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Restoring soil structure for climate adaptation

Results of changes implemented to the ‘Little Stour’ site by Kent County Council

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COLOFON

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Restoring soil structure for climate adaptation

On Shelvin Farm and Denne Hill Farm in the Little Stour catchment, Kent County Council developed the Interreg 2 Seas PROWATER site 'Little Stour' to demonstrate how the region can adapt to the consequences of climate change through Ecosystem-based Adaptation.

Kent County Council is the Local Authority for Kent County, and the Lead Local Flood Authority. It is concerned with reducing risk and impacts of flooding across the county, and ensuring its residents have a resilient water supply by working with water companies.

By implementing Ecosystem-based Adaptation measures, we want to make Kent County more resistant to the consequences of climate change. Ecosystem-based Adaptation (EbA), a Nature-based approach to climate change adaptation, harnesses ecosystem services to increase resilience and reduce the vulnerability of human communities and natural systems to the effects of climate change. These EbA measures can be integrated into adapted agriculture, forestry and environmental management.

This publication summarises the EbA measures and results implemented in the sub-sites on Shelvin Farm and Denne Hill Farm. Shelvin Farm is a stud farm in the Little Stour catchment, breeding and selling horses. It is mainly on thin chalk soils on a slope, in close proximity to a drinking water abstraction. The EbA measures implemented focused on increasing the diversity of pasture plants and changing grazing regimes to a rotational grazing pattern with more horses in smaller fields for a shorter period. The diversified rooting depths will improve the infiltration capacity of the soil, to promote groundwater recharge. Denne Hill Farm is a mainly arable farm and a LEAF demonstration farm. It uses Integrated Pest Management approaches and has changed to a minimum till practice. The EbA measures implemented as part of PROWATER focused on cover crops with deep rooting species and companion crops / living mulch to improve soil health and infiltration capacity.

The results are summarised using various steps (chapter 1 to 4) that represent the process for successful planning and implementation of climate change adaptation measures (see Output 1). Presented insights and lessons learnt can help governments (national, provincial and municipal), knowledge institutions, consultancies, managers of nature areas, drinking water companies and landowners in the design of climate change adaptation projects.

Figure 1 - The dot situates the demonstration site for Ecosystem-based Adaptation in the Interreg 2 Seas region.

1 Understanding the catchment

1.1 Geographical & hydrological context

The Little Stour and Nailbourne are an example of the globally rare chalk streams found in the South East of England, and one of three PROWATER demonstration sites there. The streams rise from the East Kent Chalk block, a chalk dominated landscape with steep hills often topped by clay soils, and dry valleys. Soils are a mix of well drained chalk soils, especially on slopes, and heavier soils on hilltops or in valleys. Preferential recharge pathways can develop where the acidic clay meets the alkaline chalk, creating solution features that rapidly allow rainfall to reach the groundwater body.

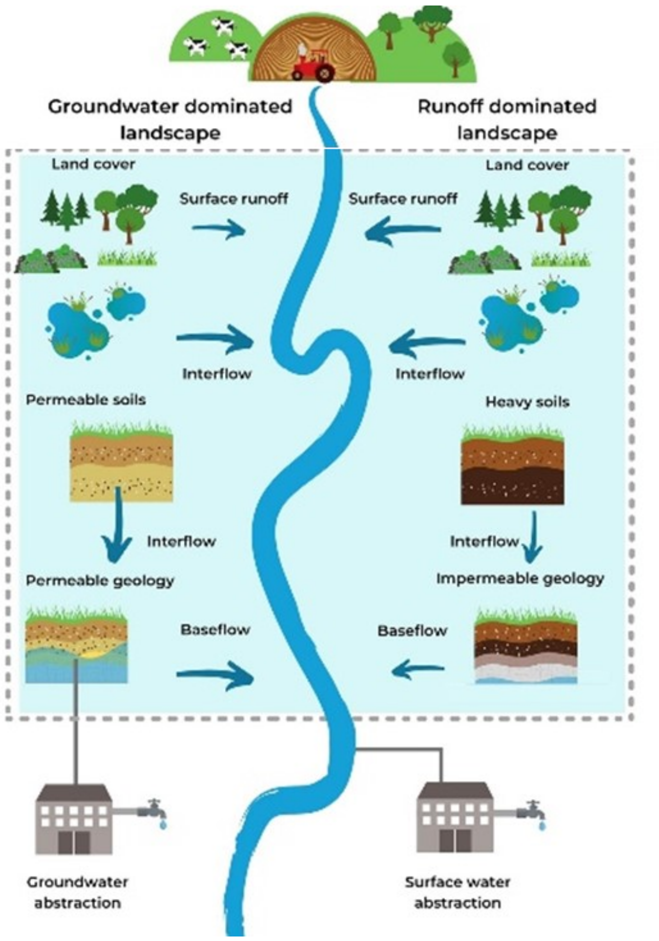

***Figure 2** – The site Little Stour is located in a groundwater dominated catchment.*

*In unmodified or sustainably managed **groundwater dominated catchments** there is little runoff following precipitation as water predominately infiltrates through permeable substrates and moves either laterally or vertically below the surface. However, modification such as surface sealing, soil compaction and land drainage reduce the ability of water to infiltrate and therefore result in greater levels of runoff. Groundwater replenishment depends on the hydrological connectivity to the surface. When connectivity is interrupted by these modifications the resilience of this water supply is reduced.*

*In unmodified or sustainably managed **runoff dominated catchments**, water predominantly moves above the surface but interflow and baseflow are still present. As above, when the landscape is modified, surface runoff dramatically increases and interflow and baseflow are further reduced. This leads to an increase in frequency and severity of low river flows during dry periods and an increased risk of flooding following periods of extreme rainfall.*

A large proportion of the catchment is arable (48%), which can be intensely cultivated and increase risk of soil degradation and diffuse pollution of water systems from fertilizer and pesticides. Woodland (9.2%) is mainly found on impermeable areas. Natural grasslands, an important asset to water resources as they protect the soil, have little nutrient input and a high biodiversity value, cover less than 4% of the area. Chalk grassland, a habitat valued for its high biodiversity, is found in the catchment. At the bottom of the Stour catchment is Sandwich and Pegwell Bay National Nature Reserve, which are impacted by eutrophication.

While the Nailbourne is an ephemeral stream, the Little Stour carries flow at all times. Abstraction (for public water supply, industry and agriculture) beyond sustainable levels leads to these rivers running low more regularly than they should. They are also impacted by diffuse pollution from agriculture, sewage treatment and septic tanks. This has led to the Little Stour, Nailbourne and neighbouring

Wingham being classified as ‘poor’ under the Water Framework Directive, and issues with the quality of drinking water supply. The groundwater body that feeds the Little Stour and Nailbourne, the East Kent Chalk, is also in poor condition due to abstraction, pollution from poor nutrient, soil and livestock management, and sewage treatment. The area can also suffer from groundwater flooding.

1.2 Human context

The Stour catchment is home to some larger towns, including Ashford and Canterbury, and significant amounts of development are in progress. Farming, leisure industry including golf courses and horse riding, energy and paper industry are some key sectors with impact on the water environment. Availability of water resources and their quality is a key challenge in the area.

The high nutrient input from (mainly) wastewater has led to a ‘nutrient neutrality’ requirement to be put on housing development in the catchment, to protect the rare wetlands at the bottom of the catchment from continued degradation due to eutrophication.

Groundwater flooding occurs in areas of the Little Stour and Nailbourne.

Shelvin Farm sits in a dry valley but experiences surface water flooding due to road runoff and runoff from compacted slopes. It falls within the source protection zone for a drinking water abstraction point, meaning that it is likely to directly influence water availability and quality from this groundwater abstraction. It includes some areas that are managed under stewardship agreements.

The Denne Hill Farm sites form part of the Barham Downs farmer cluster, which is creating a network of species rich grassland sites, and extensive areas are under stewardship agreements.

1.3 Water Resource risks & challenges

The Little Stour is a rare chalk stream that is fed directly from the aquifer, which is also the source of drinking water. Changing groundwater levels mean that its source migrates up- and downstream naturally. Low aquifer levels however mean that the headwaters flow less than expected, and the river is suffering from low flows.

Average annual rainfall in the catchment is 740 mm, of which 316 mm contribute to groundwater recharge and river flow. Climate change will bring more intense summer storms, overall reduced summer rainfall and a shorter recharge period, increasing vulnerability of the groundwater body to shorter droughts and pollution.

The East Kent Chalk is an important source for drinking water and across the whole Stour catchment all water abstractions for public water supply, which make the vast majority of abstractions, are from the chalk aquifer. The remainder are mainly for agriculture and industry and comprise both groundwater and surface water abstractions with the latter mainly focused within the low-lying marshes in the North East of the catchment. Southern Water (SW), Affinity Water (AW) and South East Water (SEW) each serve part of the Little Stour and Nailbourne catchment.

Abstraction for public water supply is impacting levels in the groundwater body, leading to low flows in the Little Stour already. By 2050, abstraction will be reduced by 30 000 -100 000 m^3/ day due to environmental protection and climate change (EA, 2020 – Environmental Ambition Document), while demand is likely to increase.

From a farming perspective, the increasing awareness of the challenges climate change brings mean an increased interest in protecting soils and crops from drought, and reducing the loss of nutrients.

2 Identifying and engaging buyers, sellers and brokers

The basic idea behind the PES (Payment for Ecosystem Services) financing model is that investments made by 'buyers' in climate change adaptation measures result in the targeted provision of ecosystem services provided by the 'sellers' (see Output 2). While the cover crop and soil management measures delivered are on a relatively small scale, they demonstrate the benefits (ecosystem services) that EbA measures can provide in the area. The main beneficiaries that are potential buyers in schemes are water companies (and their customers) who directly benefit from a more resilient water supply and reduction of pollution in the groundwater body.

It is a good example of the type of seller that is dominant in the catchment, which is mainly agricultural. Denne Hill Farm is owned and managed by the same family, while many other farms, especially larger arable farms, are managed by contract farmers who do not own the land. The landowner at Denne Hill is also a contract farmer for a number of other farms in the area. In some cases, land is owned by the wildlife trust or government bodies such as the forestry commission.

A number of organisations are acting as a form of broker in the catchment, mainly those offering environmental/agricultural advice. In PROWATER, the South East Rivers Trust together with the Kentish Stour Countryside Partnership brokered an agreement between landowners and funders, which included water company and public funding. Partners such as Natural England were crucial in making contact with farmers.

The main cost of the EbA measures delivered on Denne Hill was for the seeding and management of the cover crops.

Cost element	£
Seed cost / ha	50
Delivery/ha	90
Ongoing management (per ha for 5 years)	500
TOTAL	540/ha (5 years)

An overview of opportunities for funding measures relevant to the site is given below:

- **Environmental Land Management Schemes (ELMS) and agri-environment schemes**
  The Sustainable Farming Incentive, the first tier of the new ELMS in England, include standards on soil management at given payment rates, to support the public goods provided from these practices.
- **Existing water company schemes**
  Parts of the catchment are eligible for funding from the local water company to reduce pesticide input
- **Flood risk reduction**
  Settlements in the catchment already suffer from flooding and this is likely to become more problematic with climate change. The Environment Agency as well as Kent County Council are interested in reducing this risk and already funding NFM schemes.
- **Biodiversity Net Gain**

Across England, a mandatory 10% 'biodiversity net gain' will apply to developments and infrastructure projects. Some areas are proposing higher targets, including Kent County Council who are pushing for a 20% net gain mandate. A proportion of this gain will need to be made by creating or restoring habitats on private land, creating biodiversity credits and paying for their maintenance over 30 years.

- **Nutrient trading / neutrality**
  The need for nutrient neutrality in the Stour catchment is causing an increase of interest in nature-based solutions such as constructed wetlands to reduce the impact of P and N on protected wetland habitats. Changes in land management may be able to support some reduction in nutrient input but is unlikely to be a focus.
- **Carbon trading**
  While there are currently few established and accredited systems to trade carbon credits, there is an increasing appetite both on the buyer and seller side. This is particularly the case for woodland planting / regeneration and soil carbon, but also being developed for other habitats.

Figure 3 - Summary of the different stakeholders acting in the catchment.

3 Prioritising locations for climate adaptation measures

3.1 Prioritisation by means of the water system map

For the project PROWATER, the University of Antwerp applied the water system map to the Interreg 2 Seas area (including catchments in Flanders, the Netherlands and South England) (Output 3). This map helps prioritise where to best apply EbA measures to infiltrate and retain water, based on hydrological characteristics, soil typology and topographical information. The map identifies 'natural places' in the landscape for seepage (groundwater coming back to the surface) and infiltration.

The Little Stour is a chalk catchment with some clay caps on hilltops restricting recharge. Slopes with thin soils on chalk are particularly suitable to focus on enhancing recharge to the aquifer. Most of the catchment is productive arable land, with some pasture and woodland, and a small proportion of natural grasslands. These are often particularly well suited to less productive areas including slopes, and so can play a key role in protecting water resources by enhancing infiltration and reducing runoff without significantly increasing demand for water.

Groundwater dominated catchment

Hill top / Plateau – infiltration area, where water can infiltrate to groundwater bodies (indicated in brown)

Valley height – infiltration area, where water can infiltrate to groundwater bodies (indicated in yellow). Water that infiltrates here will have less residence time before it emerges in streams. However, flood attenuation can be achieved by infiltration.

Hill depression / Valley depression – Temporarily wet area, where runoff can be retained and slowly infiltrate. (indicated in green)

Floodplain – Temporarily wet area, where runoff and seepage can be retained and slowly infiltrate. (indicated in blue)

Figure 4 - The red circles indicate the location two of the sub-sites on the water system map. The map suggests the sites have a natural potential as infiltration (brown) and temporary wet (green) areas. However, in this agricultural field the focus wat put on soil restoration to promote infiltration, rather than temporary wet nature, so agricultural activities can maintain.

The water system map applied to the chalk aquifer of the Little Stour is challenging to interpret as groundwater levels are far below the surface and movement of water is not only bound to topography but also fissures and changes in the chalk bedrock itself. However, the mapping can be used to identify priority spots for infiltration on hilltops and slopes, where infiltration is likely to be able to contribute slowly to recharge across the season. It also shows where runoff might converge during extreme events.

Shelvin Farm, for example, includes fields in the infiltration and temporary attenuation zone. Here, focus was put on pasture management to increase root depth and soil organic matter, to enable the soil to retain more water.

3.2 Refining spatial prioritisation & EbA opportunities

Spatial planning and the choice of EbA measures implemented also considered the following:

- Main factor: landowner willingness
- Soil type and current land use
- Slope and potential for surface water input
- Anticipated water quality
- Distance from borehole

Shelvin Farm is a stud farm in the Little Stour catchment, breeding and selling horses. More diverse herbal species were introduced in the pasture and grazing regimes were changed to a rotational grazing pattern with more horses in smaller fields for a shorter period of time. Denne Hill Farm is a mainly arable farm and a LEAF demonstration farm. It uses Integrated Pest Management approaches and has changed to a minimum till practice. Cover crops were implemented with different rooting depths. The diversified rooting depths are expected to improve the infiltration capacity of the soil, to promote groundwater recharge.

3.4 Expected impact

Using the Rivers Trust Replenish tool and work done by Cranfield University, it was estimated that an improvement in soil health from 'good' to 'excellent' would increase annual recharge by 20-40mm per year, equating to 20-40m^3 water per hectare.

4 Monitoring and Evaluation

4.1 Monitoring and evaluating the impact of EbA on ecosystem services

Different indicators are monitored to estimate the impact of EbA on the targeted ecosystem services, i.e. increased water infiltration to the aquifer:

- VESS (Visual Evaluation of Soil Structure) – seasonal
- Infiltrate rate - seasonal
- Soil Moisture Profile probes – logging volumetric moisture content to 60cm depth every 15 minutes
- Soil nutrient status, organic matter, carbon

Monitoring has proved challenging due to the weather across the years being very different, with especially the first year since implementation of measures being very dry. Additionally, the siting of loggers had to be adjusted due to the design of the measure.

Additional evaluation options are modelling impacts (challenging given the nature of the change), or evaluation based on a scoring system (e.g. using the Biodiversity Metric 3.1 to assess change in habitat value, and the associated ecosystem services).

4.2 Evaluating the participatory planning and implementation process

No permits were needed. If the land was in an existing stewardship scheme, a derogation would be needed.

Funding through EU grants is well suited to implementation of capital measures that have low maintenance requirements. Soil and pasture management however are measures that require a large area with ongoing management needs (e.g. reseeding) but have low immediate costs. This makes them potentially less suitable for larger capital grant schemes, but well suited to annual schemes.

Monitoring and being able to demonstrate outcomes are key challenges for stakeholders especially on the buyer side. Robust, evidence based spatial targeting and a level of quantification is able to support buy-in.

Being able to have a demonstration site that farmers, landowners, and other stakeholders can visit has been a key part in communicating and developing a vision for the catchment. This has been partly due to the support from landowners. While there is often a drive to focus on hard-to-engage audiences, having a supportive partner that can provide a different perspective and engage with different stakeholders has been invaluable.

Landowners and farmers often highlight the importance of robust, local advice in developing a shared vision for an area, and in bringing landowners together at scale. Having a knowledgeable facilitator is key. Building strong partnerships with other organisations further creates trust and a shared message that is more likely to get buy-in from sellers.