# Water Innovation Network EIP

## INITIAL FEASIBILITY STUDY

DR. LINDSAY EASSON

ALAN KEYS MBE

PROF. JIM MCADAM OBE

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# 1 Introduction

This report is from the Water Innovation Network (WIN) – European Innovation Partnership (EIP).

WIN is a group of farmers from the Ballinderry catchment and experts in agriculture, water quality and innovation. The group is led by Ballinderry Rivers Trust with the support of an Innovation Broker. For this phase of work the Innovation Broker is Helen Keys, for the next phase of work the Innovation Broker is Ciaran McKay.

The mission is defined:

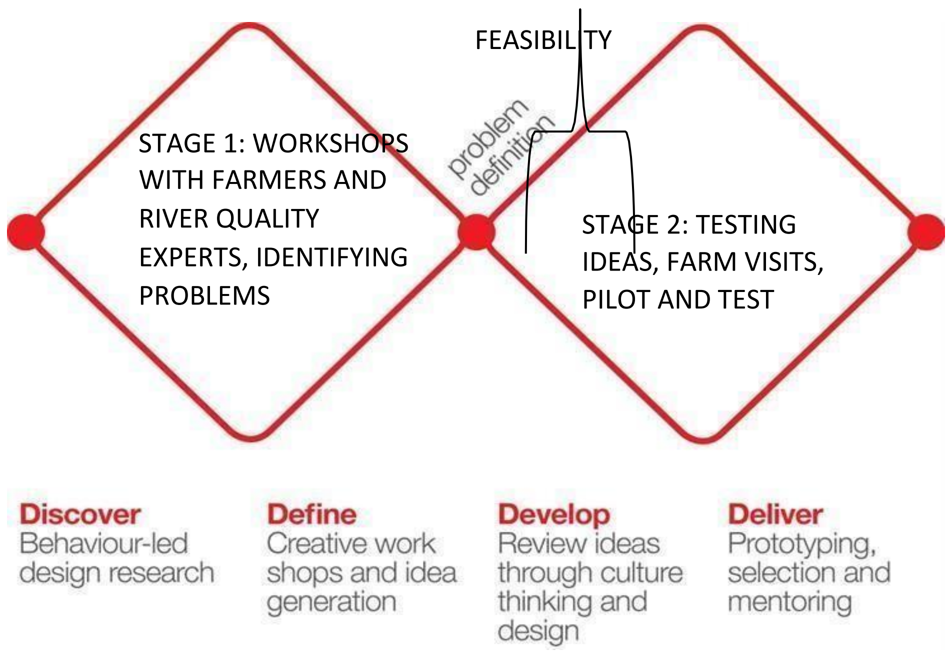
> “We are seeking WIN WIN solutions - innovative ways to make farms more productive, profitable or efficient that also protect and improve water quality.”

The Operational Group is following a design- thinking approach to achieve innovative solutions.

At Stage 1 of the programme the group worked through the first stages – making a long list of the problems , exploring the root causes and what needed to change. They brainstormed ideas and came up with some potential innovative solutions.

In this first phase of Stage 2, the task is to explore the long list of ideas – assess feasibility and design trials that can be set up in the next phase of work.

The diagram below shows where this report fits in the overall programme.



# 2 Method – what we did

## 2.1 Appointment of Expert sub-contractor consortium

This phase of work required:

- An understanding of soil, crops and land management
- Experience in setting up, managing and reporting on trials
- Knowledge of the catchment area and the farms in the catchment that might impact water quality
- A working knowledge of farms and the challenges faced by farmers
- Expertise in water quality and how to manage water on farms
- Technical expertise around water sensors and control systems

The Innovation Broker identified a team of three experts who between them could cover all of these areas.

**Table 1: Team of Experts**

| Dr. Lindsay Easson | Alan Keys | Prof. Jim McAdam |
|---|---|---|
|  |  |  |
| Background: Led the agronomy research programme at the Agricultural Research Institute of Northern Ireland, later AFBI, 1977 to 2005, and then led the Environment and Renewable Energy Centre programme there 2006 to 2012. | Background: Founder of Ballinderry Rivers Trust (formerly BREA), worked extensively with farms throughout the catchment to identify root causes of pollution and solutions. Pioneered new water quality improvement measures on farms. | Background: Research career in agri-environment scheme management and monitoring, specialising in upland grasslands and agroforestry systems. Head of the Grassland and Plant Science Branch in AFBI from 2008-2018. Currently is an Hon Professor with QUB, and acts as a facilitator for an EFS (Higher) farmers Group with the Ulster Wildlife Trust. |
| Role: Understanding of crops and land management; constructed wetlands; bioremediation of farm dirty water and of setting up and managing trials. | Role: Identifying suitable farms, liaising with farmers, identifying issues on farms causing damage to the river, designing water management systems. | Role: Knowledge and understanding of peatlands and wetlands, role of trees in farming systems, conducting on-farm trials, local knowledge. |

## 2.2 Meetings and Site visits

The team started with a Kick-Off meeting followed by a short planning meeting to pin down details for the farm visits. Eight farms were involved including pig, dairy, beef, poultry and arable. The farms involved operate at varying levels of intensity.

During farm visits the team identified specific challenges on each farm and matched these with potential innovative solutions. Some farms had more significant challenges in managing water than others. The potential schemes put forward represented a wide variation in both scale and types of proposed solutions.

TABLE 2: MEETING ACTIVITY AND SITE VISITS

| Date | Purpose |
|---|---|
| 08/12/21 | Kick off meeting Zoom |
| 19/01/21 | Planning meeting – agreeing which farms and when. |
| 06/02/21 | Farm Visit: Farm 1 |
| 10/02/21 | Farm Visits: Farm 2, Farm 3 |
| 17/2/21 | Farm Visits: Farm 4, Farm 5 |
| 20/2/21 | Farm Visits: Farm 6, Farm 7, Farm 8 |
| 25/2/21 | Design workshop 1 – walk through each farm identifying problems and potential solutions – see working doc 'Long List' on google drive |
| 9/3/21 | Design workshop 2 – discussion around resources required for each project, potential costs – see working doc 'Long List' on google drive |
| 10/3/21 | Operation Group Meeting – presentation from the expert team on potential projects |
| 19/3/21 | Hatchery and site visits: Discussing the potential for a joint project producing algae for fish food and phosphate alginate beads. |
| 29/3/21 | Meeting Chris Johnston to discuss willow planting and algae projects |
| 7/5/21 | Visit potential local wetland plant producer |
| 7/5/21 | Revisit Farm 1 with Scheme architect and farmer to agree swale layout |
| 10/5/21 | Revisit Farm 1 to measure peat depth and calculate carbon budget to rate options. |
| 11/5/21 | Costing options discussion. |
| 21/5/21 | Revisit Farm 1 to agree revised plan for works |
| 24/5/21 | Farm 2 visit to agree revised plan for works |
| 28/5/21 | Delivering troughs for raised beds to farm 3 |
| 8/6/21 | Planning- Farm 4 |
| 11/6/21 | Planning – Farm 2 |
| 14/6/21 | Planning - Farm 2 |

## 2.3 Wider consultation and research

At this exploratory stage it was important to broker in as much expertise as possible to avoid 'reinventing the wheel'. The range of options being proposed were discussed with people who have a wide range of experience at both a practical and scientific level.

Michael Costello – Horticulturalist

Alan McKeown – Aquaculture and Wasabi grower

Andrew Thompson – CAFRE Water Quality

Chris Johnston – AFBI

Regenerative Farming Ireland facebook group

Stephane Durand – EIT Food

Michaela Fox – EIT Food

Robert Greer – Contractor

Ian Marshall – QUB

Moira Dean – Institute of Global Food Security

EIP database

Michael Meharg – Lough Neagh Partnership

Simon Grey-Ulster Wildlife Trust

Paul Williams - QUB

Bernard Neeson - Horticulturist

Trevor Hutton - Architect

Kevin McGurk - Surveyor

## 2.4 Planning and costing

The team has worked together to develop a plan for the next piloting stage which can be delivered by the Innovation Broker over the next phase of the project.

This required expertise from a surveyor and a contractor/engineer on the detailed design and costing.

A budget forecast has been prepared although this is likely to change as the project evolves.

This includes a monitoring framework.

# 3 Definition of the problem

## 3.1 Farming impact on water quality

This extract from the Wildfowl and Wetland Trust provides a summary of the different ways that farms impact water quality:

- Nitrates and ammonia: mainly from fertiliser or manures, are extremely soluble and may be lost in runoff, by volatilisation or absorbed into the soil. Within the soil soluble forms of N become part of the nitrogen cycle and can be taken up by growing plants. Some may pass through the soil profile to groundwater or into rivers through drains or subsurface flow, or be lost to the atmosphere as nitrogen gas.

- Phosphorus: is much less soluble and most phosphorus in soils binds tightly to soil particles with only a small proportion available to plants. Where soil particles enter drainage water or are subject to surface run-off they will carry phosphorus with them. This can happen from tramlines, compacted fields and stubbles.

- Sediment: Loss can result from soil erosion and run off from fields under poor livestock or soil management and livestock damage to riverbanks.

- Agrochemicals: including sheep dip and crop protection pesticides lost through drain flow or soil run off, or from overspray and drift. The Environment Agency (EA) advocates treatment of pesticide washings using a biobed or biofilter.

- Microbial pathogens: faecal indicator organisms from manure can be washed into surface waters by rain, or deposition where livestock have direct access to watercourses.

At the start of the project we identified this very broad list of problems to be solved – from the perspective of the farmer and from the perspective of the river.

| FARM | RIVER |
|---|---|
| Farmers need to safely store slurry and be able to use it for fertiliser to grow crops but if something goes wrong they can face fines. | We need to stop slurry reaching the river - when it is spread too liberally on fields or worse when a slurry valve is left open or a store fails. |
| Farmers need a low cost way to store grass over the winter that doesn't damage water quality or create recycling charges / waste | We need to prevent silage effluent and plastic silage wrap from reaching the water |
| Farmers need to protect their soil against erosion to maintain their carbon stocks, and long term productivity - this means less ploughing, protecting river banks. | We need to stop soil and silt getting into the river |
| Farmers need to find the right balance in the use of fertiliser, pesticides and herbicides to maintain productivity but protect the long term health of the soil. | We need to stop pesticides, herbicides and fertiliser getting into the river to protect water quality |
| Farmers need to collect, store, heat/cool, move and dispose of water to feed to animals, clean buildings and equipment, water crops, and mix with slurry. | We need to manage how water is removed and returned to the river to prevent fish being taken up and slurry and other pollutants getting in. |
| Farmers need to find ways to get value out of the waterways | We need farmers to want to look after the river and know how to do it. |
| Farmers need to develop their business without creating more ammonia | We need to stop ammonia (from the air and from animal waste) reaching the water because it kills wildlife |

## 3.2 Identifying the issues at each farm

Through the farm visits and additional design workshops the project team homed in on the specific issues at each farm which included:-

- Farmyard dirty water running off the yards and into neighbouring watercourses and fields and making its way to the river.
- Clean water becoming mixed with dirty water around the farmyard increasing the volume of contaminated water getting to the river. Causes of this were: uncovered silage pits, broken guttering, intermittent fresh-water springs arising around the farmyard and fields.
- Roof runoff from all poultry and pig buildings likely to be contaminated with minerals was not being captured in the farm dirty water in all cases but being treated as clean water.
- Inability of schemes to cope with intermittent high rainfall periods
- High costs of remediation – there are well tested remediation measures available to farmers to prevent pollution; Integrated Constructed Wetlands (ICW's), riparian buffer zones and soil erosion techniques are all proven to work but have not been widely adopted despite the availability of grants through the Environmental Farming Scheme. The loss of productive land, the burden of paperwork associated with grants, the high costs of creating constructed wetland ponds and the high cost of planting out have all prevented uptake.
- Unproductive land – most of the farms had areas of poorly drained, boggy land which are difficult to cultivate and hard to make productive.
- A history of high phosphate levels in farm soils resulting from high fertilizer use and imported livestock diets and associated manures, was identified in some cases which was likely to be contributing to particulate runoff into water courses.
- Carefully selecting the siting of remediation options to give the best environmental outputs for the farm as a whole.

# 4 Potential Solutions

## 4.1 Dealing with Farmyard Dirty Water (FDW)

**Construction of Swales and incorporation of existing wetland areas**

Some of the participating farms had already investigated the creation of Integrated Constructed Wetlands as a means of dealing with waste water. The cost of construction and plants (estimated at about £120,000) and the loss of productive land have stopped them from proceeding.

On the farm visits it was noted that there are areas on the farms which are already unproductive as they are wet, boggy areas sometimes cut-over peatlands and often having a heavy rush cover.

It was initially considered that a low-cost system of swales (broad shallow ditches) could be used to transfer water from the yard to these 'unconstructed' wetland areas. Dirty farm water, already partly cleaned during its passage along the swales, would enter and pass through the wetland area, being further cleaned before entering the river.

This would reduce the loss of productive land near the farmyard and the swales themselves could improve the water on the way to the wetland. Both the plots between the swales and the wetland area could be planted with harvestable bioremediating plants (see next section).

Image courtesy of the DEFRA website

*Swales are effective in improving water quality of runoff, by removing sediment and particulate pollutants. In wet swales, the effectiveness is further enhanced by providing permanent wetland conditions on the base of the swale. (Mackenzie, 2015)*

Four farms were identified which each had FDW to deal with:

1: Dairy Farm

2: Beef Farm

3: Poultry Farm

4: Pig Farm

The team worked closely with the farmers and brought in external expertise from a surveyor and engineer. The use of swales was considered appropriate for each farm. Different locations and swale designs were proposed and reviewed for each farm.

The following Design Guidance is provided by the EU Commission Natural Water Remediation Measures Group.

*'Generally, swales are most efficient, and easier to construct and maintain, if the channel is trapezoidal or parabolic in shape, with shallow sides (between 1 in 3 and 1 in 4), shallow depths (no greater than 600mm) and a shallow gradient (between 1 in 100 and 1 in 300). This promotes lower velocities and increases the wetted perimeter, which in turn minimises erosion, promotes filtration and enhances safety. The base of a swale should be flat and 0.5-2m wide. (CIRIA, 2007)*

*If the natural longitudinal slope is more than 2 in 100, it is possible to use check dams in order to divide the swale into several segments, to reduce velocities and optimise storage volumes.*

*A minimum length of 30m is recommended by CIRIA (2007) to maximise water quality benefits, although it is recognised that this may be constrained by the site (i.e. a site length of less than 30m should not necessarily preclude the use of swales).' (Natural Water Remediation Measures)*

The main factors considered for location and layout of the swales were:

1. The preferences of the landowner and fit with their operations.
2. Avoiding negative environmental impact e.g. by replacing recovering peatland or valuable biodiversity habitat.
3. Avoiding any potential links or spillover into open drains or pipes which lead to the river.
4. Ease of access for maintenance.
5. Minimising the use of productive land.
6. The cost of creating the swales.
7. Shape and layout of interswale plots for optimum nutrient uptake and easier cultivation and harvest

    - 2.5m or greater to allow access for a mower
    - buried pipes to carry water between swales

TABLE 3: COSTS AND BENEFITS OF SWALES

| Costs | Benefits |
|---|---|
| Construction of swales £22 per metre - length of swales to be constructed vary between 200 and 366m. | Slow and store run-off - 52-65% (SNIFFER ) |
| Overall costs including pipework ranging from £5,000 to £20,000 - compared to the quoted cost for a constructed wetland of £120,000 | Reduce erosion |
| | Open and visible so pollution can be spotted |
| | Filtration of pollutants |
| | Land remains in production and eligible for SFP |
| | Creation of wildlife habitat |

## 4.2 Incorporation of planted areas of selected willow varieties for the bio-remediation of farm dirty waters

Scientific studies carried by AFBI and others in the last 20 years have demonstrated that willow stands can be used to receive dirty water from water treatment works *(Use of Short Rotation Coppice -SRC- willow for the bioremediation of effluents and leachates, EU 2014)* and from a farm *(SRC Willow as a bioremediation medium for a dairy farm effluent with high pollution potential, Biomass and Bioenergy, Vol 105, 2017)* by irrigation and to clean the water so that it is sufficiently clean to enter a watercourse. One trial conducted by AFBI on a 5 hectare plot over 5 years demonstrated that it provided effective remediation for up to 22 $m^3$ of FDW per hectare. In addition the coppiced willows can be harvested every two or three years as a commercial crop thus giving a return from the use of this land. Even during the winter when no growth is occurring the root zone remains active so that there is a remedial effect on the water.

In several of the schemes being proposed there is therefore a planted willow strip area which can enable a further ‘polishing’ of water which has already passed through a system of swales.

TABLE 4: COSTS AND BENEFITS OF WILLOW FOR BIOREMEDIATION

| Costs | Benefits |
|---|---|
| £600 per acre to establish | Reduced erosion<br>Flood prevention<br>Filtration of pollutants - Bioremediation capacity: $9m^3$ per acre<br>Increased biodiversity compared to pasture or arable crops<br>Supporting pollinators in late winter |

## 4.3 Generating a return

It is proposed that we will trial 3 areas of Miscanthus, willow and nettles as productive bioremediation crops. These crops have been identified as they are low maintenance, provide wildlife habitat, sequester carbon and have viable end uses. Currently they are not considered as mainstream planting and their use in this scenario can be considered novel and innovative. They can be planted and harvested using available agricultural equipment.

### 4.3.1 Willow

As already identified, Short Rotation Coppice (SRC) willow has been well demonstrated as a fast growing crop providing effective bioremediation. The willow will grow rapidly in the first year reaching up to 4m in height. During the winter after planting the stems are cut back to ground level to encourage the growth of multiple stems i.e. coppiced. Generally three years after cutback and again during the winter, the crop is harvested and continues to regrow. Willow is well established as an energy crop and a local farm has facilities to harvest and dry willow from these trials.

TABLE 5: COSTS AND BENEFITS OF WILLOW FOR HARVESTING

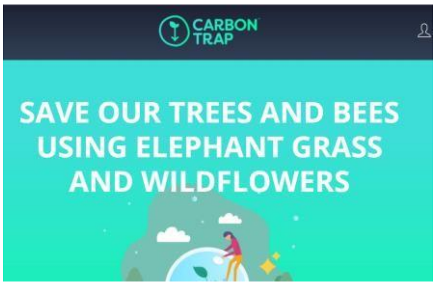
| **Costs** | **Benefits** |
|---|---|
| **Willow** (Based on TEAGASC Best Practice Guide, 2011)<br>Site preparation £80/acre<br>Machine Planting £120/acre<br>Cuttings £485<br>Chemicals £32 | **Willow:** for biomass 4t per acre £15/t[1] with harvesting included up to £250/acre [2]<br>Carbon sequestration: 4 tonnes per acre<br>Potential income streams from any new farm payment systems linked to carbon or carbon trading systems. |

[1] Based on quote from local willow harvester

[2] Scottish Government Rural and Environment Analytical Services - Report on the commercial viability of SRC willow

### 4.3.2 Miscanthus

Miscanthus is a perennial grass crop which grows up to 3m tall. It has been the subject of research as a crop and biomass fuel by AFBI as a field crop by CAFRE for use as biomass fuel. As a perennial crop it can produce annual yields of well over 10 tonnes per hectare without the application of fertilizers while also accumulating a substantial mass of rhizomes in the soil *(Performance of Miscanthus established with plastic mulch and grown from a range of rhizomes sizes and densities in a cool temperate climate, Field Crops Research Vol. 210, 2017)*. As well as a biomass crop miscanthus has other potential end products such as animal bedding or compost. It is propagated from rhizomes. It needs to be established for 2 years before it can be harvested when it is driest in April / May. It is a low maintenance crop that doesn't require additional inputs. As a plant with a C4 photosynthesis pathway, it shows higher irradiation conversion efficiency than C3 plants (e.g. Wheat) and has a more efficient use of nitrogen and water.




Miscanthus has been successfully trialled as a replacement for Rockwool in soil-less growing systems for tomatoes and cucumbers and subsequently used as solid fuel with no loss in quality. (RalfPudea, 2018) Miscanthus is also being promoted by companies selling carbon subscriptions see www.carbontrap.org A local compost company which is actively seeking peat free alternatives is testing miscanthus as a compost material which could provide a route to market.

TABLE 6: COSTS AND BENEFITS OF MISCANTHUS

| Costs | Benefits |
|---|---|
| **Miscanthus** (Costs based on Teagasc growing guide): per acre<br>Rhizomes £780<br>Planting £75<br>Cultivation £75<br>Opportunity cost £81 | **Miscanthus:** 5-7t per acre, Teagasc estimate a profit of £140 per acre for the energy market - there is potential in other markets such as compost:<br>Grow cubes £35 for 90L, compost £300 per tonne, animal bedding £200 per tonne (not including processing) Soil erosion logs - £200 per tonne<br>Carbon Sequestration: 8.8 tonnes per H after 12 years<br>Potential income streams from any new farm payment systems linked to carbon or carbon trading systems. |

### 4.3.3 Novel crops

## Nettles

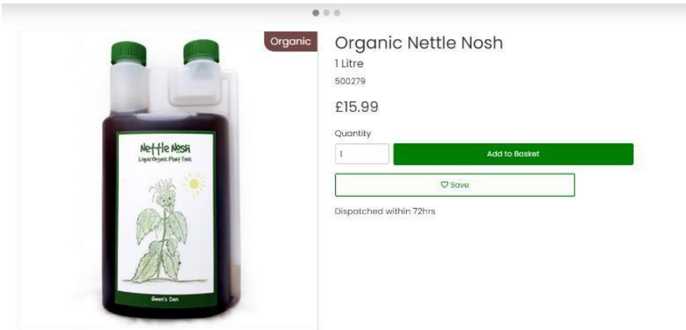

Most farmers in Northern Ireland will know that nettles grow easily in our soils and climate, they absorb nitrates, phosphates and heavy metals from the soil. They are increasingly being used to make organic liquid fertiliser, for food and fibre for textile.

Local business Noreen's Nettles from Aghalee have developed a product range based on nettles including Nettle powder, Nettle tea and Hair and scalp tonic.

This represents a potential outlet for harvested nettles.

## Nettles and Comfrey for fertiliser

Both nettles and comfrey may provide bioremediation when planted along or between swales as they have long roots and absorb nutrient, some research also suggests their use to remove heavy metals from the soil.




Harvested nettles and comfrey could be used to make fertiliser using a very simple process. Nettle fertiliser is currently marketed at £15.99 per litre.

*'Comfrey has very deep roots, which means it extracts large quantities of nutrients from far below the soil's surface, inaccessible to other plants. These nutrients are stored in its leaves. By harvesting the leaves and letting them break down, you'll have a rich, dark, nutrient-rich plant food to use around the garden. It's especially rich in potassium, making it the ideal feed to promote flowers and fruits in a range of plants, including* tomatoes*.' Gardeners World*

*'Great for folia growth and generally improving plant health. It has an added bonus of assisting in the germination of hard seeds, which will benefit from soaking in neat Nettle Nosh overnight. You can also add to your compost bin to speed up the decomposition process.'*

# Nettles for textiles

Textile companies Mallon Linen and Mourne Textiles are also researching the potential for processing nettle fibre for textile in Northern Ireland.

A large scale UK project called STING led by De Montford investigated the potential for nettle textiles, the end product is a nettle wool blend which is in commercial production by Camira in Huddersfield - billed as their most sustainable textile.

The Nettle sock yarn in the photo is marketed for £4.58 for 50g.


| **Costs** | **Benefits** |
|---|---|
| Plants £780<br>Planting £75<br>Cultivation £75<br>Opportunity cost £81 | Carbon sequestration Nettle: 1.3 tonnes per H<br>Biodiversity and wildlife habitat<br>Nettle: 6t per hectare, fertiliser: £75 for 20L made from 2kg of nettles (allow £2 a L for storage and packaging) fibre for textile: £950 per t for scutched fibre (benchmarked against sisal fibre)<br>Potential income streams from any new farm payment systems linked to carbon or carbon trading systems. |

### 4.3.4 Soil Saving Logs

Coir logs are commonly used as a measure to stabilise banks, prevent soil erosion and facilitate peatland restoration. Coir is a fibre produced from coconuts and the “logs” are most commonly manufactured in India and imported to the UK. A 3m long coir roll with stakes costs £52.40/roll, a 1m long coir roll with stakes costs £22.40/roll.

When the logs are planted up with wetland plants the price increases to £100 for a 3m length.

The proposal is to manufacture similar logs using local material like rushes, miscanthus or hemp. Biodegradable netting is readily available, more commonly used for Christmas trees. These can be used by Ballinderry Rivers Trust and by Ulster Wildlife Trust for conservation work.

The logs will be made in 2 sizes 30cm and 50cm and in 1m and 3m lengths. The overall cost to manufacture is estimated in the table below.

TABLE 7: COSTS & INCOME FROM LOGS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total weight kg | 1550 | | | | | | |
| Cost per kilo | 1.57 | | | | | | |
| COSTS | | | | | | | |
| 30cmx 1m | £4.72 | 60 | £283.35 | 50cmx1m | £11.54 | 60 | £692.65 |
| 30cmx 3m | £14.17 | 30 | £425.03 | 50cmx3m | £34.63 | 30 | £1,038.97 |
| | | | | | | Cost | £2,440.00 |
| BENEFITS | | | | | | | |
| 30cmx 1m | £15.00 | 60 | £900.00 | 50cmx1m | £22.00 | 60 | £1,320.00 |
| 30cmx 3m | £40.00 | 30 | £1,200.00 | 50cmx3m | £55.00 | 30 | £1,650.00 |
| | | | | | | Income | £5,070.00 |
| | | | | | | GP | £2,630.00 |

If they prove effective they can be made available to other bodies at a competitive rate and much lower carbon footprint.

Scaling up to sales of 150 of each 1m sausage and 50 of each 3m sausage yields an estimated gross profit of £7,860.

PHOTO 7 SALIX PRODUCTS PLANTED WITH WETLAND PLANTS

TABLE 8: COSTS AND BENEFITS OF SOIL EROSION LOGS

<table>
<tr><th>Costs</th><th>Benefits</th></tr>
<tr><td rowspan="8">Based on producing<br>60 no 30cm x 1m weighing 3kg<br>30 no 30cm x 3m weighing 9kg<br>60 no 50cm x 1m weighing 7.3kg<br>30 no 50cm x 3m weighing 22kg<br><br>Set up costs<br>Wrapper funnels in 2 sizes £360<br>Production costs<br>Biodegradable netting £300 for 4km<br>Purchase of miscanthus, hemp £400 incl transport<br>Storage £600<br>Labour £600</td><td>Managing rushes on local farms</td></tr>
<tr><td>Processed using commonly available agricultural equipment</td></tr>
<tr><td>Soil stabilisation and preventing sediment reaching the river</td></tr>
<tr><td>Biodiversity and wildlife habitat – farmers more likely to keep rushy areas, BRT manage mowing during the summer when nesting birds are away.</td></tr>
<tr><td>Improved riparian buffers – better remediation impact</td></tr>
<tr><td>Cost saving on supplies for BRT</td></tr>
<tr><td>Potential income from sale of logs £7,860 per year</td></tr>
<tr><td>Potential income streams from any new farm payment systems linked to carbon or carbon trading systems.</td></tr>
</table>

## 4.4 Productive riparian buffers and tree planting

Many options for crops that could grow in riparian buffer zones were considered - fruit or nut trees, trees for timber, berries on low bushes, flax, mushrooms on logs. The factors that were taken into account were:

- Is it suitable for growing along river banks?
- Can it be easily harvested from the proposed location?
- Can it prevent erosion?
- Can they absorb nutrients?
- Can it improve wildlife habitat?

The more novel crops presented issues in terms of management and harvesting whilst the more traditional crops could easily be planted by the farmer themselves or under other schemes.

It was decided not to bring this into the scope of this project.

## 4.5 Phosphate remediation from alginate by-product of micro-algae

QUB and EIT Food have been looking at micro-algae as a potential animal feed source for some time. A by – product of the process of growing micro-algae is alginate which can absorb phosphate from FDW and then be used as fertiliser.

QUB staff involved in the project visited the River School and some of the participating farms to investigate the potential for an on farm project which could produce fish food as well as phosphate beads.

As the production process requires laboratory conditions It was decided that an on farm trial was not feasible for this project at this stage

AFBI and QUB are currently submitting a proposal through DAERA to have a test rig based in Hillsborough to produce the biochemical beads (based on Chitosan) and 2 tanks to adsorb and desorb the phosphate.

SPIN OFF PROJECT

The phosphate based solution will then be moved to the Institute of Global Food Security where there are vertical columns that can be used to test different microalgae and feed them on the solution.

The algae solution could then be fed to fish in the hatchery in various concentrations, so there may still be some crossover with this project.

## 4.6 Water Smart Farms – the low-tech way

On each of the participating farms an audit was carried out to investigate where waste water needed to be treated to a higher standard of purity:

- To keep it contained and flowing e.g. prevent dirty water reaching the river, tanks overflowing
- to ensure it was safely contained and running appropriately e.g. through swales, irrigation or to reach animals
- to be able to remotely divert it.

The team worked with Cloud Water Controls to investigate how remote sensor technology could be used in these applications.

Potential sensor locations and diverters were identified as follows:

- on Farm 1 to manage dirty and clean water and separate it when necessary
- on Farm 1 to detect potential for overflow from a lagoon
- on Farm 2 to ensure that crops were irrigated
- on Farm 4 to detect overflowing dirty water and divert it to a tank.

Costs were established for each of these systems but at more than £10,000 per farm it was decided that this would be unlikely to be generally adopted by farms.

The team looked for other ways to solve the same problems, they designed simple systems which can be implemented for a fraction of the cost and provide much the same result.

- On Farms 1 and 2 manual diverter systems can be operated by the farmer. – see Figure 1: MANUAL DIVERTER
- On Farm 1 a diverter chamber can be installed in an existing manhole – see Figure 2: FLOOD RELIEF DIVERTER
- On Farm 4 a submersible pump and float system will automatically divert dirty water when required.

**FIGURE 1: MANUAL DIVERTER**

NOT TO SCALE

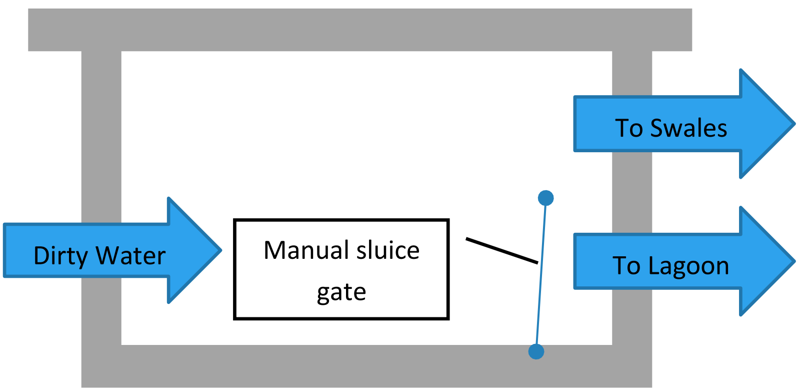
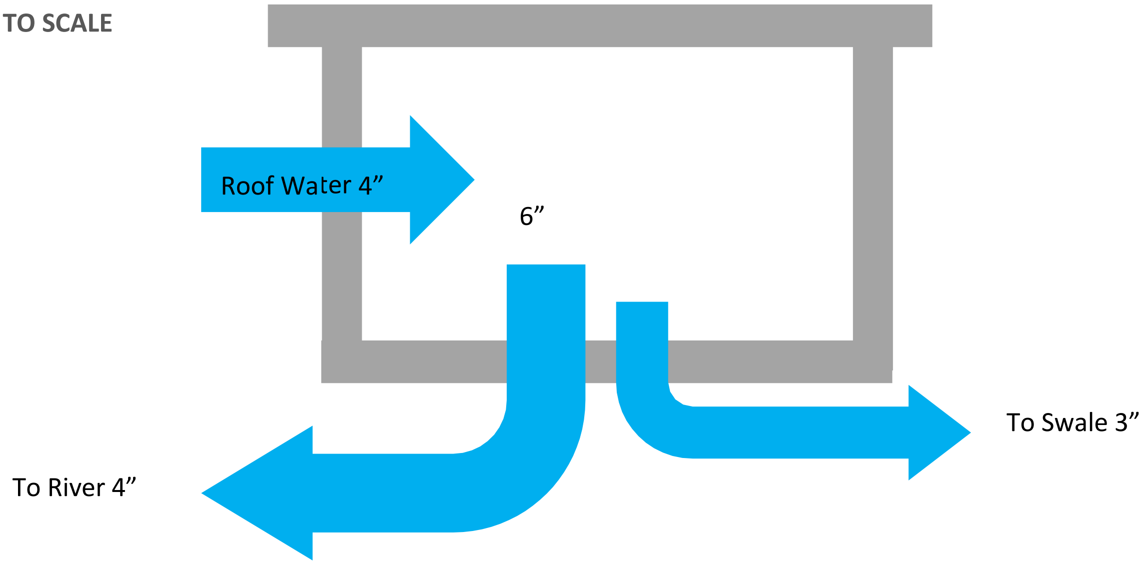


FIGURE 2: FLOOD RELIEF DIVERTER

NOT TO SCALE



## 4.7 Spring -fed local native plant nurseries

The local supply of cost effective native species for planting in wetland areas, riparian buffer zones and agroforestry schemes is likely to improve uptake.

Through the feasibility study, the team has identified a local nursery that is interested in developing a project around this.

The team also identified that a number of the farms visited had natural springs, particular to the groundwater and geology of the area that were not being utilised on the farm.

The team identified that the spring water could be used to keep nursery plants at a constant temperature and propose to set up a pilot project to demonstrate how this natural resource can be used to grow crops.

TABLE 9: COSTS AND BENEFITS OF LOCAL NATIVE PLANT NURSERY

| Costs | | Benefits |
|---|---|---|
| Labour - setting up polytunnel and prep for growing areas | £6,000.00 | Lower cost (in terms of money and carbon footprint) wetland plants and native trees – 30% saving |
| Raised beds for native trees and nettles | £1,500.00 | Locally generated Income and more diverse income for the farmer |
| Springwater supply | £1,000.00 | Lower energy input costs |
| Benching / raised beds | £1,500.00 | Retention of local genetic prevenance of plants produced |
| | | Potential to replicate on other farms with streams |

# 5 PROPOSED ON-FARM PROJECTS

## 5.1 Farm 1

**Issues:** Dairy Farm with large lagoon for slurry and silage effluent. Farm sits on slope down to a tributary of the Ballinderry River. Large unroofed silage pit has effluent catchment to the lagoon, but there is also freshwater springing up in various places around the slurry pit and yards. Some effluent may get into the dirty water system rather than the effluent system. Drainage outflow into the river at times of high rainfall has periodically shown high pollution levels.

Options considered:

a) **Roofing the silo:**

   **Conclusion:** Not within the scope of this project

b) **Diverting all identified sources of dirty yard water to a low point on the ground just below the Lagoon:**

   **Conclusion:** included in the project with some possible Intelligent flow controls/diversions valves for times of high rainfall

c) **Constructing swales running about 500 metres across from the farm to an unconstructed wetland area where it would be naturally filtered before passing through planted willows to the river**

   **Conclusion:** The unconstructed wetland is a former peat moss bog which is now actively re-growing sphagnum moss. Several naturally occurring springs are occurring across this area leading to constant infiltration into the river. This is a valuable carbon capture area with moss peat regeneration and should not be disturbed.

d) **Utilise current grassland area between the farm and the river to construct a series of roughly parallel swales** totalling about 300 meters mostly on a 1 in 180 gradient, water reaching the bottom swale will percolate into a broad band of willows between the swales and the river.

   **Conclusion:** . Feasible option which has been agreed in principle with the farmer and is being costed. Budget should include fencing and addition to peripheral field drain to ensure hydrological isolation of the swales. This is a Nature-Based Solution

e) **Design the system to have potentially harvestable plots in the 2.5m strip between the swales.** In this area plant a series of plots of different plant species(produced by the supported native plant nursery) that can uptake nutrients and possibly be of commercial value.

**Conclusion:** To be included in project with crops such as Nettles, Comfrey and selected grass species in the plots.

f) **Data gathering.** Include options for measuring the flow at various parts of the system over time, arrange periodic sampling of the inflow and outflow water, and measure the yield and composition of crop plots grown on the swales.

**Conclusion:** To be included in some form, depending on the budget available

SPIN OFF PROJECT

**This project requires a significant budget of £21,563.** As this would absorb most of the EIP funds available under this scheme it was agreed to seek funding from NIEA as a separate project.

FIGURE 3: WATER MANAGEMENT ON FARM 1

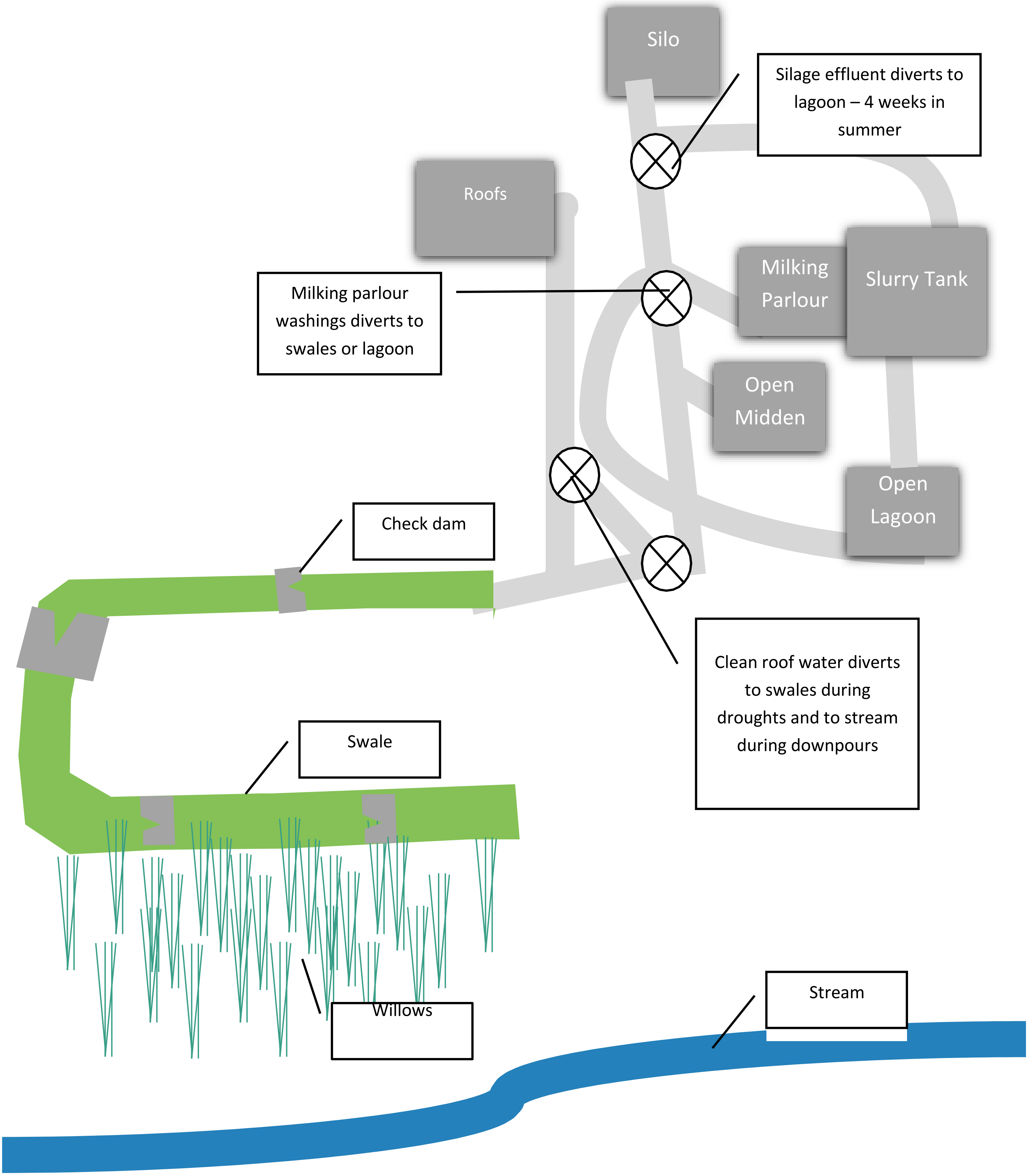
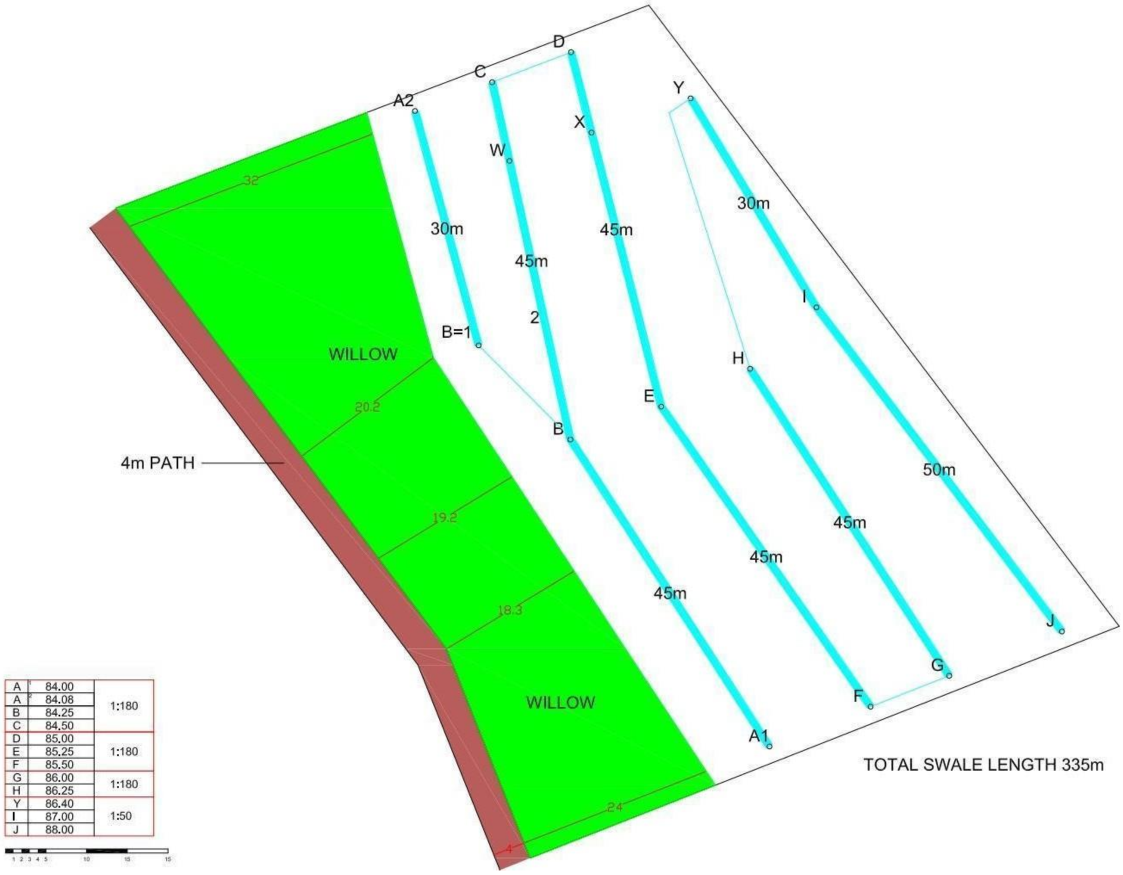


**FIGURE 4: SWALE DESIGN ON FARM 1**




| | | |
|---|---|---|
| A[1] | 84.00 | 1:180 |
| A[2] | 84.08 | |
| B | 84.25 | |
| C | 84.50 | |
| D | 85.00 | 1:180 |
| E | 85.25 | |
| F | 85.50 | |
| G | 86.00 | 1:180 |
| H | 86.25 | |
| Y | 86.40 | 1:50 |
| I | 87.00 | |
| J | 88.00 | |

## 5.2 Farm 2

**Issues:** Beef Farm above land leading down to Ballinderry River. Fresh water is leaking into the covered silage pit and leading to unwanted extra yard runoff. Cattle slurry stored in a lagoon. Dirty yard water passes overground to drain in the public road beside the farm entrance, and then passes through a drain to enter a stream carrying spring water down to the river. In the field before the river is a recently developed swamp with rushes and reeds which has become unproductive as farmland.

Options considered:

a. **Swale system to take FDW away to an unproductive area of land at the bottom of the hill – plant this up with willow and miscanthus.**

   **Conclusion:** When levels were taken it was found that a large part of the area to be planted was actually higher than originally thought and dirty water would never likely reach it or the river.

b. **A system of raised beds growing plants for constructed wetlands or other novel crops.** Whilst the site and access to spring water lent itself to this proposal the ongoing maintenance of the beds was an issue for the farmer who needed a low maintenance solution as he works in a full time job as well as the farm.

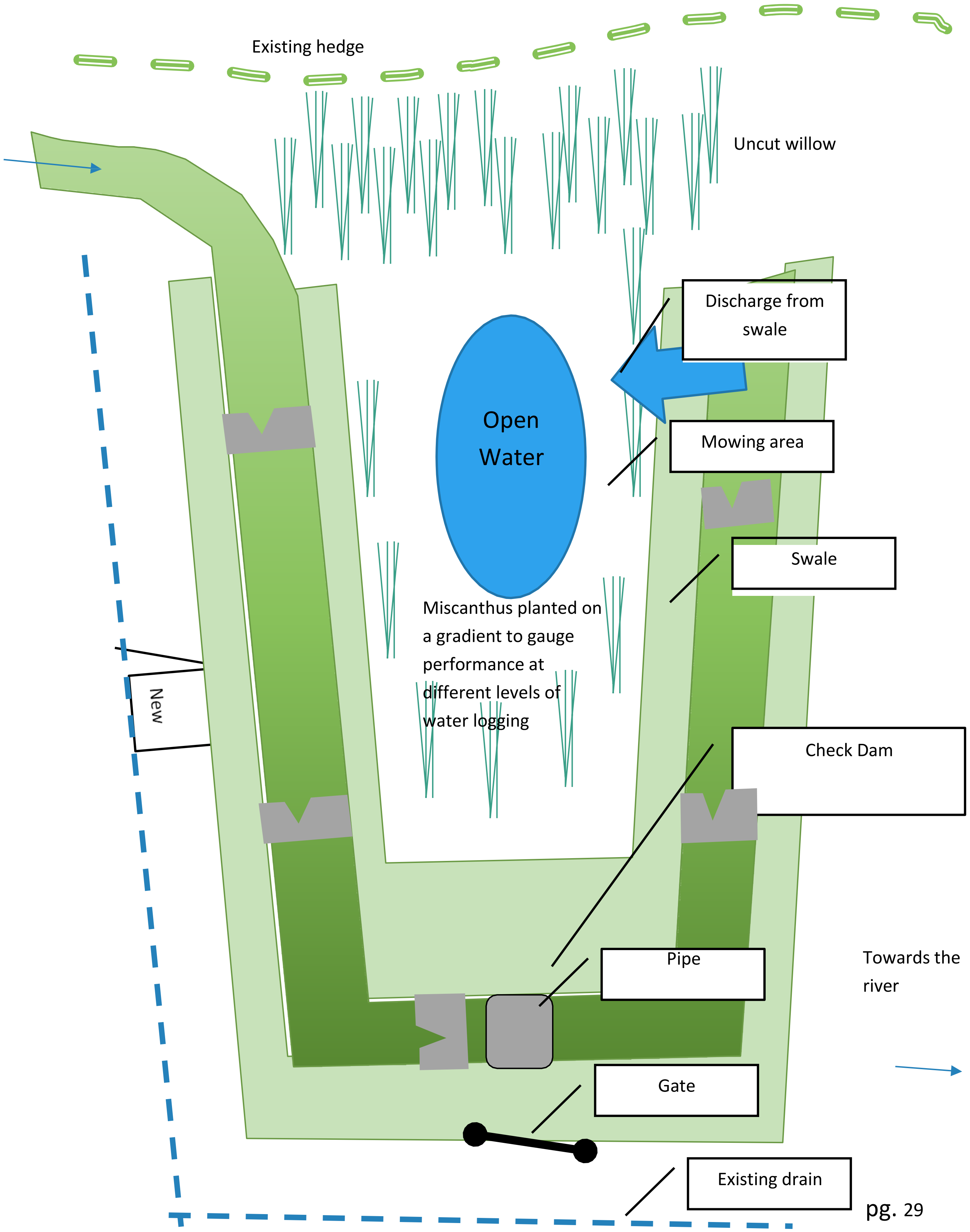
   **Conclusion:** It was decided to look for a different location for growing the plants where the farmer was interested in developing this business.

c. **Smaller swale system making use of existing unproductive land.**

   The diagram on the next page shows the proposed smaller swale system which is low maintenance, uses the lowest amount of productive land and can be accessed for mowing.

FIGURE 5: SWALE DESIGN ON FARM 2

NOT TO SCALE



## 5.3 Farm 3

**Issues:** Poultry farm on land which has cereal growing land which has been shown to have a very high phosphate content. Spring water arising around the farm flows into a stream going down from the farm to the river and passing by, but not entering, an amenity pond area which the farmer has constructed. There are two poultry houses and a run-off area where the hens can free-range. The roof water from the houses is treated as farm dirty water.

Options considered:

a. **Buffer strip along the stream.** Planting a riparian buffer strip of trees and/or plants alongside the stream which is adjacent to an arable field rich in P. This stream is enriched with P as a result of run off from the field.

   **Conclusion-** This is a low cost, effective method of slowing the flow of runoff over the land. The landowner suggested planting trees in this buffer strip. Ciaran, Alan and Jim were unsure if a buffer strip of trees alone would be sufficient to uptake the high level of nutrient runoff from this field. It was agreed the buffer strip would consist of a mix of trees and nutrient hungry plants like nettles or comfrey, which have a proven ability to uptake nutrients.

b. **Passing dirty water and spring water through raised beds.** The roof water from the poultry houses is considered dirty water, but is only lightly contaminated. It is thought this, along with the spring water on the farm, can be used to grow crops with a high commercial value, like lettuce and other vegetables, in a series of raised beds.

   **Conclusion-** Water levels were taken and it was found possible to pass the spring water and dirty water through a series of raised beds before it enters the stream behind the raised bed area. Ballinderry Rivers Trust has suitable troughs which can be used as raised beds. The farmer is interested in trialling this. A perspex roof is to be put over the troughs to protect the crops within from the weather. There is potential to grow crops year round using the spring water which is at $9^{o}$C all year.

c. **Create a single swale from the already present open drain/stream.** By planting up the banks and installing a check dam into the stream which carries the spring water we can conveniently create a single swale to remove any remaining nutrient from the field runoff and water which has passed through the raised beds system.

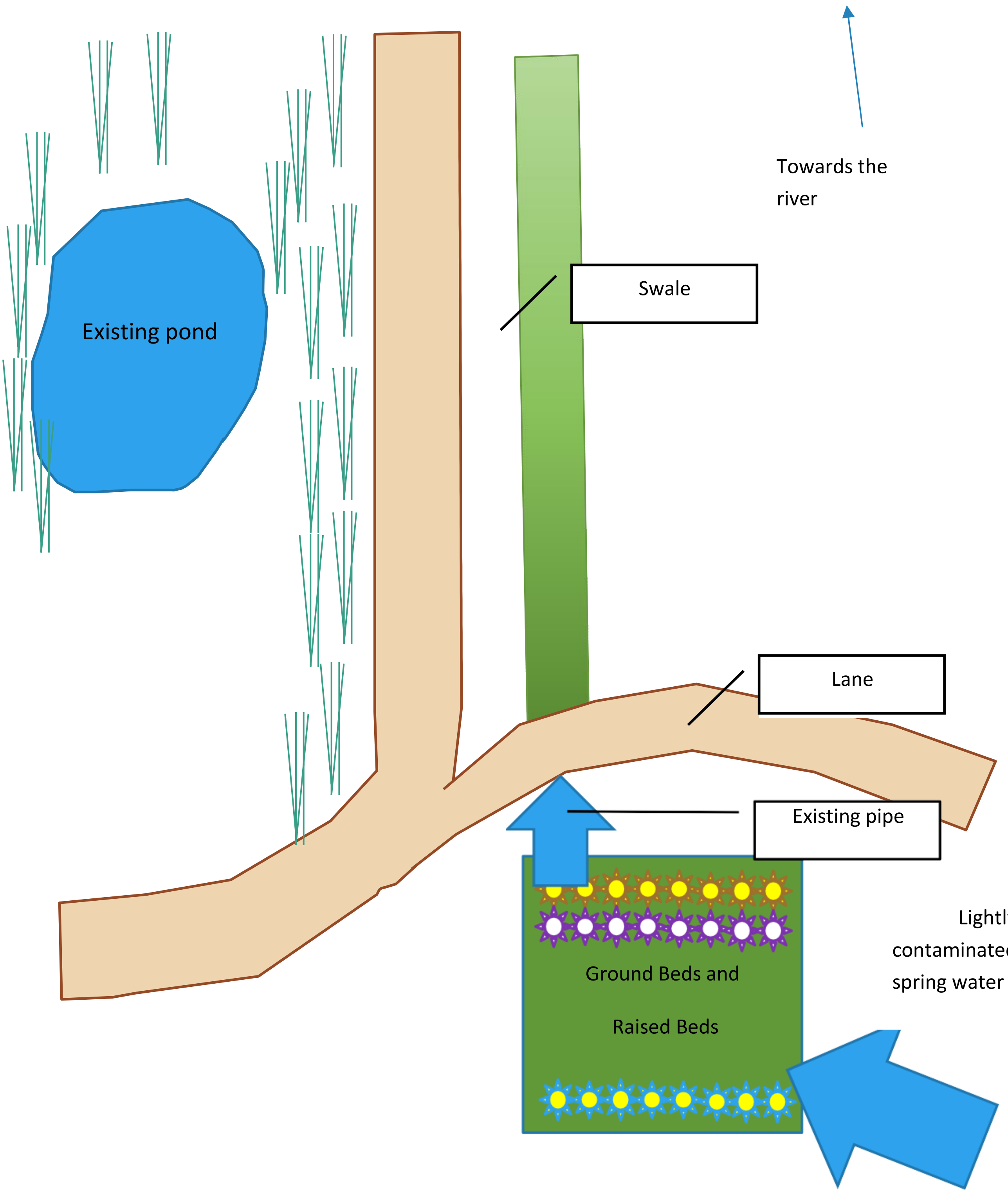
   **Conclusion-** This is a low cost measure which will further improve the potential for nutrient uptake in the system. Check dams will slow the flow of water, allowing sediment to settle out. For these reasons we have decided to do this.

d. **Plant wetland plants in and around the pond.** Initially this was proposed to uptake any nutrients which may enter the pond from the dirty water or field run off.

   **Conclusion-** It was concluded this measure is not necessary as the stream does not enter the pond and the other measures which are to be put in place should effectively remove any nutrient from the water. The land owner instead proposed planting trees around the pond for aesthetic appeal and habitat creation.

FIGURE 6: SWALE DESIGN ON FARM 3

NOT TO SCALE



## 5.4 Farm 4

**Issues:** Pig Farm in which the yard receives runoff from nearby field which can also reach a sump area used when pumping pig slurry into a slurry tank. Runoff from the year goes into a field causing it to become saturated. Not all pig house roof runoff is separated from clean water.

Options considered:

a. **Automated pump in sump with level sensor.** To prevent the sump overflowing during high rainfall events it was proposed to install an automated pump with a level sensor, which pumps the contents of the sump into the adjacent slurry store. This removes the need for the farmer to manually turn on the pump.

   **Conclusion-** This measure was found to be beyond budget and not cost effective. It was unrealistic to install this system on farm, nor was it replicable on other farms. Upon a site visit the contractor identified an alternative, more cost effective system. An automatic pump operated by a float valve. This measure is as effective, but also replicable on other farms as it is more affordable. It was agreed this measure would be included in the project.

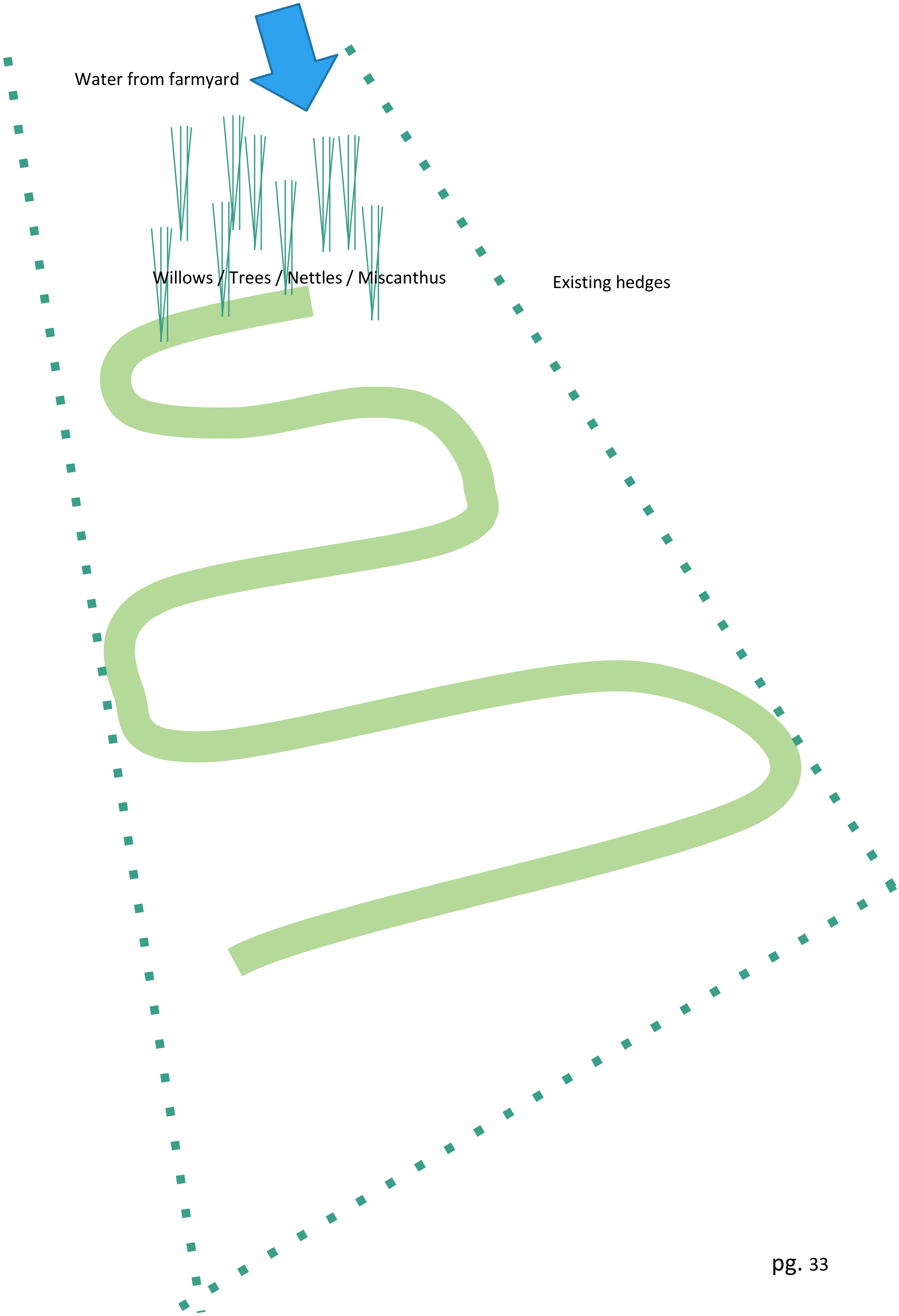
b. **Collection channel across the yard.** Install a concrete collection channel across the yard to collect yard run off to reduce the volume entering the sump.

   **Conclusion-** This measure will be a part of the project. The water collected is classified as dirty water so will be passed through the water management system.

c. **Piping water from the farmyard across the road to an area of unproductive land.** Gathering the dirty water from the farmyard and diverting it to a field across the road into a system of swales, nettles and willows. This field was identified as the most suitable area for the water management system as it is the least productive land on the farm. Initially it was proposed to start the system at the top of the field, passing the dirty water through 3 separate areas of nettles, then swales then willow. This was found to be excessive as the area in the field currently affected by dirty water was only 0.25ac, yet the system was going to take up 1.5ac. Plus, the problem will be drastically reduced when the sump pump is installed.

   **Conclusion-** The landowner proposed starting the system further down the field. This reduces the size of the system, while leaving him the better land at the top of the field for grazing. It was also decided to integrate the nettles into the interswale plots as opposed to growing them in a separate area above the swales. The landowner was also interested in habitat creation, so it was decided the area of willow at the end of the system would have a mix of trees to vary the habitat created and enhance biodiversity.

FIGURE 7: SWALE DESIGN ON FARM 4



## 5.5 Farms 5, 6, 7 and 8

Issues: None of these farms had very serious dirty water problems or water management problems. It was found on one farm that a neighbouring Water Treatment Plant was polluting the farmer's land.

Options considered:

a) **Productive riparian buffers** – as discussed previously, it was found that the novel crops investigated were impractical to harvest in the riverside locations and the traditional crops could be easily implemented by the farmers themselves under other schemes.

b) **Willow for waste water treatment -** the team approached AFBI to see if the Waste Water Treatment facility could be brought in under another scheme which would involve planting willow to treat the discharge from the station. After a number of meetings and site visits this scheme has now been approved.

SPIN OFF PROJECT

c) **Novel Crops** – through the process the team researched a number of novel crops that could be trialled on the participant farms – nettles, comfrey, wasabi, vetiver. One of the farms is trialling nettles, comfrey and wasabi on a small scale – this has not been included as a project under this scheme as it wasn't addressing a dirty water problem but it could still be considered a spin off project.

SPIN OFF PROJECT

d) **Spring fed plant nursery** - Farm 5 is run organically, is lightly grazed and managed , on a part-time basis, by the couple who own it. Heritage vegetables are being grown for seed and polytunnels and more uncovered growing beds are planned. Although there were no issues with dirty water here, the owners are keen to become involved in the propogation of specialist wetland plants and native trees. On land, higher than the farm buildings, there is a significant amount of spring water already piped to the side of a lane. It is proposed to pipe the spring water down to the propagation site and carry out trials to grow native wetland plants and trees in spring fed beds.

   If this nursery, based in the catchment area could be developed, it could produce plants for swale bank planting on projects developed on Farms 1, 2 and 3. The nursery can also service plant requirements for spin-off projects on Farms 5-8. The nursery manager has previous experience with compost experimentation and this expertise could be utilised within the project. He has experience landscaping and re-vegetating river banks. An awareness of the importance of using local provenances of crop and stabilisation plants is vital for the ecological integrity and sustainability of the various revegetation options.

## 5.6 Soil Saving Logs

The team consulted with the Rivers Trust, RSPB and UWT to identify the cost, level of use and current source of Coir Logs.

All these organisations use the logs and pay £30 to £60 for them. They are mainly imported from India via a UK based company.

The proposal is to manufacture 180 logs using biodegradable netting manually stuffed with harvested miscanthus, willow and rushes.

They will be made in 4 different sizes as described earlier and will be monitored for their effectiveness – there will be two inspections per year for the life of the project.

The logs will be installed by BRT and UWT at sites throughout the Ballinderry catchment and in other environmentally sensitive locations. They have experience in the siting and use of these soil stabilising and peat restoring products which are seen as a vital Nature Based Solution to underpin climate resilience challenges.

## 5.7 Fibre and fertiliser

The team has identified the potential for making fertiliser from nutrient rich nettles and comfrey which will be grown as part of the project. The process will need to be further researched and the end product tested.

SPIN OFF PROJECT

The potential to make textile from nettle fibre was also explored. One of the participating farms has decided to take both these ideas forward and has applied to Innovate UK for £25,000 to look into the processing and testing of both fertiliser and fibre from nettles.

# 6 Monitoring Framework

TABLE 11: MONITORING FRAMEWORK

| Measure | Method | Frequency |
|---|---|---|
| **Water Quality** | Grab sampling, sent for lab analysis. Measuring- Ammonia, Conductivity, Dissolved oxygen, Nitrates, pH, P (Sol) / Soluble Reactive Phosphate (SRP), Temperature, Suspended solids | Initially every 2 weeks. To be reviewed depending on results. |
| **Biodiversity** | Using the Cool Farm Tool to prepare an audit on each farm | Annual |
| **Carbon Capture** | Using the Cool Farm Tool to prepare an audit on each farm | Annual |
| **Awareness** | Google analytics<br>Social Media Metrics<br>Attendance Numbers | Quarterly collation of data |
| **Improved profits / reduced costs** | Tracking spreadsheet for each farm | |

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Table of Figures



Table of Tables