Appendix to the Report of the Joint Government and Industry Slurry Management and Storage Project:

WT1508 Slurry Storage and Management

Work Package Reports

Submitted to:
Defra

Nobel House
17 Smith Square
London
SW1P 2RJ

Prepared by:
ADAS

Pendeford House
Pendeford Business Park
Wolverhampton
WV9 5AP

Date 10 July 2013

This document/publication is also available on our website at:

https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

Any enquiries regarding this document/publication should be sent to us at:
Water Quality Team
Defra
Area 3D Nobel House
17 Smith Square
London SW1P 2RJ
PB 14045

CONTENTS

Work Package 1. The contribution of slurry management practices to diffuse pollution from agriculture

Prepared by

John Williams[1], Rebecca Jones[2], David Lee[3] and Prof. Brian Chambers[4]

[1] ADAS Boxworth, Battlegate Road, Boxworth, Cambridge, CB23 4NN
[2] ADAS Aberystwyth, Cefn Llan Science Park Aberystwyth, SY23 3AH
[3] ADAS Wolverhampton, Pendeford House, Wolverhampton, WV6 8TQ
[4] ADAS Gleadthorpe, Meden Vale, Mansfield, Notts., NG20 9PD

ADAS

EXECUTIVE SUMMARY

The overall objective of this work package was to investigate the contribution of slurry management practices (storage and land spreading) to agricultural point-source and diffuse pollution and water body failure under the Water Framework Directive (WFD).

- Outputs from MANURES-*GIS* were combined with Agricultural Census data (2010) on a 10km^2 grid cell basis to estimate the distribution of pig and cattle slurry production across England. The data indicated that the total amount of slurry produced in England was *c.*29 million m^3. Dairy slurry accounted for *c.*65%, beef slurry *c.*25% and pig slurry *c.*10% of total slurry volumes produced and applied to agricultural land. Cattle slurry production was mainly concentrated in Cumbria, Cheshire, Lancashire and the south west of England, and pig slurry in East Anglia and Yorkshire/Humberside

- The impact of livestock manure management practices on point-source and diffuse water pollution was investigated using information from the EA database of point source water pollution incidents. Also, data from the EA WFD Ecological Status assessment for Physical Chemical Elements datasets was used to assess the distribution of water bodies currently failing under the Water Framework Directive across England.

- Data from the EA database of point source water pollution incidents showed that from 2001-2012 direct (point-source) water pollution incidents from the handling storage and land spreading of livestock slurry ranged between 109 and 352/year. The highest numbers of incidents occurred in south-west England. The most frequent causes of point-source water pollution were from the land application of slurry and over-topping of slurry stores. The increase in water pollution incidents in 2012 (to 164/year) is a potential cause for concern as this was against the long-term downward trend. Between 2001-2012 there were 47 category 1 (major adverse effect on water quality), 261 category 2 (significant effect on water quality) and 1,566 category 3 (minimal effect on water quality) point-source water pollution incidents from the management and land application of livestock slurry.

- Manure management was estimated to account for *c.*20% of diffuse phosphorus and diffuse nitrate water pollution from agricultural land.

1. OBJECTIVE

- **To investigate the contribution of slurry management practices (storage and land spreading) to agricultural point-source diffuse pollution and water body failure under the Water Framework Directive**

2. BACKGROUND

Slurry is defined as “excreta produced by livestock (other than poultry) while in a yard or building (including any bedding rainwater and washings mixed with it) that has a consistency that allows it to be pumped or discharged by gravity”. The liquid fraction of separated slurry is defined as “slurry” (Defra, 2009; Defra/EA 2009).

The safe handling, storage and land application of organic manures is essential to minimise point-source and diffuse pollution from livestock farming systems. Livestock slurries have high biochemical oxygen demand (BOD) concentrations (typically in the range 10,000 – 30,000 mg/l) and contain valuable crop available nutrients (e.g. nitrogen, phosphorus, potassium and sulphur etc.). Direct discharge/entry into watercourses can have catastrophic consequences for fish and other aquatic life as oxygen dissolved in the water is used to breakdown organic materials in slurry. Minimising diffuse pollution is important to safeguard water quality and to enable compliance with EU Directives (e.g. Nitrates, Freshwater Fish and Water Framework Directives). It has been estimated that agriculture is responsible for *c.*60% of nitrate and 25% of total phosphorus losses to water systems in England (Defra, 2009).

2.1 Slurry storage

Slurry is typically stored in one of the following structures (Defra, 2009):

Below-ground tanks and reception pits – where excreta is typically collected underneath slats in the livestock building. The slurry is either stored in these tanks before spreading to land or transferred to other storage tanks before spreading.

Plate 1. Example of above ground ‘tin-tank’ slurry store

Above-ground circular stores **(Plate 1)** – fabricated tanks constructed typically from steel or concrete panels and built on an impermeable concrete floor. These tanks are most suitable for slurry that is easy to pump.

Earth-banked stores – typically dug into the ground. The floors and walls must be impermeable to prevent leakage to ground and surface waters. Earth-banked stores are most suited to sites with clay soils, although impermeable liners can be used on permeable soils to prevent leakage.

The Defra Code of Good Agricultural Practice - COGAP "Protecting our Water Soil and Air – A Code of Good Agricultural Practice for Farmers, Growers and Land Managers" (Defra, 2009) provides guidance on minimising water pollution from the storage and handling of livestock manures. In addition, The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations (SI, 2010) known as the "SSAFO Regulations" apply to all installations used, constructed, substantially reconstructed, or substantially enlarged after September 1991. The SSAFO Regulations set legally binding construction standards for storing silage, slurries and agricultural fuel oil, to minimise risks of diffuse water pollution. These include building stores more than 10 m away from a watercourse and ensuring they are large enough to hold 4 months slurry production and the quantity of rainfall that will occur once in every 5 years over a four month period.

The Nitrate Vulnerable Zone Action Programme; NVZ-AP (SI, 2013), which covers *c.*60% of agricultural land in England, has minimum storage requirements of 5 months slurry production for cattle and six months for pigs. The stores must also have capacity to capture average rainfall and any wash water or other liquids that are expected to enter the store during the storage period.

2.2. Land application

Farmers face many challenges when trying to minimise point-source and diffuse pollution from the management of livestock manures, including having sufficient storage capacity to ensure that slurry is applied at times when soil conditions reduce both the risk of direct runoff and diffuse water pollution. Notably, from a soil and farm management perspective, the best time to spread manures, especially on medium/heavy soils, is when they are dry and can carry the weight of heavy application machinery (e.g. in summer and autumn) without causing compaction and damage to soil structure, which would be contrary to cross-compliance objectives of maintaining land in Good Agricultural and Environmental Condition.

3. DISTRIBUTION OF ORGANIC MANURE LOADINGS ACROSS ENGLAND

Outputs from the MANURES-*GIS* programme (Defra project WQ0103), using livestock number data from the 2010 Agricultural Census on a 10km^2 grid cell basis, were used to estimate the quantities of dairy, beef and pig slurry applied to agricultural land in England (Table 2).

The total amount of slurry produced in England was estimated *c.*29 million m^3. Dairy slurry accounted for *c.*65%, beef slurry *c.*25% and pig slurry *c.*10% of total slurry volumes produced and applied to agricultural land. Cattle slurry production was mainly concentrated in Cumbria, Cheshire, Lancashire and the south west of England (Figure 1). These areas present the greatest challenges to safe storage and land application of slurry because 'high' annual rainfall volumes (between 750 and 1500 mm) increase slurry storage requirements and limit the number of days slurry can be spread on 'dry' soils (which limits the risk of direct runoff and diffuse pollution following application). Pig slurry was mainly produced in the drier parts of the country (i.e. East Yorkshire, Humberside and East Anglia) where slurry storage requirements are less influenced by high rainfall volumes (Figure 2).

Table 1. Quantities and distribution of slurry produced in England by Defra region.

Region	Manure type (million m^3)			
	Dairy slurry	Beef slurry	Pig slurry	Total
East Midlands	**1.46**	**0.80**	**0.27**	**2.53**
East of England	**0.35**	**0.37**	**0.83**	**1.55**
London	**0.04**	**0.02**	**0.01**	**0.07**
North East	**0.38**	**0.61**	**0.11**	**1.10**
North West	**4.89**	**1.02**	**0.13**	**6.04**
South East	**1.13**	**0.59**	**0.18**	**1.90**
South West	**6.63**	**1.95**	**0.29**	**8.87**
West Midlands	**2.58**	**0.99**	**0.13**	**3.70**
Yorkshire and Humber	**1.27**	**0.75**	**0.96**	**2.98**
Total	**18.7**	**7.1**	**2.9**	**28.7**

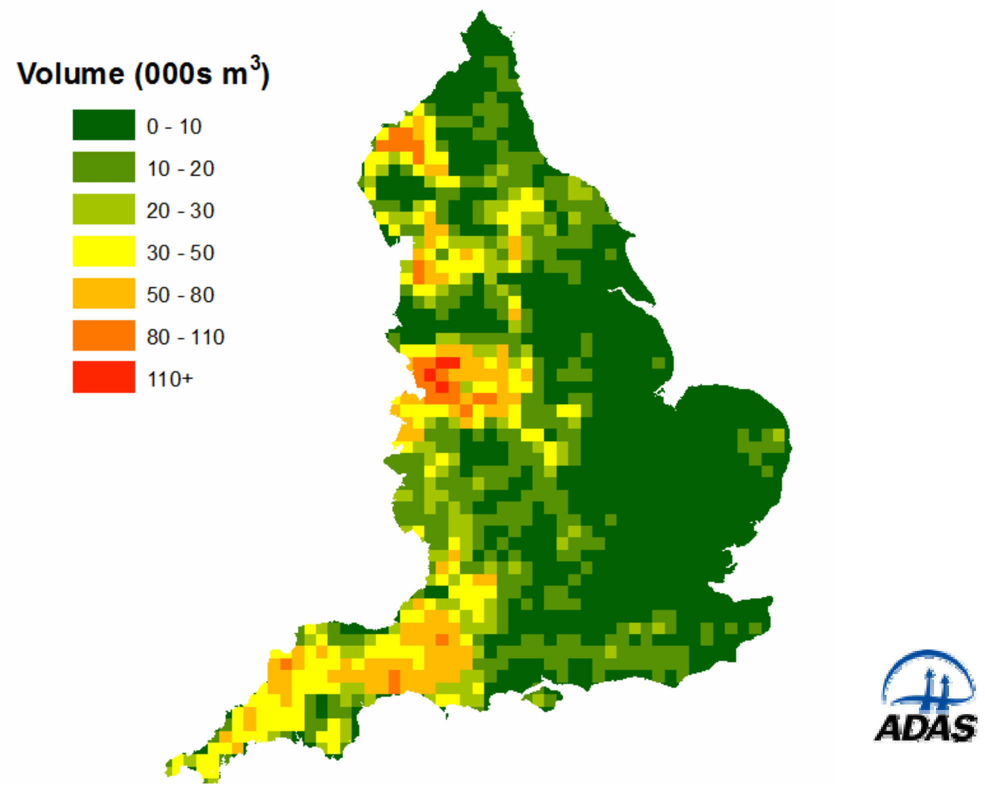


Figure 1. Distribution of cattle slurry production in England (per 10 km^2 grid cell)

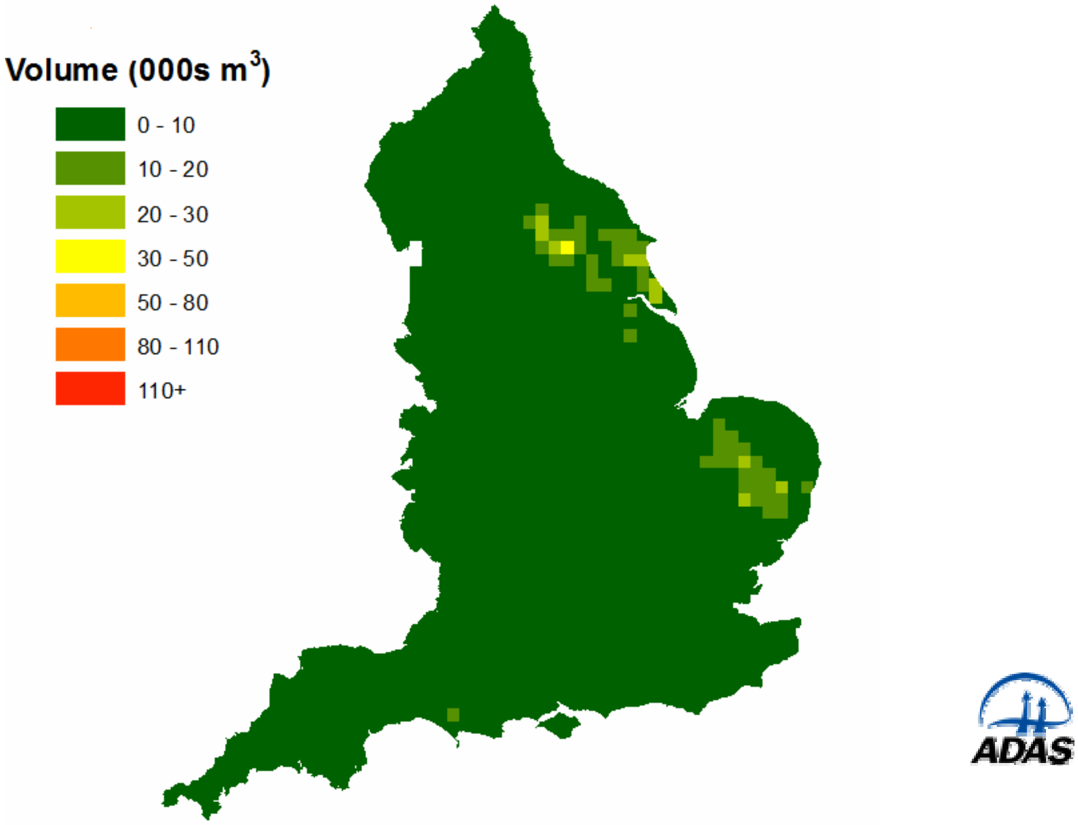


Figure 2. Distribution of pig slurry production in England (per 10km² grid cell)

4. DIRECT POINT-SOURCE POLLUTION INCIDENTS

The Environment Agency's database of point-source water pollution incidents (NIRS) was interrogated to identify the number of Category 1 -3 water pollution incidents that had occurred from the storage and land application of manures from 2001 until 2012. The data were categorised to identify the causes of the pollution incidents, *viz*:

- Leaking stores - a breach in structure that can be repaired without reconstruction and not classified as "substantially changed" in accordance with the SSAFO regulations.
- Store structural failure - a breach in structure that requires reconstruction and may have to comply with "substantially changed" in accordance with SSAFO regulations.
- Store overtopping – exceeding slurry storage capacity resulting in slurry spilling over tank or lagoon walls
- Pipe/valve failure – usually as a result of damage to valves, sluice gates or pipes
- Pump failure - failure for pump system to operate e.g. as a result of loss of electricity, failure of pump operation, back siphoning of slurry when hose left in slurry tanks
- Land spreading - activities associated with slurry application e.g. runoff from fields, umbilical system failure, failure of low rate irrigation system for dirty water , excessive application rates, applications when soil conditions are inappropriate

- Inadequate containment - no storage or lack of adequate storage no storage provided, inappropriate storage and minimal/no compliance with SSAFO regulations
- Not identified - cause of incident could not be identified

The total number of reported incidents ranged from 352 in 2002 and 109 in 2011. Notably, in the early 1990s there were around 700 incidents reported annually (Smith *et al*., 2008). The high number of reported incidents in 2002 may have been a reflection of the foot and mouth outbreak which would have limited land spreading opportunities etc. (Figure 3). The numerical increase in pollution incidents in 2012 (164 compared with 109 in 2011) may have been a reflection of the very wet weather conditions during summer and autumn 2012 which resulted in cattle being housed for longer than normal, because soil conditions were too wet for grazing. As a result, slurry storage capacity was commonly full and to stop tanks/lagoons overflowing, slurry applications were more likely to be made to 'wet' soils, increasing the risk of runoff (and diffuse pollution) following land application.

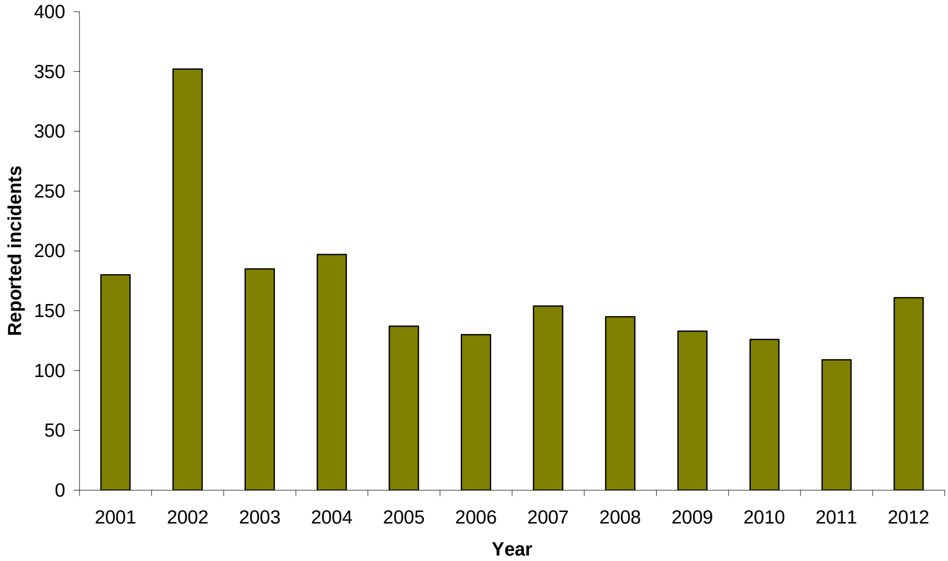


Figure 3. Point-source farm pollution incidents reported by the Environment Agency in England (2001-2012).

The highest number of incidents per year was reported in the south west of England (Figure 4), reflecting the 'large' volumes of livestock slurry produced in this part of England and 'high' rainfall (typically >900 mm), which increases slurry storage requirements from yard runoff and direct rainwater entry into the tank, and limited land spreading opportunities.

The greatest number of water pollution incidents occurred following manure application to land (range 25-65/year, excluding 2002) and the over-topping of slurry stores (range 19-44/year excluding 2002), Figure 5. These incidents were most probably a reflection of insufficient on-farm slurry storage capacity, resulting in stores over-filling and the need to spread slurry when soil conditions were not appropriate (e.g. to 'wet' soils or frozen ground). To some extent, the incidents may also reflect poor slurry management practices (e.g. leaving slurry stores full at the start of winter housing period or excessive slurry application rates at land spreading etc.). The increase in pollution incidents in 2012 following manure application and/or as a result of over-topping of slurry stores is a potential cause for concern as this was against the long-term trend; particularly if future weather conditions continue to be variable in England.

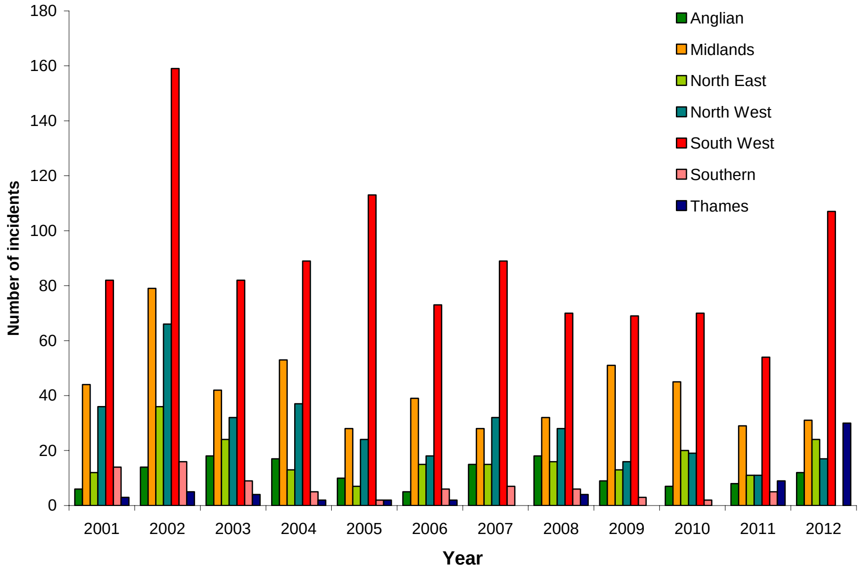


Figure 4. Point-source water pollution incidents by EA region (2001-12) region.

Pollution incidents arising from farm infrastructure failures were lower at between 8-27/year for pipe/valve failure, 8-19/year from leaking stores, 3-9/year following structural failure and 5-18/year from pump failure.

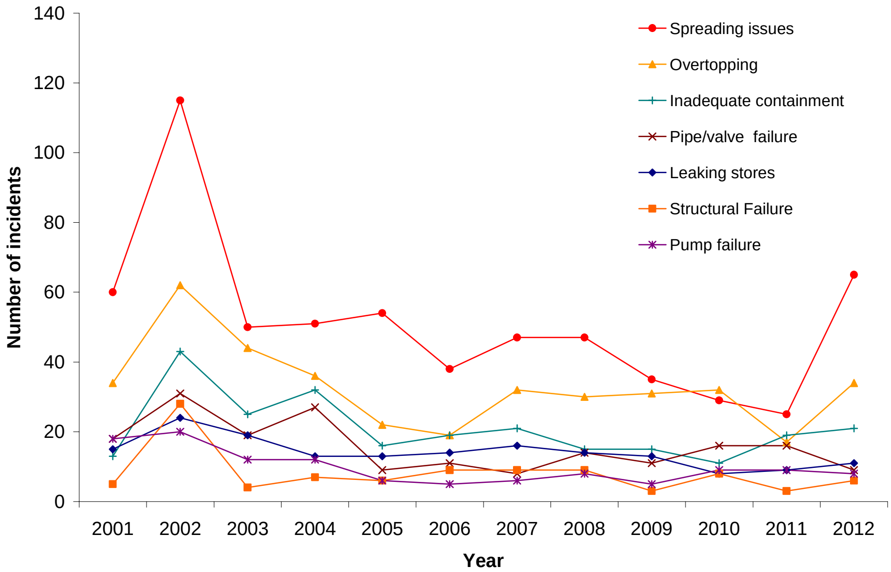


Figure 5. Causes of point- source water pollution incidents (2001-12)

The data were further interrogated to identify the severity of the point-source pollution incidents based on the following EA categories:

- *Category 1* - Major adverse effect on water quality. A persistent and/or extensive effect on water quality which has a serious effect on the quality or use of that water.

- *Category 2* - Significant but normally localised effect on water quality which has a significant impact on the quality or use of that water.
- *Category 3* - Minimal effect on water quality. Limited and localised effect on water quality which has a minimal impact on the quality or use of that water.

Between 2001 and 2012, there were 47 category 1 water pollution incidents, 261 category 2 and 1,566 category 3 from the handling storage and land application of manures in England.

For the category 1 incidents 11 (23%) were a result of inadequate containment or following land spreading, 6 (13%) were caused by pipe/valve failures, 4 (9%) following structural failure. 3 (7%) from over-topping and 2 (4%) following pump failure or from leaking stores. It was not possible to identify the causes of 8 (17%) of the category 1 incidents (Figure 6).

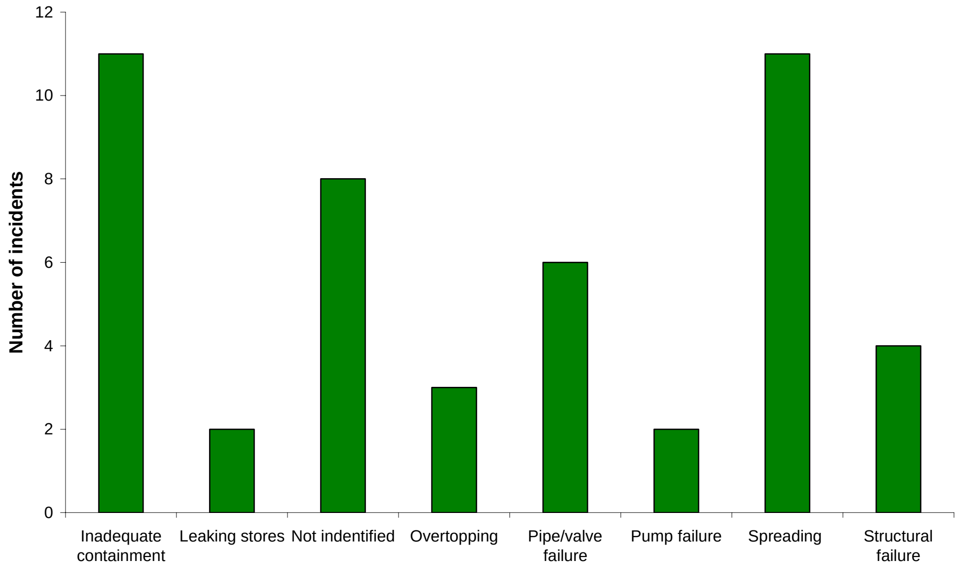


Figure 6. Causes of category 1 water pollution incidents (2001-12).

For the category 2 incidents, 78 (30%) occurred following land spreading, 48 (18%) from over-topping, 33 (13%) from inadequate containment, 31 (12%) from pipe/valve failure, 27 (10%) from leaking stores, 18 (7%) from structural failure and 9 (3%) from pump failure (Figure 7). It was not possible to identify the cause of 17 (7%) of the category 2 incidents.

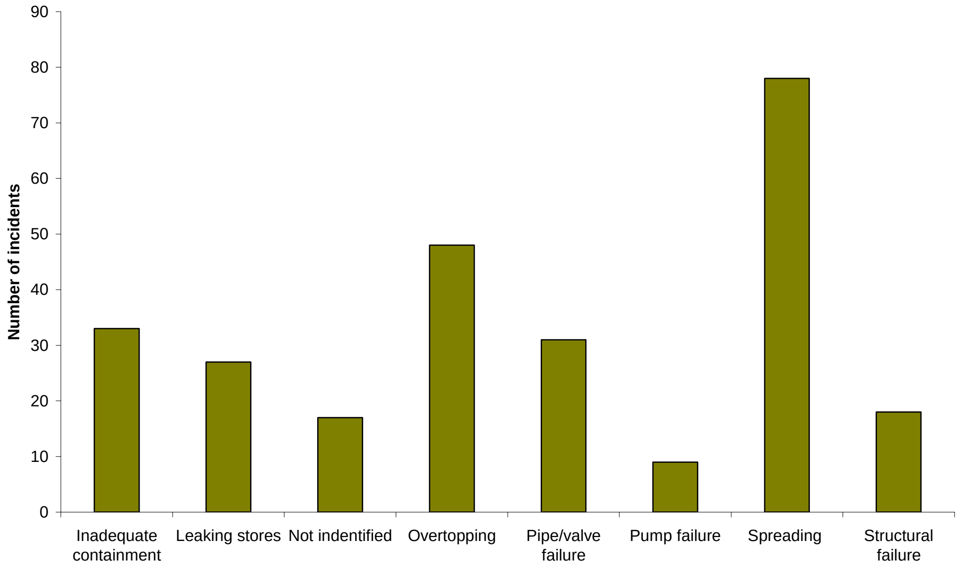


Figure 7. Causes of category 2 water pollution incidents (2001-12)

For the Category 3 incidents, 476 (30%) occurred following land spreading, 325 (21%) from over-topping, 186 (12%) from inadequate containment, 141 (9%) from pipe/valve failure, 130 (8%) from leaking stores 105 (7%) from pump failure and 69 (4%) from structural failure (Figure 8). It was not possible to determine 134 (9%) of the category 3 incidents.

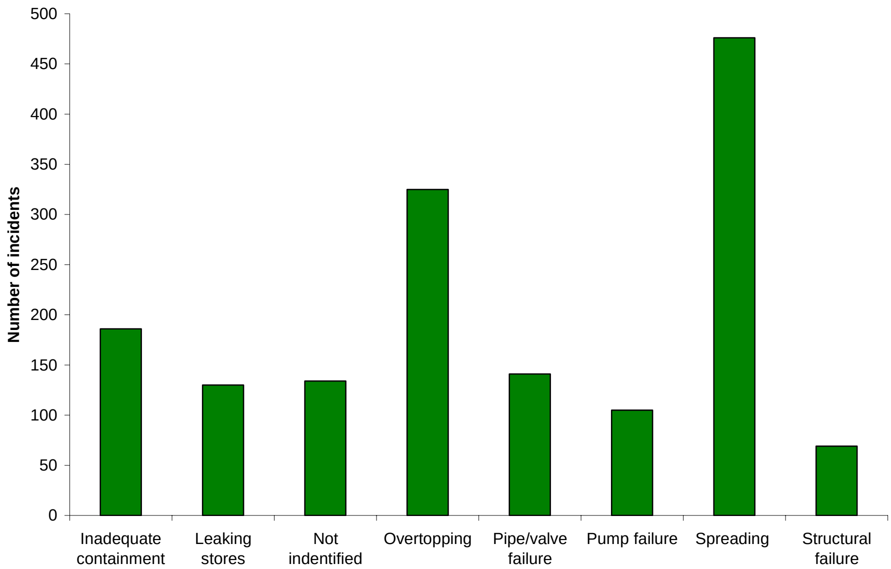


Figure 8. Causes of category 3 water pollution incidents (2001-12)

The high proportion of pollution incidents resulting from land application, inadequate containment and over-topping highlights the importance of slurry storage capacity for reducing the risk of water pollution from livestock systems. Notably, all of the point source pollution incidents would have led to increased diffuse water pollution.

5. ON-FARM SLURRY STORAGE

Smith *et al.,* (2000 and 2001) reported data from a survey carried out in the mid 1990s, which indicated that slurry storage capacities on dairy, beef and pig systems was typically between 3 and 6 months, although there was no storage for an estimated 16% of dairy and 25% of beef slurry.

Data collected from 250 Catchment Sensitive Farming Farm Infrastructure Audits from across England suggested that many farms (74%) had insufficient storage to minimise the risks of diffuse and point-source pollution. Only 26% of farms in a Nitrate Vulnerable Zones (NVZs) had sufficient storage to comply with the NVZ Action Programme (SI, 2013). For those farms not in an NVZ, 65% did not have enough storage to comply with the SSAFO regulations.

Installing new or extending existing slurry stores can require significant capital investment, with costs of construction for above ground stores typically £50/m^3 and for earth banked lagoons *c.*£40/m^3 (Nix, 2011). Results from Defra project WT0932 "Nitrates Action programme : Impacts of Greenhouse Gas Emissions and Diffuse Nitrogen Pollution" suggested that the capital cost of extending slurry storage capacity from a baseline of 3 months capacity for cattle and 4 months for pig farms to comply with the NVZ-AP (i.e. 5 months for cattle and 6 months for pig farms) was estimated at £290 million for current NVZ areas (62% of England and *c.*3% of Wales). The measures included in the 2009-12 NVZ-AP were predicted to increase fertiliser N use efficiency by 1,500 tonnes N /year giving a potential annual saving of £1.3 million based on an N fertiliser price of £300/tonne of ammonium nitrate. However, reductions in nitrate leaching losses and improvements in manure N use efficiency may be partly offset by increased GHG and ammonia emissions resulting from extended slurry storage periods (Newell-Price *et al.,* 2011).

At a farm level, there will be wide variation in the costs associated with increasing slurry storage capacity. For some farms, the cost of upgrading slurry storage would be for the whole storage period (i.e. 5 months for cattle slurry and 6 months for pig slurry), as they have little or no existing storage capacity. In contrast, other farms may already have adequate storage capacity to comply with the current NVZ-AP, in which case there would be no additional cost.

6. DIFFUSE WATER POLLUTION

6.1 Contribution of manure management to diffuse water pollution

Assessing the contribution that manure management makes to diffuse water pollution is complicated by the number of potential sources within individual catchments (e.g. discharges from sewage works, leakage from septic tanks, industrial discharges, sediment, grazing livestock and manure applications etc.). Lord *et al,* (2008) suggest that N losses to water from agricultural systems are *c.*350,000 tonnes. Chambers and Smith (1995) estimated that nitrate-N leaching losses following autumn-winter manure applications in the UK were *c.*58,000 tonnes; equivalent to 16% of nitrate leaching losses from agriculture.

Many of the water bodies where dissolved phosphorus (P) concentrations exceed Water Framework Directive (WFD) limits are located in densely populated areas of England (Figure 9), reflecting the impacts of household and industrial contributions to water pollution. The high numbers of water bodies with moderate or worse P status in the south and east of England also reflects low rainfall volumes compared with the wetter northern and western areas where rainfall dilutes surface water P concentrations

White and Hammond (2006) estimated that pig and cattle production was responsible for *c.*25% of diffuse P losses to water from agricultural systems, with losses from improved grassland, arable and horticultural production (mainly from sediment) accounting for 46%. Similarly, Anthony *et al.* (2008) estimated that manure applications contributed *c.*22% of agricultural P losses to water in Wales.

Data from the Environment Agency (2012) indicate that in 2011 nutrient losses from agriculture contributed to failure under the WFD in *c.*1,550 water bodies (equivalent to *c.*40% of all water bodies where nutrients are contributing to WFD water body failure). Nutrient runoff from agriculture was confirmed as the cause of at least 223 water body failures under the WFD, with 19% resulting from the failure of farm infrastructure (including slurry stores, silage clamps, milking parlours etc) and 33% from livestock field runoff.

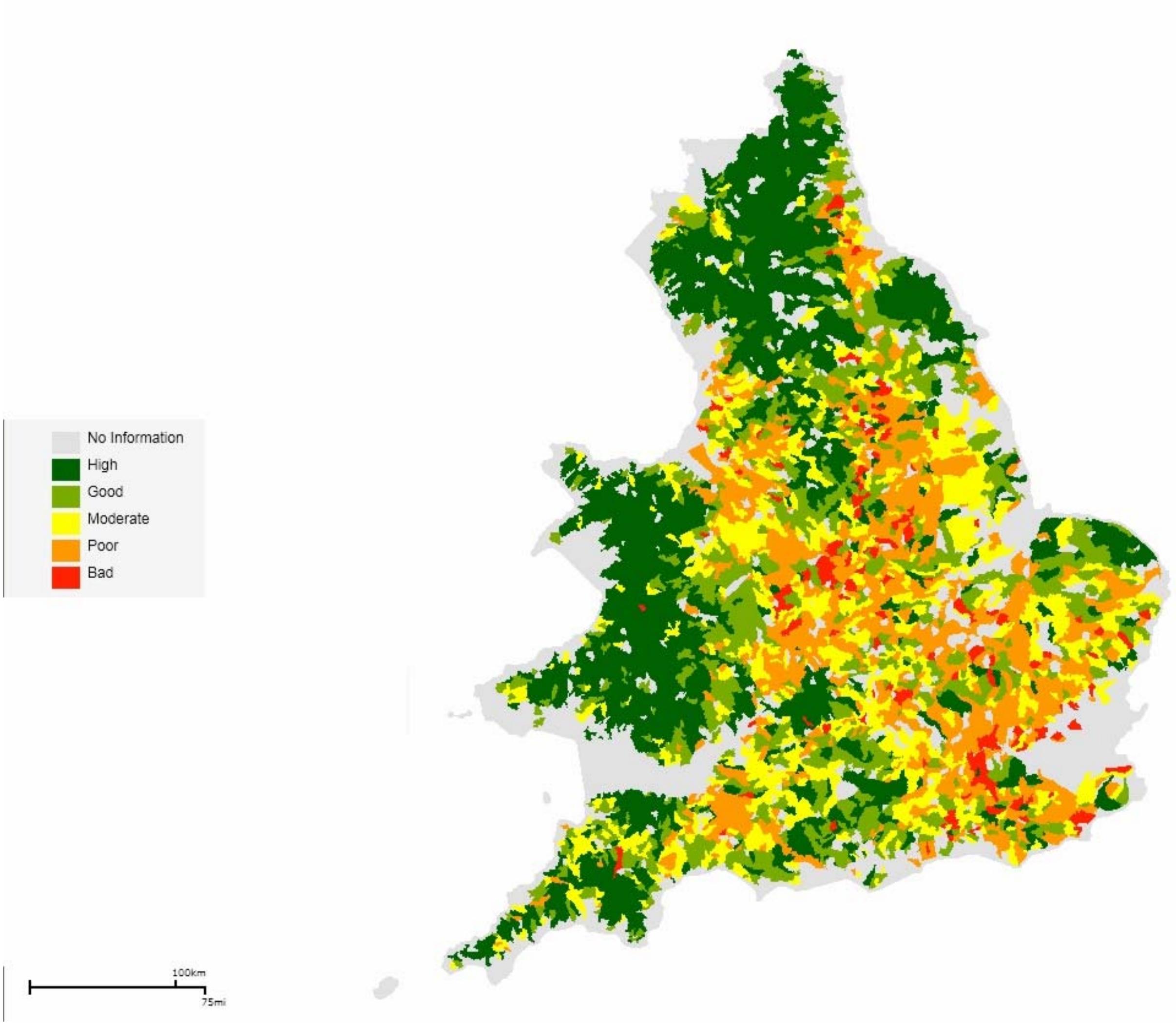


Figure 9. Water Framework Directive classification for good ecological status for physio – chemical pollutants: Soluble Reactive Phosphorus. Source Water Framework Directive surface water assessment, Environment Agency.

6.2. Assessing the risks of diffuse water pollution following slurry application

Data from Defra projects ES0106 (”Brimstone”), WQ0118 (“Cracking Clays Water”) and ES0115 (“OPTI-*N*”) were synthesised to assess diffuse water pollution risks following contrasting slurry application timings to free draining (Table 2) and medium/heavy soils (Table 3).

The data indicated that on all soil types autumn applications of high readily available nitrogen (RAN) manures (i.e. pig/cattle slurry and poultry manures) to winter cereal crops will increase nitrate leaching losses because crop N uptake during the autumn/winter period is generally low and there is sufficient over-winter rainfall to wash manure derived nitrate beyond crop rooting depth. Targeting autumn slurry (manure) applications before the establishment of oilseed rape and to grassland will encourage crop uptake of manure derived N before the onset of overwinter drainage and reduce the amount of soil N at risk of leaching. On free draining soils the risks of P and NH_4-N contamination of ground waters are low because P and NH_4 ions will be adsorbed onto soil surfaces, and in the case of NH_4-N will be converted to nitrate (and other nitrogen compounds) in the soil profile. Similarly, the risks of microbial pathogen losses are low as a result of ‘die-off’ during movement through the soil profile.

Table 2. Diffuse water pollution and soil compaction risks following slurry applications to free draining soils

Timing	Nitrate-N cereals grass & oilseed rape	Ammonium-N	Phosphorus	Microbial pathogens	Soil compaction
Autumn (Aug-Oct)	★★★/★★	★	★	★	★
Winter (Nov-Jan)	★★	★★	★★	★	★★
Spring (Feb-Apr)	★	★	★	★	★
Summer (May-Jul)	★	★	★	★	★

★ **low risk**, ★★ **medium risk**, ★★★ **high risk**

On medium/heavy soils, the risks of P, NH_4-N and microbial pathogen contamination of drainflow and surface runoff waters were generally highest where slurry applications were made to soils with a soil moisture deficit (SMD) of less than 20 mm and sufficient rainfall occurs in the 10-20 days after application to initiate drainflow/surface runoff. Summer and autumn application timings to ‘dry’ soils (SMD >20 mm) generally pose the lowest risks of P, NH_4-N and microbial pathogen contamination of drainflow (and surface runoff) waters. Similarly, the risks of soil compaction are lowest where slurry is applied in summer/autumn, as ‘dry’ soils are generally able to support the weight of heavy application machinery, without causing damage to soil structure. Minimising soil compaction is important in meeting cross-compliance objectives of maintaining land in Good Agricultural and Environmental Condition.

Table 3. Diffuse water pollution and soil compaction risks following slurry applications to medium/heavy soils

Application timing	Nitrate-N cereals/ grass & oilseed rape	Ammonium-N	Phosphorus	Microbial pathogens	Soil compaction
Autumn (Aug-Oct)	★★★/★★	★	★	★	★
Winter (Nov-Jan)	★★	★★★	★★★	★★★	★★★
Spring (Feb-Apr)	★	★★	★★	★★	★★
Summer (May-Jul)	★	★	★	★	★

★ **low risk**, ★★ **medium risk**, ★★★ **high risk**

7. SUMMARY OF FINDINGS

- The total amount of slurry produced in England was estimated at *c.*29 million m^3. Dairy slurry accounted for *c.*65%, beef slurry *c.*25% and pig slurry *c.*10% of total slurry volumes produced and applied to agricultural land. Cattle slurry production was mainly concentrated in Cumbria, Cheshire, Lancashire and the south west of England, with pig slurry in East Anglia and Yorkshire/Humberside

- Between 2001-2012 direct (point-source) water pollution incidents from the handling storage and land spreading of livestock slurry recorded on the EA NIRS database ranged between 109 and 352 / year. The highest numbers of incidents occurred in south west England. The most frequent causes of point-source water pollution were following the land application of slurry and over-topping of slurry stores. The increase in water pollution incidents in 2012 (to 164/year) is a potential cause for concern, as this was against the long-term downward trend.

- From 2001-2012 there were 47 category 1 (major), 261 category 2 (significant) and 1,566 category 3 (minor) point-source pollution incidents from the management and land application of livestock slurry.

- Autumn slurry applications are likely to increase the risks of nitrate leaching losses on all soil types. Targeting applications to grassland or before the establishment of winter oilseed rape on arable land will reduce the risks of nitrate leaching losses from autumn applied slurry.

- The risks of P and NH_4-N losses following slurry applications to free draining soils are low. On medium/heavy soils, the risks of elevated P and NH_4-N contamination of drainflow (and surface runoff) waters were generally highest where slurry applications were made to ‘wet’ soils with a soil moisture deficit of less than 20 mm and sufficient rainfall occurred in the 10-20 days following application to initiate drainflow/surface runoff.

- Manure management was estimated to account for *c.*20% of diffuse P and diffuse nitrate losses from agricultural land.

8. REFERENCES

Anthony, S., Duethmann, D., Turner, T., Carvalho, L., and Spears, B. (2008) Identifying the Gap to meet the Water Framework Directive – Lakes Baseline. Defra Project WT0750CSF, Final Report, 59 pp.

Chambers, B. J. and Smith, K. A. (1995). Management of farm manures: Economics and environmental considerations. *Soil Use and Management* **11,** 150-151.

Chambers, B.J., Smith, K.A. and Pain, B.F. (2000). Strategies to encourage better use of nitrogen in animal manures. *Soil Use and Management,* 16, 157-161

Defra (2009). Protecting our Water, Soil and Air. *A Code of Good Agricultural Practice for farmers, growers and land managers*. The Stationery Office.

Defra/EA (2009) Field application of organic manures. *Guidance to Farmers in Nitrate Vulnerable Zones Leaflet 8*. www.defra.gov.uk/environment/water/quality/nitrate

EA (2012). Pollution of Water from Agriculture. *Securing opportunities to improve competitiveness and to protect the water environment* p45

EU (2006). The quality of fresh waters needing protection or improvement in order to support fish life. Directive2006/44/EC of the European Parliament, September 2006.

Lord, E.I., Hughes, G.O., Wilson, L., Gooday, R., Anthony, S.A., Curtis, C. and Simpson, G., (2008). Updating Previous Estimates of the Load and Source Apportionment of Nitrogen to Waters in the UK. Final Report for Defra Project WQ0111, 104pp.

Newell Price, J.P., Harris, D., Taylor, M., Williams, J.R., Anthony, S.G., Duethmann, D., Gooday, R.D., Lord, E.I. and Chambers, B.J. Chadwick, D.R. and Misselbrook, T.H. (2011). An inventory of mitigation methods and guide to their effects on diffuse water pollution, greenhouse gas emissions and ammonia emissions from Agriculture. Defra Project ES0106.

Nix (2011). *The John Nix Farm Management Pocketbook 41st Edition*. The Pocketbook, 2 Nottingham Street, Melton Mowbray Leicestershire LE13 1NW.

SI (2010). The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010. Statutory Instrument 2010/639.

SI (2013). The Nitrate Pollution Prevention (Amendment) and Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) (Amendment) Regulations 2013. Statutory Instrument 2013/1001.

Smith, K.A., Brewer, A.J., Dauven, A and Wilson, D.W. (2000). A survey of the production and use of animal manures in England and Wales. I. Pig Manure. Soil Use and Management, 16, pp. 124-132.

Smith, K. A., Brewer, A. J., Crabb, J. & Dauven, A. (2001). A survey of the production and use of animal manures in England and Wales. III Cattle manures. Soil Use and Management, 17, pp. 77-87.

Smith, K.A., Chambers, B.J. and Williams, J.R. (2008). Towards sustainable recycling of farm manures: in search of practical solutions to technical problems. *In: Animal Manure - Pollutant or Resource? (Eds. T. Matsunaka and T. Sawamoto)*, pp.13-39.

White, P.J. and Hammond, J.P. (2006). Updating the estimate of the sources of phosphorus in UK waters. Defra report WT0701CSF.

Withers P.J.A., Davidson, I.H. and Foy, R.H. (2000). Prospects for controlling non-point phosphorus losses to water: A UK Perspective. *Journal of Environmental Quality*, 29, 167-175.

Project References

ES0106: Developing integrated land use and manure management strategies to control diffuse nutrient losses from drained clay soils: “Brimstone”

ES0115: Optimising slurry application timings to minimise nitrogen losses: “OPTI-*N*”

WQ0103: The National Inventory and Map of Livestock Manure Loadings to Agricultural Land: MANURES-*GIS*

WQ0118: Understanding the behaviour livestock manure multiple pollutants through contrasting cracking clay soils “Cracking Clays Water”

WT0932. Nitrates Action Programme : Impacts on Greenhouse Gas Emissions and Diffuse Nitrogen Pollution

Work Package 2. Closed- spreading period review for minimising diffuse pollution

Prepared by

John Williams[1] and Prof. Brian Chambers[2]

[1] ADAS Boxworth, Battlegate Road, Boxworth, Cambridge, CB23 4NN
[2] ADAS Gleadthorpe, Meden Vale, Mansfield, Notts., NG20 9PD

SUMMARY

The overall objective of this work package was to investigate the feasibility of adopting a ‘flexible’ approach to the setting of closed-spreading periods for high readily available N manures in relation to soil type, climate, farming system and weather.

The MANNER-*NPK* model was used to quantify the risk of nitrate leaching losses from contrasting slurry application timings for different agro-climatic zones and soil types across England. Also, a review of Defra-funded research projects investigating the effect of slurry application timings on nitrate, ammonium, phosphorus and microbial pathogen losses to water was carried out. Building upon the modelling and review data, the IRRIGUIDE drainage model was used to derive soil moisture deficit profiles for three sites, representative of the main agro-climatic zones across England, to identify application timings likely to minimise the risks of ammonium, phosphorus and microbial pathogen contamination of drainflow (and surface runoff) waters from medium/heavy soils.

MANNER-*NPK* estimates indicated that nitrate leaching losses following pig slurry application timings after the end of the closed-spreading period on sandy/shallow soil (i.e. 31 December) in low (650 mm) and medium (850 mm) rainfall areas would be around 10% of total N applied compared with losses typically in the range 30-50% of total N applied following autumn application timings. On medium/heavy soils after the end of the closed-spreading period (i.e. 31 January) estimated nitrate leaching losses in low/medium rainfall areas were *c.*10% of total N applied compared with losses typically in the range 10-20% of total N applied following autumn application timings. These data indicate that the closed-spreading periods in the 2013-2016 Nitrate Vulnerable Zones Action Programme (NVZ-AP) *are appropriate for reducing nitrate leaching losses* following the application of high readily available N manures, whilst balancing the need to apply manures in relation to crop nutrient demand.

The review of scientific evidence showed that:

- Autumn application timings are likely to increase the risk of nitrate leaching losses on all soil types, because crop N uptake during the autumn/winter period is generally low and there is sufficient over-winter rainfall to wash manure derived nitrate beyond crop rooting depth.
- Targeting manure applications before the establishment of oilseed rape (which has an autumn N requirement) was shown to reduce nitrate leaching losses, because crop N uptake before the start of over-winter drainage can reduce the amount of soil N at risk of leaching.
- Late spring and summer application timings are likely to minimise nitrate leaching losses, because of low drainage volumes and rapid crop uptake of manure derived N following application.
- On medium/heavy soils, the greatest risks of ammonium, phosphorus and microbial pathogen losses in drainflow (and surface runoff) waters were when slurry applications were made to ‘wet’ soils (<20 mm soil moisture deficit) and sufficient rainfall occurred in the 10-20 day period after application to generate drainflow (and surface runoff).

Soil moisture deficit profiles (using typical climate data) on arable land indicated that slurry applications are likely to pose a ‘risk’ of ammonium, phosphorus and microbial pathogen contamination of drainflow (and surface runoff) waters between late December and mid-March in low rainfall areas, and between early November and early April in medium rainfall areas. Information on local soil moisture deficit values

combined with short-term (e.g. up to 48 hours) rainfall forecasts could be used to help farmers improve manure management decisions to minimise the risk of diffuse water (i.e. ammonium, phosphorus and microbial pathogen) pollution following slurry application.

A flexible approach to setting closed-spreading periods for minimising nitrate leaching losses following high readily available N manure applications would be difficult to implement; *and is* not *supported by scientific evidence. Nitrate leaching losses are dependent on the volume of over-winter rainfall which is best estimated using long-term, rather than short-term, weather data. Moreover, on medium / heavy soils, accurate weather forecasting over a* 10-20 day period *(which is notoriously difficult to achieve) would be required to minimise diffuse ammonium, phosphorus and microbial pollution risks following slurry application. All other countries in the EU have fixed closed-spreading dates for organic manure and manufactured (chemical) fertiliser applications. Hence, there can be no doubt that should England (Britain) propose a 'flexible approach' to the spreading of organic manures as part of the next round of negotiations on the Nitrates Directive, the Commission would immediately signal the initiation of infraction proceedings against the UK (Britain). The Commission already consider that the duration of closed-spreading periods in England (Britain) are the least possibly acceptable; they believe that they should extend for 5-6 months at a minimum and that slurry storage capacity should be 6-7 months as a minimum.*

1. BACKGROUND

In the region of 90 million tonnes of farm manures, supplying 450,000 tonnes of nitrogen (N) and 119,000 tonnes of phosphorus (P) are applied to agricultural land in the UK each year (Williams *et al.,* 2000; Chambers *et al.,* 2000). These applications are a valuable source of plant available nutrients, however, they also pose a significant risk of diffuse pollution of the water (nitrate, ammonium, P and microbial pathogens) and air (ammonia – NH_3 and nitrous oxide – N_2O) environments. The land application of farm manures (particularly slurry) is recognised by the EU Commission as the *main cause of controllable diffuse pollution* in present day farming systems.

The Nitrate Vulnerable Zone Action Programme; NVZ-AP (SI, 2013) which covers *c.*60% of agricultural land in England, restricts the application of manures with a readily available N content greater than 30% of total N (i.e. pig/cattle slurries and poultry manures) on all soil types in the late autumn-winter period. The 'closed-spreading periods' are designed to minimise nitrate leaching (and other nutrient) losses following manure applications, with the length of the 'closed period' varying according to soil type and land use.

Importantly in an EU context, England is dominated by poorly drained (medium/heavy) soils compared to the predominance of free draining soils in Central Europe. Moreover, an EU funded project (EU, 2011) recommended in Atlantic Northern Europe (i.e. north and north-west England and Wales) closed-spreading periods for liquid manures should be from 1 September to 1 March (6 months), with a likely uncertainty of +/- 1 month. Also, in Atlantic Central Europe (central and southern England) closed-spreading periods for liquid manure should be from 1 September to 1 February (5 months), with an uncertainty of +/- 1 month. In addition, the storage capacity for liquid manures should be 1 month longer than the duration of the closed-spreading period i.e. 7 months in northern England and 6 months in central/southern England.

From a soil and farm management perspective the best time to spread manures, especially on medium and heavy soils, is when they are dry and can carry the weight of heavy application machinery (e.g. in summer and autumn) without causing compaction and damage to soil structure, which would be contrary to cross-compliance objectives of maintaining land in Good Agricultural and Environmental Condition.

The processes controlling nutrient (and microbial pathogen) losses to water are known to vary according to soil type:

Free draining, sandy and shallow soils - drainage occurs slowly over-winter by piston displacement in the unsaturated phase, with wetting fronts moving to depth at rates of a few metres a year depending on drainage volumes and the pore volume of the soil and base rock.

Poorly drained, medium and heavy soils - surface runoff is likely to occur in rapid response to rainfall events, because of the impermeable nature of the soil matrix. Where an effective drainage system is present, much of the water that would otherwise be lost as surface runoff, will move rapidly from the soil surface through macropores that have developed naturally or have been created through the installation of pipe drains, mole drains or subsoiling fissures, with transit times influenced by rainfall volume and intensity (Plate 1).

Plate 1. Cracks and fissures in medium/heavy soils.

2. OBJECTIVE

- To investigate the feasibility of adopting a 'flexible' approach to the setting of closed-spreading periods for high readily available N manures in relation to soil type, climate, farming system and weather.

3. NITRATE LEACHING

3.1. MANNER-*NPK* predictions for nitrate leaching

Outputs from MANNER-*NPK* (Nicholson *et al.,* 2010; Figure 1) were used to predict nitrate leaching losses from contrasting pig slurry application timings (supplying 250 kg/ha total N) in low (650mm), medium (850 mm) and high (1200 mm) rainfall zones (Figures 2, 3 and 4). The simulations were run for sandy/shallow and medium/heavy soils as described by The "Fertiliser Manual (RB209)" Defra (2010) in arable and grassland production.

Notes: Pig slurry represents a 'worst-case scenario' for nitrate leaching as it typically contains 70% readily available N (RAN) compared with 45% for cattle slurry (Defra, 2010). Typical annual rainfall for NVZ designated land in Britain is *c.*750 mm.

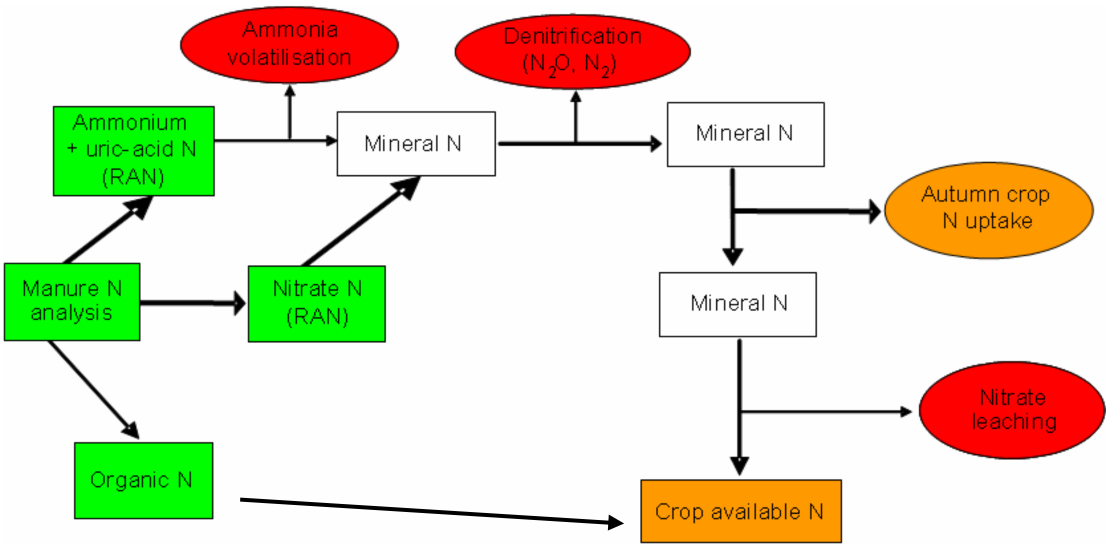


Figure 1. MANNER-*NPK* flow diagram

The model outputs estimated that nitrate leaching losses following pig slurry application timings after the end of the closed-spreading period on sandy/shallow soils (i.e. 31 December) in low (650 mm) and medium (850 mm) rainfall areas were around 10% of total N applied, compared with losses in the range 30-50% of total N applied following autumn application timings.

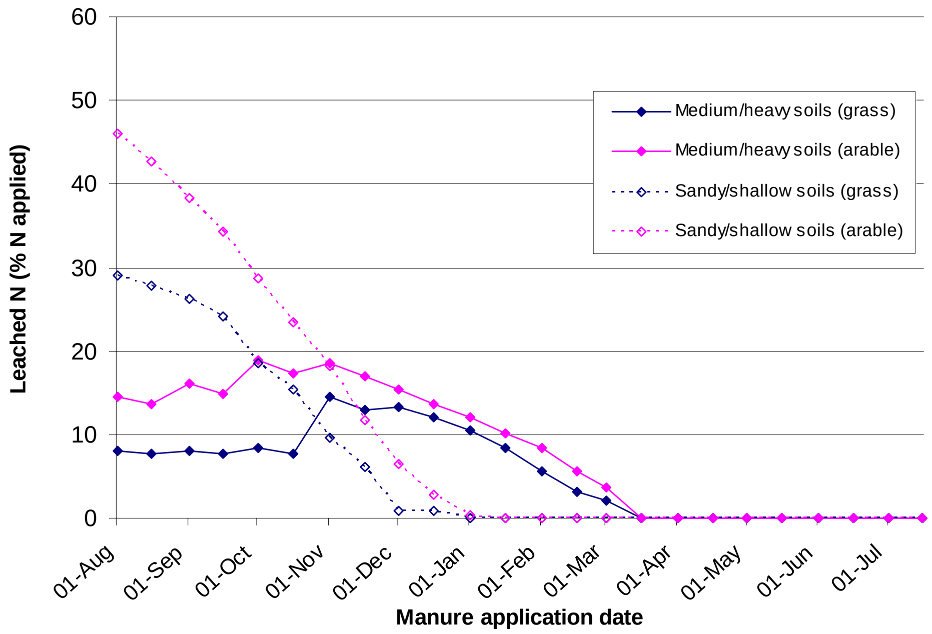


Figure 2. Predicted nitrate leaching losses from contrasting pig slurry application timings in a low rainfall zone (650 mm)

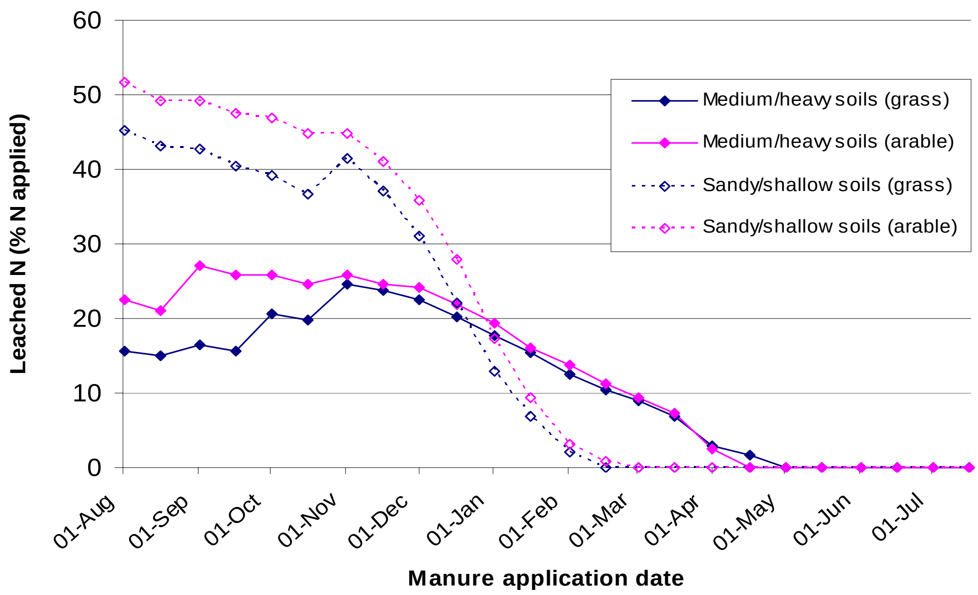


Figure 3. Predicted nitrate leaching losses from contrasting pig slurry application timings in a medium rainfall zone (850 mm)

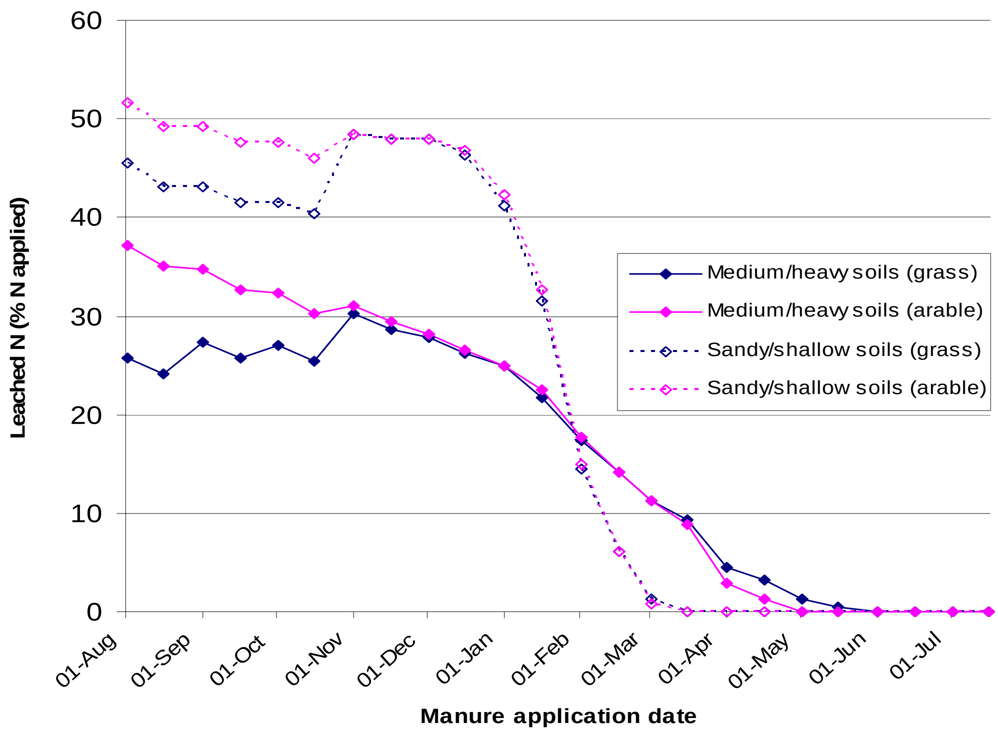


Figure 4. Predicted nitrate leaching losses from contrasting pig slurry application timings in a high rainfall zone (1200 mm)

On medium/heavy soils, after the end of the closed-spreading period (i.e. 31 January) nitrate leaching losses in low and medium rainfall areas were *c.*10% of total N applied, compared with losses typically in the range 10-20% of total N applied following autumn application timings.

These data indicate that the closed-spreading periods in the 2013-16 NVZ-AP (SI, 2013) are appropriate for reducing nitrate leaching losses following the application of high RAN manures (particularly in low rainfall zones), whilst balancing the need to apply manures in relation to crop nutrient demand.

3.2. Research evidence base

3.2.1 Nitrate leaching losses

Free-draining soils

A large body of research was undertaken in the UK pre-2000 on nitrate leaching from free draining ‘leaky’ soils, which provided the evidence base for setting closed-spreading periods for high RAN manures (Beckwith *et al.*, 1998, Chambers *et al,* 2000). On arable soils, nitrate leaching losses following September, October and November slurry and poultry manure applications were typically in the range 10-20% of total N applied (Figure 5), whilst N losses following applications in December or January were not significantly elevated above those from untreated controls. On grassland soils, nitrate leaching losses were also greatest when slurry was applied in the autumn to early winter period. However, leaching losses following slurry applications in September were lower than in October, reflecting greater grass N uptake from the earlier timing (Figure 6).

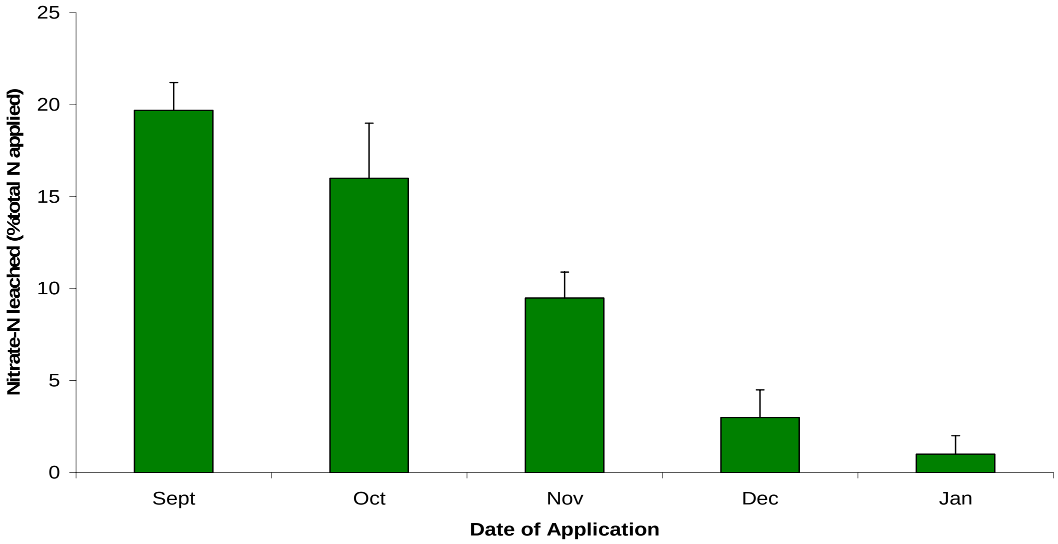


Figure 5. Nitrate leaching losses following manure applications to free-draining arable soils (Chambers *et al.,* 2000)

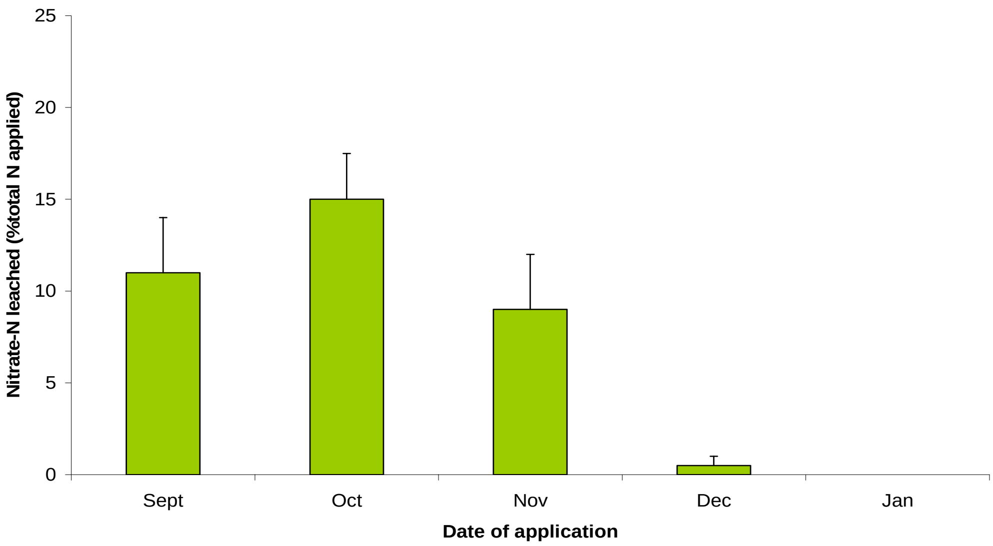


Figure 6. Nitrate leaching losses following slurry applications to free-draining grassland soils (Chambers *et al.,* 2000)

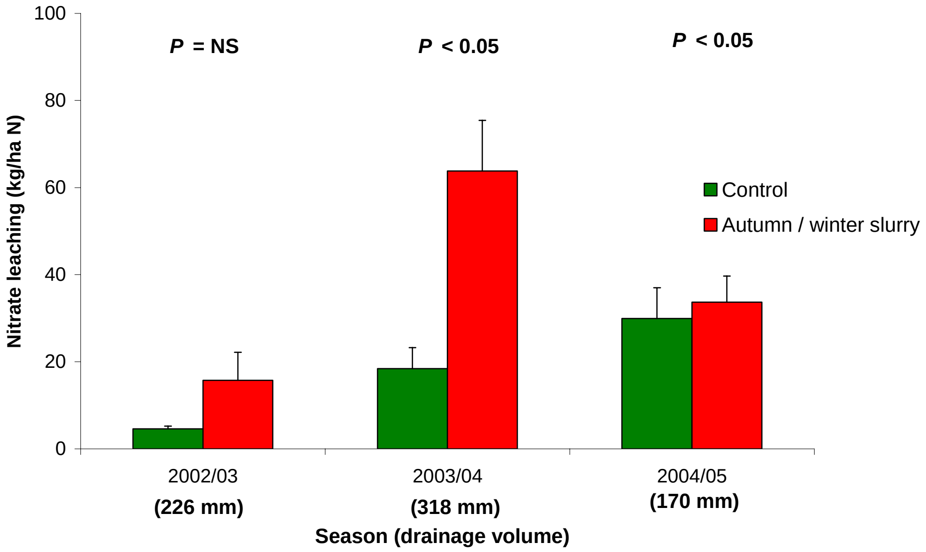


Figure 7. Nitrate leaching losses following shallow injected cattle slurry applications (Defra project ES0115)

Data from Defra project ES0115 ("OPTI-*N*") showed that nitrate leaching losses following autumn/winter slurry application timings before winter cereals were equivalent to 19-20% of slurry total N applied. In contrast, nitrate leaching losses following the application of pig slurry, before the establishment of oilseed rape, were not different (P>0.05) from the untreated control. The lower losses following slurry application before oilseed rape reflected greater crop N uptake (*c.*80 kg/ha N) between application and the onset of winter drainage, compared with winter cereal crop N uptake (*c.*5 kg/ha N). On grassland, nitrate leaching losses following autumn slurry application timings were increased (P<0.05) where drainage volumes after application exceeded 300 mm (losses equivalent to 47% of total slurry N applied; Figure 7).

Medium and heavy soils

Defra-funded experiments (projects NT1406 and NT1012) carried out on a drained clay soil (Hanslope Series) under arable production at ADAS Boxworth (1994/5 to 1997/8) showed that nitrate leaching losses following high readily available N manure applications (e.g. pig slurry and poultry manure) in autumn-early winter, were equivalent to between 11 and 20% of the total manure N applied. These losses were similar to those measured from related studies on free draining sandy and shallow soils (in low rainfall areas) and challenged the widely held view that clay soils were retentive of nitrate-N.

Data from Defra project ES0106 ("Brimstone") on a drained clay soil (Denchworth Series) at Brimstone Farm in Oxfordshire showed that nitrate losses from arable land were greatest (P<0.05) following autumn cattle slurry application timings (equivalent to 8-11% of total slurry N applied) compared with winter timings (2-6% of total N applied), Figure 8. On arable reversion grassland mean NO_3-N concentrations were significantly lower (P<0.05) than from arable land, with slurry application timing having no effect (P>0.05) on nitrate losses, reflecting grass N uptake in the autumn and the accumulation of N in soil organic matter reserves.

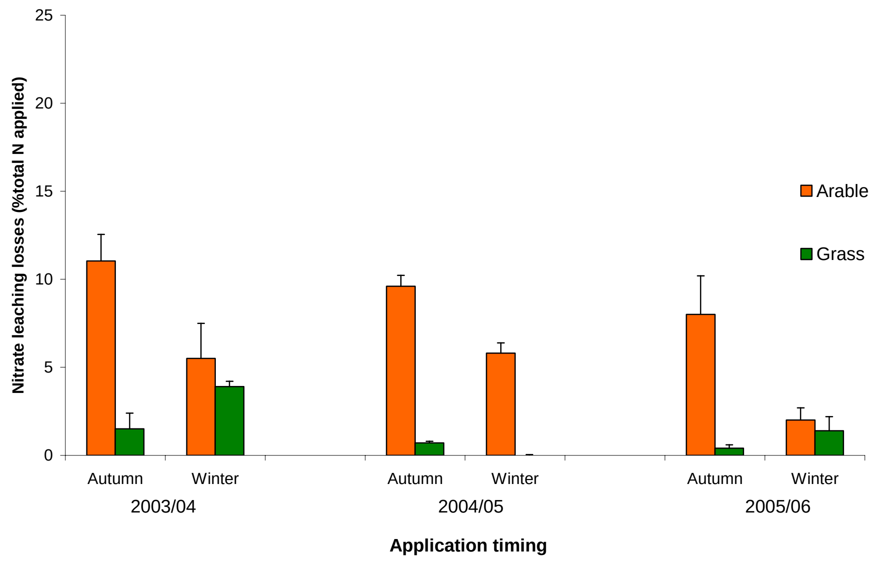


Figure 8. Nitrate leaching losses following contrasting cattle slurry applications to arable and arable reversion grassland (Defra project ES0106)

In Defra project WQ0118 ("Cracking Clays-Water"), nitrate-N leaching losses from a drained arable clay soil at ADAS Boxworth (Figure 9) were greatest following autumn (August-October) pig slurry (range 13-16% of total N applied) and poultry manure (8-12% of total N applied) applications to winter wheat. These losses reflected the high RAN content of these manures (RAN = 30-84% of total N applied) and low uptake of manure N by the winter wheat crop between application and the start of drainage.

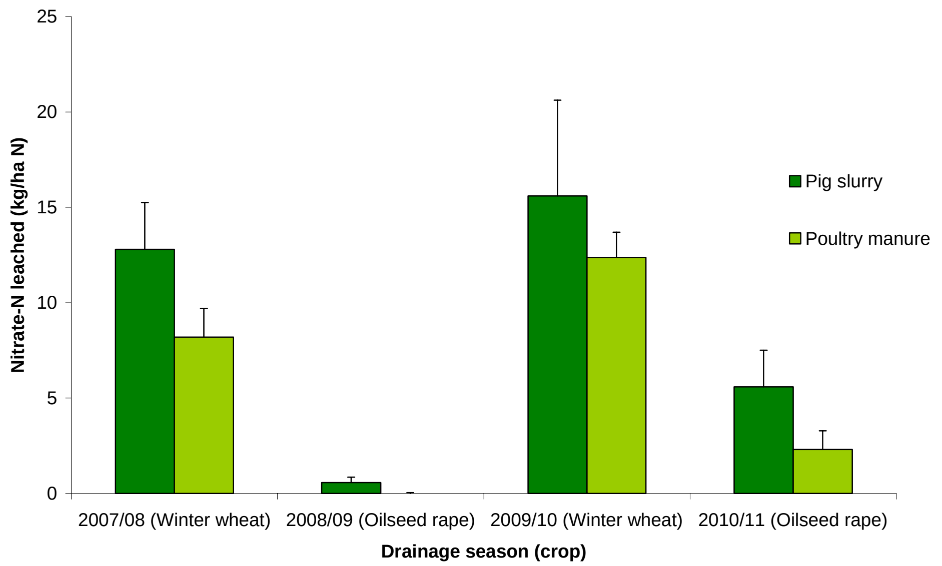


Figure 9. Nitrate leaching losses following autumn pig slurry and poultry manure applications at ADAS Boxworth (Defra project WQ0118)

Nitrate leaching losses following August slurry and poultry manure applications before the drilling of winter oilseed rape were lower (<6% of total N applied) than from winter cereal cropped land (Figure 9); reflecting the uptake of manure N by the actively growing oilseed rape crop (Plate 2). Nitrate leaching losses following February-May slurry applications to winter wheat and oilseed rape were low (<3% of total N applied); reflecting low over-winter drainage volumes after application and crop uptake of manure N.

Plate 2. Establishment of oliseed rape at ADAS Boxworth on 21st November 2008 showing the autumn applied pig slurry (left) and nil nitrogen (right) treatments.

4. OTHER POLLUTANT LOSSES

4.1. Free-draining soils

On soils where water moves slowly to depth (i.e. free draining sandy and shallow soils), the risks of ammonium and P contamination of ground waters is low because the ammonium and P ions will be adsorbed onto soil surfaces, and in the case of ammonium will be converted to nitrate (and other nitrogen compounds) in the soil profile.

4.2. Medium and heavy soils

Data from Defra project ES0106 ("Brimstone-*NPS*") showed that autumn slurry application timings to arable and grassland soils generally had no effect on ammonium-N (NH_4-N) and total dissolved phosphorus (TDP) concentrations in drainage waters. However, elevated NH_4-N and TDP concentrations were measured in drainage waters (up to 6.4 mg/l NH_4-N and 7.3 mg/l TDP from grassland, and 4.5 mg/l NH_4-N and 3.6 mg/l TDP from arable soils) when slurry applications were made to 'wet' soils (soil moisture deficit <20mm) in winter and spring, and rain (>10 mm) occurred within 10-20 days of application (Figures 10 and 11).

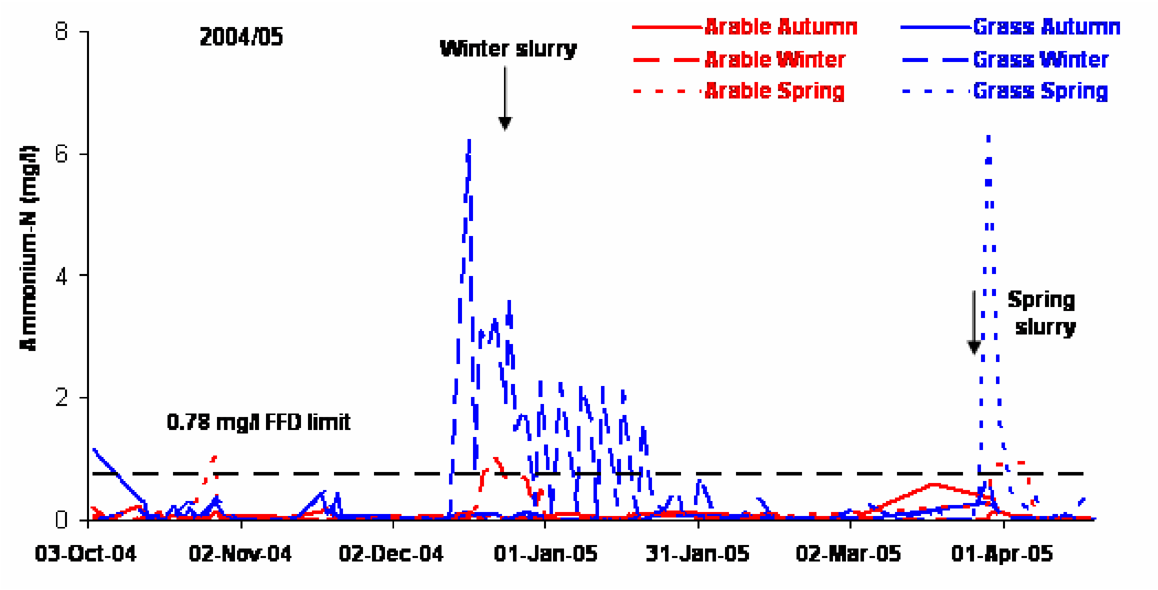


Figure 10. Ammonium-N concentrations following contrasting slurry application timings to a drained arable and grassland clay soil (Defra project ES0106)

Mean slurry NH_4-N losses were highest at 0.4 kg/ha NH_4-N (*c.*4-fold greater than background losses) following the winter slurry applications and 0.2 kg/ha NH_4-N following the spring slurry applications to grassland. In contrast, slurry NH_4-N losses from all the arable treatment plots and autumn application to the grassland plots were < 0.1 kg/ha NH_4-N.

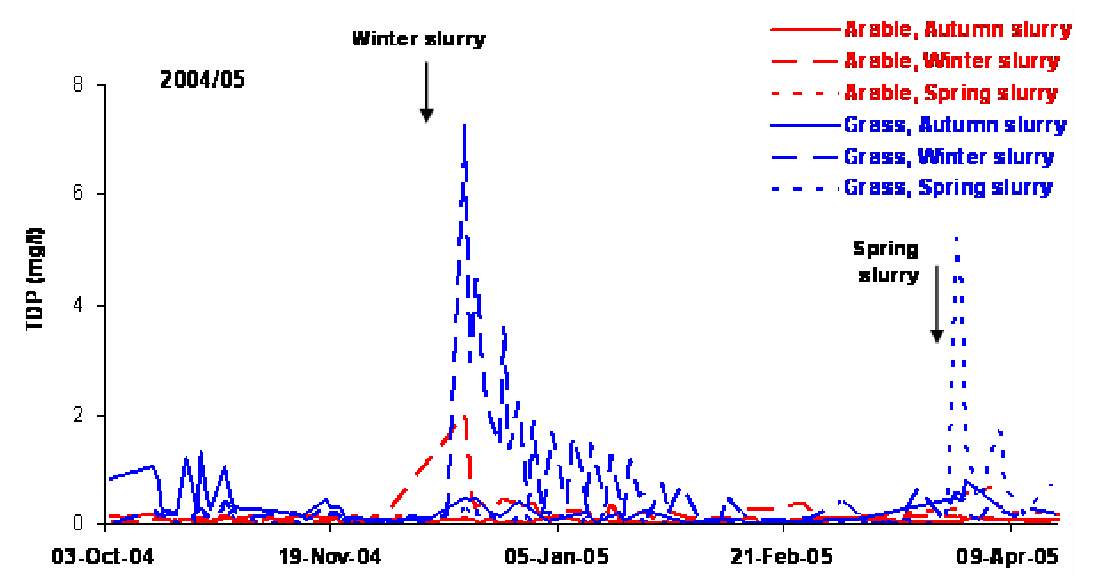


Figure 11. Total dissolved phosphorus concentrations in drainage water following contrasting slurry application timings to a drained arable and grassland clay soil (Defra project ES0106)

TDP losses were higher (P<0.05) from the grassland (range 0.08-1.17 kg/ha P) than the arable plots (range 0.05-0.27 kg/ha P) in all three study years. Also, TDP losses from the grassland plots were highest (P<0.05) following the winter slurry timings (range 0.13-1.17 kg/ha P) compared with the autumn (0.08-0.52 kg/ha P) and spring (0.08-0.80 kg/ha P) timings (Figure 12).

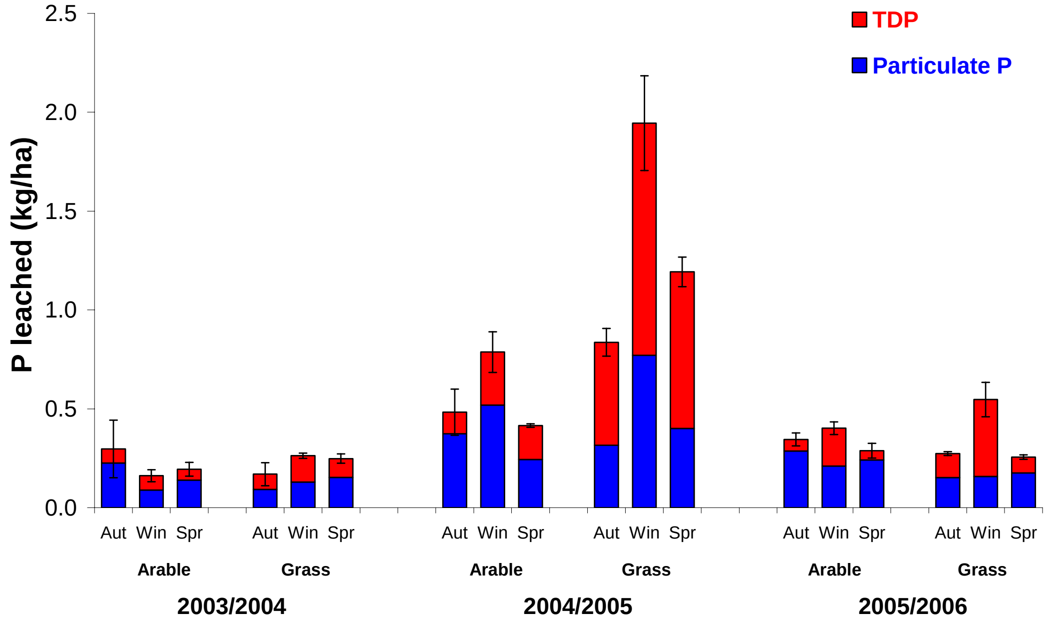


Figure 12. Phosphorus losses following contrasting cattle slurry applications to a drained arable and grassland soil (Defra project ES0106)

The higher NH_4-N and TDP concentrations and losses in drainage waters from the grassland plots most probably reflected greater connectivity between the soil surface and field drains, as a result of 'by-pass' flow in cracks/mole channels, than on the annually cultivated arable plots. Overall, slurry P losses accounted for 64% and 43% of total P losses following the winter applications to the grassland plots and arable plots, respectively. On the grassland plots slurry P losses accounted for 41% and 28%, and on the arable plots 13% and 26% of total P losses following the spring and autumn timings, respectively.

Data from Defra project WQ0118 ("Cracking Clays-Water") confirmed that soil conditions and rainfall volumes in the period after slurry applications were important factors controlling NH_4-N, TDP and *E.coli* concentrations in drainflow and surface runoff waters from arable and grassland soils at Faringdon (Oxon.), ADAS Boxworth (Cambs.) and North Wyke Research (Devon). On grassland at Rowden (Devon), the highest NH_4-N concentrations were measured following an autumn (October) cattle slurry application to soils with a moisture deficit of 15 mm and 46 mm of rainfall (in the 2 weeks after application) resulted in *c.*15 mm of water flow, with peak NH_4-N concentrations of 28.0 mg/l in drainage waters, 36.9 mg/l in surface runoff from drained plots and 14.0 mg/l in surface runoff from undrained plots (i.e. considerably higher than the EU Freshwater Fish Directive limit of 0.78 mg/l NH_4-N; EU, 2006 Figure 13).

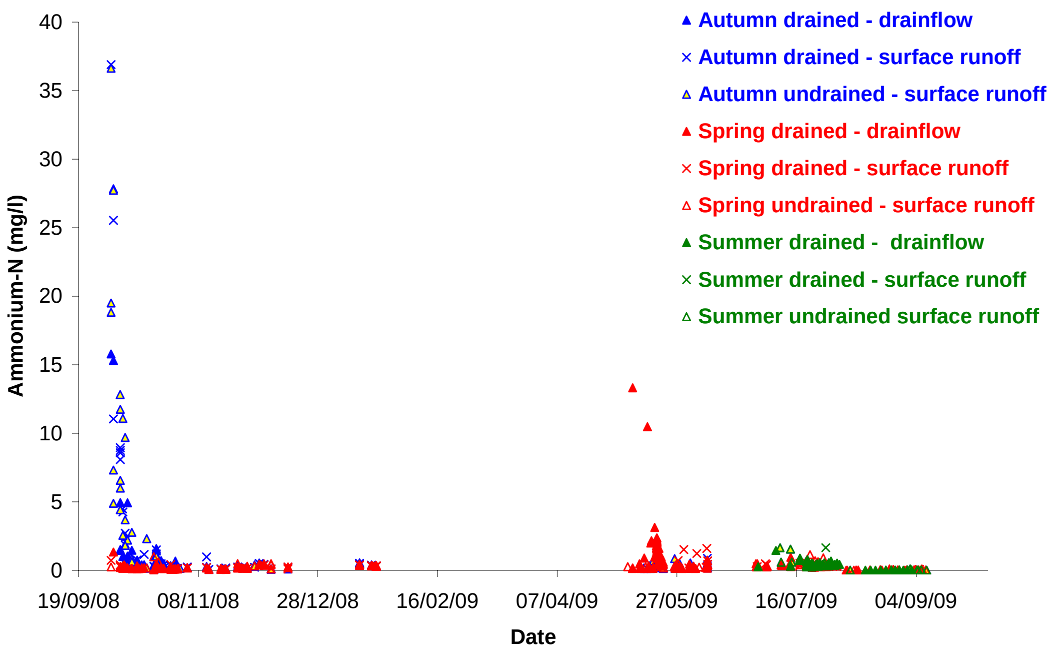


Figure 13. Ammonium-N concentrations in drainflow and surface runoff following contrasting cattle slurry applications to drained and undrained grassland at Rowden (Defra project WQ0118)

The highest TDP concentrations at Rowden were measured following a spring (May) cattle slurry application to soils with a moisture deficit of 25 mm and 133 mm of rainfall (in the 2 weeks after application) resulted in *c.*60 mm of water flow; peak TDP concentrations were 9.6 mg/l in drainflow, 11.8 mg/l in surface runoff from the drained plots and 10.0 mg/l in surface runoff from the undrained plots (Figure 14).

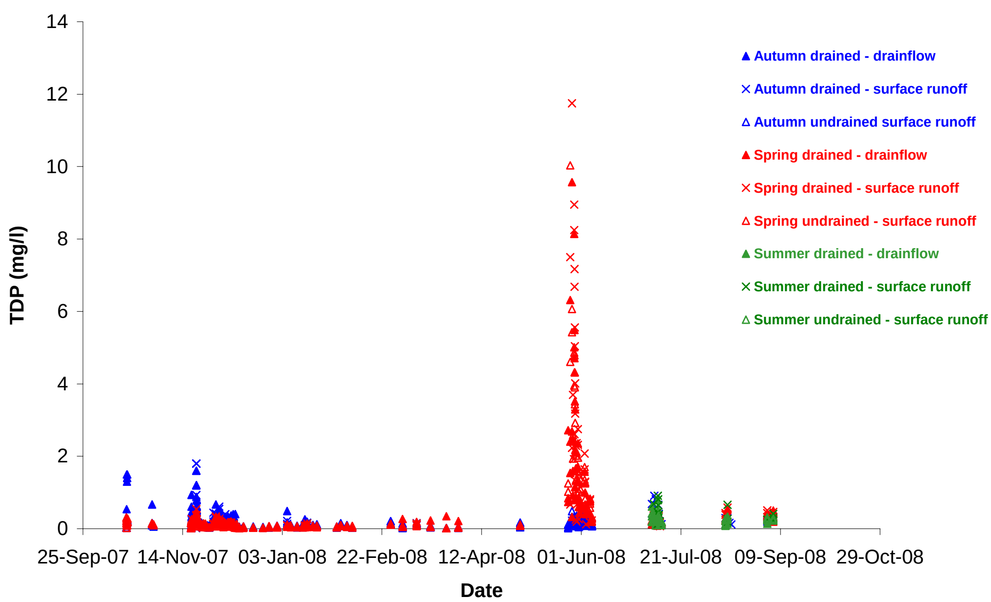


Figure 14. Total dissolved phosphorus (TDP) concentrations in drainflow and surface runoff following contrasting cattle slurry applications to drained and undrained grassland soils at Rowden (Defra Project WQ0118)

Cattle slurry applications to grassland in summer had no effect on NH_4-N or TDP concentrations in drainflow or surface runoff waters; reflecting warm soil conditions at the time of application (which would have encouraged the conversion of ammonium-N to nitrate-N and adsorption of manure P onto the soil matrix) and low drainage volumes after application.

On arable land at ADAS Boxworth, the highest NH_4-N concentrations (6.1 mg/l NH_4-N) were measured following a spring (February) 2009 pig slurry application (Figure 15) to soils with a moisture deficit of 4 mm and 6 mm of rainfall (7 days after application) resulted in drainflow.

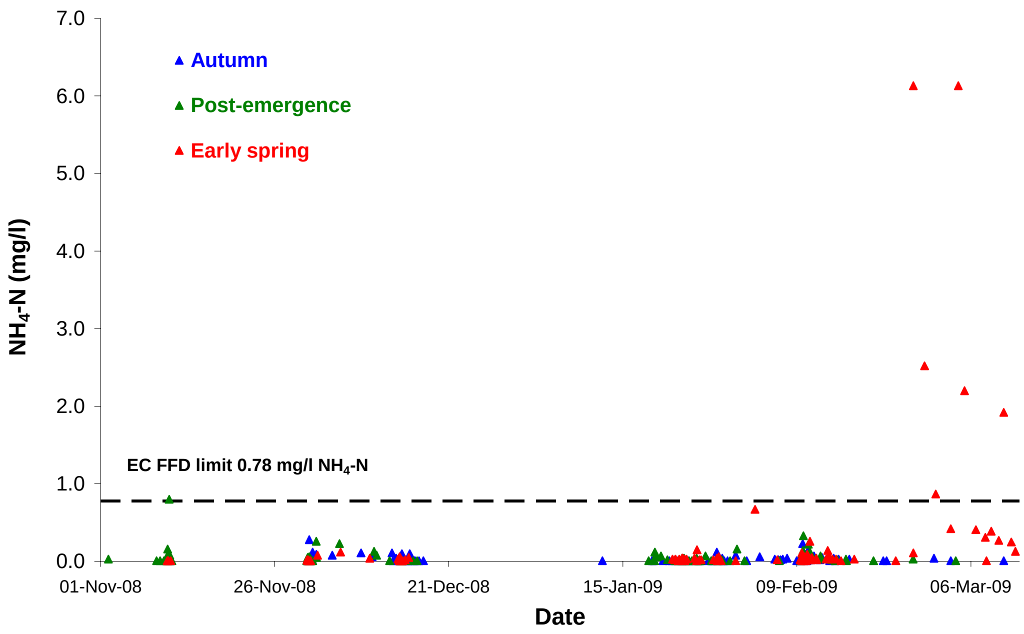


Figure 15. Ammonium-N concentrations in drainflow waters following contrasting pig slurry application timings to oilseed rape at ADAS Boxworth (Defra Project WQ0118)

The highest TDP concentrations at Faringdon (Figure 16) were measured following a spring (March) 2008 cattle slurry application to soils with a moisture deficit of 7 mm and 53 mm of rainfall (4-10 days after application) resulted in drainflow. Late spring (April) applications had no effect on NH_4-N or TDP concentrations in drainflow waters (largely) because of low drainage volumes after application.

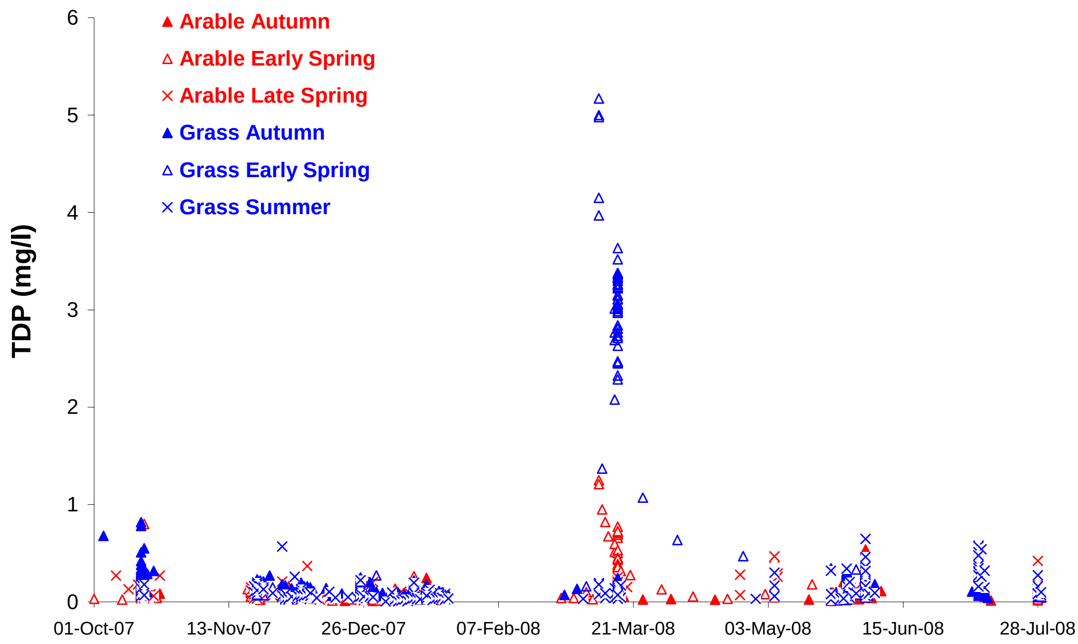


Figure 16. Total dissolved phosphorus concentrations in drainflow waters following contrasting cattle slurry application timings to arable and grassland at Faringdon (Defra Project WQ0118).

The risks of *E.coli* contamination of drainage water at all three sites were highest where drainflow or surface runoff occurred within 1-4 days of slurry application. On grassland, the highest *E.coli* concentrations (6.6 $\log_{10}$ cfu/100ml in drainage and surface runoff waters) were measured at Rowden following an autumn (October) 2009 cattle slurry application to soils with a moisture deficit of 34 mm and 17 mm of rainfall (in the 2 days after application) resulted in drainflow and surface runoff (Figure 17).

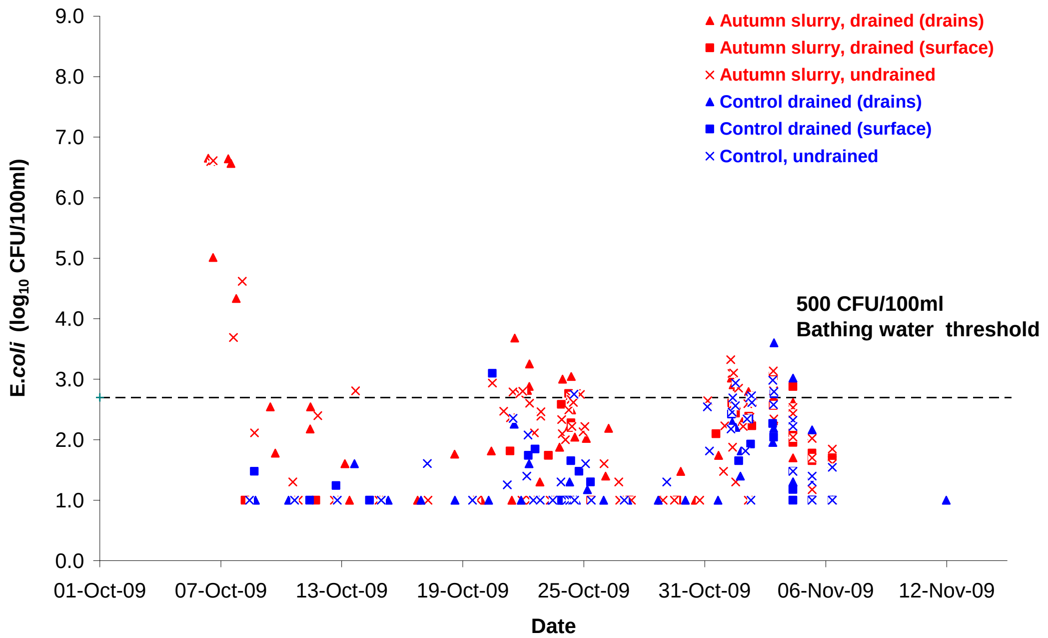


Figure 17. E.*coli* concentrations in drainflow and surface runoff waters following autumn (October) cattle slurry application to drained and undrained grassland at Rowden (Defra project WQ 0118)

Notably, following cattle slurry application to grassland at Faringdon (where 53 mm of rainfall occurred in the 4-10 day period after application) drainflow waters were discoloured, indicating that slurry had moved rapidly from the grassland soil surface through macro-pores to the field drains, with little contact with the soil matrix *(*Plate 3*).*

Plate 3. Drainage water samples 10 days after March 2008 cattle slurry application to grassland at Faringdon: slurry treated (left) and untreated (right); Defra Project WQ0118.

5. APPLICATION TIMINGS TO MINIMISE RISKS OF DIFFUSE WATER POLLUTION

5.1 Nitrate leaching

The research evidence base shows that autumn applications of slurry and poultry manure are likely to increase the risk of nitrate leaching losses on all soil types. This is because crop N uptake during the autumn/winter period is generally low and there is sufficient over-winter rainfall to wash manure derived nitrate beyond crop rooting depth. In arable rotations, targeting manure applications before the establishment of oilseed rape (which has an autumn N requirement) has been shown to limit leaching losses, because crop N uptake before the onset of winter drainage reduced the amount of soil N at risk of leaching. The risks of nitrate leaching following winter and spring timings are generally lower because drainage volumes after application are not sufficient to wash all of the manure derived nitrate beyond rooting depth.

5.2 Other pollutant losses

Data from Defra projects ES0106 (“Brimstone”) and WQ0118 (“Cracking Clays-Water”) were combined and analysed to investigate relationships between peak drainflow NH_4-N (Figure 18) and TDP (Figure 19) concentrations and the delay between application and the start of drainflow. Notably, elevated drainflow (surface runoff) NH_4-N and TDP concentrations were a result of rainfall in the days after application, rather than direct drainflow initiated by the slurry application itself (typically 35-50 m^3/ha; equivalent to 3.5-5 mm of liquid) **i.e. they were the result of ‘diffuse’ pollution rather than ‘point-source’ runoff**.

The risks of NH_4-N, TDP and E.*coli* contamination of drainage waters were highest when slurry applications are made to ‘wet’ soils and sufficient rainfall occurred in the 10-20 day period after application to cause drainflow; these conditions occurred mainly during the winter and early spring periods.

Autumn and summer application timings posed the lowest risk of NH_4-N, TDP and E.*coli* contamination of drainflow (and surface runoff) waters because soils were usually dry and warm in the days following application, allowing slurry NH_4-N to be converted to nitrate and P to be adsorbed onto the soil matrix before drainage occurred.

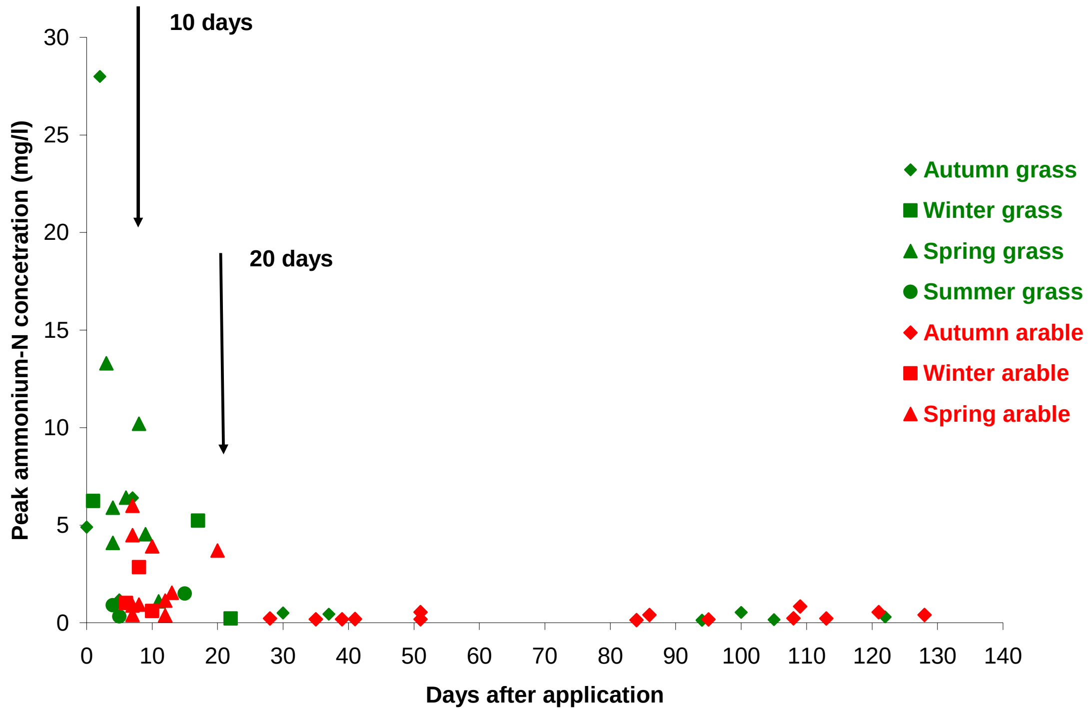


Figure 18. Delay between slurry application and peak ammonium-N concentrations in drainflow waters (Defra projects ES0106 and WQ0118).

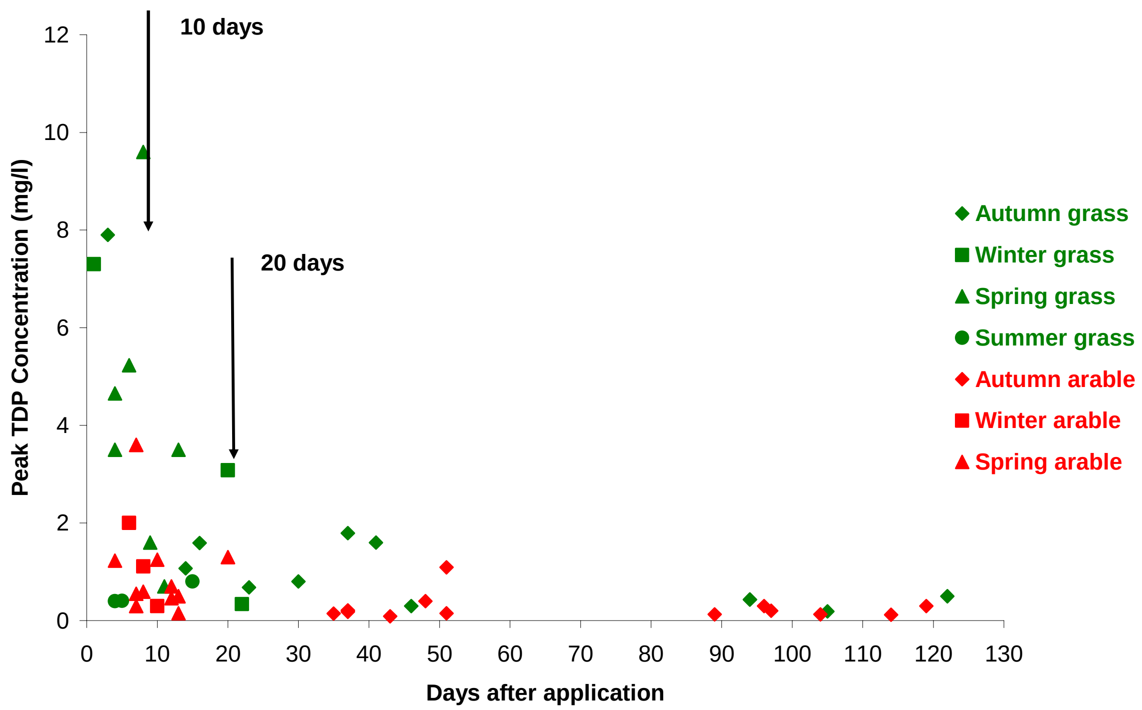


Figure 19. Delay between slurry application and peak TDP concentrations in drainflow waters (Defra projects WQ0118 and ES0106)

5.3. Soil moisture deficit profiles

Analysis of peak NH_4-N and TDP concentration data in drainflow waters (Figures 18 and 19) showed that the risks of drainage water contamination were greatest when slurry was applied to soils with a moisture deficit of less than 10 mm. Based on these data, 'simple' risk management guidelines were developed to minimise the risks of elevated NH_4-N, P and E.*coli* concentrations in drainflow (and surface runoff) waters following slurry application (Table 2).

Table 2. Risk management guidelines for slurry application timing

Soil moisture deficit (mm)	Risk
>20	Low
10-20	Moderate
<10	High

The IRRIGUIDE water balance model (Bailey and Spackman, 1996) was used to derive soil moisture deficit (SMD) profiles (Figures 19-22), at the three sites used in the Defra "Cracking Clays" project (WQ0118) i.e. Faringdon in Oxfordshire (grass and arable), ADAS Boxworth in Cambridgeshire (arable) and Rowden North Wyke in Devon (grassland). The SMD profiles (Figures 20, 21 ,22, and 23) were calculated using 23 years of climatic data for the sites; Boxworth 'low' rainfall zone (550 mm), Faringdon 'medium' rainfall zone (740mm) and Rowden 'high' rainfall zone (1,150 mm)

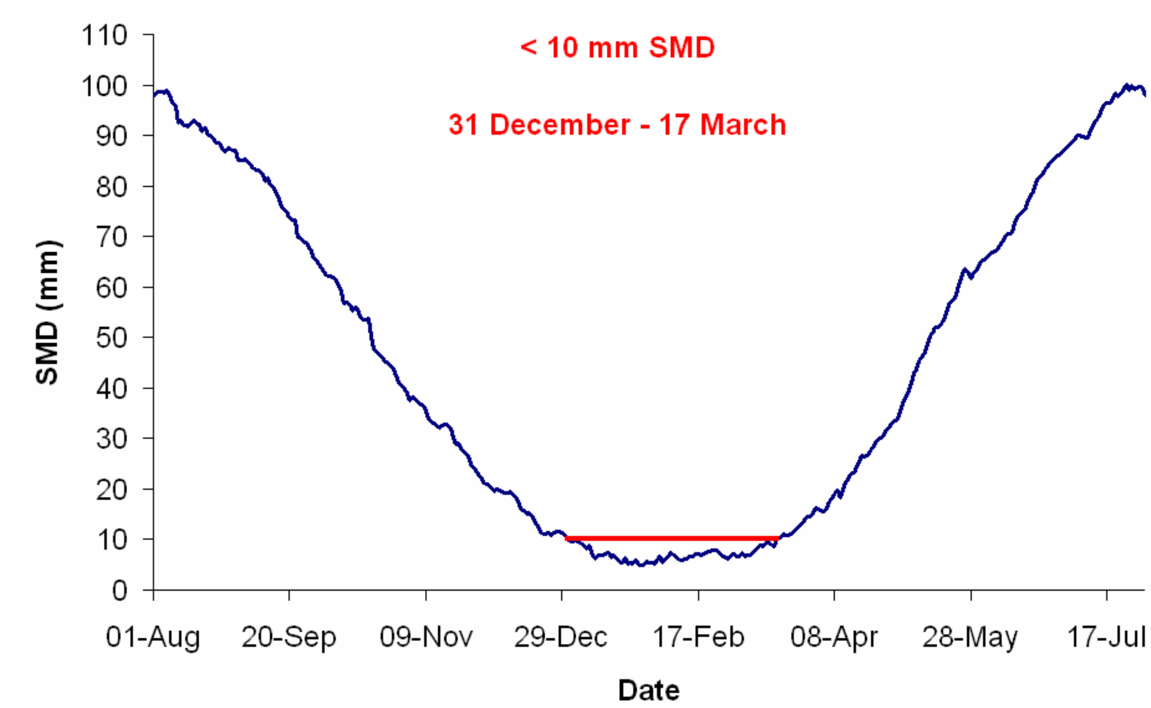


Figure 20. Typical SMD profile – Boxworth winter cereals

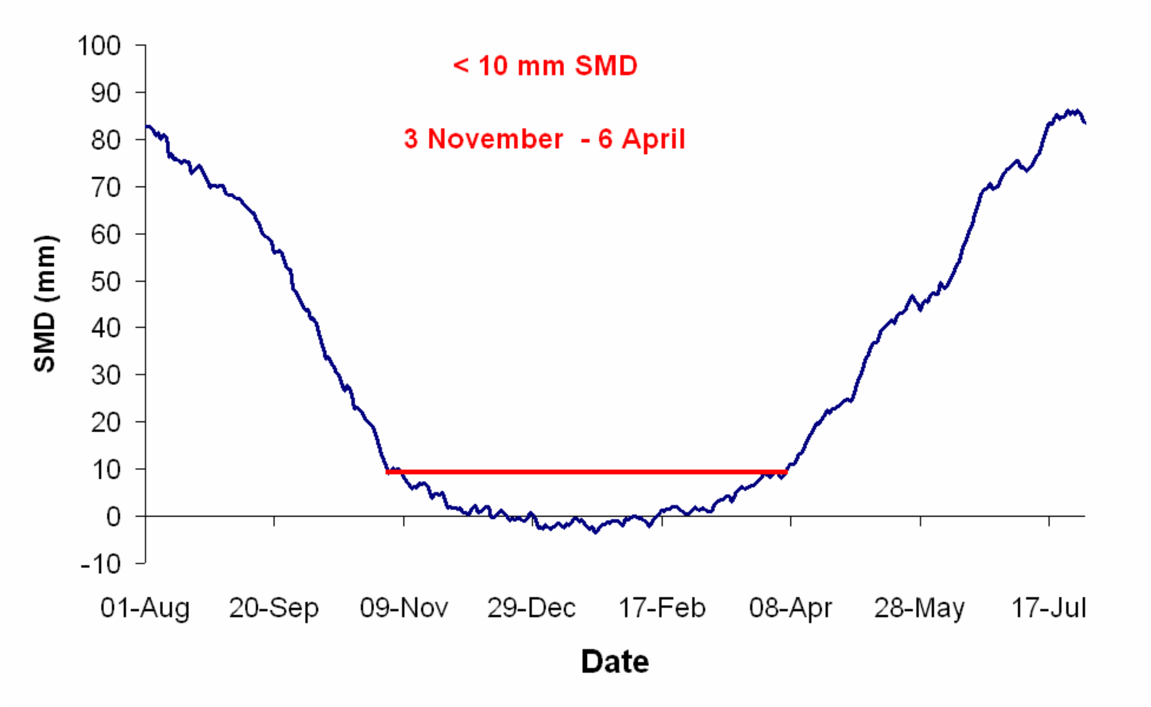


Figure 21. Typical SMD profile – Faringdon winter cereals

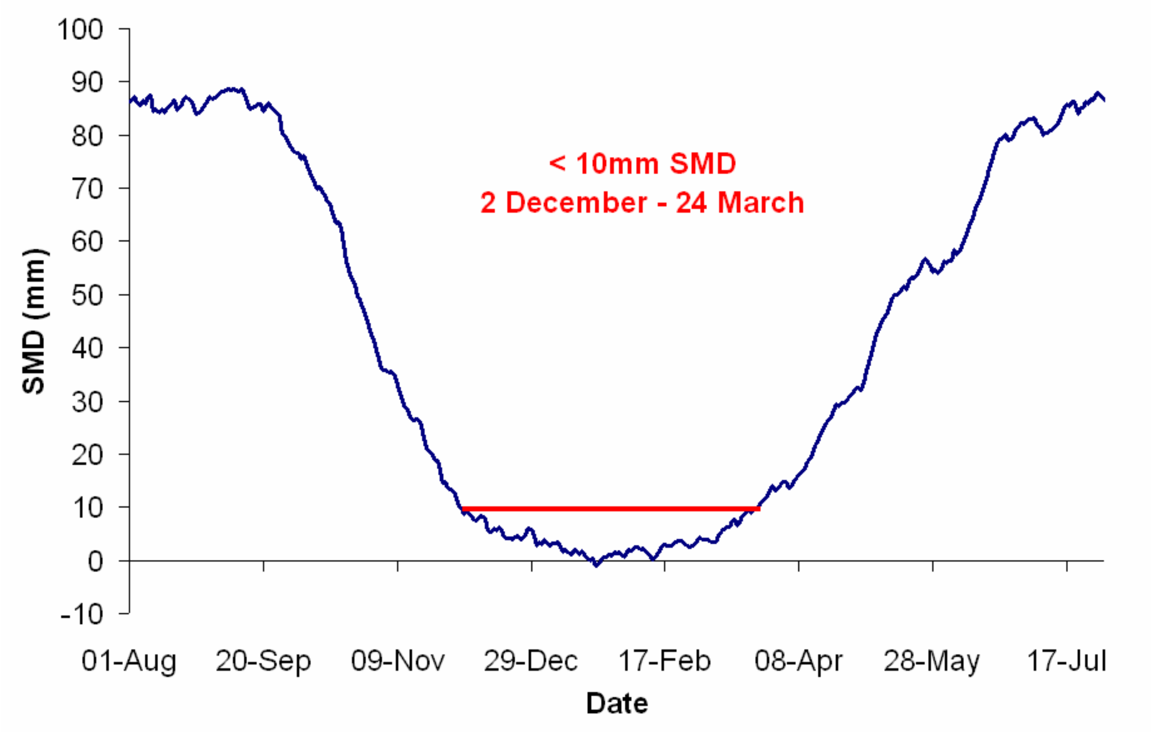


Figure 22. Typical SMD profile – Faringdon grass

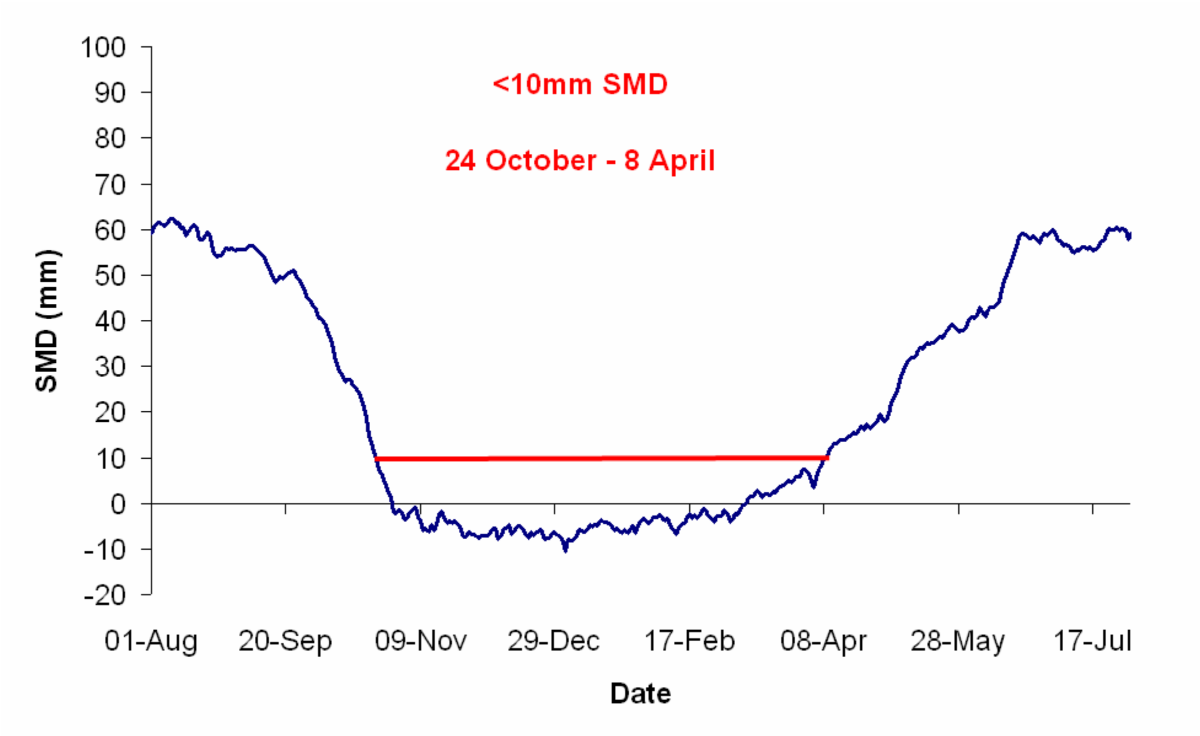


Figure 23. Typical SMD profile – Rowden grass

The SMD profiles indicated that there was likely to be a 'high' risk of elevated NH_4-N, TDP and E.*coli* concentrations in drainflow (and surface runoff) waters (i.e. the SMD <10 mm) in a 'typical' year between late December and mid-March at Boxworth (winter cereals), early December and late March at Faringdon (grassland), early November and early April at Faringdon (winter cereals) and late October and early April at Rowden (grassland). These data indicate that the existing closed-spreading periods on medium/heavy soils (1 October to 31 January on arable land and 15 October to 31 January on grassland) may not be long enough to minimise the risks of elevated NH_4-N, TDP and E.*coli* concentrations in drainflow (surface runoff) waters in spring.

5.4 Minimising risks of water pollution following organic material applications

The two causes of water pollution following the land application of organic manures are:

- **Diffuse pollution as a result of rainfall following application**; these risks are mainly influenced by SMD levels, rainfall timing and volumes etc (as described in Sections 5.1-5.3)
- **Direct (point-source) slurry runoff from land spreading**; these risks are influenced by application rate, field slopes, connectivity to drains and surface waters etc.

Direct slurry runoff can be caused by excessive application rates (resulting in surface runoff or drainflow from the slurry application itself), or where slurry cannot infiltrate rapidly into the soil (e.g. following application to waterlogged, frozen or compacted soils; particularly on sloping land). In this context a "Manure Management Plan" (Defra 2009; Defra/EA, 2009) will help farmers to assess runoff risks and to identify non-spreading areas to minimise direct slurry runoff into watercourses e.g. no spreading areas within 10 m of a watercourse, 50 m of a bore-hole, not on steep slopes, not on recently drained land etc. The Code of Good Agricultural Practice

(Defra, 2009) also provides guidance on when and where not to spread slurry in order to minimise the risks of direct slurry runoff. Undoubtedly, an important factor controlling direct (point-source) slurry runoff risks is slurry storage capacity. As a general rule, the lowest risk of direct runoff will occur on farms where there is sufficient storage capacity to provide the flexibility to spread slurry under good soil and weather conditions (Newell-Price *et al.,* 2011)

In Wisconsin (USA) the Manure Management Advisory Service (www.**manure**advisorysystem.**wi**.gov/) provides information on likely direct runoff risks for 3 days after manure (slurry) application based on forecast rainfall. For winter months, the risks of frozen ground, runoff and snowmelt are predicted for a 10 day period.

6. CONCLUSIONS AND RECOMMENDATIONS

- MANNER-*NPK* estimated that nitrate leaching losses following pig slurry application timings after the end of the closed-spreading period on sandy/shallow soils (i.e. 31 December) in low (650 mm) and medium (850 mm) rainfall areas were around 10% of total N applied, compared with losses in the range 30-50% of total N applied following autumn application timings. On medium/heavy soils, nitrate leaching losses after the end of the closed-spreading period (i.e. after 31 January) were *c.*10% of total N applied in low and medium rainfall areas, compared with 10-20% of total N applied following autumn application timings.

- Autumn application timings are likely to increase the risk of nitrate leaching losses on all soil types, because crop N uptake during the autumn/winter period is generally low and there is sufficient over-winter rainfall to wash manure derived nitrate beyond crop rooting depth.

- Targeting manure applications before the establishment of oilseed rape (which has an autumn N requirement) was shown to reduce nitrate leaching losses, because crop N uptake before the start of over-winter drainage can reduce the amount of soil N at risk of leaching.

- Late spring and summer application timings are unlikely to increase nitrate leaching losses, because of low drainage volumes and rapid crop uptake of manure derived N following application

- On medium/heavy soils, the greatest risks of ammonium-N, phosphorus and microbial pathogen losses in drainflow (and surface runoff) waters were when slurry applications were made to ‘wet’ soils (<20 mm soil moisture deficit) and sufficient rainfall occurred in the 10-20 day period after application to generate drainflow.

- Soil moisture deficit profiles from typical climate data indicated that on arable land, the risks of drainage water contamination with ammonium-N, phosphorus and microbial pathogens were likely to be ‘high’ between early November and early April in medium rainfall, and late December and mid-March in low rainfall areas, respectively. Local soil moisture deficit values could be combined with accurate short-term (e.g. up to 48 hours) rainfall forecasts to help improve farmer’s manure management decisions to minimise the risks of diffuse water pollution following slurry application

- A flexible approach to setting closed-spreading periods for minimising nitrate leaching losses following high readily available N manure applications would be difficult to implement; and is not supported by scientific evidence. Nitrate leaching losses are dependent on the volume of over-winter rainfall which is best estimated using long-term, rather than short-term, weather data. Moreover, on medium / heavy soils, accurate weather forecasting over a 10-20 day period (which is notoriously difficult to achieve) would be required to minimise diffuse NH_4-N, TDP and microbial pollution risks following slurry application. All other countries in the EU have fixed closed spreading dates for organic manure and manufactured (chemical) fertiliser applications. Hence, there can be no doubt that should England (Britain) propose a 'flexible approach' to the spreading of organic manures as part of the next round of negotiations on the Nitrates Directive, the Commission would immediately signal the initiation of infraction proceedings against the UK (Britain). The Commission already consider that the duration of closed-spreading periods in England (Britain) are the least possibly acceptable; they believe that they should extend for 5-6 months at a minimum and that slurry storage capacity should be 6-7 months as a minimum.

7. REFERENCES

Bailey, R. J. and Spackman, E. (1996). A model for estimating soil moisture changes as an aid to irrigation scheduling and crop water-use studies: I. Operational details and description. *Soil Use and Management*, 12, 122-129.

Beckwith, C. P, Cooper, J., Smith, K. A. and Shepherd, M. A.(1998). Nitrate leaching loss following application of organic manures to sandy soils in arable cropping. I. Effects of application time, manure type, overwinter crop cover and nitrification inhibition. *Soil Use and Management*, 14, 123–130.

Chambers, B. J., Smith, K. A. and Pain, B. F. (2000). Strategies to encourage better use of nitrogen in animal manures. *Soil Use and Management* ,16: 157-161.

Defra, (2009). Protecting our Water, Soil and Air. *A Code of Good Agricultural Practice for farmers, growers and land managers*. TSO, Norwich.

Defra/EA (2009) Field application of organic manures. *Guidance to Farmers in Nitrate Vulnerable Zones Leaflet 8*. www.defra.gov.uk/environment/water/quality/nitrate

Defra (2010). *Fertiliser Manual (RB209)*. 8th Edition. TSO, Norwich.

EU (2006). The quality of fresh waters needing protection or improvement in order to support fish life. Directive2006/44/EC of the European Parliament, September 2006.

EU (2011) Recommendations for Establishing Acton Programmes under Directive 91/676/EEC Concerning the Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources. Recommendations for Measures. December 2011, 139 pp

Newell Price, J.P., Harris, D., Taylor, M., Williams, J.R., Anthony, S.G., Duethmann, D., Gooday, R.D., Lord, E.I. and Chambers, B.J. Chadwick, D.R. and Misselbrook, T.H. (2011). An inventory of mitigation methods and guide to their effects on diffuse water pollution, greenhouse gas emissions and ammonia emissions from Agriculture. Defra Project ES0106.

Nicholson, F. A., Rollett, A. J., Bhogal, A., Lord, E., Thorman, R. E., Williams, J. R., Smith, K. A., Misselbrook, T. H., Chadwick, D. R. & Chambers, B. J. (2010). MANNER-*NPK*. In: *Climate, Water and Soil: Science Policy and Practice –*

Proceedings of the SAC/SEPA Biennial Conference (Eds. K. Crighton and R, Audsley), pp.328-333.

SI (2013). The Nitrate Pollution Prevention (Amendment) and Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) (Amendment) Regulations 2013. Statutory Instrument 2013/1001.

Williams, J.R., Chambers, B.J., Smith K.A. and Ellis, S. (2000). Farm manure land application strategies to conserve nitrogen within farming systems. Proceedings of the SAC/SEPA Conference : 31 March-2 April 1999 *Agriculture and Waste Management for a Sustainable Future* pp 167-179

Defra project references

ES0106: Developing integrated land use and manure management strategies to control diffuse nutrient losses from drained clay soils: “Brimstone”

ES0115: Optimising slurry application timings to minimise nitrogen losses: “OPTI-*N*”

WQ0118: Understanding the behaviour livestock manure multiple pollutants through contrasting

Work Package 3. SSAFO Review

Prepared by

Jonathan Whiteley[1], Charles Bentley[1], Tom Brassington[1], Bob Watson[2] and Nigel Belton[3],

[1] ADAS Wolverhampton, Pendeford House, Pendeford Business Park, Wolverhampton WV9 5AP
[2] Independent Agricultural Engineering Consultant
[3] Acorus Rural Property Services Ltd. Addlepool Business Centre, Woodbury Road, Clyst St. George Exeter EX3 0NR

1. SUMMARY

Levels of compliance with the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (SSAFO) and the storage aspects of the Nitrate Vulnerable Zones Action Programme measures (NVZ-AP) appear to be between 50 and 80%.

Whilst a telephone survey of farmers revealed around 70% of farmers in an NVZ considered they had enough storage, (65% outside NVZs) other work by the EA and through Catchment Sensitive Farming suggests that levels of compliance are lower at around 50% within and 30% outside an NVZ though the sample of farms is likely to be skewed, and sample sizes with most of the work considered have been small.

Levels of compliance with SSAFO construction standards are similar, with a high proportion of stores (typically 50 – 60%, depending on the source of the data) pre-dating SSAFO and therefore deemed to be exempt

The Environment Agency National Incident Reporting Scheme data reveals that though reported pollution incidents are relatively rare (an average of 148 reported incidents per annum between 2003 and 2012, with around 8700 dairy and 2000 pig producers in England) most (48%) are associated with spreading or overtopping of stores, both of which may be associated with insufficient capacity. In contrast store failure accounted for only around 5% of incidents in the period 2001 – 2012.

The costs of storage are very variable, (typically between £30 and £60 per m^3) depending largely on system choice (which may be dictated by location, geology or farming system) . Except in areas of high rainfall and with high cost storage options, roofing to reduce storage requirements appears rarely to be economically viable simply in terms of reducing storage and spreading costs. However maintenance of rainwater goods, good design of new facilities to minimise open yard areas, and covering of stores can be worthwhile, and may bring other benefits in terms of reduced emissions to the atmosphere, better working conditions, reduced feed wastage and the potential for improved nutrient recovery. Separation can reduce storage requirements and facilitate the use of more efficient and technically sophisticated spreading systems, but appears only to be economically viable on larger units.

Labour savings can generally be made through automation of slurry handling around the buildings, though the capital cost of retro-fitting such systems can be significant. More complex handling and storage systems are susceptible to mechanical failure and operator error. Slurry systems are generally operated by stockmen / herdspersons whose primary interest and responsibility is the welfare of their animals.

The approach in other northern European countries appears generally similar to that in the UK, though information has been hard to find. Impermeable structures for slurry storage and impermeable floors for silage clamps are normal, storage periods vary between states and (in Ireland) between regions. Some element of risk based construction is also evident, with additional safeguards required in some circumstances - particularly where the store is in close proximity to a sensitive receptor.

Considering fuel oil storage on farms, the safeguards provided under the Oil Storage Regulations are generally similar to those within SSAFO, however the requirement

for bunding whether within or outside a building, and the 10m clearance rule within SSAFO mean that on balance environmental protection is likely to be best served by retaining the controls on the storage of Agricultural Fuel Oil with SSAFO, though some amendments to take account of the increased use of plastic tanks and the impact of fuel theft are recommended.

A number of other recommendations are made in respect of possible changes to the SSAFO regulations, based on suggestions and issues raised by the EA and the SSAFO working party. These relate principally to harmonisation between SSAFO and NVZ requirements, clarification of definitions, the potential for changes to the rules regarding silage clamp construction, and issues around design life, repairs and maintenance, and the need for a periodic inspection regime. Aligning SSAFO and NVZ requirements should simplify compliance and enforcement without compromising environmental protection or necessarily increasing costs. We believe there are significant opportunities to facilitate the upgrading of the many existing non-compliant silage clamps through changes to the current requirements, again without compromising environmental protection, and though a requirement to undertake periodic store inspections and keep records would increase the administrative burden on farmers, it appears to offer a cost effective route to preserving the exempt status of existing facilities and further reducing risks to the environment.

2. BACKGROUND

1. The 1980s saw an increase in reported pollution incidents, many related to farm slurry storage. The failure of such storage can have a tremendous impact on the surrounding environment especially if the slurry enters a watercourse. Guidance (CIRIA 126, Farm waste storage: guidelines for construction; 1992) and legal standards (Silage, Slurry and Agricultural Fuel Regulations 1991) swiftly followed through an ownership and partnership approach with many organisations and individuals. Pollution incidents declined in response, and continued to do so for several years before stabilising.
2. The Regulations, which came into force on 1 September 1991, permitted a number of exemptions. One of these exempted existing farm waste facilities from the Regulations and a second exempted storage facilities that were being built when the Regulations were announced, as long as were completed before 1 September 1991.
3. Twenty years on similar concerns have resurfaced with anecdotal evidence suggesting an increase in the number of pollution incidents concerning slurry store infrastructure, from minor to catastrophic store failure to overtopping due to insufficient storage capacity. One particular challenge related to exempt storage facilities, which by 2012 were 20 years + old and potentially in excess of their design life.

There is little information available as to the age of stores and the impact of those coming to the end of their design life, the level of maintenance carried out and whether existing stores are of sufficient capacity, especially for farms in NVZs. In regard to this, to verify a perceived increase in pollution incidents and to ensure appropriate and proportionate action was taken going forward it was important to soundly evidence the performance and pollution risk from stores built both before and after 1991.

This report reviews the CIRIA 126 output, experiences of ADAS consultants, outputs from the Catchment Sensitive Farming project and developments in other member states to consider the following:

- Cost effectiveness of improvements to farm infrastructure to reduce volumes of rainwater and yard run off collected in slurry,
- Evaluate costs and benefits on investment
- Take into account construction standards required for storage and implications of UK legislation
- Review where fuel oil should fit in terms of over arching regulations.

Opportunity was also taken to review the suggested changes put forward by the SSAFO working Group.

3. COST EFFECTIVENESS OF REDUCING POLLUTION

3.1 Cost effectiveness of storage regulation in reducing pollution from silage, slurry and agricultural fuel oil.

Regulation of storage structures, whether for slurry, silage or agricultural fuel oil, can reduce pollution (or the risk of pollution) in three key ways:-

- Specified construction standards help to reduce the risk of structural failure or leakage.
- Locational restrictions (10m from a watercourse etc.) help to reduce the impact of any incident arising as a result of leakage or failure of a store.
- Minimum capacity requirements reduce the risk of overflow and (in the case of slurry) increase the flexibility of timing of land application and therefore reduce the risks associated with spreading in inappropriate conditions.

In comparison with an unregulated situation regulation can increase costs of the provision of storage. Again there are three key components to this:-

- The increased cost of construction to the required (and presumably higher) specification stipulated by the regulations.
- The increased costs associated with a change in the nature or form of storage.
- The additional cost of increased capacity

3.1.1 Construction standards

In practice the cost of construction to the standard required by current regulations is probably only marginally higher than the cost of unregulated construction of a similar store. Stores built from proprietary components such as pre-cast concrete or steel panels are generally only available to a specification which satisfies the relevant standard. The marginal cost of regulated construction over and above the costs which a farmer might otherwise incur with above ground storage are therefore likely to be small.

The cost of soil testing and proper compaction of earth banks in the construction of an earth banked lagoon is also minimal in relation to the total project cost. It might typically involve the hire of a vibrating or sheep's foot roller and associated operator time, and some additional time to correctly profile and build up the lining of the store at a cost of possibly £2,000 - £3,000 on a project costing £20- £30,000. – around 10%. The greater impact is likely to be the increased land-take associated with the relatively gentle bank slopes specified, which may add 30% to the footprint compared to other structures. Again this cost is typically likely to be no more than £3-£5,000 assuming a land value of £25,000 / ha. The impact on future development on the site may be of more importance - space occupied by a lagoon can't be used for a new cubicle building or silage clamp in future.

3.1.2 Approach to storage

The greatest impact on costs is where regulation of storage results in a change in the approach to storage. For example where soils are unsuitable for in-situ earth banked lagoon construction, and either a) a liner has to be installed, or b) if a lined lagoon is incompatible with the type of slurry to be stored, an alternative approach such as a concrete store has to be constructed. The cost of construction of a concrete store is likely to be at least double that of construction of an earth banked lagoon.

A forced change in the approach to storage between regulated and unregulated construction, also applies in the construction of silage clamps. The key issues in this case relate to the requirement for an impermeable floor slab and for the provision of an external drainage channel.

Where from an agricultural point of view silage might otherwise be stored on a permeable hard standing (adequate from an operational and silage quality perspective) the requirements for an impermeable floor slab are likely to raise the cost of construction using concrete or hot rolled asphalt from possibly £10 / m^2 to £30 - £50 / m^2 (excludes the cost of any walls). Though maintenance requirements of a concrete slab are likely to be lower than hardcore surface, the cost of repairs to cracked concrete also far exceed those of repair to hardcore surfaces.

The current requirement for an external drainage channel effectively precludes the construction of 'compliant' clamps with earth banks or cut into a hillside. From a health and safety point of view hillside clamps offer a number of significant benefits, since most of the risk of falls from height associated with filling, sheeting, and unsheeting the clamp are reduced. The risk of collapse or partial structural failure of walls is also virtually eliminated, however the inclusion of an external effluent drain is impossible in such structures.

3.1.3 Additional capacity

Regulation of storage capacity almost inevitably means more capacity infrastructure or an extended storage period. Meeting capacity requirements can be achieved in different ways, the costs of each vary both within and between approaches:-

- The extension of an existing store
- The construction of a new store
- The reduction in volumes to be stored to allow existing facilities to cope.

3.1.3.1The extension of an existing store.

Where practicable this can often be the most cost effective approach to increased slurry storage requirements. The cost per cubic metre of storage will generally be substantially higher than the cost per cubic metre of constructing a complete new store, but total capital investment required will be minimised. Extension of earth banked lagoons on suitable soils can be a low cost development, with transport of plant and machinery to site being a major component of project cost. Extending lined lagoons and concrete stores can be more technically challenging and therefore costly, for example a new liner for the whole store may be required. The extension of above ground circular steel stores may or may not be possible depending on the condition and specification of the existing store. If it is possible to extend an existing structure then the process is simple and could be cheaper per m^3 than a replacement store, since expansion is achieved by adding an additional ring of panels, and no extra concrete base is needed.

3.1.3.2 The construction of a new store

See section on construction to regulated standards above.

3.1.3.3 A reduction in the quantities to be stored.

This is commonly achieved by ensuring that clean roof and yard water is diverted away from the slurry system. This may involve re-routing of existing clean drains, the construction of new clean or dirty drains and the repair and replacement of rainwater goods such as downpipes and gutters. The roofing of open yard areas and silage clamps can also substantially reduce volumes to be stored, or potentially the need for a new store, but at significant cost.

Repair and refurbishment of rainwater goods is inexpensive and highly cost effective. A broken down pipe on one corner of a 30m x 24m building could discharge 135 m^3 of rainwater over the winter storage period into slurry storage in a region with 750mm of annual rainfall. Where 5 months storage is required the costs of storing and spreading this water (based on £30/m^3 storage cost for 67 m^3, a 15 year investment period at 5% interest and a spreading cost for 135 m^3 at £1.40-£2/m^3) could be in the region of £290 every year. The payback period on repair of a downpipe is therefore likely to be measured in weeks or months rather than years.

In contrast the cost of roofing is rarely economically viable solely to reduce storage volumes. Based on the example above, putting a roof over a 30m x 24m yard area would save 135m^3 of storage capacity over the winter months (£370 per annum @ £30/ m^3 capital construction cost) and annual spreading requirements of 135 m^3 at a cost of £270 per annum @£2/m^3 (Nix).

The cost of roofing 30m x 24m would probably be in the region of £6,000 per annum. (£90/m^2 over 15 years at 5%) which is four times the cost of storage and spreading. The economics become more attractive if the less tangible benefits of roofing are taken into account which include: reduced feed wastage; improved working environment; better working conditions; increased asset value of the holding. Where rainfall is higher than 750mm, storage structure more expensive, or roofing costs lower, the economics become more attractive. The option is well worth considering where providing additional capacity may require the farm to construct a new store, but a small amount of roofing, possibly making use of uprights on existing adjacent buildings, means that the current store would be big enough.

Roofing over a slurry store will also effectively increase the holding capacity of the store by diverting rainfall off the store. Many stores can be covered using a roof structure similar to covering a yard area, and the cost of a roof over a store would be similar to the illustration above, although there could be physical size constraints for example over an earth banked lagoon. Installing a flexible or fixed roof cover on a circular steel store is less challenging and can be an effective method of increasing capacity providing the existing store has been designed for the fitment of roof cover. Other methods include a floating cover placed on the surface of slurry. Covering slurry stores is becoming more common on farms, and particularly intensive pig production units operating under a permit which requires stores to be covered to control emissions.

Mechanical separation can allow storage volumes for the liquid fraction to be reduced by up to 10% for pig slurry or 20% for dairy slurry. The liquid fraction is considered as slurry under the NVZ regulations, but the stackable solid fraction will normally be handled as farmyard manure and stored either on concrete or in temporary field heaps.

3.2 Cost of Storage and Benefits of Investment

Construction cost of storage of slurries is extraordinarily variable, and can range from as little as £15m^3 to in excess of £60m^3 depending on the approach to construction, the nature and size of the store, site conditions, and other constraints. Nix 43rd edition quotes £45 per m^3 for lined lagoons to £60 per m^3 for above ground glass-lined steel stores for budgeting purposes.

Annual costs depend on the initial capital cost, the period over which the structure is financed, the cost of any repairs and maintenance, and cost of operation of pumps, agitators etc. Typically annual costs might be in the region of £1.20m^3 / year for an in-situ earth banked lagoon over 20 years, through to £2.20m^3 / year for a lined lagoon where maintenance costs are higher and life expectancy lower, £3 - £3.50/ m^3 / year for an above ground steel store and possibly £4/m^3 / year for a concrete store. Though the concrete store and in-situ earth banked lagoon may be costed over 20 years, their potential working life with proper maintenance may be significantly longer, substantially reducing actual annual costs.

There are two primary benefits of storage.

- Environmental protection and
- the opportunity to maximise the utilisation of the nutrient content of the slurry.

The value of environmental protection to the nation – the avoidance of the impact and cost of pollution incidents and the achievement of Water Framework Directive objectives and hence the avoidance of EU infraction proceedings, are likely to be very significant but difficult to estimate. The value of improved nutrient utilisation is also difficult to quantify but in addition to the (limited) direct saving in fertiliser costs to the farm business, the benefits include elements such as a reduced carbon footprint and improved balance of payments associated with a reduction in the use of manufactured fertiliser.

The benefits of improved environmental protection to the average individual farmer are likely to be relatively small. They may primarily be considered to comprise the avoidance of the cost and associated impact of prosecution and recharge of any clean up costs in the event of an incident, and the protection of Single Farm Payment. The value of the first element is almost impossible to quantify, and initial review of EA data suggests that it is typically hundreds rather than thousands of pounds, and in the event of prosecution fines are typically in the region of £5,000 - £10,000. The probability of an incident arising as a consequence of a lack of storage, and the likelihood of subsequent prosecution is very difficult to estimate, however there are in the region of 11,000 pig and dairy farmers in England, the majority of whom will store slurry, and a higher number of other cattle farmers where the incidence of slurry storage will be lower. EA Nirs data suggests there was an average of 148 recorded slurry related pollution incidents a year in England over the period 2003 – 2012 (though a significant proportion of minor incidents are likely to go unreported)

The benefit to the farmer of optimised nutrient recovery is disappointingly small. The key nutrient in this respect is nitrogen, currently valued at around 80p / kg. With a typical 6% dry matter dairy slurry containing 1.2kg / m^3 of available nitrogen, the maximum benefit of storage will be less than £1/ m^3 / year even if nutrient recovery is maximised. The situation is better with pig slurry as this has a higher available nitrogen content and the equivalent figure could theoretically be as high as £2.50/m^3 (based on 4% dry matter slurry). In practice optimised nutrient recovery will also require the use of rapid incorporation, injection or band spreading techniques, all of which increase the costs of application. Though broadcast spreading of slurries is likely to cost in the region of £1.40 to £2 / m^3, the more sophisticated approaches are likely to cost an additional £1 - £1.50/m^3 . (Nix 2013)

The economic benefit of storage could also be considered to be the avoidance of prosecution, the associated impact on credit rating, possible loss of reputation in the event of an incident, and an insurance value in reducing the risk of deductions from their single farm payment. For the majority of farms with some form of storage the impact of an incident could be significant, but its probability is not great and that of prosecution is very low. Insurance is also likely to cover the costs of clean up in most cases, at least on the first occurrence.

The impact on farm income from loss of single payment could also be significant in the case of a persistent and deliberate breach (100%), but again the risk of inspection is actually relatively low. However many farmers consider that should they receive an inspection some breach of Standard Management Requirement 4 (NVZ) is almost inevitable, and they will therefore incur a level of deduction, which is typically 1% or 3%. A 3% deduction on a £22,500 payment which might be typical on a 300 acre farm, is £675. Though this would be increased year on year should the breach persist, re-inspection in the year following a breach is currently not automatic, so the risk of second or subsequent inspection is likely to be the same as that of the initial inspection.

In general in-situ earth banked lagoons, constructed of suitably impermeable soils on a cut and fill basis, where the excavated material is used to build banks are by far the most cost effective approach to storage. The key to minimising the cost of this type of construction is in store design and site layout, reducing the distances which any excavated soil has to be moved, ensuring that nothing needs to be hauled away and that the length of any access roads or ramps can be minimised.

Adding a concrete or stone access road into the store increases the versatility of the structure significantly, but increases costs.

Where soils are unsuitable for an unlined structure, an imported liner, either clay or an artificial membrane, will be required. Due to the high cost of transport clay is not commonly used unless there is either a source of suitable clay elsewhere on the farm, or the farmer is either being paid for taking clay or provided with a free supply of delivered clay arising from a major construction project. Though very rare it has been known for a new slurry lagoon to be constructed free of charge where the construction company would otherwise be paying for disposal of the materials used in the construction.

Where buildings layout permits, automated slurry handling can reduce labour requirements. This is largely independent of store type, but relies on the use of automatic scrapers, possibly together with slurry channels, to convey slurry from building to store or reception pit, or alternatively on the use of slatted floors with storage beneath the livestock accommodation.

Improvements in application efficiency can commonly be achieved through the use of umbilical systems. The cost of these systems is high relative to tanker systems, and more appropriate to contractor operation. Many livestock farmers use contractors with specialist and high capacity equipment to empty slurry stores onto land in a timely manner. An umbilical system however is not suited to the application of small volumes or to small or scattered spreading areas where the set-up overheads outweigh the operational efficiency compared with a tanker based system. Umbilical systems require a low dry matter slurry, and work well with the liquid fraction of mechanically separated slurry.

4. NEW TECHNOLOGIES AND TECHNIQUES

4.1 Developments in slurry and silage storage / handling since 1991.

There have been a number of key changes in agricultural practice and industry structure in the last 22 years which have had implications for the way in which silage is made and stored, and slurries stored and handled, and which will also have had an influence on the level and nature of pollution incidents since the introduction of the Control of Pollution (silage, slurry and agricultural fuel oil) Regulations (SSAFO).

The changes fall into main three areas:

- those which have arisen as a result of changes in the structure of the industry (i.e. increasing specialisation and unit size, reduction in number of producers)
- those which relate to advances in feeding or housing livestock
- those which relate to changes in storage and spreading technology.

4.2 Pigs and Poultry

To put the pig and poultry sector in perspective with other livestock there appear to have been fewer fundamental changes in the way in which intensive pigs and poultry are fed and managed, than in the way dairy herds operate.

The key issues with pigs and poultry relate to housing and welfare issues, mainly

- the ban on sow stalls
- the ban on standard battery cages for laying hens

These have led to increases in the proportion of both pigs and poultry being loose housed on straw, or moved outside. The net effect of these changes has been an overall reduction in the proportion of manures handled as slurries, and an increase in the proportion handled as either solid manure, or deposited direct to land (free range). In general these changes may be seen to be environmentally beneficial, though there are inevitably adverse consequences such as increases in soil run off and erosion, associated with outdoor pig production, and localised nutrient enrichment associated with both outdoor pigs and free-range poultry.

Larger pig and poultry units have had the introduction of The Integrated Pollution Prevention and Control (IPPC) Directive, which has an aim to apply Best Available Techniques (BAT) to prevent, or reduce, emissions to air, land and water from these activities. This was replaced by the Environmental Permitting Regulations in 2008 and applies to larger pig and poultry farms with capacity for more than:

• 750 sows
• 2,000 production pigs over 30kg
• 40,000 poultry (includes chickens, layers, pullets, turkeys, ducks, guinea fowl and quail)

(Pigs reared outdoors are excluded from PPC, but free-range poultry are included.) Farms regulated under EPR require a permit to operate, which covers all aspects of farm management, from feed delivery to manure spreading. Priority areas are:
• storage of oils and materials
• integrity of buildings
• management of drainage systems
• management of manure and slurry systems.

An important requirement for slurry stores is a cover on new stores, and existing stores to be covered by 2020. These can be permeable or impermeable covers, floating or suspended structures.

4.3 Dairy cows

4.3.1. Forage for dairy cows

The changes in the way in which dairy cows are fed revolve around the reduction in the proportion of grass silage in the diet of the typical winter housed cow, and to changes in the nature of that silage. Grass silage typically still makes up well over half the conserved forage component of dairy rations, but high starch and higher energy fodders such as maize silage and whole crop cereals are also now important components. This has implications for both silage making facilities, and slurry storage as the nature of slurry is affected by diet.

4.3.1.2 Forage impact on slurry storage.

Increasing levels of starch in the dairy cow's diet tend to result in the production of higher dry matter and more glutinous slurry, than where low dry matter fodder such as brassicas, grazed grass, grass silage or fodder beet are consumed. As a result systems such as weeping wall stores, where the panel gap is designed to retain solids but allow liquids to seep through, may fail as the liquid fraction fails to drain out, leaving whole slurry retained within the structure. Such slurries are also more difficult to pump, requiring additional dilution to enable them to be effectively handled by umbilical systems for example.

The decline of self-feed silage in favour of total mixed rations is driven by the increased sophistication of diet management and formulation, but is likely to have been hastened by the introduction of the NVZ regulations. Run off from self feed silage clamps is classed as slurry in an NVZ (to which the closed season / storage requirements apply) whilst run off from a clamp to which livestock do not have access is classed as lightly fouled water to which the closed season does not apply.

4.3.1.3 Forage impact on silage storage

The alternative high dry matter forage feeds, including grass at to higher dry matter at ensiling, generally produce little or no effluent on ensiling, and therefore dramatically reduce the risk of pollution associated with silage making. Silage effluent remains highly corrosive material and has a high impact on erosion of floor slabs, joints, wall panels and steel uprights, leading to structural failure in some cases. Whist the intention of farmers is to harvest crop at high dry matter, in a poor year with high rainfall, even the best silage makers can end up with wet silage in the clamp, and maize harvested green and wet will also generate effluent.

Fodder beet when fed fresh poses little risk, however it may also result in the generation of highly polluting run off, where beet is poorly stored or frosted beet is clamped for example. Clamps may also used for the storage of other feeds such as brewer's grains or feed potatoes, carrots and other vegetable outgrades. The quantities stored are generally small (a few tonnes or tens of tonnes) seepage from either these can also be highly polluting, and should be stored in a facility with impermeable base and effluent collection. The SSAFO Regulations currently do not address this area.

The ease and flexibility of wrapped, baled silage has led to an increase in this approach to conservation of (predominantly) grass for fodder. Many smaller dairy, and also beef or sheep units, have moved from bulk clamp silage to baled and wrapped silage, whilst larger units will often opportunistically harvest small areas of later grass as baled and wrapped silage. This avoids the need to bring in contractors to cut and cart limited tonnages, and to re-open the clamp risking deterioration of the contents. Normally made from well wilted grass (or occasionally alternative fodder crops) wrapped bales normally generate little or no effluent.

4.3.2 Housing systems for dairy cows

Changes in the structure and management of the national dairy herd have resulted in a range of approaches, from permanently housed herds, through conventional winter housing, to extended grazing and even out-wintering.

In terms of slurry storage and handling the key issue has been the relative reduction in the availability and affordability of straw for bedding. Together with the potential improved milk quality and herd health benefits, this has driven a move towards the use of cubicles with scraped slurry passages, and alternative bedding systems and materials, including sawdust, paper, and sand.

Sand and similar bedding materials tend to settle out in storage and sand in particular can be difficult to handle and with high wear characteristics on pumping systems, it is not suitable for storage in most lined lagoons or in above ground stores where pumps are required. The availability of suitable storage and handling facilities can and does limit the choice of bedding material, and conversely affects the choice of slurry system chosen when installing new facilities.

Most of the alternative granular / fine bedding materials are well suited to mechanical separation, including short chopped straw, sawdust, shavings and paper / paper crumble, but tend to pass straight through the walls of a weeping wall (passive separation) system. Sand does not separate through conventional mechanical separators or weeping walls, though specialist sand separation equipment is available.

Slatted channels underneath dairy housing buildings have become more attractive to dairy farms where a comprehensive re-build or relocation has been undertaken, with the attraction of reduced labour and machinery requirement, avoiding the need for daily scraping with tractor or mechanical scrapers, and the added advantage of the building covering the store and reducing the additional storage capacity required to hold rain falling on an uncovered store.

The industry is much more aware of the impact of rainfall on open areas of yards and stores, and the cost of both storing this fouled water, and spreading it onto land at the end of the storage periods. With the introduction of capital grants in designated catchments for covering livestock gathering areas, slurry stores, and manure stores there has been an increase in fitting covers to existing storage. Constructing a roof to an existing store can have an impact on the loadings of walls and supports which must be accounted for, or alternatively a separate covering structure is installed.

This has a secondary effect on the nature of the slurries which will be less dilute and thicker in consistency.

4.3.3 Dairy industry structure

The concentration of dairying in fewer and larger units has left many grant aided stores from the 1980s and early 1990s redundant, whilst others now form the basis of the system for much larger herds of higher yielding cows. Increased herd size and output has substantially increased the volume of manure or slurry produced per unit, which either require larger storage structures, or multiple structures on the farm.

Slurry storage has commonly been a low priority for expanding units, since the value of nutrients which can be realised by optimised application system and timing is a fraction of the annual cost of storage. As a result many original stores which have been sized on capacity for smaller volumes remain a key component of the farm storage system.

4.4 Handling and application

Both slurry and manure spreading equipment has become more accurate and sophisticated in recent years. Trailed and self propelled equipment has generally become larger and increasingly expensive, leading to an increase in the proportion of manures likely to be applied by contractors. This has a knock on effect on the need for storage, since contractors generally need to be booked, and there may be a significant delay in difficult seasons where demand for contractors is high. This has been exacerbated in NVZs where the opportunities for spreading are further limited by the closed period, focussing spreading into the narrower early spring, post silage and harvest periods.

Sophisticated slurry application machinery requires homogenous slurry to achieve even application. Though most of this type of equipment incorporates some form of maceration, pre-treatment of stored slurry - stirring or separation - is generally essential to ensure consistency from load to load.

In recent years the availability and performance of umbilical spreading systems has increased substantially. The increased efficiency and reduced soil damage in comparison with trailed or self propelled machinery has driven demand for what is generally a contract operation. Umbilical spreading carries risks – split hoses or over application on headlands whilst turning has resulted in numerous pollution incidents – and also requires relatively low dry matter slurry. Additional storage to accommodate the extra water may be required, or separate storage for dirty water which can be added back to the slurry whilst mixing to create the ideal pumpable and spreadable material.

4.5 Other livestock (woodchip corrals)

Beef production has changed less than dairying. More beef cattle than dairy are likely to be housed on straw yards, producing only farm yard manure, but the nature of silage production has followed similar lines, with increased dry matter levels and extensive use of wrapped round bales.

The use of woodchip based corral systems has been trialled, and a small number of such systems are in operation. They rely on a deep layer of woodchip, generally with coarse chip on the lower levels of the bed, and a top surface of finer material, to provide unroofed accommodation for overwintered cattle. These will typically be fed silage on an adjoining concrete pad. The majority of the manure solids are retained in the upper layers of the deep chip bed, and scraped off to be composted and spread after the cattle have been turned out. The underlying layers being retained for the next winter, topped up with fresh chip. Seepage from beneath the pad is relatively low in dry matter and available nitrogen content, and is classed as slurry. A network of pipes beneath the chip (on top of a membrane on a permeable soil) conveys any seepage to lagoon storage, (again, lined on a permeable site). Though the units appear to have been successful in some high rainfall areas in both Ireland and Wales, and offer a low cost and lower impact intermediate approach than either housing or outwintering cattle uptake has been limited. The classification of the drainage as slurry and the extensive open area raising storage requirements and costs, particularly within an NVZ.

4.6 Treatment of slurries

Livestock slurry may be treated in a number of ways to improve its handling or storage characteristics, its fertiliser value, or reduce its environmental impact. Storage may be physical, chemical or biological, with mechanical treatment (active or passive separation) being the most common.

The added complexity of treatment systems in comparison with simple storage means that there is generally a higher cost, and an increased risk of mechanical or operator failure.

Whole slurry may be mechanically separated into a high dry matter / fibrous component which is handled and considered as solid manure. This material is relatively consistent, with steep angles of repose, a tendency to self-compost, and which spreads evenly. The liquid fraction which will typically be less than 1 or 2% dry matter, is easily pumpable and also relatively stable in storage. The liquid fraction will represent around 90% or so of the total volume in the case of pig slurry and 80% of cow slurry, slightly reducing overall storage requirements.

Passive separation through a weeping wall or strainer box is less effective, but avoids the need for pumps, mixing and the mechanical separator itself. It allows a smaller proportion of the liquid fraction to be removed, but as outlined above is only suitable for a limited range of cattle slurries from specific bedding and feeding systems.

Aeration may also be considered to be a physical treatment, intended to maintain the slurry in an aerobic condition and hence minimise odours. Aerators were at one stage commonly installed in above ground steel stores, but their use is now less frequent.

Biological treatment is normally through the 'seeding' of stored slurry (commonly in underfloor storage systems) with a microbial culture. These treatments are intended to increase the availability of nutrients within the slurry, reduce crusting and sedimentation and to reduce odours. Trials evidence of efficacy is limited, and use is also not common, though costs are low.

Chemical treatment is largely limited to acidification, where metered doses of sulphuric acid are added to fresh slurry, and pH is reduced to around 5.5. The treatment helps breakdown some of the fibre within slurry and to increase the level of available nutrients, whilst reducing odours. It is a relatively new approach which is beginning to be adopted by some pig producers.

4.7 Alternative storage options

A number of new or novel approaches to storage of (mainly) liquids have been developed or adopted from other industries in the last 20 years. These generally revolve around the use of flexible membranes to create either self contained bags or bladders in which silage or slurry may be stored, or as a liner for an open topped store where the framework is created of another material such as heavy duty steel mesh. These approaches may be intended to provide long term or temporary storage, or in the case of silage storage, for a single season where the membrane is destroyed as the silage is fed out.

Life expectancy of the materials used is variable, with some intended only for a single season, and others likely to last 20 years or more. Numbers of alternative storage systems in use are difficult to estimate, but the approaches have so far not been adopted on any significant scale.

5. SUGGESTED CHANGES TO REGULATIONS

The SSAFO Working Group were asked to consider a series of questions in respect of any changes or amendments needed to The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010. The questions and ADAS response are provided in Appendix 1.

The key areas of concern or opportunities for improvements in regulation are outlined below. ADAS have responded, where appropriate, to the points raised in the discussion paper.

5.1 The opportunity to harmonise storage volume calculation methods between SSAFO and NVZ regulations, in particular the establishment of a consistent approach to assessment of 'likely rainfall'.

This is a critical issue and not easy to resolve. In practice the influence of rainfall on open yards commonly raises the storage capacity required under SSAFO (4 months plus the relevant M5 rainfall) to a very similar figure to the NVZ five months with likely (average) rainfall over the storage period. Moving SSAFO to 5 months storage but adopting a common and simple rainfall standard would be beneficial. Agreement needs to be reached over a simple and reasonably accurate source of rainfall figures, with a percentage or similarly straightforward equation based on local annual rainfall derived from widely available published data such as PLANET or MANNER NPK which use postcode.

5.2 The discrepancy between the understanding of the term 'dirty water' within an NVZ and outside.

Dirty water is a common term used for dilute or low dry matter liquids, however where the material contains faeces or urine it is technically defined as slurry whether within or outside an NVZ. The NVZ term 'lightly fouled water' should be adopted within SSAFO and a list of examples provided. The basic requirement that this material should be contained must be maintained, however the potential to reduce storage requirements by agreement with the EA through the use of a manure management plan should be retained. The definition of seepage from manure stores as slurry should be confirmed.

5.3 The definition of 'substantially enlarged' and 'substantially reconstructed' within SSAFO.

A formal definition of the terms could be useful, but might also lead to boundary stretching and difficulty in enforcement where a farmer deliberately enlarges by a carefully calculated specified capacity less 0.5% for example. Formal guidance on the terms to replace the commonly accepted up to 10% capacity increase or one wall at a time, may be more useful. 10% capacity increase, 20% of wall or floor area or a surface treatment of the structure are suggested. These issues may be partly resolved through addressing item 5.8 below.

5.4 The definition of 'yard' within SSAFO and the NVZ regulations.

Yard has been taken to mean a concrete or otherwise impermeable surfaced area within a farmstead. The definition should be formalised and extended to include areas where livestock are confined on a regular basis, this would then encompass unsurfaced but semi-permeable areas such as cattle lodge floors and straw or woodchip corrals.

5.5 The potential to move the control of the storage of agricultural fuel oil from SSAFO to the Oil Storage Regulations, and the treatment of double skinned plastic tanks within SSAFO.

This is addressed separately within section 8 of this report. The recommendation is that agricultural fuel oil storage should remain within SSAFO, but that changes to accommodate double skinned plastic tanks (with appropriate safeguards) should be adopted. Design life issues may be addressed though the approach to 5.8.

5.6 The potential for risk based standards for silage clamp construction

The range of crops ensiled has increased considerably since the introduction of SSAFO, and the volumes and likelihood of effluent production has declined. The current effluent tank capacity is significantly greater than is likely to be required for many crops, and with some crops and approaches to clamp construction external effluent channels are merely decorative, and frequently omitted during construction, despite current requirements. However, where the clamp is unroofed, the specified effluent tank capacity is rarely sufficient to accommodate the M5 48 hour rainfall, and though high dry matter silage is currently the norm, the clamp may be used for much wetter materials at some stage in its operational life. Retaining the existing tank capacity requirements, with the reference also to reception tank capacity to receive rainfall off uncovered clamps, and amending clamp construction requirements may be appropriate.

Hill side or earth banked clamps, and clamps where walls are backfilled with earth are still common, and have significant health and safety advantages, but the construction of external channels and determination of the fate of any seepage are impossible. The requirement for an impermeable floor slab is taken as read. Where the walls of a clamp are designed and constructed to be impermeable (either in mass poured concrete cast in one piece with the floor or with a sealed key to the floor slab, compacted soils achieving a permeability not exceeding 10^{-9} m/s, or constructed of an impermeable material sealed to the floor slab) then the clamp should be provided with internal drains leading to an appropriately sized effluent tank. Where the walls are permeable (timber sleepers, concrete panels not cast into or sealed to the floor slab) then the floor shall extend beyond the walls and incorporate an external drainage channel.

5.7 The issue of EU vs UK requirements for design life of stores

The requirement for a 20 year design life for stores has on occasion been superseded where materials or products with European approval have been specified. This is of particular concern with plastic fuel tanks for example, and a 20 year requirement may no longer be tenable as part of the SSAFO regulations.

Other work has shown that the condition of stores and associated environmental risks are not related to the age of the structure or its design life. Introducing a requirement to monitor and maintain stores, and to record such activities may offer a way forward (see 5.8) and help to demonstrate that facilities meet the standards of the regs throughout their operating life.

5.8 The potential to introduce a condition assessment or MOT for stores beyond their design life or which are exempt from the SSAFO regulations by virtue of their age.

The approach has considerable merit, however the idea of an ‘MOT test’ for stores is fraught. Unless such tests were undertaken by the regulator the costs of storage to industry would be dramatically increased since few if any engineers would be prepared to sign off an existing earth banked structure where its internal construction had not been witnessed, and the liability implications for anyone undertaking certification are considerable. Whether sufficient numbers of suitably skilled and experienced personnel to undertake the work exist is also debatable.

The principle of regular inspection and maintenance, and recording of such activity is however very useful. A record of condition could be used to demonstrate that exempt stores are still safe, that structures not meeting the design life requirements can continue to be operated with little risk to the environment etc. (see above)

Though less rigorous than an independent test, inspection by the farmer owner, or delegated operator would have the advantage that it would be inexpensive, raise the profile of condition monitoring and the benefits of maintenance in prolonging the operational life of structures whilst reducing risks to the environment. An approach based on soil protection review model, where the nature and condition of structures including details of capacity date of construction etc could be recorded, together with the results of periodic inspections and any subsequent maintenance, could be developed. This would then be available for inspection by the EA, or could form an element of cross-compliance. Some training in store inspection to complete this activity to a good standard would be invaluable.

Alongside this approach, a structure data plate fixed on or near the store, containing details of the store's name / ID, designer, constructor, date of completion, capacity etc. should be a requirement for all new stores, along with an 'operator's manual' containing details of the structure along with operation, inspection and maintenance instructions should be provided by the constructor to the farmer.

5.9 The standards for storage of digestate and feed stock for anaerobic digester falling within the EPR regime are less clearly defined than for the storage of similar materials in agriculture. There may be merit in extending the coverage of SSAFO to include AD digestate.

The construction standards for storage of digestate from anaerobic digesters fuelled by crops is unclear. Since slurry has a definition related to excreta from animals, this would not include digestate derived from energy crops where livestock slurry is not included in the feedstock. Extension of SSAFO to include digestate would appear to be appropriate.

5.10 There appears to be no mechanism for serving notice under SSAFO to require the provision of storage for slurry outside an NVZ, where there are no existing slurry storage facilities.

Where the complete absence of storage facilities is not resulting in obvious pollution, but may be causing environmental harm the scope for action appears limited, however the risks associated with regular spreading will vary with the nature and source of the material, and the vulnerability of the site / spreading area. A blanket requirement for storage for all slurries to SSAFO standards would appear disproportionate in some circumstance, for example where the material only arises twice a year as a result of TB testing of cattle on a concrete pad.

6. CIRIA 126 OUTPUT

6.1 Objectives

The objective of this work was to gather evidence on the condition of the industry, specifically:

- types of slurry stores that exist,
- their capacity, the structural condition and
- the level of compliance with SSAFO and NVZ Regulations.

This is an evidence-based report that reliably qualifies and quantifies the performance and pollution risks from existing farm slurry storage infrastructure. In particular highlighting those near to or beyond the end of their design life, in order to effectively target future resources where needed most to secure the continuing reducing trend in the number of, and the harm caused to the environment by, pollution incidents arising from failing farm slurry stores; and to prevent harm to human and animal health.

In order to inform the decision to target resources, it was recognised that the following information would be necessary. These are referred to as "investigation areas" throughout the remainder of the report.

- Survey information by region, type and size of farm
- Condition of structures (based on site visits & polling farmers direct)

- Age of the structures, capacity and compliance, (how constructed)
- Discernable trends from available data (esp NIRS)
- Caveats
- Notes

The review was drawn wherever possible on existing data, and the results of surveys, supplemented as appropriate with desk and field surveys.

The study used five sources of information as indicated in the table below.

Table 1: Sources of information

Source of Information	Brief Description
MORI	A telephone survey among 820 farms in England who have a slurry store on their farm carried out by Ipsos MORI on behalf of the Environment Agency (EA) between 21st November and 16th December 2012. Providing a background to this work, the DEFRA White Paper 'Natural Choice: Securing the Value of Nature' (2011), identified that 'farmers and land managers play a vital role in achieving society's ambitions for water, wildlife, healthy soil, food production and the management of landscapes.'
CSF	A review of the reports completed for 250 Catchment Sensitive Farming (CSF) Farm Infrastructure Audit visits carried out by ADAS across England between 2011 and 2013 for Natural England. The requests for these visits were generated by the local Catchment Sensitive Farming Officer and as result the type of visit was identified where there were issues and / or problems in respect of storage.
EA visit	EA record on visits to livestock farms between 1st January 2012 and the beginning of 2013. These visits were: • Follow up to invitations to the EA from farmers building, or thinking of building, new slurry storage facilities. • A follow-up to a catchment walkovers, • In response to a complaint or pollution incident.
CIRIA 126	CIRIA 126 EA Asset Walkover Inspection carried out between December 2012 to April 2013.
EA NIRS	EA National Incident Recording Scheme (NIRS). This database details all Category 1 to 4 incidents for agriculture for the period 2001 to 2012.

Each of the sources yielded a different type of information as summarised below. For instance, the MORI survey consisted of a telephone interview of identified farms, while the EA NIRS exercise consisted of the analysis of ten years' data.

Table 2 What each data collection / analysis could yield

	MORI	CSF visit	EA visit	CIRIA 126 EA Asset walkover	EA NIRS
Telephone survey	✓				
Historical data analysis		✓[1]			✓
Site visits		✓	✓	✓	
Data collection analysis	✓				
Pollution incidents & trends					✓
Pollution incident by type					✓
NVZ and SSAFO compliance		✓	✓	✓	
Distinction NVZ / non-NVZ		✓	✓		
Focus on slurry stores	✓	✓	✓	✓	✓
Other types considered		✓		✓	✓
Types of assets		✓		✓	
Condition of assets		✓		✓	
Age of assets	✓	✓			
How constructed	✓			✓	
Farmer awareness	✓			✓	
Maintenance approach	✓			✓	

[1] The CSF reports that were reviewed covered training visits, carried out primarily over the last two years, and therefore some of the data is considered as historic.

The different approaches to data collection, the resulting information that could be extracted, and the statistical significance of each sub-set, is acknowledged in the discussion.

The collective analysis should be seen as providing a fair indication of the situation, given the constraints on data availability, and the extent of detailed analysis possible – particularly from the NIRS data analysis.

Also, while the MORI and CIRIA 126 data collection exercises were designed from first principles, the remaining analyses relied on historic data.

6.1.1 Structure Of The Full Report

The full report covers each of the exercises in turn, with:

- An overview of the data collection and analysis used
- A comment on the statistical significance and other factors governing the extent to which the information can be considered to represent a national picture

- On which of the “Investigation areas” identified earlier the data / analysis was able to provide information.
- A factual summary of the data and analysis. Because of the different character of each exercise, the contents of this section varies from exercise to exercise
- Conclusions from the analysis drawn out, where possible in terms of the “Information areas”
- Comments regarding data interpretation, or qualification, are highlighted in text boxes with blue text.

The conclusions are subsequently drawn together and discussed. Any differences in findings or conclusions from the data sources are highlighted here.

Finally, there are some recommendations for further work. This is broadly divided into the following areas:

- Cause And Effect
- Data Capture And Analysis
- New Solutions
- Economic Assessments
- Focus Of Effort

6.2 DISCUSSION AND CONCLUSIONS

6.2.1 Condition

Farmers believe that their stores are in good order, but data from other sources does not necessarily support this. This farmer’s assessment of his own store may be a little optimistic given the findings of the other surveys.

Condition was assessed directly in the majority of CSF visits. It was assessed by asking farmer’s opinion in the MORI survey and indirectly by an assessment of compliance in the EA Asset Inspections.

Stores built post-1991 and by a specialist contactor were regarded as being in a better condition by farmers. It is difficult to compare the Ipsos MORI and CSF data for condition, as the condition of stores was not recorded for all CSF visits. As a guide, where condition was recorded on CSF visits, 45% of stores were recorded as in good or average condition.

For the CIRIA EA Asset Walkover Inspection taking the ADAS estimate of SSAFO compliance as an indication of good store condition respectively, 43% of earth banked lagoons, 78% of cylindrical tanks, and 88% of concrete structures would have been considered in good condition. Non-compliance with SSAFO is likely to indicate that the store is more likely to be in poor condition, however, aspects of non-compliance such as design capacity, insufficient freeboard, and failure to notify the EA of construction do not necessarily reflect store condition

It could be postulated that the Ipsos MORI information shows more stores in very good / fairly good condition than is found in practice by farm visits. However the Ipsos MORI data included a lesser percentage of earth banked lagoons than the CSF and particularly the EA data. The EA data showed a lesser percentage of earth banked lagoons being in good condition based on SSAFO compliance.

The EA asset walkover showed all mass poured concrete structures to be in good condition and the ADAS CSF visits found this type of structure to be in generally good condition. Conversely concrete block, concrete panel, and weeping wall stores, were often judged to be in average or poor condition

6.2.2 Age

It is not possible to develop an age profile for stores, nor is it possible to link age of a structure to its condition.

Importantly age is not necessarily a guide to condition. Just less than half (44%) of the stores appear to have been constructed before the regulations came into force and therefore considered as exempt structures.

The EA asset walkover reported 60% of cylindrical tanks over 15 years old to be in good condition. Even one recorded to be over 30 years old, with no record of any maintenance, was also recorded as being in good condition. Over riding factors to the age of store would be:

- Quality of manufacture of store components
- Skill of constructors when installing
- Care and skill of operating stores
- Frequency of ongoing maintenance

It may be reasonable to say that for stores constructed of concrete blockwork or masonry the typical design life is probably a maximum of 15 years, but less if the wall is damaged through, say, impact leading to cracking and weakness. It is feasible that mass poured in-situ concrete will probably have a life span of 30+ years. Similarly, concrete panel stores could have a life span of 30+ years providing the joints between the panels are maintained, connecting components, and the panel structures are not damaged.

It is not reasonable to assume that all farm constructed stores will not follow SSAFO, nor can it be assumed that a store built by contractor will conform. There is evidence that specialist contractors, e.g. for above ground circular stores, will follow SSAFO requirements, but local contractors are less likely to. Awareness of SSAFO requirements may be less amongst general building contractors than specialist contractors as they have not been targeted by advisory programmes.

6.2.3 Capacity

Farmers themselves generally consider that they have sufficient capacity, whereas CSF data, although drawn from a skewed sample, and the EA Livestock visits, and Asset Walkover, suggests otherwise.

The MORI survey reported respectively 80% farmers surveyed in NVZs and 65% out of NVZs saying that they have the minimum or greater slurry storage capacity for their situation. In NVZs this refers to 5 months for cattle and 6 months for pig slurry and generally 4 months to meet SSAFO requirements outside of NVZs.

The MORI contrasts to the CSF visits which show respectively only 26% farms in NVZ, and 28% of farms outside NVZ having sufficient slurry storage capacity to meet NVZ and SSAFO requirements.

One reason for the difference could be that the CSF visits are not randomly selected. Some farms would have been select by the Catchment Sensitive Farming Officer as being known not to have sufficient storage, or farmer knowing this and requesting a visit to obtain advice on the storage capacity required. A further reason could be in the Ipsos MORI survey sufficient capacity was likely to have been based on the farmers perception and experience rather than detailed calculations based on standard excreta production figures.

The EA record of visits to farms in England between 1st January 2012 and the beginning of April 2013, to farms outside of NVZs, showed that nearly 20% of the slurry stores on the farms visited to be non-compliant with the SSAFO regulations storage volume requirement of 4 months. The 33% exempt structures identified were also thought unlikely to have sufficient capacity. 50% of the stores on farms visited in NVZs were considered to have insufficient capacity to meet the regulation requirements.

The CSF and EA visits could suggest that the MORI telephone survey overestimates the number of farms with sufficient slurry storage capacity to meet NVZ requirements. However such a conclusion should be treated with caution as there is a likelihood that the CSF, and possibly the EA visits, were biased towards farms suspected of having insufficient slurry storage capacity. The EA Nirs data indicated over topping as the highest number of the various types of incident recorded in 6 out of the 8 years between 2006 & 2013. It could be postulated that this is an indicator of wider insufficient slurry storage capacity on farms.

6.2.4 Compliance with Legislation – SSAFO

Condition. Only the CSF and EA Walkover considered the condition of the stores. The MORI survey asked the farmer what he thought was the condition of the stores. Although 60% of farmers were aware of the SSAFO regulations they were not necessarily aware of the details or implications.

Design & Construction. It is not possible to determine from any of the survey work, which of the design standards for stores were either met or breached. None of the surveys actually comment on this. There is no structural engineering evidence to support or refute any statements about the construction standards to which stores have been built. The only assessment is the EA statement in their Livestock Visits where a determination has been made on compliance of a store. For CSF visits there was a judgement made by the consultant as to a structure's compliance.

Capacity. Farmers consider they have sufficient capacity but not necessarily if in an NVZ. EA and CSF visits, and NIRS incident records suggest that capacity, and management of available capacity, are both frequently inadequate.

6.2.5 Incident trends

Issues around spreading slurry to land, peaking in 2002 and 2012, appear to be linked to a wet winter. It is important to note that the stores would have been full due to the extra rainfall. Therefore there is a link between winter rainfall and spreading issues. However, the number of store failures are relatively small in number when compared with spreading and overtopping incidents and the total number of livestock holdings.

6.2.6 Store type and condition

Table 3 below summarises the percentages of structure types (where available) for the different data sources (may not total to 100% as minority store types, e.g. under slatted floors, compound stores not included).

Table 3: Slurry store structure type

Data source	**Store type**			
	Earth banked lagoon	**Cylindrical tank**	**Concrete structure**	**Weeping wall**
	%			
Ipsos MORI	27	24	24	8
CSF				
NVZ	38	17	26	15
Non NVZ	37	28	22	10
CIRIA EA Asset Walkover	50	22	28	

6.3 Recommendations

The following recommendations are put forward for consideration.

6.3.1 Cause And Effect

1. Further analysis should be undertaken of existing data, or new data gathered, to firm up any areas of evidence where there is uncertainty. An example is number of farmers who spread during the Closed Period in a NVZ who say they have adequate storage capacity. Spreading accounts for the majority of incidents, however, it has not been possible to differentiate between spreading incidents resulting from a lack of storage, and the cause of other spreading incidents.
2. Additional data needs to be captured to identify the role of capacity, construction standards, and field operations on incidents, and to properly quantify this.
3. There is a complicated relationship between freeboard and capacity of earth bank lagoons. There is regular reporting that freeboard is compromised and overtopping occurs. Reducing freeboard allowance would be a paper exercise increasing the theoretical storage capacity of a given structure, but would not stop overtopping. The opportunity to consider freeboard requirement in terms of risk of any particular store should be reviewed.
4. Further research is suggested to identify whether a store was either built and not SSAFO compliant and failed, or SSAFO complaint and still failed.

6.3.2 Data Capture And Analysis

1. Improvements to the Nirs system should be made
   (a) for future records and/or
   (b) to enable better analysis of retrospective data.
2. There is rarely a documented record of when a store was constructed and supporting paperwork. For new stores there should be 'design' file, with maintenance log, created at the time of construction to be maintained by the farmer or designated manager of the facility.

6.3.3 New Solutions

1. Farmer's perception is that adequate maintenance is undertaken but there is no evidence to support this on the ground other than checking ranging from quite detailed to no checks carried out. It is recommended that:
   a. All new stores constructed should have an 'operators manual' with a section detailing the required maintenance programme and record of any improvements undertaken. E.g. The Soil Protection Review format and approach could form the basis for this check process.
   b. The operator's manual should include a maintenance and inspection log.
   c. The 'maintenance' section of the 'operators manual' could be introduced for Exempt structures to demonstrate that maintenance is carried out on a regular basis.

2. New stores, and existing stores falling within the scope of the regulations (where possible) should have an installers plate, as practiced on machinery, providing information on:

   - Name of the store (to avoid misrepresentation)
   - Name of installer and address
   - Date of construction
   - Standards used
   - Volume of the store
   - Storage capacity of the store
   - Freeboard to be maintained in operation.

6.3.3 Economic Assessments

1. The cost of non-compliance and of incidents to farmers is unclear and appears generally to be relatively small. The cost to the nation is also difficult to assess. An attempt should be made to quantify the true cost to the UK of pollution events and benefit-cost assessments for different scenarios undertaken.

6.3.4 Focus Of Effort – Communications

1. Overtopping and problems during spreading are the most frequently recorded incidents. Both are potentially associated with a lack of storage capacity. Providing a focus on spreading practice and soil management should help to reduce the incidence and impact of spreading problems. Addressing storage capacity issues, paying particular attention to the contribution of surface water deriving from rain, should help to reduce the need to undertake spreading in inappropriate conditions. Both of these measures will also enable improvement in nutrient recovery with consequent reductions in fertiliser purchase requirements.
2. The incidence of store failure is relatively rare, however the contribution of poor store condition to on-going water quality problems through low level and concealed point source pollution should not be overlooked.
3. Resources should be focused on farms with cattle, earth bank or masonry stores, and extensive open yard area.

4. There should be engagement with spreading contractors to improve understanding of NVZ Action Programme measures and opportunities for optimising nutrient recovery.
5. Awareness and possibly ‘training’ of installation contractors and system manufacturers in the requirements of SSAFO.
6. Consideration should be given to providing support to Environment Agency staff in respect of new and emerging technologies.

7. EXPERIENCES FROM OTHER MEMBER STATES

It has proved surprisingly difficult to determine the detail of silage and slurry storage regulations in other countries in northern Europe.

All are believed to have statutory minimum storage periods for slurries (and in many cases solid manure), or to create them by default through the specification of closed spreading periods through their various nitrates action programmes. The closed seasons vary in duration, starting dates and local or regional approaches. 12 months minimum capacity is understood to be required in Finland, whilst in Ireland a storage period of 16, 18, 20 or 22 weeks may be required depending on region / county. In Denmark the closed season is between October 1st (or after harvest whichever is the earlier) and February 1st, and 15th November and 1st of February for solid manures. Storage of farmyard manure in a sheeted field heap is permitted in Denmark, but with no return to the same site for five years. In Germany storage for at least 6 months is required, rising to up to 10 months for pig slurry, with a November – February closed season for spreading.

Construction standards for both silage clamps and slurry stores are specified in detail in Ireland, largely through the standards required for grant aid eligibility through the Farm Improvement Scheme, where 40% support has been offered. The basic requirement is that silage clamp floors are constructed of concrete and impermeable. External channels are required where pre-cast concrete panel walls are used, but apparently not in the case of mass-poured concrete, where an internal channel is recommended. A separation distance from receptors is also required – 10m in the case of existing farmsteads, 50m in the case of new units, and 60m from drinking water supplies.

The specifications for earth banked and lined lagoons in Ireland are similarly detailed. However in the case of lagoons constructed with in-situ materials, the 10^{-9}m/s permeability standard is adopted, but the thickness of the reworked layer and the nature and degree of compaction and finish is specified to one of three standards depending on a risk assessment of the site. The middle standard is largely equivalent to the recommendations of the original CIRIA guide 126.

In Denmark the basic measure is that stores shall be impermeable, but some requirements may be varied depending on a site / locational risk assessment, with additional bunding or alarms being required on some sites in proximity to water courses.

8. FUEL OIL

8.1 General comparison between the SSAFO and Oil Storage Regulations requirements.

Comparing the regulations relating to fixed installations, they are similar in requiring bunded installations, but differ in the definitions of how fill, draw off, or overflow pipes may exit the bund. They also differ in location details:

- At least 10 metres from a watercourse for SSAFO regs; not stipulated for Oil Storage regs
- Oil Storage regs do not apply to stores inside buildings, probably due to assuming impermeable floors, which is rarely the case for agricultural buildings

Section 3 of the Oil Storage regs relates to leakage detection systems for underground stores and test frequency. If these regs were to be adopted for agriculture, this could result in high installation and maintenance costs, though underground tanks on farms are uncommon.

The Oil Storage regs make useful reference to primary containment (the main store) and secondary containment (delivery pipes, etc).

The Oil Storage regs include useful requirements for storage of drums (which could be extended to waste oil, as this is often stored prior to collection), and for mobile bowsers - currently rare on farms, but their use could increase.

8.2 Observations from farm advisory visits

In carrying out farm pollution audits on behalf of Defra and Natural England over the past two decades, the following issues have come to ADAS advisers' attention:

- As older square steel tanks have become unusable, these have mostly been replaced with pedestal-mounted double-skinned plastic tanks with the gravity delivery hoses, usually exiting from a single skin and hanging on the exterior of the tank, without any supplementary bunding. In some cases there is a fairly direct path from the tank installation to a drain or watercourse (e.g. an adjacent surface water drain).
- Fuel stations with containment for fuel storage and for the delivery hose within a lockable compartment are relatively rare, with plastic being more popular than steel, probably due to purchase cost. Whereas both types are fully compliant with SSAFO regulations and pollution risks are acceptably low, the plastic tanks are particularly vulnerable to damage in the event of fuel theft.
- Damage to fuel installations and resulting pollution is becoming of increasing concern. Where tanks are pierced to remove fuel, flow will continue if the thief departs before the tank has been emptied. Contrary to the spirit of the SSAFO regs, on a gravity discharge tank it could be a lower pollution risk strategy to leave a very light padlock on the discharge valve to give the message "take what you want from the delivery pipe, but please do not pierce the tank".
- Of some concern is the integrity of double skinned plastic tanks as they age. Should the inner skin fail, what is the probability that the outer skin (subject to extremes of temperature and UV light) will be able to contain the spillage - and will it be obvious that the inner skin has failed?
- It is a relatively rare occurrence, but spillages at the tractor have occurred following overflow (leaving a tap on, or jamming open a gravity discharge nozzle). Electric discharge pumps generally avoid this risk, and allow fuel use recording as part of energy monitoring for cost saving.

Increasingly, the best practise farm solution incorporating SSAFO compliance and theft/vandalism protection is to site the farm fuel store in a secure building. One option is to place a plastic fuel station within a steel shipping container (out of sight, out of mind applies in equal measure to security).
The more popular choice is to site the new installation in a farm workshop, with a electric pump discharge to a small access hatch cut into the side of the building. If the tank is floor-mounted, within a substantial steel or block-built bund (suitably treated), then the only way to extract fuel is if the thief comes equipped with the means to suck it from the tank.

8.3 Should the SSAFO regs or Oil Storage regs apply to farms?

In principle, the **Oil Storage regs** are more comprehensive, though they would need to be extended to installations within farm buildings. Also, the SSAFO '10 metres of any inland freshwaters or coastal waters that fuel oil could enter if it were to escape' requirement would still need to apply. This may need modification to address connectivity to watercourses, e.g. via nearby farmyard surface water drains.

In reality, the **SSAFO regs** adequately cover farm installations, with the main issues being non-compliance of double shinned plastic tanks with the discharge hose hanging outside of them, and consequences of vandalism. An advisory leaflet could incorporate many of the good practise suggestions given above, particularly with respect to deterring theft and vandalism.
Modifications to the SSAFO regs could be:

- re-interpret '10 metres of any inland freshwaters or coastal waters that fuel oil could enter if it were to escape' to emphasise 'low connectivity to watercourses'
- storage of fuel in drums (and waste oil)
- use of mobile bowsers

9. LEGISLATION

9.1 Farmer's obligations in relation to the Water Framework Directive, Nitrates Directive and Cross Compliance.

The storage and spreading of manures and slurries in England is governed by a range of legislation:-

9.2 Water Resources Act

The fundamental underlying principle is that production, storage and application of manures to land should not give rise to pollution, and should protect the environment. The unconsented discharge of noxious or polluting matter to controlled waters is prohibited under the Water Resources Act 1991. Effectively there should be no seepage or run off from yards, clamps or stores, or as a result of spreading of manures or slurries on to land

9.3 Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations

The nature, capacity and construction of storage facilities is controlled by regulations made under the Water Resources Act. Construction standards for facilities used for the storage of silage and slurry are detailed in the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations, (SSAFO) originally 1991, but subsequently amended and updated, most significantly in 2010 and most recently in 2013.

The regulations take a relatively prescriptive approach to storage, both in terms of design and construction, and to a lesser extent management. From an environmental protection point of view the key issues are that stores do not leak or collapse, and that they provide sufficient capacity to ensure that spreading needs only take place when conditions are such that the recovery of nutrients is optimised and the risk of pollution minimised.

Effectively the current regulations apply to structures completed since September 1991 and those which have been substantially enlarged or reconstructed since that date. Structures which pre-date the regulations are considered to be exempt unless the Environment Agency considers that they pose an unacceptable risk of pollution, in which case they can serve notice, withdrawing the exemption and requiring the facility to be brought up to the standards of the regulations, as though the structure had never been exempt.

In terms of design, the regulations require that stores are designed in accordance with the relevant British Standard, that they are impermeable, have a design life of at least 20 years, and that they provide not less than 4 months storage capacity. The capacity must include allowance for the worst rainfall in a five year return period (M5 rainfall) on open yard areas draining to the store and the store itself, and any bedding in addition to excreta and wash water. The requirement for 4 months storage can be reduced where it can be demonstrated to the satisfaction of the Environment Agency that spreading can be carried out safely on a more regular basis. The capacity of ancillary structures which may be filled by gravity, such as reception pits, is required to be sufficient to contain 2 days production of slurries and fouled water, plus the M5 48 hour rainfall over the area draining to the structure.

9.4 Nitrates Directive

The Nitrates Directive places duties upon member states of the EU to monitor, control and reduce the levels of nitrate in water. In England those duties are discharged through the enactment of the Nitrates (pollution prevention) regulations of various dates. Under these regulations parts of the countryside where nitrate levels are high or rising are designated as Nitrate Vulnerable Zones (NVZ). Within the zones action programme measures are specified. The timing, rate and manner of application of nitrogen, and hence slurries and high available nitrogen content organic manures, is controlled, and a statutory storage period and the requirement to keep records of application imposed.

9.5 Cross Compliance

Compliance with the NVZ regulations forms part of the Cross Compliance obligation (Standard Management Requirement 4) of the Single Payment scheme. Failure to comply with the NVZ regulations constitutes a breach of Cross Compliance and may result in the loss of single farm payment.

The SSAFO Regulations govern the storage of silage, slurries (not solid farmyard manure) and agricultural fuel oil. They do not currently form part of Cross Compliance.

9.6 Environmental Permitting Regulations

Larger pig and poultry units have had the introduction of The Integrated Pollution Prevention and Control (IPPC) Directive, which has an aim to apply Best Available

Techniques (BAT) to prevent, or reduce, emissions to air, land and water from these activities. This was replaced by the Environmental Permitting Regulations in 2008 and applies to larger pig and poultry farms with capacity for more than:

- 750 sows
- 2,000 production pigs over 30kg
- 40,000 poultry (includes chickens, layers, pullets, turkeys, ducks, guinea fowl and quail)

Pigs reared outdoors are excluded, but free-range poultry are included. Farms regulated under PPC require a permit to operate, which covers all aspects of farm management, from feed delivery to manure spreading,

An important requirement for slurry stores is a cover on new stores, and existing stores to be covered by 2020. These can be permeable or impermeable covers, floating or suspended structures.

9.7 Conflict between SSAFO and NVZ

From 1 January 2012 a farm located within an NVZ, has to provide sufficient facilities for the storage of slurry and poultry manure produced by livestock, whilst in a yard or building, during the following 'storage periods':

- 1st October to 1st April (six months) in the case of pigs and poultry.
- 1st October to 1st March (five months) in the case of other livestock.

These headline statements appear to require 180 or 150 days capacity respectively. The storage capacity also needs to be able to contain the average rainfall falling onto yards draining to the store or onto the store itself.

In many instances this imposes a requirement for a larger capacity store than the 4 months (including the M5 rainfall) required by the SSAFO Regulations. Though the impact of rainfall on varying yard areas, and the difference between 4 months M5 and 5 months average rainfall makes the overall variance far from consistent.

However the opposite can also be true. The formal calculation process which farmers are required to follow (NVZ guidance booklet 4) in determining storage requirements is based on monthly averages over the storage period and the proportion of manures handled or collected as slurry. With a dairy herd which is not normally housed until November, only around 30% of manure output during October will end up in the slurry system (the remainder being dropped whilst the stock are at grass and therefore discounted). On shallow and sandy soils (with certain caveats) spreading can recommence after the first of January, and provided a contingency of 1 week's additional capacity is made, the volumes spread after the end of the closed season can also be disregarded. The net effect of this is that the storage volume assessed through the detailed calculation process may well be reduced to as little as 77 days for a dairy herd housed from 1st of November on a light land farm.. THIS FARM WOULD STILL BE NVZ COMPLIANT with little more than half the headline requirement and significantly less than the 120 days capacity required under SSAFO. However with continuously housed livestock such as intensive pigs or poultry, the headline requirement is equal to that derived through the detailed calculation procedure.

In addition there are different understandings of the term 'dirty water' for a farm inside an NVZ compared to outside an NVZ. Within an NVZ the surface water from a yard where livestock have short term access, and where an attempt is made to clear manure from the surface after use is deemed to be 'lightly fouled' and falls outside the NVZ definition of slurry. As a result it is not subject to the storage period which applies to run off from yards to which stock have continual access. Though a farmer would consider both materials to be 'dirty water' inside or outside an NVZ, they are actually both classed as slurry under SSAFO, though the 4 month storage requirement is commonly waived for low dry matter / low available nitrogen material where it can be demonstrated that it can be spread safely on a regular basis. Farms with Low Rate Irrigation systems for applying 'dirty water' onto land equally all through the year may be compromised in an NVZ area if that 'dirty water' originates from areas such as feed yards, loafing areas or weeping wall stores.

9.8 Planning

9.8.1 Policy – national and local planning policy has sought to protect the countryside from development and in some cases this has been to the detriment of agriculture (despite agriculture and rural development generally being provided with positive policies.

9.8.2 Landscape and Visual Impact Assessment (LVIA) or similar. With policies restricting development (as above) there has in many cases been an eagerness for authorities to encourage the provision of LVIA, more notably for EIA development. The consideration of landscape character and visual impact leads to subjective opinion, the need for alternative sites, abortive costs etc.

9.8.3 Permitted development rights - the introduction of the 400m rule relating to the storage of slurry or sewage sludge has increased the need for full planning permission where farms are located close to residential properties.

9.8.4 Environmental Impact Assessment Regulations 1999 (amended) – Schedule 2 development is a potential 'catch all' for development >500sq m which potentially gives rise to significant impact on the environment. Where the screening opinion is that the proposal is EIA development and requires an Environmental Statement to accompany the planning application this typically leads to the preparation of more information, increased costs, time delays and a wider consultation to include Natural England.

9.8.5 Residential amenity – greater consideration is now given to the amenity to of others. Noise, odours, proximity to a farm can all impact on the success (or not) of a planning application. The potential for a nuisance complaint is a concern to environmental health officers as consultees in the planning process. The proximity of public footpaths is a further amenity issue but also one of health and safety.

9.8.6 Validation checklist – the cost of planning/submission of planning applications is ever increasing as more information is required.

9.8.7 Time delay – application determination time can be up to 16 weeks for EIA development and longer where schemes are delayed for whatever reason and are considered as less of a priority for authorities meeting their determination targets. The statutory periods for determination are 8 weeks for minor applications, 13 weeks for major applications and 16 weeks for EIA applications.

9.9 Health and Safety

As with all work places the farm is subject to health and safety regulation, in respect of silage and slurry storage and application these are principally the Health and Safety at Work Act, the Provision and Use of Work Equipment Regulations (PUWER) and the Control of Substances Hazardous to Health Regulations (CoSHH).

Slurry and silage can and do give rise to noxious gasses, including oxides of nitrogen and hydrogen sulphide. Concentrations of gases in confined spaces can also displace oxygen and there have been several cases of asphyxiation of farm staff in recent years. Mixing of slurries and covering of slurry stores is increasingly common – driven by the need to reduce atmospheric pollution and improved spreading performance / nutrient utilisation, and these measures tend to increase the risk of encountering slurry gases.

The standards for safety fencing of stores are specified in an HSE guidance note.

9.10 Other Practical Constraints: BS5502 – 'Buildings and structures for agriculture'

This British Standard – BS5502, is no longer a standard supported by BSI. This Standard has since 1990 been the UK adopted standard for all elements of agricultural building development including structures for the storage of slurry, silage and silage effluent. The BS is cited in many advisory codes.

Because the standard is no longer supported by BSI, the data contained within the code is unlikely to be reviewed or updated and could quickly become out of date. So if BS5502 is included in future references it must be appreciated the viability of the standard may become an issue.

Currently BS5502 refer to a plethora of other British Standards many of which are now out of date and/or withdrawn and replaced by Eurocodes. For example, the standards referenced in BS5502 for concrete have been withdrawn and replaced with Eurocodes BS EN 1992-1 and BS EN 1992-3. While these codes are extremely explicit and through, they do not have the same basis for providing 'impermeable' structures as BS 8007 or BS 8110.

Appendix 1.

The Joint Industry/Defra/EA/NE Slurry Storage and Management Project

SSAFO Working Group Discussion Paper: April 2013

The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010
Link to the SI http://www.legislation.gov.uk/uksi/2010/639/pdfs/uksi_20100639_en.pdf and amendments http://www.legislation.gov.uk/uksi/2010/1091/pdfs/uksi_20101091_en.pdf

1. This paper is to consider the SSAFO Regulations, the strategic justification for them, and whether the regulations themselves are fit for purpose or require updating to reflect innovation, new technology and building materials. This paper draws on thinking by the Environment Agency about the queries and issues they deal with, issues raised by industry in the 2011/2012 consultation on the Nitrates Directive and offers some thoughts on how the regulations might be clarified and improved.

2. Before considering the detail of the regulations **the Working Group are asked to consider the following questions and identify any other issues that need to be considered**:

   - What's the problem with regard to silage making or storage of slurry and agricultural fuel oil?
   - What's the desired outcome?
   - How well are the regulations working at present?
   - How do they contribute to the desired outcome?
   - Are the SSAFO Regulations still necessary? if not, how do we achieve the same outcomes and demonstrate we are taking effective measures to achieve WFD and Nitrates rules to the Commission?
   - Should they be construction standards or a requirement for storage and a set of construction standards?
   - What benefits do the Regulations bring for the industry, for the environment and for the economy? How might these be improved?
   - If the regulations are still necessary – is the scope covering silage, slurry and agricultural fuel oil still appropriate and fit for purpose?
   - How do anaerobic digestors, and other new energy technologies eg biogas and biofuel fit in?
   - Should other bulk storage tanks, stores of nutrients or agricultural material be specifically regulated?
   - Given the regulations have been in force for over 20 years, how will the farming and agricultural construction industries react to change and how will possible changes to the regulations impact on them?

The Working Group are asked to consider the detailed structure and content of the SSAFO regulation clauses and schedules.

3. **It should be noted the thrust of these suggestions are not seeking more onerous controls overall, but :-**

- To update and clarify some requirements
- To assist general understanding, so helping farmers more easily achieve compliance
- To clarify the relationship between SSAFO Regs and the Nitrate Regs
- Having regard for the Red Tape Challenge and Working Smarter Report, review if some controls, notably regarding silage making and if controls for agricultural fuel oil may fit more appropriately elsewhere, and:
- To review if standards are appropriate for new materials or products now on the market, or where modern techniques are employed.

Wording and Overall Format

4. These regulations were written some 22 years ago, being the first 'water pollution' regulations affecting agriculture. Some parts, (in particular some definitions in Interpretation, plus Regulation 4- Storage of Slurry and wording of the Schedules, notably Schedule 2 Para 6 – Slurry Storage Requirements) could be usefully updated and clarified.
5. The suggestions below follow the order of the Regulations, rather than any priority.

Interpretation

6. **Silage** - Should we revisit this interpretation, to take account of the changes and developments in silage making since the regulations were first written?
   The aim here is to recognise changing silage-making practices, such as alkali treatment of crops (alkalage), the making of very dry silage from grass, or silage made from whole crop cereals or maize, which usually produce less silage effluent than silage made from grass and therefore present reduced pollution risk.

7. **Slurry** - The basic definition is sufficient, but EA gets queries about what to do with free drainage from solid manure - FYM, stored on hard standings away from the main farm buildings. Should we clear that free drainage from FYM stored on hard surfaces is classed as 'slurry' (as it is produced by livestock whilst in a yard or building), irrespective where the FYM is stored? Note the proposed revision by Defra/WG of FYM management in fields under the NVZ Regulations is helpful and if followed, should avoid any need for similar controls of FYM stored in fields.

8. Should we establish an unambiguous link with the NVZ slurry/dirty water rules and definitions? For example, NVZ guidance is very clear water cannot be added to slurry to make it into 'dirty water'. Should we consider the terms dilute effluent & dirty water (eg be clear that these are working terminology rather than legal definitions) and consider if different control mechanisms might apply?

9. **Agricultural Fuel Oil** - the opportunity could be taken consider whether AFO might fit better with the Oil Storage Regulations - OSRegs, but with the need to consider loss of the current "SSAFO 10m from water rule" and the exemption in OSRegs for stores inside a building - as floors in farm buildings are rarely impermeable to oil.
   This would reduce the number of regulations a farmer has to consider with regard to any type of oil used and stored on their farm, avoiding the confusion over different standards applying for slightly different uses of oil, and their storage requirements.

10. Changes might be necessary to deal with off the shelf integrally bunded tanks, where other important aspects of SSAFO are not addressed - eg delivery hoses located outside bunds and also the short life expectancy of the plastics used.

11. 'Substantially enlarged' and 'substantially reconstructed' are not defined in the regulations, although EA agreed outline parameters with DoE. should we explore either defining these more clearly, or consider requiring notification of any enlargement or reconstruction, as then EA could assess the likely consequences and advise the farmer? In making such a decision, we would need to look at the resource implications for us.

12. 'Yard' is not defined and it may be helpful if it were to be defined, to include impermeable areas anywhere on the farm.

13. 'Likely rainfall' may usefully be defined- see 30 below

14. **Regulation 5 - storage of fuel oil (if the Oil elements are retained within SSAFO)**
   Para 5(b) only allows controls to apply when the **actual quantity stored of oil exceeds 1500l.** This leads to difficulties - where it is claimed the actual quantity on any day may not exceed 1500l, even though the store capacity is clearly exceeding

this threshold. It may be worth amending this criterion to ‘storage capacity’, rather than the quantity stored at any one time.

Exemptions and Asset Life

15. Removing ‘Exempt’ status. Although this was not pursued following the last NVZ consultations, there was support for this, but there was also a misunderstanding - that the proposals inferred all stores over a certain age had to be replaced. Is there a case, where stores are over 20-25 years old, for farmers to be able to demonstrate they are fit for purpose - eg by providing an ‘MoT- type assessment’ or similar? If they fail, then improvement or replacement would be needed. If they passed, no action would be required.

16. This approach does not rely on whether a facility is currently exempt, so could be continuously applied. It should also provide encouragement to those following good practice in maintaining these systems - by accepting continued use does require demonstration that the store remains fit for purpose. [Note need to also consider implications of who might carry out the ‘MOT’ ,frequency and how the function might work and be funded]

17. The current regulations require a 20-year design life, but EA have been obliged by other legislation to accept stores with shorter lives, particularly where they are sourced from other EU countries. We need to consider how this can be reflected in amended Regulations and linked to the need for a first ‘MoT’ if the concept was accepted.

Notice Requiring Works etc. – Regulation 7

18. EA have encountered situations with the complete absence of slurry stores and it is not clear that in such a situation EA can use the Notice provisions to require a store to be built.

    Also, EA’s understanding is that the Regulations gave them power to serve a Notice whether the structure has ‘Exempt’ (pre -1991) status or not, if found to be in an un-satisfactory condition. EA believe the wording of Regulation 7 is ambiguous and needs changing. This would mean that those farmers who make the effort to maintain Exempt systems in a satisfactory condition would continue to have the benefits of ‘Exempt status’. Do you agree?

Notice of Construction - Regulation 9

19. Notification date at the design stage, as raised in the NVZ consultations seems to be widely supported. Should this also apply to enlarged and reconstructed systems?

20. We also need to consider how it will fit with Local Authority planning permission, and to clarify how the SSAFO Regs relate to the Nitrate Regs and implementation of the Nitrates Directive (and other EU legislation).

Schedule 1 Requirements for silos

21. As outlined above, changes in silage making have significantly reduced water pollution risks in many, but not all cases. Whilst the overall number of silage-related incidents is a fraction of the ‘1000 plus/ annum’ when SSAFO Regs were first proposed, incident numbers have crept up in recent years, possibly reflecting more difficult weather conditions increasing silage effluent production. Nevertheless, EA feel there is scope to review certain requirements and possible enforcement i.e. develop a situation of possible relaxation where the farmer provides appropriate mitigation measures and **where farmers first discuss proposals with EA** (This could prevail in other SSAFO aspects);
    - Silo design, including wall/ floor joint and perimeter drains - where EA have had a number of occasions recently where designs do not meet the current SSAFO standards, but are supposedly acceptable elsewhere in the EU. The situation could be more manageable with Prior Notice at the design stage -19

& 20 above, but a review of the standard might help clarify what we should accept. [Need to bear in mind that SSAFO Regs are domestic regulation]

- Silage effluent tank volume may need reviewing, with whole crop silage or maize silage being far more prevalent than in 1991. There may be a case that tanks could be over-sized in some situations?
- EA are aware that the company who markets 'Ag- bags' believes there should not be a need to classify them as 'field silage and so we suggest consideration in light of this.
- The original 1991 Regulations required cylindrical forage towers to be designed and constructed in accordance with BS 5061:1974. There were no other requirements here. Some years ago, it was decided to withdraw BS5061- because it was believed that no new such towers were being commissioned. This had no impact on those already built and so the reference was taken out in the 2010 Regulations. If there is reliable evidence from the industry to the contrary, then first it seems the BS would need to be renewed and then the reference could be put back into SSAFO. Is this necessary?

Slurry storage requirements, including Schedule 2 Para 6.

22. An update to the wording could be considered to improve clarity and make it clear the expectation is for farms to have four months storage, as a minimum, as standard across England, and additionally, in NVZs that 5 months applies for cattle and 6 months for pigs or poultry. Originally, guidance provided an opportunity for farmers to provide less than four months storage, providing they demonstrated 'safe-year round disposal/ spreading', usually by provision of a 'Farm Waste', then later, Manure Management Plan- MMP. Spreading of slurry in the winter months does not fit with the need for slurry spreading to confer agricultural benefit (with EU judgements post-dating the first SSAFO regs), and to avoid conflict- with slurry then being potentially considered 'agricultural waste'. [Note the methods for calculating storage capacity are complex and simplification of them would be worth investigating]

23. Except for those farms, where EA, or predecessor organisations agreed otherwise by provision of a relevant MMP as outlined above, all farms with slurry ought to have a minimum four months volume of storage. It may be anticipated that 22 years later, that would have been achieved throughout.

24. For farms with no storage or Exempt storage, it is not clear that such a farm must have a minimum volume of slurry storage. We suggest either a transitional provision for providing four months storage, or clarification/confirmation that a Notice to require at least four months storage capacity can be used.

25. Allowing dirty water to be spread in NVZ closed periods also confuses the position. The question of aligning SSAFO and NVZ minima could be re-visited, along with discussion and confirmation in what circumstances it may be appropriate to permit spreading of dirty water in the winter.

26. MMPs have a useful role in identifying suitable, or non-suitable spreading areas, so helping reduce pollution risks from slurry management. It may be helpful, however, to explore (in parallel with this review?) how they may be strengthened for wider benefit, eg by linking with Water Framework Directive requirements and improved nutrient management planning.

27. Should we consider appropriate standards for storage of slurry in 'bags' and artificial lined structures, which are being imported and widely marketed, but they do not fit readily within SSAFO.?

28. It was decided not to pursue changes to the slurry storage capacity calculation for SSAFO and NVZ, under the revisions to NVZ rules, but it would be useful to discuss how NVZ and SSAFO calculations may be rationalised. EA now have a working methodology for converting annual average rainfall figures into the current 'likely

rainfall' - one in 5-year rainfall used to calculate SSAFO capacity. We need to bottom out how good data can be made readily and cheaply available to farmers.

29. It may be beneficial to then define 'likely rainfall' within the regulations.

30. Linked to 22, 23 & 25 above, the alignment of storage minima could be revisited. The strong technical argument is that they are minima, and in many cases more is actually needed.
    Moving NVZs to likely rainfall might be preferable to moving SSAFO to average rainfall, and though this may be difficult, it should be considered.

Guidance

31. The structure of the guidance [http://www.environment-agency.gov.uk/business/sectors/108825.aspx] could probably be improved if it was re-written. This links with the EA work with the CIRIA 126 review.

32. Consideration also needs to be given about updating relevant paras in CoGAP http://www.defra.gov.uk/publications/files/pb13558-cogap-090202.pdf (which is mandatory within NVZs and best practice outside NVZs)

Anerobic Digestion

33. Should we consider including **anaerobic digesters (AD)** and/or related bulk storage more specifically in the regulations? Anaerobic Digestion requires an environmental permit, however permits generally refer to 'appropriate construction standards'. Digestate is treated no differently from slurry in practical terms. There have been a number of pollution incidents including some involving fatalities, so there might be a case for considering defining construction standards for AD plant and or storage as part of the SSAFO Regs. This may require an extension to the work currently reviewing CIRIA 126, the reference guidance for such standards.

34. **Constructed Wetlands** Possible consideration of bringing in use of Constructed Wetlands into the Regulations to help manage the large volumes of less-polluting yard drainage etc.- as we understand is now done in Scotland (EA are currently seeking information from SEPA on this). We do not advocate adding these to SSAFO, but examine to what extent such wetlands may be utilised to manage drainage off lightly contaminated yard areas, which if contained and stored as slurry, may overwhelm otherwise adequate slurry systems.

35. It may be helpful to discuss the requirements for permeability, where it is not referenced in British standards. For example, the permeability of earth-banked slurry stores could be reviewed and a standard included within SSAFO, or referenced to CIRIA 126, as it is not covered by BS 5502.

36. We also suggest considering what provisions are acceptable or not for more pervious soils and to look at the argument from some parts of the industry- that 'over time, some permeable slurry stores may become less permeable – due to the potential of slurry itself to help seal slurry stores'.

37. Our position is that where stores are not suitably impermeable at the outset, they cannot be considered SSAFO- compliant. It may simply be a case of dealing with this point by updating the Guidance?

Appendix 2.

The Agricultural and non-Agricultural fuel oil requirements are summarised from the respective Statutory Instruments below. They will be referred to as the SSAFO regs and Oil Storage regs when making comparisons between them.

The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010 (SSAFO regs) Statutory Instrument 693	**The Control of Pollution (Oil Storage) (England) Regulations 2001** (Oil Storage regs) Statutory Instrument 2954
1. The requirements to be satisfied in relation to a fuel oil storage area are as follows.	**3. Requirements for storage of oil – general**
	3.—(1) Oil shall be stored in a container which is of sufficient strength and structural integrity to ensure that it is **unlikely to burst or leak** in its ordinary use.
2. The storage area must be surrounded by a **bund** capable of retaining within the area— (a) if there is only one fuel storage tank within the area and fuel oil is not otherwise stored there, a volume of fuel oil not less than 110 per cent of the capacity of the tank; (b) if there is more than one fuel storage tank within the area and fuel oil is not otherwise stored there, a volume of fuel oil not less than the greater of— (i) 110 per cent of the capacity of the largest tank within the area; or (ii) 25 per cent of the total volume of such oil which could be stored in the tanks within the area (c) if there is no fuel storage tank within the area, a volume of fuel oil not less than 25 per cent of the total of such oil at any time stored within the area;	(2) The container must be situated within a **secondary containment system** which satisfies the following requirements— (a) subject to paragraph (5), it must have a capacity of not less than 110% of the container's storage capacity or, if there is more than one container within the system, of not less than 110% of the largest container's storage capacity or 25% of their aggregate storage capacity, whichever is the greater; (b) it must be positioned, or other steps must be taken, so as to minimise any risk of damage by impact so far as is reasonably practicable; (c) its base and walls must be impermeable to water and oil; (d) its base and walls must not be penetrated by any valve, pipe or other opening which is used for draining the system; and (e) if any fill pipe, or draw off pipe, penetrates its base or any of its walls, the junction of the pipe with the base or walls must be adequately sealed to prevent oil escaping from the system.
(d) in any other case, a volume of fuel oil not less than the greater of—	(3) Any valve, filter, sight gauge, vent pipe or other **equipment ancillary to the container** (other than a fill pipe or draw off pipe or, if the oil has a flashpoint of less than 32 deg C, a pump) must be situated within the secondary containment system.
(i) 110 per cent of the capacity of the fuel storage tank or, as the case may be, of the largest tank within the area;	(4) Where a fill pipe is not within the secondary containment system, a **drip tray** must be used to catch any oil spilled when the container is being filled with oil.
(ii) if there is more than one fuel storage tank within the area, 25 per cent of the total volume of such oil that could be stored in the tanks within the area; or (iii) 25 per cent of the total volume of such oil at any time stored within the area.	(5) Where any **drum** is used for the storage of oil in conjunction with a drip tray as the secondary containment system, it is sufficient if the tray has a capacity of not less than 25% of— (a) the drum's storage capacity; or

3. The **bund** and the **base** of the area must be— (a) impermeable to water and oil; and (b) designed and constructed so that they are of sufficient strength and structural integrity so that with proper maintenance they are likely to remain so for at least 20 years.
4. Every part of any fuel storage tank must be **within the bund**.
5. Any **tap** or **valve** permanently fixed to the fuel storage tank through which fuel oil can be discharged to the open must— (a) also be within the bund; (b) be so arranged as to discharge vertically downwards; and (c) be shut and locked in that position when not in use.
6. If fuel from the tank is delivered through a flexible pipe that is permanently attached to the tank, the pipe must be— (a) fitted with a tap or valve at its end that closes automatically when not in use; and (b) locked in a way that ensures that it is kept within the bund when not in use.
7. No part of the fuel storage area or the bund enclosing it may be **situated within 10 metres** of any inland freshwaters or coastal waters that fuel oil could enter if it were to escape.

(b) if there is more than one drum used at the same time with the tray, the aggregate storage capacity of the drums.
4. Fixed tanks (1) Any fixed tank used for storing oil shall satisfy the following requirements.
(2) Any **sight gauge** must be properly supported and fitted with a valve which must be closed automatically when not in use.
(3) Any **fill pipe**, **draw off pipe** or **overflow pipe** must be positioned, or other steps must be taken, so as to minimise any risk of damage by impact so far as is reasonably practicable and— (a) if above ground, must be properly supported; (b) if underground— (i) must have no mechanical joints, except at a place which is accessible for inspection by removing a hatch or cover; (ii) must be adequately protected from physical damage; (iii) must have adequate facilities for detecting any leaks; (iv) if fitted with a leakage detection device which is used continuously to monitor for leaks, the detection device must be maintained in working order and tested at appropriate intervals to ensure that it works properly; and (v) if not fitted with such a device, must be tested for leaks before it is first used and further tests for leaks must be performed, in the case of pipes which have mechanical joints, at least once in every 5 years and, in other cases, at least once in every 10 years; and (c) if made of materials which are liable to corrosion, must be adequately protected against corrosion.
(4) The tank must be fitted with an **automatic overfill prevention device** if the filling operation is controlled from a place where it is not reasonably practicable to observe the tank and any vent pipe.
(5) Any screw fitting or other **fixed coupling** which is fitted and is in good condition must be used when the tank is being filled with oil.
(6) Where oil from the tank is delivered through a **flexible pipe** which is permanently attached to the container— (a) the pipe must be fitted with a tap or valve at the delivery end which closes automatically when not in use; is fitted with

	an automatic shut off device; (b) the tap or valve must not be capable of being fixed in the open position unless the pipe is fitted with an automatic shut off device; (c) the pipe must be enclosed in a secure cabinet which is locked shut when not in use and is equipped with a drip tray or the pipe must— (i) have a lockable valve where it leaves the container which is locked shut when not in use; and (ii) be kept within the secondary containment system when not in use.
	(7) Any **pump** must be— (a) fitted with a non-return valve in its feed line; (b) positioned, or other steps must be taken, so as to minimise any risk of damage by impact so far as is reasonably practicable; and (c) protected from unauthorised use.
	(8) Any permanent **vent pipe**, **tap** or **valve** through which oil can be discharged from the tank to the open must satisfy the following requirements— (a) it must be situated within the secondary containment system; (b) it must be arranged so as to discharge the oil vertically downwards and be contained within the system; and (c) in the case of a tap or valve, it must be fitted with a lock and locked shut when not in use.
	5. Mobile bowsers (1) Any mobile bowser used for storing oil shall satisfy the following requirements.
	(2) Any **tap** or **valve** permanently fixed to the unit through which oil can be discharged to the open must be fitted with a lock and locked shut when not in use
	(3) Where oil is delivered through a **flexible pipe** which is permanently attached to the unit— (a) the pipe must be fitted with a manually operated pump or with a valve at the delivery end which closes automatically when not in use; (b) the pump or valve must be provided with a lock and locked shut when not in use; (c) the pipe must be fitted with a lockable valve at the end where it leaves the container and must be locked shut when not in use.

Work Package 4. To evaluate advice on slurry storage and land application strategies and the sources of capital available for improving slurry storage capacity

Prepared by

Jonathan Whiteley[1], Charles Bentley[1], Tom Brassington[1], John Elliott and Tony Turner

ADAS Wolverhampton, Pendeford House, Pendeford Business Park, Wolverhampton WV9 5AP

1. EXECUTIVE SUMMARY

A wealth of technical, practical and regulatory guidance (generic, published advisory information) on the storage and utilisation of slurries and manures has been produced over many years, backed up by government supported advice through group events and one- to – one meetings with farmers.

A wide range of interested parties have been, and remain, involved both in the provision of guidance materials and the organisation of activities. These include regulators, government, charitable organisations, industry bodies and associations, commercial suppliers and private sector consultancy organisations, however numbers of technical specialists with appropriate experience and skills are now very limited in number.

Current guidance is available in a variety of formats from a range of sources, though much of the information is becoming dated and is often incomplete, and overlapping from different sources. Though electronic formats are widely used and increasingly favoured as the default approach, not all farmers have effective internet access. Maintaining the availability of printed versions of advisory material is therefore still very important.

Access to more detailed individual advice, which can also be site specific, is currently variable, with Catchment Sensitive Farming the most widely available source, however this only covers the current priority catchments, approximately 45% of England, and within these most support is focused on specific target areas, of around 20%. Outside CSF target areas access to independent advice is more limited, with a range of smaller schemes and only a handful of private sector commercial consultants.

The supply trade can and does provide a useful service, but generally only in relation to their own products, and can be incomplete in extent of advice.

Funding investment in slurry and manure storage facilities can also be challenging. A direct return on investment is often difficult to demonstrate, and the initial decision to fund a project may be difficult to reach, particularly where a number of parties are involved, but there can often be other advantages of storage related to labour scheduling, soil damage through spreading in poor conditions, associated track damage etc.

Access to finance is likely to be limited where businesses are not thriving or have relatively little security. Except for a small number of restricted schemes (notably the Upstream Thinking Project) direct financial aid for investment in slurry and manure storage does not appear to be currently available. The Catchment Sensitive Farming capital grant scheme does not directly fund storage facilities but can support measures to reduce the volumes to be handled, though the sums involved are limited. The scheme is restricted to target areas and is also competitive.

2. BACKGROUND

Much effort and significant investment has been put into the development and provision of information and advice on the storage, handling and application of slurries and manures, and the associated legislation over many years.

Developments since the 1970’s have seen the mechanisms and emphasis move from Government Office booklets and individual advice on grant aided farm waste storage facilities as part of a national programme, to targeted catchment based approaches involving a variety of media and parties where the focus is on environmental protection and utilising the nutrient content of a valuable resource.

Despite this work a recent survey confirmed that only around 90% of farmers with slurry storage were aware of the SSAFO regulations.

With the ending of grant aid for slurry stores in the early 1990’s, the current reduced profitability of livestock farming, and the increased operational and legal requirements for storage, there is concern that access to funding may constrain investment in suitable and sufficient facilities on farm.

This evaluation draws on published information and personal experiences within the industry of past and current delivery projects to identify, where possible, the approach taken and success achieved, and considers the sources and barriers to funding for storage.

3. SOURCES OF INFORMATION (INCLUDING DELIVERY MECHANISMS

3.1 Guidance

There is a large amount of guidance available on environmental regulation and practices. Environmental legislation has been introduced in a piece-meal way over the last 15 years due partly to the need to take account of EU regulation, leaving a system which is now complex to understand, and in places duplicative.

Guidance is available via the following formats:

- Internet
- Leaflets and booklets (hard copy / software format)
- Promotional films / DVDs
- Articles in magazines, journals and the press
- Environment Agency fact sheets and regulatory statements (82% of the EA's environmental guidance is provided in electronic document format while 15% is provided as webpages.
- Environment Agency enquiries desk
- Industry e.g. CIRIA

The Report *Defra Smarter Environmental Regulation Review dated 16 May 2013* recorded that most guidance has been published recently but that some has not been updated for many years.

3.2 Advice

Advice is often specifically adapted and tailored to the recipient and tends to be one-to-one (face to face or over the phone) and maybe followed up in writing. Advice can also be to groups through interest groups, workshops etc

The sources of advice are varied and include

i. Government. Targeted campaigns such as Catchment Sensitive Farming (CSF) and Farm Advisory Service (FAS)
ii. Industry driven Associations, working on behalf of farmers to learn more. British Grassland and MGA
iii. Industry Levy Bodies, working on behalf of farmer members. BPEX, EBLEX, DairyCo
iv. Trade associations. ADBA.
v. Educational establishments. SWARM. An RDPE Initiative from the Rural Business School of Duchy College in Cornwall. Duchy College is a member of the Pennisula Partnership for the Rural Environment (PPRE) which combines the strengths of North Wyke Research, Universities of Plymouth and Exeter and Duchy College.
vi. Private sector consultancies – ADAS, Promar, Land Agents and Farm Business Consultancy firms
vii. Supply trade – Machinery dealers, construction companies and contractors.

3.3 Advice support 'tools'

To supplement, or in place of advisers, farmers can use a variety of advice support tools to calculate the amount of plant nutrients supplied by organic manure applications and supplementary manufactured fertiliser requirement, to meet crop nutrient requirement. These can assist in planning storage capacities and needs.

i. PLANET

PLANET is the electronic version of Defra's Fertiliser Manual (RB209, 8th Edition, 2010) with, in addition to a nutrient planning module, modules for record keeping, NVZ N max calculations, NVZ livestock manure N loading calculations, a manure inventory for calculating quantities of manures produced whilst livestock are housed, a slurry store volume calculator and whole farm nutrient balance calculator.

There is also a report printing facility included for producing the necessary reports to show compliance with the NVZ rules for nitrogen planning, organic manure and manufactured nitrogen fertiliser applications, N max, livestock manure N loading and slurry storage requirement.

PLANET is available free to farmers and advisers on a disc or can be downloaded from the PLANET web site www.planet4farmers.co.uk. PLANET contains average annual rainfall data on an STD code basis which maybe useful for slurry storage volume calculations.

ii. MANNER-*NPK*

MANNER-*NPK* is a computer programme which calculates total and available nitrogen, phosphate and potash from organic manure applications. It uses the standard organic manure analysis figures from RB209 8th Edition but these can be over written with specific analysis results for the manure being spread if these are available. For nitrogen availability it takes account of rainfall between the date of application and end of soil drainage, soil type, method of application and time before incorporation and wind speed at the time of application. It also indicates the financial value use using fertiliser prices which can be edited to those currently applicable.

MANNER-*NPK* is available free to farmers and advisers on a disc or can be downloaded from the PLANET web site www.planet4farmers.co.uk. MANNER-*NPK* is embedded in PLANET to carryout organic manure calculations. MANNER-*NPK* contains average annual rainfall data on a postcode basis which maybe useful for slurry storage volume calculations.

iii. Tried and Tested

The 'Tried & Tested' Nutrient Management Plan is the result of the industry (CSF, AIC, FWAG, LEAF, NFU and CLA) working together to deliver an aid to making nutrient planning and recording simple and practical. Information is available on the Tried & Tested web site www.nutrientmanagement.org also from which farm and field record keeping sheets can be downloaded.

It is promoted on the premise that by using Tried & Tested the user can manage their nutrients efficiently to save money and reduce environmental risks. The plan will also help a farmer meet the latest NVZ regulations in a step-by-step, manageable way.

3.4 Examples of schemes providing Advice

3.4.1 Target Catchment Farm Waste Management Plans

The scheme outline

The Farm Waste Management Campaign was launched in 1992 and ran until 2002 with the aim of persuading farmers to prepare their own farm waste management plans with ADAS assistance using the simple Defra (MAFF) Step-by-Step Guide (referred to as the 'blue booklet').

Each year between 6 and 8 catchments were identified by the Environment Agency across England.

The campaign was actively supported by the NFU and CLA. The objective being to:

- Target livestock farmers in the major catchments where improvements in water quality would be the likely result of better farming practices, and to persuade farmers to prepare their own farm waste management plans.

- To assess how well farmers were able to prepare their own plans (FWMPlan). This was to be achieved by checking calculations and examining 3-5 representative fields on the farm.

- To explain and reinforce the principles of Farm Waste Management Planning and where necessary to assist the farmer in preparing his plan, ensuring that farmers understand the risks in relation to their farm.

- To assess the level of farmer satisfaction with the service provided by ADAS.

The format of the initiative was to hold a launch meeting in the catchment inviting farmers to attend when details of their farm were obtained so a farm map could be produced and a date agreed for a visit. In support there was specially produced video what explained the preparation of a FWMPlan and the benefits.

Number of farms

Exact numbers are unknown but during the life of the campaign it is estimated 5,000 farmers benefited from the initiative. The list of catchments targeted is at Appendix 1.

Project success

Each farmer was required to complete an assessment of how effective they thought the initiative was and from the data available for the more recent years of the campaign:

- approximately 83% had little difficulty in completing the paperwork
- ADAS consultants judged that around 90% of the participating farmer had accepted and understood the principles of a FWMplan.
- Approximately 60% of the farmers indicated they would make changes to their planned manure management as a result of completing the booklet.

The initiative also identified farms where there was judged insufficient slurry storage. In 2001 38 farms out of 549 were assessed that additional storage was required as there was insufficient land available to spread on. It should be noted that 31 of these farmers were pig/poultry.

3.4.2 Catchment Sensitive Farming

<u>The scheme outline</u>

The England Catchment Sensitive Farming Delivery Initiative (ECSFDI) was launched in December 2005 as part of Defras' programme to meet the requirements of the Water Framework Directive (WFD). In 2010 the project had a name change to Catchment Sensitive Farming (CSF) under the Farm Advice, and Training Information (FATI) framework. It is delivered in partnership by Natural England (NE) and the Environment Agency (EA), funded by European and State monies.

At the start of the project 40 priority catchments in England (Wales has a similar project) were identified that had surface waters at risk of diffuse water pollution from agriculture (dwpa). This number has since increased to 79 priority catchments which include partnership catchments. See appendix 2 for a map of the priority catchment locations.

An appraisal for each catchment identified the sources of dwpa and their location. From this priority sub-catchments were targeted. Each catchment has a Catchment Sensitive Farming Officer (CSFO) who provides advice, or coordinates the provision of free advice on topics pertinent to the dwpa problems in the catchment. The target audience is farmers or land managers. Advice can be through the means of:

- one to one farm visit,
- clinics,
- workshops,
- farm walks and
- demonstrations.

The programme has also offered an annual grant scheme for predetermined priority items of 50% of the value up to a maximum of £10,000 per year per business unit.

CSF is managed within the FATI framework, with a number of approved consultancy firms to deliver the advice. Quality of delivery is key to ensure the farmer is receiving accurate information; a number of the farm visits, events and farmer reports are quality assurance checked to ensure an accurate message is being delivered by the consultants.

Having identified what and where the issues are in the catchment, the CSFO identifies the most appropriate type of advice to address the dwpa problem. This work is released through the framework as a competitive mini tender. The tenders are often a mixture of farm visits and events on a number of topics. Farm Infrastructure Audits and Slurry/manure handling are two popular topics both as farm visits and as events.

<u>Number of farms</u>

Due to how the EA record and analyse the national CSF data, it is not possible to state how many farm visits and events relevant to slurry storage and management have been delivered. The data is captured in terms of the types of recommendations made. An example of this is shown on the next page; the information for all regions is in appendix 3. Current problems with the data mean the uptake of the recommendations specific to this advice are not available.

Table 1: CSF – Number of Infrastructure and Manure Management recommendations made in the Anglian region 2006 - 2012

Region	Year	Measure Type	Number of times relevant practice recommended during one:one visit	Number of times relevant practice recommended during group event
Anglian	2006	Farm Infrastructure	6	
Anglian	2007	Farm infrastructure		195
Anglian	2007	Manure Management	635	1022
Anglian	2008	Farm Infrastructure	205	
Anglian	2008	Manure Management	856	147
Anglian	2009	Farm Infrastructure	140	668
Anglian	2009	Manure Management	646	2960
Anglian	2010	Farm Infrastructure	273	78
Anglian	2010	Manure Management	887	1200
Anglian	2011	Farm Infrastructure	169	103
Anglian	2011	Manure Management	208	83
Anglian	2012	Farm Infrastructure	295	685
Anglian	2012	Manure Management	146	363

ADAS is one of the key FATI deliverers and has delivered over 1,200 infrastructure visits and 45 events alongside 144 slurry and manure handling visits and 30 slurry events. In addition over 350 slurry/manure samples have been taken, analysed and advice given. The data for 2010 to present is illustrated in appendix 4 that shows the geographic spread of the advice ADAS has given. The majority of this infrastructure and slurry advice was given in the South West, which is linked to the high proportion of livestock units in this region.

<u>Project success</u>

Feedback is sought after each farmer engagement with CSF and a record kept of recommendations made on farm visits. A number of the visits are followed up to see what percentage of recommendations have been implemented.

- CSF has delivered to 13,000 holdings covering an area of 1.94 million hectares in the first 6 years;
- In the first six years of CSF a total of 218,596 recommendations were made;
- 57% have implemented over 62% of the recommendations they were advised on.
- The evaluation of CSF after 6 years does show that the project is successfully changing the behaviours and practices of farmers with monitored pollution incidents having dropped by up to 30%.

3.4.2.1 The South West Slurry Initiative – SW 051

As part of a wider project (which included a programme of four specialist slurry storage meetings across the South West through FAS) a number of hybrid farm training / advice visits were undertaken during winter 2012 – 2013. Though procured and managed by Natural England through CSF, the project aimed to undertake around 50 initial infrastructure visits across the South West targeted at farmers in existing and newly designated NVZs.

Where achieving NVZ compliance appeared to require significant investment or fundamental changes to the business the initial advice was then to be supported by up to 3 days of business management training / advice, reviewing the options and implications for the business. It was envisaged that up to 15 farms would receive the full package. Candidate farms were to be nominated by RPA, the EA, the NFU and through CSF.

The timescale for delivery was limited and for various reasons very few farms were nominated. The project ultimately delivered approximately 15 initial visits with five receiving business management support. The programme provided valuable support to recipient farmers who found themselves in very difficult circumstances, however the mechanism for identifying suitable candidates was flawed and the timescale challenging. A review of the project was subsequently undertaken which identified the value of the combination of engineering and business management advice and the potential to make the approach more widely available, possibly through CSF, but noting the limitations of the catchment based approach in reaching other farmers facing difficulties outside target catchments.

3.4.3 Farming and Forestry Improvement Scheme (FFIS)

The scheme outline

FFIS is a programme of financial support, with the RDPE, aimed at helping farmers, foresters, farming contractors, woodland owners and horticultural businesses in England to **improve competitiveness** through investment that meets one or more of the following objectives:

- Improve animal health and welfare
- Reduce energy usage
- Improve the management of manures/farm nutrients
- Improve soil quality
- Improve water resource management
- Improve use of forestry resources

This national fund is for projects that improve competitiveness and take a farms' performance above normal farm practice. It cannot be used to help comply with statutory regulations. Grants can only be applied for if recommended as a priority in the relevant plan(s) carried out by an adviser or vet. A single application can contain recommendations from one, two or all three technical plans / audits.

3.4.4 Resource Efficiency 4 Farmers (R4F)

The scheme outline

The R4F project works with farmers and landowners to improve their management and use of energy, water, and inorganic wastes.

From 31st May 2013 the Rural IDB Support Service delivered by Peninsula Enterprise in Somerset, Devon and Cornwall & the Isles of Scilly will no longer be available. The R4F will continue to be delivered under the Rural Focus brand. The initiative does not support slurry storage directly but through improvements to water usage then there would probably be a reduction 'waste' water being produced which would otherwise have to be stored or, at least, managed in some form.

The R4F capital grant scheme has been superseded by the FFIS scheme – see above.

Number of farms

Approximately 50% of the applications for grant are believed to have been made in the South West Region out of a total number applications across the country of 10,000.

Project success

This is being reviewed on a regional basis and no data is currently available.

3.4.5 Soils 4 Profit (S4P)

The scheme outline

S4P was launched in October 2009. It is part of the South West Agricultural Resource Management (SWARM) initiative which is an RDPE funded project aimed at helping farmers to use and manage their resource better. Any farmer based in the South West with over 5 hectares of land is eligible for the free advice. It runs on a similar principle to CSF in that farmers are offered free farm visits and attendance at events to discuss soil, nutrient and manure management. The main difference being that it is not catchment driven, but it is purely a South West regional initiative.

Number of farms

Consultants have run a total of 248 events and conducted 2,307 farm visits, 443 of which had follow up visits to evaluate how effective the advice was. The location of the advice is shown in maps at Appendices 5 and 6. This illustrates to total coverage of the S4P project, not just slurry storage and management.

Project success

The type of advice delivered pertinent to slurry storage and land application is tabled below.

Table 2: S4P – Type of advice

	Total times recommended in initial 1:1 visits up to 31 May 2013	No of follow up visits completed where originally recommended	No of times imple mente d	% of recommendations implemented
Use of Slurry Separator	151	46	12	26%
Using a Nitrogen Testing Kit	906	215	18	8%
Install a Slurry Store Cover	237	73	5	6%
Use of low level slurry applicators	664	167	37	22%
Use Shallow Injection	256	76	17	22%
Use Weigh Load Cells	485	74	10	13%
Write Manure Management Plan	742	169	123	72%
Roofing uncovered Yards / Manure Heaps	358	71	28	39%
Increase Slurry Storage/ Improve timeliness of applications	719	161	78	48%
Incorporate manures as quickly as possible	243	46	27	58%

The greatest uptake of advice is in writing a manure management plan with the least implemented piece of advice being to install a slurry cover. The cost associated with this activity could account for this. In order to be eligible for grant aid measures have to be recommended within an S4P report. In order to be eligible for grant aid measures have to be recommended within an S4P report.

3.4.6 Farming Advice Service (FAS)

The scheme outline

The FAS is a national project run by Ricardo AEA for Defra. The project aims to deliver advice through a telephone helpline, meetings, newsletters, text message updates, e-mail bulletins and a web site. .

FAS provides advice on the following subjects:

- Cross Compliance
- Nutrient Management
- Competitiveness
- Climate Change Adaptation and Mitigation

The project delivery structure consists of a technical support panel and a management group, working with regional co-ordinators through a team of accredited advisors across the country. Within a national framework drawn up in consultation with the national stakeholder group, the regional co-ordinators create an annual plan for the geographical area in which they work, and detailing the type of farming, land and issues of importance.

A proportion of meetings will have been proposed and delivered by the Regional Coordinators themselves, others will be delivered by local specialists. A significant proportion of events are delivered through third parties, where an FAS speaker appears on the platform at events organised by industry bodies, associations, farmer groups or other projects such as CSF or Rivers Trusts. Farmers can sign up for the newsletter where they can obtain information on key subjects such as new or changes to legislation, target dates such as SFP application dates and Capital Grant closing date for entries. It also has articles such as increasing organic matter etc. They can also call the helpline and access any one of the specialist advisors under the FAS. On-farm visits are not funded and so activities such as design work/capacity are not covered by FAS.

Project success

It is understood that overall the project is achieving its milestones with over 8,000 farmers, land managers and advisers attending FAS events in 2012. Cross Compliance was the most common topic of advice provided by FAS (45% of all event topics), closely followed by nutrient management (33% of all event topics). Within the nutrient management theme, the frequency of topics is as below:

Table 3: FAS delivery themes

Nutrient Management	
Soil Management and Protection	159
Soil analysis	63
Nutrient management planning	128
Fertiliser application	142
Crop nutrition	120
Manure and slurry storage	122

3.4.7 Utility Company initiatives on target catchments

3.4.7.1 SWW - Upstream Thinking (SWW)

The scheme outline

The Upstream Thinking project delivered by Westcountry Rivers Trust (WRT), funded by South West Water, aims to improve raw water quality through a collaborative approach which sees landowners informed and assisted in the protection of river catchments as part of an integrated approach to good land management. The focus being on the Tamar, Tamar Lakes Lakes, The Caudworthy, Tamar TDC, Exmoor (Wimbleball reservoir) and Roadford reservoir and included other areas in the SWW region.

Tailored one to one advice and farm plans are supported by a capital grant scheme. Grant aid was offered on anything that would improve surface water raw water within the identified catchments from fencing to complete new infrastructure and slurry storage, including separators, slurry stores, lagoons and associated equipment.

Minimum grant was under £5k and maximum £150,000 with a rate of between 50% to 75%. It is understood but not confirmed that on the legal side, the SWW grant evolved during the 3 year period from a 2 page WRT document based on a previous WRT project into a 30 page document with a 25 year deed of covenant attached for capital works above £10,000 per farm, this then had to be registered with the relevant land registry. As a result dealing with landlords, solicitors and bank managers had its challenges as all of the grant funding, was paid to the farmer on completion. The farmer therefore had to find the whole cost of the investment from the outset – all of this was made clear through the procedures that were put in place by the delivery team early on.

Number of farms

Targeting of the 400 farmers visited or contacted via meeting and events, word of mouth, website etc – 200 had WRT farm reports commissioned and out of those if the money was available all 200 would have taken up the grant offer. Initially eligibility was on the basis of first come first served and not as later on when it was assessed on requirement and risk.

Project success

Due to CSF being a constant player in the Tamar area farmers did not have the money for both streams even though WRT could match fund so they could take advantage of both. UST was a bit more of a sell easier to do in other areas outside of the Tamar.

Uptake of grant has exceeded expectations and as a result SWW are seeking further funding for 2014.

3.4.7.2 Wessex- WagriCo

The aim of WagriCo (**W**ater Resources Management in **Co**operation with **Agri**culture) was to demonstrate in pilot areas how current agricultural practices can be used to achieve the environmental objectives for ground water of the Water Framework Directive (WFD). This was an EU partnership project between the UK and German authorities. Wessex Water Services Ltd were one of five UK partners, along with ADAS UK Ltd, NFU, EA and UK Water Industry Research Ltd (UKWIR).

The project started in 2005 and was based in the river catchment of Frome, Piddle and Wey in Dorset. Wessex Water nominated a catchment officer to work with the agricultural industry with the backing of technical specialist to make improvements to farm practices across a range of activity ranging from slurry application techniques and timing to effective water conservation measures. The project demonstrated the effective dovetailing of national planning, regional action and local implementation is possible.

3.4.7.3 Yorkshire Water

The scheme outline

Yorkshire Water are major landowners and have several small to medium tenanted farms in their water catchment areas. They wanted to undertake improvements to the slurry storage to improve point source pollution and in turn reduce diffuse pollution through better timing of slurry spreading. The work was carried out as part of AMP5 and Yorkshire Water funded the improvements as a Landlord.

Number of farms

A total of 25 farms were audited with priority given to dairy farms to evaluate what additional slurry storage was required.

Project success

Yorkshire Water then undertook an investment programme to upgrade storage on a number of farms although the scope of the work was limited by the funding available. They have concentrated on the dairy farms where slurry storage was limited. It is understood that the audit of farms has indentified a back log of work on the estate much of which will have to be funded under AMP6.

3.4.7.4 United Utilities

The scheme outline

The SCamP (Sustainable Catchment Management Programme) is a partnership of Natural England, RSPB, Forestry Commission and EA with the support of the Peak district and Lake District national Parks. The programme is funded under AMP4 and AMP5 investment programmes.

Number of farms

The project covers 45 land holdings, 21 farms and 13,000 hectares designated at SSSI. A range of work is included from restoring peat bogs, providing new farm buildings for indoor wintering of livestock and for lambing to providing new waste management facilities to reduce run-off pollution of watercourses.

Project success

A total of 9 new stock buildings have been constructed although it is understood that all farms are solid manure based with no slurry and therefore there is no record of any waste management facilities being improved.

3.4.8 Regulatory (Environment Agency) promotions

An example of the type of 'regulatory' promotions is how the Devon & Cornwall area of the South West Region have operated.

Recent promotion themes have covered the following:

- Getting farmers up to speed on NVZ rules
- Slurry storage can be linked to bathing water failures
- Promoting the benefits of storage although not exclusively SSAFO make the point that SSAFO regulates storage
- Contacting all Local Planning Authorities to offer training at their team meetings on SSAFO regs so the planning officers have a better understanding of SSAFO. [It is understood uptake of this has been limited].

The mechanism for engagements that have been adopted:

- SWARM. Using the web site for articles e.g. a joint article with local planners and the link between SSAFO and planning requirements
- Extracting all the supplier advertisers for slurry equipment and storage facilities in the magazine South West Farmer and approaching them to make sure they understood the requirements of SSAFO
- Maintaining a database of all advisers and undertaking supplementary training. Numerous PowerPoint presentations are available

3.4.9 Regional Rural Development Agency (RDA) initiatives

The scheme outline

In the South West Region the two projects that featured are S4P and R4F. Both of these initiatives have been described in more detail earlier in the report.

Because the RDAs have been disbanded the relevant websites are no longer active or up to date and therefore there is little or no information available about initiatives relating to slurry storage or land application strategies.

3.5 Advice take-up and market penetration

Market penetration of CSF has made contact with 13,000 holdings in the catchment target areas.

The success of S4P is documented in the maps at Appendices 5 and 6. These maps show all types of the advice delivered, not just those pertinent to slurry storage and management.

4. MAPPING OF INFORMATION PROVISION

How to get hold of and take any notice: why take the advice up.

4.1 Guidance

The Defra document Smarter Environmental Regulation Review lists five types of guidance document that have been identified by research into the current stock of environmental guidance including SSAFO and related land spreading activities.

1. Regulatory guidance– setting out what legal obligations exist. This includes statutory guidance and statutory codes of practice;
2. Good practice – presenting possible activities and processes to comply with the law in the most effective way, as well as voluntary options (which may go beyond legal requirements) and other effective ways of behaving in an environmentally responsible manner;
3. Informative guidance – providing additional information such as cost-benefit studies, position papers, information on specific environmental issues;
4. Supplementary guidance – providing further evidence which supports and/or relates to other pieces of guidance, such as an annex or technical document; and
5. Funding scheme requirements – related to a particular funding scheme and detailing what a business must do to qualify/comply, etc.

Guidance is provided through a variety of mechanisms - from active and direct (text message alerts / reminders) to film and more passive means such as published documents, fact sheets, web pages and booklets. The majority of the five types of guidance listed above are made available in various different formats, and by many of the advisory bodies and schemes previously described. Inevitably there is overlap and some duplication, however this is often intentional – providing rapid on line access to codes of practice as well as producing hard copy for ease of reference and for those with limited internet access or skills.

The boundary between guidance (generic) and advice (specific) can be rather indistinct, and probably lies at the level of farmer meetings / farm walks and workshops, with a blend of generic and specific advice provided face to face often by a specialist deliverer.

Events of this kind are commonly organised by Industry bodies and associations, farmer groups, projects / schemes, and occasionally by suppliers, buyers or manufacturers for their customers and farmer suppliers. Examples would range from British Grassland Society local meetings through to trade events such as Grassland and Muck (RASE) and CSF meetings.

4.2 Advice

Advice is normally delivered face to face by either a specialist advisor working through a project / scheme or commercially on behalf of the farmer, or through other interested parties such as machinery dealers or contractors. The key difference between these mechanisms is that the specialist advisor will generally be independent and the advice will be provided formally with a written record, whilst the information imparted by suppliers representatives will generally be informal and is likely to be related to a specific issue, and could have a commercial influence.

5. DIVERS AND BARRIERS TO ADVICE UPTAKE

5.1 Drivers

i. Regulatory pressures

Direct regulatory pressure is likely to be a significant driver in the search for and uptake of advice, but for a relatively small number of individuals. A significant proportion of slurry handling / farm infrastructure advisory visits under various current and historic programmes have been delivered in response to requests from farmers generated by direct contact with the EA. These may be either as a result of incidents, campaign visits or catchment walkovers. Indirect referrals may also arise through CSF catchment officers.

ii. Compliance – Cross compliance

NVZ action programme measures fall within the scope of Cross Compliance. Avoiding breaches of cross compliance is always at the back of farmer’s minds, however many consider failure leading to non compliance to be an acceptable risk given the complexity of the scheme and the level of detail involved, and will be prepared to accept the relatively low financial impact of non compliance.

iii Food supply chain / food retailers

The quality assurance standards of major multiple retailers have a very significant influence on farmers and growers. Where cross compliance is within a contractual food supply obligation, changes to farming practice will be made to ensure that their obligations are discharged.

iv. Environmental protection

Though most farmers would prefer to minimise their impact on the environment, environmental protection is thought to be a driver only where there is either a particular environmental interest (e.g. fishing) or a particular problem weighing on the farmer's conscience.

v. Resource optimisation / efficiency

The nutrient value of livestock slurries and manures is measurable and quantifiable but is still generally under recognised. Anecdotally the rise in fertiliser prices generated greater interest in nutrient planning and slurry storage / application advice. Increased awareness of these issues has continued to maintain the popularity of the topic, though the true economics may no longer be as attractive as in the recent past.

Resource efficiency is likely to be a driver with some larger producers, especially those who are involved with major multiples where supply chain carbon footprints are of concern. Though there may be substantial opportunities to improve resource efficiency on smaller and older units, the level of investment in time, planning and capital required to effect changes, often means that resource efficiency opportunities have a lower profile than they probably deserve.

5.2 Barriers

i. Confidentiality

Confidentiality is crucial in the uptake of advice. The costs of implementation of advice may well be very substantial. The consequences of a lack of confidentiality could ultimately be closure of the business. Though the farmer may well choose to make the details of advice available to the regulator, it is essential that this is a matter of choice.

Suspicion over the motives of the advisor is a common starting point on initial contact during campaign activity, and even where the farmer has sought advice directly. This can be a significant barrier to the uptake of advice.

ii. Confidence

Farmers need to have confidence that the advice they receive is accurate, commercially sound, confidential, and if it isn't impartial, to know the authenticity of the consultant advisor.

The commercial interests of equipment suppliers can limit the objective of on their initial advice. Commercial suppliers will prefer to sell their own product, or products with the most margin, which may not be the most economic solution, nor meet regulatory requirements. A supplier of steel stores is likely to provide the details required, in relation to their own products, however the same supplier is unlikely to be an authoritative source of advice on earth banked lagoon construction.

iii. Time availability

Opportunity to identify and obtain guidance information, and to access advice, is frequently limited by farmer's workload, particularly on smaller units where the principal of the business undertakes the majority of hands–on work. The clearest example of this is on dairy farms where the need to milk morning and evening severely limits the operator's opportunity to attend meetings and can restrict the receipt of one to one advice to sessions between 11 am and 2pm.

iv. Accessibility

The drive is to make system internet based. However, wide tracts of the rural countryside are missing out on the Government's drive to increase Broadband speeds and some areas remain unconnected or if connected have to rely on dial-up or very slow Broadband speeds with little prospect of improvement.

Consequently, any initiative to roll out guidance via the internet would be severely limited in uptake in areas where the internet is not available or download ability is slow.

Web based information would make information available to those willing to search and look, but would not bring site specific advise and correct interpretation to individual farm enterprises. This could be enhanced with an interactive process on the site, but wouldn't replace on the ground advice.

vi Financial

The financial cost of any investment must be evaluated and justified in a business case. The financial cost of investment in infrastructure can be balanced against the returns on the investment, and this may be negative in some cases. However in some businesses, other drivers may override this barrier as described earlier.

6. PROVISIONS OF THE ADVICE (COST MODEL)

6.1 Market failure and advice provision

Where market forces either fail to deliver or cause significant damage, the government may design an appropriate mix of policy tools to influence outcomes.

The occurrence of market failure alone does not automatically imply or justify government intervention. Sometimes markets devise their own solutions to market failure problems over time, in which case intervention is not needed. In other cases, the scale or nature of the problem may not warrant intervention; or the costs of government intervention may not justify the benefits.

The source of market failure that is most relevant to agricultural regulation is externalities where the full costs and benefits of food production are not reflected in market prices, for example water pollution. The primary approach is to regulate to address these externalities with the cost of related investment being internalised to production costs and ultimately reflected in market prices. However, given the context for farm advice in the previous chapter, it is widely accepted that there is a market failure in terms of information. As such there is a case for public provision of advice to ensure compliance.

The focus for such advice is generally to change behaviour. The UK Sustainable Development Strategy model of behaviour change (HMSO 2005) shows how these policy instruments can be used to address internal and external barriers to farmers taking action (Figure 1).

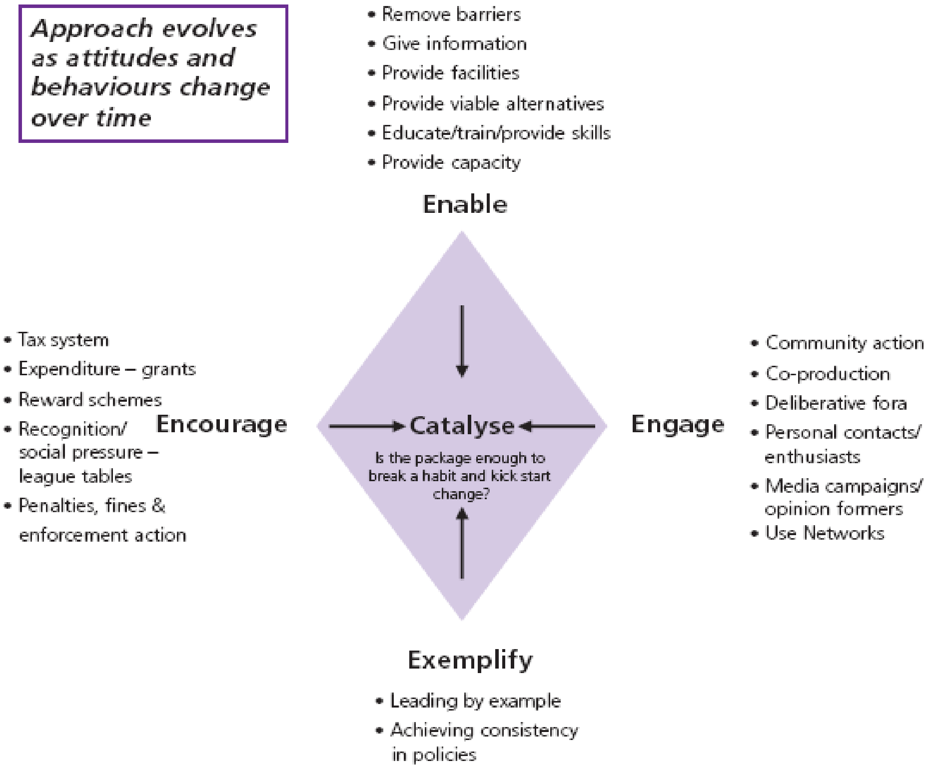


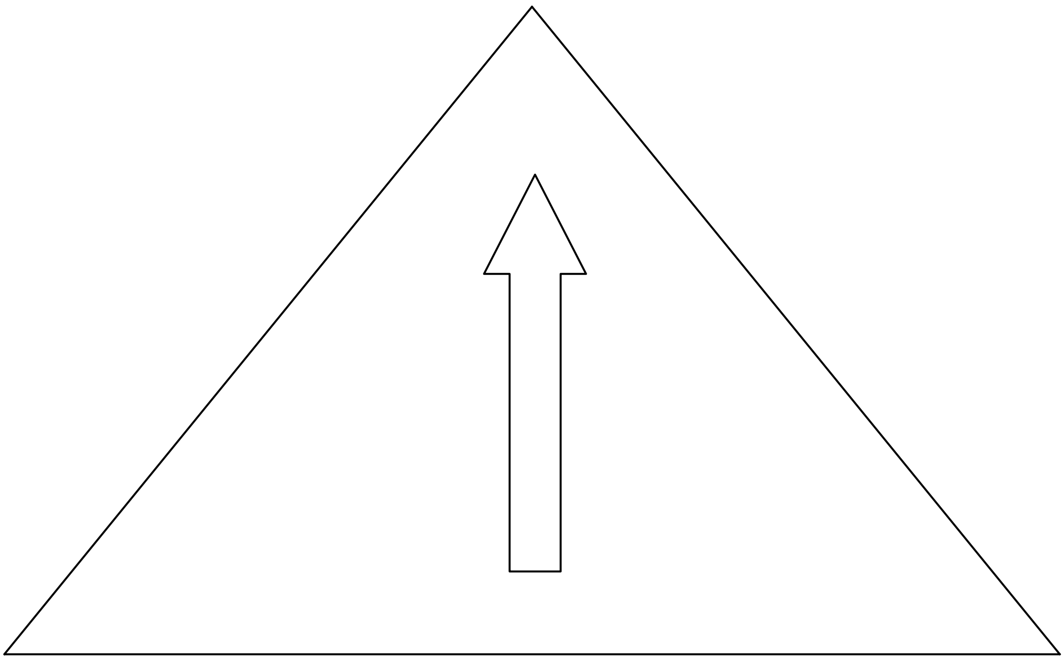
Figure 1: UK Sustainable Development Strategy model of behaviour change (HMSO 2005)

6.2 Advice Delivery Mechanism

There are a number of models for advice provision but these commonly include a range of one-to-many advice or demonstration seminars or workshops as well as some provision for one-to-one support, in view of the need for advice to be context-specific and the heterogeneity between farms.

The general approach can be summarised be the pyramid model :

Specific One-to-One Advice
Technically focused



Guidance Available to All

As the farmer or recipient of the advice moves up from the general guidance for all they move through Group events where topic specific advice is available to a Group. The focus is the One-to-One advice which tailors to the technical needs of the individual.

For provision of advice on slurry storage and land application strategies, there are several examples of the advice delivery mechanisms.

Guidance Available to all
This would be the full range accessible via the internet, leaflets, articles, promotional DVDs etc. The enquirer could ascertain a wide spectrum of information about a topical subject from guidance, sources of advice, regulation etc.

Group Activity
Events run by CSF, S4P, FAS etc coupled with meetings held by specific organisations such as NFU. More focused on selected topical or technical areas.

One-to-One
A focused block of advice for a farmer probably on a specific technical issue. Usually followed up by written confirmation of the advice as this will form part of the decision making process.

There are other products that companies have produced which provide a service to help the farmer towards the top of the triangle.

Continuity has been recognised as a strong driver on the uptake of advice, showing greatest success in areas where programmes have developed and continued over a number of years. A programme of initial visits followed up by a series of visits will develop on this theme.

As the advice delivery model approaches the top of the triangle and becomes more focused on an individual then this could be phased and a targeted approach adopted providing the level of advice and detail appropriate to farmers needs. The possible route could be:

- **First stage**. A review of current systems & slurry storage (capacity and compliance with regs / practices with respect to minimising diffuse pollution) – in other words a mini CSF type Farm Infrastructure Audit / cropping & stocking / nutrient needs and plans.

  This could be delivered by a suitable specialist adviser with appropriate experience and qualifications. Slurry storage and subsequent management can be complicated because of how the farming practice has evolved and it maybe a specialist engineer is required at the very outset.

- **Second stage**. Soil sampling and detailed NMP leading to overall slurry application strategy.

  This could be delivered by a more general adviser or more specialist input on soils and NMP. This stage could stop at this point if the farmer has adequate storage and systems and comply with regs etc). If not go on to:

- **Third stage**. Detailed advice on design / construction of new or improved facilities, costings & partial budgets of full business plan as required.

  This stage needs to be delivered by an agricultural engineer, building specialist with input from a Business Management adviser.

The Cost model would be based on the time input required from consultants and the size and complexity of the business e.g. a farmer having several units; large herds; complicated cropping etc).

6.3 Incentivisation and support

Given the very high influence that the food supply chains and retailers have on the farming industry in supply contracts, food retailers, manufacturers and processors could be involved to a much greater extent to incentivise farmers in the uptake of advise.

For example the milk and milk product suppliers could have a much greater influence on the dairy farming industry with benefits of improved consumer confidence in source of raw products. Some food manufacturers are committed to sustainability and expect their food suppliers to follow similar visions, and in some cases require it in supply contracts.

6.4 Regulatory

In Scotland, the regulatory enforcement of voluntary initiatives such as the Codes of Good Agricultural practice has increased the farmer uptake of advice. The programme has been endorsed by the industry themselves through membership bodies such as the NFU.

7. REGIONAL FACTORS THAT AFFECT IMPLIMENTATION OF ADVICE

There is a wide range of reasons and factors that can influence the implementation of advice and the following is largely based on the opinions of ADAS advisers working on agriculturally related projects.

7.1 Regulatory focus (EA)

The approach adopted by the EA varies across the country, with different priorities in each region, dependant on

- Priorities of the region
- Competition for regulation between industry sector
- Staff skills
- Staff time

7.2 Continuity

Uptake of advice is much greater where there is an established initiative operating that farmers know and are familiar with, and where continuity of staff has maintained contact between the initiatives and the farmers.

7.3 Farming type

There is a natural focus on farming type by region. For example:

- Outdoor pigs on light soils in East Anglia
- Chicken production in West Midlands
- Intensive pigs in East Midlands
- Dairy in South West Region

7.4 Catchment water quality/NVZ designation

Where water companies have water quality issues arising from a catchment then they will be actively involved or supporting advisory campaigns. These tend to be very regional and specific.

7.5 Soil and geology

The variation of soils and geology will impact on the type of slurry storage that can be feasibly constructed. For example, the suitability of earth banked structures in non clay soil areas, and underlying permeable geology. The timing and access to land for land spreading will also impact on storage type and capacity.

7.6 Specialist advisor availability

This can vary between over supply in central areas to under supply in furthest corners of the country.

7.7 Local supplier focus

Where there is a local promotion of a particular storage type then this may override lower cost alternatives e.g. above ground steel tanks on clay soils.

8. FUNDING FOR SLURRY STORAGE/HANDLING

8.1 Funding sources

Currently there are a number of funding sources available to farmers to enable them develop/maintain /improve slurry storage facilities. These fall into two main categories Private and Public.

8.1.1 Private Funding

This can come from a number of sources which will have different lending criteria.

I Farmers own capital

Capital reserves from farmers' current accounts which are in credit and/or reserves kept elsewhere e.g. investments, building societies.

Ii Bank lending

Farmers can access capital through borrowing from commercial lenders sources via increasing existing overdraft facilities and/or term loans. The main providers for the sector are the main high street Banks – in particular Lloyds/TSB, Nat West, Barclays, HSBC, Yorkshire, Santander and/or the Agricultural Mortgage Corporation (AMC)[1]. To obtain additional capital, businesses will need to meet a number of criteria relating to the business assets, level of debt, ability to service debt, record of profitability (from trading accounts) and confidence in the owner/manager's ability to manage the business and its finances.

One of the overriding issues here is that generally investment in facilities and equipment such as slurry stores has a negative impact on cashflow (whether as a one off spend or in terms of loan repayments) but no tangible benefit in terms of returns. As such the business case relies on farm revenue being sufficient to cover these additional cash needs while continuing to meet other investment needs, private drawings etc. Lenders find it easier to support opportunities which provide a commercial return or help secure the viability of the business through expansion or strengthening the asset base.

As such, much depends on the baseline strength and performance of the business as defined by its balance sheet, trading performance and track record in terms of loan repayment, staying within overdraft limits etc. The strength of the personal relationship between the bank's agricultural manager and the farmer is also important. Below, farm businesses are categorised into three groups – strong, weak and intermediate – and issues relating to access to capital discussed.

[1] AMC is a member of the Lloyds Banking Group

(a) Strong businesses

If the business is viable and secure, then the bank are likely to be prepared to support the proposal even if the cost benefit is negative – i.e. they accept that in some instances, the return for the investment in some Infrastructure investments e.g. roofing over yards is unlikely to produce a positive return but the business can carry the extra costs and still have an acceptable surplus. The customer has to undertake the improvements to continue in that area of business.

(b) Weak businesses

With clients where there is already a problem with servicing debt or business profitability not meeting drawings etc , the answer will be a clear no. Where the bank are concerned about a business, they do not feel that a premium (2-5%) on the overdraft, actually covers the extra risk and so would prefer not to be involved with these type of businesses. Arguments about allowing the farmer to continue trading etc will not be taken in to account.

(c) Intermediate businesses

The difficult cases are the businesses that are neither secure/strong, nor weak/failing but somewhere in between. Clearly owner occupiers represent a lower risk as the bank can always cover much or all of the debt though securing the land and property assets. These businesses are therefore looked on more favourable but the ability of the business to repay the loan costs on a monthly basis is their key priority as banks do not like to repossess farms.

For tenants, the first avenue with fixed equipment is to ask the tenant to approach their landlord to fund the capital infrastructure (and thus use their borrowing capacity related to the asset value of the land) and the tenants to then pay for the improvements via a higher rent.

Where the expenditure is on machinery e.g. slurry separators, slurry injection machines this is more problematic for a number of high street lenders who no longer operate a HP finance operation. Also, the high street banks were behind brands such as NFU finance ING Spectrum. The banks are likely to push the farmer in the direction of specialist HP providers that generally charge significant rates (5-10%) .

In summary, the banks are prepared to lend to strong businesses even if the infrastructure investment is unlikely to help increase profit, and for those in the middle with equity to back scheme up but for weaker businesses with poor cashflow/equity, there is virtually no likelihood that the banks will lend to fund such investments. Banks are mainly interested in funding buildings, livestock etc not machinery, e.g. injection machines unless they have a Hire Purchase arm or they are funded on the overdraft

Iii External private funding

Investment from landlords

Where the landowner is an institution such as water companies or county councils, investment in infrastructure such as slurry stores may or may not lead to increase in rents paid and funding % will vary considerably. This is much less common with private landlords who generally offload the responsibility to the tenant.

For example, Staffordshire County council has spent £350,000 in the last 2 years on 30-40 farms in their portfolio to bring slurry stores up to current regulations – they have fully funded the whole investment and have seen no return at all. All of the investments have been in earth banked stores as they are the cheapest way of complying with regulations. They see this as a necessary investment to meet regulations without improving the viability of businesses.

Grant aid from water companies
Initiatives such as South West Water's 'Upstream Thinking' where farmers bid for funding and then have to sign a Contact and deed of Covenant with the Water Company. This means that the farmers have to abide by the agreed terms to keep the grant. Yorkshire Water has been through a process of upgrading farm Infrastructure including the provision of both slurry stores and covered FYM stores because they have a number of dairy holdings.

Asset Financing

These are short term loans generally to purchase equipment. The asset may not be owned until the last payment is made and interest rates can vary from 5 to 40% per annum. These can be via HP agreements supplied by – Lombard, Lloyds TSB, Oracle, etc or short-term loans such as Nationwide corporate finance Ltd

All of the above have no restrictions on where the farm is located except for the grant aid from the water companies which only apply to parts of the area they work in.

8.1.2 Public funding

(i) Catchment sensitive farming

Grant is available under Axis 2 of the current Rural Development Programme for England (RDPE), 'Improving the environment and the countryside' and is delivered by Natural England and the Forestry Commission.

The Capital Grant Scheme is available in 79 priority catchments and is targeted at holdings within specific areas of these catchments. The 2013/14 scheme has now closed for new applications. It is a competitive scheme that is available each year with a maximum grant of £10,000 per business and the grant rate is up to 50%. Therefore to get the maximum funding the business must spent at least £20,000 it must also sign a declaration that the business is viable. To be viable the business must make a profit before depreciation that is sufficient to meet cash needs such as personal drawings, tax, capital reinvested and capital repayments.

In Wales up until December 2011 Grants for slurry storage were available under The Catchment Sensitive Farming (CSF) Nitrate Vunerable Zones (NVZ) Capital Grant Scheme . All claims for capital works must be finalised, prior to the Nitrate Pollution Prevention (Wales) Regulations (2008) coming fully into force the following day.

The Scheme, which provided grant aid for capital works which reduce pollution risks from slurry storage and run-off, such as new or enlarged slurry lagoons and roofs over manure stores. A grant of up to £30,000 (£37,500 if a young farmer) was available within the terms and conditions of the Scheme.

(ii) Farming and Forestry improvement Scheme (FFIS)

Funding is under Axis 1 and 3 of the Rural Development Programme for England (RDPE)

Axis 1 – improving the competitiveness of the agriculture and forestry sector
Axis 3 - Quality of life in rural areas and the diversification of the rural economy

FFIS is aimed at helping farmers, foresters, farming contractors, woodland owners and horticultural businesses in England to 'improve competitiveness' through investment that meets one or more of the following objectives:

- Improve animal health and welfare
- Reduce energy usage
- Improve the management of manures/farm nutrients
- Improve soil quality
- Improve water resource management
- Improve use of forestry resources

This national fund is for projects that improve competitiveness and take a farm's performance above normal farm practice. It cannot be used to help comply with statutory regulations. Grants can only be applied for if recommended as a priority in the relevant plan(s) carried out by an adviser or vet. A single application can contain recommendations from one, two or all three technical plans / audits.

Funds will be allocated between now and December 2013. Grants will cover a maximum of 50% of the total cost of projects in uplands areas (SDA's) and at most 40% of the total cost of projects in non uplands areas.

Under the Farming and Forestry Improvement Scheme, all farmers, foresters, contractors and horticulturalists in England are invited to apply for grants of between £2,500 (the minimum for any single application) and £25,000 (the maximum allowable for each farm business). Applicants will be assessed on their ability to meet one or more of six objectives listed above. Access to the scheme for farmers in the North West (Cumbria, Lancashire, Greater Manchester, Merseyside and Cheshire) will be through the current RDPE North West Livestock Programme's subsidized technical plans to help applicants meet the requirements for a successful application.

Farmers cannot apply for a grant until they have had a plan or audit completed (which must not be more than 12 months old at time of application)

In terms of **nutrient management funding under FFIS**, the scope is as follows:
The investment in, and the adoption of practises that improve the nutrient management of slurries and manures leading to improvements in soil and land management practises, reduced reliance on artificial fertiliser and reduction in cost of production.

Eligible items must achieve the above objective

- Be over and above standard farm practise
- Not be a legislative requirement or an industry obligation, and
- Fit with your current farm nutrient management plan

The following are not eligible under FFIS or RDPE

- Slurry/manure stores
- Additional rings on existing slurry stores
- Slurry tankers
- Muck spreaders

(iii) Rural Economy Grant

The £60m Rural Economy Grant was established in response to the findings of Defra's Rural Economy Growth Review which identified large grants (of £25,000 up to circa £1million) were needed in key business sectors to unlock significant rural growth potential. Outline applications need to be submitted by April 30 2012 and full application by March 2013.

The Rural Economy Grant (REG) and will provide grants to enable a significant 'game-changing', transformational performance in farm, tourism, agri-food and micro businesses in rural areas in England. Project applications will need to demonstrate that as a result of a grant their business will achieve a significant step change in performance (such as job creation, increased turnover, access to new markets, enhanced Gross Value Added etc).

The following Rural Economy Growth Review priorities are supported by REG:

- Farm Competitiveness
- Tourism
- Forestry
- Agri-Food
- Micro Enterprise Support

REG compliments the Farming and Forestry Improvement Scheme (FFIS)

The '**Farm Competitiveness-Nutrient Management**' theme under REG provides for investment to improve farm nutrient management. REG recognises that investment which advance nutrient management can have positive effects on farm viability and deliver wider benefits such as:

- Reduced need for artificial fertiliser
- Better uniformity of application
- Increased flexibility in rate and timing of application
- Reduced contamination of grass and increased flexibility with grazing
- Environmental sustainability

Eligible areas of support Defra will consider projects by farmers and farm contractors that will deliver transformational change to their business and deliver best practise nutrient management.

- Innovative investment that can be shown to be new to the industry
- Management of stored manures for example, mechanical slurry separators(not slurry and manure stores)
- Slurry application equipment for example slurry injection kit (not slurry tankers and muck spreaders

- In addition to the standard application requirement applicants need to:
- Quantify how the investment will assist with Nutrient Management for example , projected savings in artificial Nitrogen
- Identify how the proposal fits in with the wider Nutrient Management systems of the business (proposed and existing
- Agricultural contractors will need to demonstrate the level of demand they have identified for the proposed investment

Glastir in Wales

A whole farm land management scheme open to application from all farmers and land managers throughout Wales. It is designed to provide support for the delivery of environmental benefits that meet today's challenges and priorities. Successful applicants will make a commitment to deliver environmental goods for five years under a legally binding contract

The Glastir Efficiency Grant Scheme is capital grant assistance that forms part of the Glastir Entry Scheme It provides funding under the following themes

1. Manure/Slurry – capital items aimed at new or expanded storage capacity on-fram to enable better timing of applications to meet crop growth requirements , leading to savings in organic fertiliser. The theme includes clean water separation, floating cover and slurry/manure storage. Grant aid is not available in areas where expanding the storage will help meet statutory requirements – NVZ regulations.
2. Energy Efficiency – Capital items which demonstrate energy efficiency saving
3. Water Efficiency- Capital items which include rainwater harvesting equipment and water recycling systems.

Support is paid at a rate of 40% of eligible expenditure (50% for young farmers)
Mininmum grant £2000 Maximum grant £50,000
This years scheme closed on the 29-3-2013 but it says in the handbook
There will be further opportunities to apply for Glastir Efficiency Grants scheme, grant assistance and all future application windows for
the scheme will be advertised in GWLAD.

8.2 Barriers to accessing capital

8.2.1 Resistance to investment

1. Lack of financial benefits – little or no return on the investment

Farmers, land agents and Land owners generally see the erection or improvement of slurry storage as being a very expensive investment, which produces a very small return on the capital spent.

Storage facilities which are erected specifically to meet NVZ regulations mean that spreading can start at the end of the closed period which is either the 1st January or the 1st February depending on soil type and if this occurs little or no benefit accrues from the nitrogen content of the slurry. Real financial benefits from storing slurries only really occur when they are applied in the growing season using either trailed shoe or injection type machines as this is when Organic N can most effectively replace inorganic N. To achieve this however means investing in larger storage facilities and equipment which minimises the loss of N when applying slurries and thus involves larger amounts of capital investments.

Some larger farms, mainly dairy and pig units, have fully embraced this concept and as a result have significantly reduced inorganic N applications to crops.

2. Can I do something else to reduce the need for investment?

There is a perception that by some farmers that they are only making investments to meet regulatory requirements and that they can reduce the need for investment by extending the grazing season, out wintering young stock and therefore reducing the size of the slurry store required. Manures and slurries are still seen by some as a waste product not an asset. Sometimes these other actions such as out-wintering cause problems such as poaching, which increase the risk of pollution.

3. I am not in an NVZ area so why do I need storage?

Outside of NVZ areas there are a lot of uncovered feeing areas, which produce large volumes of slurries and there can be inadequate or very little storage which means these slurries are applied through out the winter period when ground conditions are poor leading to run off and thus pollution.

4. Regulations are too complex so I don't know if I need to do anything?
There are a number of farmers who have ignored the regulations as they do not understand them.

8.2.2 Inability to gain finance

<u>Private finance</u>

1. Bank/AMC – unwilling to lend.

This can be due to a number of factors which can individually or combined be a reason for rejection for increased borrowing

a) Business is already too highly geared
b) Business is unprofitable
c) Lack of security
d) The extra expenditure will not improve profit
e) Ability to service debt
f) Track record is poor
g) Accounts don't show the true financial position of the business – they are prepared to reduce tax not encourage investment.

2. Partners unwilling to lend/borrow

Within businesses there can be several individuals who have an input on investment decisions and while some may want to invest others may not want to and if this happens to be the senior individual then the investment will not take place. The factors affecting this decision are very varied.

3. Asset financing – inability to gain finance

a. Sometimes no finance on 2nd hand machinery
b. Reduction of the number of lenders in the market place
c. Interest rates are too high
d. Effect on cashflow

4. Water company grants

e. Not in the area where grants are available
f. Cannot meet the conditions in the covenant
g. Landlord will not give consent
h. Business cannot raise private element of capital
i. It is competitive and some businesses will not be able to raise the capital that others can

Public Funds

1. CSF Grants – inability to gain Grant

a. Not within the 79 priority catchments
b. Inability to raise the private 50% of investment due to competition for investment capital, bank will not Lend etc.
c. Don't want to sign the declaration
d. Don't want to meet the specified standard
e. Competitive – farmer has not scored sufficient points
f. Unwilling to let the EA on to the farm

2. FFIS

a. Inability to raise the private 50% of investment due to competition for investment capital, bank will not lend etc
b. Will only fund dribble bar not tanker
c. Design has to meet current legislation and be agreed with EA – I can do it a cheaper way
d. Landlord will not sign
e. Cashflow will not allow investment
f. Unwilling to send in the accounts
g. Not profitable

3. REG

a. Inability to raise the private 60% of investment due to competition for investment capital,
b. Bank will not lend etc
c. Will only fund eligible items
d. Design has to meet high specifications
e. Landlord wont sign
f. Cashflow will not allow investment
g. Unwilling to go through the process of a long application and do all the justification required
h. Not profitable

Table 4: Farming and forestry improvement scheme - England

Eligible item	Minimum Grant £	Maximum Grant £	Grant rate	Funding	Open or Closed	Selection process
Slurry Separator	2500	25000**	Up to 40%	RDPE	Closed	Competitive
Floating Covers for slurry pits/lagoons	2500	25000	Up to 40%	RDPE	Closed	Competitive
****Roofing of manure, slurry, silage pits***	2500	25000	Up to 40%	RDPE	Closed	Competitive

* Only on upland farms
** £25,000 is max grant available through the life of the scheme
Other eligibility criteria

1. be over and above standard farm practise
2. Not be a legislative requirement or an industry obligation
3. Fit with your current farm nutrient management plan

Table 5: Rural economy grant REG

Eligible item	Minimum Grant £	Maximum Grant £	Grant rate	Funding	Open or Closed	Selection process
Slurry Separator	25000	1million	Up to 40%	RDPE	Closed	Competitive
Slurry application equipment	25000	1 million	Up to 40%	RDPE	Closed	Competitive
****Roofing of manure, slurry, silage pits***	2500	25000	Up to 40%	RDPE	Closed	Competitive

Other eligibility criteria
1.be over and above standard farm practise
2. Not be a legislative requirement or an industry obligation
3. Assist with nutrient management

Table 6: Catchment Sensitive Farming - England

Eligible item	Minimum Grant £	Maximum Grant £	Grant rate	Funding	Open or Closed	Selection process
Roofs for slurry and silage store including self feed silage stores	0	10,000/year*	Up to 50%	RDPE	Opens each year- 2013 application period has closed	Competitive

* Only available in priority catchments

Table 7: Glastir Efficiency Grant Scheme- Wales

Eligible item	Minimum Grant £	Maximum Grant £	Grant Rate	Funding	Open or Closed	Selection process
New, extension, Modification of slurry store with associated reception pit, slurry channels and fixed equipment, Manure Store and/or Dirty water store	2000	50000	40% of eligible expenditure*	RDPW	Closed**	None
Rainwater separation- rainwater goods and protection, pipe work and associated yard reinstatement, roofing over existing dairy collection yards, existing cattle feeding areas and/or existing silage stores, diversion kerbing, re-profiling existing concrete yards	2000	50000	40% of eligible expenditure*	RDPW	Closed**	None
Slurry Separator and associated equipment	2000	50000	40% of eligible expenditure*	RDPW	Closed**	None
Roof over manure store	2000	50000	40% of eligible expenditure*	RDPW	Closed**	None
Roofing/cover or Floating cover over slurry store,	2000	50000	40% of eligible expenditure*	RDPW	Closed**	None

* increased to 50% for young farmers
** 2013 application period is closed it could reopen in 2014

Other eligibility criteria

1. Must be in Glastir entry scheme
2. Maintain investment for 10 years if a building for the use which the grant was awarded- 5 years for machinery
3. NMP
4. Storage report

Table 8: Upstream thinking £9m into 5 catchments – as far as it can be ascertained majority went on advice with some small grants of £5,000/farm

Eligible item	Minimum Grant £	Maximum Grant £	Grant Rate	Funding	Open or Closed	Selection process
Anything and everything to improve the quality of surface raw water within identified catchments from fencing to complete new infrastructure and slurry storage. New sheds, Separators, slurry stores, lagoons, tanks with or without covers – associated systems, transfer pumps, reception tanks, drainage Field and yard. Silage clamps, concrete yards. <u>No new milking parlours.</u>	Under £5,000	£150,000	50% up to 75%	SWW	Still running in Fowey catchment, closed on other 4. 16 other catchments have been shortlisted in SW for new funding round in 2014	Who ever is in catchment and wants to engage with project.

Table 9: Catchment restoration Funding £24.5 m – EA

Eligible item	Minimum Grant £	Maximum Grant £	Grant Rate	Funding	Open or Closed	Selection process
River fencing / drinking points	£5,000 – £10,000	£20,000	50%	DEFRA	Open on SW catchments	Anyone interested in engaging with WRT
Livestock crossing points	£5,000 – £10,000	£20,000	50%	DEFRA	AS above	As above
Pasture pumps	£5,000 – £10,000	£20,000	50%	DEFRA	AS above	As above
Habitat renewal / Gravels etc	£5,000	£5,000	50%	DEFRA	AS above	As above
Farm audits to identify issues for future funding	Unknown		50%	DEFRA	AS above	As above

To date, 42 projects have been approved with a combined value of £24.5 million. Approval was given to those projects which are of a high priority within their catchment as assessed by liaison panels, and where the technical experts in the Environment Agency, Natural England and the River Restoration Centre had high confidence in delivery. Many of the successful bids embraced partnership funding, collaborative working, and in some cases also supported innovation.

Table 10: Sources of Funds

Source of funds	Security required	Lending rate	Lending period
High street banks- Nat west, Midland, Lloyds, Barclays, Yorkshire,	Land/buildings or assets such as machinery or stock where they have a 2nd charge	Base rate + margin – 3-5%	5-20 years or on the overdraft
AMC	Assets preferably land – double that lent	Base rate + 2.5% plus one off lending fee	Up to 40 years
Finance companies – nationwide finance	Assets such as Machinery	40%	Minimum 12 months
Landlords	Have already got it	Agreed increase in rent	Rent increased for length of tenancy
Water companies	none	none	25 year covenant

9.0 References

Defra Project References:

FF0204 Integrated Advice Pilot for climate Change Mitigation for Agriculture and the Food Chain, Defra. ADAS, INNOGEN, RAND & AHDB

ED47617 Agricultural advisory services analysis. AEA Technology plc

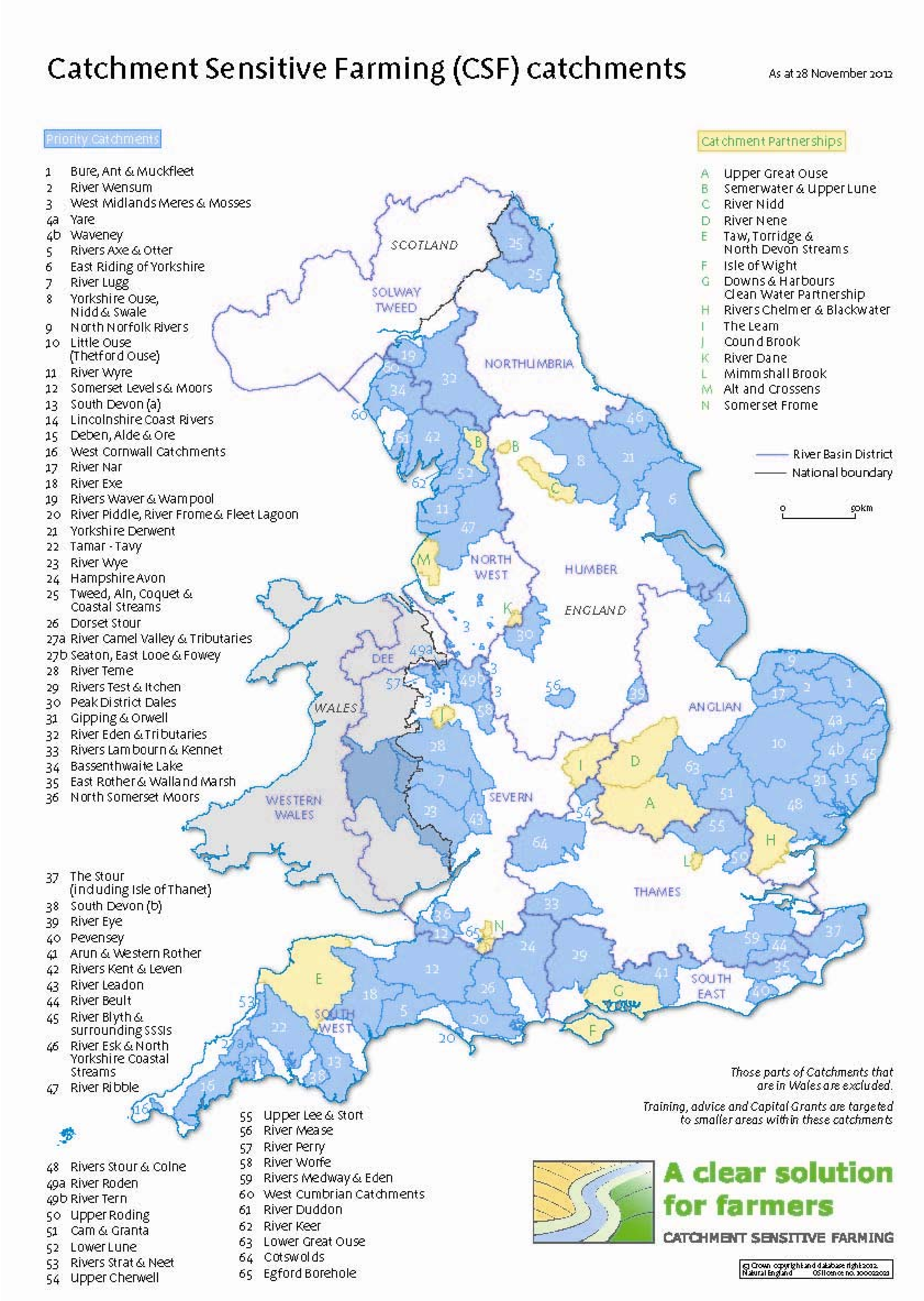
Glastir Efficiency Grants Handbook version ii September 2013

Appendix 1 List of FWMPlan Campaign Areas

[Note – the list is not complete as details of the early years is unavailable.]

Tamar
Hodder, Hindburn & Lowere Wenning
North Devon Coastal Strip
Holderness
Rea Brook
South Hams Coastal Strip
Oxfordshire Ray
Esk
Lyme Bay
River Axe
River Lydden and Key Brook
Eye/Wreake
Aldford Brook
Lower tees
Mid Devon
NALMI
River Amber
River Dane
River Ellen
Tame & Avon
Wiske & Swale
Baddington Brook
Crispey Brook
Foulness
Isle of Wight
Mid Somerset
River Camel/Allen
River Cober
River Gipping

Appendix 2 Map of CSF Priority Catchments



Appendix 3 Table of CSF Measures relevant to Slurry Storage and Management

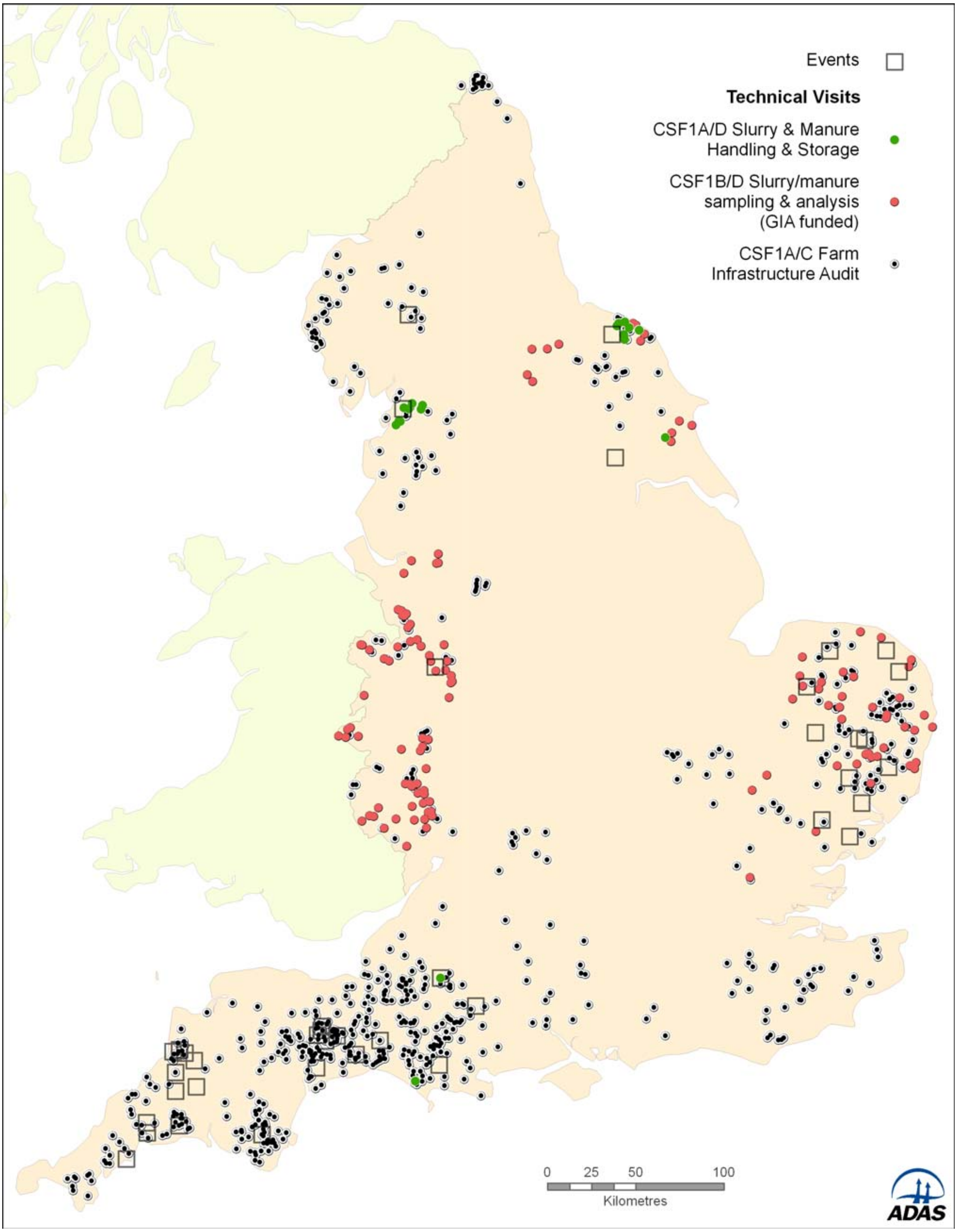
Year	Region	Measure Type	Activity	Number of times relevant practice recommended
2006	Anglian	Farm infrastructure	one to one	6
2007	Anglian	Farm infrastructure	event	195
2007	Anglian	Farm infrastructure	one to one	236
2007	Anglian	Manure management	event	1022
2007	Anglian	Manure management	one to one	635
2008	Anglian	Farm infrastructure	event	35
2008	Anglian	Farm infrastructure	one to one	205
2008	Anglian	Manure management	event	147
2008	Anglian	Manure management	one to one	856
2009	Anglian	Farm infrastructure	event	668
2009	Anglian	Farm infrastructure	one to one	140
2009	Anglian	Manure management	event	2960
2009	Anglian	Manure management	one to one	646
2010	Anglian	Farm infrastructure	event	78
2010	Anglian	Farm infrastructure	one to one	273
2010	Anglian	Manure management	event	1200
2010	Anglian	Manure management	one to one	887
2011	Anglian	Farm infrastructure	event	103
2011	Anglian	Farm infrastructure	one to one	169
2011	Anglian	Manure management	event	83
2011	Anglian	Manure management	one to one	208
2012	Anglian	Farm infrastructure	event	685
2012	Anglian	Farm infrastructure	one to one	295
2012	Anglian	Manure management	event	363
2012	Anglian	Manure management	one to one	146
2013	Anglian	Farm infrastructure	event	142
2013	Anglian	Farm infrastructure	one to one	545
2013	Anglian	Manure management	event	187
2013	Anglian	Manure management	one to one	89
2007	Midlands	Farm infrastructure	event	409
2007	Midlands	Farm infrastructure	one to one	570
2007	Midlands	Manure management	event	397
2007	Midlands	Manure management	one to one	527
2008	Midlands	Farm infrastructure	event	4
2008	Midlands	Farm infrastructure	one to one	393
2008	Midlands	Manure management	event	44
2008	Midlands	Manure management	one to one	487
2009	Midlands	Farm infrastructure	event	192
2009	Midlands	Farm infrastructure	one to one	212
2009	Midlands	Manure management	event	525
2009	Midlands	Manure management	one to one	308
2010	Midlands	Farm infrastructure	event	101
2010	Midlands	Farm infrastructure	one to one	284
2010	Midlands	Manure management	event	332
2010	Midlands	Manure management	one to one	373
2011	Midlands	Farm infrastructure	event	49
2011	Midlands	Farm infrastructure	one to one	258
2011	Midlands	Manure management	event	61

2011	Midlands	Manure management	one to one	201
2012	Midlands	Farm infrastructure	event	146
2012	Midlands	Farm infrastructure	one to one	492
2012	Midlands	Manure management	event	20
2012	Midlands	Manure management	one to one	325
2013	Midlands	Farm infrastructure	event	139
2013	Midlands	Farm infrastructure	one to one	518
2013	Midlands	Manure management	event	14
2013	Midlands	Manure management	one to one	249
2006	North East	Farm infrastructure	event	11
2006	North East	Farm infrastructure	one to one	1
2007	North East	Farm infrastructure	event	65
2007	North East	Farm infrastructure	one to one	174
2007	North East	Manure management	event	48
2007	North East	Manure management	one to one	152
2008	North East	Farm infrastructure	event	10
2008	North East	Farm infrastructure	one to one	155
2008	North East	Manure management	event	47
2008	North East	Manure management	one to one	140
2009	North East	Farm infrastructure	event	114
2009	North East	Farm infrastructure	one to one	212
2009	North East	Manure management	event	356
2009	North East	Manure management	one to one	212
2010	North East	Farm infrastructure	event	104
2010	North East	Farm infrastructure	one to one	184
2010	North East	Manure management	event	155
2010	North East	Manure management	one to one	156
2011	North East	Farm infrastructure	event	50
2011	North East	Farm infrastructure	one to one	213
2011	North East	Manure management	event	11
2011	North East	Manure management	one to one	137
2012	North East	Farm infrastructure	event	131
2012	North East	Farm infrastructure	one to one	328
2012	North East	Manure management	event	77
2012	North East	Manure management	one to one	150
2013	North East	Farm infrastructure	event	55
2013	North East	Farm infrastructure	one to one	279
2013	North East	Manure management	event	22
2013	North East	Manure management	one to one	126
2007	North West	Farm infrastructure	event	31
2007	North West	Farm infrastructure	one to one	73
2007	North West	Manure management	event	167
2007	North West	Manure management	one to one	96
2008	North West	Farm infrastructure	event	16
2008	North West	Farm infrastructure	one to one	89
2008	North West	Manure management	event	77
2008	North West	Manure management	one to one	265
2009	North West	Farm infrastructure	event	3
2009	North West	Farm infrastructure	one to one	305
2009	North West	Manure management	event	12
2009	North West	Manure management	one to one	463
2010	North West	Farm infrastructure	event	12

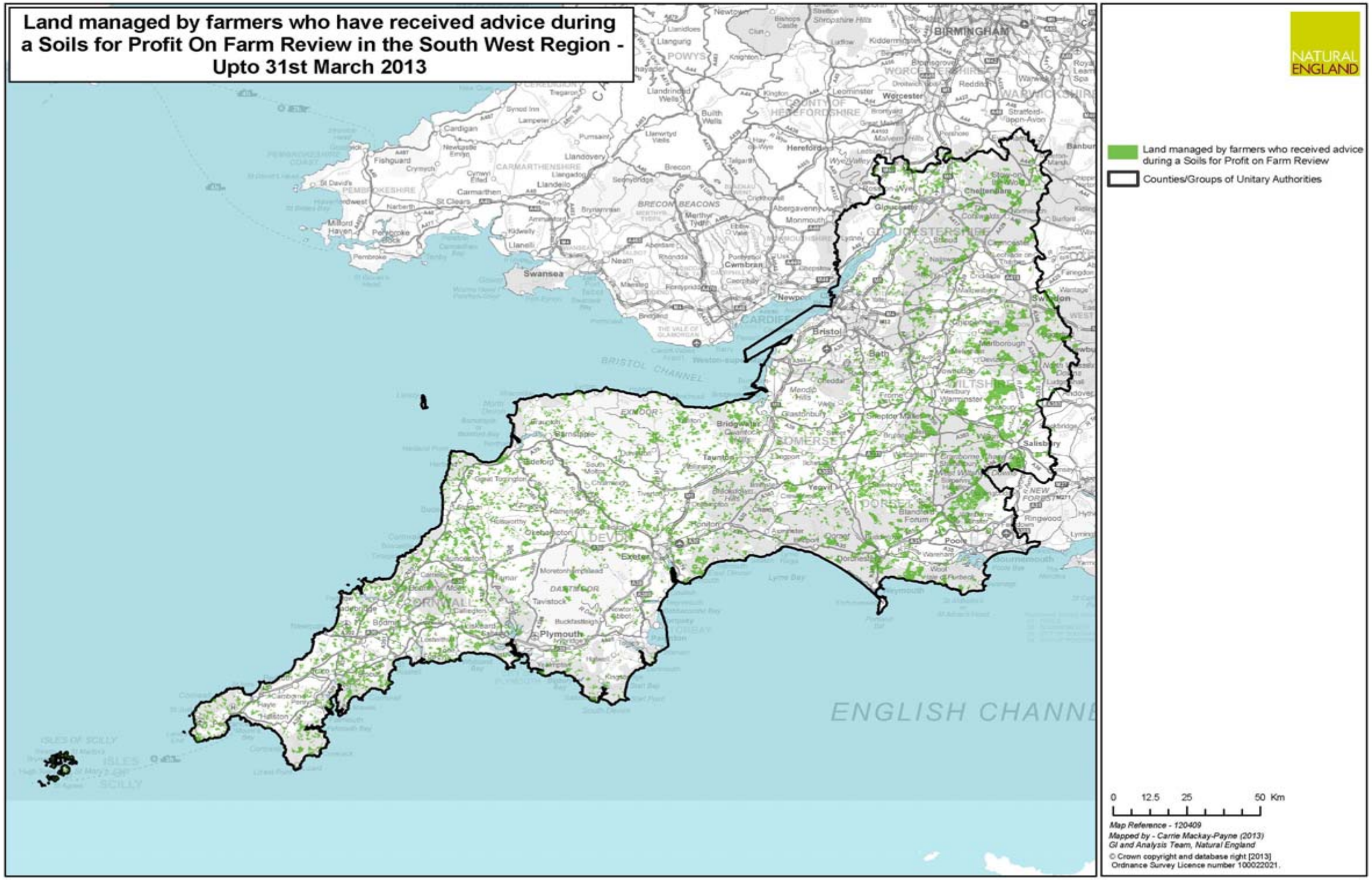
2010	North West	Farm infrastructure	one to one	223
2010	North West	Manure management	event	60
2010	North West	Manure management	one to one	281
2011	North West	Farm infrastructure	event	34
2011	North West	Farm infrastructure	one to one	409
2011	North West	Manure management	event	19
2011	North West	Manure management	one to one	339
2012	North West	Farm infrastructure	event	281
2012	North West	Farm infrastructure	one to one	922
2012	North West	Manure management	event	198
2012	North West	Manure management	one to one	778
2013	North West	Farm infrastructure	event	138
2013	North West	Farm infrastructure	one to one	528
2013	North West	Manure management	event	149
2013	North West	Manure management	one to one	597
2006	South East	Farm infrastructure	one to one	2
2006	South East	Manure management	event	2
2006	South East	Manure management	one to one	13
2007	South East	Farm infrastructure	event	18
2007	South East	Farm infrastructure	one to one	116
2007	South East	Manure management	event	52
2007	South East	Manure management	one to one	542
2008	South East	Farm infrastructure	event	14
2008	South East	Farm infrastructure	one to one	33
2008	South East	Manure management	event	52
2008	South East	Manure management	one to one	66
2009	South East	Farm infrastructure	event	143
2009	South East	Farm infrastructure	one to one	156
2009	South East	Manure management	event	470
2009	South East	Manure management	one to one	342
2010	South East	Farm infrastructure	event	135
2010	South East	Farm infrastructure	one to one	120
2010	South East	Manure management	event	60
2010	South East	Manure management	one to one	338
2011	South East	Farm infrastructure	event	49
2011	South East	Farm infrastructure	one to one	133
2011	South East	Manure management	event	123
2011	South East	Manure management	one to one	137
2012	South East	Farm infrastructure	event	56
2012	South East	Farm infrastructure	one to one	288
2012	South East	Manure management	event	14
2012	South East	Manure management	one to one	158
2013	South East	Farm infrastructure	event	113
2013	South East	Farm infrastructure	one to one	278
2013	South East	Manure management	event	7
2013	South East	Manure management	one to one	75
2006	South West	Farm infrastructure	one to one	63
2006	South West	Manure management	event	30
2006	South West	Manure management	one to one	56
2007	South West	Farm infrastructure	event	646
2007	South West	Farm infrastructure	one to one	813
2007	South West	Manure management	event	1416

2007	South West	Manure management	one to one	1061
2008	South West	Farm infrastructure	event	615
2008	South West	Farm infrastructure	one to one	414
2008	South West	Manure management	event	1033
2008	South West	Manure management	one to one	806
2009	South West	Farm infrastructure	event	328
2009	South West	Farm infrastructure	one to one	640
2009	South West	Manure management	event	910
2009	South West	Manure management	one to one	1180
2010	South West	Farm infrastructure	event	128
2010	South West	Farm infrastructure	one to one	599
2010	South West	Manure management	event	394
2010	South West	Manure management	one to one	840
2011	South West	Farm infrastructure	event	275
2011	South West	Farm infrastructure	one to one	603
2011	South West	Manure management	event	260
2011	South West	Manure management	one to one	591
2012	South West	Farm infrastructure	event	424
2012	South West	Farm infrastructure	one to one	950
2012	South West	Manure management	event	769
2012	South West	Manure management	one to one	622
2013	South West	Farm infrastructure	event	500
2013	South West	Farm infrastructure	one to one	700
2013	South West	Manure management	event	582
2013	South West	Manure management	one to one	489
			TOTAL	**54116**

Appendix 4 CSF 121s and events delivered by ADAS 2010 - present



Appendix 5 Land managed by farmers who have received advice during a S4P review



Appendix 6 Delivery outputs of S4P