Case study 33. Water Friendly Farming Project

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Main driver: Assessing potential to deliver multiple benefits for floods, pollution control and freshwater biodiversity by rural land management

Project stage: Monitoring baseline established 2010 to 2013, measures added 2014 onwards, detailed monitoring of effects 2014 onwards

Photo 1: Semi-permeable dam in the Eye Brook catchment (source: Water Friendly Farming Project)

Project summary:

Water Friendly Farming is a research demonstration project evaluating the potential of catchment scale rural land management measures to hold back water, reduce flooding, reduce water pollution (sediments, nutrients, pesticides) and increase freshwater biodiversity across the landscape whilst maintaining productive and profitable farming (Photo 1). The project has a before–after–control –impact experimental design and is operating in 3 adjacent headwater catchments on the catchment boundary of the River Welland and River Soar in Leicestershire, around Tilton-on-the-Hill. It is concerned with the whole water environment (ponds, streams, ditches) and is also comparing the comparative benefits of water resources measures and habitat creation.

Key facts:

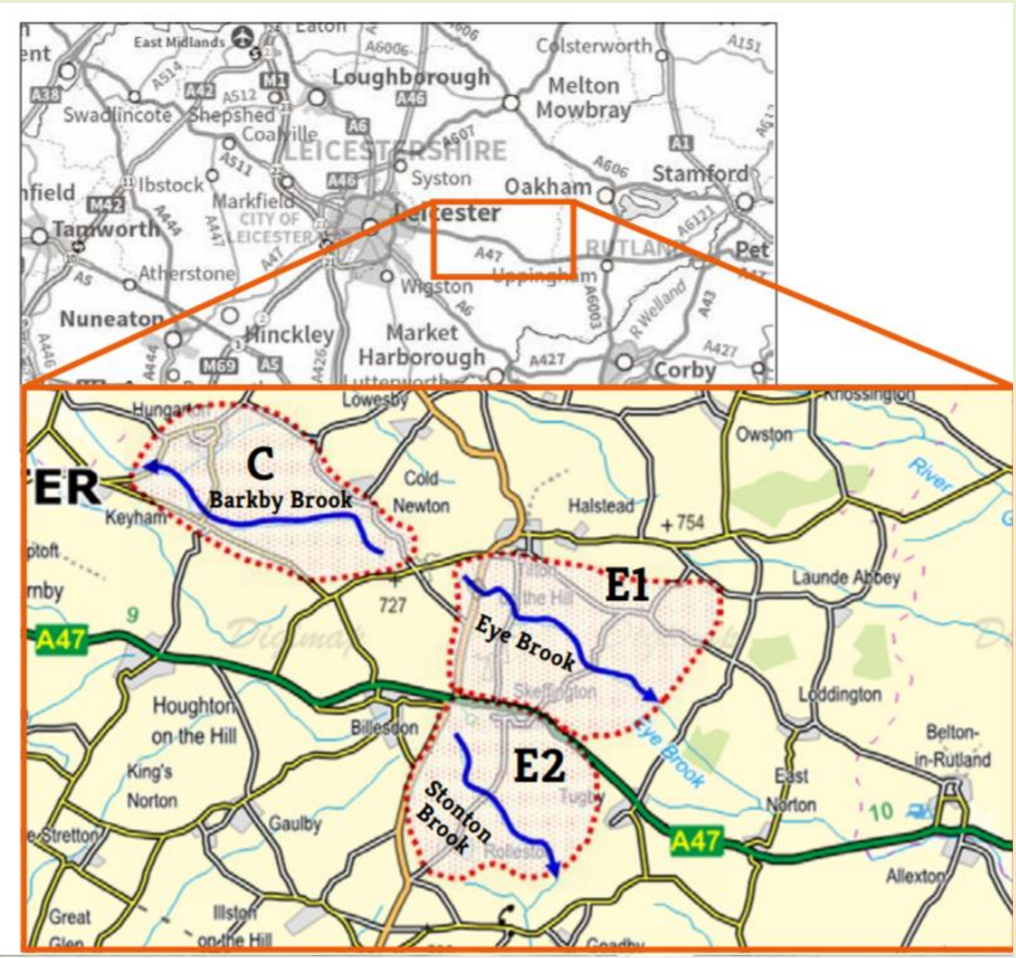
By 2017, about 30,000m^3 of temporary storage will have been installed In a 10km^2 catchment (Map 1). Modelling indicates that this is anticipated to reduce the 1 in 100 year flood peak by 20%.

Installation of clean water ponds across the landscape has immediately increased landscape level freshwater biodiversity, one of the first demonstrations of a positive, landscape-wide, freshwater biodiversity response to land management measures. Monitoring is assessing the time for which this effect persists.

Modelling of the effect of previously installed buffer strips indicates that they have reduced sediment losses from the landscape by about 30%.

There is so far little evidence that levels of phosphate or nitrate in the stream network has been affected by the land management measures; rather climate over the project period has led to a modest general decrease in nitrate concentrations, and a modest increase in phosphorus concentrations, since the initiation of the project baseline in 2012.

About 10% of water bodies in the landscape (ponds, streams, ditches) have nutrient levels that are close to 'clean water' natural background levels (that is, equivalent to Water Framework Directive high status), but 90% of the water bodies have potentially damaging levels of water pollution.



Map 1: Location of the Water Friendly Farming project area

1. Contact details

Contact details	
Names:	Jeremy Biggs, Chris Stoate, Simon Bonney
Lead organisations:	Freshwater Habitats Trust, Game & Wildlife Conservation Trust, Environment Agency
Partners:	Syngenta, Environment Agency, Chemicals Regulation Directorate, Defra, Anglian Water, Oxford Brookes University, University of Sheffield, University of York, Welland Rivers Partnership, Welland Rivers Trust
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2. Location and catchment description

Catchment summary	
National Grid Reference:	Centre of the project area: SK 745 055
Town, County, Country:	Tilton-on-the-Hill, Leicestershire, UK
Regional Flood and Coastal Committee (RFCC) region:	Anglian Northern Regional Flood and Coastal Committee
Catchment name(s) and size (km^2):	Eye Brook (10.8km^2), Stonton Brook (7.7km^2), Barkby Brook (9.2km^2)
River name(s) and typology:	Eye Brook, Stonton Brook, Barkby Brook
Water Framework Directive water body reference:	Eye Brook: study area includes part of GB105031050550; most of the water bodies in the project are not designated as Water Framework Directive water bodies. Stonton Brook: none of the waterbodies in the catchment are Water Framework Directive classified but the running water network drains into GB105031050460. Barkby Brook: the study area includes part of GB104028047440 (Syston Brook); most of the water bodies in the project are not designated as Water Framework Directive waterbodies.
Land use, soil type, geology, mean annual rainfall:	Lowland East Midlands on clay dominated soils – see Biggs et al. (2014, 2016) for full details

3. Background summary of the catchment

Socioeconomic/historic context

The freshwaters in the project area are typical of lowland England agricultural landscapes with heavy clay dominated soils. The area is roughly 40% under-drained arable farmland, 40% grassland, 10% woodland, and 10% urban and buildings. The area is mainly Defra Land Class 5 (eutrophic tills) and Land Class 6 (pre-Quaternary clays) which, together, comprise about 35% of the rural land in Britain. The project is linked to the

Game and Wildlife Conservation Trust Allerton Project, which has run a research and demonstration farm nearby at Loddington since 1992, providing an opportunity for linking relevant experimental plot and field scale research to this landscape scale project and demonstrating the results to ~3,000 visitors per year through ongoing Knowledge Exchange activities. There are also research and demonstration links to Countryside Stewardship Funding through the Stonton catchment and with Defra's Sustainable Intensification research platform (SIP).

Flood risk problem(s)

The project was not designed to tackle a specific flooding problem. Rather it was established to assess the potential for multiple benefits of holding back water in rural landscapes to reduce flood peaks and downstream flood risk. To that end, catchment modelling and observations of water retention measures are currently being linked to Environment Agency standard flood risk models on the lower parts of the Welland catchment.

Other environmental problems

The area suffers from the typical water pollution problems seen in lowland England. Some 90% of the water bodies (ponds, streams, ditches) are affected by biologically damaging levels of nutrient pollution. Streams draining arable land are affected by metaldehyde and other pesticides at levels above statutory limits for drinking water supply (Figure 1).

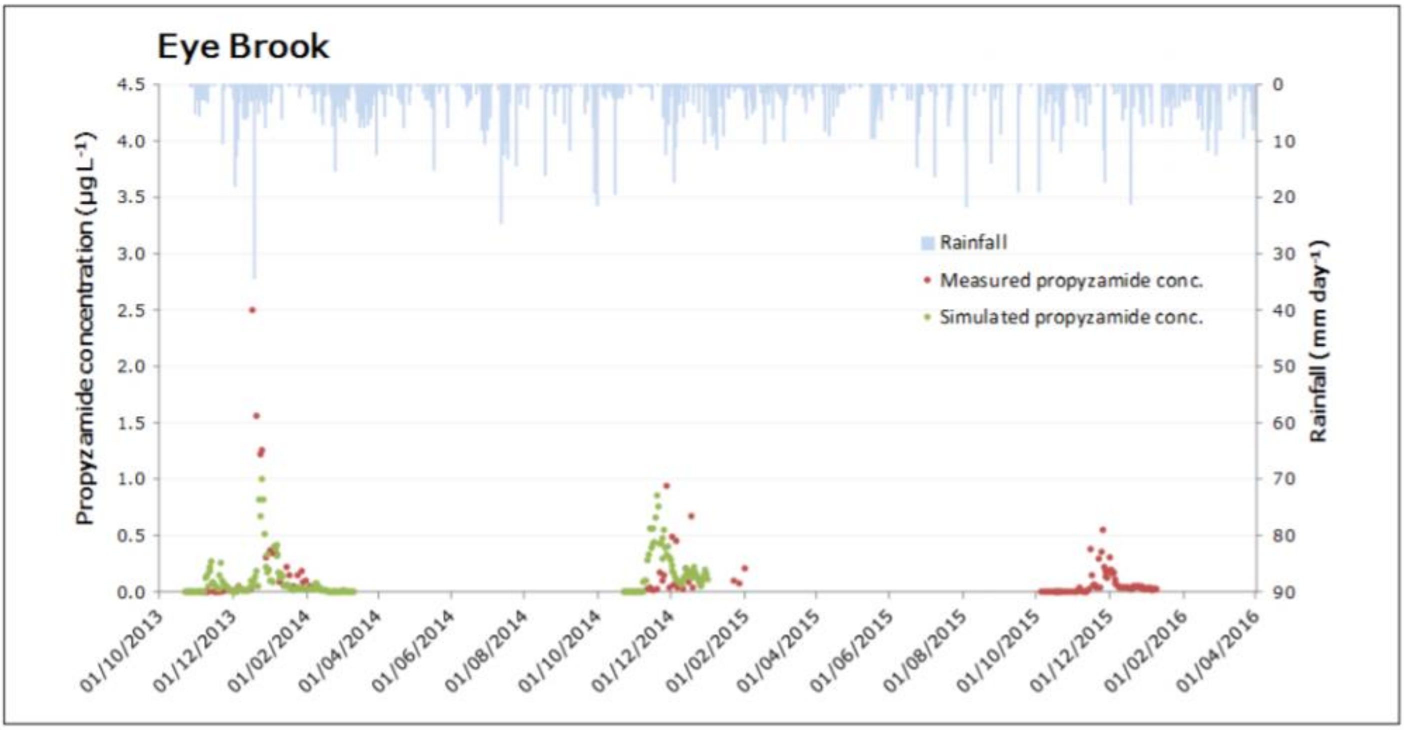

Figure 9: Measured concentrations of propyzamide (red dots) at the outlet of the Eye Brook catchment for 2013/14 to 2015/16 and comparison with simulations (green dots) with the catchment model SWAT (2013/14 to 2014/15). There were no applications of propyzamide in 2012/13 due to exceptionally wet conditions and consequent crop failure.

Figure 1: Measured concentrations of propyzamide (red dots) at the outlet of the Eye Brook catchment (source: Biggs et al. 2016)

There are very substantial pulses of sediment and phosphorus transported from the land into freshwater during storms in the project area. Each catchment has a rural sewage works which causes substantial phosphorus pollution. The study area has few protected freshwater species: low density great crested newt and common toad populations occur. Otters are seen in the area and may breed. Bullheads are widespread in the study area and one catchment (Eye Brook) has a small wild brown trout population. Some stream lengths are high status for freshwater invertebrates. There are no abstractions in the project area. About 10% of water bodies (ponds, streams, ditches) in the study area have nutrient levels that are close to natural background levels (that is, equivalent to Water Framework Directive high status). Within the study area, as is typical of lowland Britain, ponds support the largest number of freshwater species, followed by streams and ditches (Figures 2 and 3).

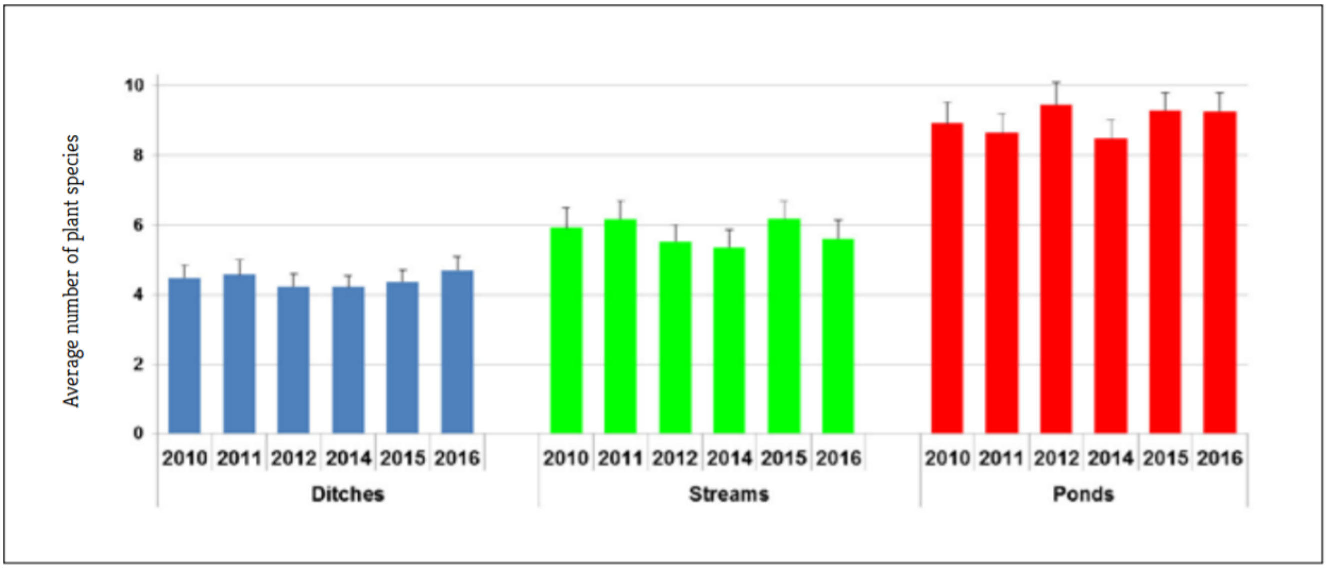

Figure 2: Comparative biodiversity of 3 freshwater habitat types found in the project area (source: Biggs et al. 2016, Figure 14)

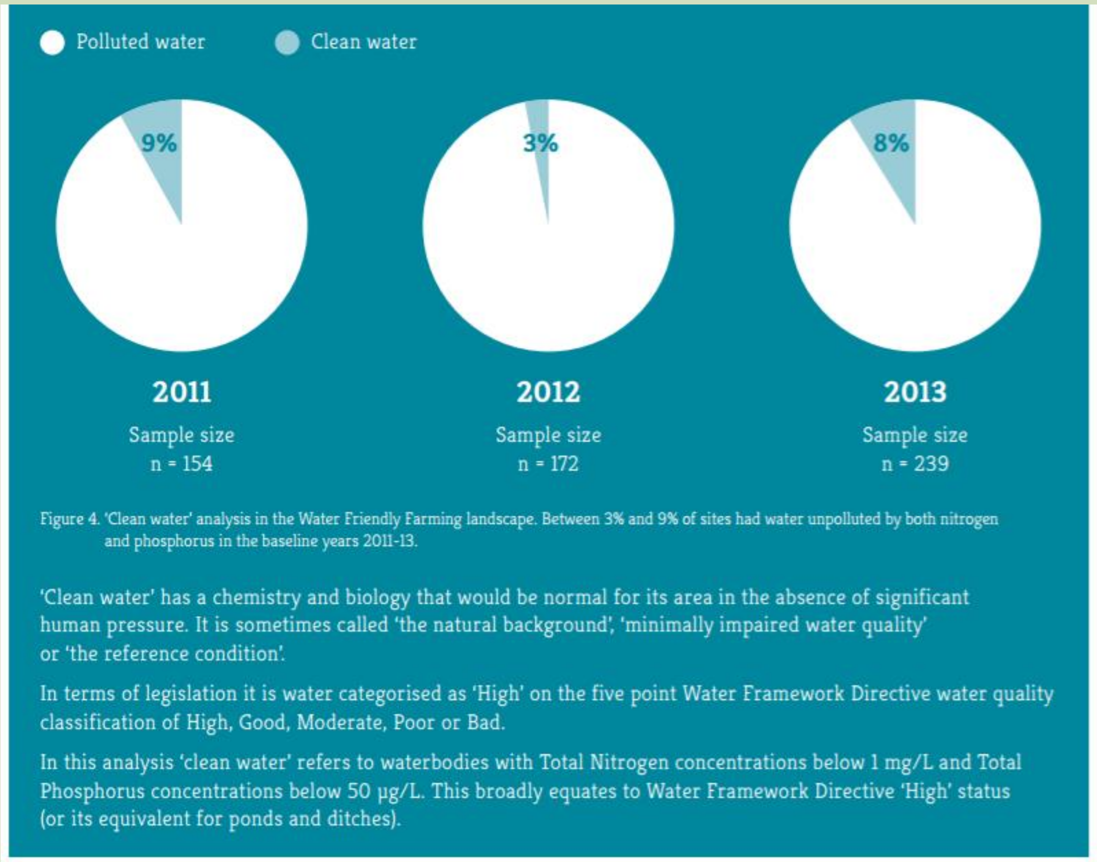

Figure 3: Proportion of ponds, streams and ditches in the project area with clean water in the baseline survey years (source: Biggs et al. 2016)

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

Understanding of the nature of the Water Friendly Farming project catchments comes from a range of observed and modelled information that has been used to define the water quality, flow and freshwater biodiversity problems of the landscape. In terms of landscape level freshwater biodiversity and water quality, the study area is now one of the best understood in Europe providing a good platform for understanding the benefits of natural land management measures. In terms of floods and flows, the landscape is typical of the lowland, flashy, landscapes of England which have the capacity to generate floods during any prolonged period of wet weather.

Generally, people have been happy to explore the concept of Working with Natural Processes (WWNP) in the study area because the project is concerned with testing the effects of land management to increase our understanding of the strengths and weaknesses of the approach. An important condition of the voluntary and participatory approach with landowners has been that the work must not impinge on the profitability of the farm businesses working in this landscape. The project explore synergies between flood risk and farm business objectives, especially in terms of soil management.

The project is concerned with obtaining evidence of the benefits of rural land management measures for bringing about benefits in the water environment. The ultimate aim of the project is therefore to provide qualitative and quantitative evidence of the benefits to enable people to be confident of the level of effectiveness of the measures achieved.

What was the design rationale?

The projects design rationale was to evaluate the overall effect at a landscape scale of measures generally believed to be beneficial for water retention, pollution control and freshwater biodiversity, and to assess whether a catchment-wide response could be detected. The focus has been on testing the overall, combined, benefit of installing measures and changing farming practices as widely and fully as possible in a working landscape and evaluating the overall combined effect of these measures. Flow control measures have been designed, using landscape models, to store specific amounts of water. Other features (bunded ditches, interception ponds, reed bed wetlands, clean water ponds) have used standard designs developed in other projects, typically using the partners' experience from earlier water management research projects.

Methods of working with farmers to support improvements in soil management that improve water retention and reduce sedimentation of downstream drainage channels are also being explored.

At present there are no traditional flood engineering elements to the project such as dredging, channel widening/deepening and engineered storage reservoirs.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	Two experimental catchments each of about $10km^2$ A third catchment has had no measures added and functions as a fully monitored control.
Types of measures/interventions used (Working with Natural Processes and traditional):	Permeable dams Field edge wetlands Support for improved soil management No traditional engineered flood control structures have been added to the catchments.
Numbers of measures/interventions used (Working with Natural Processes and traditional):	About 100 in each catchment covering all objectives of the project

	In the Eye Brook, following initial evaluation of storage constructed, a network of a further 20–30 permeable dams is being added over a 10km^2 area to control flows.
Standard of protection for project as a whole:	No attempt is being made to achieve a specific level of flood protection. Rather the objective is to assess the overall effect of land management measures (including changes to cultivation) on flows at different return period frequencies. The outputs of this work are being linked to Environment Agency flood models to evaluate the contribution of land management to standards of protection.
Estimated number of properties protected:	Not applicable – this project is not attempting to protect specific properties

How effective has the project been?

Modelling shows that a landscape-wide installation of semi-permeable dams will reduce the 1 in 100 flood peak by about 20%.

The first round of measures installed in 2014 added about 3,000m^3 of storage to each of the 2 catchments where experimental manipulations are being undertaken. Modelling showed that this has a very small and insignificant, effect on peak flows and indicated that about 10 times this amount of storage would be needed to have a useful effect on flood peaks. A network of permeable dams is now being installed across the Eye Brook landscape based on modelled designs in order to create the amount of flood storage modelling suggests is needed.

Modelling of sediment loss with models calibrated using real sediment data indicates that existing buffer strips have reduced sediment loss by about 30%. These models indicate that hypothetical complete afforestation of the catchments would reduce total sediment loads by 50%, this being the theoretical baseline sediment load of the streams.

The project area does not have any properties at risk of flooding. However, it was not an objective of the project to tackle specific flood problems; rather it was intended to evaluate the benefits of the approach in a typical lowland landscape like many of those where flooding is experienced.

5. Project construction

How were individual measures constructed?

Individual measures are generally quite small-scale and have principally been constructed by local contractors working as single excavator drivers, or in 1–2 person teams for smaller manual jobs.

How long were measures designed to last?

The measures are expected to last 10–20 years.

Were there any landowner or legal requirements which needed consideration?

All the measures were installed on private land and permission to install followed individual negotiations with the farmers and landowners.

The water bodies are not main river and flood defence consents were obtained from Leicestershire County Council.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed:	Overall, the project started in 2010 and is ongoing at least until 2020. The first phase of practical measures were installed from 2014 onwards. Having completed baseline characterisation in the period 2010 to 2013, measures are now being added progressively to the landscape. After the baseline monitoring stage, add any measures thought appropriate can be added and their cumulative benefits compared with the baseline conditions. For example, additional measures to hold back water are being added during 2016 to 2017 and can be compared with the baseline condition by a combination of real-world observation and modelling.
How was the project funded:	The project has been funded mainly by: • Syngenta (supported one full-time equivalent research staff post for ~4 years) • Catchment Restoration Fund • Environment Agency Water Framework Directive funds • RFCC • cash and in-kind contributions from all the project partners
Total cash cost of project (£):	The total cost of the project up from 2010 to 2020 is so far ~£2 million. The main part of the cost has been monitoring the effect of the project works. Installation of all measures (including negotiation with landowners) has involved ~20% of the total project cost.
Overall cost and cost breakdown for WWNP/NFM measures (£):	The overall cost of the WWNP/NFM measures across the landscape is about £200,000. Specifically for flood control the costs of design of measures have been dominated by modelling costs, which are around £30,000 for the catchments. Individual measures are very low tech and each cost in the range £500 to 2000, with the exception of more expensive individual items such as refitting a reed bed sewage treatment works. No significant annual maintenance has so far be undertaken.
WWNP/NFM costs as a % of overall project costs:	~20%
Unit breakdown of costs for WWNP/NFM measures:	The total expenditure of the project is best calculated per square kilometre as the project is concerned with managing the landscape and all water bodies in the landscape, rather than simply river length. On this basis the costs are approximately £5,000 per km^2. Note that this does not take account of agri-scheme payments for buffer strips and other measures which individual landowners may be applying.
Cost–benefit ratio (and timescale in years over which it has been estimated):	No attempt has been made to establish cost–benefit ratios, as the main objective of the project so far has been to focus all resources on establishing whether measures are

	effective at a landscape scale. Once it is clearer which measures work and which one's do not, then cost-effectiveness will be assessed.

7. Wider benefits

What wider benefits has the project achieved?

Creation of clean water ponds, off-line, across the catchments has increased overall aquatic plant species richness at the landscape level (that is, more species of aquatic plants have been found in the study landscapes in the first 3 years after the project than before). This is one of the first demonstrations of a large-scale biological response to land management measures in farmland.

Modelling work suggests that buffer strips already installed in the project areas as a result of agri-environment schemes have reduced sediment loss by about 30%.

Intensive monitoring of nutrients and sediments suggests that water quality is mainly driven by prevailing climatic conditions and sewage works pollution, rather than scheme activities. Since the establishment of the water chemistry baseline in 2012, phosphorus levels have generally increased and nitrogen levels modestly decreased, both probably as a result of drier weather in the latter half of the project. Sediment levels have shown no consistent trends.

Improved soil and crop management may have benefits for terrestrial as well as aquatic biodiversity and other water-related objectives.

The project is not specifically concerned with climate regulation, air quality, access to green space, aesthetic values, cultural activities or property values.

How much habitat has been created, improved or restored?

Monitoring is in progress to assess whether running water habitats that are classified under Water Framework Directive have improved. Funding is being sought to analyse archived River Invertebrate Prediction and Classification System (RIVPACS) invertebrate samples to undertake this analysis.

Around 20 new clean water ponds have been created in the Stonton Brook catchment (where the benefit of clean water, off-line, pond creation is being specifically evaluated), which are likely to be Priority Habitats. This work has roughly doubled pond density in the project area and has been responsible for increasing aquatic plant diversity across the landscape. Note that the area of habitat created is not being used to assess the value of small water body creation as this underestimates the significance of the habitats when compared with naturally more extensive habitat types (grasslands, fens, bogs).

Creation of new ponds may contribute to increasing the population of great crested newt (that is, measures contributing to Habitats Directive or Birds Directive to help meet Water Framework Directive requirements), but there is no monitoring data available to confirm this. However, there is direct evidence from other parts of the country, using eDNA monitoring, that creation of new clean water ponds provides new breeding habitat for great crested newts.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

Maintenance will be carried out as needed. At present the project team is still learning how much maintenance is actually needed to maintain the features installed and so has not yet established a formal management scheme.

Is the project being monitored?

Yes. A major objective of the project is to evaluate the effectiveness of land management measures for flow management, water quality improvement and freshwater biodiversity enhancement/protection.

Has adaptive management been needed?

Some minor repairs have been made following storm damage in 2012 to 2013 but, at present, most features have functioned as intended.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

Positive learning points

- It is likely that semi-permeable dams will be able to store sufficient water to reduce the 1 in 100 flood peak. On completion of the project, a detailed understanding will have been obtained of how this affects normal flood risk management operations in the Environment Agency's Anglian Region.
- There has been a rapid positive response in terms of freshwater biodiversity at a landscape level. This appears to support the partners' general view that, despite their small size, new clean water ponds have a major role to play in protecting freshwater biodiversity at a landscape level. This is because (a) ponds support more species than other freshwater habitats at a landscape scale, including many that also use running waters, and (b) ponds are a good way of providing clean water in landscapes where pollution is all pervasive and difficult to reduce meaningfully.
- The project is beginning to help calibrate the expectations from land management measures in protecting the water environment. It confirms the overwhelming impact of rural sewage works on nutrient levels, the scarcity of any type of clean water in rural landscapes, the difficulty of dealing with pesticides (except by product substitution) and the likely benefits of buffer strips.
- The project shows that it is possible to evaluate the whole water environment at landscape level, not just the traditionally monitored running water network, and to explore synergies with farm businesses for land management. This is crucial for the protection of freshwater biodiversity.
- The project shows how modelling can be used practically to address real-world problems of water quality as well as the widely recognised value of models for flow management.
- The project also puts in perspective the effects of climate compared with the measures being taken. Overall, the work provides a clear demonstration of the role of land -use in the condition of freshwater habitats.

Negative learning points

- The partners do not really see evidence-based learning as negative. Rather they see evidence of measures that 'fail' as being at least as important as the superficially 'positive' results that confirm what they hoped would happen.

10. Bibliography

BIGGS, J., STOATE, C., WILLIAMS, P., BROWN, C., CASEY, A., DAVIES, S., GRIJALVO DIEGO, I., HAWCZAK, A., KIZUKA, T., MCGOFF, E. AND SZCZUR, J., 2014. *Water Friendly Farming: Results and practical implications of the first 3 years of the programme*. Fordingbridge, Hampshire, and Oxford: Freshwater Habitats Trust and Game & Wildlife Conservation Trust.

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Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.