban - Green space	Sport and leisure facilities	122.1	4%
Urban - Other	Discontinuous urban fabric	170.2	6%
	Industrial or commercial units	59.5	2%
Woodland - Broadleaved, mixed & yew	Broad-leaved forest	10.0	0.3%
	Mixed forest	7.7	0.3%
Woodland - Coniferous	Coniferous forest	42.4	1%
	TOTAL	2,912.2	100%

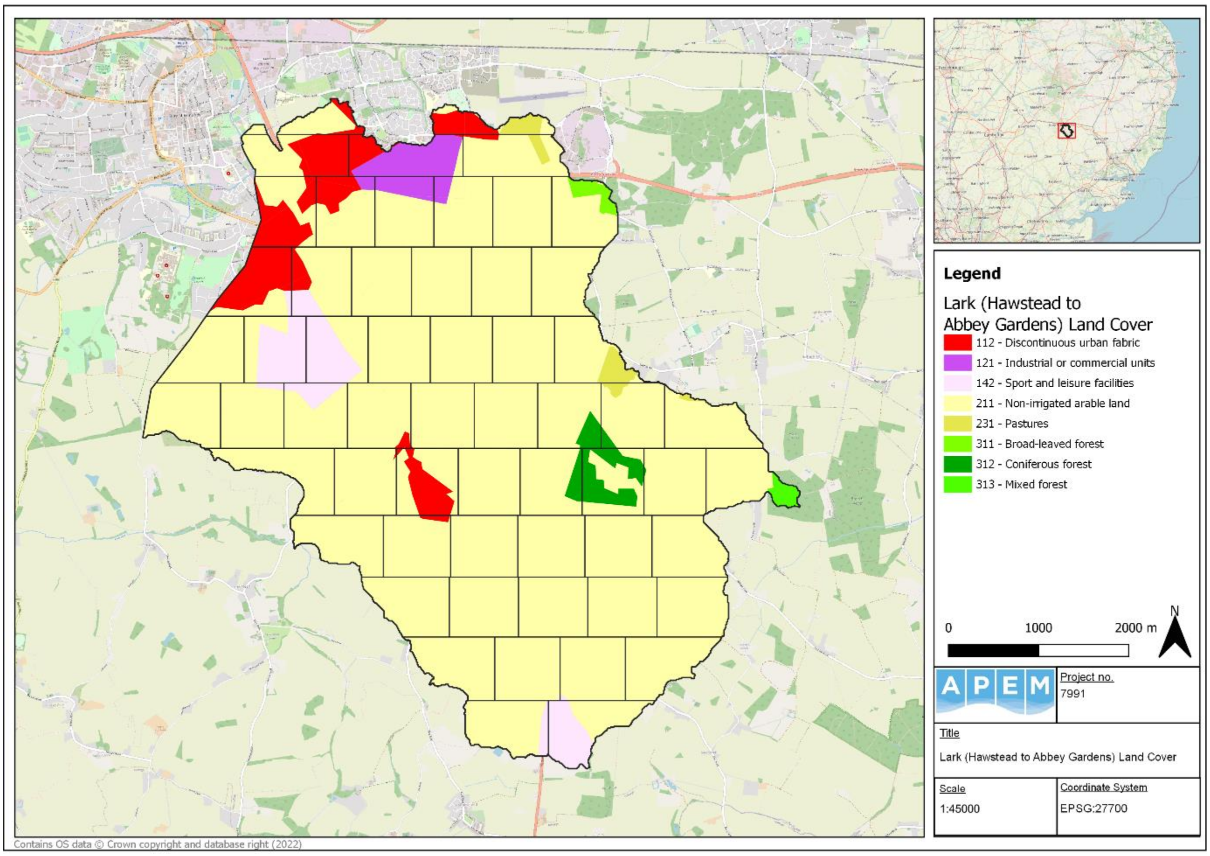


Figure 9 Lark (Hawstead to Abbey Gardens) habitat extent divided into 0.5 km² parcels

4.3 Natural capital baseline

A natural capital baseline assessment was conducted for the priority water bodies. This provides a snapshot of the current natural capital benefits (and areas which are lacking) within the water bodies and allows for a comparison against future catchment restoration/intervention.

The following ecosystem services were included for the baseline assessment:

- Agriculture;
- Timber;
- Water regulation – public water supply;
- Air purification;
- Carbon sequestration;
- Water purification;
- Flood risk;
- Recreation; and
- Physical health.

Table 11 provides information on the approach taken for each ecosystem service quantified. The majority of ecosystem services followed a similar approach to that of the EA's Natural Capital Register and Assessment Tool (NCRAT) – ensuring the approach is robust and regulatory approved.

To provide a spatial comparison of natural capital, each water body was sectioned up into 0.5 km² parcels. This allows for all ecosystem service values to be summed within each parcel across the water body – providing a visual component of where natural capital benefits and deficits are located. Each parcel is colour-coded by the value within as shown in Table 16 below. The bins for the natural capital categories (i.e. low, low-moderate, etc.) were determined in such a way that the data were evenly distributed.

Table 16 Natural capital assessment categories

Colour	Value range	Descriptor
	£0 – 42,810	Low
	£42,810 - 43,187	Low-Moderate
	£43,187 - 43,574	Moderate
	£43,574 - 54,743	Moderate-High
	£54,743 – 617,607	High

Sections 4.3.1- 4.3.4 take an in depth look at the natural capital baseline assessment for each of the priority water bodies.

4.3.1 Lark (Abbey Gardens to Mildenhall) (GB105033043051)

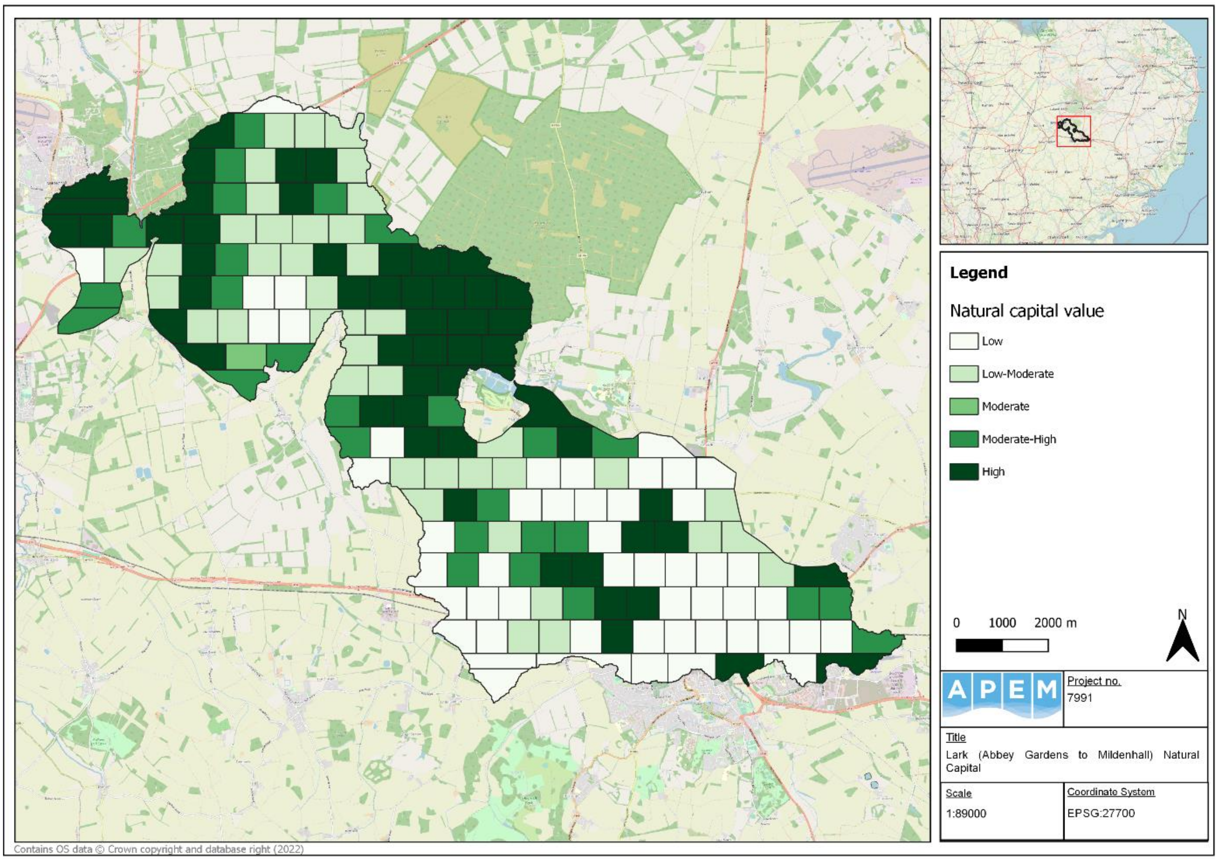


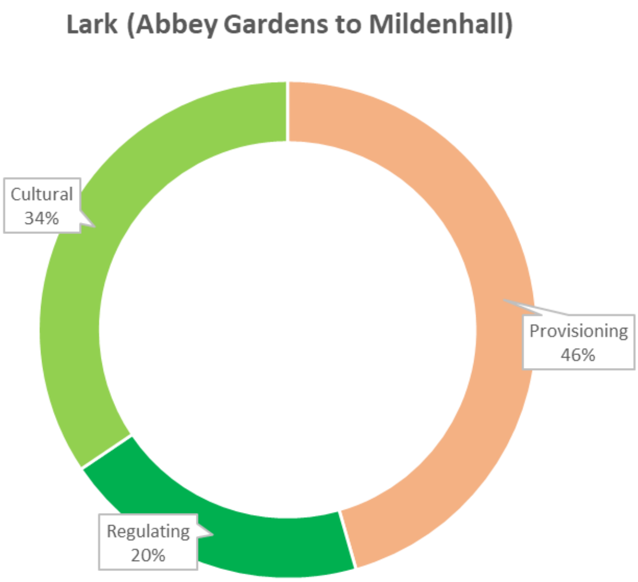
Figure 10 Lark (Abbey Gardens to Mildenhall) natural capital value divided into 0.5 km² parcels

The highest density of natural capital is mainly centred around the area to the north of the river to the east of Barton Mills (at the most upstream extent of the waterbody) and the southern extent of the King's Forest down to Lackford. North of Hengrave Hall is a notable patch of high natural capital; again, likely due to the landcover type which will provide high values of carbon sequestration and air pollution services. Areas of low natural capital value are mostly found in urban areas. As expected, Bury St Edmunds has a generally low natural capital value; although some areas of urban greenspace within Bury are showing as high or moderate-high. This is due to the high recreation value of these areas which boosts the natural capital value. Other areas of low natural capital include the quarry to the north of Fornham St Genevieve and the area to the south of the A14 by Risby interchange.

The River Lark (Abbey Gardens to Mildenhall) has a natural capital baseline that spread relatively among provisioning (46%), cultural (34%) and regulating (20%). These three categories are each dominated by individual services which have substantial monetary value to the area. Agriculture makes up 97% of the total value of provisioning services in this area of the catchment, and recreation and tourism make up (91%) of the total value of cultural ecosystem services. Carbon sequestration is a major aspect of the regulating services value, but air pollution and flood risk also have significance. Cumulatively, the baseline value of the Lark (Abbey Gardens to Mildenhall) is £11,150,650 per annum.

Table 17 Lark (Abbey Gardens to Mildenhall) ecosystem services infographic

Ecosystem Service	Lark (Abbey Gardens to Mildenhall)
Provisioning	**5,082,196**
Agriculture	4,646,666
Timber	127,801
WR-PWS	307,729
Regulating	**2,228,207**
Air purification	412,285
Carbon	1,602,152
Water purification	88,492
Water regulation - flood risk	125,279
Cultural	**3,840,247**
Recreation & tourism	3,498,523
Physical health	341,723
TOTAL	**£11,150,650**



4.3.2 *Tuddenham Stream (GB105033043010)*

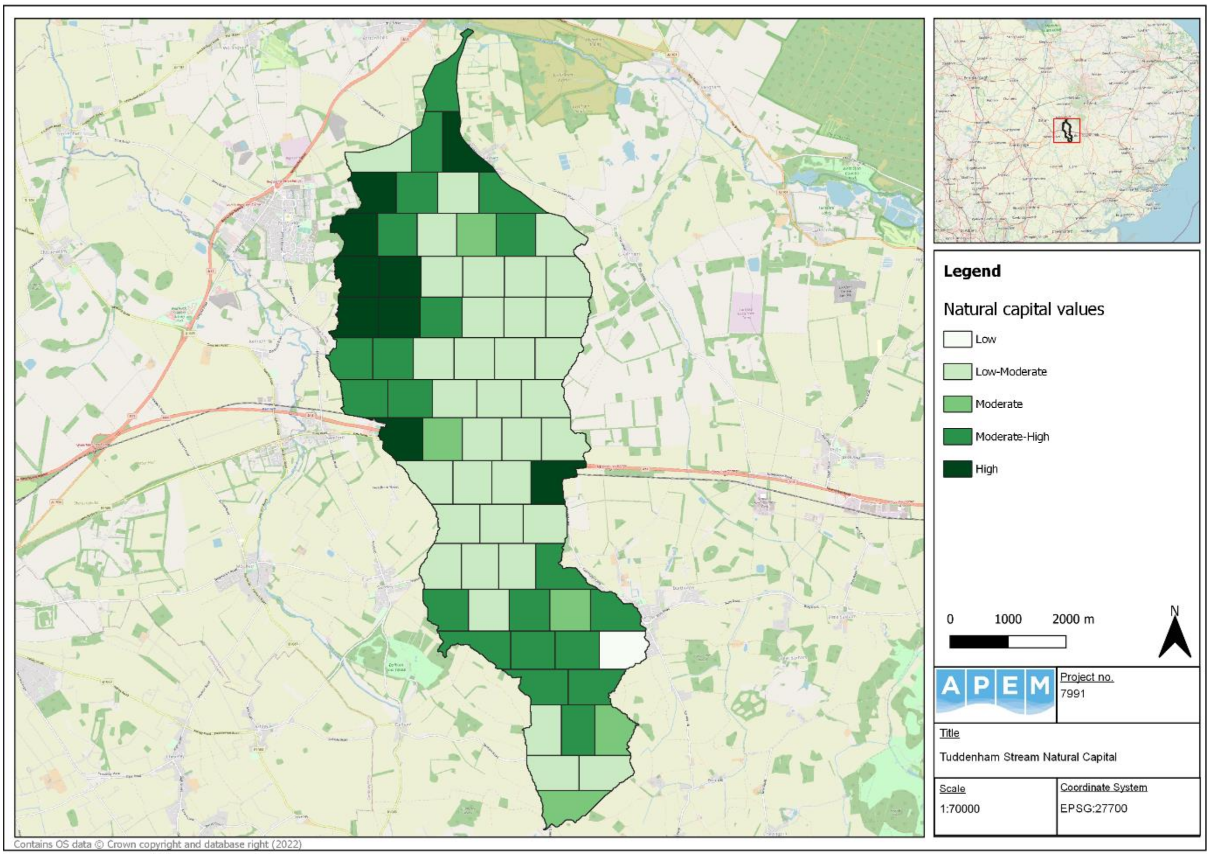


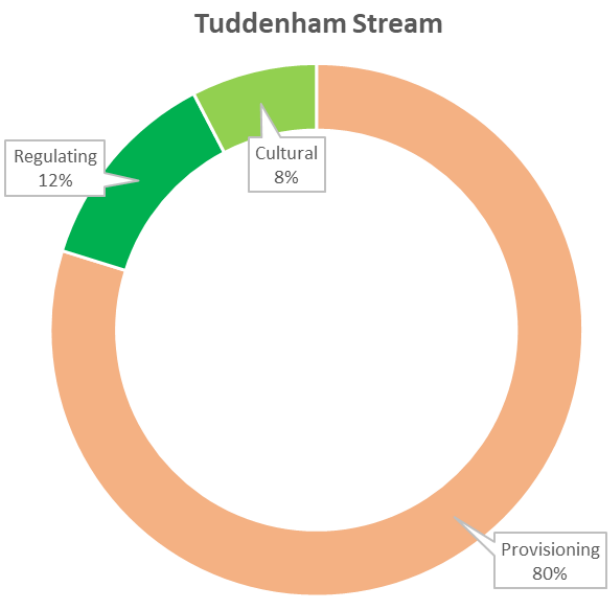
Figure 11 Tuddenham Stream natural capital values divided into 0.5 km² parcels

Tuddenham stream has areas of high natural capital density notably to the west of the water body close to Herringswell. Other key areas include a unit close to Tuddenham Mill and where the A14 enters and exits the water body west to east. There is only one area of low natural capital density which covers the south edge of the village of Barrow.

Like Cavenham, Tuddenham Stream is dominated by provisioning services which make up 80% of the total baseline natural capital value of the area, of which agriculture is the main contributor. Regulating (12%) and cultural (8%) contribute a smaller proportion of the total baseline value, of which these are dominated by carbon sequestration and recreation and tourism services. The total baseline value of natural capital services in this area is £3,506,028 per annum.

Table 18 Tuddenham Stream ecosystem services valuation infographic

Ecosystem Service	Tuddenham Stream
Provisioning	**2,815,260**
Agriculture	2,676,454
Timber	17,105
WR-PWS	121,701
Regulating	**429,687**
Air purification	95,646
Carbon	281,200
Water purification	36,074
Water regulation - flood risk	16,768
Cultural	**261,080**
Recreation & tourism	238,700
Physical health	22,380
TOTAL	**£3,506,028**



4.3.3 Cavenham Stream (GB105033043000)

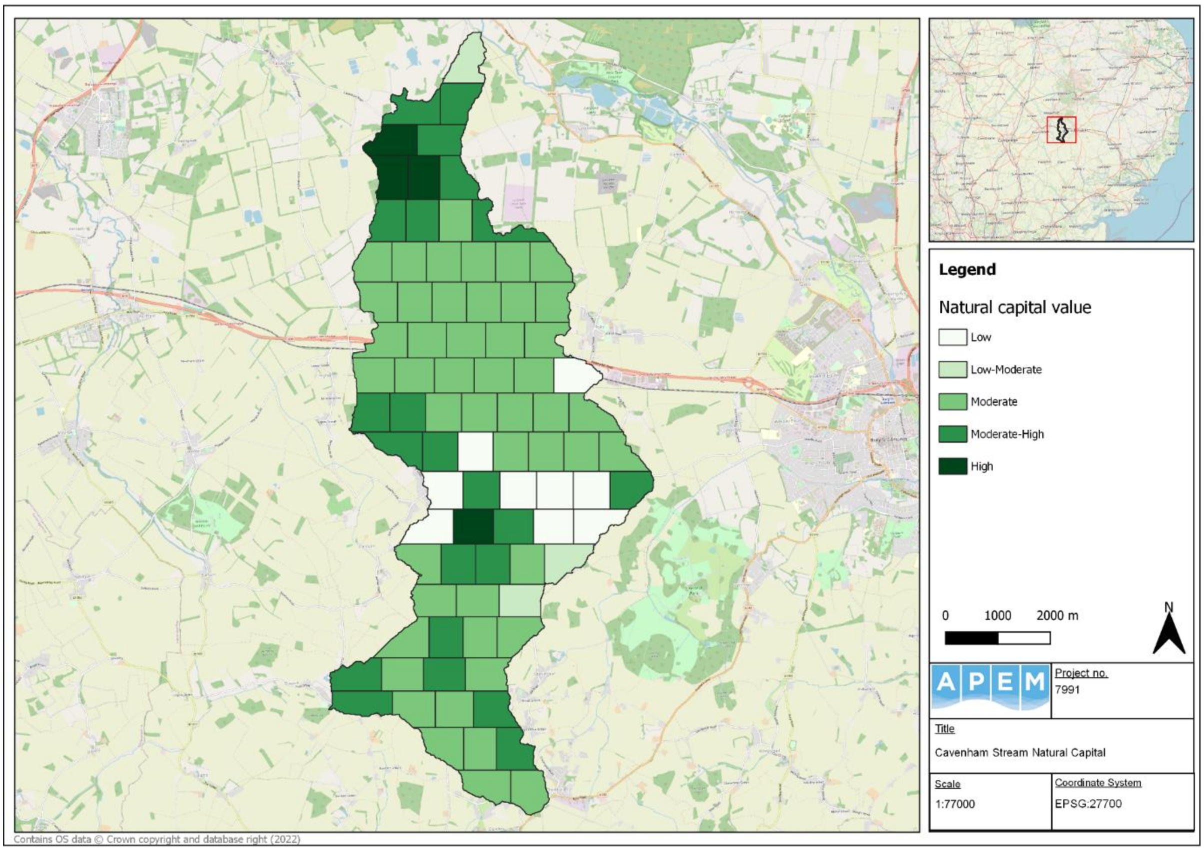


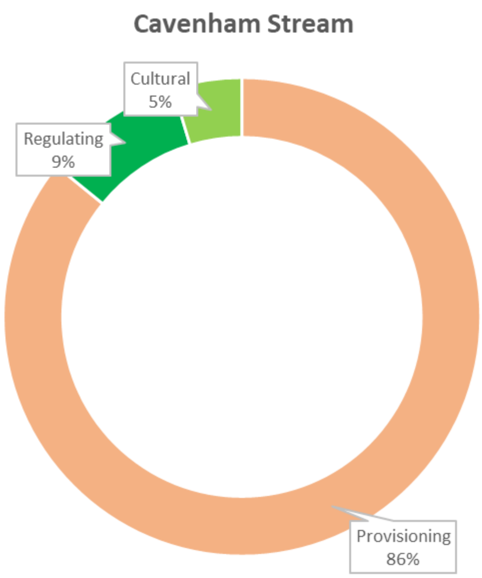
Figure 12 Cavenham Stream natural capital value divided into 0.5 km² parcels

Key areas of high natural capital density for the Cavenham Stream water body are centred around the village of Cavenham. Here this natural capital value is driven by areas of woodland and grassland, providing carbon sequestration, flood risk and recreation. Wilsumer Wood represents the other area of high natural capital density to the west of Great Saxham. The settlements of Barrow and Burthorpe represent some of the lowest areas of natural capital density as urban areas.

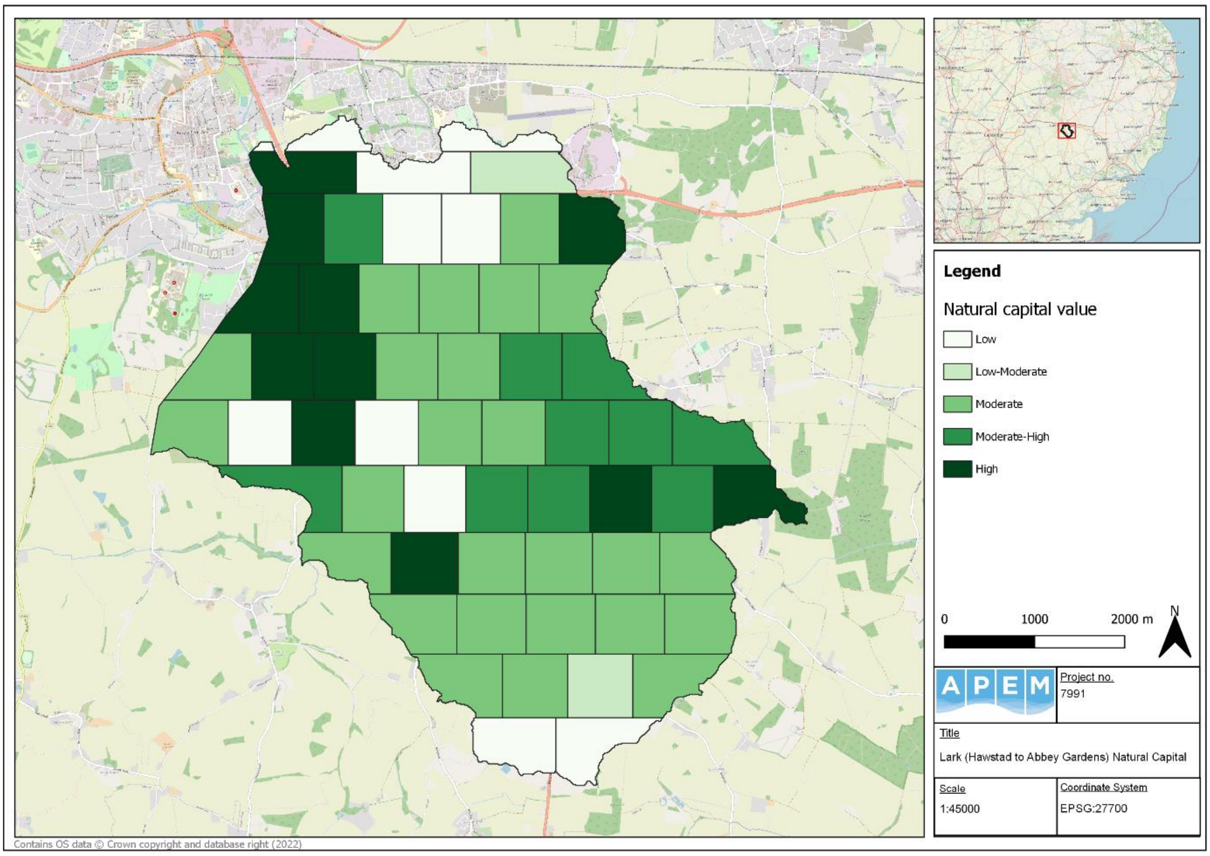
Cavenham Stream's natural capital baseline is dominated (86%) by provisioning services, particularly agriculture. Nine percent of the baseline is provided by regulating services in particular carbon and air pollution services. The final 5% of the baseline is provided by cultural services, of which recreation and tourism make up the majority. Cumulatively, the baseline value of Cavenham stream is £3,879,078 per annum.

Table 19 Cavenham Stream ecosystem service valuation infographic

Ecosystem Service	Cavenham Stream
Provisioning	**3,330,374**
Agriculture	3,168,679
Timber	10,439
WR-PWS	151,256
Regulating	**367,769**
Air purification	90,019
Carbon	223,642
Water purification	43,876
Water regulation - flood risk	10,233
Cultural	**180,935**
Recreation & tourism	165,164
Physical health	15,770
TOTAL	**£3,879,078**



4.3.4 *Lark (Hawstead to Abbey Gardens) (GB105033042940)*



A key area of high density of natural capital is to the north west of the water body. This is due to the recreation value of Nawton Park and its proximity to Bury St Edmunds. The Lark runs through in parallel to the park through farmland to the north of Sicklesmere Road.

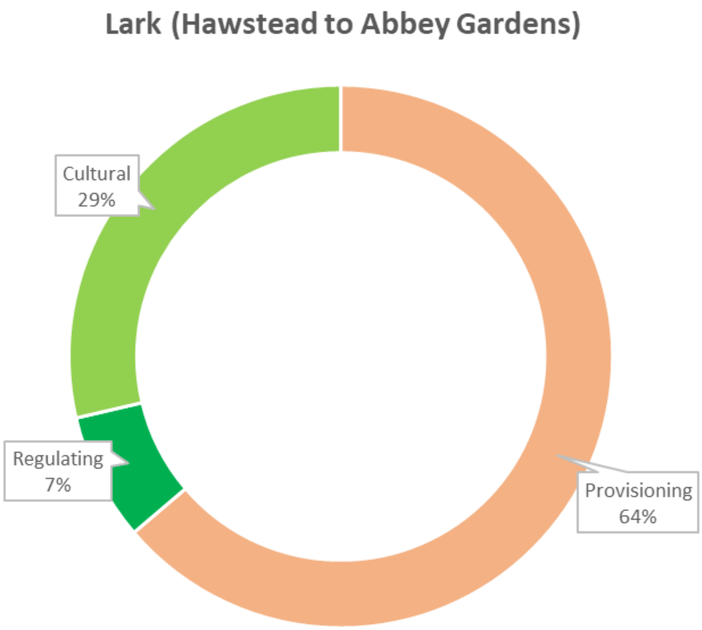
The furthest east area of high natural capital is driven by presence of Free Wood and presumably the access the residents of Bradfield St George enjoy to this recreation asset.

Areas of low natural capital are to the south of Nawton Park surrounding the villages of Sicklesmere, Great Whelnetham and Little Whelnetham. Surrounding the Moreton Hall area which is urbanised is an area of low natural capital density. Bradfield Combust at the southernmost tip of the water body is also another area of low natural capital density.

The River Lark (Hawstead to Abbey Gardens) is dominated by Provisioning (64%) and Cultural (29%) services. Both agriculture and recreation and tourism respectively contribute significant value to the area, whilst regulating services play only a minimal role in the total value, though are diverse in their services. The total baseline value of natural capital services in this area is £3,182,187 per annum.

Table 20 Lark (Hawstead to Abbey Gardens) ecosystem services valuation infographic

Ecosystem Service	Lark (Hawstead to Abbey Gardens)
Provisioning	**2,029,185**
Agriculture	1,919,284
Timber	7,324
WR-PWS	102,576
Regulating	**241,559**
Air purification	57,369
Carbon	147,394
Water purification	29,616
Water regulation - flood risk	7,180
Cultural	**911,443**
Recreation & tourism	828,239
Physical health	83,204
TOTAL	**£3,182,187**



5. Catchment measures recommendations

A long list of catchment measures was provided as options for intervention within the four priority water bodies (Appendix 2). This list includes 18 measures, ranging from channel modification, riparian improvement, and land-use change and suggested scale of the implementation. Where possible, examples were provided within the priority water bodies showing locations that may be suitable. This was not achieved for all measures – due to limitations with desk-based analysis – and it should be noted that locations given only indicate a possible fit for intervention. Additional groundwork would be required, such as a site visit to confirm measure suitability. The measures where examples were given include:

- Re-meandering of a straightened channel;
- Bypass channel;
- Channel narrowing;
- Fish pass / easement;
- Flow deflectors;
- Introduction/manipulation of large wood debris;
- Formalisation of ford crossings or animal drinking points;
- Baffles;
- Embankment removal / breach;
- Buffer strips;
- Riparian tree planting;
- Tree thinning;
- Change in land use from arable; and
- Field and road runoff capture.

These measures were selected to address the key issues of physical modification, low flows and diffuse pollution. Appendix 3 (attached separately) provides details about what benefits each measure provides.

Other key pressures of point source pollution and invasive species were determined as not appropriate to be addressed by catchment measures; and as such are beyond the scope of this project. Surface water and groundwater abstraction are also given as key pressures. Whilst the measures suggested will not reduce these; if morphology measures are deployed correctly these will improve the flow dynamics within the watercourse and improve the resilience of the environment to lower flows.

Measures were identified by tracing along the river using Google satellite imagery and selecting any areas that seemed suitable for a given catchment measure. Appendix 3 shows all examples given within the priority catchments. Each example includes an image (provided by Google Satellite), a grid reference, and the water body it is located in. A total of three examples were provided for each measure, with the exception of embankment removal/breach as this was difficult to assess using satellite imagery. Table 21 provides one such example for the riparian tree planting catchment measure.

Table 21 Catchment measure example

Riparian tree planting		**TL 76835 69031**	**Cavenham Stream GB105033043000**

Figure 13, Figure 14, Figure 15, and Figure 16 demonstrate possible locations for the implementation of the measures in Appendix 3.

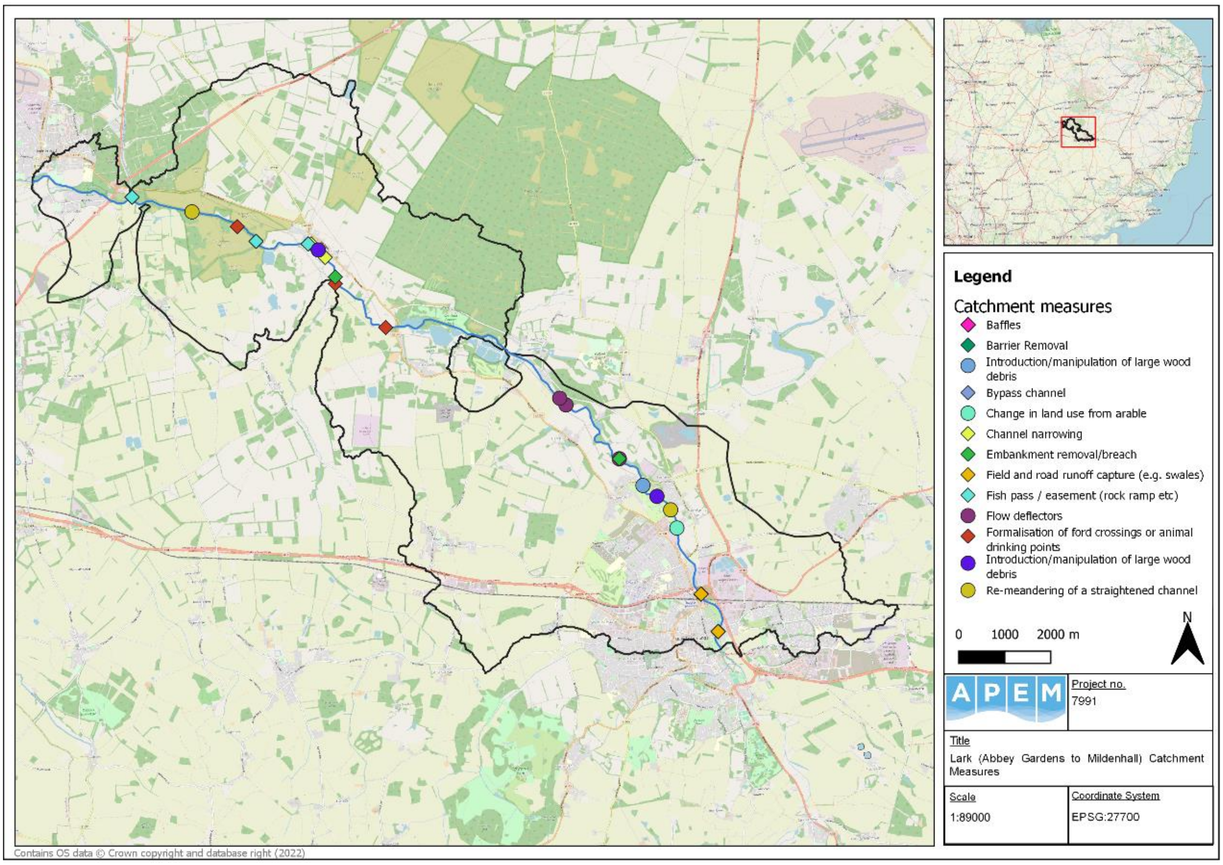


Figure 13 Lark (Abbey Gardens to Mildenhall) catchment measures example locations

Lark (Abbey Gardens to Mildenhall) contains the most catchment measure examples as it has the longest stretch of river and is most easily seen through satellite imagery. A total of 30 example locations are provided across 13 catchment measures (Figure 13).

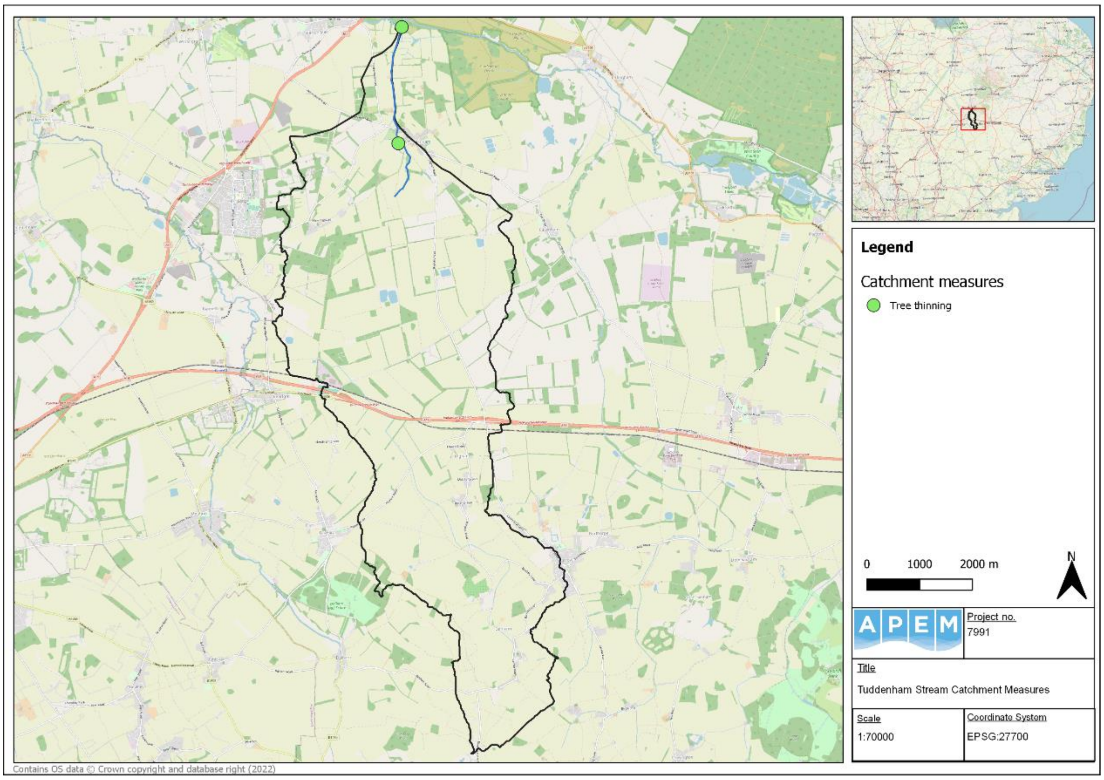


Figure 14 Tuddenham Stream catchment measure example locations

Tuddenham Stream has the fewest catchment measure examples due to difficulty viewing the stream through satellite imagery. Two example locations were provided for the tree thinning catchment measure (Figure 14).

It should be noted that land use change measures (i.e. change from arable land to unmanaged grassland) do not need to exclusively be carried out near the river bank, but anywhere with the water body boundary and these should be targeted to areas with high natural capital.

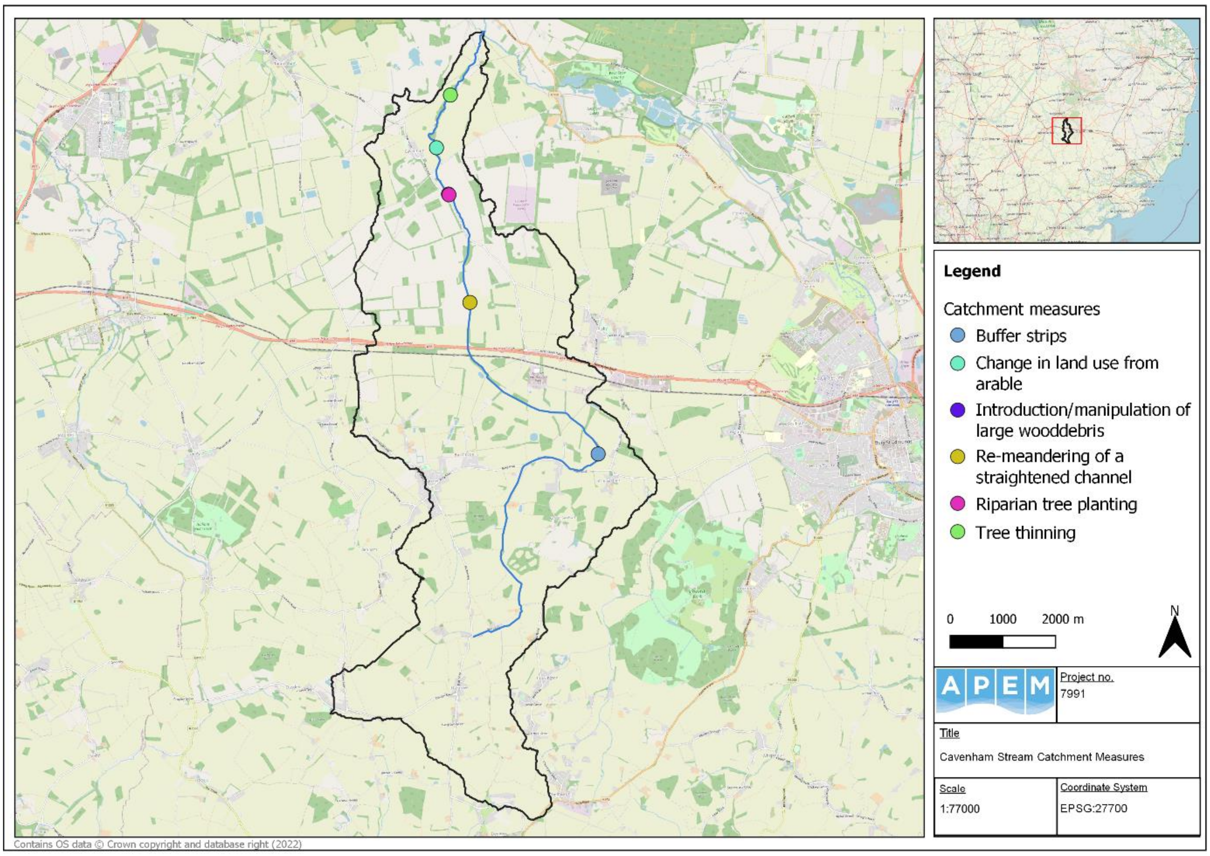


Figure 15 Cavenham Stream catchment measures example locations

Six example locations for six catchment measures were provided within the Cavenham Stream water body (Figure 15). Note: in the map above to ‘introduction/manipulation of large wood debris’ is beside the location for ‘riparian tree planting’ and is therefore hidden. Buffer strips and change in land use from arable to grassland could be implemented throughout the catchment and should be prioritised in areas with high natural capital.

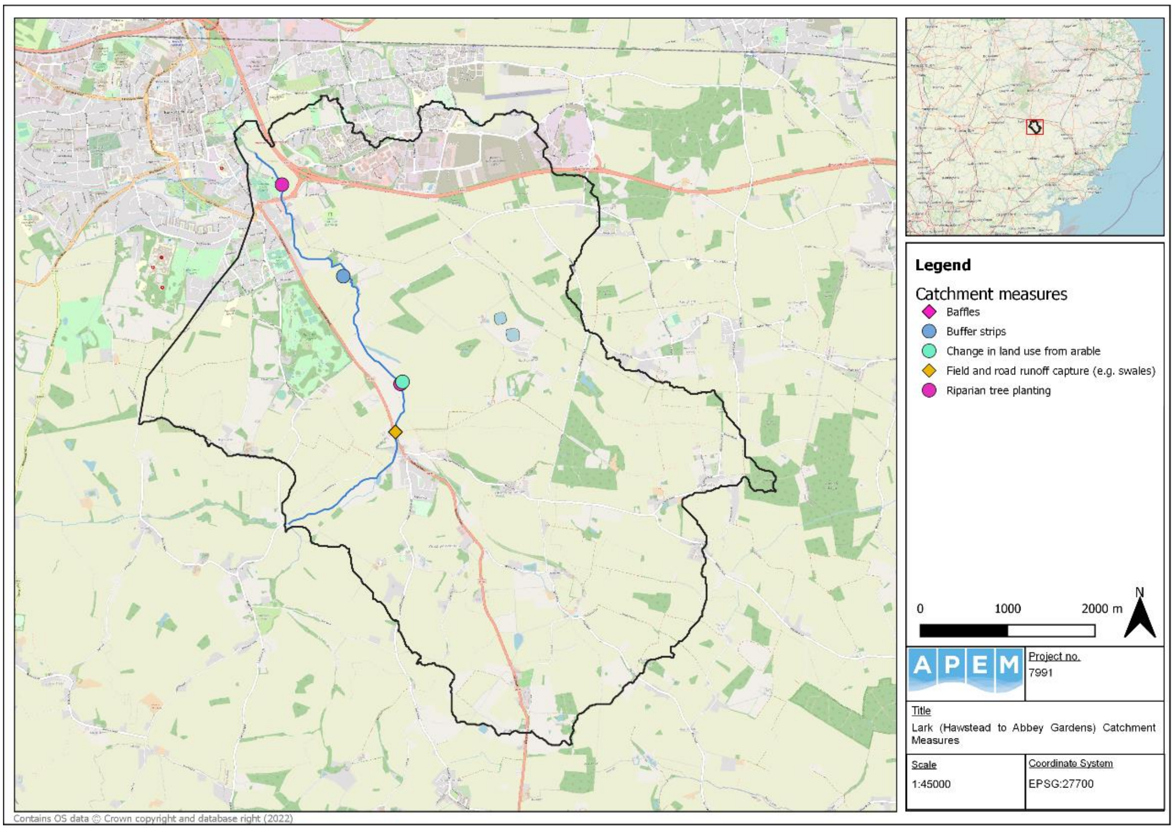


Figure 16 Lark (Hawstead to Abbey Gardens) catchment measures example locations

Within the Lark (Hawstead to Abbey Gardens) water body a total of six example locations were provided for five catchment measures (Figure 16). Note: in the map above the location for ‘baffles’ is the same as the location for ‘field and road runoff capture’, so it is obscured. Additionally, the location for ‘riparian tree planting’ is very near the location for ‘change in land use from arable’ and is mostly obscured.

5.1 Catchment measures valuation

It is important to understand that ecosystem valuation is not an exact science. Whilst some services are more straightforward to value, due to the availability of market rate data (such as agriculture) that does not mean services that cannot be monetised (such as pollination or biodiversity for example) are of less value. Where possible, qualitative, quantitative and monetised ecosystem services should be considered together when assessing the natural capital benefit of various measures, along with a sense check of ‘is this the right thing to do?’

Natural capital provides a framework to help prioritise what interventions should be implemented first as achieving the most amount of benefit; however, that does not mean to say that other measures are without value. Indeed, in an ideal world everything would be implemented in order to achieve restoration of catchments. However, with capital investment being limited, this approach provides a starting point for the R Lark Partnership, Anglian Water and other stakeholders within the catchment to begin undertaking investment that provides the most amount of benefit.

Only some measures could be quantified in terms of natural capital benefit. These have been broken down into units for valuation, but the implementation of these measures (whether individually or in combination) would result in the deployment of many of these units.

The measures that involved land use change were quantified for added natural capital benefits. These include:

- Buffer strips;
- Change in land use from arable;
- Field and road runoff capture (i.e. swales);
- Re-meandering of straightened channel;
- Riparian fencing;
- Riparian tree planting; and
- Wetland creation.

Table 22 Measures and possible benefits (per annum)

Measure	Unit	Likely benefits (not able to be quantified or monetised)	Recreation Benefit Value (£)	Other Benefit Value (£)
Buffer strips	2x100m or 0.02ha	Water quality, pollination, biodiversity	404.73	1.46
Change in land use from arable to grassland	2x100m or 0.02ha	Water quality, pollination, biodiversity, water regulation	404.73	1.46
Field and road runoff capture (e.g. swales)	10 x15m or 0.015ha	Water quality, pollination, biodiversity, water regulation	307.76	4.21
Re-meandering of a straightened channel	100m length created	Biodiversity, water regulation	n/a	2,105
Riparian fencing	2x100m or 0.02ha	Water quality, pollination, biodiversity	404.73	1.46
Riparian tree planting	2x100m or 0.02ha	Water quality, pollination, biodiversity, water regulation	404.73	32.83
Wetland creation	100x100m or 10ha	Biodiversity, water regulation, flood risk	202,366.07	2,807.72

The measures and their values detailed in the table above provide a partial calculation based on land cover change and the approaches utilised in COVER+® (with the exception of recreation). It is highly likely that these calculations are undervaluing the natural capital benefits provided by these measures. These measures are required to address the issues highlighted in the River Lark Pollution Review and Action Plan and therefore the natural capital benefit is an additional benefit.

Recreation was estimate by assessing recreational sites using the ORVal tool. Four recreational sites within each eater body was evaluated – for a total of 16 sites. Of these, the site with the lowest recreational value was selected to be used as an average value. The site selected was St Edmund's Church located in Cavenham Stream, with a welfare value of £4,533 over 0.23 ha (equates to roughly £20,237 per ha). This value was applied by the unit size for each catchment measure. For instance, £20,237 was multiplied by 0.02 to provide a total of £404.73 for the buffer strips measure.

5.2 Recommendations

1. Focus on working with stakeholders in areas of high natural capital to deploy measures to improve water quality (mostly focussed around catchment sensitive farming style measures).

It is recommended that the measures with quantifiable natural capital benefit are implemented first across the priority water bodies. Given the scale of the issues within the Lark catchment this will provide a starting point with a clear focus.

At the direction of the catchment specialists within Anglian Water; it was determined that areas with high density of natural capital are focussed on first. However, due to desktop analysis constraints, we were restricted to areas with good satellite imagery. Therefore, the example locations are not focussed within areas of good natural capital currently. The water body maps provide a strong indication of where these works should be focussed initially, and it is recommended that stakeholder engagement work is undertaken in these areas; particularly where there is one landowner (representing the most efficient way of working).

2. Deploy the measures recommended in Figures 13,14,15 and 16.

These figures demonstrate from desktop analysis the best place to implement measures that are appropriate to begin to address the key issues within the R Lark. It is recommended that stakeholder engagement is undertaken in these areas and site visits carried out to confirm the desktop analysis. Post intervention monitoring if feasible would be preferable; particularly to measure the benefit on the flow regime and any groundwater recharge and quality benefits from land use change.

3. Extend high natural capital areas into low natural capital areas surrounding urban centres.

There are some areas where high natural capital density abuts low natural capital density areas. Most of these are connected with recreation benefits and their proximity to urban areas. Recreation, whilst historically at odds with optimal catchment management, provides a valuable vehicle in which to connect the public to their environment. It is recommended that works to improve the quality of these recreation areas (in terms of addressing the water body's reasons for not achieving good status) are undertaken to provide dual benefit in terms of natural capital and WFD status.

4. Update the natural capital baseline after measures have been implemented for the priority water bodies.

Natural capital represents a powerful tool in illustrating the value of our environment to stakeholders and the public within water bodies, catchments and landscapes. It also underpins future policy; given its prominence in the 25 year Environment Plan and associated industry guidance (such as the water resource planning guideline). One of the key challenges to the natural capital approach is the appropriate updating of natural capital accounts to demonstrate the value of the environment and support the narrative and justification of many catchment measures. It is recommended that the natural capital account is updated (say at 2-5 year intervals) for these priority water bodies; given a natural capital baseline is now in existence as a result of this project. This would tie in the with flagship chalk stream project that the R

Lark catchment is part of and would provide an excellent pilot for the use of the natural capital approach in supporting catchment restoration and communication with stakeholders.

5.3 Developing this work further

There are many opportunities to further develop this work. Biodiversity Net Gain (BNG) represents a huge step change for planning policy. The Environment Bill stipulates that new developments must achieve BNG, which is measured by the biodiversity metric. This tool calculates biodiversity losses and gains (based on land use change) by providing a biodiversity unit value for an area of land. The achievement of biodiversity units (particularly with land change from agriculture to more diverse and natural land cover types) could, if deployed in the River Lark catchment, provide benefits not only for biodiversity but also to address the pressures from agriculture. Where projects within the River Lark are planned that require the creation of biodiversity units, it is recommended that these are sought within the priority water bodies. The RLCP could also look to support farmers and landowners in the creation of biodiversity units as the system is still being developed and the Local Authorities generally are struggling to resource the creation of a system to broker biodiversity units. By engaging farmers and landowners into the value of land for the creation of biodiversity units to support any development in the vicinity; land can be taken out of arable production, the farmers are adequately compensated and funded for this work, and a key challenge of developers is removed. This will help relieve some of the key pressures in the River Lark catchment.

The introduction of the Environmental Land Management scheme (ELMS) may provide additional funding mechanisms; particularly if effort is focussed on engaging landowners in the catchments highlighted by OAT and identifying BNG projects with multiple benefits for the wider catchment.

A natural capital baseline has been produced for the four priority water bodies cited within this report. This could be duplicated for the rest of the water bodies within the catchment and be used as a wider metric to measure success alongside WFD status. The methods used within the natural capital baseline are compatible with the water resource planning guideline and Anglian Water could therefore use these outputs for inclusion within their water resource management planning process (a baseline natural capital assessment is the best practice approach); or these metrics could also be included within the Water Industry National Environment Programme (WINEP) process; as these are also broadly compatible with the approach detailed in the most recently released guidance.

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Appendix 1 OAT Scores

Dataset	Score		Description
2019 WFD overall & ecological status			
High	1	None	The WFD metric was considered to be an important factor in determining catchment prioritisation. Therefore, the scoring was weighted heavier than the majority of metrics.
Good	1	None	
Moderate	1.5	Low	
Poor	2	Moderate	
Bad	2.5	High	
Flood zone 2			
<5% area	1	Very Low	As only a small amount of area was considered to be in Flood Zone 2, an absence/presence score was applied.
>5% area	1.15	Moderate	
Flood zone 3			
<5% area	1	Very Low	This metric was weighted slightly heavier than the Flood Zone 2, due to its increase risk.
>5% area	1.2	Moderate	
Number of properties at risk of flooding			
0-8.25	1.1	Low	Properties at risk of flooding were provided by an EA FOI for each water body within the Lark catchment. The bins were determined based on data quartiles to ensure even distribution. Scoring was slightly weighted as flooding risk is an important metric for consideration.
8.25-30.5	1.15	Low-Moderate	
30.5-100.75	1.2	Moderate-High	
100.75-422	1.25	High	
Population			
0-2,514	1.1	Low	The bins were determined based on data quartiles to ensure even distribution. Scoring was not weighted.
2,514-5,220	1.15	Low-Moderate	
5,220-8,376	1.2	Moderate-High	
8,376-14,880	1.25	High	
Diffuse pollution			
0-40%	1	Low	The proportion of arable land was used as a proxy for diffuse pollution. This metric was identified as being important by the River Lark Pollution Review and Action Plan so was the most heavily weighted of all metrics.
40-55%	2	Low-Moderate	
55-70%	3	Moderate-High	
70-85%	4	High	
>85%	5	Very High	
Protected species density – least concern			
0-0.06	1	Low	The density of protected species of least concern (determined by IUNC Red List) scores were not weighted. The bins were determined based on the data quartiles to ensure even distribution.
0.06-0.07	1.1	Low-Moderate	
0.07-0.14	1.15	Moderate-High	
0.14-0.40	1.2	High	
Protected species - endangered			
0	1		Protected species that are endangered were only present at 2 water bodies [Lark (Abbey Gardens to Mildenhall) and Lark (Hawstead to

0.1-0.2	1.15		Abbey Gardens)]; therefore, only an absence/presence score was applied. The score was weighted slightly higher than species of least concern.
Protected species – critically endangered			
0-0.02	1.2	Low	The score was weighted slightly higher than endangered species. The bins were determined based on the quartiles to ensure even distribution.
0.02-0.03	1.25	Low-Moderate	
0.03-0.04	1.3	Moderate-High	
0.04-0.13	1.35	High	
INNS density			
0-0.04	1.2	Low	The bins were determined based on the quartiles to ensure even distribution.
0.04-0.10	1.3	Low-Moderate	
0.10-0.15	1.4	Moderate-High	
0.15-0.40	1.5	High	
Highest site designation			
None	1	Low	Presence of a local, national or international designated site within the water body was not weighted.
Local	1.1	Low-Moderate	
National	1.15	Moderate-High	
International	1.2	High	
Local Nature Reserves (LNR)			
0	1	Very low	Proportion of Local Nature Reserve within the water body was not weighted. As only two sites contained an LNR – both of which were less than 1% of water body area – this was scored by absence/ presence.
>0%	1.1	Low	
National Nature Reserves (NNR) and Special Areas of Conservation (SAC)			
0	1	Very low	Proportion of national designated sites within the water body was weighted slightly higher than local sites. However, since only a few sites contained wither an NNR or SAC – all of which were less than 5% of water body area – this was scored by absence/presence.
>0%	1.15	Low	
Special Protection Areas (SPA)			
0-5%	1	Very Low	Proportion of national designated sites within the water body was weighted slightly higher than local sites.
5-15%	1.15	Low	
15-30%	1.2	Moderate	
>30%	1.25	High	
Sites of Special Scientific Interest			
0-5%	1	Low	Proportion of SSSIs (international designation) within the water body was weighted slightly higher than national sites.
5-20%	1.2	Low-Moderate	
20-40%	1.25	Moderate-High	
>40%	1.3	High	
Climate Change Vulnerability – Low Risk			
0-2.5%	1	Low	Proportion of area that is considered to be of low risk vulnerability to climate change was not weighted. The bins were determined based on quartiles to ensure even distribution of data.
2.5-5%	1.1	Low-Moderate	
5-10%	1.15	Moderate-High	
>10%	1.2	High	
Climate Change Vulnerability – Medium Risk			
0-10%	1	Low	Proportion of area that is considered to be of medium risk vulnerability to climate change was weighted slightly higher than the low risk metric. The bins were determined based on quartiles to ensure even distribution of data.
10-20%	1.15	Low-Moderate	
20-30%	1.2	Moderate-High	
>30%	1.25	High	
Climate Change Vulnerability – High Risk			
0-5%	1	Low	

5-8.5%	1.2	Low-Moderate	Proportion of area that is considered to be of high risk vulnerability to climate change was weighted slightly higher than the medium risk metric. The bins were determined based on quartiles to ensure even distribution of data.
8.5-12.5%	1.25	Moderate-High	
>12.5%	1.3	High	
Safeguard Zone – Groundwater			
0-5%	1	Low	Proportion of safeguard zones within the water body was not weighted. The bins were determined based on quartiles to ensure even distribution of data.
5-15%	1.1	Low-Moderate	
15-30%	1.2	Moderate-High	
>30%	1.3	High	
Greenspace			
0-0.5%	1	Low	Proportion of greenspace within the water body was not weighted. The bins were determined based on quartiles to ensure even distribution of data.
0.5-3%	1.1	Low-Moderate	
3-10%	1.15	Moderate-High	
>10%	1.2	High	

Appendix 2 Catchment measures

Recommended measure	Benefits	Measure description
Bank stabilisation / Bank reprofiling	Flows Morphology Sedimentation Water quality	Riverbanks have often been made oversteep, usually as part of an exercise to deepen the channel. The gradient often causes exacerbated erosion (bringing sediment into the water), especially if plants cannot become established. Re-grading the banks to a more natural profile helps to address this issue and to generally improve habitats.
Barrier removal	Fish passage Flows Sedimentation	Any redundant structures, such as a weir, should be removed to naturalise the channel, enable fish passage, allow for the unimpeded flow of water and re-establish natural riverine processes such as sediment transport. This should be the default option for all redundant structures, where possible.
Buffer strips	Sedimentation	The field margin next to the river is left fallow. Must be at least 2m wide; wider on steep slopes. Can be left to generate naturally, or sown with grass, wildflower mixes etc.
Bypass channel	Fish passage Flows Sedimentation	If a structure such as a weir cannot be removed, e.g because it is listed or supports utilities infrastructure, then it may be possible to bypass it with a re-routed river channel.
Change in land use from arable	Sedimentation	Arable land is often the source of significant volumes of sediment, a problem often exacerbated by poor land management practices. Changing the land use to (floodplain) meadow, pasture or woodland will significantly reduce the sediment load running off the land (and may contribute towards reducing flood risk, as run-off would be reduced).
Channel lining	Flows	The riverbed and banks are lined with an impermeable layer, often clay, to reduce leakage of flow
Channel narrowing	Flows Morphology Sedimentation	The channel is narrowed so that the width is more suitable for the "normal" discharge. This should be undertaken with the creation of a corresponding widened, 2-stage, channel for high flows, so there is no increase in flood risk.
Field and road runoff capture (e.g. swales)	Sedimentation	Swales, gulleys and ponds should be excavated in the riparian zone (or, if appropriate, further away from the river) so the loading of silt/ fine debris from fields and roads will be allowed to collect in them, allowing material to drop out of suspension. The features could be in parallel or series.

Recommended measure	Benefits	Measure description
Fish pass / easement (rock ramp etc)	Fish passage	If a structure such as a weir cannot be removed, e.g because it is listed or supports utilities infrastructure, then it may be possible to construct a fish pass or easement to enable fish passage.
Flow deflectors	Flows Morphology Sedimentation	An object, often a log or branch, is placed on the riverbed. These can be opposite pairs, to concentrate flow in the middle of the channel and to scour a poor or staggered on alternate banks to create sinuosity (especially useful in an over-widened channel). The deflectors should be embedded in the bank, point upstream (at an angle of about 30 degrees to the bank), so as to not exacerbate erosion, and be secured to the bed (e.g. with a rebar).
Introduction/manipulation of large wood debris	Flows Morphology Sedimentation	Woody material (which could range from branches to whole trees) is laid in the channel, generally on the bank margin, to improve habitat availability/ quality.
Re-meandering of a straightened channel	Flows Morphology	A previously straightened channel is re-meandered, naturalising the habitat and increasing the channel length (and therefore the availability of habitat).
Removal of resectioning/artificial channel (e.g. Sanders Park)	Morphology Sedimentation	Where possible, hard revetment should be removed to provide a natural, vegetated bank with normal riverine processes allowed to take place
Riparian fencing	Sedimentation Water quality	Fencing set back a short distance from the top of the bank to exclude livestock from channel
Riparian tree planting	Sedimentation	The planting of trees along the riverbank. Should be a combination of several trees in one area, then a space etc, to give dapled shade. Trees should also be planted at areas prone to erosion.
The addition of gravel	Morphology Sedimentation	The addition of gravel to create gravel beds, riffles or bars, to improve habitat availability/ quality.
Tree thinning	Flows Morphology	Where the channel is over-shaded by riparian trees these can be thinned out (a combination of felling, pollarding and / or coppicing) to improve instream ecology
Working with landowners to stop river dredging	Flows Morphology Sedimentation	Partnership work (workshops, education, provision of information) to reduce the damaging practice of the dredging of small streams by farmers. Over time, berm formation will occur in over-widened channels, naturally narrowing the channel to a more appropriate width which much improves the reach's habitat and ecological functioning. However, when periodically dredged the natural improvements are lost.

Recommended measure	Benefits	Measure description
Wetland creation	Sedimentation Water quality	Change in land cover to wetland habitat type. This can include the construction of in-ditch field wetlands and larger constructed wetlands.