Project Name:	**The Deel Spatially Targeted Buffers EIP**
Project ID:	**LLOC5027**
Review Period:	**End of project report**
Project Manager:	**Pádraig Fitzgerald**

Project Overview

The challenges associated with achieving good water quality in rivers and streams in poorly draining intensive agricultural catchments may be ameliorated by adopting a more spatially targeted approach to nutrient application buffer zones and biodiversity measures, focusing on flow delivery zones from critical source areas rather than the current 'blanket' approach to these measures. Biodiversity measures such as tree and shrub planting, blocking of drain outlets, creation of mini wetlands, and planting of field drains - when targeted into focused flow delivery zones - should intercept and reduce phosphate and sediment losses from critical source areas to watercourses. The Deel project utilised this innovative approach to the sizing and siting of buffer zones and installation of biodiversity measures to optimise benefits for water quality and aquatic biodiversity.

The project area covered two headwaters in the Deel (Newcastle West) river system, one in Deel (Newcastle West)_020 in County Cork and the second in Deel (Newcastle West)_050 in County Limerick (catchment areas are shown in Appendix I). Both project mini-catchments are situated within the Upper Deel Priority Area for Action (PAA). Assessments previously undertaken by the Local Authority Waters Programme had shown that both areas are impacted by elevated river phosphate levels and excessive sediment deposition on the river bed.

The project utilised EPA tools for identification of focused flow delivery zones and points with greatest risk of phosphate and sediment loss to rivers. Once confirmed at field scale, these were the locations in which suitable biodiversity measures were targeted.

Selection of measures was undertaken in consultation with the individual landowners and included planting in the expanded buffers, installation of a pond and wetland and enhancement of riparian margins with fencing and tree planting.

The work of this project is now complete and outputs are provided in this report. However, the project outcomes of improved water quality and enhanced aquatic and terrestrial biodiversity are expected to continue to develop over time as the biodiversity measures mature in the landscape. As both project catchments are located in the Deel Priority Area for Action, the work of both ASSAP and LAWPRO will continue here through Cycle 3 of the WFD, enabling the longer term benefits of the measures to be assessed up to 2027.

Outline of project objectives

- To demonstrate that appropriate siting and sizing of biodiversity measures in targeted flow delivery zones can effectively intercept phosphate and sediment runoff to watercourses from poorly draining agricultural lands.
- To demonstrate that extending nutrient application buffer zones in flow delivery zones can effectively reduce organic pollutant and phosphate transfers to watercourses from poorly draining agricultural lands.
- To demonstrate that these measures will have significant benefits for aquatic biodiversity by improving water quality; this is in addition to their direct co-benefit for terrestrial biodiversity.

- To demonstrate that targeting of these measures in focused flow delivery zones from critical source areas is a more effective way of managing farm buffers, than the *one size fits all* approach currently in use.
- To further demonstrate the value of these targeted measures in reducing the requirement for channel maintenance, by reducing sediment loss to waters.
- To increase landowner and community knowledge and understanding of water quality and biodiversity and their co-benefits.
- To inform the development of national policy in this field.

Funding

The project was successful in its application for €80,000 euro funding under the 5th EIP call to enhance farm and community biodiversity. Project management responsibilities were undertaken by Pádraig Fitzgerald from Teagasc, and were valued at an additional €18,700 of project management time across the duration of the project.

As outlined in the table below, there was a small underspend on the total budget, however the spend foreseen for measures and implementation, and for administration, were in line with the original budget lines. Expenditure from the contingency budget covered educational materials and water testing equipment.

	Project Budget		Actual Spend
Farmer Payments inc Implementation Costs	€62,000	77.5%	€60,577
Project Administration	€10,000	12.5%	€9,918
Contingency	€8,000	10%	€3,148
	€80,000	100%	€73,644

Administration/Partners

The Operational Group comprised representatives of Ballyhoura Development CLG, ASSAP (Teagasc) and ASSAP (Dairy), LAWPRO, OPW and IFI. Key stakeholders in this project were the farmers in the two catchment areas. The Forestry Service, Limerick City and County Council and Cork County Council were also project stakeholders and the Forest Service was a supporting partner.

Project Outputs

Assessment of KPI baseline

As outlined in the application documents, the project team undertook baseline condition assessment for the following:

- Habitat survey
- Site walk-over survey
- Chemistry sampling
- Biological Assessment
- Sediment assessment/shuffle tests
- Aquatic habitat assessment
- River channel sediment assessments
- RHAT assessment and habitat assessment along stretches

Chemistry Sampling

Baseline river nutrient levels were assessed by a combination of grab sampling and the use of automatic samplers with flow monitoring at the outlet of each mini catchment.

Results are summarised below with detailed results provided in the relevant appendices.

Grab samples were collected in both catchments over seven monitoring rounds:

- 14th October 2021
- 8th December 2021
- 3rd March 2022
- 20th June 2022
- 21st October 2022
- 8th December 2022
- 8th March 2023

The original GANNT chart for the project (Appendix 1) outlined that baseline monitoring would be completed by December 2021. However, due to procurement and seasonal challenges associated with availability of bare rooted trees, on the ground biodiversity measures only commenced on the fall of 2022. The effectiveness of these measures in improving water quality requires planting to become more mature and established, which will take time to achieve. Therefore, all seven grab chemistry sampling rounds are indicative of baseline conditions.

Deel (NCW)_020

Grab sampling was undertaken at three locations in the Deel (NCW)_020 sub-catchment, as shown in the maps in Figure 1.

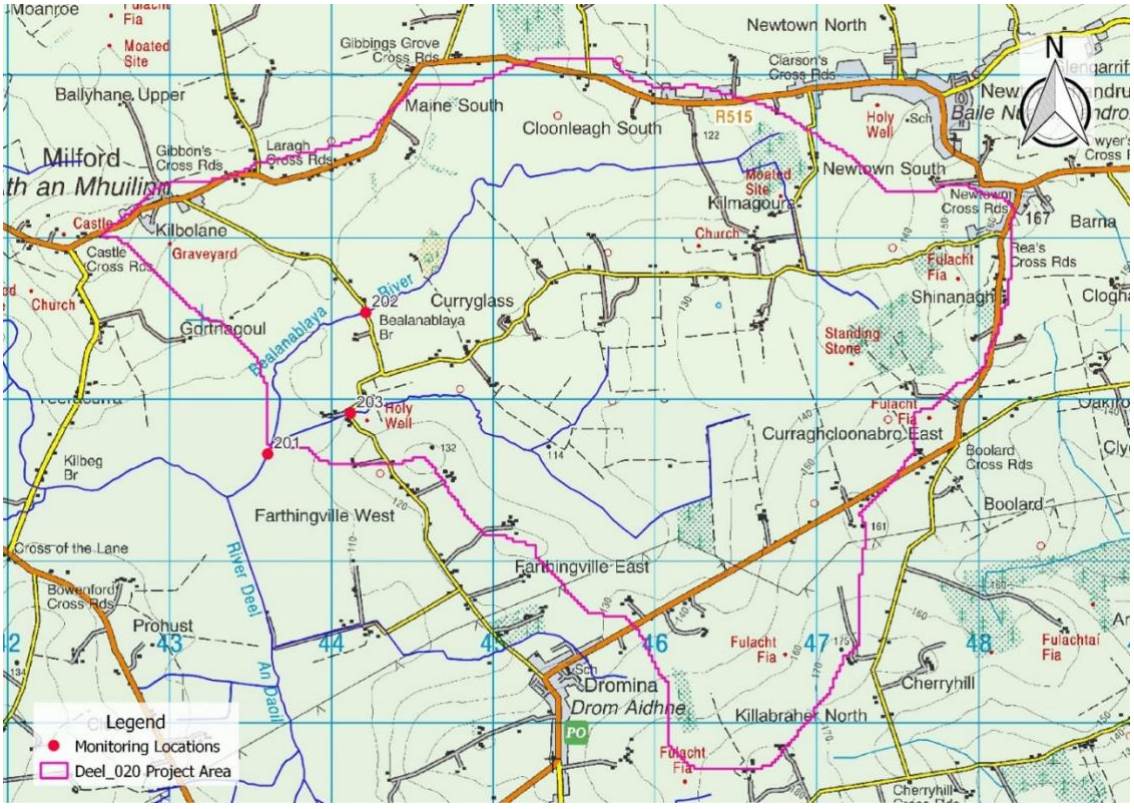

Figure 1: Monitoring sites in the Deel (NCW)_020 sub-catchment.

Baseline ammonium and orthophosphate results over the seven monitoring rounds are graphed below in Figures 2 and 3. Raw data, including pH, conductivity and total nitrogen levels are provided in Appendix II.

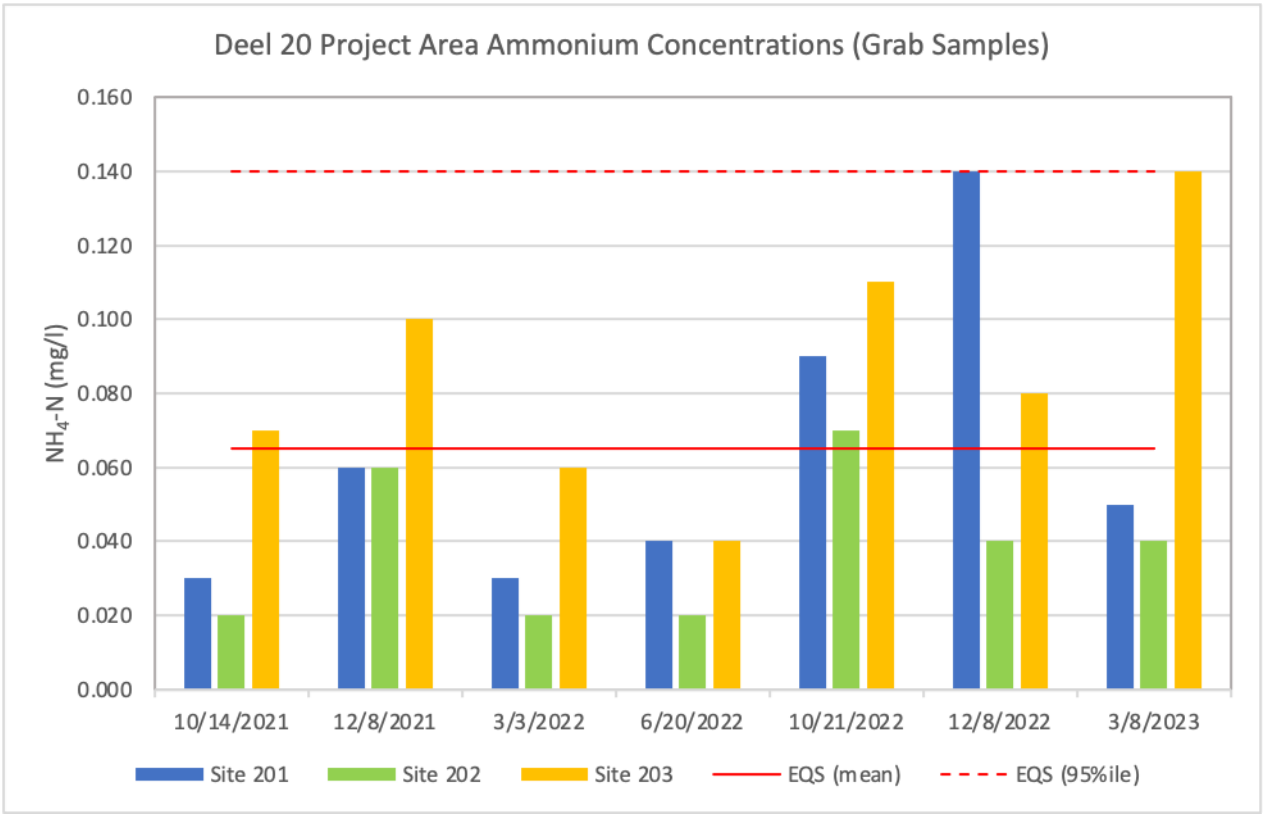

Figure 2: Ammonium concentrations in Deel (NCW)_020 sub-catchment (October '21 – March '23).

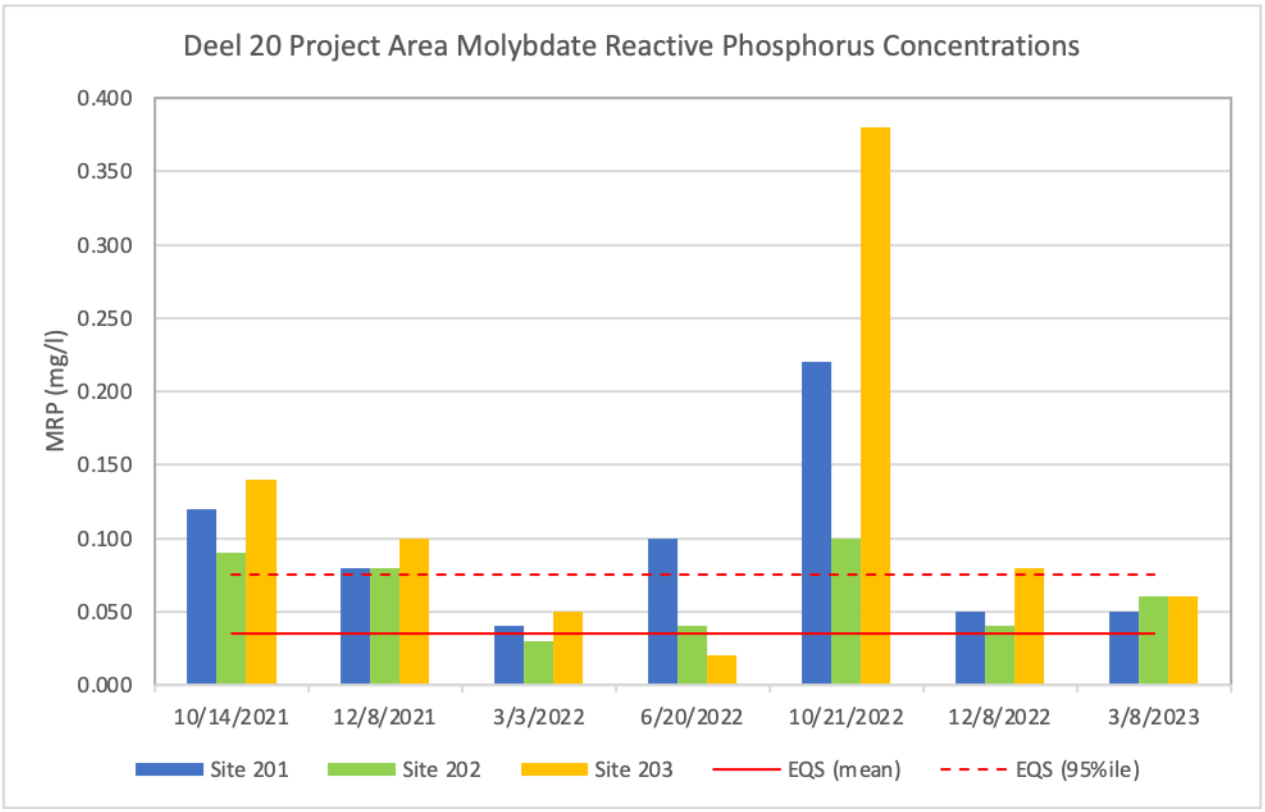

Figure 3: MRP (ortho-phosphate) concentrations in Deel (NCW)_020 sub-catchment (October '21 – March '23).

As Figure 2 shows, at both the outlet station (Site 201) and the northern tributary monitoring station (site 202), baseline ammonium levels were generally below the mean and 95 percentile EQS; the exceptions to this were in October and December 2022. On the southern tributary monitoring location (site 203), ammonium exceeded the mean and 95 percentile EQS during five of the seven monitoring rounds.

As Figure 3 shows, baseline orthophosphate levels exceeded both mean and 95 percentile limits at all stations for three of the four winter sampling rounds. Results improved in the March 2022 sampling round, but the outlet station (Site 201) was elevated again in June 2022.

Deel (NCW)_050

Grab sampling was undertaken at three locations in the Deel (NCW)_050 mini catchment, as shown in the map in figure 4. Raw data is provided in Appendix III and baseline ammonium and orthophosphate levels are graphed below in figures 5 and 6.

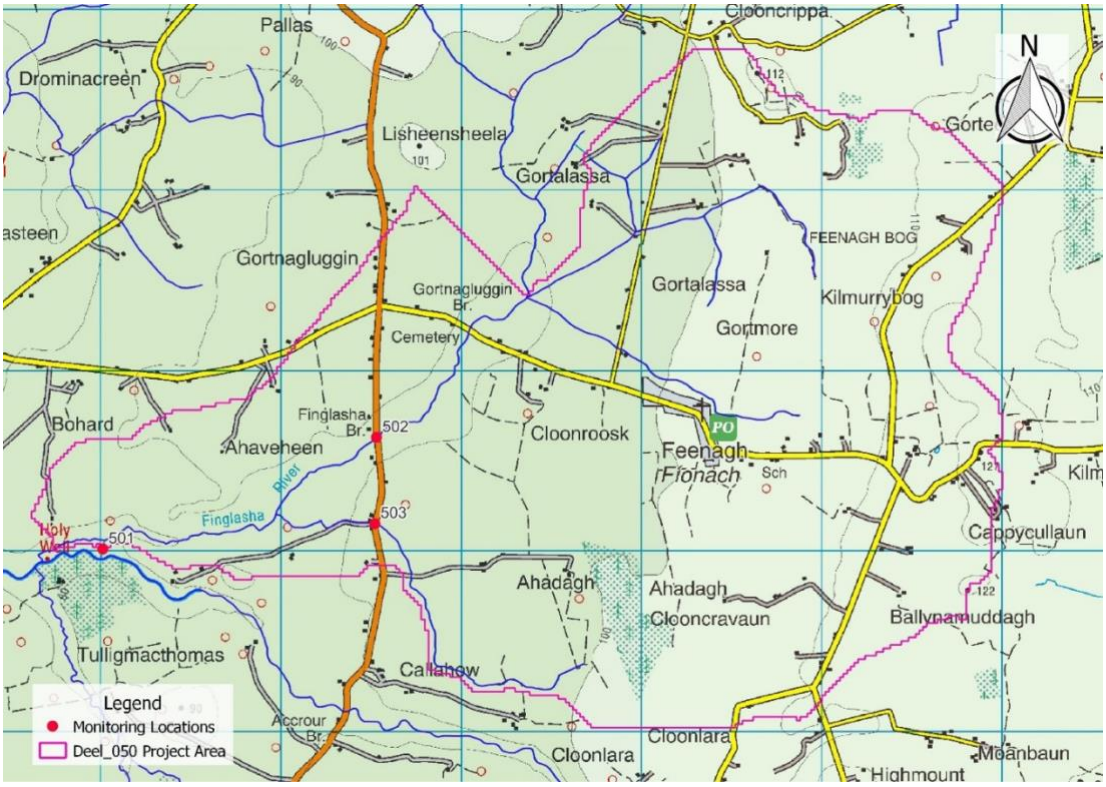

Figure 4: Monitoring sites in the Deel (NCW)_050 sub-catchment.

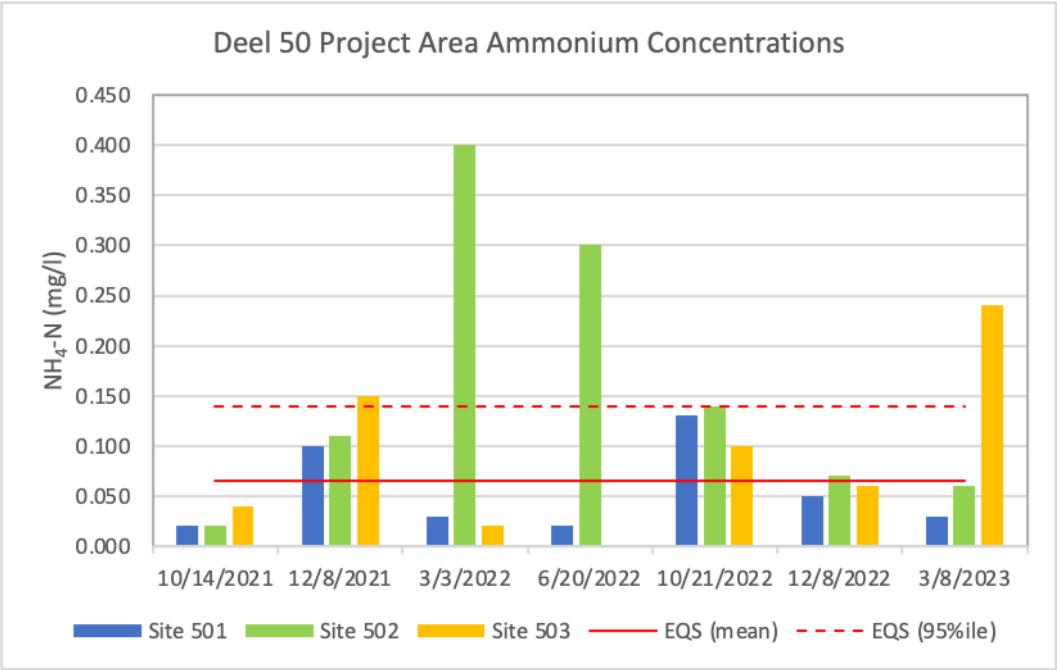

Figure 5: Ammonium concentrations in Deel (NCW)_050 sub-catchment (October '21 – March '23).

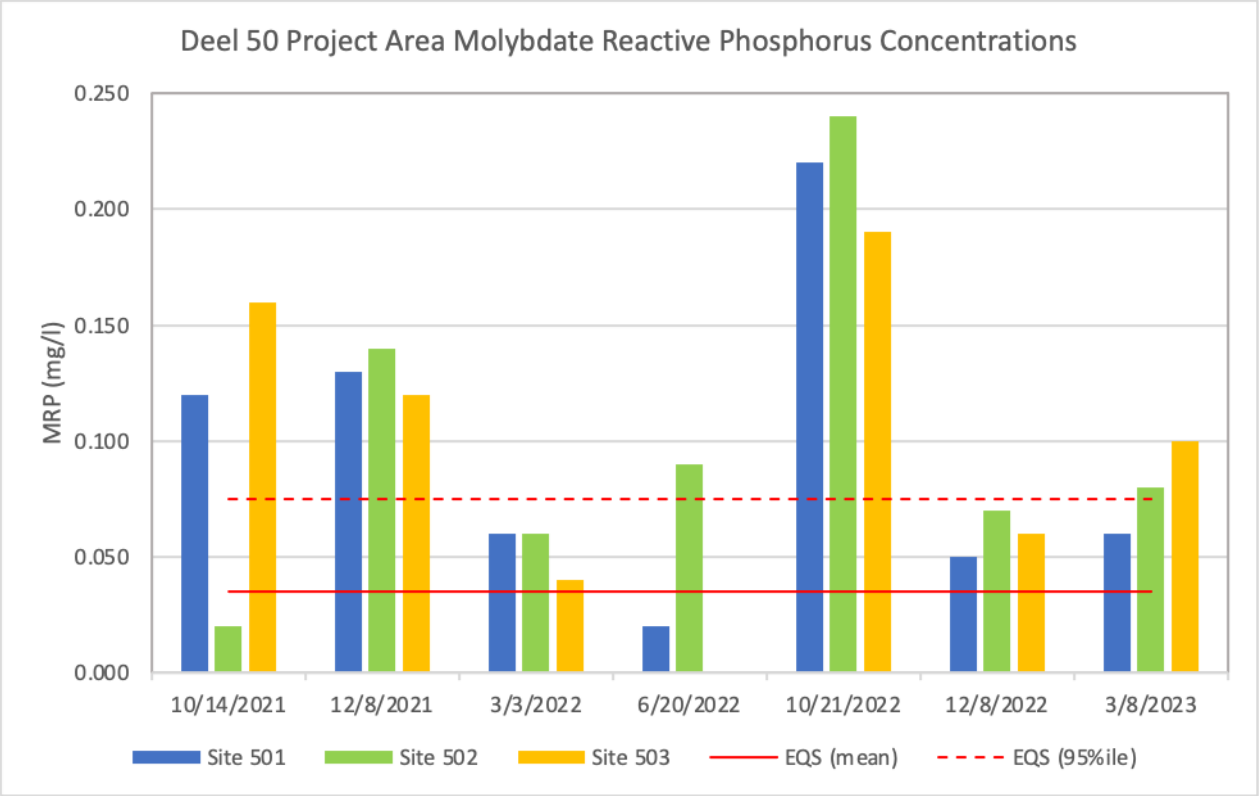

Figure 6: MRP (ortho-phosphate) concentrations in Deel (NCW)_020 sub-catchment (October '21 – March '23).

As Figure 5 shows, baseline ammonium levels varied in the Deel (NCW)_050 catchment. Results for the outlet station (Site 501) were below the 95 percentile EQS in all sampling rounds and exceeded the mean EQS in the December '21 and October '22 sampling rounds only. Highest concentrations were obtained for the northern tributary station (Site 502), with the 95 percentile EQS exceeded in March and June 2022. The southern tributary (site 503) exceeded the mean 95 percentile EQS in December 2021 and March 2023.

As Figure 6 shows, baseline orthophosphate levels exceeded both mean and 95 percentile EQS at the outlet (site 501) and southern tributary (site 503) in three of the four winter sampling rounds. In the December 2022 sampling round, concentrations exceeded the mean EQS only. On the northern tributary (site 502), baseline orthophosphate concentrations exceeded the mean EQS in six of the seven sampling rounds and exceeded the 95 percentile EQS in four sampling rounds. As the stream was dry, no sample was available at site 503 in June '22.

Storm event sampling:

Deel (NCW)_020

Use of autosamplers and in situ flow monitoring enabled diffuse phosphate losses to be measured during three storm events to establish baseline diffuse P loss per hectare in the Deel (NCW)_020 project catchment area.

Three storm events were monitored at Site 201, located close to the outlet of the Deel (NCW)_020 catchment, on the 5th/6th February 2022, 9th March 2022 and, on the 12th /13th March 2022. The autosamplers were deployed over a 36-hour period for each event, with one sample collected every 90 minutes. Flow monitoring was undertaken throughout each assessment period. Using these data, a hydrograph separation technique was applied to separate overland flow (and associated P losses) from baseflow P loss.

Table 1: Autosampler results for Deel (NCW)_020.

Event date	Total rainfall (mm)	Total overland flow (mm)	Duration of overland flow (hours)	Mean MPR concentration (mg/l)	Total TRP delivered to stream via overland flow (g/Ha)
Storm 1 5th to 6th Feb 2022	12	3.3	22.5	0.193	9.6
Storm 2 9th March 2022	35	10.7	15	0.194	30
Storm 3 12th/13th March 2022	18	4	22.5	0.084	4.5

As Table 1 shows, the phosphate concentration in overland flow halved for storm 3 in comparison to storms 1 and 2. This suggests a build-up of available P in the soil as farmers spread slurry after the closed period and then a depletion of these available P stores during succeeding storms.

Deel (NCW)_050

Two storm events were monitored at the outlet of Deel (NCW)_050 catchment (Site 501), on the 5th/6th February 2022 and 12th/13th March 22. As the contributing catchment is larger, flows responded more slowly in the storm events, and it was not possible to perform hydrograph separation as too few chemistry samples were obtained on the falling limb. Instead, for this catchment, data analyses focused on flow percentiles. Flows reached the upper 5th percentile in both storm events. Mean MRP concentrations in the upper 5th percentiles ranged from 0.12mg/l to 0.27mg/l.

The estimated phosphate losses in this range were 15 to 18kg P per hectare.

This type of storm event monitoring will continue through Cycle 3 of the WFD to assess the effectiveness of biodiversity measures in reducing diffuse P (and sediment) losses as the measures become more established and mature in the landscape over time.

Biological Assessment

Four baseline biological monitoring surveys (Small Stream Index Score) were undertaken by the LAWPRO Catchment Science team at five of the six sites in the two sub-catchment areas. Site 503 was omitted for biological assessment due to it unsuitability. Additionally, the Q-value assessments were undertaken at the outlet sites for each sub-catchment (Sites 201 and 501). Results are summarised in Table 2.

Table 2: Results of the biological monitoring surveys assessment.

Date	Site 201 (Deel (NCW)_020 outlet		Site 202	Site 203	Site 501 (Deel (NCW)_050 outlet		Site 502
	Q-value+	SSIS*	SSIS*	SSIS*	Q-value+	SSIS*	SSIS*
Sep-21	Q3	4.0	4.8	4.8	Q3	4.0	5.6
May-22	n.d	2.4	4.8	2.4	n.d	6.4	5.6
Sep-22	Q3	2.4	2.4	4.8	Q3-4	6.4	4.8
Mar-23	n.d	4.0	4.0	3.2	n.d	6.4	4.8

* Small stream index score: > 7.25 Probably not significantly impacted; > 6.5 – 7.5 Indeterminate evidence of impact; < 6.5 Probably impacted.

+ Q3-4 Moderate ecological conditions, Q3 Poor ecological conditions.

Sediment Assessment

The shuffle index is an assessment technique that is useful to add to visual assessment in circumstances where sediment is a suspected issue. The shuffle Index method measures how long it takes for a sediment plume to clear from the water column while flowing over a white tile.

Briefly the methodology involves:

• Place a white tile on the streambed in a run, and measure/estimate water depth and velocity at this point.

• Stand 3 m upstream of the tile and disturb the streambed by moving feet vigorously for five seconds.

• Allocate a score from 1-5 depending on the visibility and duration of the resulting plume in relation to the white tile downstream. (The images in Appendix III aid in this assessment).

The following table shows the shuffle index scores for the sites in both sub-catchments. All sites apart from 501 and 502 (on one occasion) were impacted by sediment. The score improved at site 502 (situated in a fast-moving reach) over the assessment period due to high flows in the previous few days which may have 'washed-out' much of the sediment. On-going monitoring of the sediment conditions will continue over the period of the WFD 3rd Cycle.

Table 3: Results of the shuffle index assessment.

	Site 201	Site 202	Site 203	Site 501	Site 502	Site 503
Sep-21	3	3	2	1	3	4
Sep-22	3	3	2	1	2	4

Aquatic habitat assessment

The aquatic habitats were assessed as part of the biological assessment process at each of the sites and the components are presented in the following table.

Table 4: Physical attributes and plants present (May '22) at the monitoring sites.

Date	Stream substrate (% cover)	Habitat	Shading	Aquatic plants
Site 201 Deel (NCW)_020 outlet	Cobble 30 Large Gravel 30 Small Gravel 30 Silt 10	Glide (50%) Run (%50)	Moderate	*Sparganium erectum*
Site 202	Cobble-10 Large Gravel 20 Small Gravel 20 Sand 30 Silt 10 Clay 10	Run (100%)	Moderate	*Nasturtium officinale* *Betula sp.*
Site 203	Boulder 15 Cobble 40 Large Gravel 20 Small Gravel 10 Sand 5 Silt 5 Clay 5	Riffle (50%) Glide (50%)	Heavy	None

Site 501 Deel (NCW)_050 outlet	Cobble 40 Large Gravel 30 Small Gravel 20 Sand 5 Silt 5	Riffle (60%) Run (40%)	Mixed	*Cladophora* *Phalaris arundinacea* *Nasturtium officinale*
Site 502	Boulder 5 Cobble 50 Large Gravel 20 Small Gravel 20 Silt 5	Riffle (50%) Run (50%)	Moderate	*Nasturtium officinale* *Betula sp.*
Site 503	Small Gravel 70 Sand 10 Silt 10 Clay 10	Run (100%)	Low	*Nasturtium officinale* *Betula sp.*

Attitude change:

Each of the 23 farmers that engaged with The Deel Spatially Targeted Buffers EIP was scored on their Farmer readiness for implementing measures on their farms. The following 6 questions were used for the survey. Farmers were rated on each question with a score between 1 to 5, where 1 very low, 2 Low, 3 Moderate, 4 High, 5 Very High.

Question: Does the Farmer……		Average score for farmers (n=23) before Measures were installed on farms.	Average score for farmers (n=23) after Measures were installed on farms.
1	Understand how biodiversity & water quality will improve by carrying out the agreed mitigation measures in the next 12 months?	3	4
2	Have the Skills to carry out the agreed mitigation measures in the next 12 months?	3	4
3	Have Experience of carrying out the agreed mitigation measures (or similar practices)?	3	3.5
4	Want to improve biodiversity & water quality by carrying out the agreed mitigation measures in the next 12 months?	4	4
5	Think that Most Farmers are carrying out similar mitigation measures? (is it the "done thing" among farmers like him/her?)	3	4
6	Have the Time, Money and Resources required to carry out the agreed mitigation measures in the next 12 months?	4	4

Overall the results showed there was a change in farmer attitude to implementing measures on farms for biodiversity and improving water quality. There was an increased change in their understanding for how the measures would improve biodiversity and water quality. They agreed that their skills to now implement these measures has now improved.

Habitat Survey:

Each farm in the Deel Spatially Targeted Buffers EIP was assessed for habitats and these were divided into habitat classes based on Julie Fossitts 'A Guide to Habitats in Ireland'. The vast majority of the land area where measures were implemented is GA1, Improved Agricultural Grassland. These habitats are the basic building blocks of the environment that are inhabited by animals and plants on farms. Habitats can be described as an area where an organism, plant or animal lives. On the farms in the Deel Spatially Targeted Buffers EIP no habitats of particular conservation importance were noted or none of the habitats were recorded that are listed in Annex I of the Habitats Directive. The following were the habitats recorded.

The most common habitat recorded on farms was **Improved agricultural grassland GA1**. This habitat category is used for intensively managed or highly modified agricultural grassland. These are grasslands can be grasslands that have been reseeded and are regularly fertilised. They are used for intensive grazing and/or used for silage making. They include mostly rye-grass swards. Large areas of permanent grassland were also recorded. These are areas that were reseeded more than 5 years. These improved grasslands were mostly species-poor. Rye-grasses (Lolium spp.) were the dominant species present. Other grasses that were found in the permanent pasture included included meadow-grasses (Poa spp.), Timothy (Phleum pratense), Crested Dog's-tail (Cynosurus cristatus) and Yorkshire-fog (Holcus lanatus). Plants that were noted in the grasslands were Dandelion (Taraxacum spp.), Creeping Buttercup (Ranunculus repens), plantains (Plantago spp.), nettle (Urtica dioica), thistles (Cirsium arvense, C. vulgare) and docks (Rumex spp.). Rushes were observed in poorly-drained fields.

Drainage ditches FW4 were recorded on farms. These included linear water bodies that are artificial maintained. Some have been excavated or modified to enhance drainage and control the flow of water. These ditches contained water and supported wetland vegetation.

Hedgerows WL1 were recorded on farms. These occurred often with treelines that formed the boundaries of fields. Hedgerow size and quality varied considerably, depending largely on management. These hedgres were mainly 5 m high and 4 m wide. Species composition were mostly hawthorn (Crataegus monogyna), blackthorn (Prunus spinosa) and bramble (Rubus fruticosus agg.). A large varity of broadleaf plant species and tall grasses occurred within these hedges.

Overall the habitats were in good condition on farms with no habitats of particular conservation importance being noted

Agreeing Measures/Installing Measures

- Identifying CSAs and flow delivery pathways: Each farm was identified within both Deel_020 & Deel_050 using LPIS data from DAFM. This was overlain with the EPAs PIP P maps & flow pathway maps which identified farms with the highest flow delivery paths/point. These farms were visited by ASSAP and a walk over survey/assessment carried out to identify and ground truth the flow pathways. Discussions took place as part of the initial farm assessment around spatially targeted buffers, what they meant & how they would fit into the farm along the flow pathways.
- Agreeing measures: After initial discussions around spatially targeted buffers, each farmer was allowed time to process what this would mean for their farming enterprise and whether it would work within their farming system. Each farm had a number of follow-up visits to further discuss the measures, the size & requirements of the measure, costings, how the claim process would work etc.
- Within each sub catchment a number of measures were put in place. In total 3050 native trees were planted along with 1000m of native hedging. Full list detailed in the table below.

Total Trees Planted		3050
Total length of Hedging		1000m
Length of River Fenced	Additional fencing completed on Limerick side	3598m
Nose Pumps		2
Solar Pumps		2
Water Troughs		16
Tile Drain Fed Wetland		1
Solar Powered Battery Fencer		1

Photo : A targeted buffer to intercept overland flow. The water in the ponded area in the picture is coming from overland flow. The outlet to the drain below the buffer is bunded & the height of the water being held within the buffer can be altered.

This area has been planted with native trees at the start of December 2022 (see picture below).

Area Planted with Birch, Alder, Oak & Hazel December 2022. (Native willow wasn't available from any nursery otherwise we would have used it also).

Photo: Water throughs installed as measures on farms.

Photo: Riverside Fencing completed as part of the project.

Photo: Fencing of farm ponds.

Engagement Knowledge transfer

Out of a total 52 farmers 23 actively engaged with the project. There was also engagement with the local tidy towns in both sub-catchments. There was lots of farmer engagement through one-to-one farm visits & call backs, local events and discussion groups. The focused one-to-one farm visits with the participating farmers allowed for detailed discussion on topics such as local water quality, PIP maps, flow pathways and nutrient movement within the farmed landscape while also focusing on terrestrial biodiversity and ways to increase it. A number of local events were attended by LAWPRO and ASSAP as part of the project such as: talk in Springfield Castel, a number of events on the local Signpost Farm, local discussion groups. An end of project event was held in December 2022 (prior to project extension) in Newtownshandrum.

Lessons Learned:

In the life of an EIP or project there are several risks and concerns that the EIP may encounter. Lessons learned from the project should be a collaborative process that allows organisational group members to learn from the project. This helps groups and ensures the same mistakes don't arise in the future. Learning about these lessons both positive and negative will help to review projects so that strengths can be identified and areas for improvement can be looked at in future projects. The organisational group met on the 9th May 2023 and reviewed the project. The following were some of the lessons learned from the EIP.

Administration of the Deel Spatially Targeted Buffers EIP Lessons:

- Procurement of materials and the administration burden for the Deel Spatially Targeted Buffers EIP was identified as being excessive for the project. The project found that for the procurement of materials by farmers to get 3 quotations for materials proved problematic. It had being written into the project proposal but when being implemented on the ground it proved difficult.
- The group suggested that the project should have been funded for a full time person was needed to drive the project on the ground. The project depended on being led by the group but still a person was needed to take ownership and drive the project forward.
- Members of the OG were happy with the level of expertise that was within the group but that better communications with the OG group was needed. This is critical for information flow within the group as to what was happening on the ground and if areas of the project needed extra help from the OG.

Lessons learned from Implementation the Measures for the Deel Spatially Targeted Buffers EIP:

- The timeframe for the imitation of the EIP through to finish was found to be too short to be completed within a year. The group found as it was coming together for the first time that it took time for the group to be comfortable with each other. The lead in time for the project to get off the ground with farmer participation needed at least six months which was half ways through the timeframe. Even though they were short EIP's they still needed to go through the whole life of an EIP in a much shorter timeframe compared to a multiannual EIP.
- The group found that on the ground signing farmers up for measures took time but also there was confusion with farmers with the new CAP and ACRES schemes being launched at the same time. This made farmers unsure about choosing measures and the issue of double funding for measures implemented.
- A large proportion of the measures in the Deel Spatially Targeted Buffers EIP were around planting trees and hedgerow. With the timing of the 1 year this did not make it easy or coincide with the planting season for these plants. An extension to the project overcame this issue but again it was noted the length and timing of the project would have benefited from a longer timeframe for planting.
- The time that it took to engage with farmers in the EIP was underestimated from the OG at the beginning. Getting information out to farmers in a clear and precise way proved difficult. Engagement with farmers started with letters, newsletters and clinics for farmers. This then moved onto meetings but in the end to get participation this needed one to one visits with farmers which proved time consuming. The fact that Covid restrictions were in place for a large proportion of the project timeframe did not help.
- The use and recruitment of Champion farmers in the EIP areas proved very good and useful. These were farmers who took the first steps which one could then use as an example for the next farmer to engage with.

Appendix I

Table 6.1: Project Management Chart

		PRE-PROJECT				PROJECT OPERATIONAL PHASE												POST-PROJECT				
		2021								2022												
		May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Post 2022
Initiating Farmer Engagement	Initial engagement with landowners																					
	Preparation of Project Charter																					
	Focused farmer engagement in the project areas																					
	Farmer commitment (signing up to Project Charter)																					
Assessment of KPI baseline	Baseline habitat surveys using aerial/satellite imagery																					
	Baseline habitat site walk-over surveys - farm specific																					
	Baseline nutrient loading surveys at catchment outlets, determined by chemistry and flow monitoring targeted at rainfall events to capture when critical source areas are most active. This will be supported by grab sampling on tributaries and streams within the two catchments																					
	Baseline Q assessment (to support existing small stream impact score data)																					
	Baseline river channel sediment assessment, for catchment outlet and on each tributary																					
	Baseline aquatic habitat assessment																					
	Completion of local river channel sediment assessments (field scale)																					
	Completion of RHAT assessment and detailed habitat survey along selected reaches																					
Agreeing Measures	Detailed farm field visits to identify critical source areas and focused flow delivery zones																					
	Agreeing suitable measures with landowner focused on these flow delivery zones from CSAs																					
	Identification of suitable reaches for enhanced riparian measures																					
Installing measures	Introduction of measures into focused flow delivery zones and points																					
	Installation of additional biodiversity measures (farm ponds, filter drains etc)																					
	Planting enhanced riparian margins along selected reaches																					
Engagement Knowledge Transfer	Design, production and placement of biodiversity signage on two public road bridges																					
	Farmer local catchment event on demo farms for participant farmers, one per catchment																					
	Local catchment event for local discussion group																					
KPI's measuring change	Local river channel sediment assessment, post measures' implementation																					
	Assessment of nutrient load reduction, post measures' implementation																					
	Post measure RHAT assessment on selected river reaches																					
Review and reporting	Interim review and assessment of the approach																					
	End of project evaluation and report																					
	Final assessment of long term effectiveness of measures (2022-2027)																					

Appendix II: pH, electrical conductivity and nutrient concentrations for the Deel_020 EIP sub-catchment.

Date	Site No.	pH	Conductivity (µs/cm @ 20°C)	Total Ammonia (mg/l N)	Orthophosphate (mg/l P)	TON (mg/l N)
14-Oct-21	201	8.2	508	0.03	0.12	n.d
	202	8.1	563	<0.02	0.09	
	203	8.2	443	0.07	0.14	
08-Dec-21	201	7.9	486	0.06	0.08	3.14
	202	7.9	497	0.06	0.08	2.94
	203	7.7	472	0.10	0.10	4.04
03-Mar-22	201	8.2	548	0.03	0.04	2.61
	202	8.2	557	<0.02	0.03	2.66
	203	8.1	524	0.06	0.05	2.98
20-Jun-22	201	8.2	576	0.04	0.10	2.03
	202	8.0	535	0.02	0.04	0.39
	203	8.2	611	0.04	0.02	0.72
21-Oct-22	201	7.7	374	0.09	0.22	1.48
	202	7.7	420	0.07	0.10	1.61
	203	7.5	323	0.11	0.38	1.61
08-Dec-22	201	8.4	533	0.14	0.05	2.38
	202	8.3	539	0.04	0.04	2.10
	203	8.3	530	0.08	0.08	3.02
08-Mar-23	201	8.4	546	0.05	0.05	2.14
	202	8.4	559	0.04	0.06	1.49
	203	8.4	537	0.14	0.06	2.99

Appendix III: pH, electrical conductivity and nutrient concentrations for the Deel_050 EIP sub-catchment.

Date	Site No.	pH	Conductivity (µs/cm @ 20°C)	Total Ammonia (mg/l N)	Orthophosphate (mg/l P)	TON (mg/l N)
14-Oct-21	501	8.4	561	<0.02	0.12	n.d
	502	8.2	564	<0.02	0.02	
	503	8.0	645	0.04	0.16	
08-Dec-21	501	7.9	539	0.10	0.13	3.74
	502	7.8	542	0.11	0.14	3.95
	503	7.6	474	0.15	0.12	1.48
03-Mar-22	501	8.3	575	0.03	0.06	3.18
	502	8.1	578	0.40	0.06	3.36
	503	8.2	573	<0.02	0.04	0.25
20-Jun-22	501	8.3	551	< 0.02	0.02	1.05
	502	7.9	565	0.30	0.09	1.52
	503			n.d		
21-Oct-22	501	7.90	498	0.13	0.22	2.55
	502	7.70	516	0.14	0.24	2.76
	503	7.40	369	0.10	0.19	0.42
08-Dec-22	501	8.4	582	0.05	0.05	3.19
	502	8.2	587	0.09	0.07	3.21
	503	8.2	559	0.11	0.06	0.32
08-Mar-23	501	8.5	598	0.03	0.06	3.00
	502	8.3	605	0.06	0.08	3.07
	503	8.3	618	0.24	0.10	< 0.02

Appendix IV: Images of shuffle index examples (Source: Clapcott et al., 2011, copyrights: Cawthron Institute).

Score 1: No or small plume

Score 2: Plume briefly reduces visibility at tile

Score 3: Plume partially obscures tile but quickly clears

Score 4: Plume partially to fully obscures tile but slowly clears

Score 5: Plume fully obscures tile and persists even after shuffling ceases