Teagasc submission made in response to the Consultation Paper on

Interim Review of Ireland's Nitrates Derogation 2019

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Introduction

This submission was made in response 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 the Interim Review of Ireland's Nitrates Derogation Programme in 2019. It has been prepared by Teagasc's Water Quality Working Group in consultation with the Gaseous Emissions Working Group. These working groups have members 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 Food (DAFM), the Research Stimulus Fund (administered by DAFM), INTERREG, Science Foundation Ireland (SFI) 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 the final year of its third 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) which support Irelands Nitrates Derogation.

This submission considers developments in farm practices that have potential to positively impact water quality, but also on greenhouse gas (GHG), ammonia and habitats & biodiversity published since the last NAP. Technological and management changes impacting on farm productivity and environmental sustainability are reviewed. Teagasc has responded to the guiding questions posed in the public consultation document and proposes how the 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).

Teagasc has adhered to three 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.

Responses to public consultation questions

Responses to the five questions put forward in the public consultation are as follows. Here we summarise the latest knowledge and propose what amendments, technologies and KT methods and supports are needed to achieve positive outcomes to these questions and to support Ireland's Nitrates Derogation. 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.

Question 1. Our livestock systems are based on the maximum utilisation of grassland. How can we increase the efficiency of grassland management on derogation farms, while protecting the environment?

Irish livestock systems are based on utilizing grass herbage, particularly grazed herbage, as the main feed source conferring many production, environmental and economic benefits to the overall production system. In order to maintain or further enhance the sustainability of these grass based farming systems, grass herbage production needs to be measured and managed to ensure its utilisation is maximised (Response 1.1). Fertilisers used on grassland farms must be sustainably managed to ensure they are efficiently used to increase grass production levels. This can be achieved by basing fertiliser application decisions on farm specific soil sampling results and tailored fertiliser and lime plans (Response 1.2). Increased fertiliser nitrogen (N) use efficiency (NUE), in addition to other milk production benefits, can be achieved by incorporating clover into grassland swards (Response 1.3), while cow N excretion rates can be reduced by optimising the crude protein (CP) and feeding rates of concentrate feed to grazing herds while at pasture (Response 1.4). These practical technologies and best management practices can be implemented on derogation farms to increase the efficiency of grassland management and simultaneously protect the environment. The benefits of these practices are further outlined as follows.

1.1. Promotion of grass measurement and management (Pasture Base Ireland)

Pasturebase Ireland (PBI), developed by Teagasc, is the national grassland database, currently it has >6,000 users. PBI has seen an increase in grass cover measurement by 50% so far in 2019, weekly farm cover measurement is close to 1400 farm covers completed weekly. 85% of users are dairy farmers with 10% beef and 5% sheep farmers. A large proportion of dairy farmers using the system already receive a Nitrates Derogation. PBI is both a decision support system and a grassland database. Users can complete a farm grass cover, feed budget, spring and autumn rotation planner. In the report section a clear profile of the actual dry matter (DM) production profile of the farm can be interrogated once sufficient farm covers have been completed over the year. The efficiency of the grassland production within farms can be established by users of PBI, and over the last five years mean grass DM production was 13.4t DM/ha. Increasing the level of pasture measurements on farms will allow farmers make better grassland decisions, increase NUE, set benchmarks for their own farms and allow for comparisons across farms. Future developments in PBI will allow apparent NUE on individual farms to be assessed and calculated. Pasture base Ireland can be accessed by logging onto www.Pbi.ie.

1.2. Soil sampling & nutrient management planning for optimum soil fertility on farms

Farms receiving a Nitrates Derogation are required to take regular soil samples (every 4 years, with maximum area of 5 ha per sample) to monitor soil fertility changes over time. This is a key part of efficient nutrient management planning as these soil test results guide nutrient application rates and timings. It is essential that soil samples are taken correctly and Teagasc has a team of trained professional soil samplers, associated with their regional advisory offices, to ensure representative and reliable soil test results are produced for fertiliser planning purposes. In addition it is critical that the correct laboratory soil testing methods are used (those that have been calibrated to the national nutrient advice for grassland a crops in the Teagasc "Green Book" (Wall and Plunkett 2016)), that are approved in the NAP.

Optimising the soil pH to ≥ 6.3 through the application of lime on acidic mineral grassland soils is a critical step in correcting soil fertility and ensuring efficient use of the N, P & K nutrients applied as fertilisers and organic manures. At optimum soil pH the soil N supply capacity of grassland soil is maximised and the uptake and efficiency of fertiliser N is improved. In addition at the optimum pH the availability of soil nutrients for grass uptake is increased and the efficiency of freshly applied P as either slurry P or chemical P (Shiel, et al, 2015). Where soils are maintained within the optimum soil pH range productive grass species and clover persists for longer and higher overall NUE can be achieved, especially where N fertilisers are appropriately managed. Improving NUE is a key measure in both the greenhouse gas and ammonia MACC analysis. The improvement of soil fertility on derogation farms can reduce emissions where N fertiliser is reduced to account for the associated additional yields.

Advisory services nationally utilise the Nutrient Management Planning (NMP)-Online system, developed by Teagasc, which has the capacity to generate a farm liming programme on a field by field basis. This system and the lime planning function will be promoted by Teagasc KT and advisory services to ensure that farmers receive practical and easy to understand liming advice for their farms. Soil pH should be optimised in the first 3 years of completing a Fertiliser Plan. Correcting soil pH to the optimum level has the potential to increase grass production by on average 2t DM/ha and offers a return on investment of 7:1 (€7 return in grass growth and nutrient efficiency for every €1 invested).

The application of N, P & K fertiliser on farms needs to be planned and delivered as an annual programme for individual farms showing the right product, right rate, right time and right place. Teagasc is developing sustainable fertiliser programmes which will be delivered through NMP-Online that will guide the right fertiliser product to the right place (field) at the right rate, right fertiliser form and the right time (4 "R" strategy for fertiliser advice and use). These sustainable fertiliser programmes aim to provide farmers with the necessary advice to achieve recommended nutrient applications in an economically and environmentally sustainable manner as possible.

More advisor time is required in the preparation of Fertiliser Plans and the updating of Fertiliser Plans during the growing season to take account of soil, weather and grass growing conditions. Administering best nutrient advice on farms is especially critical in spring when soils are colder and wetter and there is increased risk of water movement from the soil to ground and surface waters. Advice will ensure farmers make informed decisions in relation to fertiliser and manure applications which have been proven to yield production, environmental and economic benefits. In 2020 Teagasc plan to launch weekly N fertiliser advice particularly focused on spring grass and this will provide advisors and farmers with improved advice which takes account of predicted growing conditions.

Other actors (Merchants / Co-Ops / Fertiliser sales personnel) giving fertiliser advice should be appropriately trained in sustainable nutrient management advice and have access to the farmers fertiliser plans generated with NMP-Online. The Teagasc ConnectEd programme can be leveraged to reach these other actors with information and training in relation to sustainable fertiliser planning and advice. This would enable better tailoring of fertiliser programmes in line with fertiliser product ranges that are available in different locations and helping to ensure the efficient and compliant use of applied N, P & K.

Teagasc generates regular communications (Phone / Social media / campaigns e.g. Grass 10/ newsletters and popular press) with farmers on the most suitable timings (weather / soil conditions) during the key months for fertiliser and nutrient applications on farms and will promote sustainable nutrient management practices in future. Additionally, targeting training opportunities in Nutrient Management focusing on reducing loss pathways and improving efficiency could play a significant role in achieving required improvements.

1.3. Promoting the inclusion of clover in grassland seed mixes and at reseeding time on farms

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 of dairy cows) 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.

There are, however, challenges with the adoption of white clover on dairy farms. The use of white clover is not widespread on derogation farms or on farms in general, and may not be suitable for use on all farms on all soil types. The uptake of white clover by farmers has been poor as it has a reputation for (i) variable production from year to year, (ii) poor growth in spring, and (iii) for being difficult to manage. The latter includes difficulties such as maintaining sward white clover content from year to year, potentially a greater need for reseeding, a limited range of grassland herbicides and the risk of bloat in grazing livestock. While research has shown the possibilities for overcoming these obstacles through improved grazing management, over-sowing swards to maintain white clover content and the use of bloat prevention technologies, further work is required to convince farmers of the benefits of white clover from an environmental and productivity point of view. Recent research is showing that well managed clover swards are persistent (+ 6 years) and has consistent production from year to year. Ensuring that small and medium leaved white clover cultivars are sown can minimise the potential negative effects in the spring growth and promote persistency in grazed sward.

1.4. Optimise crude protein and feeding levels of concentrate feed

The crude protein requirement of a 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 1% (Shalloo, 2019). 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 12 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. It is also recommend not to feed more than 500kg of concentrate per cow in a grass based system with the overall feed supply and demand of grass matched on a per hectare basis.

Question 2. How can livestock manure be best managed to ensure its impact on the environment is minimised?

Livestock manure is a valuable nutrient source that is routinely recycled back to soils on grassland 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 (Response 2.1). 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 (Response 2.2). 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 (Response 2.3). 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 (Response 2.4). These best management practices for livestock manure can be implemented on farms to minimise environment impact and are described further as follows.

2.1. 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 is designed to calculate the volumes required for an individual farm.

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 the existing requirements ensures that organic manures are applied at appropriate times and reduces risk of nutrient losses to waters. Farmers should assess any concerns about adequate organic manure storage requirements on their farms in consultation with their agricultural advisor. Promoting compliance with the regulations and best practice e.g. apply 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.

2.2. Maintenance of farm yards and slurry storage facilities to minimise point nutrient losses

As per 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 farm yard level to prevent and reduce the level of livestock faecal deposition and dirty yards.

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.

2.3. Better manure application management and timing to improve nutrient efficiency

Slurry is an important source of nutrients (N, P & K) and its effective recycling back to grassland is essential to replenish soil fertility levels. To maximise the nutrient value of cattle slurry and reduce N losses to air a number of decisions must be made. First, ***where*** on the farm should slurry be applied to maximise P and K availability and use efficiency? Secondly, ***when*** is the most efficient time to apply slurry to maximise N recovery? Thirdly ***what method*** of slurry application to maximise the N recovery and reduce ammonia emissions (discussed in 2.2 above). The targeted application of slurry in spring, based on soil test results, will ensure the most efficient use of slurry nutrients for grass production and minimise potential NH_3 losses from occurring.

The official nutrient concentrations in slurry and organic manures are specified in the NAP (SI 605, 2017) and must be used when calculating slurry values for official nitrates derogation purposes. During the application of slurry on farms most farmers use the book values for slurry nutrients when calculating their target slurry nutrient application rates, specific to crops and soil test levels. However, research has shown that the nutrient content of slurry will vary with slurry dry matter and dilution with water (Berry et al., 2012). Knowing the actual nutrient content of the slurry will help ensure that the correct application rates N, P & K are applied to optimise soil fertility and for grass growth for either grazing or silage. Teagasc have calibrated the slurry hydrometer which is practical and low cost approach to estimate the slurry dry matter on-farms (Berry et al., 2012, Wall and Plunkett, 2016). Indeed, Buckley et al., 2015 showed that 44% of farmers adjusted slurry application rates post hydrometer use to take account of results. This low-cost and useful tool for estimating the N-P-K value will be promoted by KT and advisors to make farmers aware of its benefits and to improve slurry management practice adoption on farms.

2.4. Promote low emission slurry spreading (LESS) methods for reduced ammonia and greenhouse gas emissions

Slurry N losses in the form of ammonia (NH_3) emissions are potentially the largest loss of reactive N on Irish farms (Burchill et al., 2016), with manure spreading responsible for a quarter of all NH_3 losses in Ireland (Duffy et al., 2018). The method of slurry application will have a large effect on these N losses. When applied using LESS methods (i.e. trailing shoe / band spreader) the manure is placed closer to the soil surface or in narrow bands reducing the slurry surface area that is likely to emit NH_3 gas. Shallow injection may also be an appropriate LESS method in some Irish soils which are have flat topography and are stone free. Shallow injection places the manure in shallow slots in the soils further reducing the ammonia emissions. The acidification of slurry during storage or at land-spreading has been shown to be highly effective in other European countries. Further research is needed to assess the potential impacts on soil quality and NUE in Irish soils.

Therefore LESS is an effective technology for abating NH_3 emissions. Teagasc studies show that the efficacy of LESS for reducing N losses is less affected by weather and soil conditions at slurry spreading times compared to the traditional splash-plate application method. Slurry applications during warm, sunny and windy weather such as during summer application, is more susceptible to N loss however, using LESS during these periods (typically post silage harvest) can have the largest NH_3 abatement potential. In such conditions trailing hose and trailing shoe can reduce NH_3 by 40% and 60%, respectively (Dowling et al., 2010), with no negative trade-offs on nitrous oxide emissions (Meade et al., 2011; Bourdin et al., 2014). Simultaneously, reducing NH_3 emissions from land-spreading by switching from splash-plate to trailing shoe increases slurry nitrogen fertiliser replacement value (NFRV) from 30% to 40% in spring and from 15% to 25% in summer (Wall & Plunkett, 2016) leading to GHG emission reductions where N fertiliser are optimised in conjunction with LESS. The adoption of LESS has the potential to help improve farm NUE and reduce on-farm N surpluses.

Question 3. How should agricultural impact on soil be minimised on derogation farms?

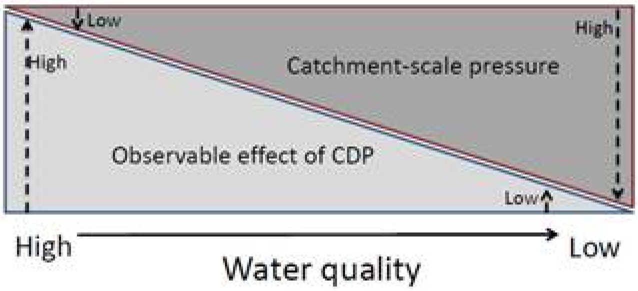
Our agricultural soils are a critical resource and underpin grass-based livestock production systems. In order to protect the quality and production potential of grassland soils and to minimise nutrient leakage, farmers can implement a number of practices where appropriate. The use of on-off grazing to extend the grazing season and increase fresh grass in the animal's diet is a proven technology which protects the soil from severe poaching and structural damage (Response 3.1). Improving the farm infrastructure such as fencing of streams (Response 3.2), the correct placement of water troughs and the design and management of farm roadways further protect soils and minimise potential nutrient losses, especially through runoff, to surface waters (Response 3.3). The correct drainage of wet mineral soils can also help to increase grassland production potential of farmland while reducing the potential greenhouse gas (nitrous oxide) emissions, especially where N fertilisers and manures are being applied to managed farmland (Response 3.4). The benefits of these practices are further outlined below.

3.1. Promote on-off grazing to avoid poaching of grassland soils

Maximising dairy cow performance from grazed pasture remains a key objective of pasture-based systems of dairy production. Dillon et al. (1995) highlighted the superiority of grazed grass relative to grass silage in terms nutritional value and lower production costs where dairy production systems are predominantly based on a combination of grazed grass, grass silage and concentrate. The greatest potential to increase the proportion of grazed grass in the diet of spring-calving dairy cows exists at the beginning and end of the grass-growing season (i.e. early spring and late autumn). A number of previous studies have observed increased animal performance in early lactation when animals are given access to spring grazing (Dillon et al., 2002; Kennedy et al., 2005). The ability of farmers to extend the grazing season in spring and autumn will depend on soil type and conditions and prevailing weather (Creighton et al. 2011). Extended grazing also presents risks for grazing systems as soil and sward structural damage caused by excessive treading can reduce long term sward productivity and greatly increase the risk of nutrient losses. Allowing animal access to pasture for a few hours per day has previously been shown to increase milk production and milk protein concentration (Dillon et al., 2002) and may be a strategy that can be implemented during periods of inclement weather. Structural damage of soil due to treading by grazing animals has been shown to reduce herbage DM production by 20–40% (Ledgard et al., 1996; Drewry et al., 2008). Poaching of soils due to animal treading can have detrimental effects on soil physical quality by causing compaction or pugging (Houlbrooke et al. 2008). The timing of N deposition in urine patches is critical to the risk of N loss from soils (Shepherd et al., 2010). When pasture growth is low during autumn and spring, there can be an accumulation of N in the topsoil (Whitehead, 1995), and excess precipitation and drainage resulting in an increased risk of losses (Shepherd et al., 2010). Both Perez-Ramirez et al. (2008) and Kennedy et al. (2009) reported that restricting pasture access time to 4 h daily and using on-off grazing onto a standoff area could be used as a tool to maintain animal performance and improve grazing efficiency and reduce the risk of soil structure loss, while also delivering environmental benefits as some urinary nitrogen can be removed from the pastures at times when risks of N loss are greatest.

3.2. Protect water quality by limiting cattle access to water courses and the correct placement of water troughs

In recent studies investigating the effects of access by cattle to streams for drinking indicates higher levels of sediment downstream of access points by cattle in both catchments with good water quality status or better, those with less than good status compared to control sites with no cattle access (O'Sullivan et al. 2018). Sediment *E. coli* concentrations were significantly higher at cattle access sites than at upstream sites (with no cattle access) in mid-grazing season (in both ≥good-high status sites and < good status sites), with a subsequent general decrease of E. coli levels at the access sites in the post-grazing season (Antunes et al. submitted). Sediment samples collected at the interface of field and stream edge (where cattle had access) had significantly higher phosphorus concentrations than sediment upstream of access point (COSAINT project- preliminary results). However, recent snapshot sampling studies did not demonstrate an increase in water column nutrients (soluble reactive phosphorus, nitrate, and ammonium) as a results of cattle access points (COSAINT project- preliminary results). Water quality (assessed using aquatic invertebrates) in streams with ≥ good status is more susceptible to the impact of cattle access than streams with <good status (Madden et al. 2019) see schematic below.



Indication that sensitive aquatic macroinvertebrates (indicators of improved water quality) increase following short-term and long-term cattle exclusion (COSAINT project- preliminary results).

In the most recent review of the Nitrates Directive - NAP (S.I. 605, 2017) from 1 January 2021 the regulations state that on "holdings with grassland stocking rates of 170kgs nitrogen per hectare from livestock manure or above, bovine livestock shall not be permitted to drink directly from waters". In addition it is stipulated that a "fence shall be placed at least 1.5m from the top of the riverbank or water's edge (as the case may be) by 1 January 2021. It will be permissible to move livestock across a watercourse to an isolated land parcel where necessary, provided that both sides of the watercourse are fenced. However, this will not be permissible for animal access to land parcels on a daily or frequent basis such as with milking dairy cows. In the case of holdings identified in sub-Article 18, supplementary drinking points may not be located within 20m of surface waters from 1 January 2021".

Teagasc KT and advisory services will advise farmers of these rule changes ahead of time to ensure that farmers are aware and take a proactive approach to identifying stream banks that need to be fenced and the siting of new water troughs with the correct set back distances (20m) from streams. These measures will help to protect incidental nutrient and sediment losses to water bodies thus protecting water quality.

3.3. Optimise farm roadway design and management to prevent nutrient losses to surface waters

The role of hard surface areas, outside the farm yard, as sources of stream pollutants generated on farms has received more attention in recent years. These areas usually cover a small proportion of land on grazed grass based dairy farms and are used as roadways for accessing the fields (paddocks) within the farm. The nature of these internal farm roadway areas is usually heavily compacted aggregate to form a solid base to support the weight of the machinery and animal traffic. Water draining from the roadway has potential to discharge directly to dry ditches and waterways if streams are in close proximity to the roadway. Ledgard et al. (1999) noted that approximately 5% of cow excreta N was deposited on roadways in a dairy farmlet trial in Waikato, New Zealand. Monaghan and Smith (2012) reported that farm lanes (internal farm road ways) on dairy farms contributed 12% of annual catchment load of Total P, 1% of the Total Soluble N and 9% of the Total Suspended Solids. The discharge of nutrients to streams during this more sensitive summer period, when stream flows are relatively low and temperatures are warmer, could lead to increased negative effects on water quality and stream ecology. Currently research is being conducted by Teagasc on ten farms to assess the effects of farm roadways on nutrient loss and water quality in Ireland (EPA funded project 0775 – "Roadrunner –Roadway Runoff and Nutrient Loss Reduction"). This work will assess the nutrient loss risks from different types of farm roadways under both frequently trafficking by grazing animals (dairy and drystock) and less frequently trafficked (drystock scenarios).

In the most recent review of the Nitrates Directive - NAP (S.I. 605, 2017) from 1 January 2021 the regulations state that "there shall be no direct runoff of soil water from farm roadways to waters. Teagasc has developed specifications for farm roadways which considers the protection of surface waters from nutrient runoff. On farms with wetter soils the management of water emanating from farm roadways presents some challenges, especially following heavy storm events. Research is being carried out to identify technical solutions for management and polishing of such soiled water. The prevention of direct run-off from farm roadways will help to reduce nutrient losses and negative effects on water quality.

3.4. Improve drainage on heavy mineral soils to maximise grass growth and nutrient use efficiency

In all cases the Environmental Impact Assessment (EIA) for drainage works in Ireland should be followed. Improving drainage on heavy mineral soils lowers the watertable enabling better utilisation at the surface. However, this practice is only applicable to soils where a watertable is present and therefore applicable to only certain landscape positions (e.g. groundwater or surface water gleys). Recent Teagasc research (Clagnan et al., 2018; Daly et al., 2017) on heavy soils has shown that nutrient losses (nitrogen and dissolved reactive phosphorus) occur in all of the major drainage designs in Ireland (i.e. shallow and groundwater designs). Greatest losses occurred from shallow disruption techniques (no watertable) such as mole and gravel mole drainage as they negate the natural attenuation capacity of the soil. Deeper groundwater drains with wide spacing installed to control the watertable proved best and allowed the natural attenuation capacity of the soil to remain in terms of N losses with soil-subsoil chemistry dictating P mobilisation or attenuation in these systems. The main connector for runoff and shallow drainage is within the open ditch network and the chemistry of the sediment and banks are important in terms of offering natural attenuation.

Currently within the GHG MACC presented by Teagasc (Measure 10) drainage of poorly drained mineral soils is a N_2O mitigation measure which could be advantageous in soils where a groundwater system is installed with a watertable control mechanism included to achieve both production and environmental goals.

Question 4. What specific actions can derogation farms take to minimise their impact on the environment?

Derogation farms can enhance their environmental sustainability by engaging with farm advisory services and implement best management advice in terms of fertilisers and nutrient management (Response 4.1), identify areas of their farms with higher nutrient loss risk and observe set back distances for nutrient applications in order to protect water quality (Response 4.2). These farms can minimise ammonia and greenhouse gas emissions by switching to protected urea as their main N fertiliser source (Response 4.3) and adopting LESS methods when land spreading their slurry (Response 2.3). In addition, their biodiversity levels can be enhanced by improving the nature and management of existing on farm hedgerows and by planting trees and new hedgerows where they can give multiple benefits (Response 4.5)**.**

4.1. Increased adoption of NMP-Online fertiliser recommendations and best practice nutrient management guidelines on farms

The preparation of farm fertiliser plans using nutrient management planning online (NMP-Online) will provide field-by-field advice for N, P & K capturing all farm information that impacts on final crop recommendations. These farm specific farm fertiliser plans show soil fertility levels on colour coded maps which easily identifies areas of the farm with high, optimum or low soil nutrient (pH, P and K) status. This valuable information can be used to target cattle slurry to fields that have high N, P & K requirements, for example silage fields and away from fields with high soil P status (i.e. P index 4) or from risky areas for nutrient loss i.e. critical source areas (CSA's). These field-by-field fertiliser plans should be prepared for each derogation farm and discussed with the farmer through an advisory consultation to ensure the efficient use of N, P & K at the correct time during the growing season. On the NMP-Online system these fertiliser plans can be updated or tailored during the growing season. This is important to account for changes in fertiliser product types (following interaction with Agri-merchants / Co-Ops / Fertiliser sales personnel) or fertiliser management due to unforeseen weather events etc.

Greater emphasis on the fertiliser plan recommendations is needed and increasing advisory contact time with derogation farmers to provide follow up advice and guidance during the growing season would increase the efficient use and appropriate timing of fertiliser applications on farms. For example text message alerts in spring time to identify suitable timing of early N applications / reminders to apply additional nutrients to build soil P & K levels, for example apply K in the autumn.

4.2. Identify and manage critical source area's (CSA's) and adhere to set-back distances for nutrient applications

The requirement for buffers / non-application zones for fertilisers are outlined in the GAP Regulations (SI 605, 2017), Part 4, Section 17. These requirements for farmers are aimed to reduce the pollution of waters caused by nitrates and phosphorus arising from agricultural land and farmyards. While the existing set back distances can greatly improve the protection of waters where risks of nutrient loss are present the 'one-size-fits-all' approach needs to be re-examined at field farm and catchment scales on a risk based approach. Using the whole catchment risk based approach for identifying pressures and pathways can be further improved using farm scale assessment of critical source areas and connectivity and has the potential to lead to a more targeted and effective use of setback distances and consequently 'break the pathway' of nutrient (and sediment) losses and would be more cost effective for the farmer. The Teagasc Agricultural Catchments Programme (ACP) has used digital terrain mapping (DTM) developed using LiDAR technology to map overland flow pathways for water and hence the identification of critical source areas for nutrient loss potential (Thomas et al. 2015). While high resolution DTM information (through LiDAR) is not currently available nationally this could be made available in future to aid in identification of CSA's and to guide the optimum location of mitigation measures to break nutrient loss pathways.

Credit should be given to farmers adopting this risk based approach. There also needs to be alignment with other payment schemes so as to ensure farmers are not penalised for implementing this approach through loss of payments due to land eligibility issues. Improvements in management of critical source areas and subsequent water quality improvements could form the basis for future environmental schemes.

4.3. Promote the use of protected urea

Grassland yields respond strongly to supplemental nitrogen (N) addition, including from mineral fertilisers. However, nitrogen loss as ammonia (NH_3) and the greenhouse gas nitrous oxide (N_2O) are negative aspects of N addition which the industry and responsible state agencies are striving to minimise. Promisingly, recent Teagasc research has shown that protecting urea with a urease inhibitor reduces loss of NH_3 to the environment by 79.5% (Forrestal *et al*., 2016). Furthermore, protected urea reduces N_2O losses by 71% compared with ammonium nitrate based fertiliser in Irish grasslands (Harty *et al*., 2016), all without compromising productivity (Forrestal *et al*., 2017). Reduced environmental losses with sustained productivity make protected urea an attractive option for sustaining the productivity of Irish grasslands and reducing environmental impact.

4.4. Promote the use of LESS methods for slurry application on farms

(Refer to 2.3 above)

4.5. Management of hedgerows for shelter and biodiversity

Ireland has a high cover of hedgerows (4%), with the average dairy farm (56ha) having over 6km of hedges. Appropriately managed hedgerows can have multiple benefits, including providing shelter for stock and improving biosecurity; intercepting overland flow and improving water quality; sequestering carbon; and acting as a refuge for biodiversity.
The environmental benefits are dependent on the quantity of these features, but also on their quality. The quality of many hedges is sub-optimal, thus the associated environmental benefits are reduced. However, some simple management practices can improve this quality:

- Leave occasional trees or bushes to mature. Mature trees and bushes provide greater feeding and nesting habitats for birds, pollinators and a variety of insects.
- The sides of hedges should be trimmed, with the top allowed to grow taller. This approach provides greater shelter and stock-proofing for animals, but also improves the diversity of habitats for wildlife.

- Replant escaped or ‘gappy’ hedgerows with native species (e.g. hawthorn, spindle, holly). Native species support a greater abundance and diversity than non-native species.
- Ensure that appropriate management is undertaken outside of the closed period from March 1st to August 31st.
- Plant additional hedgerows and trees where appropriate on farms.

Question 5. Should all intensive livestock farms be subject to the conditions of the derogation whether they apply or not?

5.1. Intensive livestock farms meeting the definition of requiring a derogation

No, a farm should not be classed as intensive unless it meets the definition of needing to apply for and receive a derogation to farm more intensively (i.e. grassland farm with an organic nitrogen loading of between 170 and 250 kg/ha N).

The Eurostat (EU 2014) glossary defines intensive farming as a “farming systems characterized by the significant use of capital and inputs relative to land. Large amounts of capital are necessary to the acquisition and application of fertiliser and pesticides to growing crops, and animal feedingstuff. Optimal use of these inputs produces significantly greater crop yields per unit of land than in extensive farming systems, which use less capital and inputs relative to land area”. They also state that “intensive farming puts a pressure on the environment, due to the high use of inputs. However, the actual effect of the use of inputs on the environment is not only depending on the amount of inputs used but also on how and when they are applied”. Farms receiving a nitrates derogation to farm more intensively fit with this definition.

References

Berry, P.B., Lalor, S.T.J., Wall, D.P., Quinn, J.P. and Frost, J.P., 2012. Comparison of different methods for obtaining representative samples of cattle slurry, Agricultural Research Forum, Tullamore. pp. 31. And at https://www.teagasc.ie/media/website/publications/2010/6094.pdf

Bourdin, F., Sakrabani, R., Kibblewhite, M. G., Lanigan, G. J. 2014. Effect of slurry dry matter content, application technique and timing on emissions of ammonia and greenhouse gas from cattle slurry applied to grassland soils in Ireland. Agriculture Ecosystems & Environment 188: 122-133.

Buckley, C. 2015. The slurry hydrometer - do farmers view it as a useful decision support tool for nutrient management? Teagasc Soil Fertility Conference 2015, Clonmel, Co. Tipperary, 16th October 2015.

Burchill, W., Lanigan, G.J., Li, D., Williams, M., Jumphreys, J. 2016. A system N balance for a pasture-based system of dairy production under moist maritime climatic conditions. Agriculture Ecosystems & Environment 220: 202–210.

Cattle Exclusion from Watercourses: Environmental and socio-economic implications *COSAINT* (ref 2014-W-LS-6).

Clagnan, E., Thornton, S., Rolfe, S., Tuohy, P., Peyton, D., Well, N., Fenton, O. 2018. Influence of artificial drainage system design on the nitrogen attenuation potential of gley soils: Evidence from hydrochemical and isotope studies under field-scale conditions. Journal of Environmental Management 206, 1028-1038.

Colmenero & Broderick 2006 Journal of Dairy Sci 89:1704-1712.

Creighton P., Kennedy E., Shalloo, L.., Boland T.M. and O'Donovan M. (2011) A survey analysis of grassland dairy farming in Ireland, investigating grassland management, technology adoption and sward renewal. Grass and Forage Science, 66, 1–14.

Daly, K., Tuohy, P., Peyton, D., Wall, D., Fenton, O. 2017. Field soil and ditch sediment phosphorus dynamics from two artificially drained fields on poorly drained soils. Agriculture Water Management 192, 115-122.

Dillon, P., S. Crosse, B. O'Brien, and R. W. Mayes. 2002. The effect of forage type and level of concentrate supplementation on the performance of spring-calving dairy cows in early lactation. Grass Forage Sci. 57:212–224.

Drewry, J.J., Cameron, K.C. and Buchan, G.D. 2008. Pasture yield and soil physical property responses to soil compaction from treading and grazing — a review. Soil Research, 46, 237–256.

Dowling, C. and Lanigan, G.J., 2008. The Effect of Application Technique and Climate Conditions on Ammonia Emissions from Cattle Slurry. In: V. Koutev (Editor), 13th RAMIRAN International Conference, Albena, Bulgaria.

Duffy P. Duffy, P., Hyde, B., Ryan, A.M., Alam. M.S. 2018. Ireland Informative Inventory Report 2018. Air Pollutant Emissions In Ireland 1990–2016 Reported To The Secretariat Of The UN/ECE Convention On Long-Range Transboundary Air Pollution And To The European Union. EPA, Johnstown Castle, Wexford.

Egan M, Galvin N and Hennessey D. 2018. Incorporating white clover (*Trifolium repens* L.) into perennial ryegrass (*Lolium perenne* L.) swards receiving varying levels of nitrogen fertilizer: Effects on milk and herbage production. Journal of Dairy Science, 101:3412-3427.

Enriquez-Hidalgo D, Gilliland TJ, Egan M, Hennessy D. 2018. Production and quality benefits of white clover inclusion into ryegrass swards at different nitrogen fertilizer rates. The Journal of Agricultural Science 156,378–386.

Forrestal, P.J., Harty, M.A., Carolan, R., Watson, C.J., Lanigan, G.J., Wall, D.P., Hennessy, D., Richards, K.G. 2017. Can the agronomic performance of urea equal calcium ammonium nitrate across nitrogen rates in temperate grassland? *Soil Use and Management* 33:243-251. doi: 10.1111/sum.12341.

Forrestal, P.J., Harty, M., Carolan, R., Lanigan, G.J., Watson, C.J., Laughlin, R.J., McNeill, G., Chambers, B. and Richards, K.G. 2016. Ammonia emissions from urea, stabilised urea and calcium ammonium nitrate: insights into loss abatement in temperate grassland. *Soil Use and Management*. 32: 92-100. doi: 10.1111/sum.12232

Harty, M.A., Forrestal, P.J., Carolan, R., Watson, C.J., Hennessy, D., Lanigan, G.J., Wall, D.P and Richards, K.G. 2017. Temperate grassland yields and nitrogen uptake are influenced by fertilizer nitrogen source. *Agronomy Journal*. 109: 1-9. doi:10.2134/agronj2016.06.0362.

Hennessy, D., McAuliffe, S., Egan, M. and Ruelle, E. (2019) What is the effect of incorporating white clover (*Trifolium repens* L.) into grazed grassland on the farm-gate nitrogen balance? Grassland Science in Europe, Volume 24, *in press.*

Houlbrooke DJ, Littlejohn RP, Morton JD, Paton RJ 2008. Effect of irrigation and grazing animals on soil quality measurements in the North Otago rolling downlands of New Zealand. Soil Use and Management 24: 416-423.

Humphreys J., Phelan P., Li D., Burchill W., Eriksen J., Casey I., Enriques-Hidalgo D. and Soeegaard K. (2017) White clover supported pasture-based systems in north-west Europe, pages 139-156. In: Legumes in Cropping Systems. D. Murphy-Bokern, F.L. Stoddard and C.A. Watson (Eds.). CAB International 2017.

Kennedy E., McEvoy M., Murphy J.P. and O'Donovan M. 2009. Effect of restricted access time to pasture on dairy cow milk production, grazing behaviour, and dry matter intake. Journal of Dairy Science, 92, 168–176.

Ledgard S.F., Thom, E.R., Singleton, P.L., Thorrold, B.S. and Edmeades, D.C. 1996 Environmental impacts of dairy systems. Proceedings of the 48th Ruakura Farmers' Conference, pp. 26–33.

Ledgard, S.F., Penno, J.W., Sprosen, M.S., 1999. Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertilizer application. J Agric. Sci., Camb. 132, 215–225.

Madden, D., Harrison, S., Finn, J.A. & Ó hUallacháin, D (2019) Cattle access drinking points on streams: impact on water quality parameters*. Irish Journal of Agriculture and Food Research* 58, 13-20.

McClearn B, Gilliland TJ, Delaby L, Guy C, Dineen M, Coughlan F and McCarthy B. 2019. Milk production per cow and per hectare of spring calving dairy cows grazing swards differing in Lolium perenne L. ploidy and Trifolium repens L. composition. Journal of Dairy Science (*In Press*).

Meade, G., Pierce, K., O'Doherty, J.V., Mueller, C., Lanigan, G. and Mc Cabe, T., 2011. Ammonia and nitrous oxide emissions following land application of high and low nitrogen pig manures to winter wheat at three growth stages. Agriculture Ecosystems & Environment, 140: 208-217.

Monaghan, R.M. and Smith L.C. 2012. Contaminant losses in overland flow from dairy farm laneways in southern New Zealand. Agriculture, Ecosystems and Environment 159,170–175.

Nui et al. 2016. Animal Production Science. 56, 312-321,

O'Sullivan, M., Ó hUallacháin, D., Jennings, E., Antunes, P. & Kelly-Quinn, M. (2019) The impacts of cattle access points on deposited sediment levels in headwater streams in Ireland. *River Research and Applications*. 35, 146-158.

Perez-Ramirez, E., R. Delagarde, and L. Delaby. 2008. Herbage intake and behavioural adaption of grazing dairy cows by restricting time at pasture under two feeding conditions. Animal 2:1384–1392.

Reid et al. 2015. Journal of Dairy Science. 98 (1): 517-531)

Shiel, T., Wall, D.P. and Lalor, S.T.J, , 2015. Lime and phosphorus for maximum productivity, *Proceedings of the* Fertiliser Association of Ireland Spring Scientific Meeting –Profiting from Soil Fertility, 50, 3-14

Shepherd, M. A., V. Snow, P. Phillips, and C. Glassey. 2010. The effect of time and rate of deposition of synthetic dairy cow urine on subsequent nitrate leaching from pasture in the Waikato region of New Zealand. Pages 174–181 in Farming's Future: Minimising Footprints and Maximising Margins. L. D. Currie and C. L. Christensen, ed. Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.

Wall, D.P. & Plunkett, M. (eds). 2016. Major and Micro Nutrient Advice for Productive Agricultural Crops. 4th Edition. Teagasc, Johnstown Castle, Environment Research Centre, Wexford.

Whitehead, D. C. 1995. Mineralization, immobilization and availability of nitrogen in soils. Pages 108–128 in Grassland Nitrogen. D. Whitehead, ed. CAB International, Wallingford, UK.