MODULE 3
SOIL & WATER MANAGEMENT

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1

- Mineral Component – Sand, Silt, Clay • Organic Matter
- Air
- Water
- Living Organisms

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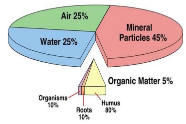

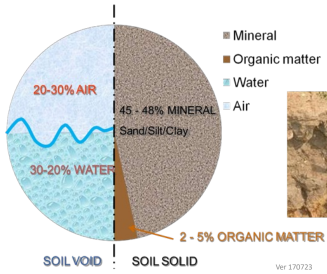

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How can we assess soil texture?

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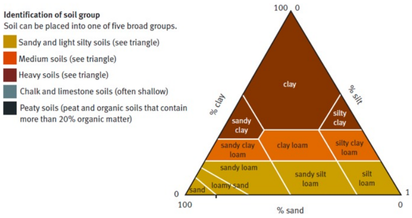
Soil Texture



Environment Agency – Think Soils

3

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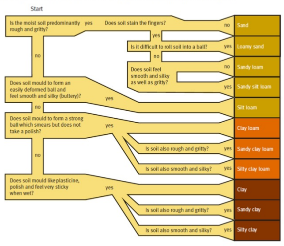
Identification of soil texture
For practical purposes you can assess soil texture by hand (follow the diagram below). Take about a dessert spoonful of soil. If dry, wet up gradually, kneading thoroughly between finger and thumb until crumbs are broken down. Enough water is needed to hold the soil together and to show its maximum stickiness.



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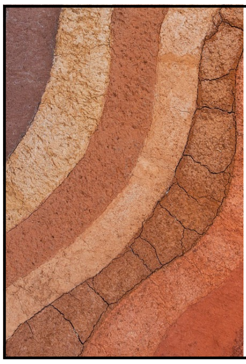

Soil Texture

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- Texture describes the ***physical composition*** of the soil

  *Note – **'composition'** not 'condition' (structure)*
- Relative proportions of sand, silt and clay within a soil

Sand: 2 mm – 0.05 mm

Silt: 0.05 mm – 0.002 mm

Clay: <0.002 mm

5

Hand Texturing

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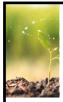
- **Primary Questions**

  (is it sandy, silty, medium or heavy)
- Predominantly Rough and Gritty? • *sandy*
- Predominantly Smooth and Silky? • *Silt loam*
- Takes a polish, sticky when wet? • *No – medium* • *Yes - heavy*
- **Secondary Questions (What's the texture category?)**
- Does it Stain Fingers? Does it roll into a ball? Some Rough and Gritty? Some Smooth and Silky?

6



Why is texture important?

Water Holding

- **Texture** determines the characteristics of a soil

e.g. soil pore space = the air and water holding capacity of a soil

- **Sandy Soils** have more **macropores (>0.05 mm),** usually *between* aggregates and free to drain under gravity
- **Clay Soils** have more micropores **(<0.05mm),** usually *within* aggregates that may require suction pressure to remove water

Texture determines soil water retention and hydraulic conductivity

7

Why is texture important?

Nutrient Holding Cation (+) Exchange

- Clay particles have a negative surface charge
- Attract positively charged cations. Example K+, NH4+, Mg2+, H+
- CEC is total negative charge of soil. Its ability to bind or hold cations
- There is a constant interchange between cations in the soil (water) solution and those held by the soil particles
- Roots exude H+ which exchange with cations on the particles

8

Sandy Soils

Coarse – rough granular particles 2.00 – 0.06mm – gives a gritty feel

Pros

- Free draining
- Easy workable
- Warm up quicker
- Good seed to soil contact

Cons

- Poor soil structure
- Leaching of nutrients
- Abrasive on machinery
- Run off
- Wind erosion
- Low organic matter
- Capping potential
- Dries out quicker in drought
- Low CEC

9

Sandy Soils

Management Consideration

- Less tillage
- Timing of drilling
- Organic manure applications
- Little and often nutrient
- No bare soil

Typical Cropping

- Potatoes
- Root crops
- Vegetables
- Short term crops

10

Silt Soils

Smooth – spherical particles – 0.06 – 0.002mm gives a smooth silky feel

Pros

- Hold moisture
- Fertile
- Light
- Well drained
- Good rooting

Cons

- Erosion wind and water
- Easy compaction
- Capping
- Slumping

11

Silt Soils

Management Considerations

- Workability
- Leaving bare problem
- Rotation
- Drains and ditch maintainence
- Water table levels

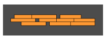
Typical Crops

- Brassicas
- Vegetable – Carrots
- Cut Flowers
- Wheat

12

Clay Soils

Flat – plate like particles < 0.002mm – gives a sticky feel



Pros
- Good water retention
- Low risk of erosion
- Nutrient retention
- More drought resistant
- Self structuring

Cons
- Difficult to work
- Late drilling difficult
- Not free draining
- Black grass problem
- Picks up on machinery tyres
- Cold and wet
- Structure damage with compaction

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13

Clay Soils

Management Considerations
- May require drainage
- Timing for drilling and working
- Cultivation
- May require gypsum

Typical Cropping
- OSR
- Wheat
- Late drilled spring cereal

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14

Organic Soils (e.g. peats)

Positives
- Good water an nutrient retention
- High N content
- Easy to cultivate
- Strong structures

Negatives
- Prone to wind erosion
- Trace element deficiencies
- Weed problems
- Prone to shrinkage and oxidation

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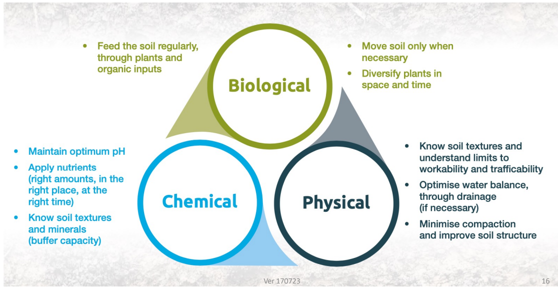
15

Soil Health



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16

Soil Structure

- Compaction
- Panning
- Capping
- Slumping
- Poaching

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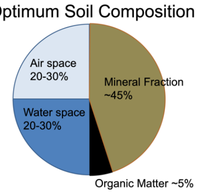
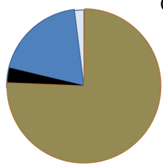
17

Optimum Soil Composition



Compaction



- Mineral Fraction increases
- Water and Air compete for little room
- No space for root growth
- Water becomes an issue! (ponding, plasticity)

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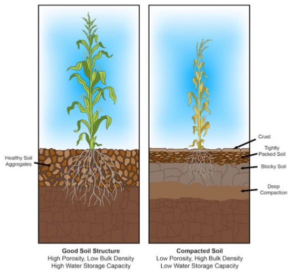
18

Good soil structure in comparison to a compact structure



19

Porosity and Bulk Density

- Porosity, gaps between the particles and aggregates
- Created by structural formation processes (shrink-swell etc.)
- Pore space affected by texture, OM, soil depth and management

- **Pores characterised in terms of their size, shape and arrangement:**

- Micropores <30µm (<0.03mm) – micro-organism habitat
- Mesopores 30-100µm (0.03-0.1mm) – air/water storage
- Macropores >100µm (>0.1mm) – rapid drainage

20

Porosity and Bulk Density

- **Bulk Density** is the weight of a soil in a given volume, and relies on the porosity of a soil
- **Greater bulk density** can restrict root growth, limit aeration and reduce infiltration and water retention
- **Low bulk density** can reduce soil cohesion, and increase susceptibility to erosion

Soil Type	Ideal for Plant Growth (Kg/l)	Restrict Plant Growth (Kg/l)	Bulk Density Range
Sand	1.6	1.8	1.2-1.8
Silt	1.4	1.65	1.1-1.7
Clay	1.2	1.47	1.0-1.6

21

Gley Soils

- Poorly drained soils – periodic or permanent waterlogging
- The lack of oxygen in the soil pores leads to anaerobic conditions
- Chemical reduction reduces Iron from Fe2O3+ to Fe2+.

  Insoluble Ferric Oxide to Soluble Ferrous Iron
- Grey/Blue colour of subsoil

22

Mottling

- In **water- logged soils**. Fe can be reduced to a soluble form and removed turning the soil grey.
- When a **root or worm channel** opens up and **aerates** the soil
- The reduced Fe oxides turning red in colour (like rust)

23

Good Soil Structure…

- Facilitates movement of Air and Water through soil
- Allows root growth and nutrient extraction
- Facilitates cultivations
- Provides a habitat for biodiversity
- Reduces risk of soil erosion


arrangement of soil mineral particles into larger u

24

Examples of good soil structure

Sandy Loam

High risk of runoff – early drilling here has helped protect soil surface

Good root structure, granular. Roots have helped to stabilise soil aggregates

Pictures: Think Soils, Environment Agency

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25

Examples of poor soil structure

Sandy Loam

Lack of surface cover and a fine tilth has led to **surface capping**

Heavy traffic has compressed the soil – resulting in **compaction** (note horizontal breakages)

Pictures: Think Soils, Environment Agency

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26

Examples of good soil structure

Clay Loam

Higher clay content creates more stable aggregates, and therefore no surface disruption and capping

Pictures: Think Soils, Environment Agency

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27

Examples of poor soil structure

Clay Loam

Surface compression has reduced infiltration, causing ponding and capping

This has cased high density packing of the soil structure

Pictures: Think Soils, Environment Agency

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28

Examples of good soil structure

Clay

Lots of grass roots and organic matter have developed good structure here

Pictures: Think Soils, Environment Agency

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29

Examples of poor soil structure

Clay

Soil compressed by traffic in wet conditions. Needs improvements to drainage

Pictures: Think Soils, Environment Agency

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30

Examples of soil structure

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Upland Peats

Soils here tend to be waterlogged for long periods. Careful grazing is required to avoid too much poaching on wet soils (right)

Pictures: Think Soils, Environment Agency

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31

Structure Formation

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- Soil aggregates are formed from primary soil particles (sand, silt clay) bound to each other by:
- **organic matter, root and microbial exudates, fungal hyphae, flocculating agents (e.g. gypsum)**
- These form peds.
- In a disturbed/man made systems these as clods
- Soil with great structure can be broken down into smaller stable aggregates

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32

Structural development
Physical Processes

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33

Effect of Tillage on Structure

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\+ breaks up large clods
- increased aeration = increase decomposition = increased OM metabolism (and structural consequences)
- Kills some of the micro, meso and macro fauna, or destroys habitats

Therefore, best management practice:

- Minimise tillage
- Till at right time, moisture and soil friability
- Increase OM = Incorporate OM residues, include rotations with grass, cover crops, green manures
- Gypsum ($CaSO4$) can be used to help structures in sodic (Na) soils and high Mg soils

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34

Degradation of soil structure

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Major causes of soil physical degradation..

- Compaction
- Tillage – heavy machinery, over cropping, disturbance
- Declines in organic matter
- Silt and salt in irrigation water
- Erosion

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35

Assessing Soil Structure

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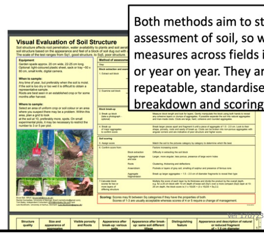
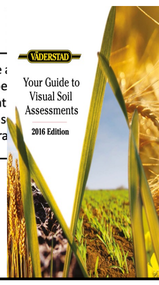
VESS (Visual Evaluation of Soil Structure)
VSA (Visual Soil Assessment)



Both methods aim to standardise a assessment of soil, so we can repe measures across fields in different or year on year. They are both bas repeatable, standardised structura breakdown and scoring



36

36

Soil Management Plan- why?

- To prevent soil degradation
- To help create optimum conditions for plant growth = Soil Structure.
- To minimise risk of run-off and Erosion
- To protect long term productivity and Organic Matter.

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37

Soil Management Plan What documents useful

- Hand texture chart
- Recent soil analyses and rainfall data
- Current and previous cropping
- Livestock systems, slurry and manure storage
- Historic maps of drains, old field maps etc
- Maps showing sensitive sites – waterways, SSSIs etc

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38

Preparing a Soil Management Plan

- **Field by field**, consider and list soil improving measures that are needed.
- **Short term** – eg corrective cultivations, subsoiling tramlines or headlands, cover cropping.
- **Longer term** – change to min-till, contour ploughing, crops eg arable to grass, wind breaks, housing stock, increasing grazed area.
- **Consider increasing OM** – eg straw, crops residues, manures. (Remember to allow for nutrients and follow NVZ timings.)
- **Field by field** (or part), identify how other aspects will be managed. Consider risks and issues as outlined in the XComp Guidance.
- **Consider risk of run-off and erosion** between current or intended rotation.
- **Map wind erosion risk areas**. Review simple measures such as wind breaks, timing of cultivations, use of cover crops, to help prevent this.

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39

Preparing a Soil Management Plan

- **If needed, change rotation**, remove areas from production, buffer strips (add to farm map)
- **Consider new gateways**, shelter belts, roadways to reduce risk of erosion and to enhance the environment.
- **Protect water courses** from livestock eg fencing, bridges and alternative water.
- **Prepare field by field description** of specific management that will be required or must be avoided in order to minimise runoff and erosion whilst maintaining or improving soil conditions.
- **Record additional management operations** required to correct soil problems during the crop cycle.
- **Repeat soil risk assessment each year**, reviewing the impact of soil management observed during the year. Update and modify the plan.

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40

Soil Management Plan – What to include

- Consideration of archaeology.
- Due consideration of relevant publications.
- Risk map of run-off and erosion, including roads, gateways and tracks.
- Assess each field (spade) for structural condition, problems and solutions.
- Consider if action needed to increase OM.
- Match land use to capability of the soil.
- Record for the following year, planned steps to control erosion, run-off, good soil structure and good infiltration of rain.
- During the year record problem such as ponding, poor growth.
- Review the plan annually to address problems.

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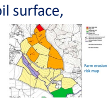
41

Preparing a Soil Management Plan

- Collect background data.
- Prepare a risk map of the whole farm, showing risk of run- off and water erosion, based on soil texture, slope and field history.
- Changes in cropping should be considered, especially if high risk crops are involved.
- Which rules require farmers to have maps?
- Indicate on the map any flow pathways where water runs across the soil surface, including water coming from off farm.
- Include surface water features and likely risk of flood or overflow.



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42

Soil risk assessment – observation

Signs of erosion that may be associated with each of the risk classes are described below. Such observations should override an assessment derived solely from the table.

- **Very High Risk Areas** – Rills are likely to form in most years and gullies may develop in very wet periods.
- **High Risk Areas** – Rills are likely to develop in most seasons during wet periods.
- **Moderate Risk Areas** – Sediment may be seen running to roads, ditches or watercourses and rills may develop in some seasons during very wet periods.
- **Lower Risk Areas** – Sediment rarely seen to move but polluting runoff may enter ditches or watercourses.

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43

Soil risk assessment – water erosion – inherent risks

Soils	Steep slopes > 7 degrees	Moderate slopes 3-7 degrees	Gentle slopes 2-3 degrees	Level ground < 2 degrees
Sandy and light silty	Very high	High	Moderate	Lower
Medium and Calcareous	High	Moderate	Lower	Lower
Heavy	Lower	Lower	Lower	Lower

'Very Steep' – 12 degrees
'Low risk', below 3 degrees, mark green of no drains, >50m from water course.

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44

Soil risk assessment – land use

Highly susceptible land uses
On Very High Risk and High Risk sites, avoid these land uses unless precautions are taken (outlined in Chapters 4 and 5 of Defra Soil Erosion 2005 Manual, and examples in GAECs). If these precautions do not control the problem then discontinue the land use.

- Late sown winter cereals
- Potatoes
- Sugar beet
- Field vegetables
- Outdoor pigs
- Forage maize
- Outwintering stock
- Grazing forage crops in autumn or winter
- Grass reseeds

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45

Soil risk assessment – land use

Moderately susceptible land uses
On Very High Risk and High Risk sites these moderately susceptible land uses can be carried out with care.

- Early sown winter cereals
- Oilseed rape – winter and spring sown
- Spring sown cereals
- Spring sown linseed
- Short rotation coppice/Miscanthus

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46

Soil risk assessment – land use

Less susceptible land uses
Consider the following land uses on Very High Risk and High Risk sites to reducethe overall erosion risk.

- Long grass leys
- Permanent grass
- Woodland (excluding short term coppice)

By altering rotations and changing land use, for example, switching from late sown autumn to spring sown crops on higher risk sites, the likelihood of erosion can be reduced significantly.

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47

Most commonly used indicators for 'soil health' indicators

Biological indicators	Chemical indicators	Physical indicators
Soil organic matter (SOM)	Nitrogen (N): mineralised N (N-min), ammonium (NH4+), nitrate (NO3-)	Soil structure (e.g. aggregate stability)
Number and diversity of macro- and microorganisms	Macro-nutrients: phosphorus (P), potassium (K), magnesium (Mg)	Compaction
Number and diversity of Mycorrhiza (AMF), and root colonisation	Micro-nutrients: e.g. iron (Fe), copper (Cu), boron (B), manganese (Mn), etc.	Erosion
Number and diversity of earthworm populations	pH	Water-logging
Respiration rates	Electrical conductivity (EC)	
Enzymatic activity	Cation exchange capacity	
Microbial profiling	Salinity	

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48

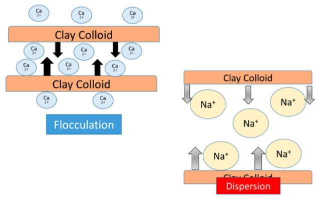
Soil Erosion Features

- Sheet Erosion
- Soil Wash
- Rills
- Gullies
- Deposition

49

Structural development
Chemical Processes

CEC & clay flocculation
Monovalent ions (Na+) vs.
Divalent Ions (Ca2+)

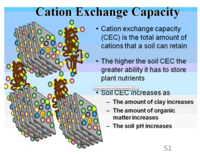


50

Cation Exchange Capacity

- Degree of exchange depends on the bonding (adsorption)strength of a particular cation
- Monovalent cations (Na+, K+, H+) tend to be easily replaced by divalent cations (Mg2+, Ca2+); Ca2+ being the dominant cation;
- Potassium is preferentially adsorbed (non exchangeable K+ is held between the clay lattices) over other cations

Cation(3+)	Cation(2+)	Cation(+)	Neutral(0)	Anion(-1)	Anion(-2)
Macronutrients:					
	Ca^{2+} Mg^{2+}	K^+ NH_4^+		NO_3^- $H_2PO_4^-$	dihydrogenphospl HPO_4^{2-} SO_4^{2-}
Micronutrients:					
Fe^{3+}	Fe^{2+} Mn^{2+} Zn^{2+} Cu^{2+} Ni^{2+}		$B(OH)_3$	Cl^-	molybdate MoO_4^{2-}



51

Cation Exchange Capacity Summary

Rating	CEC meq/100g	Notes
Very Low	0-10	Sandy Soils, Little OM, nutrients easily leached
Slightly Low	10-15	'Loamy' mineral soils, some leaching
Normal	15-40	Good to high nutrient holding capacity, greater Clay content
High	>40	High Clay or OM content, nutrients may ne tightly bound

52

What does soil biota do?

Healthy soil biological systems is essential for soil function, particularly:

- **Carbon Dynamics** – decomposing plant residues
- **Nutrient Cycling** – decomposition, N-fixing, mycorrhizal associations
- **Soil Structure Maintenance** – aggregation, pore space, channels
- **Pest Regulation** – beneficial predators

53

Who Lives in the Soil?

Macro/Megafauna
Size range > 2 mm

- Earthworms
- Ants
- Woodlice
- Centipedes
- Amphibians and reptiles
- Mammals
- Birds

Combined 100's individuals from 10's of species

Mesofauna
Size range 100 µm – 2 mm

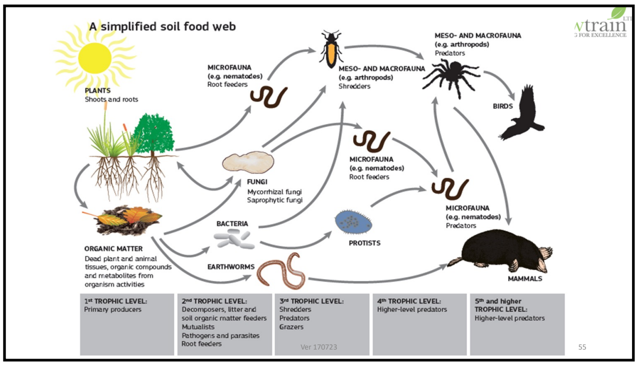
- Tardigrades
- Collembola
- Mites

Combined 1,000's individuals from 100's of species

Microfauna/flora
Size range 1-100 µm

- **Bacteria** 100 billion cells from 10,000 species
- **Fungi** 50 km of hyphae from 100's of species
- **Protozoa** 100,000 cells from 100's of species
- **Nematodes** 10,000 individuals from 100's of species

54



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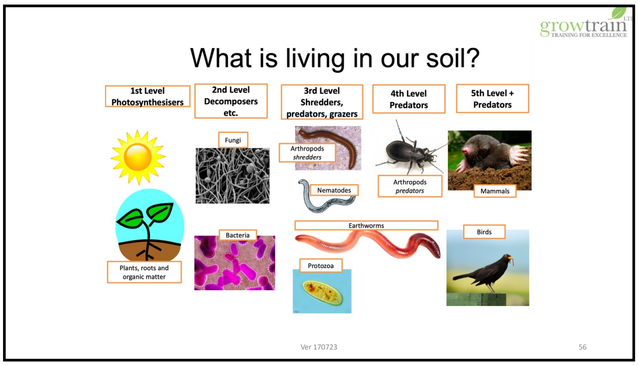
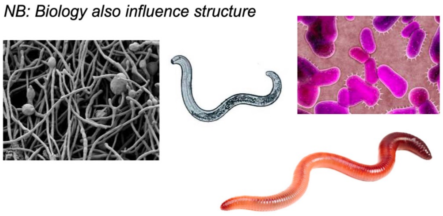


56

Habitat for soil biology

The arrangement and amount of pores, particularly micropores, is essential for soil biology to function

NB: Biology also influence structure



57

Earthworm count

Select the correct table below for your land use: Table 1 for cropping and Table 2 for grassland.

Table 1. Cropping

In the table below, locate the data range for your result for specific benchmark values and management notes.

Soil status	Threshold values (per 20x20x20 cm spadeful)	Management notes
Investigate	≤3	**INVESTIGATE** Depleted. Crop rotations characterised by high tillage intensity and low inputs of organic matter through roots, residues and organic manures are often associated with low earthworm numbers. Reducing tillage intensity and increasing organic matter inputs wherever possible will benefit soil biology and is likely to be reflected in increased earthworm numbers.
Review	4–8	**REVIEW** Intermediate. Deep burrowing earthworms are most strongly affected by tillage practice with low populations in crop rotations with regular ploughing and intensive cultivations for seed-bed preparation, e.g. for potatoes. Considering the earthworm species present and the balance between juveniles and adults can be useful in giving more information about the factors affecting earthworm populations.
Monitor	≥9	**CONTINUE ROTATIONAL MONITORING** Typical. There is no right number. In cropping systems, no or non-inversion tillage coupled with regular inputs of organic matter can lead to large and diverse earthworm populations. Considering the earthworm species present and the balance between juveniles and adults can be useful in giving more information about the factors affecting earthworm populations.

Note: Table taken from AHDB's 'Soil Health scorecard approach: Sampling protocol and benchmarking tables England and Wales' Version 1.0

58

Table 2. Grassland

In the table below, locate the data range for your result for specific benchmark values and management notes.

Soil status	Threshold values (per 20x20x20 cm spadeful)	Management notes
Investigate	≤9 or predominantly one species	**INVESTIGATE** Depleted. Acid wet grasslands, especially those which are waterlogged for a significant part of the year, are often associated with low earthworm numbers. Often the main factors affecting earthworm numbers and diversity need to be addressed through physical (drainage) or chemical (liming) interventions. These changes are also likely to benefit grassland productivity as well as soil biology and are likely to be reflected in increased earthworm numbers.
Review	10–19	**REVIEW** Intermediate. High-rate applications of slurry or digestate are often associated with the short-term disturbance of earthworm populations. Considering the earthworm species present and the balance between juveniles and adults can be useful in giving more information about the factors affecting earthworm populations.
Monitor	≥20 with good range of eco-types	**CONTINUE ROTATIONAL MONITORING** Typical. There is no right number. In grasslands neutral and moist, but well-aerated, soils with diverse swards are often associated with large and diverse earthworm populations. Considering the earthworm species present and the balance between juveniles and adults can be useful in giving more information about the factors affecting earthworm populations.

Note: Table taken from AHDB's 'Soil Health scorecard approach: Sampling protocol and benchmarking tables England and Wales' Version 1.0

59

Biological N2 Fixation to NH4

Rhizobium sp
Frankia sp
Form nodule

Azotobacter sp (aerobic)

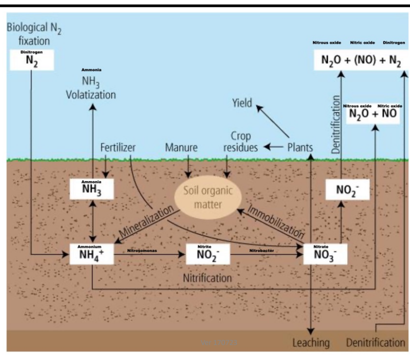
Clostridium sp (anaerobe)

Anabaena sp (photosynthetic)

Associative N Fixation

Azotobacter paspali with The tropical grass Paspalum notatum

Azospirillum sp and cereal roots



Denitrification
NO2 to N2O+(NO)+N2

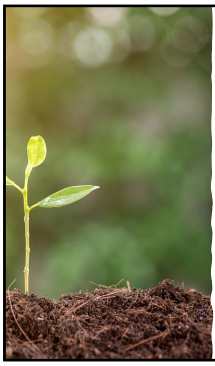
Thiobacillus denitrificans
Pseudomonas sp
Agrobacterium sp
Bradyrhizobium sp

Nitrification

NH4 to N02
Nitrosomonas sp
Nitrosolobus sp

NO2 to NO3
Nitrobacter

60



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Structural development Biological Process

- Roots, animals (burrowing) and micro-organisms
- Roots can hold soil together, create structure as they separate, compress and dry soil during growth
- Root channels allows infiltration, aeration & break up clods
- Decomposing roots form organic matter, & as binding agents
- The rhizosphere (root zone) is an important kick off for the biological food webs in the soil

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61

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The Water Environment (Water Framework Directive)

- Is the most substantial piece of EC water legislation to date.
- Requires all inland & coastal waters to reach "good status" by 2015 (and ongoing to 2027).
- In England and Wales the **EA** is 'the responsible body'
- The Directive came into force in 2000, and became part of UK Law in December 2003.
- Covers *surface*, *ground* and estuarine water.

Through River Basin Management Plans and Programmes of Measures to:

- Enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands which depend on the aquatic ecosystems
- Promote the sustainable use of water
- Reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- Ensure progressive reduction of groundwater pollution

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62

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Water Framework Directive takes a 'River Basins Approach

- Each River Basin covers an entire catchment from source to estuary
- 110 identified in Europe
- Danube largest
- 11 River Basin Districts in the E & W

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63

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South East River Basin

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64

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Surface waters

For surface waters there are two quality classifications for water bodies,

ecological and chemical.

To be in overall 'good' status both ecological and chemical status must be at least 'good'.

Principle of one out, all out.

Ecological classification comprises:

- condition of biological elements, eg fish
- concentrations of supporting physico-chemical elements, eg oxygen or ammonia
- concentrations of specific pollutants, eg copper.
- and for high status, largely undisturbed hydromorphology

Ecological - Five levels - High, good, moderate, poor or bad. 'High' = largely undisturbed conditions.

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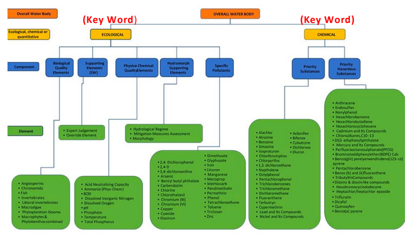
Surface waters classification hierarchy



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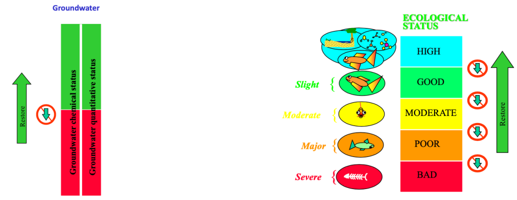
66

Objectives of Water Framework Directive

- 'Successful implementation of the WFD will go a long way to protecting all elements of the water cycle and enhancing the quality of our groundwaters, rivers, lakes, estuaries and seas for now and for future generations.'



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67

How are we doing?

Ecological and chemical 2015 classification for surface waters

England

No. of water bodies	Ecological status or potential: Bad	Poor	Mod	Good	High	Chemical status: Fail	Good
4,679	136	765	2,966	805	7	137	4,542

Anglian RB

No. of water bodies	Ecological status or potential: Bad	Poor	Mod	Good	High	Chemical status: Fail	Good
603	13	106	419	65	0	7	596

- Live look. https://environment.data.gov.uk/catchment-planning/OperationalCatchment/3508

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68

Water Protection Zones could be used to implement change

- The statutory instruments are already in place to implement Water Protection Zones.
- The EA could use WPZs to achieve the WFD objectives.
- WPZs provide the EA with additional powers to use positive and prohibitive measures
- So far only been imposed once.
- EA introduced a WPZ on the River Dee (Wales) in 1999.
- This controls point sources of industrial chemical pollution in the river.
- P options might include detailed NMPs, licences for septic tanks, high P requiring crops (potatoes?) cannot be farmed.
- Roads and industry equally targeted.

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69

Ground Water

- Once contaminated harder to clean than surface water consequences can last decades;
- Frequently used for the abstraction of drinking water, for industry and for agriculture, so pollution can endanger human health and threaten those activities;
- Provides the base flow for many rivers (up to 90% of the flow in some watercourses) and can thus affect the quality of surface water systems;
- Acts as a buffer through dry periods, essential for maintaining wetlands.
- For groundwater, good status has a quantitative and a chemical component.
- Quantity and over abstraction are important.
- Groundwater must not be polluted at all (WFD takes a precautionary approach).
- Pollution must be detected and measures taken to prevent it.
- Quality must not deteriorate.
- Why not an ecological status for groundwater?

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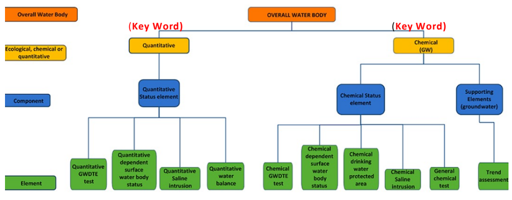
70

Ground water classification hierarchy



GWDTE = Groundwater Dependent Terrestrial Ecosystems

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71

Water Chemical Pollution

Most standards are set to support EU directives, such as:

- Groundwater Directive
- Dangerous Substances Directive
- Nitrates Directive
- Drinking Water Directive
- Many directives are coming under the WFD umbrella as 'dighter directives'

Example standards (Drinking water):

- Pesticide: max concentration = 0.1um/l or 0.1ppb
- Total Pesticide = 0.5um /l or 0.5ppb
- Nitrate: maximum concentration = 50mg/litre

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72

Water Quality
Nutrient & Manure Management

- Nutrient and manure plans
- Utilisation of organic amendments
  - manure
  - sewage sludge
  - green waste

Low emission spreading techniques

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73

Sediment – why it matters

- Loss of soil
- Carries P
- Ecology
- Navigation
- Flood Risk
- Water Pollution
- Amenity

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74

Phosphorus and silt summary

- Only small amount is found in soil solution.
- Most strongly bound to soil particles or organic matter.
- Gets into water primarily attached to soil and organic particles it becomes available for plant growth

Minimise risk of P losses to soil at several stages in the P cycle.

- Land Use
- Soil Management
- Livestock Management
- Fertiliser Management
- Manure Management
- Farm Infrastructure

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75

Rural Sustainable Drainage Systems (Rural SUDS)

Landscape scale soft engineering:

– Small ponds to catch fast flow (could be grassed,CS)
– Simple sediment traps
– Buffer strips
– In-ditch Wetlands ie widened vegetated areas
– In-ditch see page barriers
– Bunds

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76

Simple Arable Sediment Trap

77

Natural Flood Management

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78

Nitrogen – the Challenge

Agriculture's contribution to diffuse pollution is estimated to be:

60 per cent of nitrate emissions to water;

>80 per cent of UK ammonia gaseous emissions; and

5-10 per cent of ammonium-N in water standard failures.

79

Water Quality Support Organisation

The Voluntary Initiative
CFE Championing the Farmed Environment
The Rivers Trust
Catchment Based Approach
TRIED & TESTED PROFESSIONAL NUTRIENT MANAGEMENT
Environment Agency
Department for Environment Food & Rural Affairs
Catchment Sensitive Farming
WATER for LIFE from Southern Water.
NATURAL ENGLAND
south east water

80

Failure points and solutions - FYM

Excessive amounts of FYM and fertiliser

Applications too close to a water course

Insufficient allowance for nutrient value of FYM

Livestock depositing manure directly into water

Rectify by

Efficient diet formulation

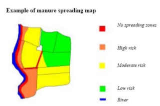
Manure storage

Spreading eg rapid incorporation

Correct application amount and accounting

81

Manure Management Plan



1. Produce a map showing the risk of spreading manure on the area of land
2. Identify areas where manure/slurry should never be spread – account for soil type, slope, proximity to watercourses, housing
3. Calculate the minimum area of land needed for spreading the manures
4. Identify the area of land needed for spreading sewage sludge or other organic waste.
5. Update the plan if the area of land changes.
6. Assess whether extra storage is needed for slurry and dirty water.
7. Update the plan if slurry or dirty water production increases.

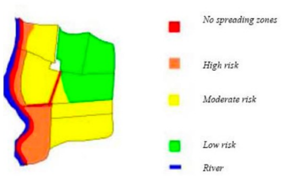
82

Risk Assessments in NVZs Organic N

Produce a risk assessment and map to show suitable locations for spreading manures.

Manures must NOT be spread:

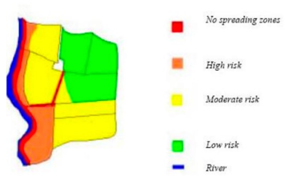
- Steep sloping land (>12%) where there is a significant risk of causing water pollution
- Within 50m of a spring, well or borehole
- Within 10m of surface water or (dry ditches)



83

Risk Assessment map

- RED: NO spreading: steep sloping land, within 50m of a spring, well or borehole, within 10m of surface water
- Orange: very high risk: fields next to a water course, spring or borehole at field capacity and a steep slope; fields likely to flood in the winter
- Yellow: high risk: moderate slope and well drained or slight slope with slowly permeable soil
- Green: low risk, tolerating year-round application



84

Types of Pollution

Point-Source:
- Pollution from a single point, often the farmyard eg. spillage, leakage
- c.80% of all pesticide pollution is thought to be due to point- source pollution.
- Introduction of Control of Pollution Silage, Slurry and Fuel Oil Reg. 1991 led to point pollution from these sources falling from 3,000 to 1,000 incidents/year

Diffuse:
- Can arise from many sources eg. leaching, drain-flow, surface run- off, spray drift etc.
- Individual impact can be small but collective impact damaging

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85

Key Diffuse Pollutants

POLLUTANT	IMPACT
Sediment (eg silt)	carry adsorbed pollutants eg pesticides
Phosphate	eutrophication
Toxic materials (eg pesticides)	danger to aquatic organisms and public health
Nitrate	eutrophication
Faecal Organisms	potential danger to public health
High BOD materials eg. milk, silage effluent, slurry	oxygen depletion

Most sediment entering catchments is from agriculture as is 40-50% of phosphate and about 70% nitrogen.
84% of SSSIs show signs of eutrophication.
Agricultural pollutant cleaning cost from drinking water is in excess of £250m/annum.
(Agriculture also contributes to air pollution through emissions of ammonia and the greenhouse gases methane and nitrous oxide.)

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86

Diffuse Pollution

- Comes from many fields or sources in a catchment.
- Individually may be minor, but cumulatively can be a problem
- **Source – Pathway – Receptor**

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87

Water Quality
Reduce Diffuse Pollution

- Mitigation techniques:
- Rotation
- Farm Infrastrature
- Yard & track management
- Buffer strips
- Beetle banks
- Sediment traps

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88

Point Source Pollution

- Comes from a single identifiable source such as a store or field.
- Includes pesticides, nutrients, oil, sheep dip.
- May be attached to soil, or in solution or direct

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89

Eutrophication

- Nutrient enrichment of ecosystem disturbing balance and quality.
- Mainly caused by P & N

- Max Nitrate 50mg/l

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90

Landscape - Slope

Steep fields can cause water runoff at a rapid rate, especially where water percolation is slow

- **HIGH RISK** >7 degrees
- **MODERATE SLOPE** 3 – 7degrees
- **GENTLE SLOPE** 2 – 3 degrees

Water can still flow on gentle slopes especially where **percolation** is slow

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Always Remember the Principle

Source	Tackle this first
Pathway →	(Sometimes this is a road)
Receptor	Protect this as a last resort, if source and pathway measures may fail.

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92

Pesticides - reducing impact

Use	Use ICM to aid crop decisions
Drift	Low drift application equipment
Use	Use buffer strips (LERAPs, CS)
Review	Review pesticide handling and washing out - biobeds etc
Keep	Keep sheep away from water courses after dipping

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93

Water Quality
Plant Protection Products

- Choice
- Storage
- Transportation
- Filling
- Application

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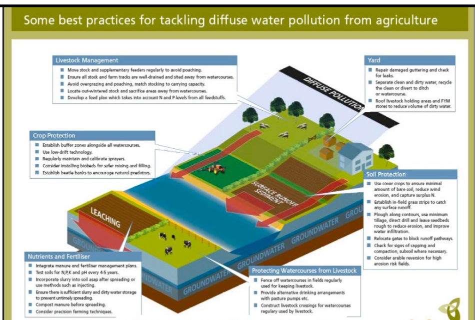

Always approach problem using source-pathway-receptor process

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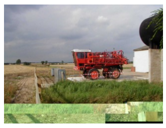
Farm Biobed Systems -

to limit point source pollution from pesticide handling and washdown areas.

Background Research Summary



Developed for the Crop Protection Association and Agricultural Industries Confederation by ADAS. The assistance of the Environment Agency, SEPA & the Farming Unions is also acknowledged. This is part of the voluntary initiative to minimise the environmental impact of pesticides

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96

Pesticides in water: sources of contamination

Diffuse	Point Source	Non-crop use
drift	tank filling	roads
drainflow	waste disposal	pavements
surface flow	washings	railways
interflow/base seepage	faulty equipment	other hard surfaces
leaching	spillages	amenity areas

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97

Pesticide Handling?

Loading
- Filling
- Mixing
- Moving

Part of the Application Process

Small Quantities High Concentration

Washdown
- Interior
- Exterior

Disposal Operation unless "applied" in the field

Large Quantities Lower Concentration

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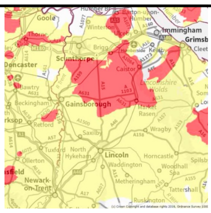
98



Catchment Sensitive Farming

- Targets areas at risk for WFD, due to agriculture.
- Advice **NOT** Regulation
- Helps target Countryside Stewardship
- **Joint NE, EA and DEFRA project**

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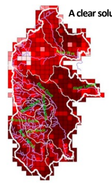
99

Sources in the Peak District Dales

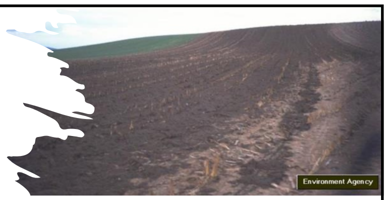
- **Livestock Production -**
- Nutrients
- Sheep Dip

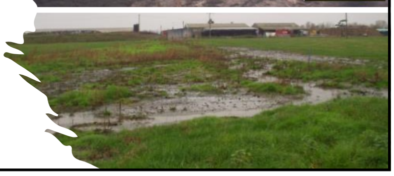


Catchment Sensitive Farming

100

Source

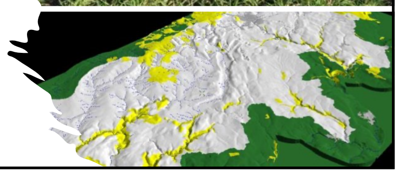




Catchment Sensitive Farming

101

Pathways



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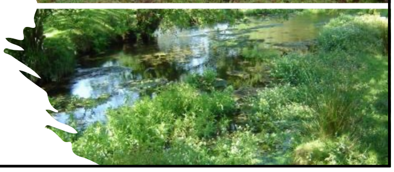
102

Receptor - River Dove

- Nutrients feed algae
- Algae dies releasing toxins

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103

Receptor

the North Sea – nutrients feed excessive seaweed and phytoplankton


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104

Not just arable!


Catchment Sensitive Farming

105

Separating clean and dirty water

Tried & Tested Think Manures 2017

Slurry pathways have been excluded from this diagram for clarity and as such the diagram below represents only the difference between clean and dirty water and assumes that:

- The cow shed and dairy parlour have been scraped to remove excess dung
- The collecting yard has been regularly scraped.

Clean Water

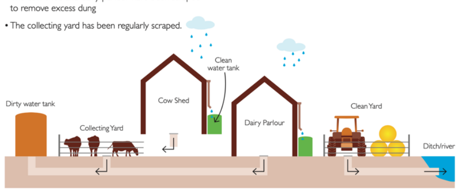
Rainfall run-off from roofs and *clean* yards not soiled by dung or urine. Also rainfall from covered silage clamps if it is not contaminated with effluent.

Dirty Water

Run-off/wash water from yards or buildings, lightly soiled with dung and urine (for example rainfall run-off from regularly scraped/brushed yards and wash water from a parlour where excess dung has been removed before hosing down) which is collected separately from other slurry. Contamination of clean water may also arise from yards soiled with waste feedstuffs, spilt fertiliser, and so on.

Slurry

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 also defined as slurry.



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106

Water Quality Livestock Management

- Medication – Zinc from sheep
- Sheep Dips
- Worming Agents
- Animal Feed
- Grazing Management
- Water course access

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107

Farming Rules for Water April 2nd 2018

Assess pollution risks

You must take into account the risks of runoff and soil erosion from these factors:

- the angle of slopes, in particular if angle is **> 12 degrees** amount of ground cover
- distance to inland freshwaters, coastal waters, wetlands, springs, wells or boreholes
- **soil type** and condition **presence and condition of land drains**
- You must **identify the risks** that apply to your land and your activities.

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108

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Before you use manure or fertiliser

You must plan each application of manure or fertiliser on your land.

Applying includes:

- **spreading** on the surface of the land
- **injecting** into the soil
- **mixing manure or fertiliser** with the surface layers of soil

For all farming and hortic. land you must plan how much fertiliser or manure to use, so you do not use more than your crop or soil needs

- by assessing the pollution risks
- by taking into account the **weather conditions** and **forecasts** at the time you want to apply **manure or fertiliser** on your land

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109

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Soil tests for cultivated agricultural land

- If you're applying manure or fertiliser to cultivated agricultural land, you must also plan by using the **results of soil tests**.

Cultivated agricultural land is both or one of the following:

- land you've ploughed, sowed or harvested at least once in the last year
- land where applied organic manure or fertiliser at least once in the last 3 yrs

Results of soil tests must show the pH and levels of:

- **N** – you can use the soil nitrogen supply calculator instead of a soil test
- **P,K** and **Mg**
- Soil test results must be no more than **5 years old** at the time of application.

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110

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You must not use fertiliser:

- on **waterlogged**, **flooded** or **snow covered** soil when the soil has been frozen for **>12 hours** in the past **24 hours**
- within **2m of inland freshwaters, coastal waters, a spring, well or borehole**
- where risk factors mean there's a **significant risk of pollution**

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111

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Must not use manure:

- on waterlogged, flooded or snow covered soil
- when soil **frozen for > 12 hours in the past 24 hours**
- **within 50m of a spring, well or borehole**
- **within 10m** of inland freshwaters or coastal waters **unless you're using precision** equipment or you're managing land for specific environmental benefits
- where risk factors mean there's **a significant risk of pollution**

6m exception for precision equipment

Can apply manure no closer than **6m** from inland freshwaters/coastal waters if use:

- a trailing hose or shoe band spreader
- a **shallow injector** (no deeper than **10cm**)
- a dribble bar applicator

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112