CHAPTER 6

STRUCTURES, EARTHWORKS AND RACES

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6.0 STRUCTURES, EARTHWORKS AND RACES

Farm structures and associated earthworks and management practices can impact on the environment. Such structures may include farm buildings and housing, silage and feed bunkers, farm raceways, road and stream crossings, stand-off pads and feed pads with their associated effluent storage facilities, irrigation dams and streambank engineering.

For information on farm dairy design and effluent storage and treatment facilities, refer to the Dairying and the Environment Committee manual Managing Farm Dairy Effluent.

6.1 GENERAL PRINCIPLES OF PLANNING AND DESIGN

Sound initial planning and design are a worthwhile investment in any project, as stopgap measures for problems at the design stage can involve high cost and stress. Environmental impacts should be taken into account when planning, alongside economics and farm practicalities.

As part of the planning procedure:

- find out if a resource consent or a building consent is required for the activity
- talk to other farmers about the advantages and disadvantages of their design, and about their experiences with advisors, suppliers and contractors
- get expert advice from appropriate sources e.g. Regional Council staff, consulting officers, product suppliers and independent advisors. In addition to sound theoretical knowledge, an advisor should have experience with local conditions – check out envirodirect.co.nz for local listings
- consider current farm operations and land use, and the influence that new structures and activities may have on these. Determine likely property expansion, increases in herd size, changes in land use, future subdivision or residential development and location of other farm buildings and structures in relation to the proposed development
- use a plan of the property (i.e. aerial photograph or plan drawing) to identify waterways, natural drainage patterns, prevailing wind direction and soil types
- assess environmental and safety risks associated with the failure of the system (e.g. road crossing collapse, breached dam embankments).

Options for collecting reliable information and designing the structure include the following:

- a 'do-it-yourself' approach where responsibility of accuracy lies with the farmer. Shop around, as prices for labour and materials can vary. Beware of unskilled labour
- employing an independent designer to obtain design and equipment specifications. Farmers can then select components for the minimum cost, similar to competitive tendering. In return for their fee the designer will carry the responsibility of the system operating correctly. As with all contracts, these points should be made clear in writing before the work is started
- construction company representatives may act as designers. In this case, the responsibility of ensuring that accurate information is gathered rests with them. However, as the equipment and materials specified are tied to company products, choice may be limited.

6.1.1 Selecting the right design

When faced with a variety of design options for a farm structure, it is important to consider the following:

- environmental effects and council requirements
- food safety and dairy industry requirements
- cost
- labour
- maintenance
- safety
- effects on other parties
- aesthetics and visual impact.

No single design is best for every situation. Structures need to be adapted to suit individual properties. All designs can fail, even if only temporarily. Successful structures are those that are accurately designed, correctly sited and well maintained.

6.1.1.1 Environmental impacts and Regional Council concern

When selecting a design or management system, consider its ability to operate to the satisfaction of the Regional Council and protect the environment.

Farm structures and associated management procedures should not create adverse environmental effects e.g. air pollution/odour, discharges to waterways, or upstream flooding.

The collection and treatment of effluent from various points where it can become concentrated is important, to avoid an illegal discharge into waterways or leaching to groundwater.

Storage facilities for fertiliser and silage should be well sited and built to avoid leakage and pollution.

Construction activity and the final structure may cause sediment runoff, erosion, and barriers to fish passage. These effects should be avoided.

Erosion and sediment during earthworks can be minimised and controlled by:

- keeping disturbed areas small and time of exposure short by staggering construction
- working in drier months
- preventing stormwater from entering the exposed site (e.g. with perimeter drains or bunds)
- saving topsoil and replacing it on the disturbed area, and stabilising it as soon as possible (with vegetation, geotextiles, hay or mulch). Stock should be excluded from disturbed areas
- retaining sediment on site e.g. with haybales, silt fences or silt traps/ settling ponds
- avoiding steep areas or areas near watercourses for siting earthworks.

Regional Council regulations need to be adhered to, so that environmental effects are avoided, and farmers are not faced with fines and legal action. Some Regional Councils have guidelines (e.g. for earthworks), or they may promote certain designs or operational practices and discourage others.

Overall environmental impacts can also be reduced through good design, e.g. by designing a structure to last and to be energy efficient. Energy efficient buildings make good use of local site conditions, with windows to the north for solar heating and natural ventilation. They are well insulated to minimise the need for heating. They also use sustainable building materials (refer to 6.1.2 Construction materials).

6.1.1.2 District Council regulations

Each District Council has its own set of requirements for positioning of certain structures in relation to houses, roads and boundaries. Before building a structure, check with your local District Council for siting requirements and the need for a building consent and/or property memorandum.

6.1.1.3 Food Safety and Dairy Industry requirements

The health and hygiene practices on the farm and within the farm dairy are closely monitored by overseas markets and have a considerable effect on the marketability of dairy products. Hence, the Dairy Industry has worked with the Food Safety Authority to put hygiene regulations in place that must be followed to help promote the industry to overseas consumers. These are contained in the Farm Dairy Code of Practice NZCP1.

For farm dairies and farm dairy race requirements, see the Dairying and the Environment Committee manual Managing Farm Dairy Effluent.

Other buildings may also require consideration of the Farm Dairy Code of Practice. All buildings within 20 m of the farm dairy should be kept clean and well-maintained. No yard or building can be sited so that it obstructs the tanker collection of milk. Such buildings must also be kept clean for hygiene purposes. If a septic tank is installed, this must not be within 10 m of the farm dairy or within 45 m of the dairy water source. A toilet with no septic tank shall not be sited closer than 45 m from the farm dairy or tanker loop.

Tanker roads require special attention. They must be kept free from all obstructions, fenced from stock and not used as cattle races. Where controlled grazing is carried out on the loop and roadway, it must be done in such a way as to not affect milk quality. Cows should not cross the tanker track. Any crossing that is within 45 m of the farm dairy must be made of concrete or similar material that is easily cleaned, and effluent from this crossing must not be allowed to pond, but should drain into an effluent disposal system.

The following distances for structures or activities from the milking area, milk receiving area and milk storage area and collection point must be observed:

Effluent ponds and offal holes	45 m
Whey pits	45 m
Silage, baleage	45 m
Pigs	45 m
Dead animals	45 m
Poultry, dog or livestock housing	20 m
Loafing barns and feed pads	20 m
Hay barns, hay	20 m
Other supplementary feed (not over a concrete pad)	20 m
Fertiliser bins/storage	20 m
Bulk fuel storage	20 m
Sumps	10 m
Sewerage tanks	10 m

The farm dairy water supply must also be protected. Where this is a surface water supply, it should be at least 45 m away from any offal pits, rubbish pits, sumps, sewage facilities, feed pads, silage pads, chemical preparation and storage facilities and fuel tanks. If it is an underground supply, care should still be taken that bore heads are not at threat of chemical or effluent contamination.

6.1.1.4 Cost

Capital costs and ongoing costs generated by the need for labour, maintenance and debt servicing are important. Ongoing costs may be high when capital expenditure is low.

Costs may also arise through Regional Council charges for consent applications and compliance, and penalties if systems should fail.

6.1.1.5 Labour

The farm structure must be managed correctly to function in the manner for which it has been designed.

The following matters should be addressed:

- what labour will be required to manage the structure? Will it be available?
- what is the ongoing labour cost of various design options? How can labour inputs be minimised?
- what design will minimise the time spent collecting effluent from various structures and managing its treatment?
- what training is required for farm staff in operation of structures and facilities for safety, animal welfare, hygiene and environmental protection?

6.1.1.6 Maintenance

A farm structure design that requires minimum attention and maintenance is desirable, especially maintenance requirements during busy times in the season. The time, labour and finances required for maintenance can be broken down into daily, regular and annual commitments.

Daily maintenance involves successfully using and monitoring the associated management of the structure. Stock may require shifting or feeding. Facilities may need to be washed down. Records of use may need to be kept to meet legal responsibilities.

Regular maintenance involves oiling machinery, replacing components and repairing structural damage.

Annual maintenance commitments include repainting or repairing the structure, annual cleaning out of facilities used on a seasonal basis and providing documentation for resource consent compliance or renewal.

6.1.1.7 Other interested parties

It is desirable to consult at the design stage with your dairy company (for relevant structures), and other interested parties, especially those who may be affected by the proposal or associated management programme. Minimisation of nuisances such as flies, dust, odours and noise deserves consideration.

When considering any system, it is wise to liaise with neighbours and affected parties who may have input into Regional Council decisions. Where any major earthworks are involved, early consultation with local Maori can help avoid locating on sites of cultural significance.

6.1.1.8 Safety

Safety for farm workers, visitors and family is a prime concern for dairy farmers. Any effluent storage facility must be fenced. Enclosed effluent storage facilities and offal pits should not allow the access of children. Toxic substances must also be safely isolated.

Principles outlined in safety and health legislation need to be adhered to. Farmers, farm workers and company staff who routinely visit farms must be made aware of the dangers.

Safety should also be considered in terms of design loads. Farm structures may be subject to loads from stored contents, retained earth where structures are partially buried, snow loads where structures are roofed, wind loads and traffic where there is vehicle access. A careful assessment of these loads is necessary to prevent structural damage and associated danger to occupants, farm workers or stock. Engineering assessments of some structures (e.g. bridges) are required at regular intervals.

6.1.1.9 Aesthetics and visual impact

Part of a farm's value lies in its aesthetic appeal and this can also influence the acceptability of a new structure to neighbours, District Councils and other interested parties.

An attractive visual effect can be achieved by:

- sympathetic siting of buildings and structures (e.g. avoiding very visible ridgelines and not blocking view sightlines)
- the use of colours that blend into the environment
- minimising land disturbance during earthworks and tracking
- screen planting to mitigate the visual impact of unattractive or large farm structures.

Be aware that passers-by may be offended by some farm management practices (e.g. leaving dead stock out for removal, or standing cows off in what may appear to be cramped conditions.) Pick the location for these activities carefully and shield them from roadside views.

6.1.2 Construction materials

When choosing materials for a farm structure, the following should be considered:

- permeability. Any structure which contains effluent, silage leachate, agrichemicals or fuels will need to be impermeable
- corrosion resistance. Silage effluent, chemicals and fuels may be corrosive. Therefore, the structural materials should be made corrosion resistant. The quality of the concrete has a major influence on the protection of the concrete structure. As limestone is dissolved by acidic silage effluent, it should not be used in or underneath a silage bunker.
- materials supporting the foundations. Materials that support the foundations of farm structures must be properly specified, placed and compacted in order to provide a firm and stable base. To avoid problems of long term settling of base materials, select well-graded material (less than 75 mm), place the material in layers no greater than 150 mm thick and consolidate each layer separately.
- embodied energy and life cycle of the materials. Different construction materials require different energy inputs in their extraction from the original source, manufacturing and transport. Similarly, they may have other environmental impacts throughout their 'life cycle'. This may be due to their origin (e.g. from a sustainable forest,

vs a non-sustainably managed timber source or a non-renewable resource such as oil for plastics). There may be environmental impacts from their processing (e.g. timber treatment chemicals). At the end of their useful life, some materials can be recycled (e.g. metals) or reused (e.g. some timbers) while others cannot (e.g. plasterboard that breaks easily). The durability of the material is also a factor, as longer-lasting materials will need replacing more often, wasting resources. These considerations are part of the overall environmental impact of a farm structure.

6.1.3 Siting and site investigation

The importance of a safe site choice cannot be overemphasised. The choice of site is a key to practical operation, minimal maintenance, and the prevention of pollution. Once a farm structure has been built on a poor site, there is little that can be done to remedy the situation, and pollution risks or ongoing costs can be high.

The steps involved in a thorough site investigation include the following:

1. A desk study. Find out about setback distances by checking Food Safety Authority regulations (refer to 6.1.1.3 Food Safety and Dairy Industry requirements) and by checking with Regional and District Councils for their requirements. Study maps and plans of the area - older plans may reveal important features such as in-filled quarries, old building lines and wells. See if the Regional Council and District Council have any such plans and documents. In mining areas, enquiries should be made about past and present mining operations and problems with subsidence. Councils may also have a register of waahi tapu or significant cultural sites that should not be disturbed.
2. Site reconnaissance. Inspect the site for conditions that may cause building difficulties. Overhead or underground power lines should be avoided - consult the local power company for guidance on precautions and safe working procedures near power lines.
3. Soils investigation. Inspections should be made of the soil profile throughout the proposed site.
4. Consultation (refer 6.1.1.7 Other interested parties).

Critical factors to investigate include topography, soil properties, siting in relation to groundwater and surface waterways, climate, wind direction, the proximity of residential housing, accessibility and hygiene are all considered.

6.1.3.1 Topography

Minimise the potential for structural flooding and flushing during rainfall. Runoff from nearby waterways, catchment areas and higher terraces should be avoided. The farm structure should not be sited in areas that:

- are likely to flood
- have steep slopes that run toward a watercourse, spring or borehole. Steep slopes not only pose an erosion and slippage threat, but can also prevent machinery access
- have slopes greater than 1 in 10. These may be subject to soil creep. Leaning walls, fences or trees are evidence of soil creep
- have abrupt changes in topography. This may indicate changes in soil type and soil strength leading to subsidence.

Where practicable, farm structures should be in a slightly elevated position and/or have stormwater diversion channels built around them.

6.1.3.2 Soil properties and groundwater

All farm structures should be sited away from high water table areas. Seasonally high water tables can affect the ability of a structure to be used (e.g. an underpass or a storage facility). Sites covered in reeds, rushes and willows are an indication of high water tables.

It is advisable to take soil cores to look at underlying soil types, even well below the foundations. From these, the depth to the water table and the drainage characteristics of the soil can be established.

Heavy soils with a deep water table are preferable for farm structure foundations. Silt or clay soils are ideal. Avoid building over fractured rock or on sites where settling is likely to occur. Sites recently cleared of trees, drained, or similarly disturbed, should be avoided. The ground should be allowed to stabilise before being built on. Peat soils can be expected to settle over time.

Drainage systems near the site should be noted. If the area is mole or tile drained, it may be best to keep the structure as far away as possible. If necessary, move all land drains so that they are at least 10 m clear of the proposed site.

Check with the Regional Council whether there are local problems with sulphate-bearing soils and groundwater as these will affect the strength of concrete foundations and floors. If so, test for sulphates in the soil and groundwater. Appropriate cement in the concrete may be recommended for sulphate situations.

6.1.3.3 Proximity to residential housing

When planning the location of a stand-off pad, feed pad, silage bunker, fertiliser storage area or effluent treatment system, consider the impacts on neighbours.

A number of factors strongly influence the risk of nuisance problems arising from such structures, including:

- distance from neighbouring properties
- prevailing wind direction in relation to neighbouring properties
- local topography and vegetation. Exposed sites allow wind dispersal of odour, while treebelts can help to reduce noise impacts
- season and time of day when the structure is most in use
- management and maintenance of effluent systems.

Regional Councils or District Councils require farmers to have minimum buffer distances between public areas and certain farm facilities. Check with your local council.

6.1.3.4 Location in relation to surface waterways

Wherever possible, avoid siting farm structures near a surface waterway (i.e. closer than 20 m). Offal pits and silage bunkers should be well away (i.e. further than 100 m). Regional Councils may have specified setback distances for some structures or activities.

6.1.3.5 Accessibility

Attention should be given to all-weather access to the farm structure.

Pipelines, construction machinery, tractors and other vehicles should all have a straight run to the structure. Such machinery may be required to get around the entire outside of the structure. This will be difficult if it is built into a hillside or on steep slopes.

For ease and to minimise costs, structures may be sited in the vicinity of the farm dairy, as long as Food Safety Authority regulations permit (refer to 4.1.1.3 Food Safety and Dairy Industry requirements). Site them so that it is easy to check that everything is working correctly and to quickly identify and respond to trouble.

Power costs of pumping effluent from stand-off pads, feed pads and silage bunkers can be high. Wherever possible, site them on a high point so that gravity can be used to convey effluent to a suitable disposal system.

6.2 SILAGE FACILITIES

Silage is any crop (e.g. pasture, maize) conserved by sealing it in anaerobic conditions. Silage leachate is one of the most contaminating wastes generated on the farm. With the trend towards more intensive feeding systems there is an increased potential for silage leachate problems to occur, either by runoff to surface waterways or by leaching into groundwater. For this reason, structures for silage storage must be carefully designed.

6.2.1 Silage leachate

Serious pollution problems can arise from the leachate that drains from silage stacks and pits, starting within 24 hours of construction and continuing for about eight weeks (refer Figure 6.2-1).

FIGURE 6.2-1

SILAGE LEACHATE

The amount of leachate produced depends on various factors, but particularly on the moisture content of the crop or pasture when it is stored. Inadequate wilting of the herbage before storage will result in large volumes of liquid remaining in the silage. Inadequate coverage and sealing of stacks or pits, allowing rainwater to drain through the stack compounds the problem of leachate production.

While volumes of silage leachate are relatively small, leachate is one of the strongest on-farm wastes in terms of its pollutant potential (refer Table 6.2-1). Silage leachate is approximately 200 times stronger than raw domestic sewage and 40 times stronger than farm dairy effluent. The leachate is very acidic and has high levels of nutrients (including ammonia-N which is toxic to fish). Even small amounts of silage leachate entering waterways can cause damage. As the leachate breaks down in the water it uses up oxygen that fish and other aquatic life need to live.

TABLE 6.2-1

CHARACTERISTICS OF SILAGE LEACHATE

Characteristic	Typical amount (for design purposes)
Volume	30 l for every tonne of well made silage but ranges from 10 to over 200 litres
BOD_5	30 - 80 g/l
Dry matter	6 - 110 g/l
Lactic acid	0 - 26 g/l
Acetic acid	0.5 - 6.5 g/l
Water-soluble carbohydrate	1 - 31 g/l
Total nitrogen	1 - 5 g/l
Potassium	1 - 8.5 g/l
Calcium	0.2 - 3.6 g/l
pH	4

6.2.2 Wilting of herbage

The key to minimising silage leachate is making good quality silage by correctly wilting the crop prior to ensiling. Consider the following:

- leafy grass ensiled without wilting will produce around 500 litres of leachate per tonne
- grass wilted to 20% dry matter before ensiling will produce 50 to 120 litres/tonne
- grass wilted to 25% dry matter before ensiling will produce 30 litres/tonne.

Therefore the problem may be largely overcome if the dry matter content is kept to 25% or more (the point at which it is very difficult to wring any moisture from a handful of the grass).

It is important, as far as possible, to make silage during fine weather. A minimum of six hours drying in the paddock after cutting is required in fine weather, with around 24 hours recommended. However, even wilting for 3 - 4 hours can be beneficial. Mechanical conditioning can assist by increasing the speed and evenness of wilting.

Wilting has the added benefits of improving the feed quality of the silage, reducing feed losses during storage and producing less odour.

If the crop cannot wilt due to wet weather, if fresh crops are put into the bunker, or the sump is too small to cope, consider the following:

- placing straw bales on the bunker floor to soak up leachate
- mixing absorbent materials with the crop before it is ensiled.

6.2.3 Silage bunkers

A well-designed silage bunker should be constructed in a suitable site and securely covered to reduce the risk of leachate loss and improve the quality of feed.

6.2.3.1 Site selection

Refer to 6.1.3 Siting and site investigation. Silage storage facilities should be sited on an area that is:

- not within 45 m of the farm dairy to comply with Food Safety regulations
- at least 50 m away from waterways and dams, but up to 200 metres where the land is steep (check with your Regional Council for local rules)
- situated well away from areas prone to flooding or where there is a high water table
- away from any subsurface drains - check for old drainage systems.

Where soils are coarse-textured or groundwater may enter sensitive waterways (e.g. lakes), it is best to construct a free-standing, sealed bunker on high ground.

6.2.3.2 Construction and covering

Properly constructed and sealed pits or bunkers will allow better compression and sealing of the silage stack, significantly improving quality and reducing wastage.

Cover stacks with a plastic cover (refer Figure 6.2-2). If done during and immediately after construction this will minimise rainwater entry into the stack and therefore the volume of leachate draining out. Pay particular attention to the edges.

In the case of free-standing stacks, a cut-off trench should be dug around the stack to divert any water running off the paddock. Timber (e.g. half-rounds) should be placed at the edge of the cut-off drains to hold the cover in place.

FIGURE 6.2-2

A WELL COVERED SILAGE STACK

In the case of pits with sides, grass should be stacked higher than the sides and the cover should extend and be secured over the sides.

The base should be solid and extend out beyond the bunker walls, with channels in it or a gradient to allow collection of the leachate. Floors should slope at 1 m in 50 m towards drainage channels. A channel should also be laid across the front of the bunker (refer Figure 6.2-3). Liquid should not be able to pass through the bunker base unless it is collected by drains leading to a sump.

Use either concrete (with a water/cement ratio less than 0.4 : 1) or hot rolled asphalt. Silage leachate is extremely corrosive and can damage concrete and steel. Adding silicon or silicate to concrete can help protect against acidity and pitting. Asphalt may be more corrosion-resistant than concrete.

FIGURE 6.2-3

SLOPING CONCRETE BASE

Concrete floors need to be laid properly to ensure liquid can not pass through them. Expansion joints in concrete lined pits should be sealed with a flexible compound to prevent leachate draining through into groundwater.

Clean and inspect walls, floors and drainage channels of bunkers when they are empty and mend any cracks, corrosion or other faults before silage is made again.

6.2.4 Silage leachate storage

Leachate collected from the silage stack should be contained for removal. Collect it in a channel and direct it into a watertight storage sump (refer Figure 6.2-4).

The sump should be resistant to corrosion and preferably made of a single piece of material with no joints. A storage capacity of at least 3 m^3 per 100 tonnes of grass ensiled is recommended. This will initially require emptying every 2-3 days. The sump should be checked regularly to ensure it is coping.

Silage leachate should not be directed into normal drainage systems.

FIGURE 6.2-4

A SILAGE BUNKER SUMP

6.2.5 Leachate disposal options

Silage leachate should be diluted and treated before being stored and spread on land, or used for animal feed. It is preferable not to use effluent treatment ponds to treat silage effluent unless the ponds have been specifically designed to cope with this. However, silage lechate can be directed to effluent storage ponds prior to land application.

Be aware that adding silage leachate to organic wastes can produce lethal gases and strong odours. Therefore, do not add silage leachate to organic wastes in confined spaces or apply a combined slurry to land where an odour problem could cause a nuisance.

6.2.5.1 Land application

The best method of disposal, after at least a 1:1 dilution with water, is to spray irrigate or spread the leachate on to pasture at a rate of 25 m^3/ha. This will supply 25 -75 kg/ha of nitrogen, 25 kg/ha of phosphate, and 100 kg of potassium, making it a valuable fertiliser.

The leachate will scorch pasture if it is not diluted before being applied to land.

6.2.5.2 Feeding leachate to stock

Fresh, uncontaminated, undiluted leachate from well-preserved silage has successfully been fed to cows at a rate of 10-20 litres/cow/day. Feeding trials show that fresh silage leachate contains high concentrations of protein, lactic acid and soluble carbohydrates (refer to Table 6.2-1). An average intake of 18 litres is equivalent to 1 kg of barley.

Plastic troughs are ideal as leachate is corrosive to concrete and galvanised troughs. Fresh drinking water must always be available.

Leachate should only be fed to stock when fresh (to avoid the risk of toxic levels of nitrate building up). In addition, the leachate must be from well-made silage where the correct fermentation processes have occurred. If the quality of the silage is good and it is well compressed, the pH falls quickly and suppresses undesirable bacterial growth.

Some of the undesirable bacteria are spore-forming organisms which can contaminate milk and cause post-processing problems (e.g. with cheeses). Apart from these bacteria, Listeria may be present in silage with a high pH that can result in ill health and abortions in cows. There may also be fungal issues in poorly preserved silage as decomposition advances, with associated health risks of mycotic abortion and secondary pneumonia and liver abscess, though these are more likely to be associated with feeding bad silage than feeding leachate to stock.

6.2.5.3 Farm dairy effluent ponds

Silage leachate should not be directed into standard oxidation pond systems unless they have been specifically designed and sized to handle it. The leachate from an average sized silage pit (~300 tonnes) would be equivalent to 30 to 75 days' input from a 200 cow farm dairy and is likely to seriously overload the pond system.

6.2.6 Baled silage

Let material you are going to bale wilt until it contains at least 25% dry matter. Laboratories can assess dry matter accurately, or the "squeeze test" can be used to give an estimate.

To do this test:

- break up the grass or silage into lengths of 2-3 cm
- roll into ball about twice the size of a golf ball and squeeze for 30 seconds in your fist
  - if juice runs out easily, dry matter is around 18 - 20%
  - if a little juice runs out, with difficulty, dry matter is around 20 - 25%
  - if your hand is damp, and sample remains in a ball, dry matter is around 25 - 30%
  - if sample does not stay in a tight ball after squeezing dry matter is over 30%.

This will prevent leachate from being produced inside the packaging.

Wrapped or sealed silage bales should be sited away from waterways, bores, springs and land drains. When unwrapping and feeding out the bales, do it some distance from waterways.

If the packaging contains leachate, dispose of the liquid as for leachate from silage pits (refer to 6.2.5 Leachate disposal options).

Silage wrap needs to be disposed of correctly (refer to 7.2.1 Plastic silage wrap).

6.2.7 Top tips for silage facilities

- **Site the silage bunker at least 50 m from waterways and drains and well away from areas prone to flooding or high water tables.**
- **Wilt the cut pasture to 25% dry matter to improve feed quality and reduce the volume of leachate produced.**
- **Construct bunkers with a concrete or asphalt floor and collect effluent through channels flowing to a sump.**
- **To stop rainwater entry, cover bunkers with a plastic cover and construct diversion ditches around the bunker.**
- **Either feed silage leachate to stock while still fresh or dilute it and apply to land.**

6.3 ROAD CROSSINGS

Where dairy farming is prevalent near residential areas, councils are faced with formal complaints concerning cows crossing roads and using roads as races. Complaints are usually concerned with:

- animal waste on motor vehicles
- pedestrians encountering messy roads and footpaths
- the image that tourists have of our rural areas
- the detrimental effects cow manure has on chip seal and road surfaces
- traffic delays.

Many District Councils now have bylaws in place restricting stock crossings or the use of public roads for moving stock. Bylaws are local laws that apply within a certain area e.g. within a district, or if it is a regional bylaw, within a region.

In some cases a permit is needed for a road crossing. It will probably be a District Council condition of approval for stock crossings or races that the farmer holds public liability insurance for any damage to third parties.

Road crossings are also a collection point for effluent. If stock cross over a road without the use of a removable mat then many District Councils require the road to be washed. This generally involves the use of a high-pressure hose, generating a significant amount of washwater to be managed. In many cases a storage facility is required to hold effluent until it can be pumped to the treatment system or applied to land. When designing the storage facility, consider the duration of hosing and the volume of washwater produced. Care is needed because storage facilities can be quickly filled if stormwater runoff from the road cannot be diverted away from the facility.

To solve the problem of road crossings and using roads as races, the following may be constructed:

- road underpasses
- road over-crossings
- roadside raceways.

6.3.1 Road underpasses

Underpasses are usually necessary when stock cross a busy road. Consult your local District Council in the first instance to find out if you need approval to build one. If it is a State Highway consult with Transit NZ.

Underpasses may be of the 'concrete box' type or of a 'multiplate pipe' type (refer to Figure 6.3-1)

FIGURE 6.3-1

CONCRETE BOX AND MULTIPLATE PIPE TYPE UNDERPASSES

6.3.1.1 Preparation

Underpass design is specific to every site and will require full attention by a consulting engineer and surveyor.

An underpass is usually designed at right angles to the road centreline.

A minimum of 600 mm between the road surface and the pipe is usual for a multiplate pipe underpass compared with 300 mm for a concrete box underpass.

An underpass is usually designed to allow the access of farm vehicles as well as stock. If it is very low, signs should be put up as a warning.

Figure 6.3-2 shows the sectional view of an underpass design.

The location and specific siting of the underpass are extremely important (refer 6.1.3 Siting and site investigation). Underpasses have been rendered useless because of groundwater filling them (refer to Figure 6.3-3). If the underpass fills with water it is likely the farmer will have to install a pumping system to remove it. This situation is best avoided with good siting in the first instance.

FIGURE 6.3-2

SECTIONAL VIEW OF AN UNDERPASS

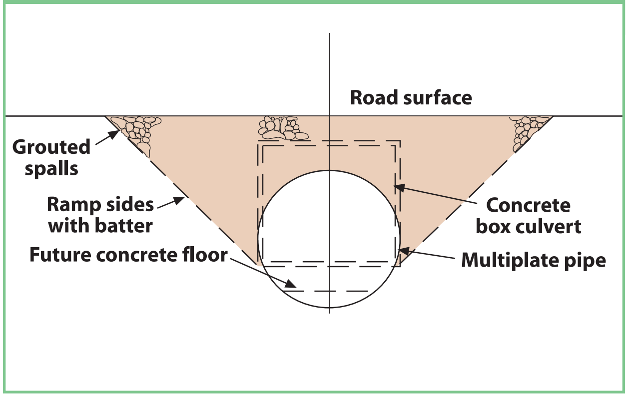


FIGURE 6.3-3

WATER FILLED UNDERPASS

Underpasses should be sited on an area that is:

- well away from where there is a high water table or springs
- not at the bottom of a hill or gully or in other places where runoff water can flow through. If at all possible, construct on higher ground where water will drain out of the underpass without pumping
- accessible to stock and farm vehicles.

Anti-float designs are available if it is necessary to site the underpass where there is a high water table.

Any water that does collect in an underpass will be mixed with sediment and effluent and must be disposed of properly. It is not legal to divert, discharge or pump this water into a nearby watercourse without a resource consent. It will instead have to be properly treated either by pumping it to an effluent treatment pond designed to cope with the additional loading, or by applying it to land in accordance with the Regional Council's rules (which may also require resource consent). Contact your Regional Council at the planning stage to find out what is needed.

Do not have the gradient for access in or out too steep. Gradients greater than 3 : 1 (i.e. horizontal : vertical) are too steep for stock. Vehicles struggle with gradients greater than 10 : 1, or 4 : 1 with a 4 x 4 tractor.

Underpass width should not be less than the track width leading up to it to prevent cow flow issues.

Full engineering drawings describing the work to be done should be included in the specifications put up as part of the tender response. These will be used in the tender, for subsidy applications, and for District Council approval/registration, building consents, street opening permits and Transit New Zealand approval.

Contractors are generally responsible for checking in advance with the relevant service authorities (e.g. roading authorities for roadside channels and power, telephone, or gas companies) as to the presence and position of services. They must also ensure that work does not cause any damage to these services.

6.3.1.2 Materials

Bedding materials, backfill materials, rock used for the construction of head-walls and riprap, and concrete strength should be specified by the engineer.

Contractors generally test and supply all materials required for construction. A certificate of compliance for all materials will be supplied to the engineer before delivery to the site. The certificate of compliance must not be more than 3 months old and should cover both sampling and testing.

6.3.1.3 Underpass construction

Construction usually involves excavation and construction on one side of the road through to near completion before the other side is assembled, to assist traffic flow.

When tenders are called for, contractors outline their responsibilities on the job. Contractors are usually responsible for:

- control of any water as required. All phases of the construction sequence should be conducted in the dry and the passage of water should be maintained at all times. If a waterway is to be diverted, the Regional Council will need to be contacted
- removal of existing structures
- removal of unsuitable foundation material and inspection of the foundations by the engineer to determine the supporting quality of the foundation. Unsuitable material is excavated and replaced with compacted granular fill
- excavation for and the supply, placing and compaction of granular bedding material beneath the underpass. The excavation should be safe from collapse or slips at all times until construction and backfilling are complete
- supply of materials, assembly and placement
- backfilling of the culvert to formation level and scaling
- excavation of the access tracks to the underpass
- reinstating any services after installing the underpass such as cables or water channels on the side of the road (refer Figure 6.3-4). If services are taken over the underpass, ensure that they are high enough for vehicles to pass under
- supply of all plant and labour necessary to carry out the works
- provision for the safe passage of traffic.

The successful tenderer will then supply and install the underpasses in accordance with the drawings and specifications.

Do not overlook the installation of appropriate means to deal with effluent that may collect in the underpass, to ensure this does not discharge to a nearby waterway.

FIGURE 6.3-4

PROTECTING CABLES

Safety during construction
Contractors should comply in full with the Health and Safety in Employment Act (1992) and in particular, should follow procedures set out in the Code of Practice for temporary traffic management (Transit New Zealand, November 2004). Contractors should:

- prepare quality plans including the 'Method Statements' for the planning, detailing and construction of the works in accordance with the specifications and a 'Traffic Management Plan' for public safety and traffic capacity management
- take all reasonable precautions to prevent accidents while undertaking the work by erecting barriers, signs or devices to cause traffic to slow down, or fences across roads or around dangerous places

- supply lighting at night for any dangerous place
- fill in, cover or enclose any hole, well, excavation or other place dangerous to persons passing along the site
- enclose the site with a fence
- ensure that all trenches and other excavations are securely and adequately supported by timbering cages or sheet piling where required
- advise all sub-contractors and employees of these requirements.

6.3.1.4 Underpass costings

There may be some funding available for underpasses, by applying to either the local District Council or to Transit New Zealand, particularly where a newly constructed road splits a property into isolated sections.

Costs of the materials and contracted work associated with the planning, design and construction of both multiplate pipe and concrete box underpasses are extremely variable and are largely dependant on site conditions (particulary water table levels and the use of the road where the underpass is being installed) and purchase price of underpass units.

6.3.2 Road over-crossings

Where stock cross a road regularly at one particular point, consideration should be given to installing a heavy, durable road pavement e.g. of concrete (refer to Figure 6.3-5). Such over-crossings should be limited to situations where excessive maintenance costs are likely to be incurred to sustain the roading. This work would need to be at the property owner's cost and to a standard determined by the District Council.

FIGURE 6.3-5

AN OVER-CROSSING

Where an over-crossing is in use, it is best that stock be:

- held back, whenever possible, 50 m from the road prior to crossing
- attended by a drover stationed on the road edge to ensure that continuous progress is made
- driven in a safe manner, using only exit and access points to and from the road. This will ensure that damage to the road and road flanks will be minimised.

6.3.2.1 Over-crossing construction

The following guidelines are suggested when constructing a road over-crossing:

- take a direct route across the road. In the case of an adjacent dairy unit or a split dairy unit, gateways should be sited opposite each other where practicable, or at the nearest access points to the two parcels of land
- wide gates should be erected at the race entrance on each boundary to ensure the steady and unrestricted flow of stock
- the entrance and the race itself should be constructed of hardfill material, with a cambered, free-draining profile for at least 15 m from the edge of the seal.

Crossings should be sited so as to have clear visibility in both directions to allow a safe stopping distance for road users, relevant to the speed environment of the road (e.g. 160 m for l00 km/h designated roads). District Councils may have specific requirements for visibility distances.

Warning signs of a prescribed standard should be erected and maintained by the farmer (refer Figure 6.3-6). These should comply with current standards for colour, shape and size. Hinged signs have the advantage of only being opened when the crossing is in use.

FIGURE 6.3-6

WARNING MARKERS

FIGURE 6.3-7

OVER CROSSING CLEANING FACILITY

6.3.2.2 Cleaning over-crossings

Provision should be made for the clearing of manure, mud and debris from the over-crossing surface after use. This commonly involves washing down the road with a high pressure hose (refer to Figure 6.3-7).

The washwater should be directed to a temporary storage facility, and can then be pumped to the existing effluent treatment system at the farm dairy or applied to land.

When designing the storage facility, consider the duration of hosing and the volume of washwater produced. A stormwater diversion facility for when the crossing is not in use will ensure the storage area does not get filled with clean runoff from the road.

Rubber matting can also be used during stock crossing to protect the road from damage and avoid the need to clean the road.

6.3.3 Roadside races

Where it is not practicable to construct an internal race, a roadside race may be required (refer to Figure 6.3-8). If the road reserve or road needs to be used, then a Resource Consent or dispensation from the District Council may be needed.

The consent is likely to be for a fixed term (e.g. 1 year) and subject to conditions.

Such conditions are likely to be in line with the construction and operational recommendations given in 6.3.3.1 Roadside race construction and 6.3.3.2 Roadside race operation.

District Councils may require the roadside race and associated fencing to be removed and the flank reinstated at any time and at the farmer's expense. Notice should be given by the District Council within a timeframe set out in the permit.

FIGURE 6.3-8

A ROADSIDE RACE

6.3.3.1 Roadside race construction

The following guidelines are suggested when constructing a roadside race:

- the race should be as short as possible. The width of the race should be 3 m minimum and 5 m maximum
- electric fences or batten posts are best for roadside fences, rather than waratah standards or similar steel posts. Roadside fences should comply with any conditions set by the District Council
- the race pavement should be a hard fill
- siting must give due regard to the requirements of all road users, including pedestrians
- the fence and edge of the race should be no closer than 3 metres from the edge of the carriageway. Any closer would make it difficult for the District Council to carry out maintenance
- a road should generally have a race on one side only
- construction and use of a race should not pollute waterways
- reflective hazard markers or roadside hazard marker posts should be maintained at a minimum of 100 m intervals alongside a roadside race.

The farmer is likely to be held responsible for locating, avoiding and providing for the reinstatement of underground services and culvert drain structures.

6.3.3.2 Roadside race operation

The following guidelines are suggested when operating on the roadside race:

- stock should not be left in the race during the hours of darkness where they could create a road hazard
- if stock cross the road, then the recommendations for road crossings should be considered (refer to 6.3.2 Road over-crossings)
- give consideration to the effect of the race and stock movement on properties fronting the road in question, and where the race and subsequent stock movement are adjacent to a public place or amenity.

6.3.4 Top tips for road crossings

- **Consult with the District Council, Regional Council and Transit New Zealand at the planning stage.**
- **Site underpasses where they will not be liable to inundation or water flowing through them. Make provision for removing water that collects in the underpass.**
- **Store the water from underpasses and road over-crossing washdown in a temporary holding facility before transferring it to the effluent treatment system or applying it to land.**
- **Ensure stormwater diversion is in place on road over-crossings so that the washdown storage facility is not filled with clean road run-off when not in use.**
- **Do not leave stock in any roadside race during the hours of darkness.**

6.4 FARM RACES

Correct race construction is essential to limit stock congestion and health problems and to avoid environmental effects. Bad race design will result in a build-up of muddy areas and animal effluent, which may then be washed off into waterways. Poor up-front design will also raise lameness incidence and increase maintenance costs.

Useful information and farmer case studies can be found in the New Zealand Farm Environment Award Trust publication "Low Impact Tracks and Races."

6.4.1 Lameness

Lameness may increase culling and replacement costs, affect the body condition of cattle through the inability to graze freely, affect genetic gain due to difficulties in mating, result in increased veterinary costs, animal remedies and dumped milk, and incur extra workload.

Milk production is also affected, particularly where lameness goes unnoticed or untreated. A 20% reduction in milk production can be expected if 2 to 3 days elapse before lameness is detected, treated and cured. Milk production will decrease only 1% if the lameness is treated within 12 hours of onset.

Animal welfare issues are of concern to overseas markets. Lameness is central to animal welfare concerns, as it is avoidable through good management and design of facilities.

The degree of lameness in the herd is affected most by:

1. Race condition. Cows that are walked on well constructed and maintained races with an appropriate surface are less likely to suffer from lameness.
2. Patient handling of the herd. Cows must be walked to the farm dairy at their own pace and be able to place their feet accordingly. Pressure herding causing cows to bunch up, and herding in the dark will affect poor foot placement.

Other contributing factors include:

- pressure. The use of dogs may contribute to lameness, as may the pressure from backing gates used to push cows or top gates being too close. Bail entrance and exit design can force cows reluctantly into a milking position or make them take a sharp turn leaving the shed. Where yards are too small cows have to twist to readjust their position to find their milking order. Stray electricity can also cause problems
- weather conditions. Rainfall increases the incidence of lameness. The dampness of the ground contributes to softening of the sole and lower resistance to bruising. Also, increased water on an incorrectly designed race will erode the surface material and expose the abrasive base materials, which may damage hooves on the track and/or be carried onto the concrete surfaces
- herd hierarchy. More cows have sore feet in the spring as the hierarchical order develops. The highest incidence of lameness occurs among heifers, and among cows at the rear of the herd on the track and in the yard
- stage of lactation. Of all lame cows, 85% are likely to have been affected in the period 10 to 90 days following calving. This may be due to changes in husbandry at calving, reintroduction into the milking herd, changes in nutrition, metabolic stresses associated with calving or an association with oestrus mounting activity
- time. The amount of time a cow spends in the yard waiting to be milked will add to the stress on an animal. It is advisable to split large herds to reduce both the time in the yard and the time spent walking to the dairy
- poorly maintained foot baths. Where stones accumulate in the foot bath they can damage hooves.

If sole injuries are the most common, look at track construction and surfaces. If white line injuries are more common, look for causes of pressure in the shed or yard and pressure on the tracks. Signs that cows are under pressure include heads raised up, cows tight in yards, reversing out of tight spots or bail entrances, and legs at angles anchoring against pushing.

Lameness can become a vicious cycle, as poor track conditions can slow the herd down and make farm staff more impatient to move them on, which can result in further hoof damage.

6.4.2 Race construction

Correct race construction is essential to ensure low maintenance and avoid lameness. Races must be built using appropriate materials and shaped and drained properly.

Farm tracks in steep areas, near streams or where a lot of earthmoving is required may need a resource consent from the Regional Council.

6.4.2.1 Food Safety and Dairy Industry requirements

Food Safety Authority regulations backed by the Dairy Industry require that all farm races and yards shall be sited to minimise the risk of flooding and contamination, and shall be free-draining with no ponding of race runoff within 45 m of the farm dairy. Races must be made of concrete for a distance of 10 m from the milk storage room, milk receiving room and edges of the pit or milking platform. These concrete races must fall to a drainage point connected to the effluent system (refer to Dairying and the Environment Committee manual Managing Farm Dairy Effluent and Farm Dairy Code of Practice (NZCP1)).

6.4.2.2 Suitable materials

When deciding on suitable materials, cost and availability must be weighed up against cow comfort and durability.

In making a choice:

- ask other farmers in the area what they use and their satisfaction with those materials
- take advice from consulting officers, experienced contractors and farm advisors
- consider your herd size, distances travelled and the likely amount of use
- consider durability of surfaces, as light materials may be carried away by heavy rain.

For a base, use pit gravel, river gravel or rotten rock. Consider incorporating 15-30% clay with the gravel to hold it firmly in place.

For a wear surface, use a softer material such as crusher dust, but nothing so light that it will wash away quickly (e.g. pumice or sand).

Where hard, sharp metal is carried into concrete yards this may cause a problem with bruising of the hoof. To avoid this problem, a brittle material such as limestone, pumice or crusher dust is best used in the lead-up to the yard. A nib wall will also help remove stones from cows' hooves before they step onto the concrete.

6.4.2.3 Shaping and construction

Cow flow is interrupted by poor angles and turns and sudden changes in direction. Raceways and gates must be wide enough to permit free movement. The race must widen as it reaches the dairy as this is often a point of congestion.

Races should provide two accesses to each paddock where possible, to avoid pugging while shifting stock in winter.

Good race construction ensures a sound base - a well-compacted, crowned layer of suitable walking material. The crown must have enough gradient to ensure runoff of water without being too steeply angled to be uncomfortable for cows. A 3-5% slope is ideal, while a slope over 8% is not recommended.

Use skilled contractors to build races. Although this may seem expensive, attach a real cost to the use of your own labour and equipment and consider the relative of cost of doing a good job once vs the need for frequent re-working.

Construction involves the following (refer to Figure 6.4-1):

1. Removal of grass and topsoil.
2. Construction of a base. Ensure the base is above the water table. Lay no more than 150 mm at one time and compact it well. A filter fabric may be used under the base.
3. Crowning of the race base material for drainage and a smooth surface, leaving no puddles or holes. When grading, a grader is better than a tractor-mounted back blade.

4. Providing a suitable wearing course for cows to walk on and to prevent seepage into the base. Use at least 50 mm depth of smooth surface.
5. Providing adequate compaction. Rolling compacts the metal as it is being placed. Where cows do the compacting, lameness results; where vehicles are used, the wheels do not cover the entire race width.

Where tracks are being cut into slopes, it is best to design gentle batters or fence off steep batters to minimise erosion. Batter surfaces should be left rough to enhance revegetation, and sown with grass as soon as possible. The track width at gateways and bridges should be the same as the width of the main track.

Correct race widths are given in Table 6.4-1.

FIGURE 6.4-1

RACE SHAPE

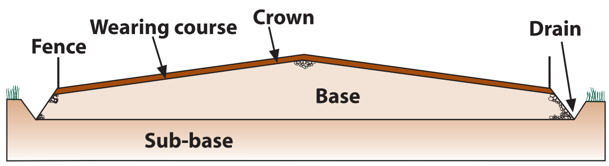


TABLE 6.4-1

RACE WIDTHS

Herd size	Race width (mm)
<120	5.0
120 - 250	5.5
250 - 350	6.0
350 - 450	6.5
>450	Variable (eg. with split herds)

Bridges, unpub; Dexcel

6.4.3 Race drainage and effluent management

Poor drainage on farm tracks can result in increased lameness.

A failure to remove water from races may also result in effluent build-up and channelling into waterways. Farm races can be a significant contributor of sediment, P and faecal pollution to waterways.

Designing the race to get water off quickly can also result in significant savings by reducing the frequency of re-metalling and drain and culvert clearing.

Race drainage is helped by shaping the race with a crown (on a flat gradient), or on easy contours with a cross slope so that water drains directly off across the track without channelling.

FIGURE 6.4-2

DIVERTING RUNOFF FROM TRACKS TO PASTURE

Source: New Zealand Farm Environment Award Trust, 2003

Pollution of waterways can be avoided by the adequate use of cut-offs, culverts and grassed water channels beside the race, directing run-off to rough grass patches or wetlands. The build-up of a lip of vegetation or sediment at the race edge should be periodically removed by spraying or chipping with a spade, so that runoff is not prevented from spilling onto pasture (refer to Figure 6.4-2).On tracks with a reasonable gradient, the New Zealand Farm Environment Award Trust estimates that the cost of installing a culvert every 150 m can be recouped in less than four years if water is kept off the track, preventing metal from washing away.

6.4.3.1 Open drains beside races

Where open drains are near to races, run off from the race should be prevented from directly entering the drain. A fence should be erected well away from the drain to prevent stock access. Consider creating a low (20 cm) bund between the race and the waterway to prevent direct runoff. Another option is to leave filter strips of rough grass to trap sediment and effluent washed off races before it gets into drains and waterways.

6.4.3.2 Effluent on concrete races

Effluent on concrete races near the yards should be directed to a collection point feeding into the treatment system. Careful contouring and a nib wall alongside the race will allow washwater to be captured when the race is hosed down. This will avoid runoff to land and ponding that may breach Regional Council rules and Food Safety Authority regulations.

6.4.4 Management considerations

Consider the following management suggestions to reduce lameness and protect races:

- be patient when moving stock
- graze heifers close to the farm dairy yard
- calve heifers earlier than the rest of the herd
- keep heavy vehicles off races where possible. Use bikes, not tractors. Keep speeds down.

Using races to stand cows off in wet weather is not recommended as this increases effluent loads on the race and results in surface deterioration and lameness problems.

6.4.5 Top tips for races

- **When considering the race layout, plan to allow stock to flow along their natural paths, and avoid steep gradients. Watch how water flows during a rainfall event to help site the track and drainage points.**
- **Create a gentle slope on approaches to gates, bridges and culverts to reduce pressure on stock and waterways.**
- **Keep water off the race to prevent lameness and minimise the need to replace race surface materials. This will also protect waterways from build-up of runoff.**
- **Crown the race to drain off water and to provide a smooth surface, and compact the metal as it is being placed 150 mm at a time. Top the race with an appropriate wear surface that is easy on cows' feet.**
- **Have plenty of cut-offs or culverts on tracks, and divert runoff away from waterways into grassy areas or wet patches.**
- **Where culverts discharge into loose fill or erodable soil, construct a flume or small concrete apron to prevent erosion.**
- **Carry a spade on the farm bike to use the time while moving stock to clean cut-offs and culvert inlets and remove shoulders on the side of the race, allowing water to flow off onto paddocks.**
- **Design gentle batters or fence off steep batters to minimise erosion. Keep batter surfaces rough to enable grass to re-establish.**

6.5 WATERWAY CROSSINGS

Where waterways are crossed regularly by stock, a permanent crossing is needed. Installing bridges or culverts where stock regularly (more than twice a week) cross a watercourse is one of the targets of the Dairying and Clean Streams Accord which is also part of the Dairy Industry Strategy for Sustainable Environmental Management. A permanent crossing will prevent stock from:

- fouling the waterway
- disturbing the streambed
- eroding the banks and damaging vegetation.

It will also have farm benefits in:

- reducing travel time on the farm
- reducing lameness and stress amongst the herd
- providing easier access when streams are running high
- improving the value of the farm.

The Dairy Industry Environmental and Animal Welfare Policies note the importance of waterway crossings and the Dairying and Clean Streams Accord aims to have crossings in place in 90% of cases by 2012 where stock cross a waterway more than twice a week.

The two options are a bridge and a culvert (refer Figure 6.5-1 and Figure 6.5-2). Bridges generally place less restriction on stream flows and are best for larger waterways. They usually have low maintenance requirements. Culverts are cheaper where stream flows are not high and streams do not carry too much sediment. However they must be appropriately sized and placed and require ongoing maintenance.

Useful information on culvert and bridge layout and siting can be found in the New Zealand Farm Environment Award Trust publication "Low Impact Tracks and Races" and in the "Clean Streams" publications that have been put out by Dexcel in conjuction with Regional Councils. The Ministry for the Environment has also published a set of guidelines on bridges and culverts.

Bridges require specific design by an experienced contractor or consulting engineer. Advice should also be sought for culvert design on appropriate size, placement and armouring, especially for larger culverts or areas of high rainfall or high erosion risk.

A resource consent may be needed for any permanent crossing - check with your Regional Council. In some cases, bridges also need a permit from the District Council or Department of Conservation (where there are piers set into the river channel).

Fords (refer to Figure 6.5-3) are no longer acceptable to Regional Councils or the dairy industry unless they are used only for the passage of vehicles and must provide a passage for fish.

FIGURE 6.5-1

A BRIDGE PROTECTS THE WATERWAY WHERE STOCK CROSS

FIGURE 6.5-2

A CULVERT IS APPROPRIATE FOR SMALLER WATERWAYS

FIGURE 6.5-3

FORD TYPE CROSSINGS

6.5.1 Bridges

Advice should be sought from the Regional Council and District Council about consent requirements. An engineer should be engaged to assist with design – check out www.envirodirect.co.nz for a listing of local consultants.

When designing, consider the following:

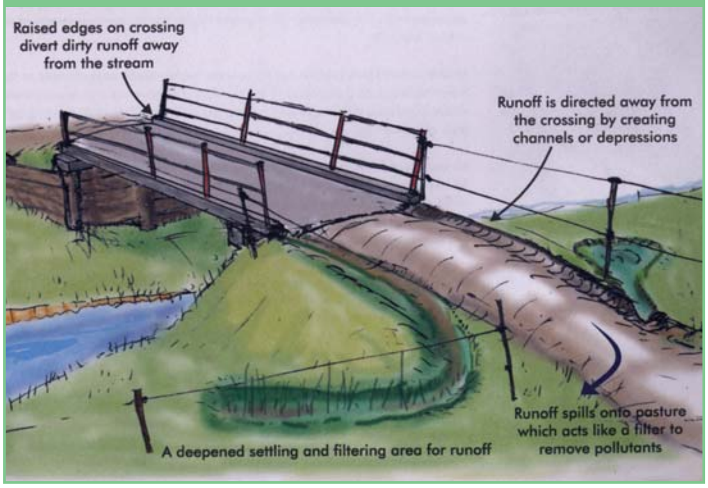
- standardised plans or pre-fabricated bridges or bridge parts can help reduce cost (refer to Figure 6.5-4)
- bridges for large dairy herds benefit from a wide deck surface
- placing the bridge at a narrow point will keep the span length down. However, avoid locating the bridge on a bend, as sediment will build up on the inside
- if possible, avoid having piers in the waterway to leave the water flow undisturbed
- construct the bridge high enough to allow for passage of high stream flows. Ensure the underside beams are at least 500 mm above the adjacent land so that debris can pass underneath when the channel is full
- raise the bridge above its approaches to reduce runoff from tracks and races reaching the bridge, but avoid any blockage of the flood plain
- build a concrete or wooden verge on the bridge to prevent effluent from flowing into the waterway
- channel runoff away from the bridge out into grassy filter areas or into adjacent paddocks, rather than straight down the bank to the stream (refer to Figure 6.5-5)
- erect signs stating weight and speed restrictions
- check the bridge regularly for any maintenance needed. Monitor the abutments for signs of erosion and check for damage to the bridge deck.

FIGURE 6.5-4

A PREFABRICATED BRIDGE

FIGURE 6.5-5

DIRECTING RUNOFF FROM BRIDGES AND BRIDGE APPROACHES FROM WATERWAYS



Source: New Zealand Farm Environment Award Trust, 2003

The costs to construct a bridge vary depending on bridge location, access to the site, the bridge span required, the expected bridge loading, abutment piling, and erosion protection. For a typical situation the costs generally range from $2,500 to $4,000 per metre span of the bridge.

6.5.2 Culverts

It is important to check with your Regional Council and District Council in the first instance to see if a resource consent is required. If you are part of a drainage scheme, check with the drainage authority before installing a culvert.

Culverts are generally cheaper to install than bridges but carry a higher maintenance cost. Culvert costs vary with the location, pipe material and the pipe size. Typical costs would be in the range of $2,500 to $25,000 depending on size and location.

When installing a culvert, the key factors to consider are size, placement to allow fish passage, spillway provision, protection from erosion, and design of the approaches. Careful consideration of these factors will save costly maintenance or replacement later.

6.5.2.1 Size

The size of culvert depends on the size of the catchment draining into that point, the intensity of rainfall expected in the locality and the slope, and to a lesser extent the vegetation cover and soil type above the culvert. The bigger the culvert, the less likelihood of problems with blockages, blowouts or erosion from over-topping. The minimum recommended culvert size is 300 mm as smaller culverts are easily blocked by only a small amount of debris. Choosing a size larger than you think is necessary will give a more robust design and less likelihood of failure with only a minor increase in up-front cost.

Check the size of culverts in similar-sized catchments and stream channels nearby to see what is working effectively. Do not install a culvert that is smaller than existing ones upstream. It is recommended that culverts have a minimum diameter of 1.2 x the channel width + 0.5 m (for culverts greater than 500 mm). For culverts less than 500mm the diameter should be 1.2 x the channel width. In some cases a multiple barrel culvert will provide better capacity than a single large culvert. For large culverts it is wise to seek advice from an engineer.

The Ministry for the Environment website has a set of culvert and bridge construction guidelines that can help you to calculate the correct culvert capacity for your local area. Go to:
www.mfe.govt.nz/publications/land/culvert-bridge-oct04

If the culvert is very long, baffles may need to be placed inside it so that fish can rest as they are swimming upstream. Seek advice from your Regional Council or Department of Conservation for simple designs.

6.5.2.2 Placement

It is critical that the floor of the culvert is set below the stream bed level to avoid a vertical drop at the downstream end (refer to Figures 6.5-6 and 6.5-7). Even a small 'waterfall' at the outlet can prevent some native fish from migrating to upstream feeding and breeding areas. 'Waterfall' outlets will also be prone to erosion of the channel below. Table 6.5-1 shows the depths at which a culvert should be buried into the stream.

FIGURE 6.5-6

EVEN A SMALL 'WATERFALL' AT THE CULVERT OUTLET CAN PREVENT FISH PASSAGE

Source: Environment Waikato

FIGURE 6.5-7

BEDDING THE CULVERT INTO THE STREAM ALLOWS FISH TO TRAVEL UPSTREAM AND REDUCES EROSION AND MAINTENANCE LATER

Source: Environment Waikato

TABLE 6.5-1

DEPTHS FOR CULVERTS TO BE SET INTO STREAMBEDS

Size of culvert	Depth to bury culvert into steambed
Less than 600 mm	75 mm
600 - 1000 mm	100 mm
1000 mm or bigger	150 mm

Ministry for the Environment, 2004

Rocks can be placed downstream of the culvert to create ponding at the culvert outlet. Alternatively rocks can be placed under existing culverts that have a 'waterfall' outlet to try and build up the bed level and allow fish access into the culvert. It is also sometimes possible to use a flexible corrugated pipe with water trickling through it as a fish pass between waterways where there is an obstruction to free passage.

Culverts should be positioned in a straight stretch of stream, with the same gradient and alignment as the stream channel.

Ideally a crossing should be placed at the narrowest point of the stream with flat approaches on either side.

6.5.2.3 Spillways

A spillway is an area to the side of the culvert where water can flow if the culvert overtops. It should be wide and level across the path of the flow, away from the fill material, and grassed to prevent scouring.

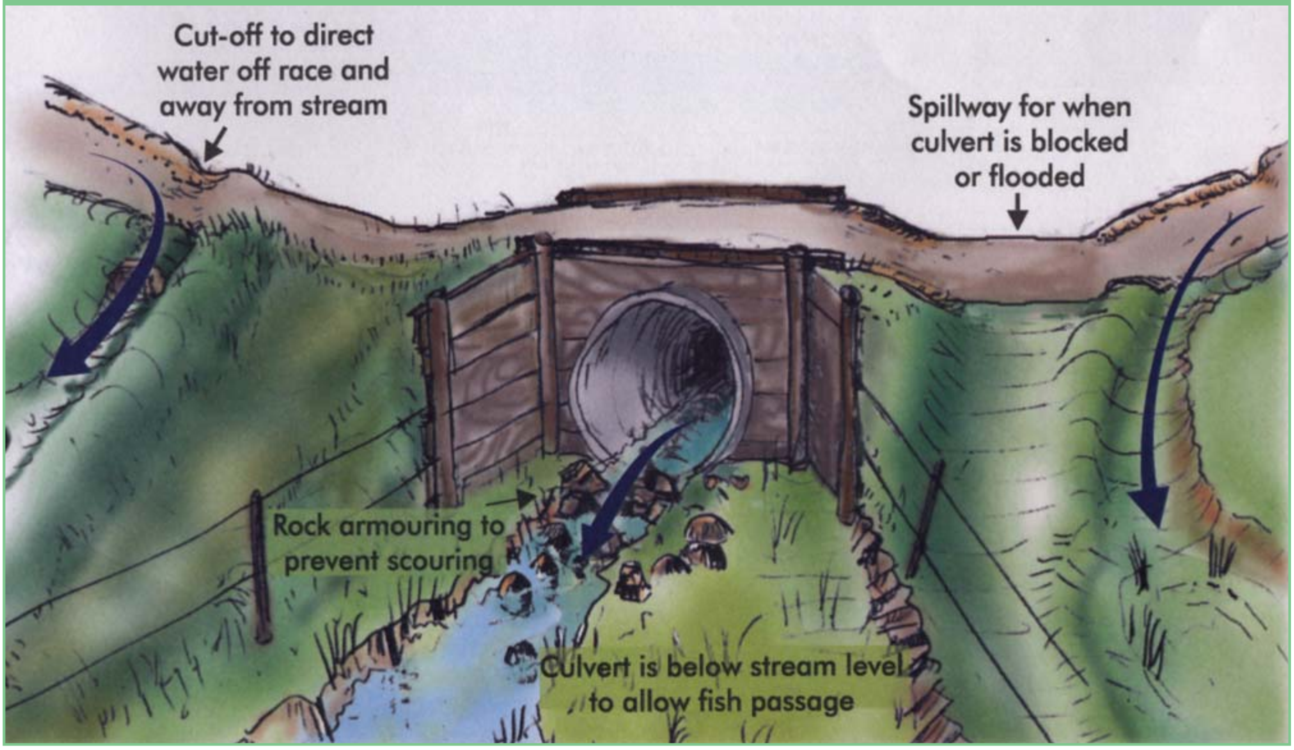
The outlet side of the spillway should be gently sloping back to the stream and may need to be rock armoured to prevent erosion.

The cost of building a spillway can be as little as an hour of extra digger time, but it can save on replacing the culvert later.

Figure 6.5-8 shows spillway placement for a culvert.

FIGURE 6.5-8

SPILLWAY PLACEMENT FOR A CULVERT



Source: New Zealand Farm Environment Award Trust, 2003

6.5.2.4 Erosion protection

Armouring materials should be used such as rocks, concrete filled sandbags or constructed headwalls around the culvert and below the outlet to prevent the loose fill from being eroded. However, be careful that large objects cannot fall in upstream and then block the culvert during high flows. A variety of headwall constructions may be suitable including pre-cast concrete, posts with timber lagging, gabions, in-situ concrete and rock. Strong headwalls are especially important where the spillway is over top of the culvert.

Fill over the culvert should be no higher than 1 m to avoid water backing up and increasing the likelihood of damage. The fill depth should be checked against the pipe manufacturer's recommendations, to ensure the pipe is capable of supporting the load. In most cases a minimum of 0.5 m of compacted material is needed above the culvert.

Clean backfill around the culvert should be compacted during construction and it is important that the bedding (the material the pipe is directly sitting in) is firm and supports the culvert.

Minimise sediment going into the stream during construction by using haybales, bunding, sediment traps or silt fences and minimising disturbance around the stream.

Laying rocks in the streambed at the culvert outlet will help prevent undermining of the culvert and improve conditions for fish to pass through the culvert. Rocks 200-300 mm in diameter will be suitable for most situations, preferably with a geotextile layer below to prevent fine material washing away and gradually eroding the area.

6.5.2.5 Approaches

Runoff from tracks leading to and from the culvert should be diverted away from the stream using cut-off drains (refer to 6.4.3 Race drainage and effluent management).

6.5.2.6 Maintenance

It is important that culvert entries and outlets are kept clear of debris. Check regularly, particularly before predicted storms and immediately after heavy rain.

6.5.3 Top tips for waterway crossings

- **Get professional engineering advice about loads, design and sizing for bridges and culverts.**
- **Check to see if a resource consent is required for your crossing.**
- **Ensure bridges have a lip on them and divert effluent from the bridge surface and approaches via cut-offs and channels into rough pasture or wet patches.**
- **Bury culverts into the streambed so that fish can pass freely upstream and to minimise erosion at the outlet.**
- **Spend a little extra on a bigger-sized culvert pipe to avoid a costly replacement job later.**
- **Build a flat, grassed spillway beside the culvert to take flows in high rainfall events.**
- **Ensure bridge abutments and culvert inlets and outlets are protected from erosive water flow by suitable armouring with durable materials.**
- **Maintain culverts regularly and check for blockages when heavy rain is predicted.**