Teagasc submission made in response to the Consultation Paper on

4th Review of Ireland's 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 the 4th Review of Ireland's Nitrates Action Programme in 2020. 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 (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 its fourth 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 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 affecting farm productivity and environmental sustainability are reviewed. Teagasc has responded to the guiding questions 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.

Teagasc modeling of impact of farm nitrogen mitigation measures to deliver catchment based nitrate load reduction estimated by EPA

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 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.

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” on 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 tailored advice across the year depending on grass growth and weather conditions. PastureBaseIreland and the grass growth prediction model (MOST) allows this dynamic advice to be provided on an on-going basis and should be part of future strategies to reduce nitrate loss.

Responses 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 non-GAP regulation measures

1.1. Chemical fertiliser Register.

The purpose of the register is to provide for accurate tracking of fertiliser sales and provide a more realistic picture of where fertiliser is being applied to land. It will bring a level of regulation to the industry which is needed to ensure chemical fertilisers are used for optimum efficiency. The proposed new chemical fertiliser register will place the responsibility on merchants to register chemical fertiliser sales against individual farmer's herd numbers. This data will be reported periodically to the DAFM, where it will feed into the Department's analysis of farming activities generally, and more specifically into assessing compliance with the requirements of the GAP regulations.
It is anticipated that the process of developing the legislation to provide for the fertiliser register will take in the region of 18-24 months, with an expected lead-in time of 6 months after publication for full compliance.

Streamlining the process of recording and submitting farm records

The management, maintenance and submission of farm purchase and usage records for fertilisers, and other inputs, in accordance with the GAP regulations presents challenges for farmers and farm advisors in terms of the time demands and administrative burden to complete these tasks throughout the busy farming season and at the year-end prior to submission of these records to DAFM. This process of record keeping needs to be streamlined and a level of automation may provide an avenue for achieving this. Similar to sales records for milk and meat etc. which can be electronically collated and reported, under the proposed fertiliser register, if fertiliser purchases could also be collated electronically removing some of the administrative and time consuming tasks for farmers and advisors.

The proposed fertiliser register facility should provide farmers with information on maximum N 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 done before the end of the closed period. This will allow the purchase of fertiliser in advance to meet crop requirements. A plan 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 and ideally this should be based on a nutrient management plan.

- In planning, farmers are risk averse and fearing penalties, are being cautious – the amount of fertiliser allowed is based on the stocking rate – (livestock units/ha). 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; which could affect fertiliser allowances in the same calendar year. 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.

- Currently if any stock changes take place during the year this will affect the kg/ha Org. N which affects the available N and P permitted on the holding. If stock numbers reduce or increase and puts the farm into a different band for total permitted N or P then the NMP prepared at the start of the year is incorrect. In this situation farmers may need to correct the stocking rate to planned levels and adjust the NMP during the same calendar year to allow the farmer to adjust the chemical fertiliser to be bought for the remainder of the year. However, in practice there is little action that can be realistically taken after the problem is discovered.

- 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 enabling 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.

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, 2018) 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.

1.2. Review of the Agricultural Sustainability Support and Advisory Programme (ASSAP)

The Agricultural Sustainability Support and Advisory Programme (ASSAP) was introduced as a more collaborative approach to achieving positive water quality outcomes for Irish agriculture. Funding from DAFM and DHLGH has enabled Teagasc to provide 20 advisors and funding from the Dairy Processing Co-ops have provided 10 advisors as part of the Dairy Sustainability Initiative (DSI).

There is a commitment in the current programme for government to expand the ASSAP programme, however in order to expand and improve the programme, some clarity is needed on the future role and scope of ASSAP. As a result, an assessment of the programme is currently being prepared by Teagasc to be carried out by a panel of external experts from outside ASSAP. The assessment will focus on the rationale, efficiency, effectiveness and sustainability of ASSAP.

The assessment of ASSAP is due for completion before the end of 2021 and the recommendations will be sent to the Minister

Report on assessment of ASAP

The evaluation of the ASSAP programme has been completed in mid-September by a panel of external experts and a final report will be published by Teagasc in early October.

All farmers in priority areas for action (PAA's) should be notified that they are in a PAA, and informed about the issues with water quality within that PAA. They should also be notified that they can avail of the free ASSAP service.

Part 2. Response to proposed new GAP regulation measures

2.1. Slurry Storage and Management:

The management of organic manure, especially slurry, is an important area for the potential reduction in losses of nutrients to the environment.

For farmers that do not wish to operate in a derogation, or who are at a lower stocking rate the requirement is to retain at least minimum legal capacity, however, reduced manure storage through out-wintering will only be allowed on farms with stocking rate less than 100 kg N/ha.

• *From 1st January 2022 it shall be a requirement that all slurry must be applied by;*

a. *30th September for 2022 for Zones A, B and C*

b. *15th September for 2023 and subsequent years for Zones A, B and C*

• *From 1st January 2023, farmers stocked >170 kg N/ha must demonstrate clear separation of slurry and clean water management in the farmyard.*

• *From 1st January 2022, all newly constructed external slurry stores must be covered. All existing external slurry stores should be covered as soon as practically possible, but no later than 31st December 2027.*

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.

<u>Slurry storage capacity - ensure storage capacity matches planned stock numbers</u>

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 farm yard 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 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.

Under the proposed changes to the slurry application period i.e. shortening by up to 30 days by autumn 2023, 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 period 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).

The earlier closed spreading date (15th September) for slurry application may also negatively impact slurry import and applications on tillage farms as ploughing and sowing of the main winter cereal crops would not likely commence until later in September or October.

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 of bovine slurry is stored in slatted tanks (67%) 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.

2.2. Soil Water Storage and Management:

The control and management of soiled water from farmyards needs greater emphasis across all delivery mechanisms for the NAP. The addition of soiled water to slurry tanks is causing many of the issues related to storage capacity that are being observed across the country.

It is proposed to address this issue in the following manner;

• *Soiled water must be collected and kept separate to slurry on all holdings,*

• *From 1 Jan 2022 - To reduce the impact of nutrient losses in the riskiest period, the spreading of soiled water will be prohibited between 15th November and 15th January.*

• *All holdings producing soiled water must have a minimum of 4 weeks' storage in place by 31st December 2024.*

Best management of soiled water on farms

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 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

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

2.3. Livestock excretion rates:

The excretion rate of all livestock categories (As per Table 6 of the regulations) is being reviewed as part of the NAP following the most recent increase in the annual livestock nitrogen excretion rate for the dairy cow (from 85 kg/ha organic N to 89 kg/ha organic N). Additionally, the EU Commission have raised issues with Ireland's approach of a single organic output figure and have requested Ireland to evaluate allocating an excretion factor to the dairy cow based on milk yield.

DAFM has undertaken some preliminary analysis and provisionally estimate that if banded against annual milk yield, dairy cows would produce an organic output per cow as follows:

Band 1 <4,500kg = 80 kg Organic N/ha

Band 2 4,501 to 6500 kg = 92kg Organic N/ha

Band 3 > 6,500kg = 106 kg Organic N/ha

It is proposed to introduce these new excretion rates in a phased manner into Table 6 of the new Good Agricultural Practice Regulations, commencing on 1st January 2022.

Representing future dairy cow excretion rates in a planned manner

The modelling of N excretion rates for dairy cows requested by DAFM is outlined in the report https://www.teagasc.ie/media/website/publications/2021/Nitrates-Modelling-Final.pdf. The banding system included in the nitrates consultation document included three categories based on kg of milk delivered. There can be significant year-to-year variation in milk yields. Therefore, a three year rolling average should be used to calculate a farms milk deliveries per cow. Banding will result in significant change for a numbers of farmers, ideally as stocking decisions are made at least a year in advance, a lead-in period for stocking rate changes may be necessary.

2.4. Dairy Industry N reduction initiative:

The Dairy Sustainability Ireland (DSI) Working Group has commenced a project to look at options for driving N reductions at both national and catchment scales.

The project is at its initial stages at present and its main focus is on:

- Driving improvements in slurry management,
- Promoting compliance with GAP reg's requirements,
- Change Management Strategy to drive N reductions,
- Communications/knowledge transfer programme, linked to ASSAP,
- Major behavioural change programme around slurry storage.

Further work on the proposal will continue in the coming months, with input from key stakeholders including Teagasc, DAFM and DHLGH. In order to have an impact the project must have the full commitment of the industry and be adequately resourced before the Nitrates Action Programme is finalised.

Teagasc support for DSI initiative

The NAP consultation proposes to cut in the maximum levels of chemical N. This is aimed at:

- Reducing the losses in N losses in N sensitive catchments leading to water quality improvements in rivers, lakes, estuaries and ground water
- Reducing gaseous emissions from chemical N fertiliser
- Moving towards the Farm-to-fork objective to cut fertiliser and reduce losses of nutrients to the environment.

The dairy industry have outlined areas where they can work with suppliers (farmers) to achieve these objectives while at the same time maintaining or increasing the productive capacity of the sector. The focus of the project is broadly in line with objectives. This includes:

- The improvement in slurry management and application from a spatial, temporal and method of application perspective.
- Providing best advice to farmers in effectively managing the nitrogen applications to optimise output while minimising losses to water and air.

The dairy industry has considerable influence with suppliers and has a broad range of communication channels in place. The commitment to utilise this influence to improve sustainability outcomes and farm incomes is to be welcomed. Teagasc supports this DSI initiative and will be promoting these messages through a number of projects including the ACP, ASSAP and signpost farm programme as well as its mainstream KT activities.

2.5. Chemical Fertiliser Controls:

Updated scientific revisions in the Teagasc Green Book (2016 and 2020) will be included in the next iteration of the technical tables of the regulations where appropriate Additionally, the nitrogen allowances as outlined in Table 12 of the regulations will be reduced by 10% nationally, and potentially up to 15% in some areas based on the EPA catchment assessment report. These areas will be determined by the Nitrates Expert Group and any reductions in specific catchments will be undertaken on a phased basis.

The period when the application of chemical fertilisers to land is prohibited will be extended in Schedule 4 of the regulations. It is proposed to extend the dates when chemical fertiliser application are prohibited as follows

• *In counties Carlow, Cork, Dublin, Kildare, Kilkenny, Laois, Offaly, Tipperary, Waterford, Wexford and Wicklow, from 15th September to 31st January.*

• *In counties Clare, Galway, Kerry, Limerick, Longford, Louth, Mayo, Meath, Roscommon, Sligo and Westmeath, from 15th September to 3rd February.*

• *In counties Cavan, Donegal, Leitrim and Monaghan, from 15th September to 19th February.*

Additional chemical fertiliser allowances for certain tillage crops (Table 16, Schedule 2) will be reviewed.

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

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.

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 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%.

2.6. Sewage/ Industrial Sludge's:

The application of sewage sludge to agricultural land is controlled by local authorities through the maintenance of sludge registers and inspection/enforcement programmes. The control of other industrial sludges (including sludge from dairy processing industry) is managed, where applicable, through IPC licences granted by the EPA. A comprehensive understanding of the movement of sludges and the application of sludges to agricultural land is required to ensure the existing controls are fit for purpose. During the NAP review, the Nitrates Expert Group will be working with the various stakeholders to adequately address the risk from this ever-increasing nutrient source.

Research supporting best management of sludge's land spread on agricultural soils

Teagasc has conducted a number of research studies to evaluate the nutrient, heavy metal and potential contaminant concentrations in different sludge types. This research has investigated effects of land spreading these sludge types on agronomic and environmental indicators and the results and recommendations are summarized as follows.

Dairy processing sludge (DPS)

Worldwide dairy processing plants produce high volumes of dairy processing sludge (DPS), which can be converted into secondary derivatives such as struvite, biochar and ash (collectively termed STRUBIAS). All of these products have high fertiliser equivalent values (FEV, Ashekuzzaman et al., 2021a,b) but future certification as P-fertilisers in the European Union will mean they need to adhere to new technical regulations for fertilising materials i.e. content limits pertaining to heavy metals (Cd, Cu, Hg, Ni, Pb and Zn) and individual European countries have set limits for synthetic organic compounds and pathogens. Research in Ireland has centred on characterising the different types of DPS produced around the country (Ashekuzzaman et al., 2019a,b) and to a limited degree initial work on losses to waters (which were found to be low) after land application has been investigated (Ashekuzzaman et al., 2020). DPS contents depend on product type and treatment processes at a given processing plant, which leads to varied nutrient, heavy metal and carbon profiles. These products are all typically high in nutrients and carbon but low in heavy metals.

In a comprehensive study across nine Irish dairy plants, the concentration of heavy metals (i.e. Cr, Cu, Ni, Pb and Zn) was examined in all major DPS types with lowest concentrations found in DAF sludge and highest in AD sludge (Ashekuzzaman et al., 2019). Overall, the heavy metal concentrations across all tested DPS samples were significantly lower than limits set by the EU for avoiding accumulation in agricultural soil to which sludge is applied (CEC, 2008) and the levels were below those of livestock manure, and composts. The result of the Irish study are in line with the current knowledge on heavy metals content of DPS and indicate that heavy metal concentrations will not be a limiting factor for legal application rate of DPS to agricultural soils (Ashekuzzaman et al., 2019). Further work needs to concentrate on examining their pathogenic microorganism and emerging contaminant profiles in addition to conducting an economic assessment of production and end-user costs related to chemical fertiliser equivalents.

Human sewage sludge (biosolids)

A national survey of sewage sludge was carried out by Healy et al. (2019, EPA report) to characterise the metal characteristics of human sewage sludge (biosolids) spread on land in Ireland and also to examine for the first time some other products such as personnel care products found in these sludges. In addition losses of metals and nutrients as compared with dairy organic fertilisers were explored in field studies (Peyton et al., 2016). The impact of biosolids spread at the maximum application rate on grassland had no adverse impact on surface water quality when compared with other organic wastes. With the exception of Cu in runoff from lime stabilised biosolid treatments, all runoff samples from the biosolid-amended field plots were below their respective surface water standards. The concentrations of metal of the treated sludge from the Waste Water Treatment Plants (WWTPs) examined as part of this study were below the maximum allowable concentrations of metals for use in agriculture in the EU. Personnel care products such as tricolsan or triclocarbon, for which no regulatory standards for sewage sludge exist, were present in the treated sludge from the WWTPs examined. They were below the concentrations measured in other studies; the concentrations of these parameters may, however, vary throughout the year. Under the conditions monitored, metal and E. coli concentrations in the four biosolids were not considered to pose a measurable risk to human health when spread on land, although caution is warranted. While current EU and international regulations govern certain priority metal pollutants and bio-essential elements, other emerging contaminants that are potentially harmful to human health are omitted from the regulations. This means that, potentially, a number of emerging contaminants are being applied to land without regulation.

2.7. Phosphorus Build-up.

The P Build-Up facility is considered an important mechanism to balance soil fertility and achieve optimum nutrient efficiency at farm level. In this context, the annual maximum fertilisation rates of phosphorus on grassland adopting increased P build-up application rates will be reviewed and it is being proposed to include the measure in the next programme and extend this facility to farmers operating above 100 kg N/ha.

Adoption of appropriate phosphorus build-up rates for farmed grassland soils

The decline in soil phosphorus (P) levels and the persistence of these low P levels, when combined with sub-optimal soil potassium (K) and pH levels, has resulted in a situation where approximately 21% of Irish soils that were tested in 2019 had optimum status for all three parameters (Teagasc 2020). While extensively managed soils and those primarily providing enhanced biodiversity value may not need soil fertility levels within the agronomic optimum range, the large proportion of agriculturally managed soils with poor soil fertility status threatens the environmental and economic sustainability of Irish farming as in these sub-optimal conditions N and P use efficiency are reduced. Low overall soil fertility provides a poor return on fertiliser expenditure on nutrients other than that which is deficient, especially fertiliser nitrogen (N), and results in limiting crop growth conditions and increased risk of nutrient loss to the environment. Where strategies to improve N use efficiency such as adoption of grass-clover swards are taking place, low soil P fertility levels are a major limiting factor to maximising the opportunity for clover establishment and persistence. In addition, on grassland soils where N fertilisers and organic manures are being applied, soil with optimum soil test P (STP), i.e. P index 3, have been shown to have lower nitrous oxide (N_2O) greenhouse gas emissions compared to soil with sub-optimal soil P fertility levels (O'Neill et al., 2020). The dual benefits for agronomy and environment from correcting soil P fertility status are critical for the agricultural sector and this improvement must be achieved in a relatively short time frame if Ireland is to meet the targets set out for water quality and greenhouse gases by 2027 and 2030 respectively.

The adoption of appropriate P build-up rates for grassland soils on farm operating above 130 kg/ha organic N in SI 605, 2017 have led to improvements in soil P fertility; in 2017 approximately 63% of farms had sub-optimal soil P fertility i.e. P Index 1 and 2, and in 2019 the proportion of soil with very low and low soil P fertility had decreased to 50%. This shows the potential for improving soil P fertility where the higher P build-up rates are available to farmers. There is still much more improvement to be achieved on farms and the proposal for adoption of appropriate P build-up rates on farms operating above 100 /kg/ha organic N, based on the latest science, will enable the majority of farmers to achieve improvements in the fertility of their grassland soils and the associated environmental benefits which are critical.

<u>Science supporting P build-up allowances</u>

The higher levels of P allowance for soil P fertility build-up are based on several studies carried out in Ireland. These studies show that the mean annual build-up application of P required to raise Morgan's soil test P (STP) by 1 mg/L was on average 66 kg/ha for P index 1 soils and 44 kg/ha for P index 2 soils (Culleton et al., 2002; Courtney et al., 2017; Fox et al., 2016; Pettit et al. 2017; Fox et al. 2016). At the application rates allowed in the current baseline regulation (20 kg/ha for P index 1 soils and 10 kg/ha for P index 2 soils) it would take, on average, 21 years to move the soil from P index 1 to 3 based on adjustments with soil sampling, and in the

Index 2 case above would take 12.5 years. For soils at lower levels within these indices the time spans are even longer. For example, a soil with a P level of 1.0 mg/L STP the lower end of P Index 1, would be expected to take, on average, 24 to 25 years to reach P index 3.The rates of change in soil P outlined in the examples are, clearly, much slower than is feasible for a modern, sustainable farming sector. These types of lags in achieving optimal P status greatly hinder the development of the sector and expose farmers to increased financial risk as they are prevented from achieving efficient levels of production. At the same time land at sub-optimal P status is rendered more vulnerable to nutrient loss since crop growth and nutrient uptake (N, P, K, S etc.) is impaired.

Phosphorus build-up allowances for tillage soils

The additional soil P build-up allowances should be extended to tillage soils to help improve soil P fertility levels. Currently 50% of tillage soils have sub-optimal soil P fertility i.e. P Index 1 & 2, and there has been very little improvement in tillage soil P fertility over the last number of years (in 2017, 56% soils tested had sub-optimal P fertility and in 2020, 50% soils tested had sub-optimal P fertility). Improving soil P fertility levels in tillage soils would improve grain yields and increase N use efficiency by the crop, and hence reduce the N surplus in the soil, which could potentially be leached. A recent trial carried out by Teagasc showed that winter wheat grown on soils with optimum fertility (P Index 3) increased grain yield by 1.5t/ha compared to low P fertility soils (P index 1 & 2) given similar applications of fertiliser N. This clearly demonstrates that winter wheat crops are more yield responsive to soil P fertility than to in-season fertiliser P applications. In addition, by extending the P build-up allowance to tillage soils it would encourage greater use of organic manure application for tillage crop production and to build soil P fertility in tillage soils, plus adding valuable soil organic matter to tillage soils.

Phosphorus allowances for grassland on high pH soils

Lower soil P availability for plant uptake and issues related to the overestimation of soil P availability using the Morgan's extractable P method on grassland and tillage soils with high pH ≥ 7.0 may lead to undersupply of soil P for optimal grass and crop production. To overcome this on tillage soils, in the NAP a 20 kg/ha P additional allowance is provided on high pH tillage soils at P index 4 based on current soil test results. A review of P allowances is needed for grassland soils with high pH to assess if a similar P allowance should be specified. Grassland soils with soil pH ≥ 7.0 should have P allowance consistent with the 20 kg/ha P allowed on cereals (i.e. 80% of the Index 3 rate of 25 kg/ha). This would help to reduce significant production and environmental impacts of less than optimal P supply for grass swards on farms with these soils. In addition, a review of soil P test methods for high pH soils and the advice provided based on the soil test results is required to improve the estimation of soil P availability on farms.

Environmental assessment of phosphorus allowances

Based on the latest scientific studies using modern grass and crop cultivars and encompassing a range of Irish soil types (Culleton et al., 2002; Sheil et al., 2016; Courtney et al., 2017; Fox et al., 2015) the current soil P allowances for build-up enables farmers who opt in for build-up allowances to apply up to 50 kg/ha P for increasing soil P fertility on index 1 soils and up to 30kg/ha P on index 2 soils. While this P build-up allowance leads to an increase in the chemical P fertiliser permitted on the farm it is targeted towards soils that have depleted STP levels only, as the allowance is based on soil testing and will therefore only impact specific fields within farms. There is limited or no negative environmental impact of this solution as it

has been identified in the original formulation of the regulations that soils within or below the agronomic STP range (i.e. ≤ P Index 3) are low risk of P loss to waters, where P application rates are equal to soil and crop requirements. The proposed solution will not increase the P application on these low P soils to levels above soil and crop requirements, but merely enable farmers to build-up their soil fertility steadily within a reasonable time frame (~ 4-5 years).

Recent studies of soil P mobility in river catchments in Ireland showed that the threshold for P availability/mobility across these grassland soil types was within the STP range from 5.9 to 8.7 mg/L (Morgan's P) (Daly et al., 2015). This threshold range was further confirmed in a study by McDonald and Wall, (2016) across the Agricultural Catchments Programme sites. On a range of Irish tillage soils, Regan et al. (2014) concluded that the critical STP threshold range for soils to comply with the MAC (0.03 mg DRP/L) for surface waters was 7.83 to 11.31 mg/L Morgan's P. These P mobility threshold ranges sit above the current Index 3 range (5.1 to 8.0 mg/L) for grassland and within that for tillage crops (8.1 to 10.0 mg/L). This indicates that building soil P levels within the P index 3 range, and even to the top of P Index 3 provides agronomic and environmental sustainability for the farming system.

Mandatory training requirement – to ensure that farmers opting to avail of the P build-up allowances manage the nutrient applications in a sustainable and environmentally friendly manner they must attend P build-up training course. These courses provide training and the latest knowledge to farmers on key aspects of nutrient management, agronomy, water quality protection, reducing gaseous emission losses, maintenance of biodiversity and health and safety on the farm.

Built-in safety margin - to ensure the risk of P loss to water is minimised the proposed build-up rates for P index 1 and 2 (50 kg/ha and 30 kg/ha respectively) are set at 80% of the minimum required levels to build soil P levels to the top of the P Index 3 band (8.0 mg/L) over the four-year soil testing interval. For example, to move a soil with a P level of 5.0 mg/L STP (top of P Index 2), to the top of P Index 3 (8.0 mg/l STP) would, on average, require 150 kg/ha of P (50 kg/ha for each 1 mg/L STP increase). Over four years this equates to an annual application of 37.5 kg/ha of P. Allowing for a 20 % safety margin below the 37.5 kg/ha rate gives a figure of 30 kg/ha (80% of 37.5). Similarly, assuming soil with a P level of 3 mg/l STP (top of P index 1), on average, 62.5 kg/ha of P would be required over four years to raise soil p levels to the top of P index 3. By applying the 20 % safety margin, the 50 kg/ha figure is arrived at.

Time limited - these allowances will only be available on fields with P Index 1 and 2 over the 4 year soil testing interval (maximum duration that the soil sample is valid and a new soil sample is required). This allows for a maximum increase in STP of approximately 2.5 mg/L STP at P Index 2 and 4mg/L STP at P Index 1. In either case these levels of increase will leave the soil, at most, within the P Index 3 range. At that point the farmer must either: complete another round of soil analysis and use the results to plan P applications as specified in the regulations, or assume P index 3 for the whole farm and apply crop requirement only.

Achieving optimum soil nutrient status - by increasing the P build-up allowance and facilitating farmers to improve their soil nutrient status at a reasonably rapid rate, the overall risk of nutrient loss should be reduced. Well managed soils with optimum status for P, K and pH will provide conditions for optimum crop growth leading to better nutrient use efficiency as well as more nutrient uptake and offtake.

2.8. Green cover on tillage ground:

To reduce any potential losses of nutrients post-harvest and building on current requirements to naturally regenerate a green cover within 6 weeks post-harvest, it is now proposed that shallow cultivation of harvested crops must be undertaken 7 days post-harvest.

Additional requirements are needed for late harvested crops i.e. Potatoes, Forage Maize and late harvested spring cereal crops especially those in critical sources areas. These will include the identification of critical sources areas for these crops and putting in place appropriate buffers to protect any intersecting water bodies.

Management of green cover on tillage land

Establishment of green cover as soon as possible on fields planned for spring crops will be beneficial to reduce the risk of nutrients during the fallow period. Teagasc research has shown that natural regeneration following a light cultivation can be as effective as a sown cover crop. The current proposal to establish natural regeneration within 7 days of the cereal harvest will be a challenge for farmers due to the following considerations at that time of the year:

- Labour and suitable machinery availability. The cereal harvest is a very busy time of the year and with the increase in machinery size and capacity skilled labour tends not be available on farm to carry out many skilled field operations from harvesting to baling to cereal transport plus the field cultivation of stubbles to establish natural green covers.
- Weather can be a major limiting factor during harvest to carrying out many intensive field operations and in many years field conditions may not be suitable during the proposed time frame to establish natural regeneration especially for later harvested cereal crops. Harvesting the cereal crop & removing straw in good conditions will be the priority during period of time.
- Best practice - Where grass weed problems have been identified it is recommended best practice is to use a stale seedbed where possible (along with a host of other measures) for autumn germinating grass weeds. But grass species differ in their post-harvest control. While it is good practice to shallow cultivate as soon as possible to encourage germination of volunteer cereals, blackgrass, sterile and great brome, other brome species (meadow, rye & soft) need to be left on the soil surface as they require light to break dormancy. This period could be up to 4 weeks.
- Weeds such as volunteer oilseed rape should be left on the surface to chit and not cultivated immediately to avoid the seeds becoming dormant and requiring additional chemical control in following crops.
- Field cultivation operations, including cultivation depth, will have a large influence on the success or failure or green cover. Shallow (2-4cm) will give the best chance of success but >4cm often results in a lot of loose soil and very little green cover established. There is concern that many farmers do not have the ideal equipment/expertise for this task. This could potentially result in cultivation of land with inappropriate equipment resulting in loose soil with limited green cover generation resulting in sediment and phosphorus losses in surface runoff and increased N leaching losses

- Straw removal generally takes more than 7 days due to conditioning of straw to be suitable for baling plus time to remove bales depending on weather and soil conditions.

There may also be other options such as auto casting during harvest or broadcasting seed into the standing crop that would facilitate green cover establishment. However, more research is needed on these techniques in Irish conditions to optimise their use.

Management of critical source areas (CSA's) associated with late harvested potatoes, maize & cereal crops

Identify CSA's in fields and put in place suitable field buffers to reduce the risk of potential nutrient loss after harvest. Additional advisory support is required to help farmers identify field CSA's along surface watercourses such as in the ASSAP programme.

The use of arable grass margins adjoining surface watercourses will reduce sediment losses during maize or potato harvest. Manage field access points (gateways) to reduce the loss of run off from fields post crop harvest. For example, divert field run-off to buffer strip / margins to reduce run-off risk with direct access to surface watercourses.

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2.9. Organic Matter Determination:

In the current regulations, there is a requirement that "An occupier of a holding located in an area where soils have an organic matter content of 20% and above, as defined on the Teagasc- EPA Indicative Soils map, shall ensure that the soil test undertaken includes organic matter determination. The phosphorus fertilisation rate for soils with more than 20% organic matter shall not exceed the amounts permitted for Index 3 soils. Soil organic matter determination shall not be required where it is certified by a Farm Advisory System Advisor that soils on a holding/field in such areas are mineral soils"

There has been various amendments afforded to the implementation of Organic Mater determination through SI 65 of 2018 and DAFM Circular 02 of 2020, however, the soil sampling for organic matter from soils within the EPA Indicative layer needs to be considered as part of the next NAP and the best approaches for its implementation.

The procedure for the certification of a soil as a mineral soil is provided under the current regulations, however, in order to streamline the process where soil samples are required in some instances and certification in other instances, the regulatory framework require a more streamlined approach to ensure consistency and accuracy of OM estimation.

Therefore, from 2022, all soils in the indicative Teagasc/EPA layer for >20% OM are required to be soil tested for Organic Matter.

Process of certification a soil type as mineral or organic

The EPA indicative organic matter (OM) layer (map) provides an indication of areas across Ireland where there are soils with high levels of OM. Soil sampling and laboratory analysis will provide a definitive answer if a soil is mineral or organic/peat for a particular field or parcel of land. As the levels of organic matter in soils change very slowly, once confirmed as mineral or organic/peat there should be no requirement to re-sample these soils every 4-5 years as is required for soil pH and phosphorus. In addition, on farms where soil samples have been taken and analysed for OM levels since the introduction of SI 65 of 2018, there should be no further requirement to re- sample for OM determination.

The practicality of this measure on farms is somewhat complicated as the OM layer does not always follow field boundaries. Currently the organic soil designation is applied to the full LPIS area where part is overlaid by the OM layer. This may lead to ambiguity if a full field is considered to have an organic soil type where only part of it is crossed by an OM layer. Clarification is required form DAFM on how to deal with full or part fields are to be dealt with in NMP's. Where a soil sample is taken from a field where part of the area has an organic soil and the remaining area a mineral soils clarification is required on how this should be handled and whether the field split accordingly and two separate soil samples should be taken corresponding to each area.

2.10. Soil Tests:

A soil test refers to the results of an analysis of a soil sample carried out by a soil-testing laboratory that meets the requirements of the Minister for Agriculture, Food and the Marine for this purpose. The analysis of phosphorus, specifically the Morgan extractable P test, is currently used to determine the Soil P Index.

A review of the soil test methodology for phosphorus availability will be undertaken, however, guidance is required on the best approach to consider to ensure phosphorus availability is evaluated correctly.

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 could be Mehlich-III has been tested 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 Campaign announced by the Government.

2.11. Grazing Land Management:

In terms of short-term grazing, only land within 30km allowed to be considered in stocking rate calculation.

Currently for Nitrates Derogation Farms, Commonage and Rough Grazing are permitted for inclusion for 170kg N/ha allowance. In order to protect these areas further and the whole farm nutrient planning process, it is proposed to reduce these below the 170kg N/ha threshold.

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.

2.12. Review of the Technical tables:

In some instances, the information is not up to date in the technical tables and these will all be considered as part of the review.

Examples include the nutrient content of livestock manures including pig slurry and poultry manure and whether existing slurry storage capacity figures are considered to accurately reflect changes in animal size over the last number of years.

Availability of Scientific Data and Information to Inform Changes in Tables in Schedule 2 of the GAP regulations

Teagasc has reviewed the tables in Schedule 2 and based on the latest science and considering factors and information required to improve the utility of the GAP regulations to provide guidance for farmers and farm advisors for improving nutrient management and the protection of water quality responses have been provided in Table 1.

Table 1. Availability of new scientific data and information to inform changes in the Schedule 2 tables.

Schedule 2 table number and description	Response detailing availability of new data and information to inform changes in each table
Table 1 Slurry storage capacity required for sows and pigs	No new data available to inform changes
Table 2 Slurry storage capacity required for cattle, sheep and poultry	In general, there is no new data available to inform changes in the manure production for different animal types, and consequently new information to inform changes in slurry storage capacity for the animal types. New research will be needed to establish and update the volumes of manure production for bovines in current farming systems, according to different age and production type categories and for different feeding/winter housing systems to support Table 2. Concerning volumes of soiled water production on farms the water use and quantities of dairy washings may be different according to dairy milking facility type e.g. Herringbone vs Rotary vs Robotic. The inclusion of up to date information on the quantities of soiled water that needs to be stored and subsequently applied to land will guide farmers and advisors during the development of NMP. A number of recent studies (Murphy et al, 2014; Shine et al., 2018; Shorthall et al, 2018) have quantified water consumption on Irish farms and provide data to estimate of water used during the milking process and for washdown for different dairy milking facility types.

Table 3 Storage capacity required for dungstead manure	No new data available to inform changes
Table 4 Average net rainfall during the specified storage period	Met Eireann may have up to date information on average net rainfall quantities over the last decade. This information could be used to assess if changes to Table 4 for open tanks where freeboard must be included.
Table 5 Storage capacity required for effluent produced by ensiled forage	No new data available to inform changes to Table 5.
Table 6 Annual nutrient excretion rates for livestock	New average annual nitrogen excretion figures for dairy cow (89 kg/ha organic N) need to be updated in the tables. Results of modelling N excretion for dairy cows based milk yield (kg) are available to inform future updates in N excretion. For poultry litter production, there are no figures in these tables. Standard values would help farmers and advisors to estimate quantities of poultry litter available during nutrient management planning.
Table 7 Amount of nutrient contained in 1m3 of slurry	New figures from research (Berry et al., 2012) sampling slurry on Irish farms can be used to update the nutrient levels (dry matter%, total N , total P and total K) in cattle slurry (Table 7) This information has been disseminated in the Teagasc "Green Book" of Major and Micro Nutrient Advice (2016 & 2020) (Table 9.1)
Table 8 Amount of nutrients contained in 1 tonne of organic fertilisers other than slurry	Table 8 needs to provide clarity, where non-animal manures are imported onto the holding, as to the requirements when developing an NMP. For example, would certified analysis of material on a fresh weight basis to establish N and P availabilities be acceptable? Such average book values for N and P for such material be included in Table 9. New available nutrient values for poultry broiler manure has been included in the Teagasc, Green Book. In addition new research has been conducted to evaluate layer manure as the N input source for spring barley production (2 years work)
Table 9 Nutrient availability in fertilisers	The adoption of LESS technologies will affect the availability of N applied to agricultural land. Current slurry N availability levels (40% fertiliser N replacement value) specified in the SI 605, 2017 are appropriate for the trailing shoe application method. Therefore

	this is currently taken into account for NMP's and fertiliser allowances
Table 9A Nutrient availability in compost	The quantities of digestate coming from anaerobic digesters that will be land spread is likely to increase in future. Information on digestate may need to be included in tables 8 and 9. Depending on feedstock the N and P availability for digestate needs to be defined as livestock manure or non-livestock manure. New information has been disseminated in the Teagasc "Green Book" of Major and Micro Nutrient advice (2016 and 2020) Table 9 may need to define compost in more detail in order to prepare official NMP. Could the available N & P be based on certified analysis of the compost material?
Table 10 Determining nitrogen index for tillage crops	New research has been completed to evaluate the soil N supply in arable soils. This work showed that previous cropping history and soil mineral N in spring were two variables explaining most of the variation in soil N supply. This information was used to assess the current N index and will support minor changes according the previous crops in the rotation (Walsh et al. 2015)
Table 11 Phosphorus index system	There is a potential issue with reduced soil P availability on high pH grassland soils (pH ≥ 7.0). Coupled with this the Morgan's soil test (effective for acid soil types) and corresponding P index system which has been co-opted into the regulations may indicate higher potential P availability than in reality in these high pH soils. As the fertiliser P allowance is linked with the soil test further evaluation and assessment of research data and information for grassland P requirements for high pH grassland soils is needed. This information will inform Table 11 and Tables 13A/B.
Table 12 Annual maximum fertilisation rates of nitrogen on grassland	New N fertiliser advice for grass-clover swards (>20% annual white-clover content in the sward) have been included in the Teagasc "Green Book" of Major and Micro Nutrient Advice (2020). This information can be reviewed and used to inform Table 12.
Table 13A Annual maximum fertilisation rates of phosphorus on grassland	No new data available to inform changes
Table 13B Annual maximum fertilisation rates of phosphorus on grassland adopting increased P build-up application rates	These P build-up allowances for P index 1 and 2 soils are based on the latest science and has suitable environment impact assessment measures associated with it. The P build-up allowance is discussed in detail in point 2 above.

Table 14 Annual maximum fertilisation rates of available nitrogen on grassland (cut only, no grazing livestock on holding)	No new data available to inform changes Clarification is required on how the 85 kg/ha organic N grassland stocking rate is calculated in this table.
Table 15 Annual maximum fertilisation rates of phosphorus on grassland cut only	No new data available to inform changes.
Table 16 Maximum fertilisation rates of nitrogen on tillage crops	Review of the current SI 605 2017 there are a number of crops missing, with lesser agricultural land area devoted to them. The inclusion of maximum N and P fertiliser application guidance for these crops would provide clarity when preparing fertiliser plans for farms. Nutrient advice based on relevant research for many of these crops has been included and disseminated in the Teagasc "Green Book" of Major and micro Nutrient Advice for productive agricultural crops, Chapter 22. Arable and forage crops: Triticale (spring & winter), Winter rye and Arable silage, Westerwolds, Lupins and Mscahthus are not included. These crops potentially have emerging distillery energy & feed markets. A review and clarity is required for fertiliser (N & P) allowances where double cropping is carried out on a farm to provide clarity for advisors and farmers when drawing up NMP's and to ensure compliance with GAP regulations.
Table 17 Maximum fertilisation rates of phosphorus on tillage crops	Similar for max P rates for tillage crops, see response to table 16 above
Table 18 Maximum fertilisation rates of nitrogen on vegetable crops	Based on the latest scientific research on nitrogen application rates for potatoes new advice has been disseminated in the Teagasc "Green Book" of Major and Micro Nutrient Advice (2016) and has been implemented in SI 605 2017
Table 19 Maximum fertilisation rates of phosphorus on vegetable crops	Similarly, the max P rates for vegetable crops has been updated in 2017, see response to table 18 above.

Table 20 Annual maximum fertilisation rates of nitrogen on fruit/soft fruit crops	Based on the latest scientific research on nitrogen application rates for fruit/soft fruit crops new advice has been disseminated in the Teagasc "Green Book" of Major and Micro Nutrient Advice (2016) and has been implemented in SI 605 2017
Table 21 Annual maximum fertilisation rates of phosphorus on fruit/soft fruit crops	Similarly the max P rates for fruit/ soft fruit crops has been updated in 2017 see response to table 20 above.
Table 22 Phosphorus excess limits Article 34	The transitional arrangements for application of pig manure expire in 2020. This will reduce the quantities pig manure that can be applied on agricultural land from 2022 onwards and may create difficulties for farmers who have been unsuccessful in finding suitable additional spread lands for pig manure during this transitional period up to end 2020. We propose to extend the transitional provision (as cited in Article 34 of SI 605 of 2017) for a 3 year period to promote the use of pig manure applications on farms as a substitute for chemical fertiliser N & P sources. The advantages of this are as follows: • This promotion will encourage a change in farmer behavior and help reduce the reliance on imported chemical fertilisers on Irish farms. • Teagasc is developing Demonstration and Sign-Post farms to improve the "sustainability" credentials of our food producers. The use of pig manure to replace chemical fertiliser will be assessed under the "cabon foot-print" heading and the farming community will be more informed of the benefits of such a substitution. The proposal to extend the Transitional Provision would be seen as a very positive move to support this, • Using locally produced pig manure to reduce their usage of imported chemical fertilisers is in keeping with the Green Deal Goals as recently advocated by the European Commission, • The benefits of using pig manure over a number of years in a tillage situation has multiple benefits for soil fertility, soil quality and environmental sustainability. While the use of pig manure each year may replace the requirement for some chemical fertilisers the long term benefit is an increase in soil organic matter (SOM) and improved soil structure.
Schedule 1 Soil Test Expiry of fertiliser allowances for high pH tillage soils based on soil testing	Clarity is needed within these tables and the SI where soil samples expire on high pH soils, if the P allowances for tillage crops cease until new soil samples become available?

2.13. Air Quality (Low Emission Slurry Spreading).

From an air quality perspective, ammonia provides the most significant challenge from agriculture. The current regulations provides for the compulsory usage of Low Emission Slurry Spreading (LESS) equipment for all farmers operating above 170 kg N/ha and Derogation farmers.
To meet our Ammonia and AgClimatise targets, the further compulsory implementation of LESS for more farmers will be required. In order to align with these targets, the compulsory usage of LESS will be introduced

- *for all farmers operating above 100 kg livestock N/ha from 2023*
- *and for all Pig farmers from 2023 onwards.*
- *all organic manures applied to arable land must be by low emission or incorporated within 12 hours of application.*

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

The adoption of low emission slurry spreading (LESS) technology, such as trailing shoe or trailing hose has led to reductions in ammonia-gas and GHG emissions from livestock farms in Ireland. Slurry N losses in the form of ammonia (NH_3) emissions are potentially the largest loss of reactive N on Irish farms, with manure spreading responsible for a quarter of all NH_3 losses in Ireland (Duffy et al., 2020). 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 reducing ammonia emissions and improving the N availability from slurry in other European countries. Further research is underway to assess the potential impacts on soil quality and the extent of N use efficiency (NUE) gains that can be achieved at farm level across 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, 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, 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.

Further adoption of LESS has the potential to help improve farm NUE and reduce on-farm N surpluses. This can be achieved by the following approaches.

i. To achieve the targets set in Ag-Climatise a significant number of farmers need to adopt LESS by 2022 and a gradual increase in the adoption levels beyond then is required
ii. Broader implementation of LESS on its own will not achieve significant water quality improvements. The management and application of LESS must be incorporated into a farm specific nutrient management plan, where the slurry can be targeted to fields at the appropriate timing and application rate to match nutrient uptake by the grass or crop and to replace chemical N and P where appropriate. This will help reduce nutrient loss to the environment, reduce nutrient surpluses and in turn protect water quality.
iii. The focus needs to be on improving the temporal and spatial management of slurry application. This will involve reducing application when there is a risk of loss to water, with appropriate consideration of soil moisture deficit, temperature, weather forecast and predicted growth. Achieving this will require significant KT focus with the use of tools such as a Sustainability Planning System and nutrient management plans.
iv. Large quantities of slurry being applied by agri-contractors (approximately 50%; Hennessy et al. 2011) and it is likely to increase. Farmers that are dependent on contractor services for slurry application are not in full control of the application method, depending on the availability of equipment within the pool of locally available contractors. More widespread adoption of LESS is dependent on the availability of equipment from contractors in addition to farmer-owned equipment.

While lack of availability of LESS equipment in some areas has caused a lag in uptake on some farms to date. Grant aiding the purchase of this equipment by DAFM through the targeted agriculture modernisation scheme (TAMS) has helped farmers adopt this technology more quickly. In addition, further training of farmers, farm advisory services and contractors will help to achieve the associated agronomic and environmental benefits from using LESS to increase slurry N use efficiency, reduce chemical fertiliser applications and costs while simultaneously reducing emissions of N to the environment. Training and advice for farmers around slurry management during storage is also needed to help to reduce other technical issues with LESS technology such as increased working downtime due to machinery blockages due to bale silage, plastic and other foreign objects entering the slurry tank. Additionally, the likely availability of LESS equipment to achieve the proposed implementation dates should be considered.

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