

Don't tolerate depressions or hollows holding water and vertical drain banks.

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Wet soils can't be fixed in wet conditions, so good forward thinking farmers should plan when dry on how to avoid wet soils. Some have phoned or emailed us, but should have started by reading this chapter.

Half metre deep spinner drains should be installed about 30 m apart to remove excess rain as quickly as possible, rather than fewer deep drains that suck moisture out of the soil in dry weather.

Perfectly drained soils are ones that hold the optimum amount of moisture and have surpluses run away as it falls which is what we did by inventing a spinner drain digger in 1957. See below.

They end up looking like this depression which drained spring water from the hill beyond it. They can be deepened at any time, even in winter.

I worked on this heavy clay Tatanui, Waikato, farm in 1955 and was left to clean the metre wide

by metre deep drain by hand with a shovel, while the owner, George Yarrall, went to golf, which as the owner, he was entitled to.

Instead, I used his tractor and grader blade to pull the drain bank off to the middle of the paddock that had grown turnips. He was very pleased. I took this photo in 1990 when by

chance I consulted for the new owner of the farm on Whakahongi Road, Tatanui. Animals had grazed to the bottom of the drain, so for 35 years it had not needed cleaning, and might never need anything done to it. Being wide allowed flood water to move away faster. There were weeds and pugging on the left flat paddock and none on the right because the shaping gave it drainage. The pugged foot paths on the left can cause mud to splash onto teats and increase mastitis and somatic cell counts.

If a cow calved near the left bank where it was dry, her calf could stagger under the fence and into the drain. Calving cows on the right paddock would be 100% safe because cows don't like calving on slopes, so would go to the centre.

The copper, chrome and arsenic (CCA) treated pine posts should be three times further apart (17 m) to save work and costs.

The farmer had been using superphosphate and water soluble fertilisers which washed into the drain causing the longer pasture growth there. I changed the new owner to reactive phosphate and elemental sulphur which don't wash or leach, costs less, and made pastures growth faster for a longer period and more even.

If both sides of a drain are pulled off, a one or two wire high power fence can be installed which need not be as deep as this. This was done on all drains on both our farms.

Also, instead of digging holes and ramming posts, use 6 cm by 6 cm treated pine pointed posts driven in with a large hammer. The required number of large Pinlock black insulators can be stapled on as a winter job. Pinlocks allow the wires to be let down and be pinned down so animals can be moved from paddock to paddock without walking to gates and pugging in wet weather.

Pasture eating pests such as Grass grub, Black Beetle, crickets and others, prefer dry soil conditions



so breed in drain banks and overdrained areas. Cows don't calve on slopes or near wide V sloped drains like the above, whereas some cows will calve next to a normal drain with vertical sides where it is drier. The new born calf can then stand up and sometimes stumble into the drain.



Underground pipe drains bad

Some imagine that subterranean drainage (field tiles or porous plastic piping) is the best, but it is the worst, because it is the costliest and most time consuming to install, doesn't last forever because they silt up with soil and have to be replaced. They also reduce soil fertility by leaching elements (your money) and polluting rivers at the same time.

This pasture had 12 tonnes of LimeMagPlus per hectare in the last few years onto soils with adequate P and K levels, but still lacked clovers and modern pastures of wide leafed ryegrasses like Bealey NEA2. It had the typical faults of subterranean drainage, i.e., plants that coped with wet soils.

Councils use these to measure pollution from high N farms.

Improving varieties in pastures

Over-sowing is far better, cheaper and faster than drilling. Broadcast seeds four days before grazing. This allows the seeds to get moisture from the long grass and to swell. If the cows do eat any of them, they will come out in the manure and grow very well in that. The rest of it can be buried from the soil from installing spinner drains, so killing two birds with one stone. This has worked for us and many others.

The best time of the year to do that in the Southern Hemisphere winter rainfall areas is from mid-March. So if working on a three week grazing rotation, the whole farm would then be done in that time.

The advantages of oversowing even good grasses with plantain and other varieties are tremendous. See > Pastures > Seeds for Pastures & Oversowing.

How much does pugging cost? It is very costly. If your soil is a wet puggy type, as in raw peats or heavy clays, so can't be changed, so improve it, farm Jerseys or crosses, young beef, and shape and drain it correctly. Don't think that farming sheep will solve it, because they don't like, and don't do well on wet soils.

When I was on the Government Lands & Survey advisory committee it took me a year to convince them of this. Their 1,000 ha Ruku Block on Collins Road, Hamilton, shown here, deteriorated under their management because they expected one man to manage and improve 1,000 hectares of rush and Manuka covered deep poor coarse peat that needed improving, with LimeMagPlus (see Elements > Calcium) and shallow drains 30 metres apart. They bought beef and sheep at the Frankton sale and after they ran out of pasture, sold them for less than they paid for them.



These weeds in 1984 in the road (in background) paddock on our just bought Greenhill Rd farm near Hamilton, were caused by seepage at the foot of a hill and a lack of LimeMagPlus. In three years of ownership we never boom sprayed for weeds, and grew none and ended up with pastures like on the right.

Aim to get rid of excess rain quickly through shallow depressions as shown below. The depression in the middle is



where a spinner drain was made in ten minutes in 1986 and photographed in 2009. No more work was done on it, and no cleaning or fencing were needed.

Some blame our wet winters, but every winter is wet, but there are solutions. Some very heavy clays are difficult.

This photo shows one shallow spinner drain in the foreground and the neighbour's farm beyond it. He and others have asked me why our pastures were weed-free and better. I explained; drainage, 5 tonnes of LimeMagPlus per hectare chisel ploughed in before resowing pastures. See Soils > Cultivation. Don't gasp at the quantity applied, it is only 2 tons per acre. Three tonnes more per hectare (1.2 tons per acre) were then harrowed or shallow cultivated in on top. This is essential because the tops of soils need more LimeMagPlus (see Elements > Calcium) than deep areas, to discourage weeds, grow more clover with more nodules to make more nitrogen. The profit made from LimeMagPlus is better in 90% of New Zealand's lime starved farms, than from most other investments.

This photo in the drought of May 2013 was our second farm, improved from bankruptcy to profiting, bought in 1984 and sold in 1987 and starved for LimeMagPlus ever since then. It is two paddocks south of the one above it. The green horizontal strip in the top left shows how the neighbour's farm has improved with LimeMagPlus, while as shown, our old farm has deteriorated dreadfully.

We had a 60 cm deep spinner drain which storm water could run into. This metre deep excavator drain cost ten times more per metre and had to be fenced. The spoil was spread next to it, so heavy rain water could not enter the drain, resulting in ponding, growing willow and other weeds, and pugging.



Those who think that their farm is very wet so they can't get their neighbour's production, suffer, while positive people on wet land don't even see the objections and say, "I'm going to improve my drainage and also farm smaller animals."

Benefits of optimum depth and spaced surface drains

- Excess rainfall is taken away as non-polluting clean water.
- No wet weather ponds or puddles drowning pastures, soil microbes and earthworms.
- Less pugging and mud.
- Mud on pastures means animals eat less so produce less. Also eating soil adversely affects their digestion and health, and reduces the absorption of some important minerals, and in high manganese soils makes animals sick. Manganese is one of the worst toxins and stressor for grazing cows in high Mn areas of NZ. See Elements in Soils > Minerals in Soils > Manganese
- Less mud on udders, reduces teat chapping and mastitis.
- Lower somatic cell counts, and less time wasted on teat problems.
- Animals prefer the clean pastures on correctly drained soils, so eat and produce more.
- More pasture growth in wet winters.
- Higher production from pastures including more legume nodulation.
- Earlier grazing and harvesting in spring after cold wet winters.
- Pasture winter kill through pugging and exposed soil freezing are reduced.
- On some under-drained soils, pasture manganese levels can get excessively high and be toxic to animals making them nervous and stressed. Adequate drainage and LimeMagPlus reduce this.
- Acid conditions which develop in excessively wet soils can cause yellow low-protein slow growing pasture.
 - Continually wet soils have poor soil structure, which further aggravates their ability to self drain.
 - Less lime is needed to keep soils from becoming acid.
 - Aerobic soils which warm up more quickly in spring, encourage beneficial activities, and allow roots to go deeper.
 - Less pugging means less carbon dioxide release.
 - Soils acquire and hold more organic matter, in other words more carbon.
 - Leaching of fertility is reduced.
 - Less underground pollution from leached fertility.

Spinner drains also make good flood irrigation ditches and if necessary are easily blocked with sand bags or similar.

A Washington State client rented some wet land for next to nothing, put in spinner drains every 20 metres and made a lot of money out of it because pasture grew prolifically. The owner of the land could not believe what he saw because, "The pasture had never grown like that before." The cost was less than one tractor hour per acre.

It is better to have them a bit closer rather than a bit too far apart. If too far apart -

- Animals walk along the drier edges of drains rather than walking evenly over the paddock.
- Low wet areas occur. Water works its way from them through the soil to the drains causing bog holes.

If a spinner drainer is not available, ask contractors or use a disc plough or grader blade, but move the spoil (unwanted drain soil on the bank) well away so water can enter the drain, and not create wet areas behind the spoil. Too frequently ones sees large pools of water building up in paddocks behind drain cleanings. Liver fluke can breed in these puddles and wet soil weeds such as rushes, Buttercup, Willow weed, Pennyroyal and couch can establish in them and then spread, sometimes causing a farmer to spray the whole paddock, when, had the hollows been filled, and shallow drains installed, weed growth would not have occurred.

Don't leave the spoil in heaps to breed crickets, black beetles, grass grubs, etc.

The exception to the levelling rule is where a silage stack pad is to be made. In this case it is a good idea to make a raised area with a gradual slope away for good drainage. It is important to position this well away from drains and waterways to prevent pollution from any silage effluent and/or from the mud which can develop around a stack when feeding out or self feeding.

Position the raised area so that self feeding can be done on the warm, sheltered, sunny side of the stack, or loading for feeding out can be done from the windy dry side to help dry out any tractor made mud. If the same site is to be used regularly, install a hard surface.

Where shallow surface drains are installed in paddocks, it is best to start them about 20 metres away from the lane and run them to the drain at the back of the paddock, so that no culverts are needed, and the cows can walk around the lane end without having to jump drains and make mud holes. If paddocks are to be harvested, they can be mown in two or three blocks, depending on how many drains are put in. Doing this doesn't take much longer than going round and round one paddock, as long as the drains are parallel to the side ones. If a shallow spinner drain is put through a paddock following the low areas, then it should be done any time in autumn, and by the time the paddock is harvested in summer, machinery should be able to go right through the depression. If this is decided on, ensure that the drains are not put in too deep.

It may be necessary to take levels to see the water will run away from the lane to the back drains. If not, and drainage through the middle of a paddock is still required, then wide culverts will have to be put in at the race ends.

In peat, culverts should be put in about 450 mm lower than the bottom of the drain, because peat sinks, and if this is not done the pipes will all have to be lowered within a few years. A sump hole should also be dug at the top end of the culvert to catch silt, and culvert pipes should also be installed on a good slope so that they don't get silted up. At least metre long pipes should be used, not short field tiles, which move and can then block. Where not much flow is expected Novaflo (porous plastic piping) can be used, but it has to be deep enough to allow ample soil over the top, to it prevent being squashed or chisel ploughed up. In these shallow drain culverts, have the pipes much wider than normal, to save putting timber edges, which take more work and get pushed around as mobs of cows cross.

Dig a hole at the entrance side to catch soil which would otherwise block the culvert.

In peat the drains may have to be further away from hills to allow for the decomposition on the peat at the base of the hill, so as to prevent the drain ending up on the side of the hill after the peat has sunk.

Pugging and mastitis

We frequently read about how much mastitis costs, how much weeds cost, how much facial eczema costs, but unfortunately, seldom about how much pugging costs, but driving around grazing areas in our wet winters and springs, we see damage that pugging causes. It increases mastitis, which is a high cost.

Most soils, treated correctly with LimeMagPlus, chisel ploughing for growing summer forage crops

and for resowing, shaping to allow heavy rain to run to 60 cm deep spinner drains, are reasonably free draining, and because our total stocking rate per hectare is not as high as on some farms, and we use faster rotations and higher residuals, we don't have mud or as many weeds.

Wet areas need correcting when possible.

On-off grazing

Some farmers never consider this and environmental bodies don't like it because it can be abused.

Some dairy farmers in wet conditions may use the cow yard or build an expensive concrete pad which needs another effluent disposal system, or they may use sacrifice areas.

The neighbour's paddocks, changed from buttercup covered to improved pasture after 4,000 kg of LimeMagPlus per hectare, as seen in the top left background, greener and more free of weeds.

Below was the drain in the Hamilton City Council bush behind our current home when bought it in 1999, after hand cleaning it every year.

We took over looking after the bush and the drain. On the right is the drain now. We made the slope even, so there are no pools. We did the same on our farms.

We planted this grass. There is a smaller variety. All came from the Hamilton City Council nursery.

Below was the 'bush' containing noxious plants such as Arum Lilies, Ivy, Woolly Nightshade, Convolvulus and Wandering Jew everywhere which has taken ten years to get rid of with Grazon, a low toxin spray. Digging it out when there are so many other weeds, is difficult.

In wet soils some dairy cows pug into the ground almost as much as they eat. This is serious enough, but, also the rate of regrowth is reduced to zero for two or more weeks, at a very critical time of the year when pasture is needed. Paddocks which have not been pugged will grow 30 kg of dry matter a day. This loss represents 400 or more kg per hectare, something no dairy farmer can afford to lose.

These next two photos are DairyNZ's Scott Farm at Newstead in July 2012.

The ryegrass pulling shows a lack of LimeMagPlus causing the roots to grow horizontally because they won't grow through aluminium and into lime starved soil caused by not enough LimeMagPlus. I estimate that the pasture calcium in the three photos are about 0.04%. They should be 0.8%.

At field days with lots of ryegrass pulling, no one except our subscribers and me knew the cause.

Just today, 16 July 2013, an establishment staff member told me of bad ryegrass pulling and that none of the staff knew the cause.



Causes of low profits

1. Too many cows. Most New Zealand dairy farms are over stocked. See the spreadsheet Dairy cow numbers for max profit kg. Some farmers who have decreased cow numbers by about 8% have increased profit and two and three decades ago won Fieldays Farms of the Year Profit competitions. If sold in winter from a 500 cow herd at \$2,000 each would give \$800,000 to reduce the mortgage and save \$1,500 per cow, per annum, so would increase net profit by \$60,000, totalling \$860,000, plus the usual extra production per cow, that almost all get.

2. Leaving the stock on for too long.

3. Poor drainage.

4. Badly contoured paddocks with low wet areas.

5. Need to subsoil, to allow moisture to move down, rather than sit on top.

6. Lack of Calignosa and Terrestris earthworms to keep the soil friable and porous.



7. Heavy cows. Watch a large cow in wet soils, and see the damage each step makes compared with a light cow. Some breeds take short steps, and walk daintily, while others take long steps, and walk heavily. On heavy puggy soils, farm lighter animals.

8. LimeMagPlus improves soils which then grow more clovers, recover more quickly after pugging and after grazing, and grow more pasture than urea or other nitrogen products do.

There are soils that don't respond much to drainage and care, so still pug.

For example lime improves the structure and water absorbing and holding ability of some soils, and yet can have little effect on others. Don't go on the pH. Soils with optimum calcium levels (0.8% in ryegrass) can be high in organic matter and grow good pasture even in dry weather.

Do LimeMagPlus trials of three and five kg on one metre wide and ten metre long strips on **your** farm to see what gives the best results in every respect, including earthworm population, friability, weed decrease, etc., but remember that with calcium and its synergisms, it may be a year or two before you see the **full** benefits. Five tonnes per hectare of LimeMagPlus on Greenhill Road consolidated lime-starved soils, after seven months, and increased dry matter yield by 150%.

Treatment

1. Drain correctly. This doesn't mean deep drains, very shallow V drains and correctly shaped paddocks can pug a lot less than adjacent paddocks with deep drains that are not shaped. I don't recommend humping and hollowing, but I do recommend a very gentle slope to the drains.

2. Subsoiling improves the drainage of soils with iron pans, but benefits some other soils very little. Again, trials are the only way to be sure on your farm, unless your soil type is similar to ones which have shown a good response. Northland clays, peats, Horotiu sandy loam and other soils with hard pans and ironstone pans have shown excellent responses when using a subsoiler. The design of the subsoiler is important. For example, on peats the conventions 50 to 80 mm tips don't do much more than create green strips where they have been, whereas a full width 250 mm tip has increased production by up to 50%, and improved the drainage so that no water at all lies on top.

3. On wet paddocks, the subsoiling should be done from the drains in towards the middle of the paddock, or crosswise from drain to drain. Where you have to lift it before the drain, to allow for the front of the tractor, turn round and back into the drain, and subsoil to the lines coming towards the drain.

4. Subsoiling a paddock that has hollows could encourage the water to move towards those hollows, and increase the drainage problem. See Soils > Cultivation for the results of subsoiling trials, and full details on wide tipped subsoilers with a vibrator to further shatter the soil.

5. The use of LimeMagPlus to improve the drainage capabilities and structures of soils is seldom appreciated. pH figures seem to dominate the thoughts of some. Care, however, must be taken to avoid over-liming on its own, because this can be just as bad as under-liming, and can bring on imbalances like an excess of molybdenum in peat soils, and lower zinc and boron levels in most soils. See Elements > Zinc and Boron.

6. The swing to using reactive phosphates and elemental rather than treated superphosphate will decrease the acidity of soils, but won't change the necessity to apply lime occasionally on most soil types. The recommendation for Hamilton clay loam, a common soil in the central Waikato, is two and a half tonnes per hectare every five years, when using conventional potassic super mixes. If using neutralised fertilisers like those recommended, the five yearly applications will either not be necessary, or can be at much lower rates.

7. Peat soils require more than Hamilton clay loams. Lime starved soils have shown marked responses to receiving three tonnes per hectare only three years after being regrassed with 8 tonnes per hectare chisel ploughed in. Dairy cows remove 900 kg of calcium per hectare per year.

It is important to have more calcium in the top layers of all soils than in the lower layers.

After a capital dressing has been applied, regular amounts of lime are better than occasional heavy dressings, and are more economical, because it saves outlaying too much money sooner than necessary.

As soils become more fertile, they can become more vulnerable to surface pugging. Again lime helps in this respect, because it speeds up the breakdown of organic matter, and encourages earthworms, which aerate the soil.

Soils that have had acid fertilisers applied for many years without lime can get a buildup of dead organic matter on the surface which breeds facial eczema spores. The acidity of organic matter discourages earthworms from consuming the dead material, which then builds up, and increases mould and facial eczema spores.

Pugging reduces the buildup of organic matter on the surface, but is not the recommended way of correcting the problem, unless there is a thick mat through inadequate liming and grazing over a long period. In which case apply a capital dressing of LimeMagPlus, and another if necessary. Many farmers who have not applied enough lime for decades have had to apply four tonnes per hectare three times to achieve optimum soils and pastures, or five tonnes twice.

To check your paddocks, get a spade and see what is happening. There should be very little dead material on the surface, a high organic content for the next 70 mm, and the soil should be friable down to about 200 mm or more.

During the dry part of the year, earthworms will be curled up in tight balls in their summer dormant position well down, and for the rest of the year they should be a good strong colour, and working actively at close to 40 per spade spit.

In the moist and fertile areas of your farm, the earthworms should remain active even through summer, provided everything else is in order. I have seen soils which have been limed have a higher moisture content and active earthworms right through dry summers, while adjacent ones which had not been limed were drier, and had only a few summer dormant earthworms.

On farms with very wet clay, like some in the Hauraki Plains, a wintering pad is recommended. Although usually referred to as wintering pads, they should also be used at any time of the year for any stock before pasture damage occurs.

On/off system

There are many ways of operating an on/off grazing system.

Animals can be moved from the grazed area once they have taken it down to about 1,000 kg of DM/ha when they are dry, or 1,500 when they are milking, and moved to a wintering pad, a sacrifice paddock, or a corner of the paddock being grazed, to reduce damage to the whole paddock. The chosen areas of each paddock should be lower fertility, drier areas. Initially, the animals will bawl and perform, but after about three days they become accustomed to the routine.

Farmers who adopted this method ended up with a good season about 10% up in production, while many of their neighbours were almost that much down.

When using any on/off system, the movement of the animals must be planned, in order to avoid making more mess than would have occurred had they been left where they were. This can be achieved by moving them on an off along the side of a paddock adjacent to a drain, or by moving them across the un-grazed grass, which won't pug as much as pasture grazed short.

If you have a farm prone to pugging, then it could be better working on a slightly faster rotation, and grazing the herd on shorter grass over a bigger area, rather than working on a long rotation through winter, and grazing the herd on longer grass on a smaller area.

Pugging should be avoided, because once pugged, it will pug more quickly next time, because it can become sealed and the water lies in the pug holes. Our second farm on the right was 106 ha (262 acres) on Greenhill Road near Hamilton with very few paddocks and drains. The back 30 hectares shown here, had no drains. The owner had to sell or go bankrupt! We subdivided it and installed spinner drains around most of the 106 one hectare paddocks that we fenced which were 40 metres wide and 250 m long (1 ha or 2.47 acres), as shown on page nine of a free item "Author."

Perfect drainage is essential before grazing wet soils. As has been said, everything begins with the soil, and drainage is the first thing to get right. Without soils we'd have nothing, without good soils we'd not have much, so we must always work towards improving our soils in every way possible. A healthy soil is a living entity of microbes, bacteria, insects and animals (earthworms), breathing, producing, growing, and making the soil more alive, fertile and productive. Soil life aerates the soil, turns organic matter (OM) into humus and plant food, and releases minerals to feed microbes and growing plants.

All these things slow down or stop when soils are waterlogged, even for short periods. Undulating land will usually look after itself, but not always as explained later.

Subsoiling can improve some areas like this, but not all soils. Shallow surface drains do a better

job. See Leaching.

Don't complain about wet land - fix it. If soils get wet and/or pug, shape them so that heavy rain runs away as it falls, if necessary by installing shallow spinner drains or V drains with a grader blade or disc plough, both pulled fast.

This offset spinner drain digger that we invented in 1963 and made and sold several, can clean several kilometres of drains in a day. Vogal NZ Ltd then made them for us and then sold out to Paddon Direct, Ferrier Rd, Winchester, South Canterbury, New Zealand. Phone +64-03-615-5582. Fax +64 03 615 5583. Email. chris@paddon.co.nz

We installed 17 km (11 miles) of half metre deep spinner drains on our first farm of 89 ha (220 acres). I could clean them all and spread the soil in three days with an offset spinner drain digger like this one that I made, reducing pugging and weeds, with many other benefits mentioned below.

Our second farm on the right was 106 ha (262 acres) on Greenhill Road near Hamilton with very few paddocks and drains. The back 30 hectares shown here, had no drains or subdivision. The owner had to sell or go bankrupt! We subdivided it and installed spinner drains around most of the 106 one hectare (2.47 acre) paddocks each 40 metres wide and 250 m long, as shown on page nine of the free item "Author."

This shows spinning the drain bank off on 10 metre deep peat that could not be walked over before draining and cultivating. It was on Woodlands Road, Gordonton, behind our first farm on Piako Road.

Always have the drain on the gate side of the paddock so they can be checked when animals come out of the paddock.

Make sure that there is an even slope in drains with no puddles so for much of the year it is dry so not subject to some of the laws for drains.

New drains

In New Zealand there are regulations regarding drains & waterways which have to be complied with before installing new drains or culverts or changing drains. See Soils > Peat Part 2.

Top priority

The priority for a good soil is drainage that may require 60 cm deep spinner drains 30 to 40 metres apart. Under-drained soils usually have poor soil structure, which aggravates its ability to be self draining. Use nature first and then low-cost things. A soil's self draining ability can be improved by avoiding pugging and machinery packing, using correct fertilisers, liming where required, earthworms, and anything which improves soil structure and encourages deep rooting. When old roots die they leave pores which act as drains into the subsoil. Adequate lime and phosphorus make aluminium less available so perennial ryegrass roots, in particular, can go deeper.

Many areas in a lot of countries suffer low production of everything, from a lack of drainage, causing tight soils so weeds, liver fluke, no earthworms, and machinery damage when bouncing about on pugged ground.

Spinner drainers can be operated by most three point linkage tractors of more than 30 kw with a power take off, which, through a drive shaft and clutch, drives the blades which cut and spread the soil, leaving a neat drain, the depth depending on the tractor PTO height, the number of passes and how much vee shaping is done.

Once accustomed to spinner drains, they are no problem. They need be only about 60 cm (24")



wide an 50 cm (20") deep so you can drive across them on an angle, harvest and fertilise the paddock in long strips instead of round and round, and save work because the wet soil weeds decrease, paddocks remain smooth because of less pugging, and earthworms and soil microbes don't get flooded out.

No one likes drains and the associated maintenance, but if they are needed, then the sooner they are put in the better. Frequently only shallow surface drains are required to remove the problem and with a spinner drain digger, there is less excuse for poorly drained areas. Rear ones can be purchased in most countries now for a few thousand dollars.

Share one with neighbours because it will be used for only a few days each year, or hire one, or use a contractor. It takes three or four cuts to put in new drains which takes about an hour to do 300 metres, and they can be cleaned at two kilometres an hour (1.25 mph) - but only when soils are wet and soft, not when dry and hard.

Even hill pastures, where water runs down from one paddock to the next, benefit if spinner drains or disc plough or grader blade furrows are run along fence lines on the contour, back into the gully, with a very gradual fall, to avoid erosion. This form of hillside draining applies on heavy wet clays where runoff occurs. Tauhei in the Waikato has heavy clay which grows rushes (*Juncus*) even on steep slopes where a tractor can only just go. Spinner drains along each horizontal fence or every 30 metres leading runoff to the gully reduced rushes and made grazing easier. Most soils can cope with the rain that falls on them, but not with that which runs onto them from higher ground, so cut it off with contour drains to run the water on a gradual slope into the valley. On a long sloping hill, contour drainage furrows may be necessary about every 30 metres.

Wet soils

Pasture on land which is under-drained doesn't even grow well during dry spells, especially if the weather changes suddenly from wet to dry. The area may look green, but yields can be low because the shallow rooted pasture grows slowly until the subsurface moisture decreases and the roots deepen.

In very dry conditions the stock may spend most of their time nibbling in these green areas but may not be getting much. Farmers don't always realise just how little grass and how many weeds (pennyroyal, buttercup, etc.) grow in wet calcium deficient areas.

Subsoiling, especially where there are iron or hard pans, can improve drainage, as well as reduce drying out, by improving deeper rooting and better moisture movement, both down and up. However, on some soils such as Hamilton clay loam (an old New Zealand volcanic, hard clay), subsoiling gives absolutely no benefit, and can even be negative by creating cracks and encouraging weed growth in them. Know your soil and what it responds to. If unsure do trials with a borrowed or hired subsoiler. Tips must be wide (20 cm 16 inches) to lift and aerate the soil above the tips.

When cultivating, avoid any implement which causes horizontal layers in the soil, or hard pans (rotary hoes, mouldboard ploughs, and disc ploughs (o a lesser degree), because these decrease the soil's natural ability to drain. Deep chisel ploughing improves the soil's ability to be self draining, and also improves the structure (provided there is adequate lime and organic matter). A Spadehoe also gives thorough deep cultivation and mixes lime into the soil in one operation without creating a hard pan.

Also avoid cultivating very wet soils too much. To make potter's clay one works the soil and it loses its structure and becomes a compact lump. Doing this to heavy clay soils with farm machinery or cattle can soils for years. Lime or gypsum can help correct this problem depending on which is needed, but try to avoid pugging soils with animals or machines.

Poorly drained soils have less oxygen and more carbon dioxide, fewer plant roots, and reduced uptake of the main elements - calcium, phosphorus, nitrogen, potassium and magnesium. Anaerobic (waterlogged) soils are cold, usually more acid, and increase the solubility of iron and manganese to high or even toxic levels in some pastures.

Most farmers spend considerable time and money aiming to achieve healthy animals, but in many cases achieving healthy soils is not given the same attention.

Pasture can be the most valuable of crops, so the land it grows on should be treated as one would treat it for a row crop.

If water lies on the surface at all, then surface drainage is lacking. Excess precipitation should be able to run away cleanly as it falls. If it lies for half a day, it waterlogs the soil, leaches fertility, pollutes underground water, drives out oxygen, and kills some earthworms and soil micro organisms, which are the life of soils. In summer when pastures are growing, warm water lying on the perennial ryegrass and

clovers can kill them through suffocation. This is not a problem in winter, but should still not be allowed.

Under-drained wet soils also leach valuable fertilisers, particularly nitrogen and sulphur, into underground water and waterways causing pollution. With high water tables, roots don't grow downwards, don't access fertility at lower levels which then leaches further down and into underground water, and pasture growth is slower.

Quite often dry weather starts suddenly. If roots are shallow because of under drainage, growth stops quickly.

When developing new land, there is no need to get the drainage perfect ahead of liming, fertilising and fencing and buying more animals. Try and improve it as you go, so that expenditure is allocated to the best profit earners as you improve everything together. There is not much benefit in having the best drained land in the county if it has too few stock, so that the pasture is not fully fed or is under-utilised and becomes long and unproductive.

Where deep drains have already been installed, the drain banks should be pushed in or removed, and spread in low areas, around water troughs, and in a large raised radius in from gateways. The drains will then be V shaped so easier to clean, for animals to graze, and they move flood water faster because water on the surface travels faster than that below, especially when the banks of steep drains are rough or have weed growth.

This weedy hollow should have soil from the drain bank pulled into it, and or a wide V drain formed to allow water to enter the drain.



Avoid concrete pads, unless essential

New Zealand's farming is intensive grazing pastures with high power electric fences, not concrete.

Some NZ farmers have built concrete wintering pads which require effluent catching and spreading, when ones of peelings, bark, chips or shavings don't, can be moved and can be improved. I believe it is best to improve the farm's drainage first after which pads may not be necessary. Some have built herd homes at tremendous expense. These require work and maintenance. A dairy farmer who installed one then disliked farming because of the extra work of moving animals, feeding and cleaning. Valuable animal manure, instead of growing pasture the day after dropping, is stored under the cows in herd homes losing the polluting nitrogen and sulphur into the air.

Again, improving drainage and planting shelter trees could be a better option by providing natural shelter and shade, and reducing pollution from stored manure. See Shelter, Cold, Heat and Barns and also read Pollution.

Italian trials in the 1950s found that poplars along waterways and around ponds and lakes used and reduced soil nitrogen moving to the water and going underground. Also see Soils > Cultivating by chisel ploughing which deepens soils, gives increased storage volume for holding fertility and moisture and reduces leaching and gives other benefits, such as deeper pasture roots which use more N and grow more pasture in dry weather.

Bog holes

These should be filled in or drained because they -

- Increase in size as stock carry mud away and pollute the surrounding pasture.
- Reduce pasture production.
- Encourage the growth of couch (quack) grass, one of pastures' worst weeds.
- Encourage the breeding of liver fluke.

The solution is to pull drain banks off and change straight sided drains to V drains, to shape paddocks (fill low areas, build up areas around gateways and water troughs, shape slopes to fall to drains) before cultivating and to lime and cultivate thoroughly right to the drains. Before cropping is the time to do these things. Paddocks not to be cropped for a number of years should also be shaped and

oversown in autumn.

Where hollows are left, animals pug these in wet conditions which increases their size over the years by carting the mud away on their feet. If drain banks are left, they can become a breeding ground for dry soil loving insects such as crickets and grass grubs. As in all farming systems, the aim should be to get rid of the cause, not treat the symptom. Before thinking more about how much work it is, get prices from motor scraper and similar contractors. You could be surprised at how quickly they can do it, and how little it costs.

If an area is on a shallow rock layer or similar “undrainable” soil, you could fence the area off and plant trees or make a dam and plant trees like weeping willows or poplars around it. If the water level is low enough, drains from the surrounding area could run into it.

Planning

If you don't have a good eye for levels and don't have access to a suitable level or theodolite get prices for doing the job. There are electronic levelling devices which guide machines and operators at whatever fall required, so get several contractor prices before trying to save money by doing drainage yourself. Don't always take the lowest price, but decide after looking at other jobs the contractors have done.

Drains along fence lines should be installed on the far side of cross fences so that when going down the lane to fetch animals, one can look down the drain from the gate to ensure no animals are stuck, and not have to go to the far side of the paddock just to check the drain for stuck animals.

Types of Drains

Soil drainage can be by large open drains, tile or subsurface drains (moles, tiles and porous plastic piping), or by spinner surface drains.

Subsurface drains (tiles, Novaflo plastic porous piping or mole ploughed) take some fertilisers with the water, wasting money and causing pollution, whereas surface drains seldom do this because they allow rain to run away as it falls, as clean water.

Good surface draining ensures that soils don't become so wet that they become anaerobic and drown out earthworms and soil microbes, whereas subsurface drainage only works after the soil has become wetter than optimum.

Excess magnesium in soils makes them compact, easily pugged and difficult to drain. Organic matter and calcium only lime help improve it, but they don't change it. Shallow spinner drains at about 30 metres apart help allow excess rainfall to run away rather than lie on the pasture and making it impossible to be grazed without pugging. Under these conditions, drains at 30 metres have changed the soils to be well drained, while at 40 metre spacings the areas remained lower producing, with wet patches being pugged. On less puggy soils drains 40 to 50 metre apart may be adequate.

The best form of drainage on wet flat land is lots of shallow spinner drains, and the worst forms are a few deep drains or excessive hump and hollowing. However, a slight rise away from drains to the centre of paddocks is ideal. Slight hump and hollow drainage on very heavy wet clays have been installed in some areas, however the hollows can become wider bog holes, and the humps encourage animals to camp on them so get all the animal manure. They can dry out encouraging poor pasture species until fertility builds up from camping (at the expense of the hollows), crickets and grass grubs. Hollows remain wet, weedy and poor.

In most years many areas have wet periods at some time, so, where applicable, good drainage is an important aspect of pasture farming, especially with today's tendency towards mob stocking. It is hard to graze under-drained paddocks in wet weather without damaging them.

Sometimes farmers spend tens of thousands of dollars a year on fertiliser and/or seed, but nothing on drainage, even in situations where an annual \$1,000 to \$2,000 on drainage would give a better return. Fertilising poorly drained paddocks is wasteful.

Optimum drainage for two and a half cows per hectare may not be satisfactory for three per hectare.

On poorly drained wet heavy clays and peats, spinner drains may have to be installed at 30 metre intervals or closer, while on less wet soils drains further apart may be enough. Most flat land and some hills benefit from having them along all fence lines. They cut off heavy rain running from paddock to paddock and improve the effectiveness of the fences.

In time the bank is pushed in and the drain becomes a shallow V shape with pasture growing right through it as seen below.

If peaty, they should be further away from the hill, to allow for the decomposition on the peat at the base of the hill, to prevent the drain ending up on the side of the hill after the peat has sunk.

Major advantages of spinner (rotary) drain diggers are that they can dig and clean drains at about two kilometres an hour per cut, and spread the dirt as they go. By staggering the cuts a wider and deeper drain can be spun out.

Underground drainage

These systems don't work until the soils are water-logged and they remove fertility with the water and pollute waterways. Environmental bodies use them to measure pollution from excess effluent and fertiliser applications. They have improved the drainage in some paddocks, however, the problems are their high cost and their not working efficiently for more than 5 years in peat or 25 years in mineral soils before they silt up, get blockages or move out of line. Thirty to sixty centimetres deep surface drains can achieve far better results at a fraction the cost.

Every agricultural contractor should have a spinner drainer and anyone wanting to supplement their farm income in wet areas should have one to clean their own drains in a day or two, leaving time to do others in the area, or hire it to neighbours.

To prevent over-draining, drains and main drains should stop running about two weeks after rain stops, unless it is a large area inadequately drained or there are strong springs or overflows from springs or lakes which can flow all year. Outlets can be damaged by machines cleaning main drains. Check and open outlets at the beginning of each wet season.

Mole ploughing

As in everything, no one thing or system is always perfect so where a surface drain is impractical a mole drain may help, in some soils, but should be considered **only** where surface drainage can't be used, because they have the same disadvantages of underground drainage.

Outlets can be damaged by machines cleaning main drains. Check and open the outlets at the beginning of the wet season.

All moles must be put in with a fall to the outlet, which on flat land could mean starting from the outlet drain deeply and gradually lifting the mole as travelling.

Lifestyle properties drainage and bush areas

This drain was in the Hamilton City Council (HCC) bush area behind our 37 Ellerslie Avenue



property we moved to in 1999. It had slipped like this because HCC staff removed all the vegetation from both sides of the drain (illegal and prosecutable on farms) which they thought they were cleaning. We managed to show HCC bosses the erosion and mosquito breeding mess and said that we would look after the drains and whole area. We planted this non-aggressive native grass given to us by their Gerard Kelly who delivers plants at no charge from their colossal nursery. He is intelligent and caring. We had to fence the dogs and children out because in summer the dogs liked running up and down in it (Illegal for animals to do on farms, but happens in towns.) and children liked blocking bits to make little dams. We shaped the drain bottom so that the slope and flow were gentle and even, and planted the banks that the council had bared. Look at the clean sandy bottom on the left now that nature developed within a few years of correct management without abuse.

This is the HCC bush area no one looks after and below right is what the HCC do nothing with. Arum lilies, convolvulus, Cannas, Ivy, Wandering Jew, bracken and other weeds cover their area which now can't be walked through, and encourages litter from bad people.

Avoid over-draining

Fear is often expressed about over-draining, but this is impossible with shallow surface drains, irrespective of the number. When a soil is correctly drained, pasture roots go deeper, with the result that pastures grow faster in both wet and dry conditions.

Over-draining occurs only when drains are too deep. Soils can then become so dry that they crack and create breeding areas for crickets that consume pasture. Rain then runs down the cracks instead of soaking in to all the soil so pasture growth after dry periods is slow.

Our farm discussion group in the late 1950s had one member who had a few nearly two metre deep drains on his peat, complained about peat taking too long to become moist and grow pasture every autumn. As you will have read, we halved our two metre drains to one metre deep V drains in our two metre deep peat within two weeks of buying our first farm. It took only one day, and could have saved animals getting stuck in them.

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