Teagasc submission made in response to the Consultation Paper on

Proposed Additional Measures for Ireland's 5th Nitrates Action Programme

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Introduction

This submission responds to the consultation process run jointly by the Department of Housing, Planning, Community and Local Government (DHPCLG) and the Department of Agriculture, Food and the Marine (DAFM) inviting views and comments on proposals for new measures as part of Ireland's 5th Nitrates Action Programme in 2025. It has been prepared by Teagasc's Water Quality Working Group in consultation with members of the Teagasc Climate Centre. Members are drawn from both the Knowledge Transfer and Research Directorates of Teagasc. It was prepared following consultation with colleagues across Teagasc using their collective knowledge and expertise in agri-environmental science and practice and the implementation of the Good Agricultural Practice (GAP) and Nitrates Derogation Regulations.

Teagasc has and continues to pursue a comprehensive research and advisory programme to address knowledge gaps on the interaction between agriculture and the environment as identified in reviews of national and international research. This research is conducted by Teagasc in collaboration with a range of Irish and international research institutes and universities, and supported by the Department of Agriculture, Food and the Marine (DAFM), the Research Stimulus Fund (administered by DAFM), Horizon Europe, Science Foundation Ireland (SFI), Dairy Research Levy and STRIVE (administered by the Environmental Protection Agency). The Agricultural Catchments Programme (ACP), which has as its principal objective the evaluation of the Nitrates Directive - National Action Programme (NAP) measures, has been funded by the DAFM since 2008 and is currently in its fifth four-year phase. Its outputs contribute significantly to the efficacy of current NAP measures and to this submission.

This submission builds on previous Teagasc submissions made during the reviews of the GAP regulations in 2010 (Schulte et al., 2010) and 2013 (Shortle et al., 2013) and 2017 (Shortle et al., 2017) and 2019 (Spink et al., 2019) and 2021 (Spink et al. 2021) which support Irelands NAP and Nitrates Derogation.

This submission considers developments in farm practices that have the potential to positively impact water quality, but also greenhouse gas (GHG), ammonia and habitats & biodiversity published since the last NAP. Technological and management changes affecting farm productivity and environmental sustainability are reviewed. Teagasc has responded to the guiding questions and proposed measures posed in the public consultation document and proposes how the NAP and Nitrates Derogation can be supported, based on the outcomes of its environmental research programme, supported by reviews of the current scientific literature.

The objectives of these proposed amendments are:

- To achieve more effective protection of the rural environment.
- To improve efficiency of agricultural production
- To rationalise and simplify the operation of the Nitrates Directive - NAP and Nitrates Derogation regulations.
- To reflect relevant measures in Teagasc's greenhouse gas and ammonia Marginal Abatement Cost Curves (MACC).

- To ensure that relevant measures maintain, or, enhance above ground and below ground biodiversity and natural and semi-natural habitats on agricultural land.

Teagasc has adhered to four guiding principles in the preparation of these proposed amendments:

1. All proposed amendments, technologies or knowledge transfer (KT) methods are based on solid scientific research from published sources;
2. All proposed amendments, technologies or KT methods have been assessed in terms of their environmental impact, with emphasis on the impact on water quality, and with cognisance to potential impacts on biodiversity, greenhouse gas and ammonia emissions;
3. All proposed amendments/technologies or KT methods have been cross-evaluated against each other to ensure consistency and synergy between all proposed amendments.
4. All proposed amendments, technologies or KT methods have been assessed in terms of their cost effectiveness as costs of implementation, upkeep and administration were considered as part of the cost benefit analysis.

Response to Public Consultation Questions

Responses to the questions put forward in the public consultation are as follows. Here we summarise the latest knowledge and propose what amendments, technologies and knowledge transfer (KT) methods and supports are needed to achieve positive outcomes to these questions and to support Ireland's Nitrates Action Programme. Each of these responses is supported by scientific knowledge and based on existing science and data, and the publications are provided in the reference section.

Part 1. Response to proposed measures in the GAP Regulations

1.1. The reduction in maximum stocking rate

Teagasc understands that according to Nitrates Directive rules that the areas where the stocking rate limits under derogation have been reduced from 250 kg/ha to 220 kg/ha organic N are based on the water quality data from a subset of sites within the larger national water quality monitoring network in Ireland. This subset of water quality monitoring sites are in accordance with Article 10 of the Nitrates Directive (91/676/EEC). However, the EPA Targeting Agricultural Measures Map identifies more areas where water quality is not meeting the regulatory standards and where measures are required to reduce N and, or, P losses to water. It is our understanding that Ireland will seek to use the full national water quality monitoring network and associated data as the basis for assessing change in water quality under Article 10 in the future. Using this larger data set will likely result in more areas having their maximum stocking rate limits reduced from 250 kg/ha to 220 kg/ha organic N where water quality is not meeting these criteria.

Appropriate criteria and indicators for assessing practice change linked to water quality

The reduction in maximum stocking rate from 250 kg/ha to 220 kg/ha organic N on farms in receipt of a Nitrates derogation in catchments where water quality is not meeting the regulatory water quality standards stipulated by the European Commission (EC), was based on a number of specified criteria as set out in Article 12 of the Commission's Implementing Decision regarding Ireland's Nitrates Derogation. Based on the science underpinning the nutrient transfer continuum (Wall et al., 2011) and the hydrological lag time moderating trends in water quality within the Irish catchments (Fenton et al., 2011), water quality is unlikely to change or improve according to these criteria mainly due to short timeframe set out to assess this change in water quality. A large proportion of the agricultural areas of Ireland have long lag times between management changes and improvements in water quality, but also have large capacities for denitrification. It is important that this is taken into account during policy development because the implementation of changed management practices may not lead to any improvement in water quality with respect to nitrate within the prescribed legislative timeframes (Fenton et al., 2009). More discussion of the scientific research findings and water quality data generated by Teagasc, including the Agricultural Catchments Programme, is needed in order to set out appropriate criteria, including selecting appropriate indicators to assess potential change in water quality and consideration of suitable timelines leading to expected water quality improvement in the future.

Impact of reducing maximum stocking rate on nitrogen leaching

Teagasc modelled the impact of reducing maximum stocking rate from 250 kg/ha to 220 kg/ha organic N on nitrate leaching to 1 meter depth and farm profitability (https://www.teagasc.ie/media/website/publications/2023/The-Impact-of-Nitrogen-Management-Strategies-within-Grass-Based-Dairy-Systems.pdf). Using the MoSt GG model reducing organic N from 250 kg/ha to 220 kg/ha (12% reduction), was predicted to reduce N leaching by 2.2 kg/ha (3.6%) at one meter depth. Simultaneously reducing organic N from 250 kg/ha to 220 kg/ha also reduced farm profitability by €374/ha.

1.2. Reduction the reliance on chemical fertiliser

Fertiliser use on Irish farms

The use of chemical fertiliser in Ireland has declined significantly since 2018 (DAFM fertiliser sales statistics). At nation level fertiliser N has reduced from 408,495t N in 2018 to 280,569 t N in 2023; fertiliser P from 46,387 t P in 2018 to 30,762 t P in 2023; fertiliser K from 120,267 t K to 81,956 t K in 2023. This equates to a 31.3% reduction in N, a 33.7% reduction in P, and a 31.9% reduction in K fertiliser use nationally over this period. These significant reductions in reductions in P and K use nationally are likely to have negative consequences for soil fertility which is a critical driver for N use efficiency and mitigating gaseous emissions.

At farm level comparing 2023 versus 2020 the application rate of N, P and K across all farms have reduced by 21% (16.5 kg/ha), 25% (2.3 kg/ha) and 22% (5.3 kg/ha), respectively (NFS, 2024). On dairy farms the application rates of N, P and K have reduced by 19% (34.7 kg/ha), 28% (3.8 kg/ha) and 25% (9.3 kg/ha), respectively. On beef farms the application rates of N, P and K have reduced by 25% (-14.3 kg/ha), 26% (-1.8 kg/ha) and 27% (-4.6 kg/ha), respectively. On sheep farms the application rates of N, P and K have reduced by 34% (-14.9 kg/ha), 35% (-2.3 kg/ha) and 34% (-5.1 kg/ha), respectively. Over the same period the application rates of N on tillage farms have remained relatively constant (+1.7 kg/ha), while the application rates of P and K have reduced by 17% (-3.7 kg/ha) and 8% (-4.6 kg/ha), respectively. Although the percentage reduction in fertiliser use was slightly lower on dairy farms compared to drystock farm, the absolute reductions were much greater i.e. the reduction in N fertiliser use on dairy farms was almost 2.5 times greater than that on beef farms (-34.7 versus -14.3 kg/ha N). These significant reductions in reductions in P and K use

Modelling the effects of chemical N fertiliser management scenarios on N leaching

The Department of Agricultural, Food and Marine requested Teagasc to model the impact (environmental and economic) of a number of farm nitrogen mitigation measures in order to inform policy of the best current and potential actions to deliver the catchment based nitrate load reduction estimated by the EPA. The assessment was confined to nitrate losses from freely draining soils where farming intensity is greater than 130 kg/ha organic N per year.

The modelling of chemical N fertiliser application rates and timing scenarios requested by DAFM is outlined in the report https://www.teagasc.ie/media/website/publications/2021/Nitrates-Modelling-Final.pdf.

The following scenarios were requested to be investigated:

1. Chemical N reduction of approximately 10% and 20% i.e. chemical N application rates of 250, 225 and 200 kg/ha.
2. Delaying the first chemical N application in spring from 15 January.
3. Finish final chemical N application in autumn earlier than 15 September.
4. Uneven distribution of chemical N fertiliser across the farm i.e. applying 300 and 350 kg N/ha on the grazing platform.
5. Stocking rate reduction- 250 kg N/ha (2.74 cows/ha) versus 230 kg N/ha (2.52 cows/ha).
6. High platform stocking rates- 340 kg N/ha (3.73 cows/ha) and 430 kg N/ha (4.72 cows/ha).
7. Spreading slurry during the closed period; 12% and 25% of slurry spread during the month of December.
8. Implementations of using precision farming to increase N use efficiency.
9. Options for banding organic N excretion rates for dairy cows.

In summary this modelling showed large year-to-year variation in N use efficiency (22.0-32.5%), and year-to-year variation consistently surpassed any management intervention within this modelling framework. Findings from the Agricultural Catchment Programme also show significant year-to-year variations. The use of precision N application strategies, taking cognisance of meteorological conditions would improve N use efficiency and reduce losses to the environment. Precision management advice has been issued weekly by Teagasc since 2020, based on modelled grass growth, weather forecast and leaching risk, which will be further refined over the coming years. Precision application strategies will also be important in the timing of the first chemical N application in spring. The modelling showed that reduction of chemical nitrogen from 250 kg N/ha (while applying best farm practices) to 225 or 200 kg N/ha resulted in N loss reduction of 1.4 and 2.7 kg N/ha respectively. Starting N application later in spring (1st of February) and finishing earlier in autumn (1st of September) while applying 250 kg N/ha with an organic N stocking rate of 250 kg N/ha reduced N losses by 0.5 kg N/ha.

The reduction of chemical N in specific catchments identified by the EPA catchment assessment must account for differences in soil types across the catchment and within farms, which along with weather are key controlling factors in N loss. Consideration should also be given to the combined effect of multiple measures affecting a farm simultaneously leading to larger reductions in maximum chemical fertiliser rates that are allowed on farm, which in reality could be in excess of 10-15%.

The results of this modelling work have been used to inform the Teagasc response to the proposed measures put forward in the NAP consultation paper. A report "The Impact of Nitrogen Management Strategies within Grass Based Dairy Systems" this modelling work is available at https://www.teagasc.ie/media/website/publications/2021/Nitrates-Modelling-Final.pdf. A key outcome from this report centres on the need for management of nitrogen to be handled in a dynamic basis using precision timing, rate and location. For example, moving fertiliser N application dates was appropriate in some years and not in other years. Similarly the year-to-year variation in weather, grass growth and nitrates loss suggests a need for farm specific tailored advice across the year depending on grass growth and weather conditions.

PastureBaseIreland (PBI) and the grass growth prediction model (MoSt GG) allows this dynamic advice to be provided on an on-going basis and should be part of future strategies to reduce nitrate loss.

Limiting N use on farms with low stocking rates

Farms with a low stocking rates typically use very low levels of N and P fertiliser. Based on the national fertiliser advice by Teagasc (Wall and Plunkett 2020) farms with a stocking rate ≤85 kg/ha org. N would plan to use a total of 40 kg/ha N on grazing ground per year and would plan to use a total of 125 kg/ha N for their first cut silage ground. At these levels of chemical N input these farms operate at a very low N balance and chemical fertiliser N use would not pose a significant risk of nutrient loss from the soil.

Lower stocked farms have been an important source of fodder when stocks became scarce i.e. summer 2018 and winter 2023/2024. Implementing a new maximum allowed N rate of 90 kg/ha on a whole farm basis on lowly stocked farms (≤85 kg/ha org. N) may limit their potential to respond to such situations and limit their potential to produce much needed fodder in the form of silage or hay for use by other farms.

Adoption of clover into grassland swards

Results from Teagasc research indicate that perennial ryegrass-white clover swards compared to perennial ryegrass only swards have the potential to replace up to 100 kg fertiliser N/ha, where white clover content is 20% to 25% of the annual sward biomass (Murray et al,. 2024) Over the past 4 years, white clover seed sales have increased by 60%, 302 t from (2021 to 2024 – year to date) compared to 128 t (2011-2014). Much of this increase in clover sales has been derived from increasing clover by over-sowing into permanent pasture, rather than reseeding. There has been extensive KT support to increasing clover use at farm level, which does seem to have increased awareness at farm level, the reseeding measure in the NAP has had a beneficial effect on increasing clover use. Red clover seed sales have increased to 70 t seed in the past 4 years compared to <10t in the period (2011-2014). The N fertiliser target is to reduce fertiliser use to 300,000 t by 2023, this has been achieved, the transition to grass/clover swards is well underway at farm level.

National fertiliser register

The national fertiliser register facility should provide farmers with information on maximum N and P allowed based on BPS information and livestock numbers and provide in-season information and periodic updates on the remaining fertiliser allowances on their farm yet to be drawn down in future purchases. For this, a running total for chemical N and P fertiliser purchased is deducted from the starting maximum chemical N and P allowed on the farm and information on the remaining balance of N and P is provided during the year. Teagasc have previously developed a fertiliser tracker App to help farmers, agri-professionals and merchants ensure compliance with fertiliser limits based on a nutrient management plan (NMP), however, access to live information on remaining fertiliser allowances to be drawn down would help farmers to better plan fertiliser purchases and use over the growing season. Assisting farmers in recording, tracking and decision making around NMP's will encourage best practice around NMP and on-farm decisions to maximise optimal soil fertility.

Enabling earlier nutrient management planning on farms

As part of the Nitrates Action Programme (NAP) each farmer is required to have a nutrient management plan by the 31st March of the relevant year for his/her farm setting out the limits of chemical fertiliser that can be applied on that farm. In the case of farms applying for a nitrates derogation the requirement is for a yearly application to be submitted to the Department of Agriculture Food and the Marine (DAFM) and a comprehensive plan must be on file with DAFM and updated at least every four years. Applicants must also submit records of chemical fertiliser use.

The current system based on the use of the actual year's records has a number of difficulties associated with it, which cause problems for farmers and planners.

- To be effective, nutrient management planning needs to be carried out ahead of the decisions to purchase fertiliser. Therefore, an NMP for the farm needs to be completed before the end of the closed period. This will allow the purchase of fertiliser in advance to meet crop requirements. Under the current system a NMP completed in the first quarter (start Feb to end March) may be too late to inform the purchase of fertiliser and the early applications. In fact, increasing numbers of farmers want to forward buy fertiliser at the end of the year to avail of cost savings and ideally this should be based on a nutrient management plan.
- In planning, farmers are risk averse and fearing penalties, are being cautious. The quantity of fertiliser allowed on a farm is based primarily on the previous year's stocking rate i.e. livestock units/ha or, on the crop type and potential yield. This caution is one of the factors contributing to the fall in soil fertility. If either the amount of livestock or the land base changes during the year the actual stocking rate could be different from planned levels. This can change the amount of chemical N and P permitted and where a farmer has proceeded with a fertiliser plan prepared earlier in the year; this could lead to a sanction/fine for over application. To reduce this risk at farm level, advisers generally advise clients to plan for lower application levels than allowed (or required) on a precautionary basis.
- Currently most farmers wait until final annual N and P per hectare figures from DAFM are available at the end of January before having their NMP plans prepared. For derogation farms this is reinforced by the requirement for fertiliser records which are based on a calendar year and generally prepared based on final end of year statements from suppliers relating to the purchase of chemical fertiliser. In general the planning and records are carried out together. This process leads to most NMP's, being created after the end of the closed period.
- This on-going NMP adjustment to changing stock numbers is rarely done due to time involved for the farmer and the Agricultural consultant and limited options for corrective action. The alternative for practitioners is to take a risk adverse approach in recommending a safety net of reduced chemical N and P fertilise leading to further reduction in soil fertility levels on farms.

Consideration in the regulations should be given to enable farmers and agricultural advisors to develop and submit nutrient management plans during winter, prior to the commencement of the new fertiliser season. This would help farmers to make better decisions on fertiliser needs for the coming season and to better plan slurry and fertiliser applications targeting the right nutrient source, at the right time, at the right rate, in the right place

1.3. Reporting of Organic Nutrient Movements

Appropriate distribution and application of organic manures for crop production is critical for meeting agronomic, economic and environmental sustainability targets on farms. The spatial targeting and application of organic manures should be based on soil sample results and a field-by-field nutrient management plan. This will calculate the crop nutrient requirement and the quantity of a particular organic manure type that can be imported onto a farm.

Coupled with this, the notification of organic manure movement may help farmers to manage slurry movements in a positive and transparent manner. However, the introduction of a four-day rule to notify organic manure movements as proposed is too short a timeframe considering that the majority of farmers rely upon the support of FAS approved advisors to complete the online movement for them. Even when the DAFM Organic Movements App becomes available notifying within four days will be very challenging for advisors to receive communications and instruction from client farmers that movements of organic manures are taking place and to have time to take the necessary actions for a large farmer client base. Teagasc suggests a minimum of 10 working days as a reasonable time frame for notification of organic manure movements as it would provide time for communications between farmers and advisors during busy periods and provide sufficient time for the advisor to take the necessary actions to notify DAFM on behalf of the farmer client. This would also provide a sufficient time for the process where annual leave or sick leave may be a limiting factor.

It is important that organic manure is utilised effectively and that manure exports and imports on farms are facilitated under the NAP regulations and subsequent on farm inspection process. Solid manure applications and slurry spread by LESS or even by splash plate will be visible for greater than 3 weeks after being applied to grassland or in standing crops and can easily be verified upon inspection. Slurry may also be placed into holding tanks on the receiving farm where it will also be available for inspection. Exceptions are when organic manures are incorporated into the soil upon application prior to sowing/reseeding time, which is beneficial to reduce ammonia emissions. In most cases the movement of organic manures between farms can be verified visually upon inspection and without the requirement for further tracking of the equipment used to transport the organic manure. The implementation of GPS tracking system for organic manure movements will lead to additional costs for contractors and famers and will require financial support under TAMS or another method.

1.4. To mitigate overstocking of land areas

Management of short-term grazing only land and commonage and rough grazing

Where a farmer is actively grazing and fertilising short-term grazing area declared on BPS that is outside of the 30km limit proposed, Teagasc proposes that such lands should be included in organic N calculations as long as the farmer can demonstrate that they manage these lands in a similar manner to their home farms.

Separately, the responsiveness to nitrogen inputs in areas of commonage and rough grazing is likely to be low. Such areas are extensively managed and cannot, therefore, make a significant material contribution to nutrient management planning and nutrient recycling for derogation farms.

1.5. Nutrient excretion rates of the young bovines up to two years of age

Teagasc supports using the updated nitrogen excretion values for young bovines in the age categories 0-3, 4-12 and 12-24 months, as they better reflect actual N excretion rates and are fully supported by science. Teagasc completed analysis based on a request from DAFM in relation to young stock https://www.teagasc.ie/media/website/publications/2024/Livestock-nutrient-excretion-rates-.pdf. A key output of this analysis was that there was a difference in organic N excretion per month which was related to animal growth rates and animal intake. The total organic N over the first three months of life was close to 1kg, while as animals got older their organic N increased. The total organic N of 0-1 year olds was 21kg. Following a further request from DAFM organic N for males and females were separated for 13-24 month old animals. Again based on growth rates and intake the organic N between males and females was different.

1.6. Managing Crude Protein in concentrates fed to dairy cows

The crude protein (CP) requirement in the diet of a dairy cow is dependent on various factors including stage of lactation, milk output, etc. On average, Irish dairy cows have a requirement for a diet between 15 and 17 CP%. In general good quality grazed grass can have a crude protein concentration of over 18%. Therefore when cows are at grass there is no benefit to feeding concentrates with high crude protein. In fact there can be a deleterious effect as the cow must use energy to excrete excess nitrogen. A number of studies have been completed in Moorepark over the past 10 years which show no benefit from feeding rations with high crude protein concentrations when cows are grazing. In fact reducing the crude protein concentration of the diet could also reduce the surplus/organic N output of a cow while also helping to reduce ammonia emissions and ultimately and potentially most importantly reducing N loss to the environment. This is a key measure in both the greenhouse gas and ammonia MACCs. A 1% reduction in CP of dairy ration reduces N excretion by 2kg. A 1% reduction in N excretion leads to a 3-6% reduction in Greenhouse gas and Ammonia emissions (Colmenero & Broderick 2006; Nui et al. 2016; Reid et al. 2015). When cows are at grass the recommendation is to use rations with 10 to 14% CP. Supplementation with higher CP concentrate is only justified when the main forage in the diet has low CP- i.e. stemmy grass, silage, drought conditions This was the case for parts of the summer of 2024 in some parts of the country that were effected by drought for prolonged periods of time. There is a need to increase the crude protein content of the ration in these situations if concentrate is being fed. Similarly if there is significant amounts of grass silage in the diet (<13% CP) there would be a need to increase the crude protein of the rations offered. To allow for that flexibility and to still obtain the benefits of lower organic N every opportunity should be taken to lower the crude protein of the concentrate where possible.

Teagasc supports the facility for farmers to voluntarily opt in under NAP rules to reduce the level of crude protein in concentrate feed and gain recognition of the herds lower N excretion rates in subsequent calculations of stocking rate (kg/ha organic N). This facility will more accurately reflect the actual N excretion rates on farms and is fully supported by science. https://www.teagasc.ie/media/website/publications/2024/The-impact-of-reducing-the-maximum-crude-protein-content-of-concentrates-fed-to-dairy-cows-.pdf

1.7. Concentrate feed during the grazing season

Typically in a pasture based setting in Ireland crude protein is in excess. A number of studies have been completed to evaluate the impact of concentrate crude protein (CP) on animal performance over the past number of years. There is significant research completed in this space over the years across the research performing organisations of Teagasc, UCD and from AFBI in Northern Ireland. These provide consistent outputs. A study carried out by Mulligan et al., (2004) compared a high CP% concentrate 24.2% versus a low crude protein concentrate 9.4%. They showed no significant effect of concentrate crude protein levels on milk yield. A study by Burke et al., (2007) where a high crude protein concentrate was compared to a low (19.4% versus 9.6%) showed there was no milk solids yield effect observed. In a study by Reid et al., (2015) where extremely different concentrates were compared (27.7% versus 8.6%), no performance effects were observed. In reality it could be expected that when cows are offered good quality grass reducing the crude protein of the concentrate would not have a negative effect on performance. However when grass quality is low and/or when grass silage is in the diet, there is more likely to be an effect on performance. Therefore the reduction in concentrate crude protein to 14% will help reduce nitrogen loading. However, farmers should be aware and use higher crude protein when needed (and based on advice from a nutritionist/advisor).

1.8. Increase Clover Use

White clover has considerable potential to lower greenhouse gas (GHG) and ammonia emissions from pasture-based ruminant livestock systems when biologically fixed N (BFN) associated with white clover replaces manufactured fertiliser N. Greater replacement of fertiliser N by BFN results in greater benefit in terms of lower GHG and ammonia emissions. Recent research has shown that there is considerable potential to reduce fertiliser N use on farms, by including white clover in perennial ryegrass swards and availing of BNF, while maintaining pasture DM production (Egan et al., 2018; Enriquez-Hidalgo et al., 2018) and increasing animal performance (Egan et al., 2018; McClearn et al., 2019), while also increasing N-use efficiency on farms (Hennessy et al., 2019). In contrast to GHG and ammonia, this reduction in fertiliser N input, however, is likely to have little impact on water quality. The reasons are: lower fertiliser N input is replaced by greater BFN (i.e. less fertiliser promotes greater BFN), which is equally prone to losses to water; (ii) there is the same amount of N cycling within the system (at the same stocking density) and hence, the same likelihood of losses, particularly from urine patches under grazing (Humphreys et al., 2017). Promoting the use of white clover is a key measure in both the GHG and ammonia MACCs and will deliver verifiable reductions in emissions when N fertiliser is reduced.

The past three years has seen a large increase in clover use at farm level. Research at Teagasc shows that grass-white clover swards, receiving 100 kg/ha N less chemical N fertiliser than a grass-only sward (250 kg/ha N), produced similar levels of pasture (13.4 t DM/ha) over an eight year period. The use of precision Nitrogen management in combination of grass/clover swards will lead to better N efficiency at farm level. Increase user based developments in PastureBase Ireland (PBI) (Nitrogen planner, paddock clover score recording) and the integration of the MoSt grass growth model will allow farmers make better grassland decisions at farm level. PBI continues to be highly used at farm level with >132,000 farm covers measured in the system in 2024, 152,000 farm covers were measured in the system in 2023.

Clover pilot farm study

To further promote the use of clover at farm level, in 2020, a group of 36 farmers from across the country were enrolled in the 5-year Clover-150 programme. The farms included a range of land types, geographical spread, climate conditions and farming enterprises. White clover was established on the farms through a combination of reseeding and over-sowing. In 2020, the Clover150 farms had clover on <10% of their milking platform area and by the end of 2023, 64% of the milking platform area had clover, with an average clover content of 23%. Data from the Clover150 farms shows that chemical N fertiliser application in 2020 was 232 kg/ha N and pasture production was 14.4 t DM/ha. By 2023 chemical N fertiliser application declined by 76 kg/ha N and pasture production was 12.9 t DM/ha. In 2020, farm gate N surplus and N utilisation efficiency (NUE) were 194 kg/ha N and 31%, respectively, by 2023, the farm gate N balance had reduced by 54 kg/ha N (to 140 kg/ha N), while farm gate NUE had increased to 36%.

1.9. Restriction of unprotected urea

Promote the use of protected urea

Helping farmers manage the fertiliser purchases and to assess if the optimum mix of N, P, K & S etc. is available to optimise soil fertility and nutrient efficiency on the farm is important to achieve agronomic, economic and environmental sustainability. Grassland yields respond strongly to supplemental nitrogen (N) addition, including from mineral fertilisers. The switching from CAN and straight urea to protected urea is a critical measure in both the greenhouse gas MACC (Teagasc, 2023) and the ammonia MACC (Teagasc 2020) for reducing gaseous emissions to comply with national and international obligations. It is important that this is reflected in all policy and regulations to ensure that there is a rapid switch to protected urea as early adoption will result in greater cumulative reductions in N_2O over the period 2021 to 2030. Automated record keeping at national level provides the verifiable activity data for national greenhouse gas inventory compilation so that farmers can be sure that they can get credit for their use of protected urea and the environmental benefits that accrue from its use.

Protected urea has been shown to have the same agronomic performance as CAN and a greater nitrogen use efficiency compared to urea. Protected urea has verifiable greenhouse gas and ammonia reductions which are included in the national inventories. Support is required by all parts of the agri-food industry to ensure that farmers have access to protected urea and are encouraged to use this technology. Continuing difficulties encountered by farmers in purchasing protected urea needs to be addressed through wider availability of the product. Quality assurance is required to ensure that when farmers purchase protected urea that it complies with all required standards. As more low emission fertiliser products, bio-fertilisers and bio-stimulants come to the market it will be important that there are verifiable emission factors for these fertilisers. The emerging fertiliser technologies need agronomic, environmental and safety factors to be quantified and accounted for. Clearly, there is a need for the regulatory body to ensure that farmers are provided with appropriate, timely and accurate information around the available protected urea products and their approval and potential to be counted within national gaseous emissions inventories. Including a record of fertiliser type on farm in an automated system might provide an opportunity for individual farmers to benefit from being able to demonstrate their own environmental credentials.

Use of unprotected urea fertiliser

The National Air Pollution Control Programme indicates a cap on unprotected urea use of 30,000 tonnes of N nationally. This will limit straight urea use on farms from the current levels used in recent years (41,368 tonnes N as urea sold in 2024). Unprotected urea can be used in certain circumstances with comparative grass and crop yield performance to other N sources. When straight urea is incorporated into the seed bed (soil) at planting time for spring crops it has been shown to be a reliable source of N for the developing crop and has low ammonia and GHG emissions associated with it. Similarly, when urea is applied to grassland soils with sufficient moisture levels to help urea movement into the soils or during weather conditions that are conducive to low ammonia emissions, typically in spring, it can achieve similar agronomic performance to other N sources.

It is important the use of straight urea does not contribute to significant quantities of ammonia emissions being recorded in the national inventory. Under the UK regulations, the use of straight urea is constrained to the spring in an effort to reduce ammonia emissions. For Ireland, to implement a similar policy, research is required to develop emission factors for unprotected urea that differentiate between the season of use or method of application e.g. incorporation.

Urea in liquid form (Liquid N fertiliser)

On grassland, the use of urea in liquid forms (also referred to as liquid N) such as urea ammonium nitrate (UAN), acidified liquid urea, or solid urea fertiliser which is dissolved in water, has grown on farms in recent years. The application of urea and ammonium-N in different liquid N formulations can lead to improved accuracy in application of N, which will also benefit water quality and the protection of biodiverse habitats along field boundaries. Ongoing Teagasc research on UAN and acidified liquid urea applied to grassland indicates that these liquid N formulations can achieve similar grass DM yield as solid fertiliser N forms. Early results indicate the these two liquid N formulations may have benefits in terms of GHG emissions, with lower nitrous oxide emissions compared to CAN, and potential for lower ammonia emissions compared to straight urea (granular form). More research is required to confirm these results over multiple years and across different soil types before drawing any final conclusions from this work. Research is also needed to investigate the agronomic and gaseous emission performance of solid urea fertiliser dissolved in water.

On arable crops the use of urea ammonium nitrate (UAN) can allow more even application of N than can be achieved with granular materials particularly at wider bout widths and in less favourable conditions (raining or windy within limits). This can be particularly important for larger growers who typically work at wider bout widths and are often obliged to apply in conditions where wind might make even application of solid fertiliser more difficult. Uneven application of N will lead to reduced efficiency of use of fertiliser N particularly in the areas receiving excess N. There can be environmental benefits to the use of UAN also as there will be a sharp cut-off at the field edge with little or no fertiliser ending up in the field margin or beyond which can be difficult to achieve with granular fertilisers. There is a risk of loss of N due to ammonia volatilisation but as urea comprises at most 50% of the N in UAN the risk is substantially reduced compared to granular urea, at the same N application rates. In addition urease inhibitor products suitable for use with UAN are available and can be mixed with the UAN at the time of application where the conditions at application give rise to high risk of ammonia volatilisation. Where significant loss of N via volatilisation does not occur the efficiency of UAN is similar to that of CAN.

Part 2. Response to proposed new Non-regulatory measures

2.1. Teagasc-led "Better Farming for Water" Campaign

The Teagasc led Better farming for Water campaign is using a multi-actor (farmers, advisors/researchers, agri-food industry, community, government) approach to support farmers will ensure that challenges and solutions to address local water quality are delivered at farm, catchment and regional scale

The key impacts of the Better farming for Water campaign include:

- Enhance farmers' knowledge of local water quality and pollution pressures
- Reduce nutrient, sediment, pesticide and pathogen loss to water bodies
- Reduce the number river water bodies with agriculture as a significant pressure
- Increase the proportion of river water bodies achieving high/good ecological status

2.2. Inspections and other enforcement activity to build compliance

The Teagasc led "Better farming for water" campaign will engage farmers in relation to adequate organic manure storage and the sustainable management and application of organic manures to soils. The aim is to make farmers aware of the regulatory requirements and to support farmers to take steps to have sufficient organic manure storage capacity and to utilise the nutrient resources efficiently and sustainably.

Teagasc advisors are often requested by farmer clients to support on farm inspections and this can place additional pressure on advisory services during busy periods of the year. When the Local authority (LA) target a catchment for inspections a small number of advisors may receive multiple requests for support in a short time frame to assist farmers in responding to the LA's inspection query. Teagasc requests that a reasonable time frame of at least 20 days is provided for the LA to receive a response to a request for information. This time frame is necessary for advisory services to have sufficient time to deal with each request on a farm-by-farm basis.

2.3. Improving Organic Manure Storage Capacity

Research on slurry production and slurry storage requirements

Adequate slurry storage on farms is critical to enable the correct slurry application rates to soils during appropriate weather and soil conditions. This will help farmers to manage this valuable nutrient resource more efficiently and help to protect water quality. In the Republic of Ireland, current regulations require 0.33 m^3/cow/week for slurry storage and 0.21 m^3/cow/week for soiled water storage (SI 113 of 2020). Preliminary findings are emerging from a Teagasc nationwide monitoring programme, which was established in the first half of 2023, involving 100 dairy farms selected to represent variability in location, climate, scale, stocking density and developmental stage. These findings are suggesting that in winter 2023/2024, slurry tanks collected an average of 0.414 m^3/cow/week, while soiled water tanks collected an average of 0.30 m^3/cow/week in peak months (Tuohy, personal communication). However, the monitoring programme noted that a significant volume of water, estimated at 20-40 L/cow/week (0.02-0.04 m^3/cow/week) equivalent on average, is entering storage tanks. If these rates were to be adopted, slurry storage requirements would increase by approximately 20%, while soiled water storage requirements would increase by approximately 33%, outside of allowances for rainfall runoff. The dataset is incomplete and any summary analysis is preliminary in nature and should not be interpreted as the final outcome of the study. While the findings will inform policy decisions related to storage requirements, any changes to current regulations will involve consideration of various factors beyond the scope of this study. More data is being collected to provide a full understanding of overall volumes collected in this study and will be available later in 2025.

Ensuring slurry storage capacity and best management of organic manures

Livestock manure is a valuable nutrient source that is routinely recycled back to soils on farms. In order to increase the efficiency and enhance the environmental sustainability of manure management on Irish farms, all aspects of the manure management chain need to be considered. First farmers should assess their livestock manure storage requirements to ensure they have the required capacity to store the quantities of this valuable resource produced over the winter closed period and the nutrients it contains. In order to protect water quality, manure storage and collection facilities, including yards etc., must be in good working order and managed in a manner that nutrient loss through runoff or leakage does not occur. When this manure is being recycled back to grassland soils during land spreading, it should be applied during the spring period to soils with the largest nutrient requirement, minimising the total requirement for chemical fertiliser. Finally, the use of low emission slurry spreading (LESS) methods will minimise potential N losses during land-spreading and reduce the ammonia emissions associated with slurry. These best management practices for livestock manure can be implemented on farms to minimise environment impact and are described further as follows.

Slurry storage capacity - ensure storage capacity matches planned stock numbers

The requirement for slurry storage for farmers is outlined in the GAP Regulations (SI 605, 2017), Part 2, sections 5 – 14 and schedules 3 & 4. The regulations require farmers to have in place sufficient organic manure storage for all livestock over the winter housing period. The location of the farm (Closed spreading period zone) and the number of livestock over the winter period determines the volume of storage required. The Teagasc NMP-Online system includes calculations to advise the volumes required for an individual farm and will indicate if there is sufficient storage available for the livestock on a farm. Further clarity is required for assessment and calculation of farmyard manure (FYM) storage requirements to enable farmers and advisors to assess their total manure (slurry, FYM and soiled water) storage requirements for their farm. In addition, promoting compliance with the regulations and best practice e.g. applying spring slurry applications on low risk fields for nutrient transfer, through advisor/ farmer engagement and other Knowledge Transfer mechanisms, is the best way to ensure impacts on the environment from nutrient loss are minimised, this is a key objective of the Teagasc led “Better farming for water” campaign. This also ensures that slurry tanks are emptied in good time and that maximum slurry storage is available on farms at the start of the closed period for slurry spreading.

Periods when slurry applications are prohibited

Compliance with organic manure storage conditions also ensures that farmers can comply with the requirements of the GAP Regulations (SI 605, 2017), Schedule 4; Periods when application of fertilisers to land is prohibited. Full compliance by farmers with these requirements ensures that the majority of organic manures are applied at appropriate times (early in the growing season when plant nutrient demand is highest) and reduces risk of nutrient losses to waters as well as offsetting chemical fertiliser inputs.

Increased slurry storage capacity will be required on many farms where slurry is produced between mid-September and mid-October. Building this additional storage will lead to significant costs on some farms. This situation may arise in confined indoor livestock production systems, where indoor buffer feeding is provided to livestock or were on-off grazing management is practiced during periods of inclement weather in an attempt to extend the grazing season and protect soils and the environment. Recent research shows that when cattle slurry is applied in early October under good soil conditions and when grass is actively growing that it presents lower risk for nutrient loss compared to chemical fertilisers and other manure types (Herbert, et al., 2021).

Covering of slurry stores leading to reduced ammonia emissions

This measure is currently accounted for in the national emission inventory by using the percentage of covered vs uncovered stores observed in the facilities survey (Hyde et al., 2008) and the emission factors associated with both types of slurry stores. By recording activity data on the percentage of covered vs uncovered stores for future years, the associated ammonia mitigation will be reflected in the national emission inventory.

A clear definition of open slurry stores is required. Currently the majority (67%) of bovine slurry is stored in slatted tanks which are classified as 'covered', with the remainder stored in uncovered tanks, such as open over ground tanks (30%) (EPA, 2019). Fitting a slurry store with a cover significantly reduces ammonia emissions (Sommer et al., 2006). There are different types of covers, such as the natural crust formed on the slurry surface, straw, floating expanded clay balls and other floating materials, flexible covers and rigid roofs. The range of materials used as covers are associated with different levels of efficacy in their capacity to abate ammonia emissions. While tight lid covers exhibit ammonia reduction efficiency of approximately 80% compared to 60% for flexible covers and 40% for floating materials (Resi et al., 2015), there are also considerations around the applicability of different cover types to retrofitting existing and installing in new slurry tanks. Tight lid covers are the most expensive to fit, while flexible covers are lighter and therefore require less complicated engineering solutions, especially to retrofit. However, the conversion from uncovered to covered bovine slurry stores can present difficulties. Depending on idiosyncrasies of individual farm layouts, adaption of existing structure may be logistically difficult in terms of implementation of a flexible floating slurry cover. The costs involved and health and safety aspects for upgrading and covering existing slurry stores may also be significant and need to be considered.

Supporting farmers who previously availed of out-wintering

Farmers with stocking rates between 100-140 kg/ha organic N, who previously availed of reduced manure storage requirements through out-wintering of livestock in accordance with the regulations will need time to put in place the required slurry storage on their farms.

Best management of soiled water on farms

Since the implementation of the GAP Regulations (SI 605, 2017) farmers are obliged to minimise the amount of soiled water produced on their farms from livestock on concrete yards. The best way to achieve this is by a high standard of management at farmyard level to prevent and reduce the level of livestock faecal deposition and dirty yards. However, some production systems such as winter milk herds produce proportionally more soiled water throughout the winter period and routinely apply the soil water produced to grassland when soil conditions are suitable. Recent research across 60 Irish dairy farms shows that soiled water produced on Irish dairy farms contains low levels of nutrients (N and P) and the mean BOD was < 2500 mg/L regulatory limits (Minogue et al., 2015). For example, the annual soiled water produced on a typical Irish dairy farm stocked at 1.9 cows/ha this soiled water could supply approximately 13.1 & 1.7 kg/ha N and P respectively. This system of applying soiled water to land throughout the year has helped to prevent soiled water being added to slurry, especially over the winter period, and has enabled farmers to maintain sufficient slurry storage for the closed spreading period according to their zone.

Farm yard management and the minimisation, control and storage of soiled waters is a key part of the ASSAP farm assessment, and part of all farm advisory work when preparing the farm derogation plan using NMP Online. Currently ASSAP advisors engage farmers on a one-to-one basis to provide them with a better understanding of the issues involved. With an improved understanding, farmers are better able to implement and adhere to the GAP requirements on soiled water.

Initial indications from the ASSAP suggest that through improved advisor/farmer engagement and knowledge of issues involved, there is scope for improvements to be made on implementation of existing regulations that will yield a reduction of nutrient loss from farmyards. Additionally there is also potential for ammonia loss reductions from housing and hard standings to be gained from this new advisory intervention on farms.

Soiled water storage

Where additional storage is required, this could be in the form of separate soiled water storage. However, we would suggest that where a farm already has sufficient storage capacity for slurry and soiled water combined, there shouldn't be a requirement for additional separate soiled water.

2.4. Nutrient Balance and Animal Feed sales/ import database

The nutrient balance is specific to each farm and relates to the nutrients moving onto the farm in the form of feed, fertiliser, (and if slurry was being imported) versus the nutrients leaving the farm in the form of milk, liveweight, crop produce, feed or slurry if being exported off the farm. The nutrient balance reflects how well the farm is using bought in nutrients and it creates a number/benchmark for farmers to work on/reduce. Teagasc, Bord Bia and ICBF have developed a web based platform called AgNav that can be used to calculate the figure. The balance figure is calculated based on utilising the SDAS information around farm inputs, ICBF animal information as well as data from meat processors, milk processors and marts. All of this information together allows a robust estimate of the farms balance to be calculated. Within AgNav there is a decision support tool to allow farmers to increase their understanding around the impact of changing parameters on nutrient balance. The process of generating the balance number will be rolled out nationally to all beef and dairy farmers who are reducing their balance numbers.

2.5. Multi-species Swards

Results from a lysimeter study in Ireland (Egan et al,. 2025) indicate the strong potential role for plantain (PL) to reduce nitrate leaching from grass-clover swards across a broad range of soils. Strong mitigation effects were evident with 30% plantain in the plantain-grass-clover sward. In another study (Healy et al, 2024) conducted over 3 consecutive years (2020 – 2023) the inclusion of plantain into grassland was also shown to mitigate N leaching. In year one of the study, the swards were in the establishment phase, in years two and three swards were established. Urine was applied to PL and PRG monocultures on both a free draining Cambisol and a poorly draining Gley soil in either autumn or spring for the first two years of the trial. In year 3, urine was applied to the same treatments in either mid or late autumn. Plantain showed no ability to significantly reduce total nitrogen (TN) leached during the establishment year or within spring applications relative to PRG. Established PL (year 2 and 3), within the autumn treatments, consistently reduced TN leached by an average of 22% across the three applications relative to PRG. This study has demonstrated that established (>18 months old) PL monocultures can be utilised to reduce N leaching loss.

A review by Pinxterhuis et al. (2024) also concluded that plantain had strong potential to mitigate nitrogen losses to the environment. In another 2024 review of plantain effects on nitrate leaching, (Eady et al. 2024a) concluded that “many research studies supporting the beneficial impact of plantain do not stand up against scientific scrutiny associated with methodology and interpretation of data”. Follow-up responses to critiques of that study were also published (Eady et al. 2024b).

There is currently an increase in publication of livestock studies of multi-species swards in Ireland and elsewhere (e.g. Roca Fernández et al. 2016; Grace et al. 2018, 2019, Baker et al. 2023, Hearn et al., 2024, Woodmartin et al, 2024, Jezequel et al. 2024), and a review of this literature would be timely. There are also several ongoing research projects that are investigating effects of multi-species mixtures on livestock performance (beef, sheep and dairy). In general, none of these show that multi-species perform worse than grass-clover (at the same nitrogen level), and some show enhanced performance of multi-species swards.

Many of the systems grazing studies have been instrumented with ceramic cups with a standardised method which will allow reporting of nitrate leaching to 1m across a number of farm systems (dairy, beef, sheep), soil types and geographical locations. Further research is needed to inform optimal grazing management of multi-species swards.

Looking to future research needs, there is a need to investigate any additional effects of using multi-species mixtures over a two-species grass-clover combination, and for such investigations to include a range of agricultural and environmental responses. As large numbers of farmers implement multi-species swards, there is a need for a corresponding KT support to ensure that swards are managed according to best practice, and for the evaluation of farmers' experience with the use of multi-species swards. The potential for multi-species swards to enhance resilience to climate change and weather events is relatively unexplored, and of growing importance as one potential farm-scale strategy to promote resilience (Lüscher et al. 2022),

2.6. Modelling the Impacts of Agriculture on Water Quality

Hydrological modelling and modelling the effects of biophysical conditions, climate (and weather) and farm management practices is an active area of research for Teagasc. This research work requires significant resources in terms of staff time and data to constrain and train the models. Models (MoSt, Erin) have been developed by Teagasc to predict nitrogen uptake and cycling in grassland soils and include a prediction of N loss from the root zone. Similar models are not currently available to predict nutrient loss from arable soils.

However, a significant limitation for modelling the impacts of agriculture and the NAP on water quality is that no models currently exist for Irish conditions to link nutrient flux and transformation between the root zone in the soil (1m deep) and the groundwater or ultimately to water body (river, lake etc). Such models are required to better understand the effects of hydrological lag-time on water quality in different catchments with different biophysical and geological contexts and to identify when the effects of changes in management practices will have an effect in the receptor i.e. river, lake, groundwater etc.

2.7. Pilot Project to inform development of the Sixth NAP

The proposed pilot project to implement a framework of measures as set out in the Natura Impact Statement (NIS) to inform the 6th NAP will require significant personnel and time resources. The NIS Framework is high level and a science based process will be required for selecting the effective measures for each of the selected pilot catchments. For this pilot to achieve it aims, significant data and analysis is required to appropriately characterise the issues leading to declining water quality in selected catchments. This analysis and information is required before the selection of potential measures or targeted advisory programmes to help improve water quality could take place. With just 12 months until the 6th NAP will be implemented, there is limited time for developing an evidence base for effective measures.

2.8. Updating calibrations for national soil tests:

Review of research on soil test methodology for phosphorus

The Morgan extractable P test is currently the approved national soil test for estimating soil P availability under the NAP. Morgan's is designed for acidic soil conditions and the extractant is buffered to a low pH. Morgan's P provides a satisfactory indication of bioavailable P for plant growth on acidic mineral soils with relatively low pH (<7.0), however, in certain circumstances i.e. calcareous or soils with high pH levels, it does not always provide a satisfactory estimate of P availability to inform fertiliser and manure management decisions on farms. On high soil pH soil the Morgan's P test can over-estimate the levels of P availability. Therefore, the resulting soil test information and corresponding advice for such soils and fields may not be accurate.

A suitable alternative candidate soil P test the Mehlich-III has been evaluated by Teagasc Johnstown Castle and may provide additional benefits for general soil test efficiency in that it is an efficient multi-element soil extracting solution. Mehlich-III can also be used to provide information on soil P buffering and be used to provide indications of rates of P build up required by different soil types. However, changing to Mehlich III P test requires a full field calibration data-set (P response curves developed across a range of soil types and environmental conditions for specific crop types) to develop robust critical thresholds. This soil P test calibration data set is required to accurately account of evolving grass/crop productivity due to new varieties and management over time. The calibration information is also required as a basis for developing an appropriate soil test index system based on the alternative soil P test for Ireland.

However, such calibration data for soil tests is not comprehensive across different soils and crop types and is therefore not available, at present, to underpin the adoption of a suitable alternative soil P test for Ireland. New research is required to update soil P response data for grassland and to develop a full calibration data-set for a suitable alternative soil P test e.g. Mehlich III, for Ireland. It is also important so that there is harmonisation between statutory soil testing methods and those used in the National Soil Sampling Scheme (DAFM). Mehlich-III is a key parameter that has been included in this scheme and cannot be fully leveraged to provide improved advice to farmers without the appropriate scientific underpinning.

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