

Underpasses for moving livestock under expressways

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Introduction

This Primefact discusses aspects of the design of livestock underpasses under expressways. It incorporates livestock behaviour and the safety of the handler as the key areas in their design.

Livestock crossings under expressways and motorways use either a boxed culvert tunnel or a fenced laneway running above the normal water line under an existing bridge or causeway.

While the following guidelines refer to the boxed culvert type of crossing, some may be relevant for fenced laneways under bridges.

Boxed culvert tunnels may be long, ranging from thirty to sixty metres in length. Existing tunnels are often equal in height and width with sides ranging from three to four metres. The tunnels may have a dual purpose by also acting as an additional culvert to allow water to pass under the road in times of flood. The tunnels are lit by natural sunlight from each end of the tunnel, sometimes in combination with one or more skylights, usually in the middle of the tunnel. The skylights in some existing tunnels also act as drains, allowing water to drain out of the median strip between the two carriageways above.

These guidelines have been developed using personal experiences of the authors, information on the behaviour and movement of livestock through conventional handling systems and information gathered as a result of inspecting ten existing underpasses (under-carriage crossings).

New boxed culvert tunnel under construction



They are relevant to the construction of under-carriage tunnels for the movement of domestic livestock, principally cattle, sheep, horses and goats. They do not refer to the movement of native fauna.

The design of the tunnel and livestock handling yards need to take into consideration livestock movement, vehicle movement and occupational health and safety of people using the tunnel.

Principles of design and livestock handling

Livestock have evolved as prey animals, and feel most safe when in large mobs in familiar surroundings. They prefer to see a wide distance in all directions and to have surrounds that enable them to move freely away from predators

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and other perceived threats. Underpasses are unnatural structures; they are dark and narrow, and untrained livestock will not move into them if they have a choice.

Livestock can be encouraged to use the tunnels through learned behaviour, livestock handling techniques (making the animal think that moving through the tunnel is less of a threat than staying where they are) or by designing handling yards at the tunnel entrances that encourage the animals into the tunnel.

Once lead animals start moving through the tunnel, most others will exhibit natural following behaviour.

If livestock have a positive experience the first time they use the tunnel, they will be more content to use it again.

Tunnel dimensions

The tunnel needs to be large enough to allow a number of animals to move side by side through it. Lead animals will encourage others to follow.

The tunnel needs to be high enough for tall animals such as horses and large cattle to comfortably walk through. It should be at least 3 metres high.

The tunnel needs to be wide enough to allow vehicle access with enough room for both the driver and passenger to get out of the doors on each side of the vehicle. This means that the tunnel should be at least 3.5 metres wide at its narrowest point. If the tunnel contains gates or safety barriers, the tunnel would need to be wide enough to allow for these. Ideally a four metre by four metre boxed culvert would be more suitable. This would also allow fire trucks and tractors to use the tunnels.

The floor of the tunnel needs to be even, firm and non slip. Rough finish concrete would be suitable.

If the tunnel is likely to receive flood water it should have a sufficient slope to prevent ponding and deposition of sediment.

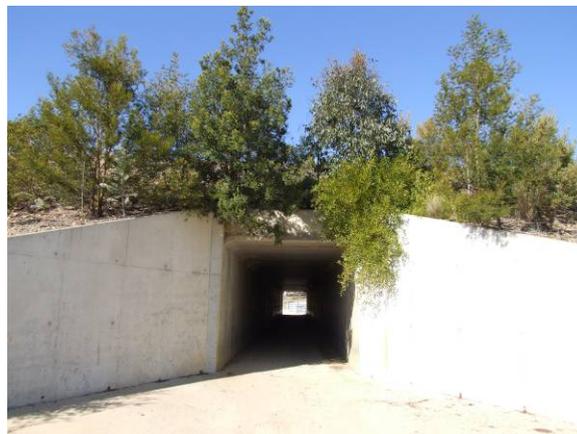
If possible, any localised runoff water should be diverted away from the tunnel floor, preferably into a separate culvert, or internal covered drain. This is to prevent unnecessary water entering the tunnel surface which will be likely to cause animals to balk.

If skylights are used to drain water from the median strip between the two carriageways, they should only do so during considerable rainfall

events. They should not be designed to drain water continuously.

Vehicle movement and noise from the carriageway are deterrents to livestock entering the tunnel. Visual and noise barriers need to be erected at either entrance. These may be natural vegetation or artificial structures.

Vegetation above tunnel entrance will reduce



visual and noise deterrents to stock entering the tunnel

Yard design

Handling yards need to be erected at both ends of the tunnel for gathering, holding and moving livestock through the tunnel. They should be positioned to run at right angles to the tunnel entrance. Tunnels can be aligned to run at a diagonal to the roadway to allow more space for locating the handling yards if required.

Tunnel positioned on the diagonal relative to



roadway

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The yards should be made up of three areas:

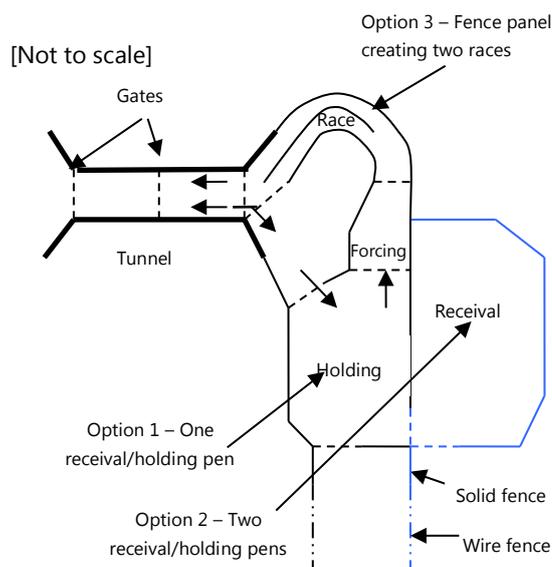
- one or two receival/holding pens
- a forcing pen to move animals into
- a curved race leading into the tunnel.

Receival/holding pens

- The receival/holding pens are the first pens the animals are mustered into from the paddock. They are the larger pens (options 1 and 2).
- They are normally rectangular but without sharp corners. The size of the first pen (the receiving pen) will depend on the size of the mob being handled.
- These pens should allow one square metre per sheep and four square metres per cow. Pens should be sized to allow one person to move the animals. Two smaller pens are often better for handling stock than one large pen.
- The entrance or gateway into the pen should be as wide as the minimum width in the tunnel. For larger receival pens a wider entrance may be more suitable.
- Animals should enter the holding pen at 90 degrees to the tunnel entrance.
- Animals should not see the tunnel until they have progressed through the forcing pen into the curved race.
- Only one side of the holding yard fence leading into the forcing pen is angled (see Figure 1, example yard design).
- The surface of the receival yard should be dirt, except in low lying areas that are likely to be boggy.
- Gravel would be more suitable than concrete. If the surface is concrete it must have a 'stencil' finish to prevent animals from slipping.

Forcing pen

- The forcing pen is designed to hold a small number of animals from the main mob (it is easier to begin to move a small mob through the race).
- The pen needs to be large enough for animals to feel comfortable to enter, but not large enough to prevent adequate pressure on the animals to move them into the race. The forcing pen may be a third to a quarter of the size of the holding pen.
- Figure 1. Example yard design



- One side of the forcing pen fence should be in line with the race entrance and the other side should be angled at 30–35 degrees to the race entrance.
- The surface of the forcing pen should be concrete or gravel.
- If the surface is concrete it must have a 'stencil' finish to prevent animals slipping over. The 'stencil' can be a diamond shape heading in the direction of the slope of the yard. This assists rainfall to remove manure and debris from its surface. Ideally the slope should be away from the tunnel entrance.

Curved race leading into the tunnel

- The race is designed to lead animals directly into the tunnel.
- It is smaller than the holding yard and as a result prevents too many animals being moved through the tunnel at once. This reduces the risk of the first animals entering the tunnel being smothered by following animals if the leaders stop.
- It should be no wider than three metres to maintain sufficient pressure for the animals to keep moving forwards.
- A fence panel running down the centre of the race in effect creates two races which may encourage forward movement as animals move side by side (option 3).
- Animals move willingly around curves and corners and will follow one another as they move around the race.

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- Generally animals want to move back towards the holding yard from where they entered. A curved race mimics this behaviour.
- The animals will move around the curved race following their escape instinct. This enthusiasm will lead them to the entrance of the tunnel.
- The light at the end of the tunnel helps to encourage the animals through the tunnel as it shows the way to escape.
- Once the animals have good experiences getting to and moving through the tunnel they are more likely to accept it in future.
- A gate hinged at the tunnel end of the race can be closed across the race which will direct livestock into the holding yards as they exit the tunnel.
- The surface of the curved race should be concrete or gravel.
- If the surface is concrete it should also have a diamond pattern. Animals move better on the flat than downhill. If the land slopes, the direction of the movement should be across the slope if possible.

Handling yard panel dimensions

The yards need to be designed to handle both small and large livestock such as sheep and cattle. Dual purpose yards pose some challenges. Materials used need to be strong enough to handle the largest of animals. Railings need to be spaced to prevent the smallest of animals escaping and to prevent larger animals getting their legs caught between railings.

- The height of the yards is 1500–1700 mm.
- The lower half of the yards (sheep height) should contain four round or curved tubular rails or cables that are spaced from the floor at 120 mm, 120 mm, 120 mm and 150 mm.
- The diameter of the rails could vary as long they are sufficiently strong to withstand a heavy beast standing on them.
- The minimum recommended diameter is 40 mm for rails and 8 mm for cable.
- In this section of the fence, *W strap* or *roadway safety railings* are *not suitable*. They contain sharp edges which may damage animals' legs that are caught between the railings. These materials would be suitable in the upper half of the yards (cattle height).

Timber is not recommended due to its higher maintenance requirement.

- Galvanised pipe or tubing with a minimum diameter of 50 mm or cable with a minimum 8 mm diameter is suitable.
- The space between the rails or cable should be no greater than 180 mm.
- Fence and gate posts should be a minimum of 75 mm in diameter and be concreted a minimum of 1200 mm into the ground.
- Fence panels in the holding or receival pens should be a maximum of 3 m wide and 2.5 m wide in the forcing pen and curved race area.

Lighting

Livestock will move more freely through well lit facilities. They can see quite well in the dark and will walk towards light but they avoid dead ends. They will balk at shadows or direct rays of sunlight containing reflective particles such as dust.

Well lit tunnels will encourage better movement. It is important to maximise the light that enters the tunnel as it will draw the animals through the tunnel.

If skylights are used for lighting it is important that the light be diffused to the ceiling and walls. Direct sunlight forms a distinct shadow on the floor, causing the animals to balk and should be avoided.

If the skylights also act as drains, the mechanism used to diffuse the light will need to be able to handle this runoff and the potential debris that it may contain.



Skylight producing direct light – this light should be diffused to stop animals balking at shadows

Risk assessment

It is important to assess the risks to the livestock and the occupational health and safety of the stockperson.

Following are some possible risks associated with these stock crossings and some solutions.

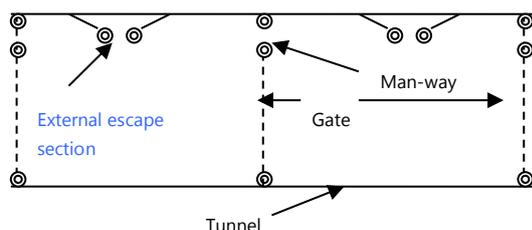
Animals turning around when they are part way through the tunnel and running back the way they came.

- Insert a gate with a quick release latch at either end of the tunnel. Once animals enter the tunnel, close the gate through which they entered.

Animals turning in the tunnel and trampling the stock person.

- In tunnels longer than 30 m, insert a gate half way along the tunnel. This gate can be closed once livestock move past. Beside the gate, insert a 'manway' to allow the stock person to get through. The recommended gap for this should be 300–450 mm, depending on design. This gate would also act as a baulk to prevent animals turning and moving back to the entrance. It is important that the gate can swing 180 degrees and be latched against the wall of the tunnel.
- Insert an external or recessed escape section with barrier every fifteen metres along the tunnel.

Figure 2. Position of gateways and manways inside the tunnel



Stockman standing fifteen metres from tunnel entrance

Vehicles breaking down and occupants unable to get out by opening the vehicle door.

- The tunnel needs to be wide enough to allow vehicle access with room for both the driver and passenger to easily get out of the doors on each side of the vehicle. This means that the tunnel should be at least 3.5 metres wide at its narrowest point. If the tunnel contains gates or safety-barriers the tunnel would need to be wider to allow for these.

Vehicle noise from expressway scaring animals as they approach the tunnel.

- Insert artificial or natural vegetation noise barriers above and on either side of the tunnel.

Riders on horseback getting injured from unexpected horse behaviour in the tunnel.

- Erect signs instructing riders to dismount before entering the tunnel.

Animals or stockmen getting caught in flood water.

- Erect signs instructing users the tunnel is a floodway and not to use it if flood conditions are likely.

Yards associated with tunnels that are located in flood ways can potentially collect debris from floodwater. This debris can cause water to bank up or be diverted in other directions, potentially causing damage to the expressway.

- Assess the risk of such events occurring and provide adequate safeguards to allow the water to get away safely.

People or animals falling from the top of the tunnel entrance.

- Install a barrier across the top and down the sides of the entrance.



Safety barrier positioned above tunnel entrance

Producer experiences

In the process of developing these guidelines, four producers were interviewed to collect their experiences using livestock crossings under expressways and motorways. The following are their comments.

Producer 1



- Boxed culvert.
- Two carriageways wide with minimum distance between.
- No skylight or artificial light.
- Curved access into tunnel on homestead side and straight entrance on the other.
- The livestock's first experience using the tunnel is generally from the curved side. As a result they generally have a good experience which makes the return journey much easier.
- Cattle are easier to move than sheep.
- Need to apply more force with sheep the first time.
- Stock need to be trained. Once they have passed through once, they generally have no real problems.

- If time allows, train stock by firstly allowing them to make their own way through the tunnel, i.e. leave them in the yard at the entrance to the tunnel.
- The forcing yard is approximately 5 m wide. It is too wide to provide sufficient force – would like it to be narrower.
- Use the tunnels frequently, so high traffic areas through gateways needed to be filled with gravel. The country gets fairly wet and boggy – recommend concrete.
- All gates are welded onto posts to prevent theft.
- Concrete needs expansion joints to prevent cracking.
- Important to have non-slip concrete similar to Wagga saleyards.
- Concern that the culvert has no guard or fence to prevent people or animals such as rabbits or other vermin falling down into tunnel entrance.

Producer 2

This producer has two big tunnels and one small one.



Big tunnels

- Two tunnels are eight metres wide by four metres high, made of corrugated steel.
- The main reason for the large size was due to restricted access issues with the property.
- There are no yards, only a laneway leading into the tunnels. This laneway is about 20 m wide.
- There are no skylights or artificial lighting.
- Once stock are trained there is no trouble getting them through the tunnels.
- Stock sometimes get scared by the traffic noise from large trucks. On a few occasions

they have taken fright and busted over the gate at the end of the lane. Cattle seem to get scared the most.

- The floor of the tunnel and laneway is gravel. Over time this gravel wears and washes making access difficult. Would recommend concreting the whole thing.
- Can drive machinery through (for example small PTO header or 100 hp tractor with implements).
- Being able to move farm machinery from one side to the other is important.



Smaller tunnel

Smaller tunnel

- Three metres by three metres.
- Boxed culvert under an off ramp (short).
- Originally had a netting yard.
- Once stock have been trained they have no problem.
- In summer, stock use it for shade.
- Can just drive 100 HP tractor through without implements. Can just get out of tractor in tunnel if drive on one side.
- Sheep tracks can divert water into tunnel. Attention needs to be given to prevent normal runoff entering tunnel.
- Tunnel also acts as floodway.
- Potential for stock to smother if trying to get large mob through tunnel at once. Need to split mob into smaller mobs.

Producer 3



- Three metres by three metres boxed culvert.
- Longest tunnel between Yass and Sydney.
- The road over it is eight lanes wide.
- Yards leading into tunnel are concrete. This is important as gravel would wash into tunnel with flood events causing animals to baulk.
- The holding yard is made of netting. It contains a large wing making it easier to get stock into holding yards.
- The holding yard is large enough for 600 – 800 sheep.
- The tunnel is used for both cattle and sheep.
- Cattle tend to baulk a little more than sheep. However, generally there is no problem getting animals through the tunnel.
- Handling pens are made of guard rail. The gaps between the guard rails are approximately 150 mm. This is important as it prevents dogs and lambs escaping through yards onto the expressway.
- There are no skylights or artificial light in the tunnel. Originally thought they would never get stock to use the tunnel. Surprisingly the stock travel quite well through the tunnel. Skylights would be a hindrance as they would cause more shadows and things for animals to baulk at. The light at the end of the tunnel is sufficient.
- It is harder to get stock through tunnel if it is raining and there is localised runoff entering tunnel. It is important that there is a drain to divert runoff into the main culvert.
- It is important that skylights do not act as drains. In wet years they would likely be running water constantly. This would greatly increase the difficulty in getting livestock through the tunnel.

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- Once you get animals started they usually travel through the tunnel quite well.
- Often drive Landcruiser through tunnel, but need to park on one side to make it easier to get out.
- UHF radio works in the tunnel.
- Tunnel not big enough for fire truck.
- Ideally would like a super span (7.2 m corrugated steel dome), or a four metre by four metre boxed culvert. This would allow enough space for a fire truck and plenty of room to get in and out of vehicles.

Producer 4



- Fenced laneway under bridge, on the high side of the creek.
- Can get all machinery through.
- Steel laneway, six metres wide.
- W strap safety railing.
- All concrete, important due to floodway.
- Stock rarely balk at bridge or noise.
- Important not to move too large a mob, as young sheep especially could be smothered if the front ones were to balk and the others kept running over the top.

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and those currently under development provided valuable background to these guidelines.

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