Medway Natural Flood Management Report

The final report following the Defra and FRAMES funded project to install natural flood management techniques to four sites in the Medway catchment in Kent

south east rivers trust

Environment Agency

Interreg North Sea Region FRAMES European Regional Development Fund

EUROPEAN UNION

Part of the Medway Flood Partnership

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Contents

Glossary

Defra	Department for Environment, Food and Rural Affairs
ELMS	Environmental Land Management Scheme is replacing the Common Agricultural Policy as the government farm subsidies scheme following Brexit. It is still in creation and the final details of it are yet to be confirmed but the government have stated that it will focus on providing farmers with payments for the provision of public goods, such as flood risk reduction.
FRAMES	The Flood Resilient Areas by Multi-LayEred Safety (FRAMES) project assesses the impact of and build resilience to flooding and climate change across the health and social care sector in Kent.
JNCC	The Joint Nature Conservation Committee (JNCC) is the statutory adviser to the government and devolved administrations on UK and international nature conservation.
KCC	Kent County Council
LiDAR	LiDAR or Lidar is a method for determining topography of landscapes, by targeting an area with airborne laser and measuring the time for the reflected light to return to the receiver. Lidar is used to make high resolution digital 3-D representations of areas on the earth's surface, due to differences in laser return times, and by varying laser wavelengths.
LWSs	Leaky Woody Structures are partial blockages of watercourses using natural materials (tree trunks) to slow the flow, help water spill out of the channel (reducing flood risk downstream) and kick-start natural processes.
MFP	Medway Flood Partnership The Medway Flood Partnership (MFP) was formed in 2017 to better coordinate work to manage flood risk and increase resilience and recovery across the catchment. The MFP brings together local partners, national agencies, NGOs and community representatives in a strategic, multi-agency partnership, taking a whole catchment approach.
MFAP	Medway Flood Action Plan The MFP published the Medway Flood Action Plan (MFAP) in December 2017. The document sets out actions to help reduce flood risk and increase preparedness and resilience to flooding. The actions are set out under 3 themes: • Capital Investment and Maintenance • Community Resilience • Natural Flood Management

NFM	Natural Flood Management NFM aims to slow the flow of water using techniques such as leaky woody structures (LWSs), storage bunds, tree planting, improving land management practices and restoring natural river forms such as meanders. NFM solutions can complement existing traditional manmade defences by holding back flood water and reducing the flood peak.
Scalgo Live	Scalgo Live is a mapping software tool that allows the investigation of landscapes to view the size and extent of an area contributing water to a chosen point and the flow pathways from that point to the nearest downstream depression. It can inform the layout of new developments and interventions to determine the impact on flow pathways, flood risk areas and the volumes of water in and arriving at those areas. It can be used to design climate adaptation initiatives or to ensure that new infrastructure and urban development do not collide with critical risk areas.
SCIMAP	SCIMAP is a mapping tool that provides a framework to consider where in the landscape diffuse source water quality and floodwater pressures are coming from and hence where mitigation actions would be most effective. SCIMAP works by identifying where there is a significant source of the pressure, related to attributes such as land cover, topographic position and ground slope gradient, and the connectivity, which is the ease with which material can make it to the channel. The SCIMAP framework considers four environmental pressures: 1. sediment, 2. nutrients (N and P), 3. microbial pollution (FIOs such as E. coli) and 4. flood hazard generation.

Executive summary

The Medway Natural Flood Management (NFM) project installed NFM solutions at four separate sites within the Medway catchment. These were chosen from a shortlist of priority catchments drawn up by the Medway Flood Partnership (MFP).

The project was delivered over four years (2017-2021) by the South East Rivers Trust (SERT), in partnership with the Environment Agency and with funding from the EU Interreg North Sea FRAMES project and the Department for Environment, Food and Rural Affairs (Defra). It forms part of a wider national programme of NFM projects which was funded by Defra to help improve our understanding and bridge data gaps about NFM techniques and their value to flood risk management and the wider environment.

The Medway NFM project team worked with 10 landowners in total and provided advice and ideas to many more. In total, the project has:

- Reduced flood risk to over 100 properties;
- Provided environmental benefits including 8.2km of watercourse, 200m^2 of online wetland habitat and 5,750m^2 of offline wetland habitat;
- Enhanced 2.3ha of lowland meadow and 11ha of ancient woodland.

This has demonstrated the value of NFM to biodiversity, water quality and the physical habitat within streams which will improve water management and restore more naturally-functioning of headwaters. Monitoring and evaluation has provided valuable information on how to implement NFM, the costs and practical considerations. Time limitations on the project has limited our ability to quantify the benefits and so longer-term datasets on interventions and changes to flow are needed.

The Medway NFM project illustrates that landowner cooperation is critical to the success of NFM projects. For the future, more information about potential financial incentives for landowners may help encourage participation. Where the multiple benefits stretch to water companies and other partners, this can bolster the project's profile and deliverability.

Investment in engagement and education will be crucial in altering traditional drainage practices and gaining further landowner cooperation and stakeholder buy-in in the future.

Unlike some of the other pilot projects where large areas of land are owned by a few landowners, much of the Medway catchment is made up of smaller landholdings. As a result, the project team had to identify and build relationships with many landowners which took time and added further complexity to the project.

By delivering some of the first NFM work in priority sites in the Medway, this project has laid strong foundations for further NFM projects in the future. There is an appetite for wider uptake of NFM and the outcomes would benefit the catchment if implemented more widely.

The predicted increase in flood risk in the region due to climate change, as well as widespread degradation of the water environment, are clear potential beneficiaries of wider implementation of NFM. The Medway NFM project has built the capacity of the MFP and its partners to deliver NFM and has established good relationships with key stakeholders, including landowners, funders, practitioners and local communities.

To realise the full potential of the benefits NFM can provide in the Medway, the momentum and lessons learnt from this project should be seized upon by the MFP. Future practitioners and funders of NFM in the Medway should work together to implement NFM strategically, monitor its impact, continue to engage and educate others.

1. Introduction

The aims of this report are to:

- Document the Medway: Natural Flood Management (NFM) project in detail and the process it followed;
- Quantify the benefits it provided;
- Communicate the lessons learnt to inform similar projects in the future.

This report has been prepared as a reference document for internal use by the Medway Flood Partnership (MFP) and its partners, as well as fellow NFM practitioners. The report will be made available to others upon request. The appendices include project summary information in table formats.

1.1. The concept of Natural Flood Management

Rivers are dynamic features of the landscape. They change over time as a result of the natural processes of erosion and deposition, that shape and drive constant change. One such natural process is when rivers flood their floodplains. For centuries, we have systematically drained the land by adding field drainage and ditches throughout the landscape., speeding up the flow of water to the sea, to improve land for agricultural production.

Flooding can pose a serious hazard to human life and the national economy, with an estimated cost to the British economy of £1.6 billion in 2015-16 alone (Environment Agency, 2021). As communities have developed more rapidly over the last few centuries, conflicts between flooding and human occupation have become more frequent and we have sought to prevent the negative impacts of flooding. Traditionally this has been through constructing flood defences and a combination of straightening and dredging rivers and removing trees. However, a series of serious flood events in England in the early 21st century, the projected increase in future flood risk due to climate change and population growth, has prompted a rethink of the approach to managing floods.

Constructing conventional, hard-engineered schemes alone is untenable, as highlighted by the government-funded Pitt Report in 2008 (Environment Agency, 2018, p4): “flood risk cannot be managed by simply building ever bigger hard defences”.

The Pitt Report instead suggested a shift in focus to managing flood risk more holistically by slowing the flow and holding water for longer throughout the catchment. This can be done by restoring natural processes to rivers using Natural Flood Management (NFM) solutions such as: leaky woody structures (LWSs), storage bunds, tree planting, improving land management practices and restoring natural river forms such as meanders. These NFM solutions can complement existing traditional manmade defences by holding back flood water and reducing the flood peak (Figure 1.).

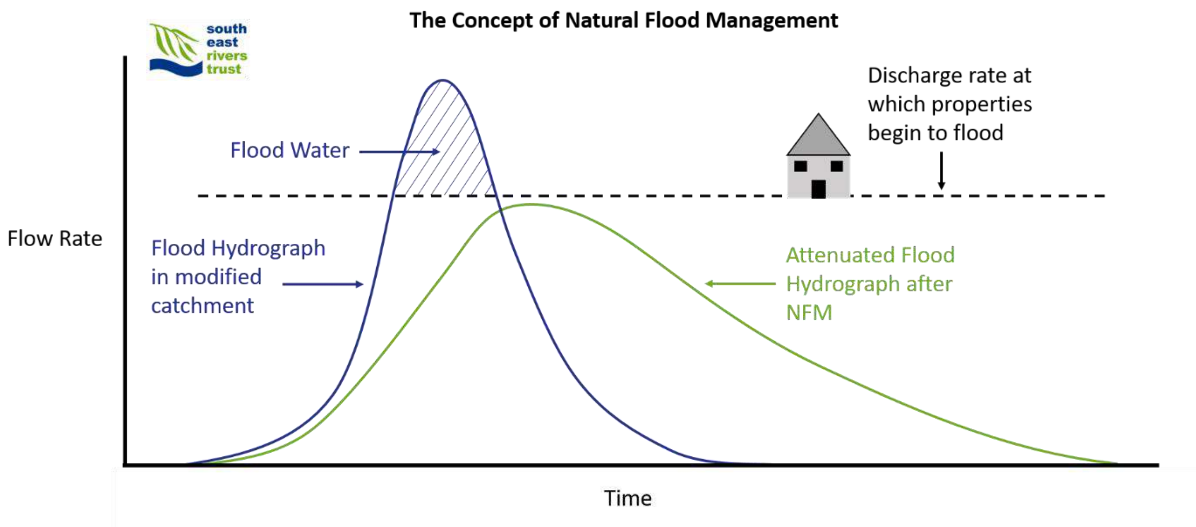

Figure 1. Graph to show NFM impact on storm hydrograph and lower flood peak

NFM can be used to take a more holistic, catchment-level approach to managing flood risk. It can be particularly effective in headwater areas, smaller or more rural catchments, where engineered defences may be less cost-effective, or in areas where impermeable clay can increase the risk of flash flooding (Nicholson *et al*, 2019).

1.1. The National NFM pilot

In November 2016, the Environment Food and Rural Affairs Committee (EFRAC) published a report on ‘Future Flood Prevention’. This stated:

“More frequent, more intense storms resulting from climate change will in future put more people at risk and increase flood impacts. The Government has increased budgets for flood risk management, but this level of funding is unlikely to deliver sufficient protection in future decades.”

It went on to say that the Department for Environment, Food and Rural Affairs (Defra) should commission a large-catchment trial to test the effectiveness of natural flood risk management approaches such as installation of leaky dams, tree planting and improved soil management, alongside other measures.

On 25 November 2016, the Secretary of State for Defra responded to a question in parliament, saying *“There are concrete barriers, which are very important, and we have had 130 new schemes since January, better protecting 55,000 homes. However, natural flood management—slowing the flow, and looking at ways to work with the contours of our environment to improve protection - is also vital. I can announce that we have been given £15 million to invest in further projects to do just that.”*

1.2. Addressing the knowledge gaps in NFM

At the beginning of 2017 the Environment Agency’s evidence base for NFM showed that such actions:

- Can be effective at reducing flood risk in smaller magnitude floods and in small-to-medium size catchments;
- Are most effective when complementing engineered flood defences, rather than offering a replacement;
- Consistently provides additional environmental benefits.

By analysing the archive of successful NFM case studies, the Environment Agency identified several knowledge gaps which a larger-scale trial of NFM could help to address. These included:

- The need for observed data to help quantify the level of flood protection provided by different NFM measures, or a combination of NFM measures;
- Further investigation of the flood risk benefits of NFM in different settings, specifically:
    - Catchment size;
    - Catchment geology;
    - With a variety of NFM techniques used.
- The need for more information about the additional environmental benefits NFM could provide, and how these benefits might increase a catchment’s resilience to climate change;

- A better understanding of the potential challenges of implementing NFM in a wider setting and how these might be overcome, in particular how we work effectively with landowners.

1.3. The Medway NFM project

In the Medway catchment, flooding events in 2013/2014 raised the public and political profile of local flood risk. As a result, the Medway Flood Partnership (MFP) was formed in 2017. The MFP's role was to better coordinate work to manage flood risk and increase resilience and recovery across the catchment. The MFP brings together local partners, national agencies, NGOs and community representatives in a strategic, multi-agency partnership, taking a whole catchment approach. In December 2017, the MFP published the Medway Flood Action Plan (MFAP), which set out actions under three themes to help reduce flood risk and increase preparedness and resilience to flooding. The themes were:

- Capital Investment and Maintenance;
- Community Resilience;
- Natural Flood Management.

The MFP was successful in securing funding for the Medway NFM project from Defra's £15 million pilot scheme. The Medway NFM project formed actions 29-33 of the MFAP (Figure 2.):

Action	What we're going to do	Where?	When?	Owner	Who else will support this work?
29	Through the FRAMES project, identify priority sub-catchments where natural flood management techniques will achieve greatest benefit in reducing flood risk in the catchment. Carry out modelling and identify the techniques to achieve this.	Catchment wide	2017/18	South East Rivers Trust	Environment Agency Natural England Forestry Commission Kent County Council
30	Through the FRAMES project, work with local communities and landowners in priority sub catchments to design and deliver natural flood management schemes which will test land-management techniques.	Catchment wide	2018-2021	South East Rivers Trust	Environment Agency Natural England Forestry Commission Kent County Council
31	Develop a funding strategy to identify and secure additional resources for natural flood management measures across the catchment. This will be a live document and reviewed regularly.	Catchment wide	2017/18 and reviewed regularly	South East Rivers Trust	Environment Agency Natural England Forestry Commission Kent County Council Southern Water
32	Through the FRAMES project, coordinate the use of existing mechanisms and networks across the partnership to build understanding of the wider benefits of natural flood management techniques and encourage landowners and tenants to consider implementing them within their current practices.	Catchment wide	2018-2021	South East Rivers Trust	Natural England National Farmers Union Country Land and Business Association Environment Agency Kent County Council

Figure 2. Extract from the Medway Flood Action Plan

The Medway NFM project partnership was led by the South East Rivers Trust (SERT). SERT are a regional Non-Governmental Organisation dedicated to conserving and restoring rivers and their catchments in the south east of England.

The Medway NFM project was funded by:

- The EU (FRAMES): £149,213.12;
- The Environment Agency: £355,000;
- Maidstone Borough Council: £70,000.

The FRAMES (Flood Resilient Areas by Multi-LayEred Safety) project aimed to assess the impact of, and build resilience to, flooding and climate change, across the health and social care sector in Kent. FRAMES used the multi-layered safety concept to manage future risk by:

- Improving flood prevention measures;
- Developing spatial planning measures;
- Building emergency preparedness and response capability;
- Reducing future risk through resilient recovery.

1.4. Medway NFM project objectives

The objectives of the Medway NFM project, for its Defra financial contribution, were:

- The project will demonstrate a reduction in flood risk to at least 51 properties within the Medway;
- Deliver at least 20km of mitigation measures to WFD priority watercourses and contribute to creating or improving at least 20 hectares of priority habitat;
- The project enhances the evidence base of natural flood management schemes by providing monitoring of at least 50% of the projects in line with national monitoring guidance;
- The project will build on investments from within the Defra group and from external partners in each area to deliver value for money and providing at least a 50% match funding;
- Reach the communities, landowners and partners in the 3 sub-catchments, working with land managers to co-design NFM and realise multiple benefits;
- Provide published data and report by the end of the project period on the calculated benefits of NFM on flood risk and the wider environment.

The project team identified some critical successful factors to delivering on the objectives (Figure 3.).

	Critical Success Factor	Measurement Criteria	Importance: 1-5 (1 = highest)
1	South East Rivers Trust and other partners able to deliver required capacity and capability of staff to manage project delivery	SERT provide sufficient staff time and capability to run the project Phase 1 Projects delivered in 2018	1 1
2	Landowners engage with NFM and offer sufficient land to deliver projects	Projects are successfully developed across sufficient land to meet: - Flood risk targets - Biodiversity & WFD targets	1 3
3	Communities and partners engage with NFM and focus their objectives to include NFM thereby enabling delivery	Positive working relations with partners Financial contributions (match) secured	2 2
4	Obtain consents and permits or agreement from lead flood authority/IDB/ Environment Agency /landowner to deliver projects	Agreements and permits for all projects to be delivered Agreements with landowners for long-term maintenance	1 1

Figure 3. Critical success factors in Medway NFM project

1.5. Flood risk and geography of the Medway catchment

The River Medway rises in the High Weald in West Sussex and flows in a north-easterly direction through Kent before discharging into the Thames Estuary at Sheerness. The upper river drains the Ashdown Forest to the south before it is augmented by a major tributary the River Eden, draining the Surrey Hills to the west, upstream of Royal Tonbridge Wells. The river flows through the towns of Tonbridge, Maidstone and the Medway Towns conurbation. It is approximately 113km long and has a catchment area of approximately 2,400km^2. The fluvial floodplain is at its widest between Tonbridge and Yalding, where flood risk is high, before the river is joined by its other major tributaries, the Rivers Teise and the River Beult. The valley then narrows, as it passes through the North Downs around Maidstone, before the discharges into the estuary at Allington. The river between Tonbridge and the sea is modified for navigation with associated lock structures throughout.

Historic records show major floods approximately once every 10 years with floods in the 1920s, 1947, 1960, 1963, 1968, 1974, 1979, 2000/01, 2013/14 and 2020. With Yalding being particularly affected. The Flood risk zone and urban areas are shown in Figure 4. The project aimed to consider this broad area, which includes many other affected communities, small villages, hamlets and scattered farms.

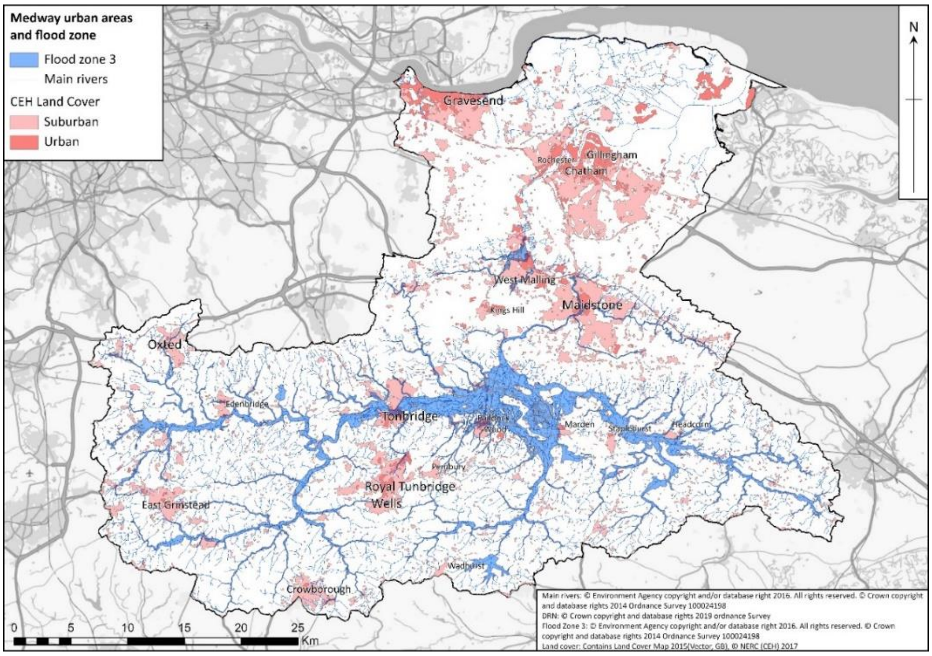

Figure 4. Map showing flood risk and urban areas in the Medway catchment

Geology is a significant factor in contributing to drainage networks, flood risk and how and where floodplains form and are used. The geology of the catchment is shown in (Figure 5.). The bedrock geology upstream of the Yalding area is the Wealden group, made up of mudstone (dark green on the map) are based on clay and are impermeable. Catchments on this bedrock can be highly responsive to rainfall events and face a significant risk of flash flooding. Figure 5 also shows the sub-catchments identified as priorities for delivering NFM interventions, based on Environment Agency and Local Authority local knowledge. Sub-catchments such as these, where settlements are in the flood zone and historically affected, were suggested as prime candidates for benefitting from NFM. Implementing NFM solutions in catchments with varying impermeable geologies also helps to provide data on how effective NFM is under differing geographic attributes.

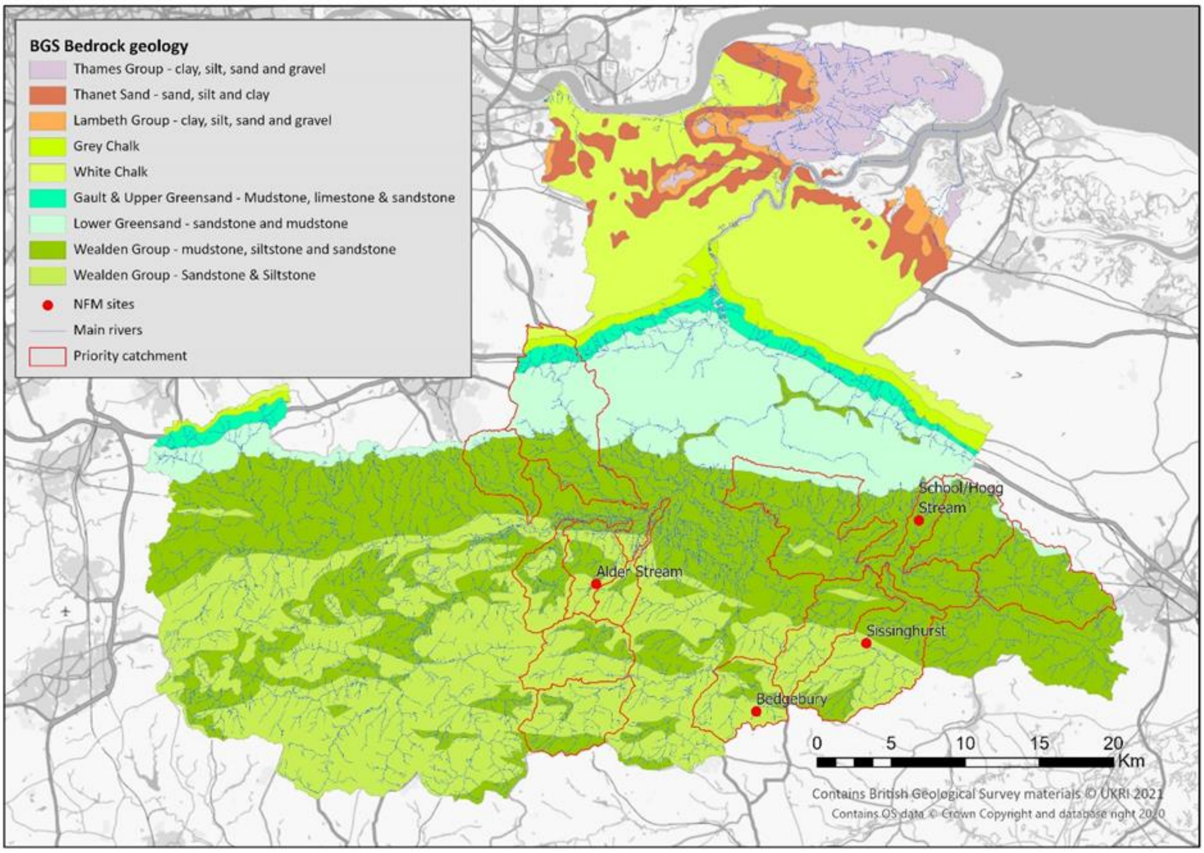

Figure 5. Map showing Medway catchment geology and eleven priority catchment initially identified for NFM implementation

The catchment has been widely altered through deforestation and land drainage for agriculture, and this has altered or inhibited many natural processes. The Medway catchment is largely rural but includes towns such as Tonbridge and Royal Tunbridge

Wells, and several small towns and villages, connected by major roads and railway lines. The predominant land uses in the catchment are arable and horticulture, broadleaf woodland and improved grassland, which is predominantly used as pasture (Figure 6.).

The impact of urban areas on increasing surface runoff is well understood. However, runoff and downstream flood risk can also be affected by land management practices, including land/field drains and ditches designed to move water downstream as fast as possible. Grazing and arable farming can also lead to soils becoming compacted and degraded, increasing runoff rates. With a large percentage of the priority sub-catchments (Figure 5.) and upstream land use dedicated to pasture (improved grassland) and arable farming, these fields are often drained which can exacerbate the risk of flash flooding.

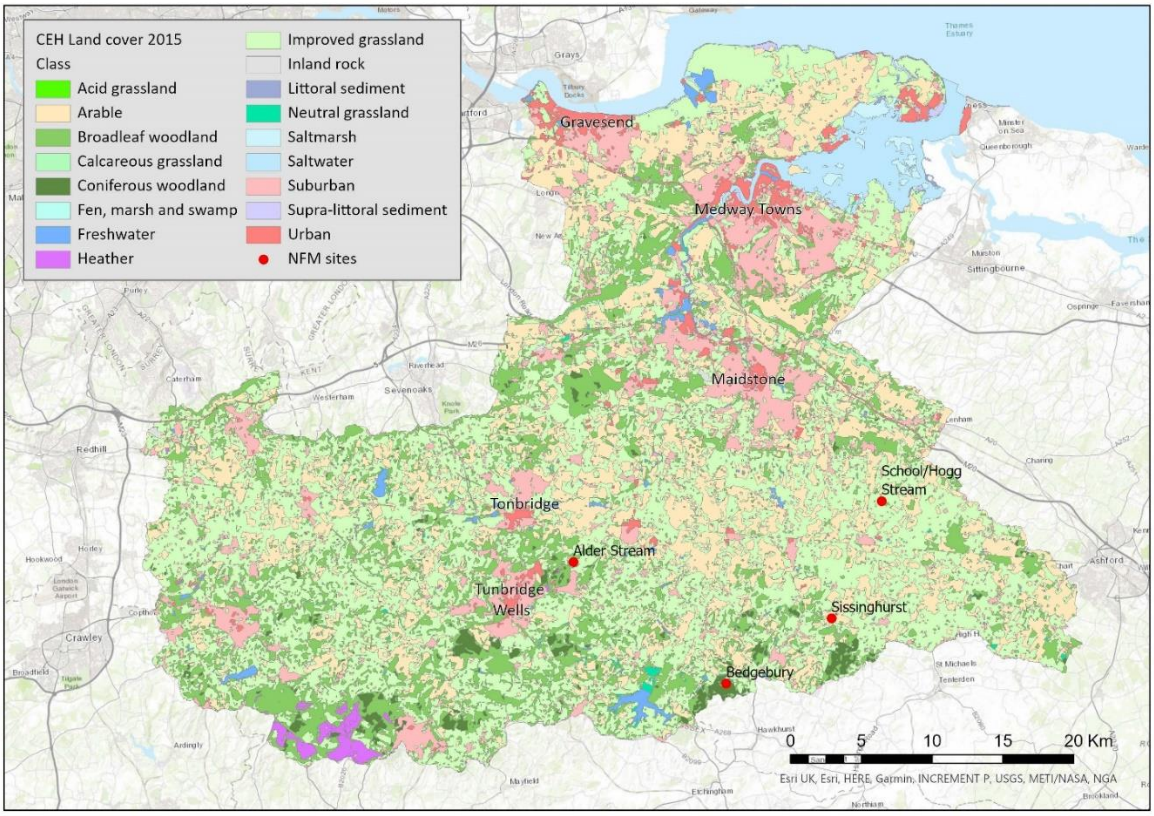

Figure 6. Map showing land use in the Medway catchment

As a result, there are multiple opportunities throughout the river and its catchment to enhance natural features and kick-start natural processes. In many instances, this could be achieved using NFM techniques to also improve river habitats, particularly if the watercourse lacks trees and/or woody material in the channel, or is incised

(Figure 7.), straightened, or disconnected from the floodplain. Fencing to exclude livestock can also reduce soil compaction and reduce run-off rates (Figure 8.).

Figure 7. A deeply incised section of the Hammer Stream (a tributary of the Medway). The channel is disconnected from its floodplain for all but the most extreme flows.

Figure 8. Example of ancient woodland degraded by livestock. The area was fenced off as part of the Medway NFM scheme to restore the woodland and provide flood risk benefits.

The south east is at the forefront of the effects of climate change in England, therefore trialling NFM to determine their benefits for climate change resilience is important. Where the benefits do not impact on current land use, there is scope to apply NFM solutions in the Medway to reverse widespread historic drainage of the land for agriculture. This also increases drought resilience by increasing water availability, and has significant application for increasing resilience to climate change the south east region.

Wet woodland is a 'priority habitat' in the UK Biodiversity Action Plan (BAP) by the Joint Nature Conservation Committee (JNCC), which places it amongst the British habitats 'most threatened and requiring conservation action' (JNCC). It is estimated that wet woodland occupies 50,000 - 70,000 ha of land in the UK (UK BAP, 2011), and in the south east of England, it is particularly under increasing threats from climate change due to hotter and drier summers. In the High Weald of Kent, particular conservation value is attached to 'gill woodland', which is associated with steep-sided valleys, high humidity, and ancient origins. Wet woodland can be enormously rich in biodiversity (Figure 9.), and the gill woodlands of the Weald are of high conservation value for their unique diversity of oceanic ferns, mosses and liverworts, that are outside of the generally western Atlantic distribution.

Figure 9. The forest floor at Bedgebury forest showing the species-rich flora supported by the wet woodland ecosystem

Although it has not been accurately quantified in academic studies, it is likely that when kept wet, wet woodlands sequester more carbon than other forms of woodland in a similar fashion to raised bogs and peatlands (Figure 10), making it an important mitigation measure in limiting further climate change.

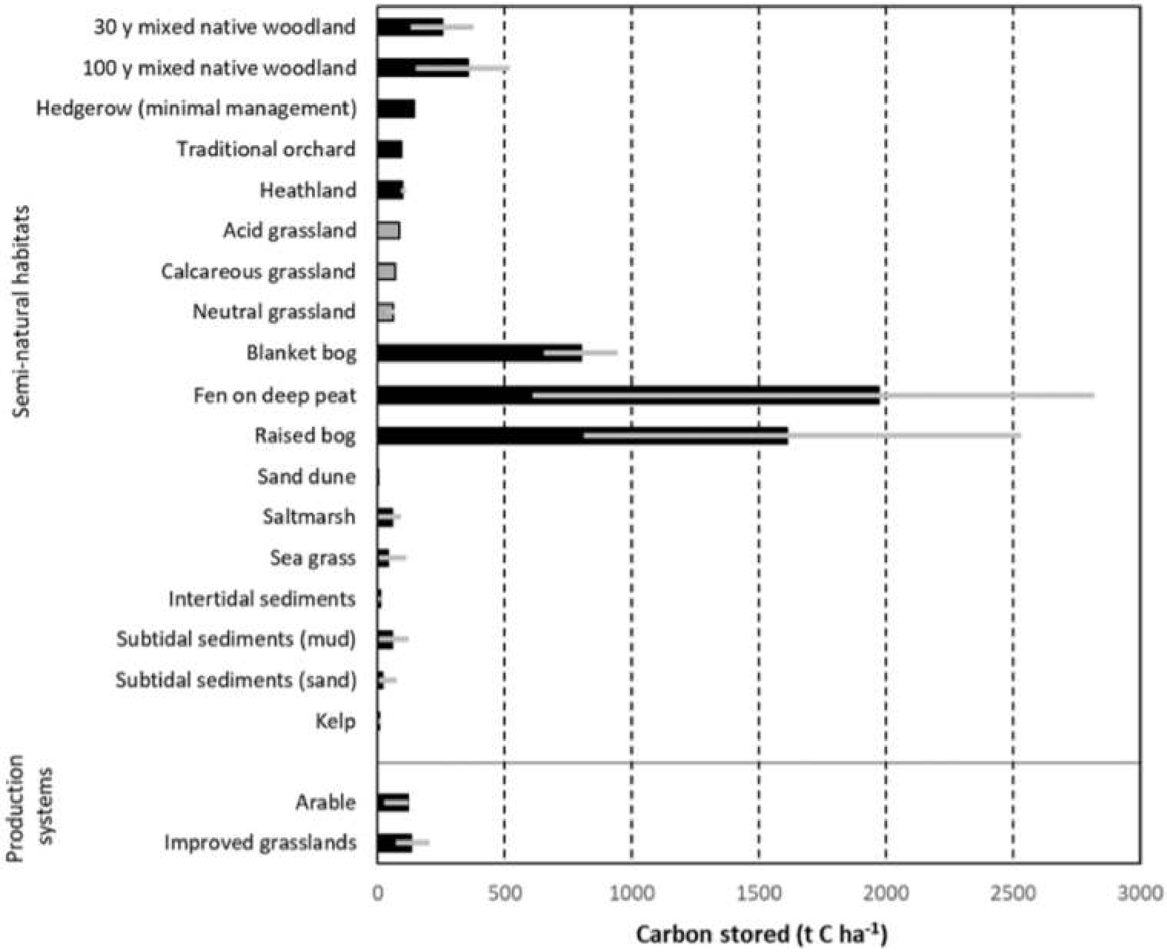

Figure 10. Natural England (2019, pvi): Carbon storage in contrasting habitats

1.6. Site selection

National NFM mapping identified multiple sub-catchments in the Medway to be amongst the top sites in the country that could benefit from utilising NFM techniques. In order to narrow down where to deliver NFM, local knowledge of known properties at risk from flooding, combined with the deliverability of the other objectives, was used to identify priority sub-catchments. Initially, 11 priority sub-catchments (Figure 5.) were identified as potential candidates for NFM. Landowner engagement was carried out across these sub-catchments to screen for initial acceptability. In addition, the following criteria were used to helped us narrow down these priority sub-catchment to select sites to work on:

- Number of properties that would benefit from reduced flood risk;
- Small headwater sub-catchments where NFM would be effective to monitor change;
- Potential projects that formed clusters of activity would help with monitoring and demonstrating benefits;
- Landowners who agreed to a 6-year maintenance and monitoring agreement with SERT;
- Sites that could have work delivered on within the timescales of the project;
- Opportunities for public engagement and showcasing of techniques;
- Innovative NFM designs, or site characteristics that could bring new information to the National NFM datasets.

SERT and the Environment Agency worked with the MFP's NFM Steering Group to initially scope landowners and land holdings that, based on these criteria, could be approached about participation. Following some initial work raising awareness of the project, over 30 landowners were liaised with (many were visited) to discuss potential projects on their land. At some sites, an appraisal of NFM options was undertaken. These potential options were then discussed with landowners to make decisions on if they would be delivered, based on making a judgement on the cost of the measures and opportunity cost for landowners, against the potential flood risk and additional benefits the measures could deliver. Work was started at Bedgebury Forest and Sissinghurst, it was then decided to concentrate on just two other waterbodies, so interventions throughout the catchment could complement each other and have an additive effect to reduce downstream flood risk to communities of Five Oak Green and Headcorn. This would also focus our delivery and ensure efficiencies were achieved with the remaining time and budget available.

The 4 NFM project areas (Figure 11.) selected were:

1. Sissinghurst Castle estate;
2. Bedgebury Forest and Pinetum;
3. The Alder Stream catchment upstream of Five Oak Green;
4. The School Stream catchment upstream of Headcorn.

NFM at all four sites would collectively contribute to the project objectives and demonstrate potential costs associated with scaling up NFM to provide multiple benefits at a catchment scale.

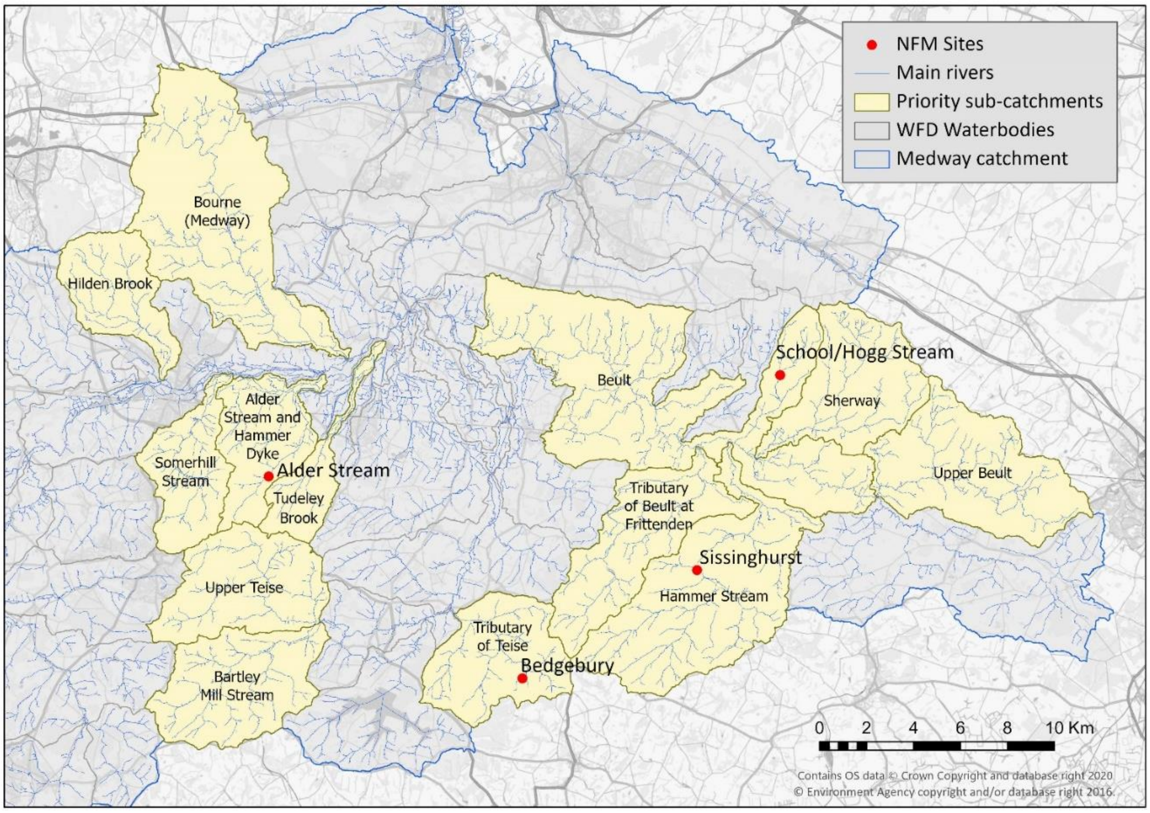

Figure 11. Map showing the priority catchments within the Medway and the four sites for NFM measures

2. Site one: Sissinghurst

2.1. Baseline flood risk and geography

Sissinghurst Castle Garden estate is owned and run by the National Trust. It is an historic residence with multiple listed buildings and decorative gardens. It is amongst the National Trust's most popular sites, with almost 200,000 visitors in 2017. The house and gardens cover 2ha but the wider estate is approximately 180ha, and including woodland, pasture and arable fields. Habitat provision and ecological monitoring of key species is run in partnership with other organisations. Sissinghurst Castle sits on the Hammer Stream, a tributary of the River Beult, that joins the Medway at Yalding (Figure 12.). The Hammer Stream catchment was a priority sub catchment to trial NFM, as it offers the opportunity to demonstrate 'slowing the flow' and store water upstream of the Yalding and Headcorn areas. There were no specific properties identified as directly benefiting from carrying out NFM at this site. However, the site had significant potential to demonstrate ecological enhancements through selected NFM measures, and increasing public engagement with NFM by showcasing interventions to visitors. The Hammer stream has been straightened and significantly deepened, disconnecting it from its floodplain. This has allowed much of the catchment to be used more intensively for agriculture, including at Sissinghurst where the stream side fields were used for arable production for 100 years. For this site, the focus was a former arable field at the confluence of the Hammer Stream and Sissinghurst Stream. It was under Countryside Stewardship and had recently been converted to a meadow, however it rarely flooded and was high in nutrients, meaning the flora within the sward was species-poor.

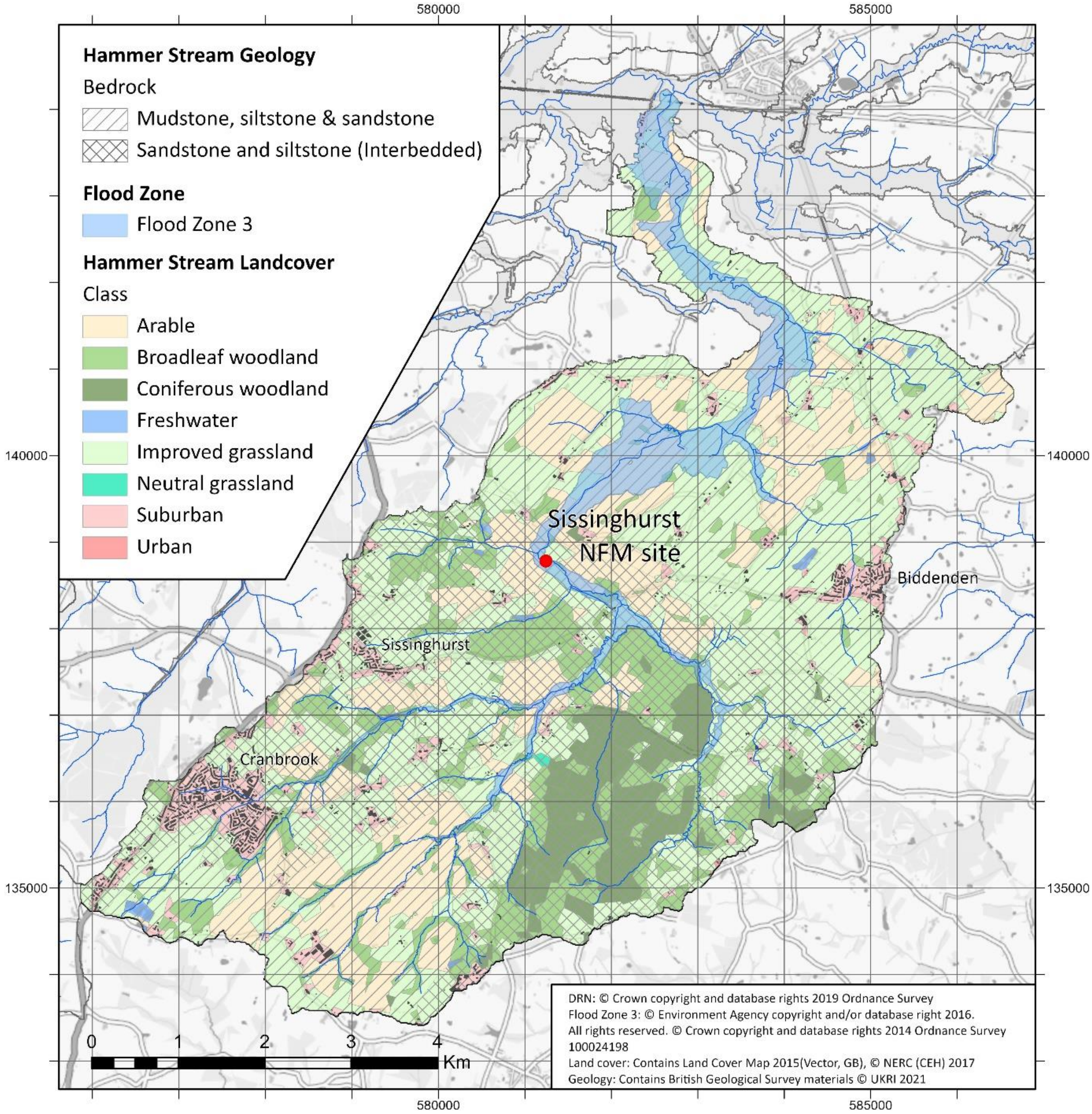

Figure 12. Map showing geography of Sissinghurst site and the surrounding Hammer Stream catchment

2.2. NFM opportunity mapping

The site's management team were active participants in identifying opportunities to deliver the additional benefits that NFM solutions could provide. The National Trust began creating their own "beaver dams" in woodland on the Sissinghurst Stream, to see how the stream reacted to slowing the flow measures and have looked across the estate to understand how flow paths reach the river. LiDAR in the floodplain of the Hammer Stream was examined (Figure 13.), which revealed the location of a paleo channel as a depression through a field known as Frogmead Meadow. It was not possible to re-connect the stream to the floodplain for storage due to the project timescales and budget. Instead, we explored storing water from the Sissinghurst Stream tributary in a new wetland created in Frogmead Meadow. Soil testing, ecological surveys, an archaeological assessment and a watching brief were required. The project bordered the Upper Medway Internal Drainage Board catchment and was on an Ordinary Watercourse.

A number of consents were required in order to allow delivery of the project. This included:

- Planning permission;
- Consent from the Upper Medway Internal Drainage Board;
- Waste exemption compliance in relation to use of excavated material;
- Compliance with an Environment Agency ‘low risk position statement’ on the use of a structure which can impound or divert the water;
- Agreement from Kent County Council (KCC) that the project did not require their permission.

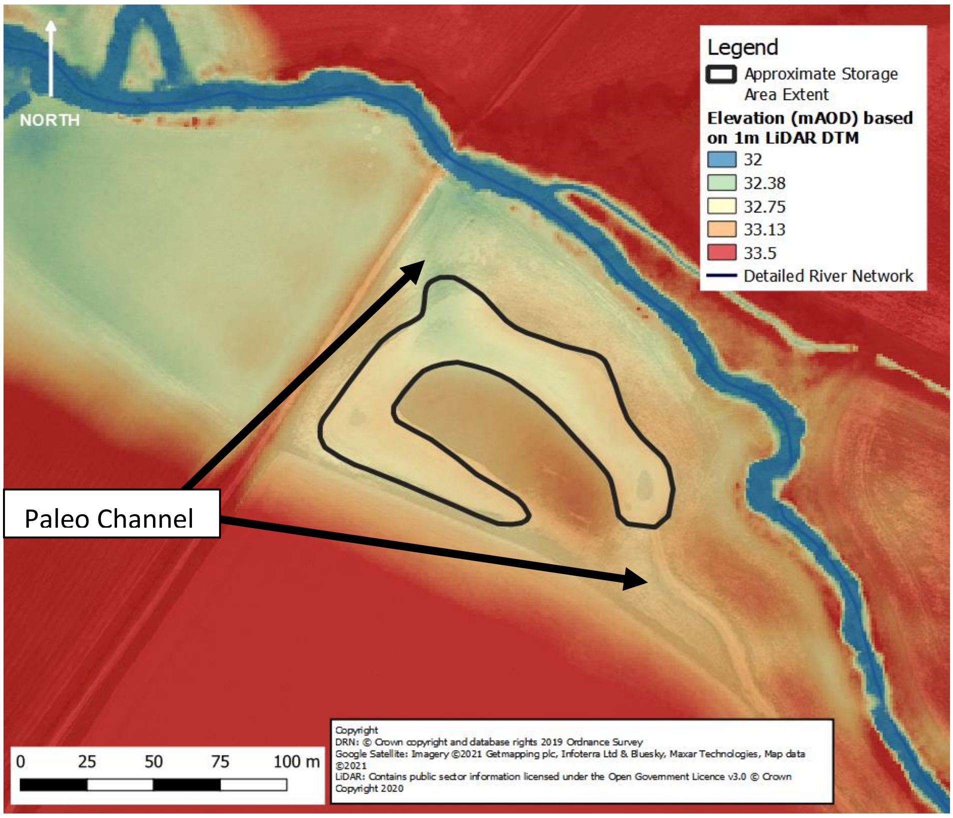

Figure 13. LiDAR highlighted the historic path of the Hammer Stream and identified a good location for the restoration of an offline pond

2.3. NFM measures introduced

A wide and shallow scrape was created within Frogmead Meadow (Figure 14), adjacent to the Hammer Stream. The shape of the scrape was based on topographic low points. An offtake channel was constructed to divert water to the meadow from the Sissinghurst Stream in periods of high flows.

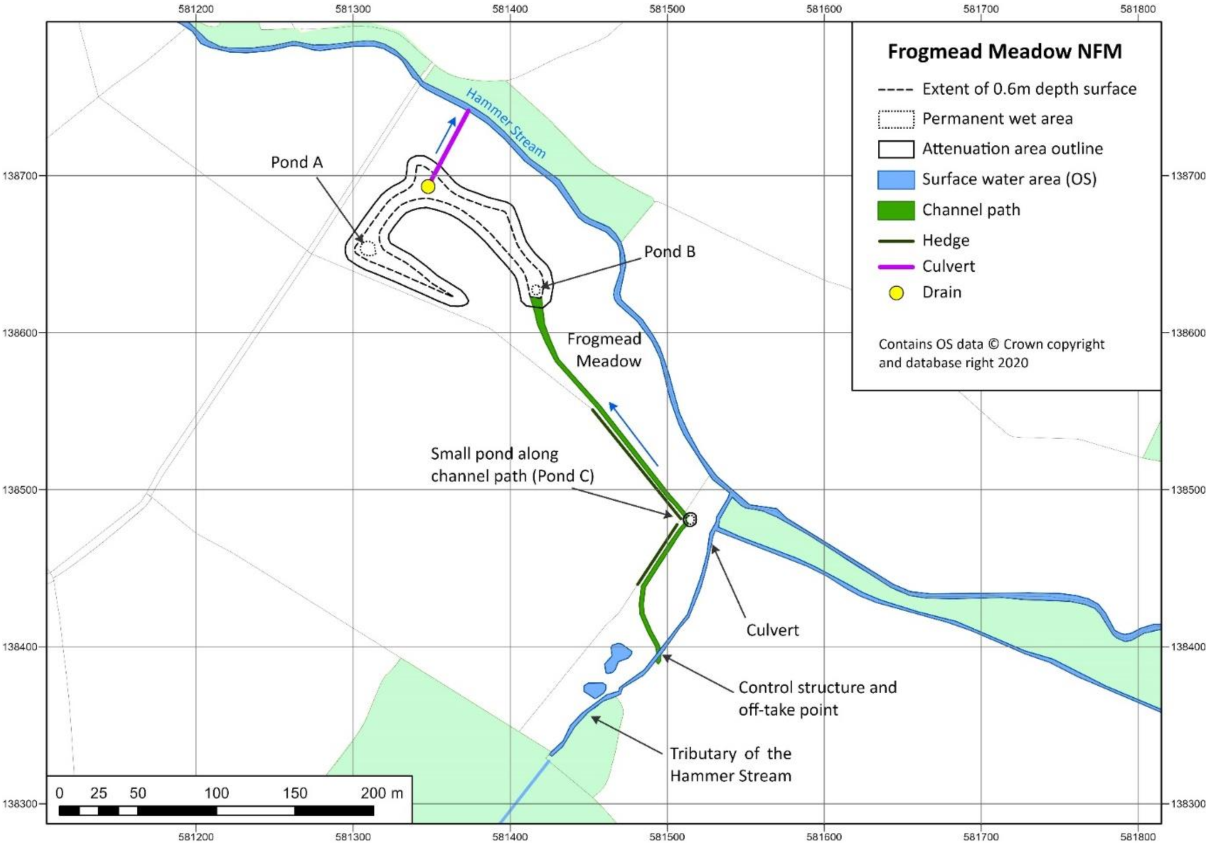

Figure 14. Plans for the installation of the scrape and offtake channels at Sissinghurst

The contractor excavated the scrape in two phases, photos in Figure 15. The first phase removed the topsoil, which was transferred and spread in an adjacent field outside of the floodplain. This added nutrients to an arable field. The second phase removed the low-nutrient sub-soil, which was spread within Frogmead Meadow with the aim of reducing available nutrients further. This was beneficial for managing the field as a wildflower meadow and ensured no material needed to be taken off-site in line with our waste exemption. It also reduced the carbon footprint of the project. Two deeper ponds were excavated within the scrape to retain water for a longer period and provide a diversity of depth. Finally, National Trust volunteers reseeded the site using a local wildflower mix.

Figure 15. Photos showing stages of scrape creation

There was limited space for the new high flow diversion channel around field boundaries. Due to the existing Countryside Stewardship agreement these would have been difficult to alter. As a result, the channel had to be fairly straight and uniform to reach the site. At the most constrained point where the channel turns a corner, we created a small pond to reduce erosion risk on the outside bend and provide a silt trap to reduce deposition in the meadow scrapes (Figure 16.).

Figure 16. Off-take channel corner pond (left), and control structures (right)

A control structure (Figure 16.), consisting of metal sheet piles, was needed on the Hammer Stream to encourage high flows down the off-take channel and into the scrape. Following construction, the bed of the off-take channel was found to be too low, allowing too much flow into the scrape and out of the stream. The original design was therefore modified to include additional plastic piles on the off-take channel.

As noted above, site restrictions meant that sections of channel that was created were straight and uniform. This allowed water to pick up excessive speed, particularly when the channel was new and contained no vegetation. This was mitigated by planting up the bottom of the channel with resilient aquatic plants and adding check dams to slow the flow. An existing land drain was retained to slowly drain the scrape, ensuring that flood capacity is available. Finally, a French drain was also added within the restored flood meadow to help drain water when water levels exceed the capacity of the scrape. An interpretation board (Figure 17.) was designed and erected at the footpath near the flood meadow to engage and educate members of the public about NFM. This was done in consultation with all funders and the National Trust.

Figure 17. Interpretation board installed between path and flood meadow at Sissinghurst

2.4. Monitoring results

Flow data was recorded within a culvert downstream of the off-take channel, providing data both pre- and post- construction.

In addition, water level was recorded at three sites:

- on Sissinghurst Stream upstream of the control structure for the off-take channel;
- in the scrape/wetland itself;
- on the Hammer Stream, downstream of the site.

A sample of the monitoring data collected is presented in Figure 18. The water level data demonstrates how the scrape/flood meadow functions as a storage area during storm events. The scrape was shown to take approximately one week to empty after filling up in a rainfall event. This is a relatively long period of time for an area designed specifically as a flood storage area, as it means that the available storage may be reduced if two storm events occur in quick succession. However, as this was a demonstration site it was felt the timing wasn't critical for flood risk reasons, and more prolonged water retention might have more benefits for biodiversity. The National Trust will continue to monitor the site to provide future data on how wildlife is using the site.

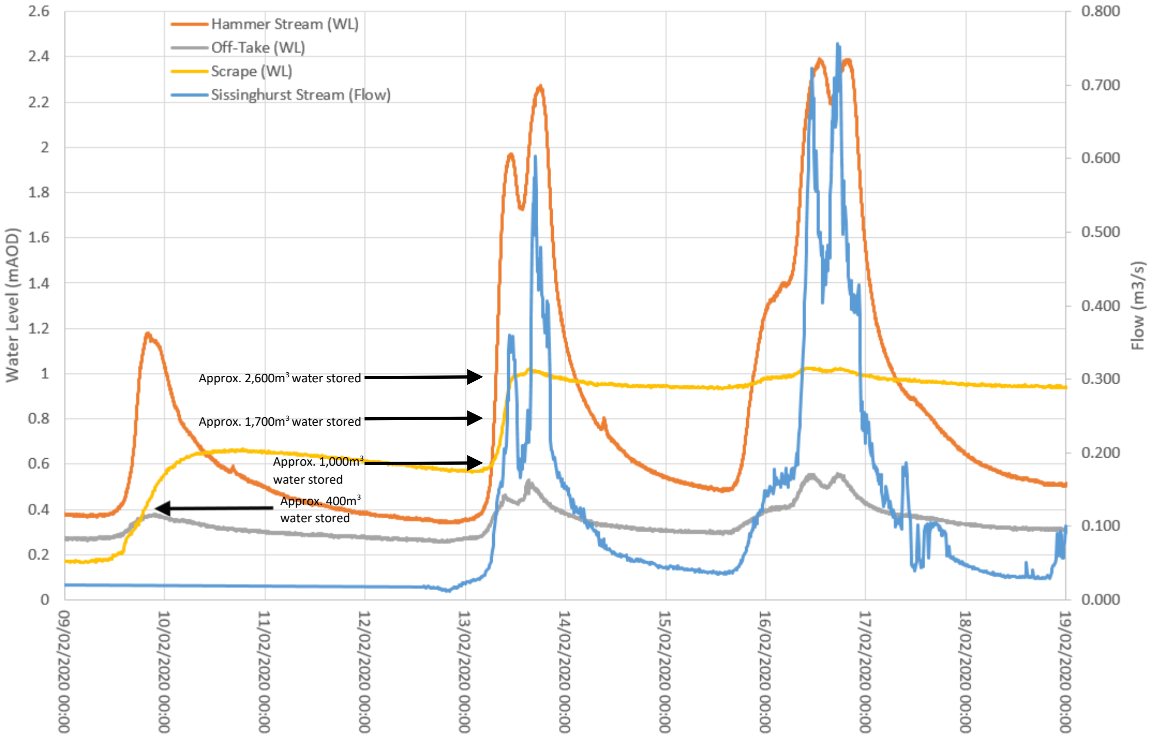

Figure 18. Water level and flow monitoring outputs at Sissinghurst during Storm Ciara (9 Feb 2020) and Storm Dennis (15/16 Feb 2020)

Figure 18. above shows that water levels within the scrape were relatively low prior to the rainfall brought by Storm Ciara on 9 February 2020. The water level in the scrape increased as water levels in the Sissinghurst Stream rose, though the scrape did not reach capacity. During the rainfall event on 9 February, the scrape contributes effectively to reducing flows in the Sissinghurst Stream, and subsequently the Hammer Stream. Flow recording indicates that in a 24-hour period during Storm Ciara, approximately 18,500m^3 of flood water flowed down the Sissinghurst Stream. In a 36-hour period during Storm Dennis (15-16 Feb 2020) approximately 37,500m^3 of flood water flowed down the watercourse. Both values are adjusted to exclude base flow, with a high-level estimate of 0.01m^3/s. If empty at the beginning of each storm, the scrape/storage area has the capacity to store approximately 14% and 7% of these volumes respectively. In reality, the water levels in the scrape did not reduce significantly immediately after Storm Ciara. As a result, the available storage capacity

of the scrape was much lower when the flow in the Sissinghurst Stream increased on 15 and 16 February. These 2 storms therefore demonstrated that the scrape contributes to flood risk reduction downstream by collecting up to 2,600m^3 during high flows, although the chosen design limits this function if the storms have less than a week between them.

2.5. Environmental benefits

Our aim was to boost habitat provision further by re-creating a wildflower meadow habitat and providing food sources for pollinators (Figure 19.). The slow draining scrape offers up to 0.5ha of additional wetland habitat throughout the year, which will boost biodiversity for a catchment otherwise lacking in unimproved grassland. As the plant communities establish, the exact habitat types created will be monitored and described.

Figure 19. Wetland habitat provided by the restored meadow (left) and wildflowers in full bloom in the meadow (right), the seeds for which were sown by National Trust volunteers

3. Site two: Bedgebury National Pinetum and Forest

3.1. Baseline flood risk and geography

Bedgebury National Pinetum and Forest is run and owned by Forestry England (Figure 20.) and is the world's largest pinetum. The pinetum is dedicated to preserving a diverse collection of tree species from across the world for scientific study and the provision of a unique 140ha habitat and public space on Kent's High Weald Area of Outstanding Natural Beauty (AONB).

Figure 20. Bedgebury Pinetum has been stocked with 1000s of plant species for research purposes, and provides a picturesque and unique area of green space

Bedgebury Forest is adjacent to the Pinetum and is 1,050ha in size. It is an ancient woodland site but has been historically drained to maximise the space for commercial conifer plantation, and therefore the cover of native species is limited. In more recent years, thinning has taken place which has successfully restored semi-natural habitat to the understory, where this has occurred. However, the site still contains many stands of intensive conifer plantation with barren understorey, and there are large areas of rhododendron.

The 'Tributary of the Teise' catchment has two main branches at this site, one through the pinetum, the other through Bedgebury Forest. The name of the site itself, Bedgebury, derives from the old English for bend, referring to its rivers. The River Teise catchment is sparsely populated, and downstream of this tributary only a small number of properties are located in Flood Zones 2 and 3. The Teise has an extensive floodplain and joins the River Medway near Yalding, where many properties have experienced significant flooding, for example during the winter of 2013/2014. In the wooded, higher-reaches of the sub-catchment the soils are clayey with slightly impeded drainage beneath sandstone and siltstone rock. This geology (Figure 21.) contributes to the ephemeral nature of its streams, as the small areas of sandstone creating the heathy character of parts of the site are efficiently drained, leaving the forest dry during the summer. Throughout much of the forest, the wider floodplain of the stream creates ephemeral wet woodland which adds to the diversity of habitat at the site. Wetter parts of the woodland support a diversity of lichens and mosses.

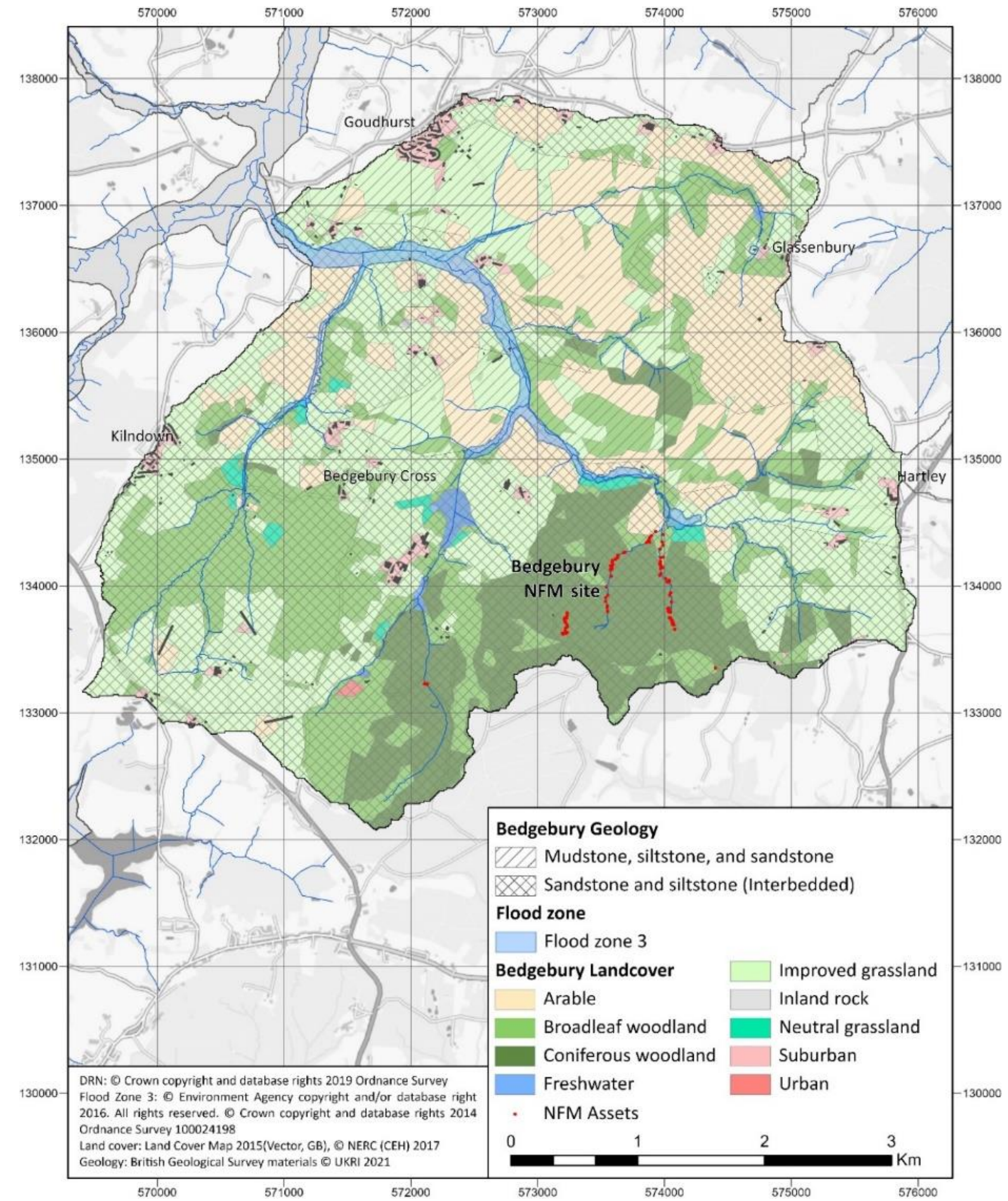

Figure 21. Map showing NFM measures introduced to Bedgebury site

3.2. NFM opportunity mapping

The Bedgebury site offered a large area of habitat to demonstrate how NFM can change hydrology and store water within a managed commercial woodland. It also offered the opportunity to demonstrate the additional benefits NFM measures (for example LWSs Figure 22.) can bring. These benefits include:

- Increasing the resilience of wet woodland habitat to climate change;

- Increasing water availability and resilience to drought by prolonging the supply of water downstream during the summer months;
- Reducing incision in streams by kick-starting natural processes;
- Increasing the diversity and amount of semi-natural habitat.

Figure 22. A LWS installed on the water course in Bedgebury Forest. The photo shows that the stream was quite incised prior to installation, especially relative to the width of the stream.

Forestry England allowed the felling of trees along the watercourses for the project, selecting species or individuals that were of limited or no commercial value. Forestry England were an enthusiastic partner on the MFP's NFM Steering Group and actively participated in this NFM project. Having worked with multiple other partners to deliver a variety of conservation techniques and engaging features on site, the Bedgebury staff brought valuable experience to the project.

Towards the end of the project, it was decided to include a public demonstration site within the pinetum to help promote NFM to the site's half million annual visitors. A stretch of river, running along a well-used path in the pinetum, was identified as a suitable location for some 'demonstration' LWSs with an information board to explain NFM to the public. With the wider channel sitting down the slope from the adjacent path, there was a good opportunity to build a LWS across the floodplain to hold back a large volume of water and create an online wetland habitat. LWSs are typically built in series as an insurance against any LWSs coming loose and large volumes of water and logs being washed downstream. The site allowed for a series of four LWSs to be constructed to show how LWSs work to attenuate water cumulatively.

3.3. NFM measures introduced

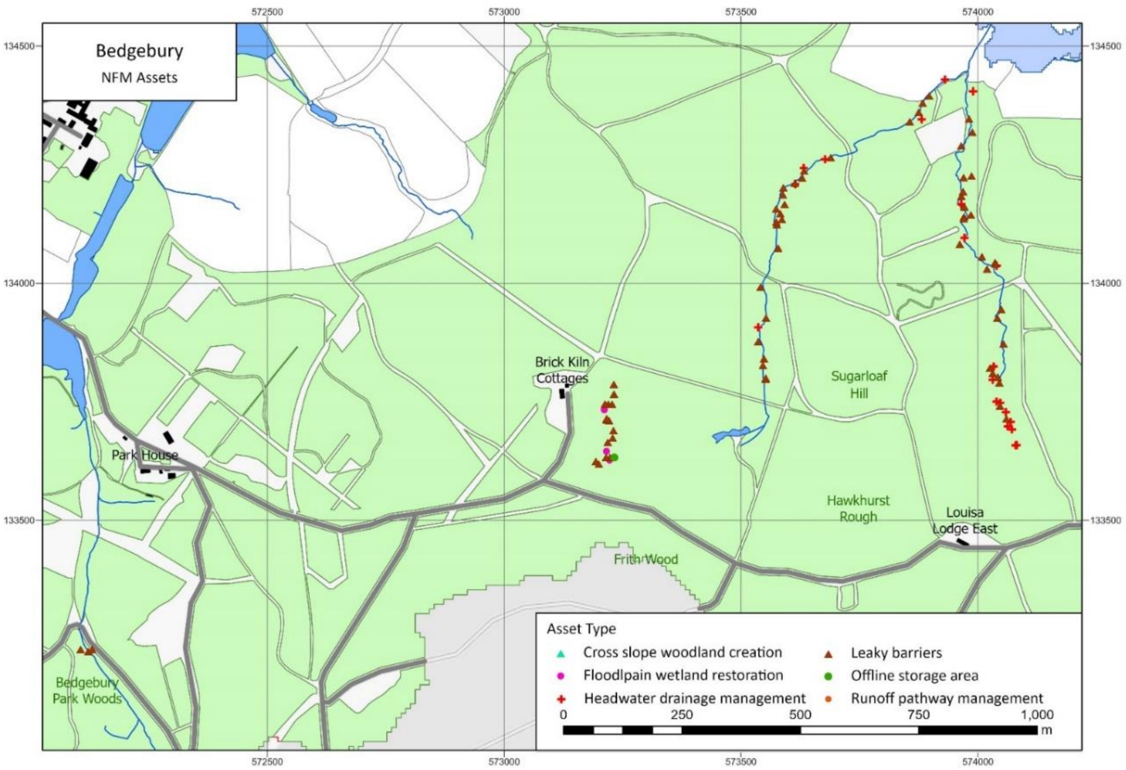

Figure 23: Map showing the NFM assets introduced at Bedgebury Forest and Pinetum.

In Bedgebury forest, 63 LWSs and 20 gulley stuffing interventions were installed (Figure 23.). The structures ranged from small (1m across; Figure 24.) that stuffed small deep channels, to larger wider structures (12m across) that flooded large areas of the forest floor. One small offline storage area was also created (Figure 25.). LWSs and a short, hand-dug channel were used to divert water into a natural depression in the woodland. A leaky bund was created to increase the potential storage of the feature (estimated at 150m^3) and allow water to slowly drain out following storm events. Fixed point photography and a level gauge was used to monitor the amount of water diverted into this area. The smallest structures were installed in the forest by The Conservation Volunteers, East Sussex, over two winter seasons (Figure 24.). Larger structures were installed by two contractors. The contractors were supported by up to two delivery team staff members from SERT. Four larger and more eye-catching 'demonstration' LWSs were also installed along the watercourse in the pinetum (Figure 25.), with the main aims of creating online wetland habitat and engaging pinetum visitors in NFM and its techniques and benefits. In total, approximately 2km of watercourse had woody material introduced.

Figure 24. A small LWS in Bedgebury forest

Figure 25. Photos of offline storage area in Bedgebury forest, created using LWS

Figure 26. The largest and most downstream of the series of 4 demonstration LWSs installed at Bedgebury Pinetum, alongside paths that experience a high footfall.

south east rivers trust

3.4. Monitoring results

1,500m^3 of water storage was created by the NFM assets introduced at this site, clearly demonstrating how altering woodland management can help reduce downstream flood risk. However, the focus of the benefits was to demonstrate the holistic management of woodland that can benefit biodiversity and water management throughout SE England's ancient woodland resource.

3.5. Environmental benefits

Larger LWSs held back large quantities of water, creating areas of online wetland habitat. Approximately 2ha of wetland was created or enhanced along 2km of waterbody. The wetland areas are starting to be colonised by a variety of aquatic plants (Figure 27.). They have provided habitat for smooth newts and common frogs to breed, as both were seen in the wetland areas created, after the LWS construction (Figure 28.). Ecological surveys would be needed in the future to prove the benefits, although photographic evidence to date illustrates the changes to habitats, and some of the species using the sites.

Figure 27. Series of LWSs in Bedgebury forest (left) creating areas of online wetland habitat.

Frogs during spawning season 2021 (above), in an online wetland, created by LWSs.

There is a huge quantity of leaf litter and moist, unconsolidated material on the forest floor in Bedgebury, as is natural for a wet woodland. Two years after their installation, the LWSs had collected significant amounts of woody debris, leaf litter and several centimetres of silt from the watercourses (Figure 28.). This storage can also have carbon storage benefits in wet woodland. The volume of organic material and silt being collected by each LWS provided evidence of the large extent to which the LWSs could improve water quality in the catchment. The material was embedding the LWSs into the stream, making them part of the landscape, so the structures are likely to have longevity.

Figure 28. Photo showing the build-up of woody material, leaf litter and silt upstream of a LWS in Bedgebury Forest

As well as creating small wetlands and increasing habitat diversity along the watercourses, the increase in woody material was helping to kick-start natural processes, evident from the added dynamism that was brought to the stream. The material collecting was correcting the incision of the channel, immediately upstream of LWSs, reconnecting the watercourse to its floodplain. In periods of high flow, the stream was overflowing its banks onto the forest floor, and in places, creating new pathways (Figure 29.). This increased wetting has increased biodiversity of the habitat (Figure 30.) and will make the wet woodland habitat more resilient to drought in hotter and drier summers in future years. It also provided an additional benefit to downstream riverine habitats by preventing large volumes of silt from being deposited downstream, where it can negatively impact river gravels.

Figure 29. Photos showing new ephemeral flow paths through the forest. Installing LWSs has allowed debris to collect which has corrected the incision and allowed the stream to spill out of its channel.

Figure 30. Bog Beacon (*Mitrula paludosa*) benefiting from the wetter forest floor after the installation of LWSs.

Within the Pinetum, a series of four large LWSs were installed (Figure 31). Elsewhere in the forest LWSs were made to look natural and inconspicuous with a variety of techniques (Figure 32. & 33.), however these structures were made to look constructed in order to capture the attention of visitors. These demonstration LWSs created 200m^2 of online wetland habitat which was well colonised by a variety of aquatic plants and animals (including a large number of frogs and tadpoles), adding to the interest. The high footfall on the site, combined with the eye-catching design, meant that members of the public regularly asked the contractors about the project during installation. An information board will be installed on the site to provide interpretation of the NFM, as well as website links to allow them to find out more about the project.

Figure 31. The series of 4 large demonstration LWSs were located alongside a path (running along the watercourse from the left of the photo) in the well-visited Pinetum.

Figure 32. Alder tree cut using a hinging joint, ballasting a LWS whilst allowing the tree to continue to grow in its new prone position and make the LWS regenerative.

Figure 33. Contractor (far bank) can be seen moving a large, felled tree using only winches. On the near side of the bank, there has been minimal disruption to the soil and riverbank as trees have been felled and moved using low-impact methods.

4. Site three: Alder Stream

4.1. Baseline flood risk and geography

The Alder Stream sub-catchment (Figure 34.) is in the Middle Medway, just south east of Tonbridge. The stream flows from south west to north east, largely in parallel with the A228, towards Five Oak Green. The village is exposed to significant flood risk due to several culverts located around the village, as well as the topography flattening out towards the floodplain of the River Medway to the north.

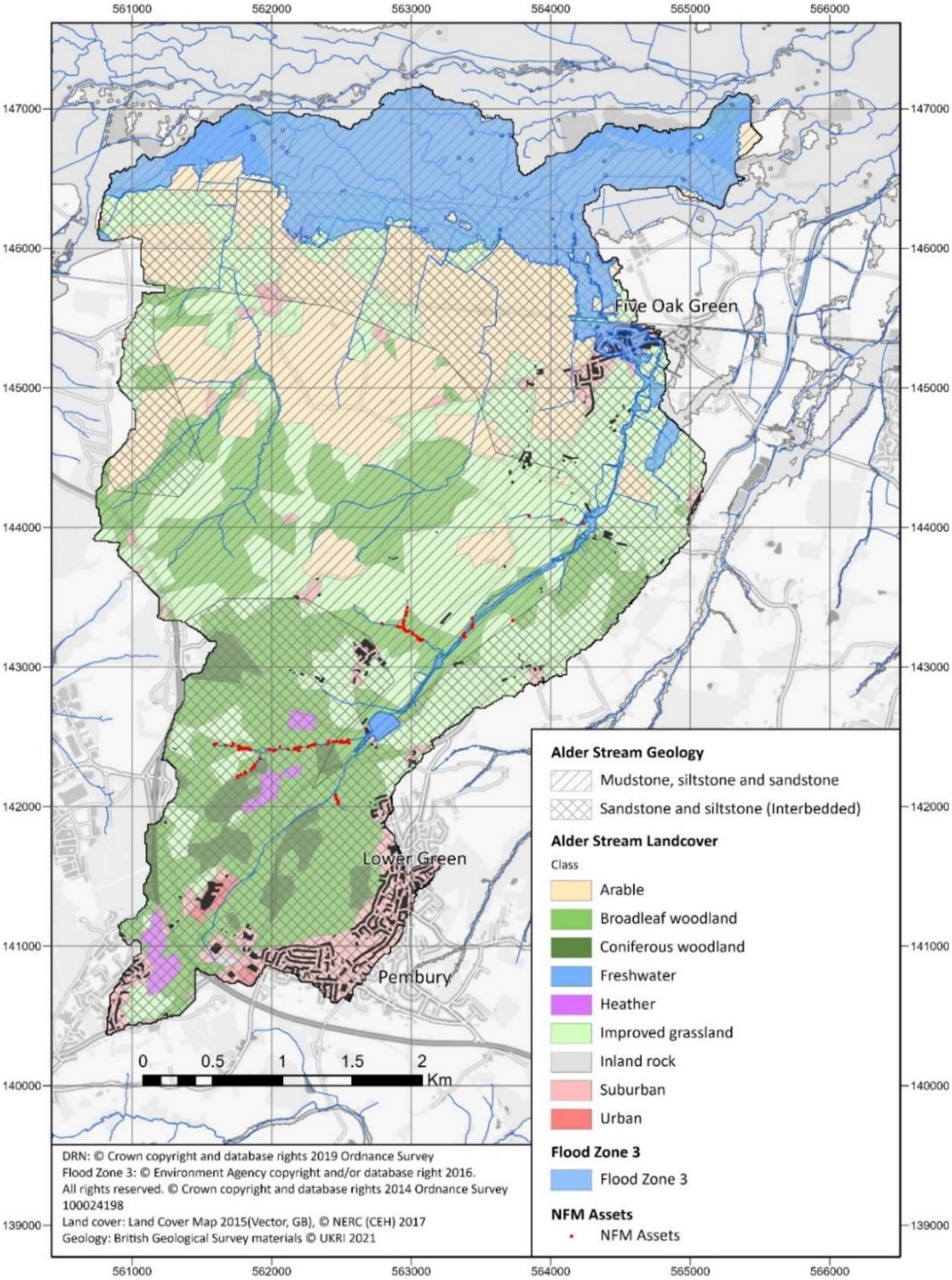

Figure 34. Geography of the Alder Stream catchment

In the headwaters of the catchment is Pembury Woods, which is mostly owned by the Hadlow Estate, with South East Water owning a smaller part. South East Water also own the majority of Marshleyharbour Woods, south of the A228 (Figure 35.). The Hadlow Estate's woods are managed by the RSPB, as part of the Tudeley Woods Nature Reserve (Figure 36.). Pembury wood ends where the stream enters a large culvert underneath South East Water's reservoir. The culvert is very large and was assessed to be no impediment to flood flows. On the contrary the culvert is likely to speed up the flow of water.

The upper reaches of the catchment in the woods are gills – steep-sided wooded valleys, which are characteristic of the High Weald, where the streams have cut through the sandstone to the impermeable Wadhurst clay at the base. On the highest ground, there is a significant presence of heather. On the upper slopes, the woodland is managing through coppicing, and tracks of heathland and sphagnum dominated flushes have been opened up to retain diverse habitats for insects, plants and birds. The wet woodland is in the lowest parts of the ghyll valleys is incredibly species rich (Burnside *et al*, 2006). The long, probably uninterrupted history of woodland cover gives them a distinct humid microclimate, which has created boggy ancient wet woodland, heavily populated by fungi, ferns, lichens and bryophytes. Of particular note for the project was the recent loss of willow tit as a breeding bird to the woods, and the need to protect the important bryophyte community.

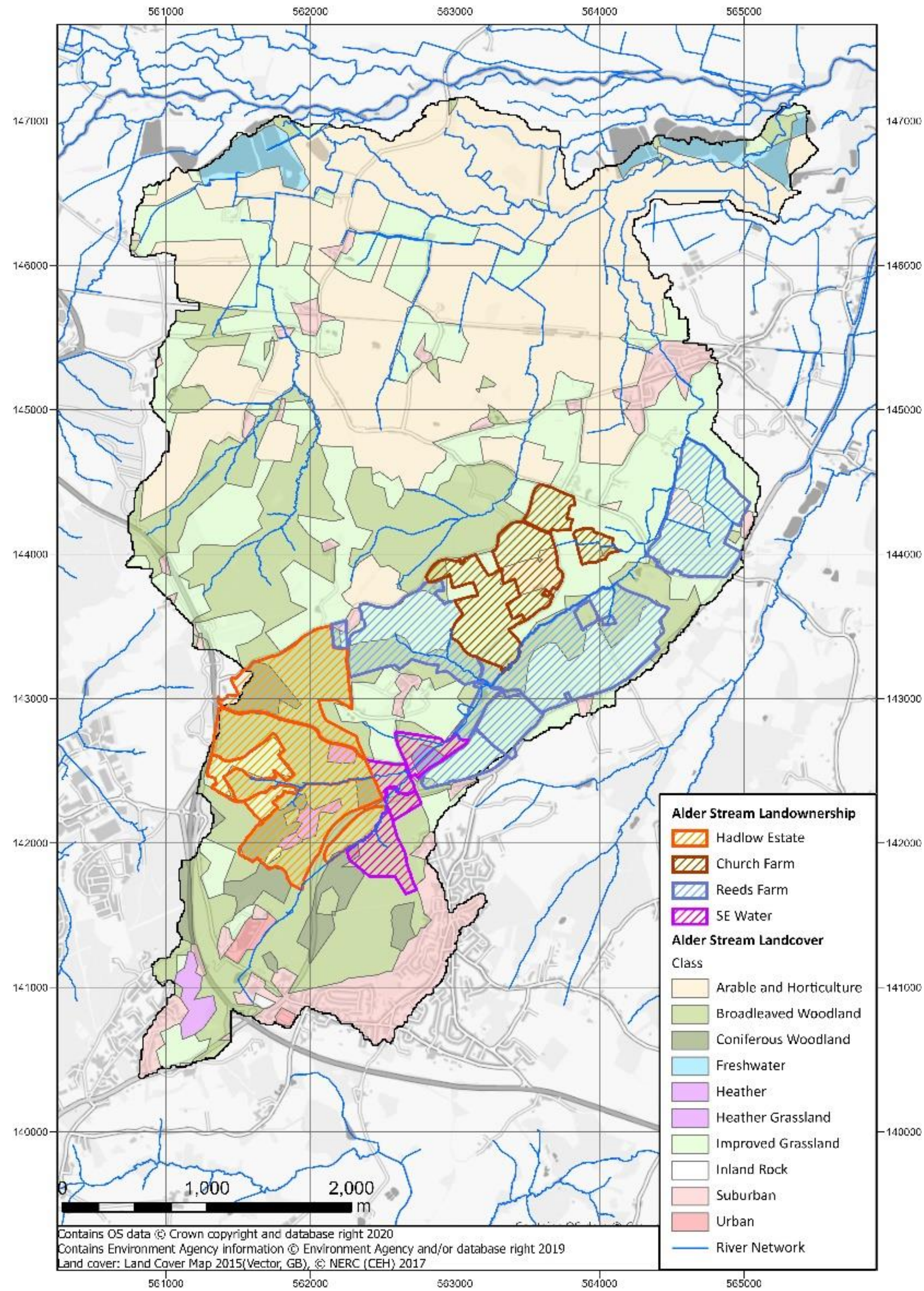

Figure 35. Map showing indicative land ownership of the main sites used for NFM in the Alder Stream catchment

Figure 36. The main Alder Stream channel running through the ghyll of Tudeley Woods Nature Reserve.

Downstream of the reservoir the river continues through woods and an old mill site, next to a house, before being joined by a tributary from Church Woods. Reeds Farm is a mix of orchards, pasture, and woodland. Before the project, the pasture was intensively grazed and this included the unfenced ancient woodland, Milrough Wood. The heavy grazing in Milrough Wood had damaged the understorey by preventing the natural regeneration of ground flora and compacting the soil. Springs rise in the valley sides where the underlying geology changes from sandstone to clay, forming flow paths to the Alder Stream. These were heavily poached by livestock along with the woodland. The majority of Reeds Farm along the river is used for pasture but there are also areas of orchards on higher ground, further from the main channel. Church Wood (also owned by Reeds Farm), on a tributary to the north had no livestock pressures and is another gill, with a mixture of ash and oak woodland.

The part of Church farm within the project area is entirely on a clay subsoil. In early 2020, the cottages on Alders Road flooded. During that storm event, water left the main ditch that discharges to the Alder Stream (Figure 37) and crossed the fields into the smaller drainage network to the north-east of the cottages, and then flooded the cottages. Water from both ditches (north and south of the cottages) is directed towards culverts by the Alders Road cottages (Figure 38), before joining the main river. Both culverts are small in diameter relative to the peak flow that can include surface run off from the road.

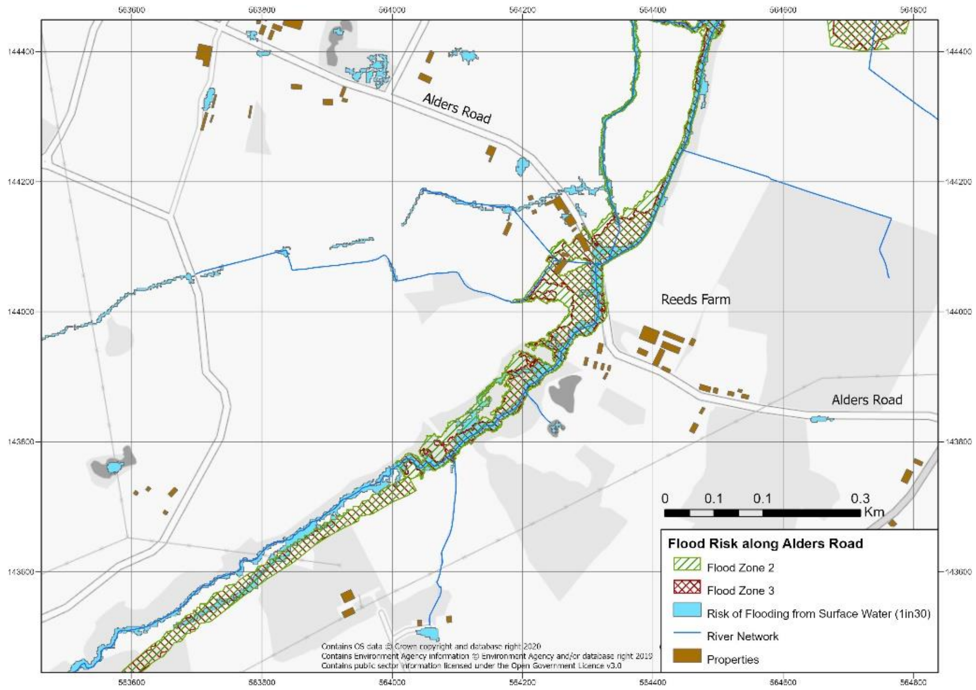

Figure 37. Map showing the ditch/main river network leading to Alders Road cottages (flow west to east).

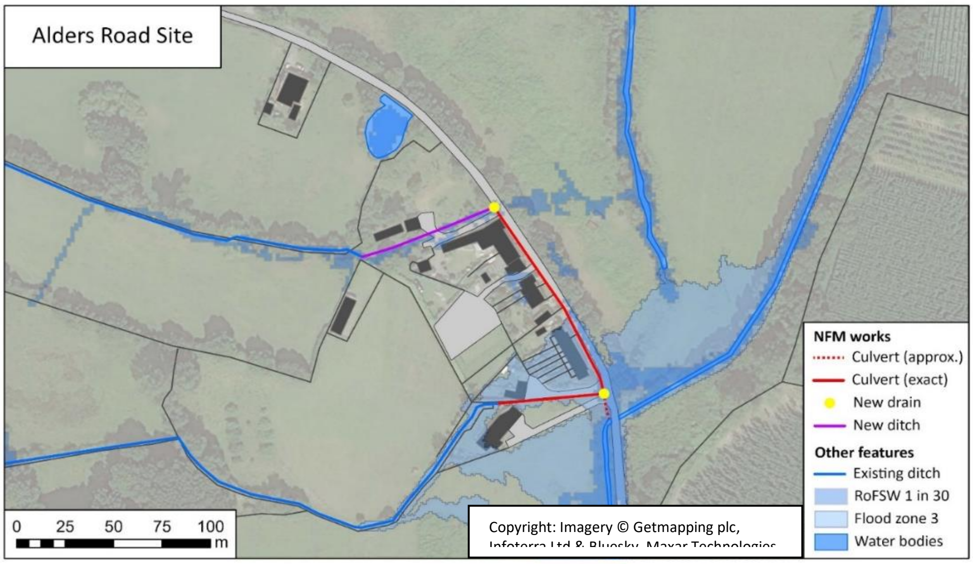

Figure 38. Map showing the Alders Road cottages relative to modelled flood risk zones (surface water and flood zone 3) and the ditches draining Church Farm and their culverts.

The property at the southernmost end of the cottages has a ditch running through the garden with a brick control structure (Figure 39.), which diverts some excess water into a neighbouring field.

Figure 39. The resident of the most southerly house in the Alders Road cottages has erected a brick control structure many decades ago that diverts the flow of the ditch in times of peak flood to stop the ditch from being overwhelmed closer to the houses.

Downstream of Alders Road, the stream passes through more pasture with hop gardens on the higher ground. Poaching is evident on some of the pasture, and compacted soils, on the access tracks of the hop gardens, provide numerous flow pathways, which will accelerate run off. Approximately 1,500 people live in Five Oak Green where approximately 125 properties are at risk of fluvial and surface water flooding.

In the Storm Ciara flood event in February 2020, approximately 30 properties were flooded in addition to the nine properties flooded at the Alders Road cottages (Figure 40.). As part of a Section 19 report by KCC into the event, using a nearby rain gauge in Paddock Wood, it was estimated that Five Oak Green and other area in the sub-catchment had received in excess of 28mm of rain in one hour and in excess of 38mm in one day – this made the event a flood with approximately a 3.3% chance of happening in any given year. Flooding on a lesser scale than in 2020 has also occurred during 1960, 1963, 1968 and 2000 (Figure 41.) and every year since 2008 (inclusive), with the exception of 2016 (e.g. Figure 42.).

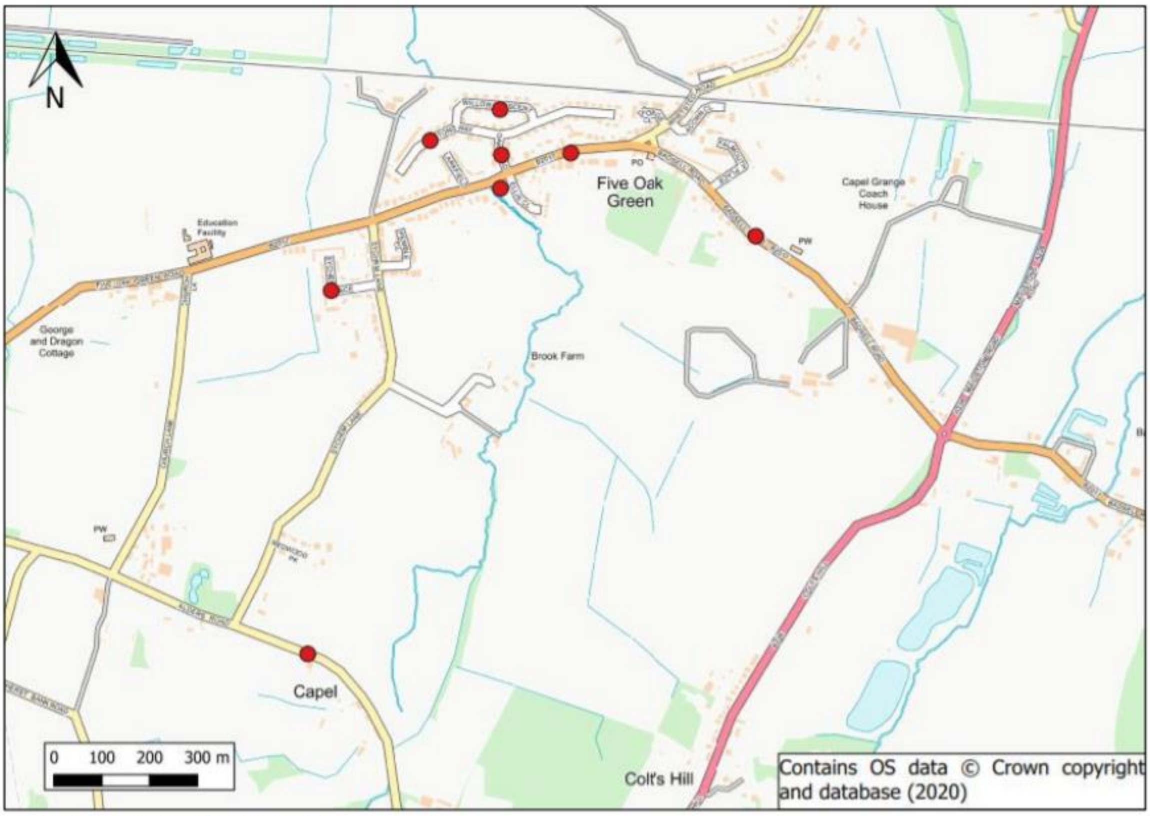

Figure 1 Location of reported flood incidents

Figure 40. KCC map showing the locations of properties that flooded in Storm Ciara in February 2020 in Five Oak Green and the Alders Road cottages. Taken from KCC's Section 19 report.

Figure 41. Local resident's photograph of Flooding at the Alders Road cottages in 2000


Kent 999s
@Kent_999s

FIVE OAK GREEN: Flooding also at Five Oak Green near Tonbridge. Firefighters say they have been dealing with flooded properties at Sychem Place.

8:14 PM · Feb 9, 2020 · TweetDeck

Figure 42. A tweet from Kent_999s showing flooding at Five Oak Green from Storm Ciara in February 2020

4.2. NFM opportunity mapping

Desk-based opportunity mapping was carried out within the catchment to explore the potential for NFM, and to target engagement with landowners. The opportunity mapping utilised SCIMAP (Diffuse Pollution and Flood Water Source Mapping; https://scimap.org.uk/; Figure 42.) and the Environment Agency's Risk of Flooding from Surface Water mapping to identify potential flow paths. These were ground-truthed through catchment walkovers during wet weather, as well as engagement with landowners, to make sure that the mapping reflected real flow paths. Google satellite images and the Environment Agency's Working with Natural Processes datasets were both used to carry out an initial assessment of what NFM measures might work in the catchment. These were then discussed with landowners to explore how they might fit in with their use of the land. Finally, the Environment Agency's Flood Map for Planning was used to gain an initial understanding of the risk of river flooding from the Alder Stream.

All of the woodland sites were very suitable for the installation of LWSs. In Pembury Woods, the gills are deep and the valleys themselves are boggy in places and without footpaths. Therefore, installing a series of LWSs along the channels, creating temporary water storage, would not impact on site users. In Marshleyharbour woods, on the south side of the A228, the gills were much less deep and there were existing footpaths much closer to the meandering stream. Therefore, whilst it was possible to install LWSs along the watercourses, the designs needed to avoid flooding the paths. The ability to make the woods wetter and retain water for longer, had the potential to increase the biodiversity value of Tudeley Woods Nature Reserve, to preserve the bryophyte interest, and perhaps one day encourage willow tits to return.

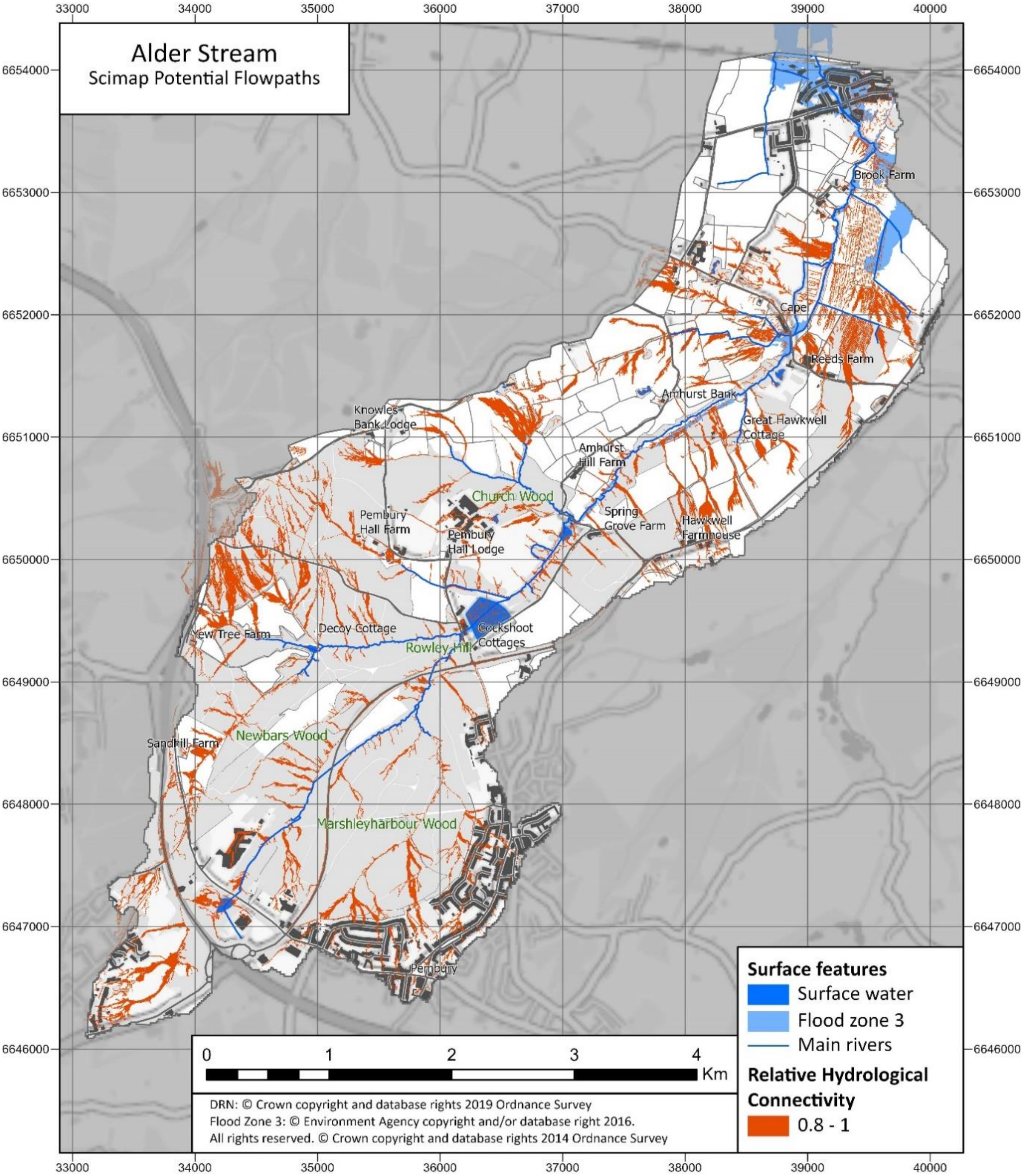

Figure 43. SCIMAP was used to map flow pathways throughout the catchment (https://www.scimap.org.uk/)

Reeds farm has a mixture of ancient woodland and pasture, but was intensively grazed by sheep, which had compacted the soil and damaged the understorey of ancient woodland (Figure 44. & 45.). The opportunities identified included continuing to add large LWSs across the width of the floodplain and fencing off the ancient woodland and flow paths in the pasture from livestock, to prevent compaction and allow recovery of these soils. This would not only slow the flow with natural regeneration, but also significantly improve the woodland habitat. The improved habitats should also increase absorption as well as the interception of water.

Figure 44. Bluebells starting to grow at Milrough Wood in the spring after being fenced off from grazing

Figure 45. Ancient woodland at Milrough Wood, on Reeds Farm, showing an ungrazed left bank (owned by another landowner), and sheep grazed right bank at Reeds Farm, which was fenced off as part of the project.

Figure 46. SCIMAP showing flow pathways through Church Farm towards Alders Road

Scalgo Live software was used to simulate flow paths in the area. This tool can estimate where water is likely to flow across a landscape when a certain amount of rainfall is applied (Figure 47.). Scalgo has the advantage of estimating potential volumes of surface water ponding for rainfall events. It also allows changes to be made to the terrain map quickly, which was useful where the ditches west of Alders Road (Figure 48.) weren't accurately represented. Importantly, discussions and walkovers with residents and the Environment Agency after the February 2020 flood event allowed the outputs of Scalgo to be ground-trothed and tweaked to better reflect the reality on the ground. This created an improved baseline to simulate NFM options and explore their potential impact.

When a bund along the main tributary west of Alders Road was simulated, Scalgo showed that the water could be partially diverted to the southern ditch, flowing around the southern side of the cottages. A more-even distribution of floodwater between the waterbodies would reduce the maximum peak discharge of the northern-most ditch. Additional works, including raising the height of the control structure in the ditch close to the property of the southernmost cottage and creation of a scrape in the adjacent field, were also required.

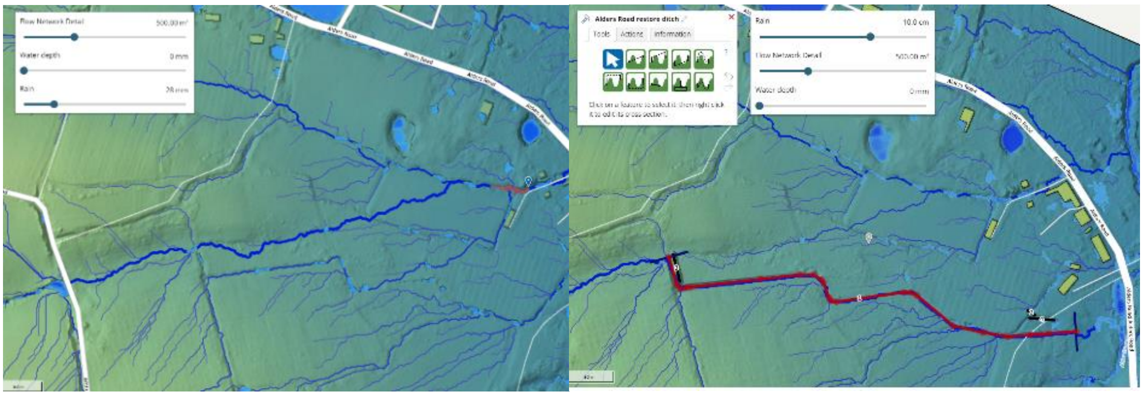

Figure 47. Scalgo software showing flow pathways in simulated high rainfall events without (left) and with (right) a bund installed.

Figure 48. Photo showing the initial condition of the jagged ditch network to the south of Church Farm leading to the south side of the Alders Road cottages.

4.3. NFM measures introduced

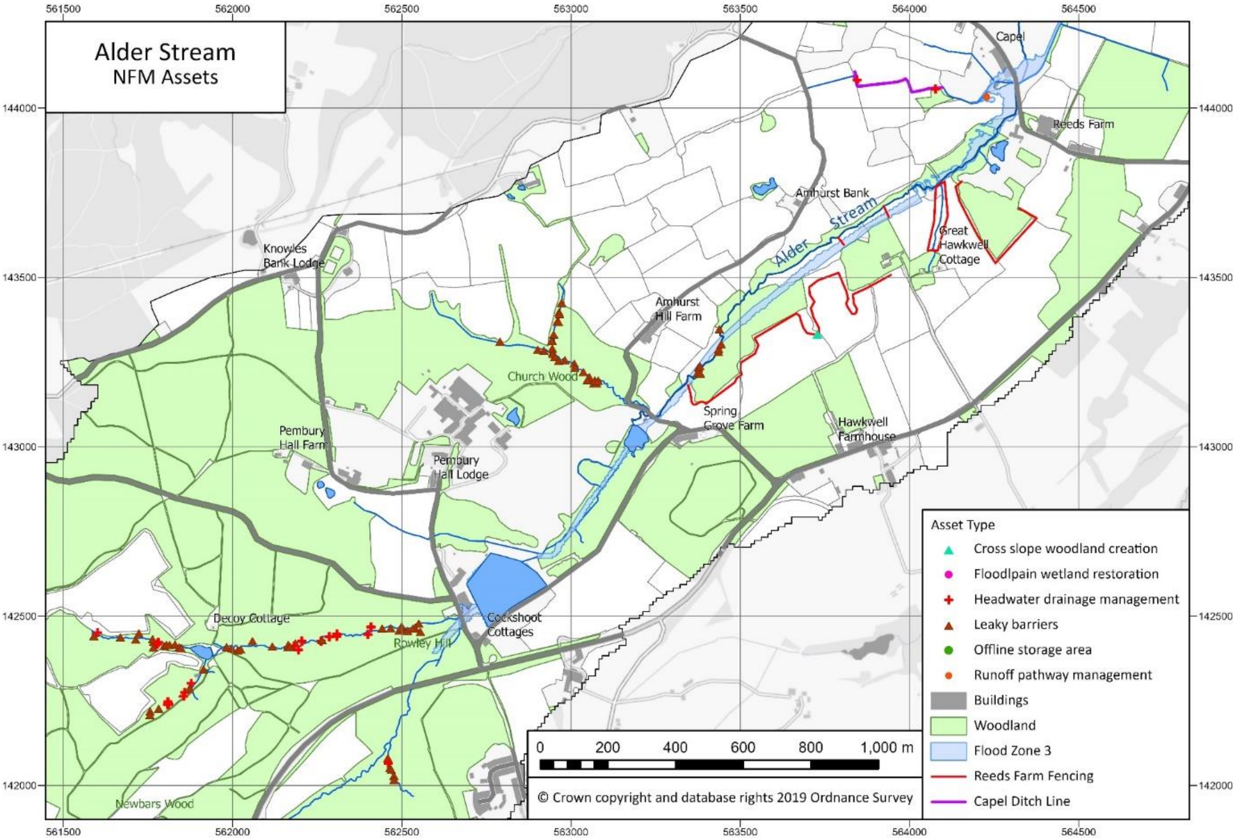

Figure 49. NFM measures installed in the Alder Stream catchment

Figure 49. shows the extent of the assets installed in the Alders Stream catchment. In the upper reaches a mixture of 61 LWSs and gulley stuffing interventions were installed at Pembury Walks. The Conservation Volunteers constructed the LWSs and stuffed the gulleys with brush and lateral logs. Where the channel and the wider flood channel became larger and bigger, stronger LWSs were required, and these were installed by contractors. Like other ancient woodland sites, the same experienced woodland contractors were used to sensitively move trunks and branches into place without requiring machinery in the wood. This prevented damage to the understorey. They installed 11 LWSs on South East Water's land, five in the wider, boggy channel north of the A228 and six on the smaller, more-incised tributary south of the A228 (Figure 50.).

Figure 50. (Left and centre) LWSs installed in Pembury Walks and on the more incised stream south of the A228. Far right: Gulley stuffing in the headwaters at Pembury Walks.

25 LWSs were installed by contractors along the Y-shaped tributary in Church Wood (Figure 51.). Along the main river in the valley on Reeds Farm, eight large LWSs were installed across the wider floodplain. On Reeds Farm, approximately 11 ha of old ancient woodland was fenced off from sheep to allow it to regenerate naturally and offer more habitat, as well as flood risk mitigation (Figure 52.).

Figure 51. LWSs installed in Church Wood (left) and across the wider floodplain on the main river running through the valley at Milrough Wood (right)

Figure 52. Ancient woodland fenced to prevent compaction by livestock, to restore the soil condition and understorey.

On Church Farm, excavators were used to create a bund where the southern tributary was bursting its banks and then flowing eastwards overland towards the northern ditch leading to the Alders Road cottages (Figure 53.). The southern ditch was de-silted to ensure it had adequate capacity. The control structure, in the southern ditch had a layer of concrete blocks added to it. Excavators were also used to dig out the off-shoot and scrape in the adjacent field to accommodate water diverted by the brick control structure (Figure 54.).

Figure 53. Left: Excavator removing soil and silt from the southern ditch to restore its capacity. Right: Fully restored ditch.

Figure 54. Top left: an excavator excavated an off-take channel from the brick control structure on the south side of the Alders Road cottages. Top right: extra layer of concrete blocks added to brick control structure. Bottom: the off-take flows into a scrape that was also dug out in a field used for pasture.

4.4. Flood risk benefit provided

Since each LWS is constructed from natural materials and installed on varying topography in different positions, each structure will perform differently. Best assessments on their flood risk mitigation can be made by assessing how they worked in principle and their collective impact. Observations on site and through limited time-lapse data suggest that, in general, the LWSs are performing well to back up and store water during high flow events, as well as slowing down flow. However, information on the impact on flow velocity is not available due to the difficulty of monitoring flow velocity in the field. Time-lapse footage indicates that there is a clear difference in water level upstream and downstream of most LWS designs showing that water is being held back and slowed down. However, for some this difference is less clear and therefore in these cases the impact is likely to be mostly related to slowing of flow, as opposed to storage of water. Surveying of all NFM measures indicates that approximately 1,500m^3 of storage has been provided across the catchment upstream of Alders Road.

Assessment of flow monitoring during Storm Ciara can provide some context of the volume of the storage provided by the NFM features. Peak flow in the Alder Stream at Alders Road was recorded as approximately 3.7m^3/s (Figure 55.), with total flow during a selected 2-hour period of approximately 19,000m^3. It should be noted there is a level of uncertainty associated with this estimation. Importantly, the impact of NFM is not just in storage of water but also the effect of slowing the flow. To have the greatest impact on downstream flood risk, there would need to be storage capacity available in NFM features to store peak flows. If the storage provided by NFM is filled up early in a storm event, then there is no storage capacity left to hold peak flows back. The data outlined above would suggest that NFM features will have a benefit in terms of flood risk mitigation, though further work in the catchment is likely to be required to accurately quantify this.

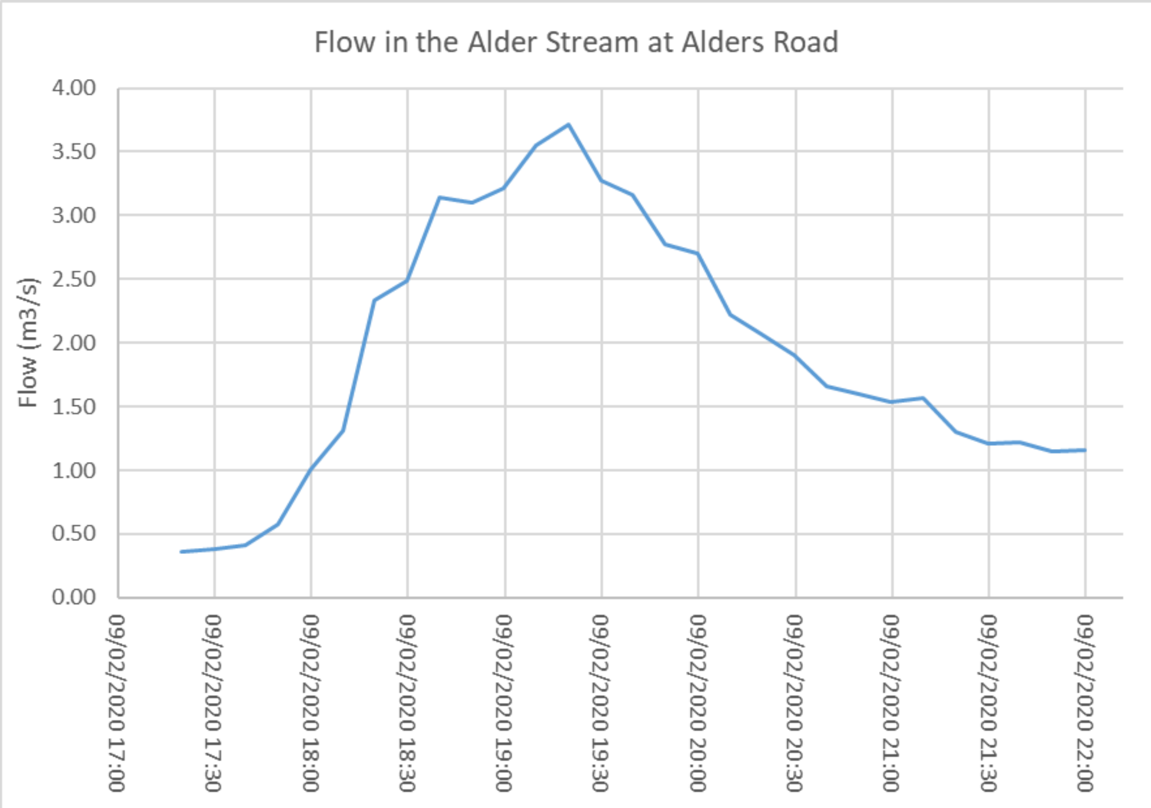

Figure 55. Flow data for the Alder Stream at Alders Road. (Note the lack of a smooth hydrograph indicates flow estimates will have some uncertainty) Source: SERT

However, generally the proposed 'slow the flow' and diversion measures at Alders Road should have a positive effect on reducing the risk of pluvial flooding of the 9 properties during certain rainfall events. The impact of the NFM measures will be assessed following future storm events. The above graph shows flow in the Alder Stream at Alders Road during the February 2020 storm event. Surveying of the culvert indicated that, at this point at least, flows did not reach the top of the culvert and spill out of the channel. Flow data is derived from a flow meter inserted into a brick culvert and therefore the data has a degree of uncertainty as it is unlikely that flow over the sensor is entirely uniform, at least in comparison to standards expected of a formal flow gauge.

4.5. Other benefits provided

The LWSs in the ghyll wet woodland are visibly holding back significant quantities of water and wetting up larger areas of the forest floor. This is creating more diverse river habitat and should increase wetland features in time. Sediment collected in gullies and behind LWS should improve water quality, begin correcting stream incision and increase carbon storage. Increased storage of water will likely improve the resilience of this priority habitat (wet woodland) to the hotter and drier summers projected in future years, due to climate change.

The photographs displaying the positive impact the LWSs are having on the volume of water being held in the wetland (Figure 56., 57. & 59.) therefore indicate that LWSs could be a valuable tool in the preservation of wet woodland habitat. As LWSs age and collect more material, the stream and surrounding wetland character is likely to change. We hope that future monitoring can record how the watercourse and floodplain responds and demonstrates the expected benefits.

Figure 56. Photographed in winter 2020/2021, one year after installation, the LWSs in Pembury Woods create visibly higher water levels and a slower flow upstream of where they are installed.

Through its individual officers, the MFP engaged with the local community (those at risk of flooding). Connections formed by the delivery organisation (SERT) with/between partners, residents, landowners and the local flood warden all greatly enabled the implementation and informed the design of the project. On the Alders Road in particular, engagement helped the creation of measures that address the complex flood risk faced by the cottages, due to the network of flow pathways, ditches and culverts. Community involvement has also increased awareness of the NFM project, increased residents' receptiveness to the measures by developing their understanding and encouraged their future involvement in the management of their flood risk, in partnership with other organisations.

Figure 57. Regenerative LWS design: willow stakes, used to secure LWSs, have taken root and that the LWS is starting to regenerate, as shown by their new shoots (left). LWSs include hinged trees (right).

Figure 58. Photo showing water being diverted to the south side of the Alders cottages in January 2021, following the installation of the bund in December 2020.

5. Site four: School stream

5.1. Baseline flood risk and geography

The School Stream is a small tributary of the River Beult, one of the main catchments of the River Medway. The School Stream catchment is small and begins at the Greensand Ridge to the north of Headcorn. Below the escarpment springs, the watercourse is rainfall-dependent flowing over undulating Wealden clay, making it vulnerable to flashy flows after rainfall. The sub-catchment is mostly agricultural with a high percentage of pasture, some modern orchards on the highest slopes, and small blocks of woodland (Figure 59.).

The properties at risk of flooding are concentrated on the lower reaches in Headcorn, close to the School Stream and Beult confluence. Headcorn has a population of approximately 4,000 people (City Population, 2021). About 14 properties are at risk of flooding from the School Stream and have experienced multiple flood events. According to KCC, Headcorn's sources of flood risk include:

- Sewer flooding;
- Surface water flooding on roads;
- Fluvial flooding from ditches, the School Stream, and the River Beult (Figure 60.).

Although flood events can take place in Headcorn independent of high flows on the River Beult, it is important to note that surface water flooding and sewer flooding risk is 'exacerbated when drainage is limited by high fluvial levels' (KCC, 2017, p9). Given the flashy nature of the catchment, NFM therefore offered an opportunity to help with flood risk from the School Stream, although other risks could be tackled in future projects. While holding water back in the School Stream catchment alone might not prevent flooding in Headcorn, as a small catchment, it presented a key opportunity to implement catchment scale NFM, in a setting where its benefits could be quantified.

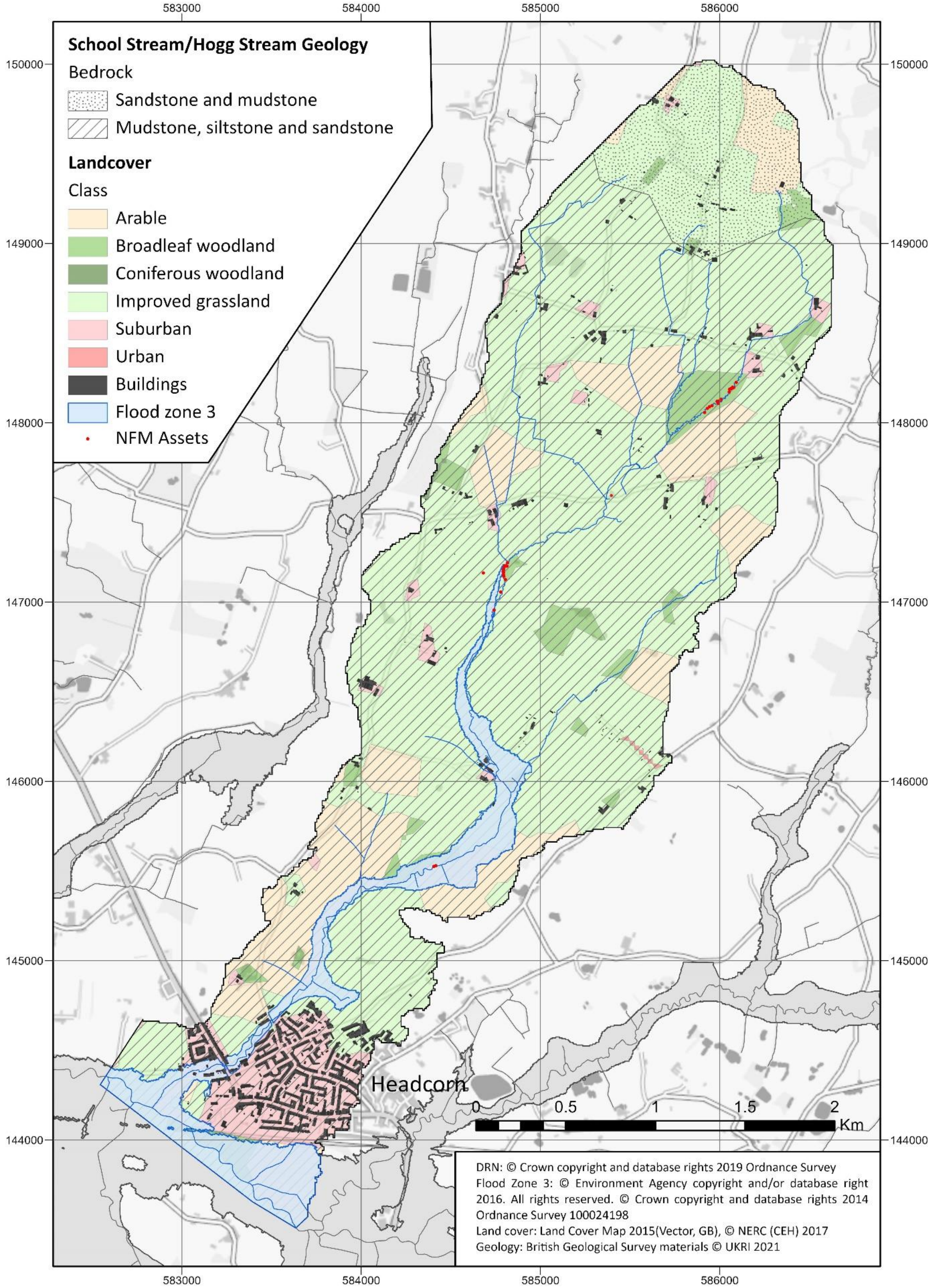

Figure 59. Geography of the School Stream catchment

Figure 60. Fluvial flooding of the park in northern Headcorn, nearby to many properties along Ulcombe Road (photo from Kent Online)

The most upstream landholding successfully worked on was Birch Wood (Figure 61. & 62.). This ancient woodland site has two tributaries flowing through forming a confluence at the very southern extent. The river planform appears to be naturally meandering and prior to the project had no woody material in the streams. Much of the woodland consisted of conifers, although there had been no management of the trees in many years.

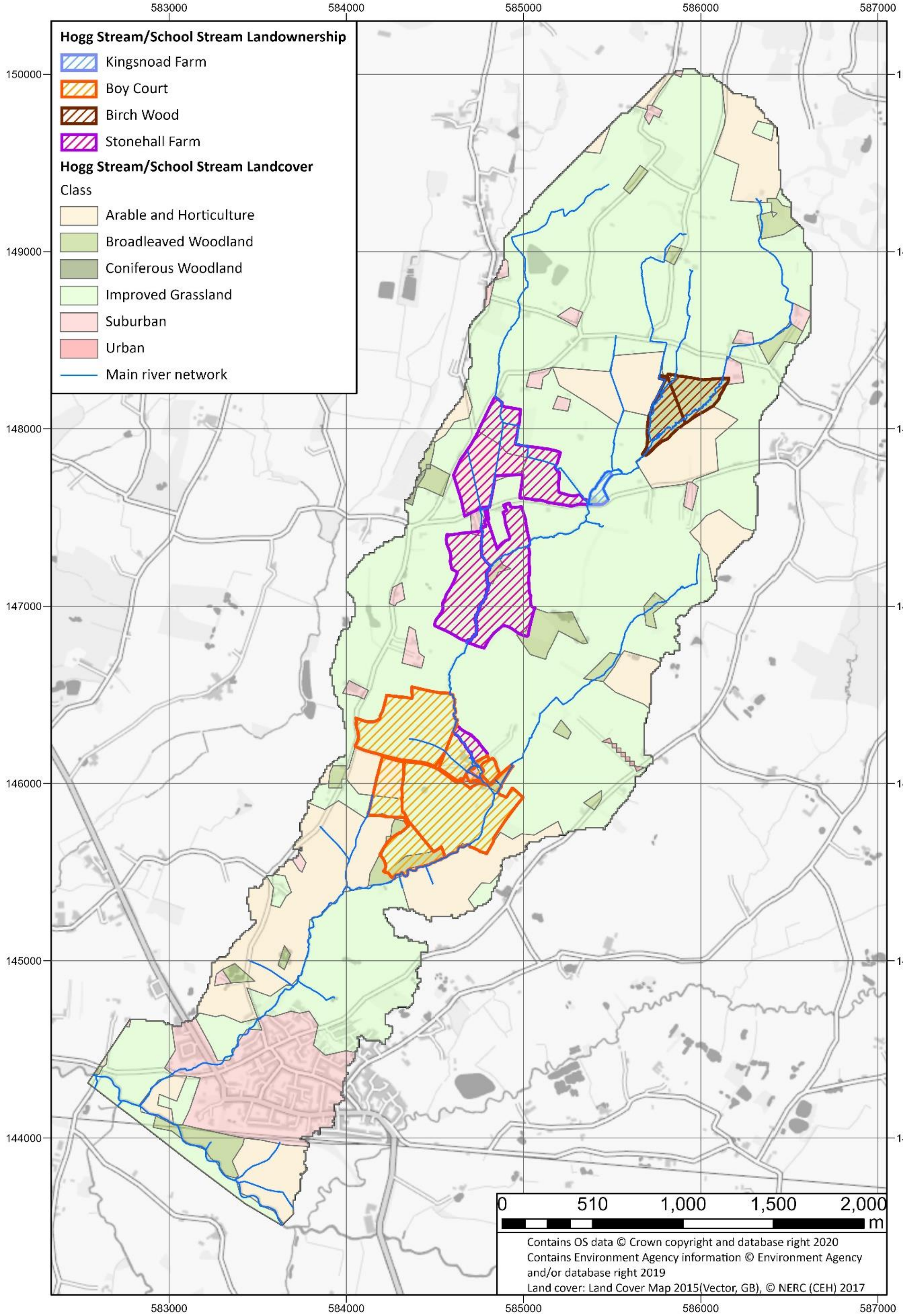

Figure 61. Indicative landholdings in School Stream sub-catchment

Figure 62. Eastern tributary in Birch Wood (northern most site on School Stream project) (above). The eastern tributary in Birch Wood following a rainfall event (below).

Further downstream Kingsnoad was the site of a former pond that had silted up (Figure 63.). It is thought to have been the site of a small quarry. The silted quarry site had few plants of interest and was being colonised by willow and birch.

Figure 63. The original site at Kingsnoad.

Stonehall Farm is a mixed farm containing several hundred metres of the School Stream (Figure 64.). On the site, the stream passes the remains of an old dam and meanders through a riparian ancient woodland (as indicated by the ground flora, wildflowers and the wild service tree on the site), though not officially identified until now.

Figure 64. School stream at Stonehall Farm; wild service tree (right) (ancient woodland indicator)

At Boy Court Farm (Figure 65.) the stream runs between both arable and pastoral fields for several hundred metres before entering a woodland. Flow paths in the woodland indicated that the river often floods the wood, possibly for significant periods of time in the winter.

Figure 65. In the woodland on Boy Court Farm, the woodland floor was wet over a large area well into the springtime

5.2. NFM opportunity mapping

The project targeted over 20 land holdings, however the fragmented ownership of the catchment meant it proved challenging to engage with many land owners. The School Stream had frequent high rainfall events during the project (Figure 66.), so in a number of places, vegetation and erosion clearly demarcated the flood plain. This wider floodplain offered the opportunity for very large LWSs in Birch Wood and on Stonehall Farm. SCIMAP was used to identify flow pathways (hydrological connectivity) in the catchment, highlighting opportunities for NFM interventions (Figure 67. & 68.).

Figure 66. Rainfall events lead to periods of fast and high flow on the School Stream, shown here further downstream towards Headcorn, just upstream of the playing fields that flood (as shown in Figure 61).

On observing the flashy nature of the catchment, despite the small size of the stream, the decision was taken to build particularly large and strong LWSs. A farm report was written for Stonehall Farm to help scope additional NFM options and other environmental measures for the whole landholding that could be integrated into a more holistic plan for the farm. In the woodland at Boy Court Farm, the stream was better connected with its floodplain and so LWS design could be adapted to focus on additional benefits such as water quality. LWS design could be tailored to capture silt and organic material to improve downstream water quality and restore more natural flooding processes to the woodland.

At Kingsnoad, the focus was the former quarry pond and its potential for water storage. The depression left by the quarry pond provided an opportunity to create additional flood storage capacity by diverting water into the pond in high flows. The historical land use had had a profound impact on the topography and the depression the quarry pond had left meant relatively little digging work would be needed to deliver the intervention. The pond was designed to include spillways and a bund (with a drainage pipe) to manage water levels (Figure 69.). De-silting the pond would also have a minimal environmental impact due to the lack of biodiverse habitats at the site.

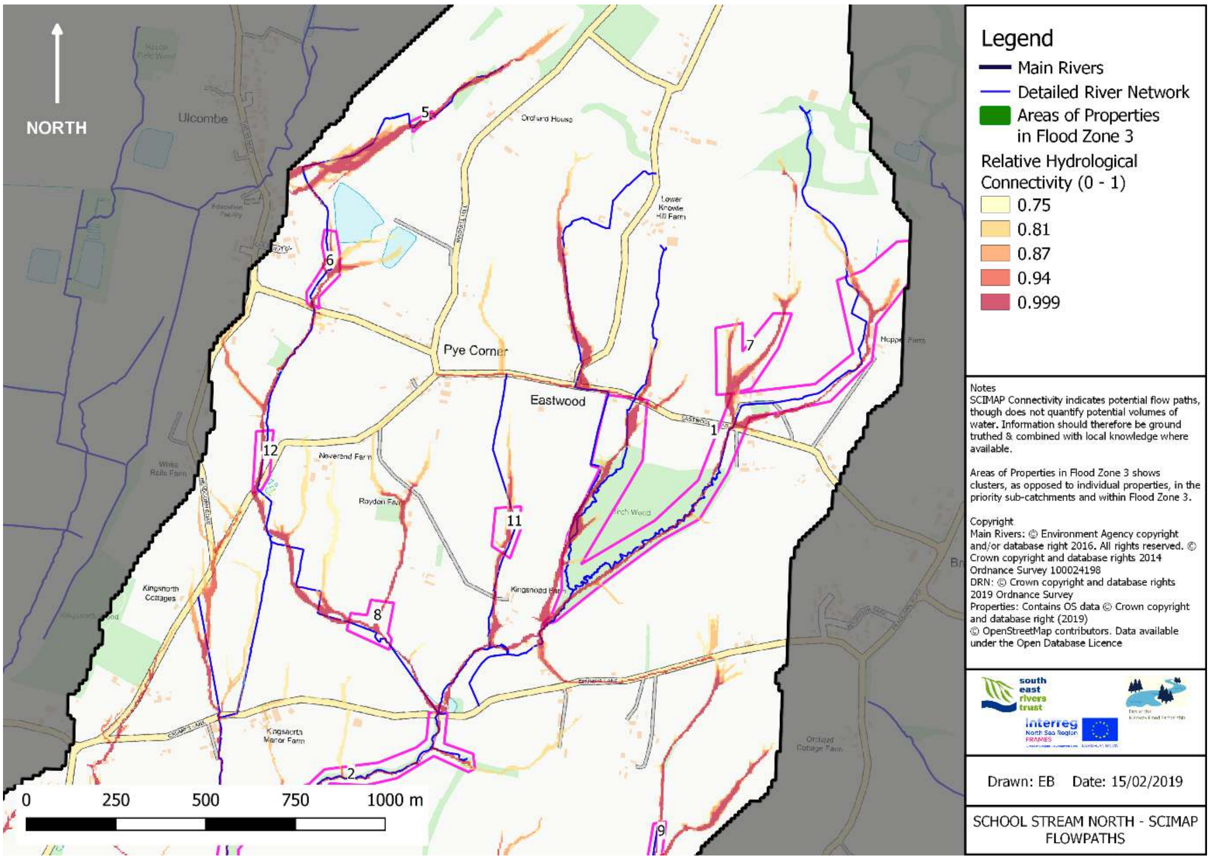

Figure 67. Flow pathways (hydrological connectivity) in the catchment, highlighting opportunities for NFM interventions.

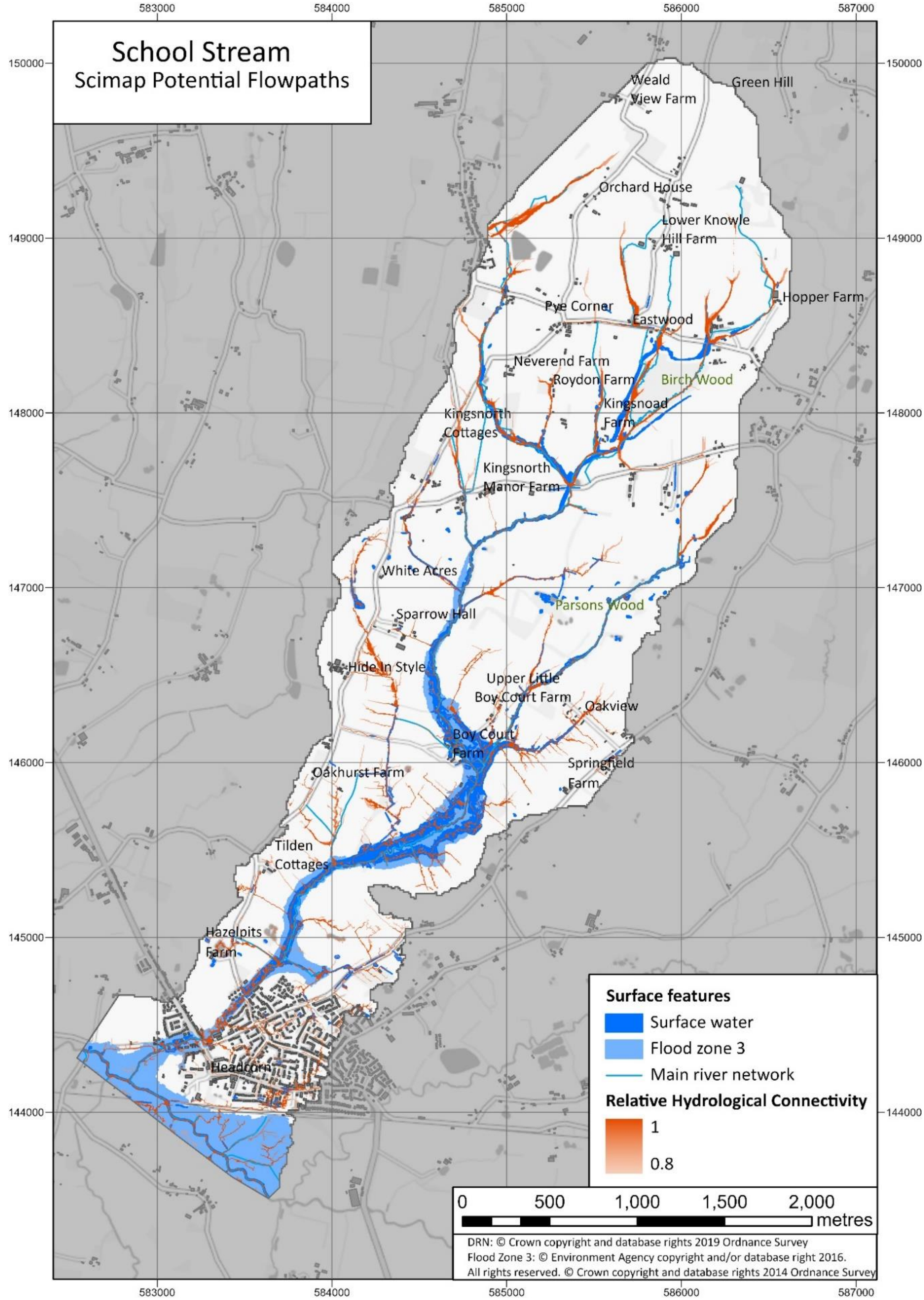

Figure 68. Flow pathways (hydrological connectivity) in the catchment, highlighting opportunities for NFM interventions, mapped using SCIMAP.

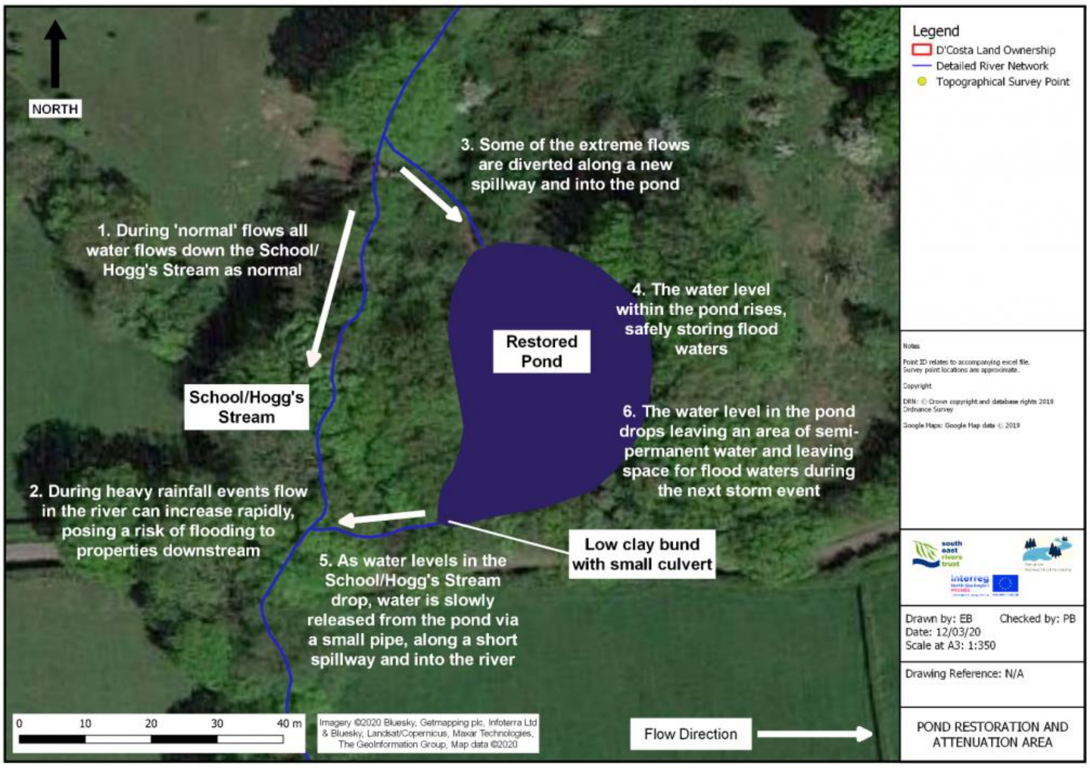

Figure 69. Annotated design for Kingsnoad pond, developed from opportunity mapping and site visits.

5.3 NFM measures introduced

Figure 70. shows the full extent of the NFM assets that were introduced. 15 LWSs were installed on the eastern tributary in Birch Wood. They were relatively large LWSs, mostly constructed using 10+ metre logs. 12 similarly sized LWSs were installed at Stonehall Farm (Figure 71.). All of these structures occupied the channel and the floodplain and were built considerably higher than the top of bank. One LWS at Stonehall Farm was built in a channel that only holds water during periods of flood. Six smaller LWSs were installed at Boy Court Farm and a small offline storage pond was installed at Kingsnoad.

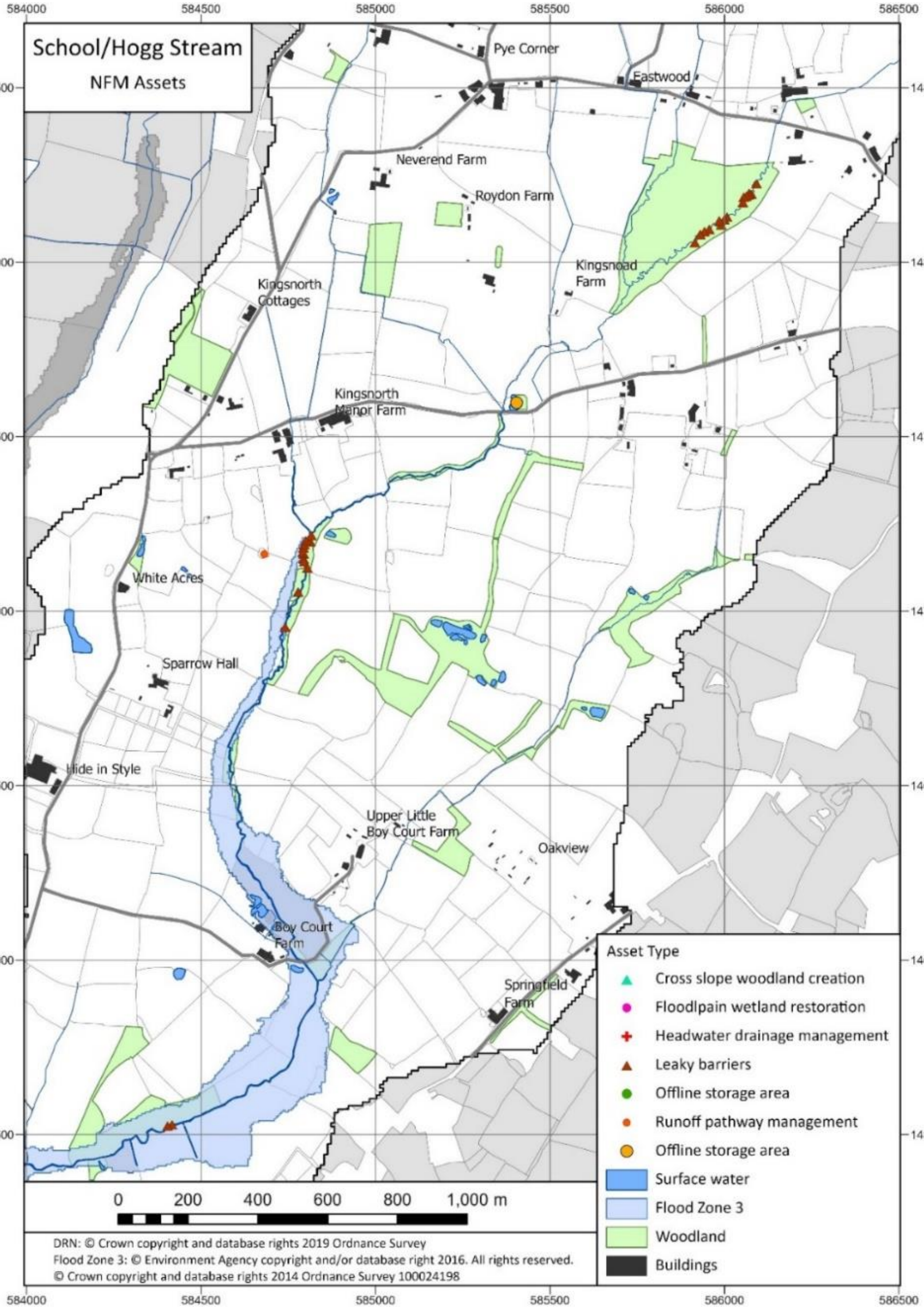

Figure 70. NFM assets introduced in School Stream catchment

Figure 71. Series of large LWSs installed on eastern tributary in Birch Wood (top). LWSs constructed at Stonehall Farm (bottom), including one braced against the historic dam on the site (bottom right).

At Kingsnoad, the trees in the area were thinned out by forestry contractors before sediment was dug out to restore the pond, but with significantly increased storage capacity. The material was deposited outside the floodplain, whilst the good quality clay excavated was used to create a bund at the downstream end of the pond. This bund holds back water and creates extra flood storage capacity. A pipe was inserted through the bund to slowly drain the area. The pipe was set so that the original pond habitat was re-created. During storm events, water can enter the pond from the School Stream via a new offtake channel, raising the level in the pond by approximately 0.8 m and providing additional storage capacity. As the level of the

School Stream drops, the pond drains back down to the semi-permanent water level within 24 hours, ensuring capacity is available for the next storm event. The pond created approximately 600 m^3 of flood storage (Figure 72.). The pond was designed so that, if it becomes full in a flood event, flows divert naturally back towards the School Stream so that the bund does not risk being overtopped and eroding.

Figure 72. Kingsnoad pond one year after installation (left). The bund and pipe maintain the desired water level (centre). Offtake channel from main river to the pond (right).

At Boy Court Farm, there was evidence of flow paths outside the channel, along the forest floor, showing the stream was flooding and therefore functioning quite naturally. As a result, the design of the LWSs in the wet woodland at Boy Court focused on capturing silt and debris to improve water quality (Figure 73.).

Figure 73. Willow was weaved through a LWS on Boy Court Farm, adapting LWS function to capture silt and offer maximum benefits to the specific site.

5.3. Flood risk benefit provided

Time lapse footage of LWSs during storm events gives confidence that the structures are effective in storing water and slowing the flow downstream (Figure 74.). The LWSs are estimated to store approximately 1,800m^3 of water. As with the Alder Steam, time-lapse footage and site visits during rainfall events indicates that there is a clear difference in water level upstream and downstream of most LWS designs (Figure 75.). However, for some this difference is less clear and therefore the impact is likely to be mostly related to the slowing of flow, as opposed to storage of water. However, determining the exact impact on the speed of flow, and particularly the impact on the downstream hydrograph, is very challenging. While it would be good to focus in on this in future work, monitoring impact on speed of flow was ultimately found to beyond what was possible with the resource available on this project. Perhaps on future projects, having a dedicated PhD student or research project could help find out more about the impact of LWSs on the speed of flow.

Figure 74. LWSs in Birch Wood in a flood event. A higher water level is clearly visible upstream of the LWS and debris collected is also visible, improving the water quality.

Figure 75. LWS at Stonehall Farm after a rainfall event, visibly holding back large quantities of water and slowing the flow.

Kingsnoad pond and flood storage area has performed as intended, as demonstrated in the graphs below (Figures 76. and 77.). Water level loggers have been placed in the School Stream at Kingsnoad Pond and downstream at Headcorn, and within Kingsnoad Pond itself. The second graph (Figure 77.) shows water levels in the School Stream and Kingsnoad Pond during one storm event.

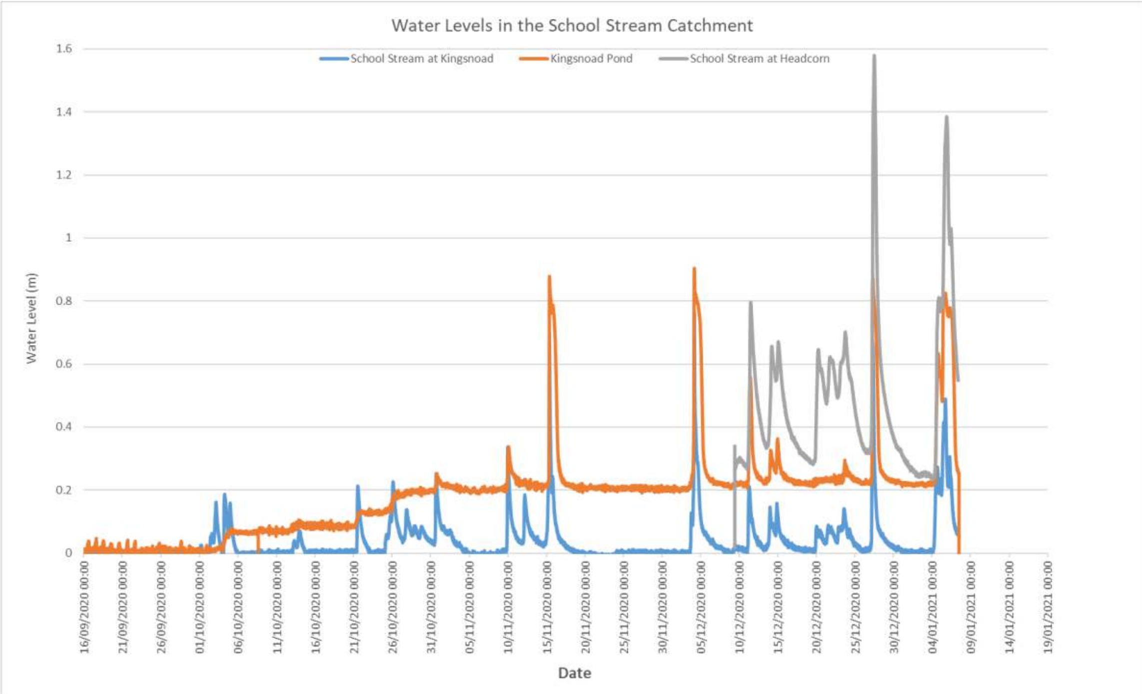

Figure 76. Graph showing the flood storage (water level) provided by Kingsnoad Pond during high flows on the School Stream during a storm in February 2020

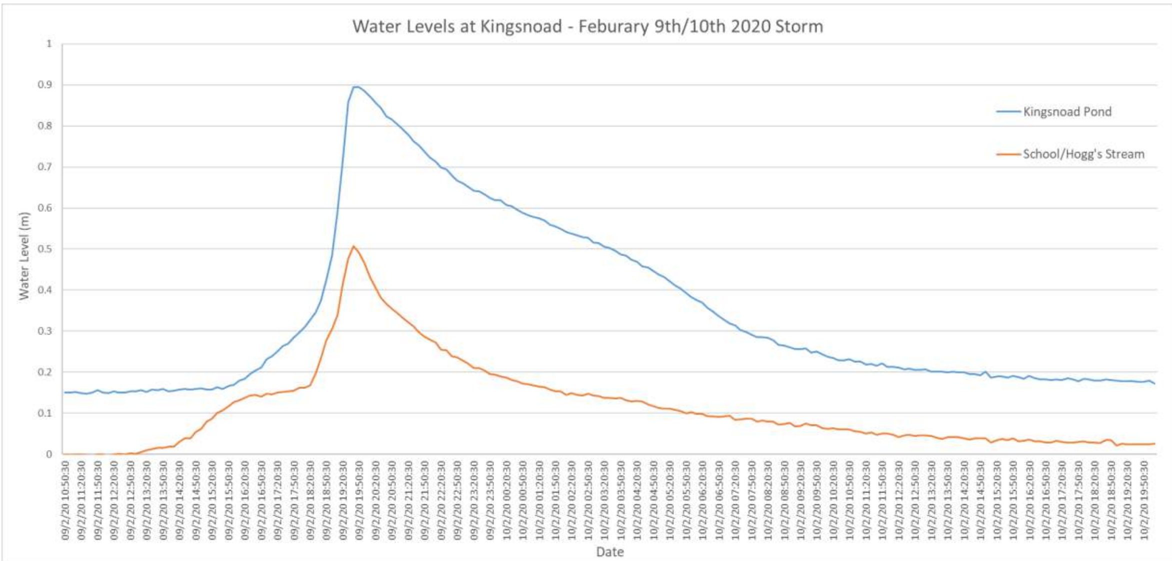

Figure 77. Graph showing the flood storage (water level) provided by Kingsnoad Pond during high flows on the School Stream, by Kingsnoad pond and further downstream at Headcorn, during a storm in February 2020.

These data show that water levels in the pond increase during the rising limb in the School Stream, peaking at, or just after, peak water level in the School Stream. This means that the pond is providing effective flood storage and attenuating the flood peak. A pipe drains Kingsnoad Pond to a set level in under 24 hours (12-16 hours in this case), thereby storing water during high flows, but ensuring that there is available capacity should 2 rainfall events occur in close succession.

On-site investigation during high flows indicated that at peak levels, water was flowing out of the pond via a natural low point. This low point was subsequently raised to maximise the storage within the pond. The drainage pipe invert was set at a level to provide a semi-permanent water level to provide biodiversity benefits, whilst ensuring available flood storage year-round. Regular site visits to the pond indicate that water is retained within the pond well into the summer. During high flows, silt enters the pond and over time it will begin to build up. Silt depths are being monitored alongside water levels. The pond will need maintenance to periodically de-silt it in order to retain flood storage capacity, and ensure a valuable ecological habitat. The project has also been successful at delivering on landowner hopes and expectations.

Peak flows downstream have not been monitored due to the difficulty associated with flow measurement and the Environment Agency does not manage any monitoring stations in the sub-catchment. Therefore, whilst there is confidence that Kingsnoad Pond is providing effective flood storage and having an effect in attenuating peak flows, the impact on the downstream hydrograph is unknown. Long term monitoring of Sissinghurst scrape helped inform the design of Kingsnoad Pond, enhancing its effectiveness in terms of flood storage and attenuation.

5.4. Other benefits provided

As on other sites, LWSs offered additional benefits. They created diversity within the river habitat and collected silt and debris, which we hope will improve water quality. Some of the LWSs at Stonehall Farm were enhanced with faggot bundles (bundles of finer branches) on the upstream side (Figure 78.), which made them even more effective at trapping silt and debris from the stream. Meanwhile the designs of the LWSs at Boy Court Farm were tailored to collect sediment and leaf litter to kick-start natural processes for the river to spill over the woodland floor.

Figure 78. LWSs at Stonehall Farm, enhanced with faggot bundles, became even more effective at trapping silt and debris

A number of pioneer flora and fauna species have been identified at the pond, including several species of dragonfly and damselfly. Figure 79. & 80. show the pond in mid-June 2021, with water levels only just below the drainage pipe invert. Over 20 species of plants colonised in the first year, suggesting these were found in the seed bank, from when the site was previously a pond. The Low Weald is an important area for ponds, and a key area for protected species such as great crested newts.

Figure 79. Over a year after its installation, Kingsnoad pond had been colonised by a diverse range of plant and animal species.

Figure 80. Kingsnoad pond was quickly colonised by aquatic and marginal plants including water plantain (left) and celery-leaved buttercup (right).

The School Stream can run quite turbid (Figure 81.). Diverting water into Kingsnoad pond brings significant volumes of silt (Figure 82.), which settle out, improving water quality before it returns to the stream. However, it is worth noting that this will likely have implications for future maintenance requirements of the pond, if it collects large volumes of silt every year.

Figure 81. Turbid water of the School Stream, upstream of Kingsnoad pond. (left) and silty water diverted into Kingsnoad pond (right).

6. Lessons learnt

Below are the general and specific lessons learnt throughout the development and delivery of all aspects of the project, and from the data gathered.

6.1 Monitoring and Data

General monitoring

Monitoring NFM is challenging and the evidence base for its effectiveness in different catchment sizes, settings and during a variety of storm scenarios is still relatively sparse. As the features are not heavily engineered, they do not conform to strict designs and many will evolve over time. The impact of NFM on flow is particularly difficult to record accurately, due to limited baseline data. Within the Medway catchment, gauging stations exist only in a few specific locations, meaning that the peak flows in small sub-catchments, such as the School Stream and Alder Stream have been estimated, although some recording data has been collected by the project. Assessment of individual features provides confidence that they are working as intended and providing a range of multiple benefits, including flood storage.

NFM can store and slow water – it needs to be scaled up throughout the catchment

It is evident from this project, and from wider research, that significant volumes of flood storage may be required throughout a catchment to mitigate downstream flood risk. Through the variety of interventions delivered, approximately 8,000m^3 of extra water retention was created by this project. This volume is extremely small relative to the River Medway. However, as well as storing more water during flood events, rolling out these measures more widely could help make the catchment more resilient to climate change in future years by prolonging flows during spring and summer. This emphasises the importance of taking a catchment-scale view. Work carried out has demonstrated that NFM can be effective (at the site-scale) in storing and slowing flow and providing multiple benefits, including added value for the landowner. Wider research suggests that when scaled up, these benefits can reduce downstream flood risk for small to medium sized catchments and during storm events.

Incorporate a degree of flexibility into the design of NFM

This allows small changes to be made to features to improve their performance, if required. Continued monitoring of features, as well as site visits during storm events, can help inform any adaptations. This has been the case in this project, with monitoring of Sissinghurst demonstrating a need to alter the offtake channel so that water wasn't taken in low order rainfall events, as well as informing design of Kingsnoad pond. In addition, knowledge-sharing events held by FRAMES partners were highly valuable in passing on experience and innovations.

Equipment

Equipment wasn't always reliable and was prone to damage or not working correctly. Some remote locations could not get a good signal for telemetry to work, and others were prone to theft e.g. time lapse cameras. For remote sites it will be worth considering to what extent monitoring adds value to the project, and fully scoping on-site risks before proceeding.

Future monitoring

It is important to encourage all practitioners to focus on the monitoring and evaluation of projects and enable them to do so accurately and independently. Support from universities and research institutions will help. It would also be useful for practitioners to be supplied with up-to-date guidance on how best to quantify the benefits provided. Continuing to build up the evidence directory to support the application of NFM is invaluable. A stronger emphasis on monitoring and reporting needs to be in place so that people can see how to add to existing data on projects in the future,

6.2 Large Woody Structures

LWS storage capability

In total, up to approximately 4,800m^3 of storage is estimated to have been provided across the Medway through the creation of LWSs. Time-lapse footage and site visits during wet weather have provided evidence that the LWSs are functioning well. Each LWS will also have an important effect in slowing down the flow of water, reducing its energy and connecting the channel with its floodplain. Many LWS have been created in channels which are dry for many months of the year, but which can turn into torrents rapidly during rainfall events. Flow monitoring on the Alder Stream indicated that approximately 19,000m^3 of water flowed within the Alder Stream at Alders Road in a 2-hour period during Storm Ciara. This compares with approximately 1,500m^3 of storage provided by LWS.

LWS adaptation to sites

When constructing LWSs, both volunteers and contractors had to adapt to the conditions of each site. Factors that bore an influence on LWS placement and design included the materials available on site, the contours of the land and the natural features and bends of the rivers. Effective LWS placement and design therefore became a process of adapting to the site, a process which benefitted directly as experience in constructing LWSs increased.

LWS experience aids delivery

The experience gained at Bedgebury went on to help with the other sites, as volunteers and contractors all improved their delivery and knowledge.

LWS built using experienced contractors helped with quality and design

The contractors we used to build the larger LWSs were experienced foresters. They had good ecological knowledge of the trees and habitats with which they were working, they were able to minimise impact on the surrounding habitat when installing the LWS. They used nearby source material to construct the LWS and used winches to move the logs around, negating the need for vehicle access.

LWS variation in design

The large number of LWSs created has improved our understanding of the types of LWS that were most practical to build and most effective at holding back water. The fact that the re-creation of natural forms (wood in the channel) has kick-started natural processes to provide these benefits meant that they were more likely to be sustained in the longer term. Not every site will have the space to provide the restoration of connectivity to the floodplain, but where this is possible it can be explored with the landowner's consent.

LWS sustainability in design

As we were working in existing woodlands, we sourced woody material wholly from site which reduced the time taken to create LWSs, the carbon footprint of the work and its cost. No wire or metal or even alteration to the riverbanks was required to secure the LWSs to make them safe. Wooden stakes, fashioned from logs, were used to secure LWSs.

LWS as regenerative, long lasting interventions

If possible, willow or alder stakes were used, which gave LWSs a better chance of becoming regenerative if the stakes took root. The contractors were innovative in other ways to give assets the best chance of being regenerative and allowing natural processes to maintain the positive impacts of any features installed. When appropriate, trees were partially felled or hinged to ballast woody material, whilst allowing the tree in question to stay rooted and continue to grow in its new position. The idea was to allow LWSs to form a part of the landscape and regenerate, therefore ensuring their positive impacts continued and they would remain stable and safe.

LWS help absorb the energy

Monitoring of LWSs in the sub-catchments has demonstrated that the LWS are effective in reducing the flow energy. Whilst no further funding is available for monitoring, it will be continued for as long as possible. This offers opportunities for further work, for example by a university, to provide more information on the benefits of the work carried out.

6.3 Offline ponds

Storage capability

Up to 3,200m^3 of flood storage has been provided by creation of Kingsnoad pond and Sissinghurst scrape. Monitoring has shown that both provide effective flood storage during events, with Kingsnoad being designed to drain fastest to provide flood storage more effectively. At Sissinghurst, in two storm events approximately 14% and 7% of these volumes were held from the stream. Figure 83. (below) shows the drainage pipe and the bund at Kingsnoad pond. Experience from partner rivers trusts proved valuable in choosing a design, including added flexibility due to limited baseline flow data. In this case a drainage pipe was used, which can be reduced in diameter if it is found to be draining the storage area too quickly, or increased if needed to increase the depth of semi-permanent water. Monitoring carried out so far indicates a good balance has been found. The drainage pipe was positioned to prevent draining the pond below approximately 1 metre depth. This ensures that there is consistent habitat provision, whilst ring-fencing flood storage capacity for heavy rainfall events. How offline ponds are drained should be considered when designing them and deciding which of the multiple benefits is most desirable in the given area. The bund was seeded with a grass mix to reduce the risk of erosion.

Figure 83. Sowing seed mix was successful in vegetating the pond's bund to make it less likely to be eroded.

The ease of creating the pond at Kingsnoad demonstrates that the creation of multiple ponds throughout the landholdings on the School Stream is possible, which would help manage far more water and silt in this catchment. The cost of completing Kingsnoad was £12,600, therefore future projects could be scaled up to store much larger quantities at a similar cost/benefit ratio.

Maintenance

Kingsnoad pond is collecting significant volumes of silt (Figure 84.). It is amongst the assets that are giving the earliest indication of the level of maintenance that will be required in the future to retain the benefits they provide. Future funding of maintenance or continual creation of new features will be needed.

Figure 84. The spillway to Kingsnoad pond has accumulated noticeable levels of silt in the year following its installation.

6.4 Diversion ditches

Utilising modern software to model changes provides reassurance that diverting flows can work as an effective flood risk reduction measure, such as at Alders Road cottages. Anecdotal evidence also helps demonstrate the change in flow paths and any increased storage.

6.5 Community engagement

Demonstrating NFM increased local knowledge and interest

By demonstrating how NFM works, knowledge and interest has increased and with this the hope that nature-based solutions will continue to be used throughout the Medway. When applied widely across a catchment, as opposed to in isolated areas, NFM will have its greatest benefit.

Involving universities will add value

Having additional academic support on monitoring projects, would help to provide the resource and expertise to carry out more effective assessment of the performance of NFM, though modelling may still be required.

Experienced conservation volunteers are invaluable

Involving volunteers provided a cost-effective means of delivering small LWS construction on a significant scale. However, this process was made considerably easier by having an experienced and reliable team from the Conservation Volunteers available, and capacity to manage the volunteers by SERT.

Visible public displays on NFM help with building community knowledge

The large series of LWSs at Bedgebury illustrated a public interest in NFM, habitat creation and kick-starting natural processes. The enthusiasm that members of the public had for the LWS was encouraging and it benefitted from the high public profile that restoring natural processes has been enjoying in the media recently. The demonstration LWSs clearly capture the imagination of many pinetum visitors, building enthusiasm for NFM. As a Steering Group member, Forestry England were supportive of helping the Medway NFM project and so offered the Bedgebury site early on in the project. We were grateful for this as it was a useful site to trial a variety of designs, working at changing scales, and with volunteers and contractors. This provided a good training ground for taking NFM to other sites and has provided important lessons on design and construction.

Influencing

Successful landowner engagement requires the ability to explain the concept well, particularly to those used to land drainage improvements. Assuring land managers, and the public, about safety and managing misconceptions are crucial. The resources required in time and expertise should not be under-estimated. The Alder Stream project demonstrated the value of community backing in NFM solutions. Their knowledge of actual flood events helped us to tailor NFM designs. With sufficient community interest in NFM measures, landowners can help be persuaded of the value of participating and so help to deliver more NFM.

Building a network of experience

The project has allowed the delivery organisation (SERT) and the contractors they used to gain valuable experience in the design and construction of LWSs, with minimal carbon footprint and disruption to surrounding habitats. The organisations involved have also built up a network of contacts to deliver more work in the future, including contractors, landowners, communities and key partner organisations.

6.6 Biodiversity benefits

Retaining some water within NFM sites for longer provides multiple benefits

The meadow/scrapes on this site at Sissinghurst and the pond at Kingsnoad both showcase the biodiversity benefits of storage for different time periods. Long term monitoring will demonstrate these benefits at the site scale more precisely. However, if scaled up throughout the catchment they would provide significant landscape scale multiple benefits. The capacity and diameter of the drainage pipe and the angle and depth at which it is set are the main variables to consider in offline storage/scrape design, so as to influence its functionality. Flexibility of design can also be added by installing a pipe and adding a reducer, which can be removed if the storage area drains too slowly. Alternatively, a flexible pipe can be added to alter the level to which the storage area drains, increasing or decreasing the level to which the scrape drains.

Ancient woodland site opportunities

Many ancient woodlands are below their ecological capacity. On the Alder Stream restoration of the understorey, reducing soil compaction, and the natural expansion along flow paths are an added tool to slow run off, and promote biodiversity. These ideas can be used elsewhere, particularly on small woodlands. 6.9ha of wet woodland benefitted from this project, as well as approximately 8.2km of watercourse through provision of woody material to the channels. 11ha of degraded ancient woodland was fenced off for recovery from overgrazing.

Restoration of natural processes

The addition of series of LWSs to wet woodlands and watercourses should help to kick-start natural processes that will restore more varied stream habitats and more wetland features. In the short time of the project there was some evidence that this was beginning to take place, such as the storing of sediment and the creation of new flow pathways through the woods. This will increase the resilience of rivers and wet woodlands to climate change.

Enhancing meadows in the floodplain

In this project 2.3ha of lowland meadow has been enhanced by reducing nutrient levels and re-seeding with a wildflower mix. This will demonstrate how it is possible to restore lost habitats in clay catchments although it may take many years to reach its potential.

6.7 Construction considerations

Delivering for landowners and good relationships are important

The National Trust is pleased with the performance of the scrape/storage area at Sissinghurst. The scrape provides flood storage, biodiversity, and landscape character benefits, so the scheme can be deemed a success.

Ensure there is a maintenance plan in place

For some NFM interventions we would like to monitor to see how they evolve before planning maintenance (e.g. many of the larger LWS). But for Sissinghurst and Kingsnoad we already know there will be a need to desilt and manage structures, pipes and channels to ensure they continue to operate. Whilst these are very low and easy works to do, they will require a commitment from landowners. It is best to avoid as many of these types of requirements when scaling up NFM in the catchment, except where long term maintenance agreements are in place, or work can otherwise be guaranteed.

Contributions (in kind) from landowners, and other partners are invaluable

The National Trust was an enthusiastic landowner and brought many benefits to the Sissinghurst project, including extensive in-kind contributions to the development and delivery of the project, knowledge and general support.

Liability

Some land owning organisations were hesitant about signing up to the project due to the perception of potential liabilities on their landholding. Whilst this project was able to overcome this by agreeing to stick to the available guidance on LWS design, it would be useful to have something stronger for guidance to help conscientious estates officers or other professionals to have more confidence in agreeing to appropriate measures.

6.8 Funding

Land management funding

Most landowners were not in Countryside Stewardship so there was not a significant blocker to doing work, however, the future Environmental Land Management Scheme (ELMS) will aid conversations, if it provides sufficient funds to enable changing management in floodplain areas to store water. Many landowners would like to provide environmental benefits but will need a scheme that provides maintenance payments to be able to participate.

The number of landowners that need to take part in order for catchment scale work to be effective will always be high. Therefore, working at a catchment scale is, and will remain, much more challenging until more certainty is provided around ELMS, which will hopefully offer incentives that:

- Compensate the farmers adequately for both the effort of implementing the projects and the level of responsibility the farmers are taking on;

- Incentives that value the importance of NFM in priority catchments, thus encouraging take up;
- Enable engagement with local experts to ensure implementation is done to the best standard and is effective.

Working on farm businesses, with no maintenance fund in place meant there were more challenges with agreeing projects. This was exacerbated by uncertainty around how payments for NFM on their land might work following the transition from the CAP (Common Agricultural Policy) to ELMS. Due to ELMS not being finalised, many farmers were hesitant to commit to participating in the Medway NFM project.

Landowners whose sites' financial viability did not depend upon the productivity of their land more easily agreed to take part in the project, especially if the flood risk benefits and environmental benefits were compatible with their own objectives.

National funding framework for NFM

A funding framework that encourages NFM is needed, particularly in sub-catchments where alternatives are not viable, with attainable flood risk mitigation metrics to prioritise where this takes place, including monitoring, maintenance and reporting.

This will have added benefits, such as helping to challenge traditional views on land drainage where alternative management may have greater multiple benefits.

Partnership projects

Partnership working can produce results that are greater than the sum of their parts, by:

- Coordinating and prioritising work throughout catchments/regions;
- Making projects more appealing for others to become a part of;
- Pooling partners' resources, expertise and contacts;
- Making managing flood risk on a catchment-scale more viable through facilitating coordination between landowners.

However, partnership working also poses challenges and lessons on partnership working from this project can certainly be taken. Clarity and consensus on outcomes are vital and aligning processes to make co-working practical is also important – partners must be willing and able to be flexible to work together effectively. The EU-funded project was bound to a three-year timeline, as well as some other quite rigid terms and conditions. Being joint funded by the Environment Agency meant that the project required internal Environment Agency approvals. Environment Agency business case approval was set up for traditional flood risk projects, so at the time, did not cater for the unique approach that NFM provided, and delivery timeframes for the project altered after the project had started.

Compare NFM projects nationwide

This project was one of Defra's national NFM pilot projects (Figure 85.). Therefore, in order for lessons learnt from this tranche of projects (in the Medway) to be meaningful in informing a national rollout of further NFM projects, they should be contextualised against the other projects that took place across the country. This is outside the scope of the evaluation of this project, but the Environment Agency is collating and summarising information from all pilot projects to provide an overview.

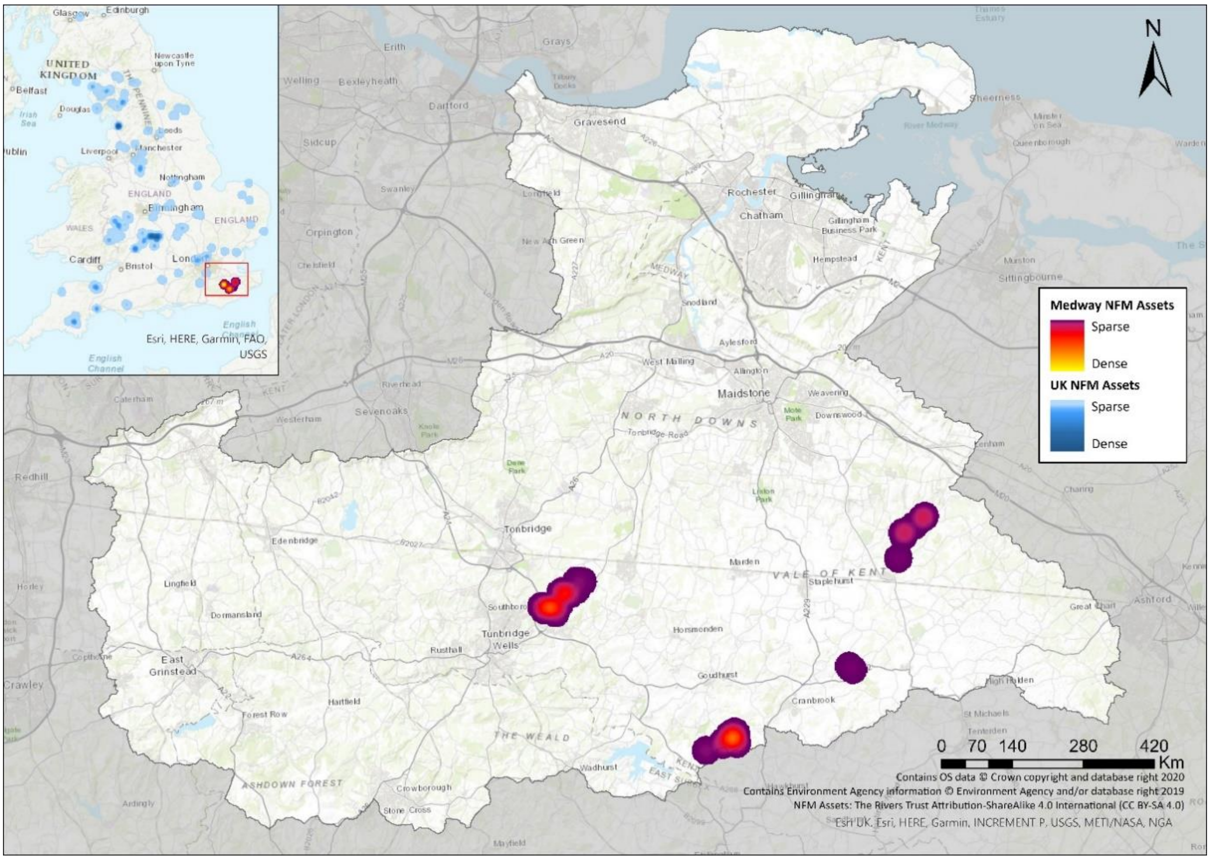

Figure 85. Map showing Medway NFM sites in relation to all other sites of Defra's national NFM pilot scheme

7. Conclusions

The objectives of the Medway NFM project were mostly met:

- The projects demonstrated a reduction in flood risk to over 51 properties in the Medway catchment including many homes in Five Oak Green, and some in Headcorn;
- We delivered woody material to 8.2km of watercourses, protected and enhanced 11ha of ancient woodland, and created 3.3ha of habitats of meadows, ponds and natural woodland regeneration;
- We provided monitoring for our projects, which have demonstrated the effectiveness of some of the interventions, although further studies and data gathering are advised to improve information;
- A 37% match of Environment Agency funding was achieved together with in-kind staff support making the total likely over 40%;
- Communities and landowners were widely liaised with throughout the Medway catchment, even though the project only physically delivered on 4 sub-catchments;
- This report provides the data and evidence for the project together with summary sheets.

For future NFM projects we recommend:

- Scoping out and delivering more NFM projects elsewhere in the catchment (and the south east region). There are clear benefits to be realised;
- Particularly emphasising the environmental benefits of NFM, such as managing water better for flood risk and climate resilience, the creation and diversification of wetland habitats, and the kick-starting of natural process in headwater streams;
- Building on the momentum developed through this project. The Medway NFM project has built a clear framework, and momentum to conduct more NFM work. This foundation for future work comprises:
    - The multi-agency experience built up in NFM delivery;
    - The notable number and range of additional partners and landowners engaged;

- The clear benefits illustrated by the partnership approach taken (the foundation for which was laid by Medway Flood Partnership);
- The range of contacts accrued within the catchment; and the shortlist of other sites/sub-catchments in region/catchment that could clearly stand to benefit.

Potential benefits of a more systematic and mainstream implementation of NFM solutions, where appropriate, throughout the Medway catchment include:

- Capitalising on relationships built with landowners in the Medway and the south east; further developing regional multi-agency expertise in NFM delivery;
- Improving and developing the evidence base for the benefits of NFM;
- Increasing and developing awareness and understanding of NFM and its benefits; reducing notable flood risk in Medway/south east;
- Healthier, more diverse, and more resilient river systems and their catchments;
- More data to inform the ongoing development of ELMS to renew and reinvigorate land management across England.

Carrying out more NFM scoping and implementation on a regional basis could be supported by:

- Formal studies that are informing the ELMS scheme taking into account lessons learnt from this project and similar projects and acting upon them when amending ELMS policies;
- The ring-fencing of sufficient funding for monitoring and evaluation in future projects;
- The ring-fencing and provision of funds for NFM asset maintenance for landowners;
- A commitment to the collation and analysis of this project and others like it from across the country and a focus on analysing them to create outputs that inform national policy but also best practice for NFM practitioners.

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