Rural Water Commission of Victoria

Farm Channels For Border Check Irrigation

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Farm Channels for Border Check Irrigation

It is worth taking a good look at the components of the farm channel system because large gains in the ease and speed of watering can often be obtained by the removal of bottlenecks and faults. A well-designed and well-maintained channel system is also necessary to obtain the maximum benefit from new layouts.

Head Loss

Before we look at the individual components of the farm channel system, the term "head loss" should be understood. In practice, this means a drop in the height of water flowing through a structure, or along a length of channel.

There must be some loss of head for flow to occur. This is the same as saying that water flows only downhill. However, in the flat country typical of Victoria's irrigation areas, head losses must be kept to a minimum if the farmer wishes to maximise the area of land that can be irrigated. In one extreme case of poor channel design, land that was 300 mm above the former limit could be irrigated once all unnecessary head losses in a long farm channel were eliminated.

The major cause of head loss in channels is the presence of weeds. Fast flow velocities, which are the result of steep channels or small structures, are also accompanied by large losses.

A channel structure (culvert, channel check, or bay outlet) with a large opening and slow flow causes less head loss than one with a small opening and fast flow. As water flows through a structure, a visible step down in the water surface, coupled with turbulence, usually indicates that the opening is too small for the flow; this means an excessive head loss. The water backs up on the upstream side of the structure, and this may cause it to overtop the banks. If the backing up extends right back to the meter outlet, the rate of flow will be reduced, causing the meter wheel to slow down.

As water passes through a restrictive structure it speeds up, and energy is released when the water slows down again. This usually causes turbulence, which can undermine structures and erode channel banks. It is therefore important to protect structures and banks by the appropriate placement of rocks, bricks, or stones.

The Dethridge Meter

Most properties in Victoria's irrigation areas are supplied by a Dethridge meter outlet. In the past, two sizes have been used, "Large" and "Small", depending on the flow rate required (See Table 1).

A recent development is the Dethridge-Long meter, which is a much improved (hydraulically) modification of the Dethridge meter. Each type requires a head loss, to operate as a measuring device (Figure 1). However, the more efficient Dethridge-Long meter requires less head loss, delivering up to twice the flow as the conventional Dethridge meter at a given head loss. Alternatively, it has less than half the head loss, at a given flow rate within the Dethridge meter range (see Table 1).

While the conventional Dethridge meter will remain for many years as the most common meter wheel, the Dethridge-Long meter is attractive where higher flows are desired, or where minimum head loss is required. It is available now for such situations.

TABLE 1 - OPERATING DETAILS FOR METER WHEELS								
	Dethridge - Long Meter				Dethridge Meter			
	Large		Small		Large		Small	
Standard Supply Depth (mm)	380		200		380		305	
Wheel Speed r.p.m.	Flow ML/d	Head loss mm	Flow ML/d	Head loss mm	Flow ML/d	Head loss mm	Flow ML/d	Head loss mm
3	3.8	4			3.4	12	1.6	16
4	5.0	6			4.5	18	2.2	20
5	6.3	10	0.8	5	5.8	27	2.7	25
6	7.6	14			6.9	38	3.2	32
7	8.8	17			8.0	51	3.7	38
8	10.0	19			9.2	68	4.3	50
9	11.3	21			10.3	84	4.8	64
10	12.5	25	1.7	10	11.5	110	5.3	80
12	15.1	35	2.0	14				
14	17.6	50	2.4	18				
16	20.0	75	2.6	23				
20			3.4	42				
24			4.1	160				

Notes:

1. The flow and head loss details apply for the standard supply depths given, with the meter outlet door fully open. Varying the supply depth may alter the flow conditions signficantly. The flow may be regulated by partically closing the meter outlet door, effecticely reducing the supply depth.

2. The head loss figures shown correspond to the maximum tailwater level possible to achieve the flow at that supply depth.

3. The small Dethridge-Long meter is available with a pipe approach which has higher losses than the figures shown for the open channel approach.

Where a flow of 10 ML/d (for example) is required through a conventional Dethridge meter, a head loss of 80 mm is needed. To achieve this, the farm channel system must operate so that the tailwater level (the farm channel running level immediately below the meter wheel) does not rise above the maximum level for that head loss (180 mm over the "lip" of the meter emplacement for this sized meter). If it does, the flow rate and the meter wheel will slow.

Hence, the head loss through the meter wheel, and more particularly, the Commission channel SUPPLY LEVEL, is critical to efficient operation of the farm irrigation system. Where a new layout is being designed, the Supply Level should be obtained from the Water Commission's District Manager. This determines the highest land that can be irrigated from that particular meter outlet.

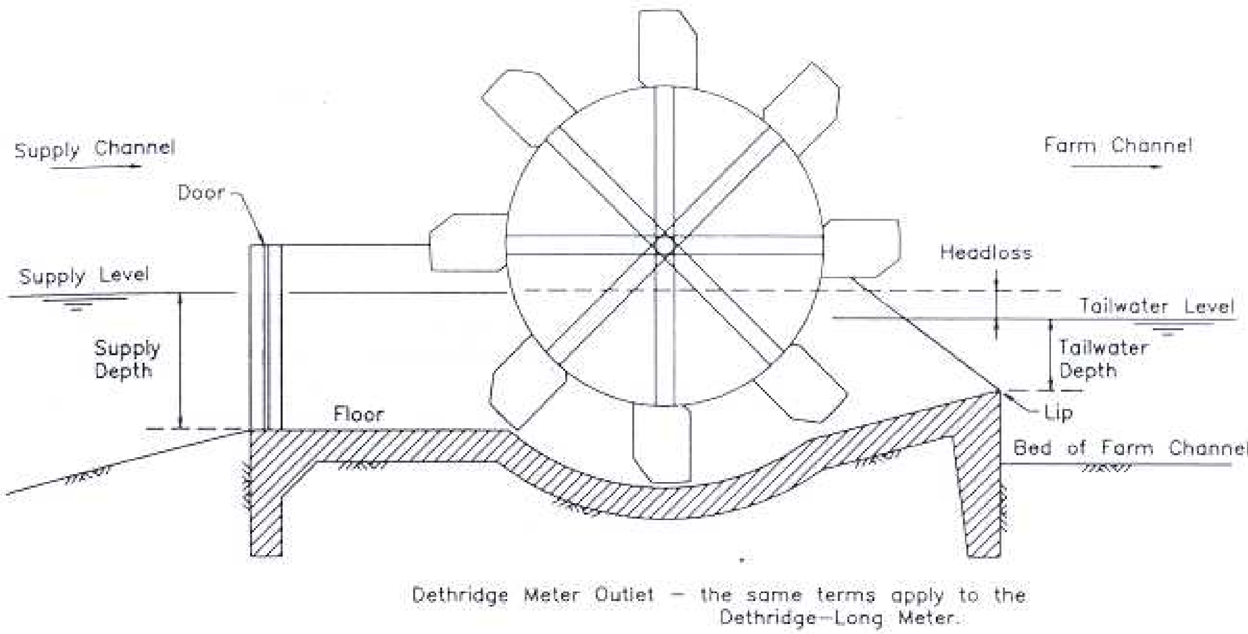

Figure 1. Dethridge Meter Outlet

Commanded Land

If land is to be watered by gravity, then the source of the water must be higher than the land. The Water Commission has specified that the highest land to be irrigated ("commanded") must be at least 150 mm lower than the Supply Level in the Commission channel. Away from the meter outlet, this command level is lowered at a slope of 0.01 per cent (1:10 000), plus head losses through any structures. This is equivalent to a vertical drop of 10 mm every 100 m horizontal distance, with additional drops to allow for the head loss through any culverts or checks.

A new irrigation layout is an opportunity to increase irrigation efficiency by using extra head to obtain higher flows, or to increase the area of irrigable land by minimising head losses.

Alternatively, even minor earthmoving could result in commanded land becoming uncommanded. Again, it is extremely important to find out the Supply Level in the Commission channel from the District Manager. It would be disastrous (and embarrassing!) to spend thousands of dollars on earthmoving only to find that the resulting layout could not be irrigated properly.

The Commission specification of commanded land is 150 mm or more below the Supply Level. This figure is the absolute minimum. For a new layout, the highest bay level should be no less than 220 mm (preferably 250 mm) below the Commission Supply Level. This allows for a head loss of 80 mm through a large meter outlet at 10 ML/d, with a further 40 mm head loss through the bay outlet and 100 mm depth of flow on the bay.

In marginal command situations, a flow of 5 or 6 ML/d and very wide bay outlets (2 m or 2 x 1 m), with relatively low head loss could be tolerated. In this case, the highest bay level could be 180 mm below the Commission Supply Level. Attempting to irrigate land at the official maximum command level of 150 mm below Supply Level usually results in slow irrigation, with supply flows of 3 to 5 ML/d and depths of flow on the bay of 60-70 mm. This may be acceptable on very small bays, but it is hardly acceptable for a modern layout.

An alternative is to install a Dethridge-Long meter wheel. At 10 ML/d, it has a head loss of slightly less than 20 mm. This saving in head loss over the standard Dethridge meter wheel may enable reasonably efficient irrigation of marginally commanded land.

Remember, the recommended figure of 220 mm below Supply Level for the command level must be increased to allow for head loss in the channel and for any structures between the meter wheel and the land to be irrigated.

In many cases, the Commission channel often runs at a slightly higher level (perhaps up to 100 mm higher) than the official Supply Level. This level may be apparent as a "high water mark" on the headwall of the meter outlet. Previously, this has provided a safety margin for some poorly designed systems.However, it is strongly recommended that farmers and designers of channel systems do not rely on assuming levels other than the Supply Level provided by the Commission. The Commission cannot guarantee supply above the Supply Level. Relying on higher levels, even if the channel has commonly been run at a higher level, is quite risky. The channel may not be run at that level in future.

The Channel

The size of the channel required depends on:

- The flow to be carried;
- The grade or slope of it (or the head loss available between the supply point and the area to be irrigated);
- The "roughness" of the surface of the channel bed and batters (in practice, the amount of weed growth).

The size of relatively flat channels supplying marginally commanded land is often crucial, because the head loss has to be kept to a minimum.

Flow

This is determined by the flow available from the meter outlet, or the capacity of a pump, or the flow rate available from a dam.

Slope

- The flattest practicable slope is 0.01 per cent (1:10 000).
- If the required head is available, 0.02 per cent (1:5000) is preferable, so the channel can drain out better.
- For short sections of channel, 0.03 or 0.04 per cent (1:3333 or 1:2500) may be used.
- Slopes as steep as 0.1 per cent (1:1000) should rarely be used and only when the soil is suitable. The high velocity of flow occurring in steeper channels will erode many soils. Drop structures (channel checks or modified channel checks) will be necessary to reduce velocities.

Generally, channels should be constructed on a relatively flat grade to minimise the number of channel checks (and hence the cost).

On flat land, the number of channel checks should also be minimised, in order to reduce head losses.

Dimensions

Table 2 gives recommended channel dimensions for common flow rates at slopes of 0.01 per cent (1:10000) and 0.02 per cent (1:5000). Figure 2 explains the terms used in Table 2 and Table 2a.

A steeper slope will result in a shallower depth of flow at the given flow rate. Alternatively, a steeper channel would carry a greater flow at a given depth of flow. For example, the 5 ML/d channel in Table 2 could carry up to 10 ML/d at a slope of 0.04 per cent (1:2500).

TABLE 2 - RECOMMENDED CHANNEL DIMENSIONS						
Flow ML/d	Slope		Bed Width m	Top of Pad Width m	Flow Depth (above bed) m	Pad depth below design water level m
	1:x	Percent				
5	5000	0.02	1.2	4.4	0.28	0.07
	10000	0.01	1.2	4.7	0.33	0.10
10	5000	0.02	1.5	5.3	0.37	0.13
	10000	0.01	2.0	6.0	0.39	0.16
15	5000	0.02	2.0	6.6	0.40	0.11
	10000	0.01	2.0	7.1	0.48	0.15
20	5000	0.02	2.5	7.3	0.42	0.14
	10000	0.01	3.0	8.2	0.47	0.18

Notes: These dimensions apply for the following conditions:

a) There is only a small amount of weed growth (Manning's n = 0.04)

b) The slope of the batters is 1:2 (vertical:horizontal).

c) Freeboard after consolidation is 0.15 m for flows up to 10 ML/d, and 0.25 m for larger flows.

d) The crest width of the consolidated bank is 0.3 m. Wider banks (with wider crests) are recommended for elevated channels (see Table 2a).

TABLE 2a : MINIMUM CHANNEL BANK CREST WIDTHS	
Height of water level above ground level (not top of pad) (m)	Minimum bank Crest Width (m)
Less than 0.3	0.3
0.3 - 0.5	0.5
0.5 - 1.0	0.9

Even wider banks (with wider crests) are desirable where soils of marginal stability are used.

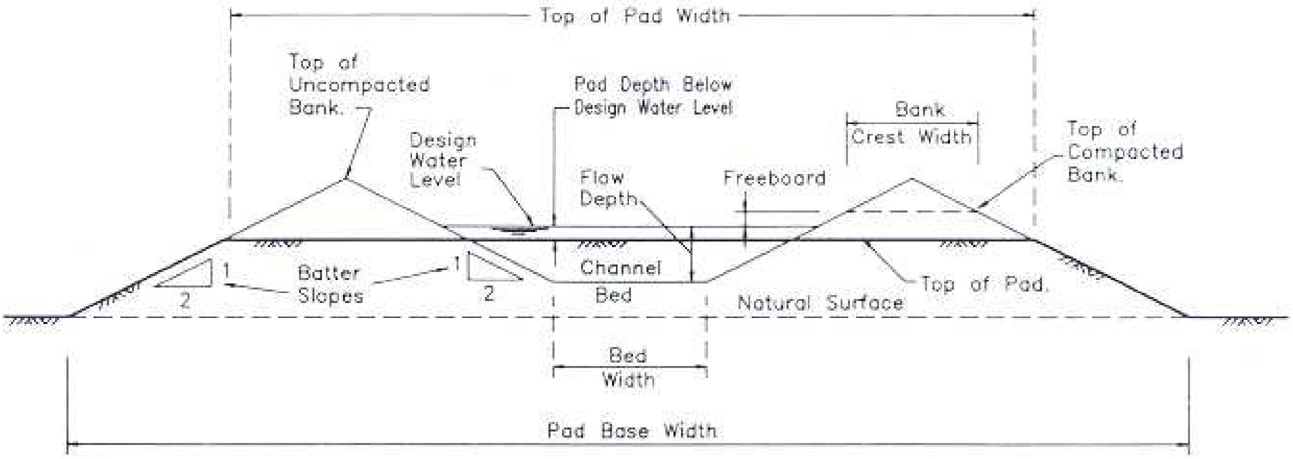

Figure 2. Construction of Channel on a Pad

Weed Control

Table 2 assumes that there is a small amount of weed growth in the channel. More weed growth would increase the depth of flow at a given flow rate. With excessive weed growth, the channel would not be able to carry that flow rate. Weed control by chemical or mechanical means is essential maintenance.

Large channels minimise the effect of weed growth, and allow the occasional use of a tractor to control weed growth by slashing or cultivating. However, flow depths of less than 0.3 m should not be adopted, even with wide channels. Small amounts of weed growth on the bed restrict shallow flow depths severely. An exception is where a steep channel is required. A wide, grassed channel may be appropriate to avoid erosion.

Construction

Channels can be formed by:

- a "Mile-a-day" channel former attached behind a tractor or in front of a bulldozer;
- a road grader;
- a hydraulic excavator.

Each machine has its advantages and disadvantages. Generally, a road grader is preferred as it can build a range of sizes, is relatively quick and compacts the banks. Whichever machine is used, it should be laser-controlled for accurate grade and level control.

Channel Pads

To achieve the desired slope and level of a channel, it is usually necessary to first construct an embankment or channel pad, upon which the channel is then formed. Channel pads are usually constructed by elevating scrapers, although "carry-graders", more commonly used for laser grading, are sometimes used. Particularly if a carry-grader is used, care should be taken to avoid excessive powdering of the earth for the pad.

The top of the pad should be laser-graded before the channel is formed. Even where the existing surface is apparently at the appropriate level and slope, it should be laser-graded before forming the channel, which should also be done under laser control. Some excavation may be necessary where the required pad level is lower than the natural surface. Remember, the aim is to provide a uniform slope for the finished channel.

The top of the pad is constructed at the same slope as that required on the completed channel. The level of the top of the pad relative to the design water level, and the width of the top of the pad, vary with the dimensions of the channel. That is, they depend on the channel bed width, the bank crest width, the batter slope, the flow depth and freeboard required. Table 2 gives the top of pad level relative to design water level, and the top of pad width for a range of channels. Table 2a gives the minimum bank crest widths required for various design water level depths above the ground surface. Figure 2 illustrates these terms.

Remember, the aim is to achieve a particular design water level and channel cross-section. The design water level is higher than the top of the channel pad because of the method of construction of the channel on the pad. Earth is taken from the centre of the pad and placed on the sides, thus building up the banks of the channel to a level higher than the original top of the pad (see Figure 2).

Table 3 gives the total pad width and volumes of earth required to construct a typical channel to various heights. Where different sized channels are required, advice should be sought about appropriate dimensions for pads.

TABLE 3 - VOLUMES OF EARTH FOR CHANNEL PADS

Water Level above natural surface m	Top of Pad above natural surface m	Bank Crest (Table 2a) m	Top of Pad Width m	Pad Base Width m	Volume Per m length (see Note 2) cubic m
0.2	0.04	0.3	6.0	6.2	0.24
0.4	0.26	0.5	6.3	7.3	1.80
0.6	0.48	0.9	7.0	8.9	3.80
0.8	0.68	0.9	7.0	9.7	5.70
1.0	0.88	0.9	7.0	10.5	7.7

Notes:

1. These dimensions apply precisely to a channel with 2.0m bed and a running depth of 0.4m, with freeboard of 0.15m and 2:1 batters. Such a channel could carry 10 ML/d at a slope of 1:10,000 (Table 2).

2. The volume is the final volume of the pad. Compaction must be allowed for in the earth brought in. 30% compaction is commonly assumed. Hence, for a pad containing 100 cubic metres, 130 cubic metres of borrow are required.

While the dimensions in Tables 2 and 3 are precise, in practice such precise dimensions are rarely achieved. In practice, it may be desirable to build the pad perhaps 5 cm higher than designed, which will result in slightly larger channel banks. It is preferable to err on the generous side, if anything.

However, it is desirable to be fairly precise with the level, slope and width of the bed of the finished channel, particularly where command is marginal.

The channel should be drained between irrigations, to minimise weed and yabby problems. Ideally this would be done by emptying the channel onto the last bay to be irrigated. To do this, the bed of the channel would have to be higher than the lowest bay level. Generally, it is not practical to have the channel bed higher than the bay surface because of the earthworks required to construct the pad. In marginal command situations, it is not possible. If it is not possible to have the channel bed above the bay surface for one or two bays at least, then it may be possible to drain the channel after irrigation into a drain, preferably one that will take the water to a drainage re-use system.

The channel should be designed to provide the desired command level. A higher channel is normally only required to cross low ground. Where automatic irrigation is required, there may be special design requirements.

Soils

In silty or dispersive soils, or cracking clays, the width of channel banks and pads should be increased over the dimensions shown in Table 2a. The crest width should be perhaps 1.2 m and the batter slopes 1:3; this will significantly increase the overall width of the channel and pad, and the volume of earth required.

Topsoil should be stripped before dumping the pad, especially if the finished channel section will intersect the topsoil.

Topsoil should not be used to construct the channel pad, but it may be desirable to line the completed channel with topsoil, particularly if the clay subsoils are prone to cracking and/or dispersion. A channel constructed on a pad composed mainly of topsoil is likely to seep excessively. Lining the channel with perhaps 20 cm of topsoil should prevent drying out and cracking of clay, and so avoid failure of the channel. Alternatively, lining a failure-prone channel with road making gravel has been successful. There is enough clay to seal, but the stone content results in minimal shrinkage.

Good compaction of channel pads and channel banks is desirable, particularly where soils are suspect. This is best achieved with moist (not sticky) soil. Usually, the weight of a scraper achieves good compaction of the pad. Forming the channel by road grader usually achieves good compaction of the channel bank, by running the wheel of the grader along it.

Where high channel pads are required, or the soil is suspect, advice should be sought.

Channel management

The initial filling of a new channel should be done over several days, to allow the soil to wet up slowly and consolidate. Rapid filling may result in bank failure.

Channels should be fenced off to exclude stock, particularly with new, unconsolidated channels. In particular, mature cattle can cause a lot of damage. Once the channel banks are consolidated, young cattle or sheep may help control weed growth. However, it is still desirable to control their access to the channel, to minimise wear and the resulting maintenance requirements. Stock access to channels can only be restricted if an alternative stock watering supply is available, such as stock troughs.

Channel Structures

Culverts

Culverts are required for stock and machinery access, and may also be used where a channel must be taken under a drain.

To minimise head loss, culverts should be of adequate capacity (Table 4) and should be installed so that water flows smoothly into and out of them, as shown in Figures 3 and 4.

TABLE 4 - CULVERT DIAMETER

Flow ML/d	Pipe Diameter mm		
	Low Head loss (10-20 mm)	Typical Head loss (25-40 mm)	High Head loss (60 -80 mm)
5	450	380	300
10	600	525	450
15	680	600	525
20	760	680	600

Notes:

1. These conditions apply for culverts up to 8 m long.
2. Two parallel pipes can effectively carry twice the flow.
3. The culvert should be installed so that both ends are submerged when the water is flowing.

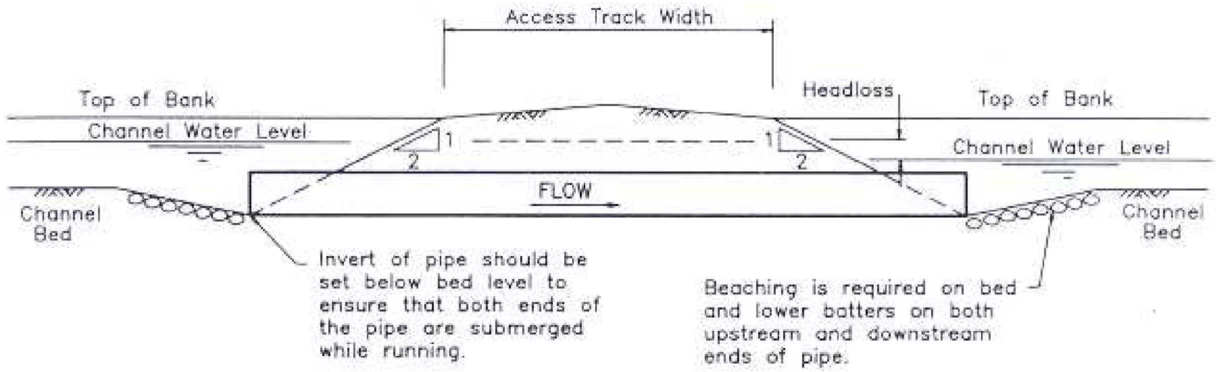

Figure 3. Pipe Culvert (no headwalls)

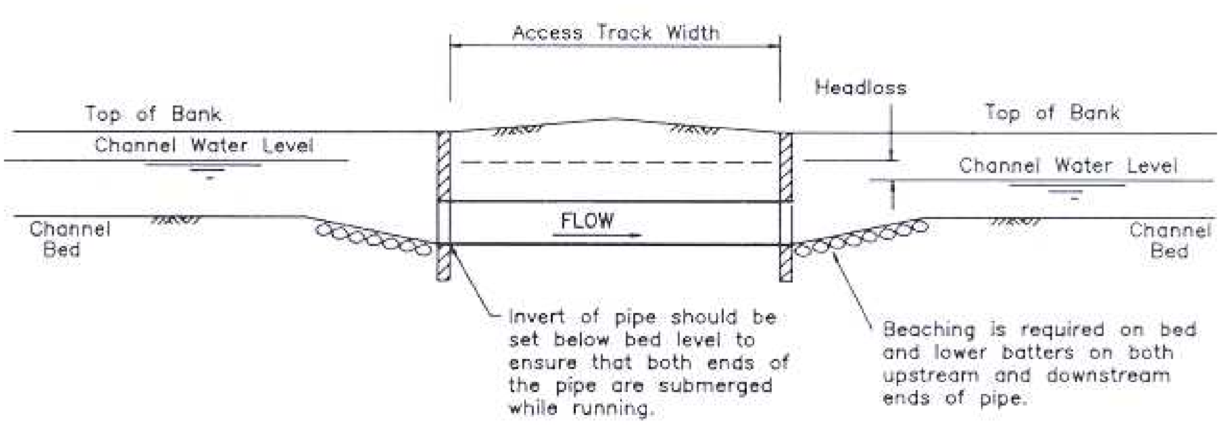

Figure 4. Pipe Culvert (with headwalls)

Note that culverts need to be set some depth into the bed of a typical farm channel, so that they are submerged by at least 50 mm when the water is flowing. On installation, the channel bed should be graded out from either end of the pipe to minimise the amount of silt that will be deposited in the pipe, thereby restricting the capacity of it. After some time of operation, it may be necessary to clean out such culverts if their cross-sectional area is reduced by more than say 10 per cent.

Concrete headwalls should be constructed at each end of culverts, so that the full length of the culvert can be utilised without slumping or erosion at the ends.

Where culverts are significantly longer than the 8 metres for which Table 4 is applicable, additional head loss will occur. Concrete pipes are supplied in 2.44 metre lengths. While pipes can be cut, 4.88 metres is recommended as the minimum length of a culvert (that is, two pipe lengths) where headwalls are used. Longer culverts are recommended where no headwalls are used, or particular access requirements exist. There is very little head loss to be saved by having shorter culverts.

For operating conditions not covered in Table 4, advice should be sought.

Where it is desirable to have even less head loss than that shown in Table 4, a clear-span bridge may be more economical than larger pipes. A clear-span bridge obviously incurs no head loss penalty.

Channel Checks

Channel checks are used to control the flow of water, and as drop structures when the required water level between two sections of channel is different. The head loss through channel checks depends on the depth of flow as well as the width of the opening. The widths given in Table 5 are for typical depths of flow. See also Figure 5.

A wide range of prefabricated concrete and steel channel structures are available. Alternatively, concrete structures can be poured on-site. These are often preferred, particularly for larger channels, as they are less prone to leakage around them.

Care should be taken in installing structures. Inadequate dimensions, or poor compaction of the backfill material could result in leakage or "washing out". This would make the structure unstable or even render it useless, if the water ran around the outside of it instead of passing through it.

The sills of channel checks should be set at the bed level of the channel to enable it to drain out completely.

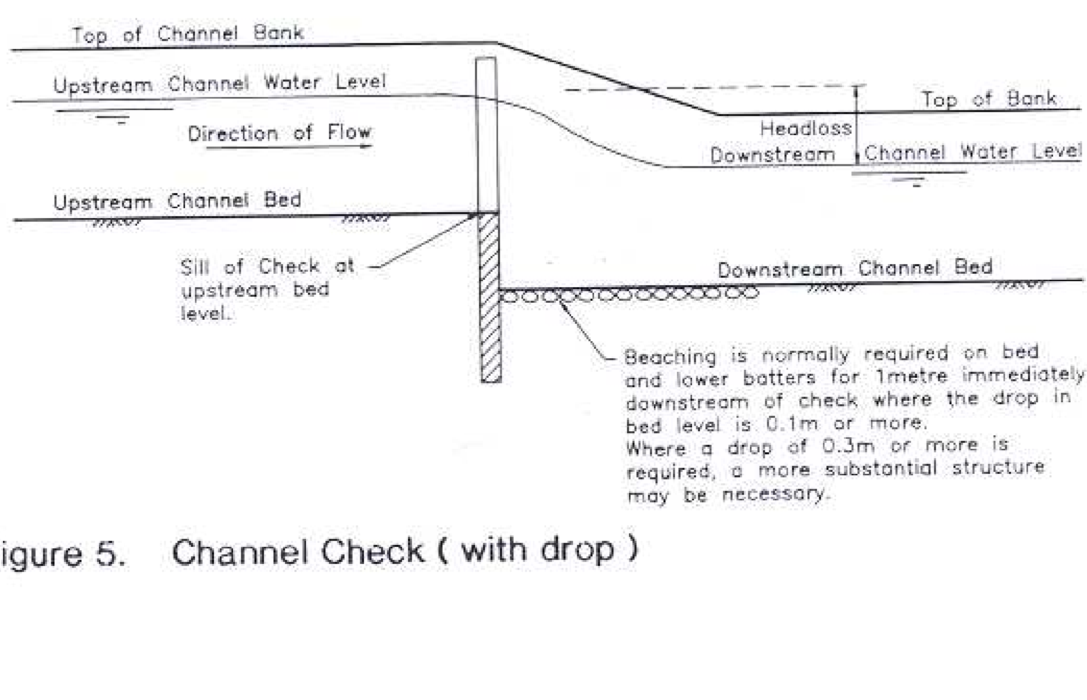

Figure 5. Channel Check (with drop)

Channel checks are often combined with culverts. The combined structure is cheaper to construct, and incurs less head loss than two separate structures. Prefabricated pipe ends with doors fitted may be appropriate.

Where a drop in the channel bed level of 10 cm or more occurs, beaching may be necessary to prevent excessive erosion.

TABLE 5 - WIDTH OF DOOR OPENING FOR CHANNEL CHECKS

Channel Flow Rate ML/d	Depth of Flow m	Width of Opening m		
		Low Head Loss (10-20 mm)	Typical Head Loss (25-40 mm)	High Head Loss (60-80 mm)
5	0.3	0.6	0.45	0.35
10	0.4	0.8	0.6	0.45
15	0.5	1.0	0.8	0.55
20	0.5	1.2	1.0	0.75

Notes:

1. The door must be fully open, and the sill must be at the upstream bed level.

2. To obtain the minimum height of door, add 0.1 m freeboard to the depth-of-flow figure. While 0.15 m freeboard is recommended for channel banks, 0.1 m is acceptable for structures, which are much less prone to damage or wearing down. For larger channels where 0.25 m of bank freeboard is required, 0.2 m of freeboard is appropriate for structures.

Bay Outlets

Bay outlets control the flow of water onto the bay. There are three main types: pipes, doors (or weirs) and siphons. See Figures 6, 7, 8 and 9.

The choice between doors and pipes is sometimes a personal one, but also depends on cost and the head of water available over the bay. Generally, where the available head over the bay is limited, doors are preferable, and cheaper than the equivalent pipes and fittings required. For higher heads, where some head loss is even desirable, pipes are preferred and cheaper (at the smaller sizes).

In dispersive soils where washing out of outlets is likely, a well-installed door-type outlet is probably safer than a pipe, where "tunnelling" beside the pipe can occur after the bank has dried out and shrunk away from the pipe. A concrete cut-off wall or "collar" can help overcome this where pipes are required.

The installation of pipe outlets is an attractive option where a laneway is desired beside the channel. Pipes through a combined channel bank-laneway make access to the upper end of the bays simple. With doors, access is only possible over the channel, by culvert or bridge, or at the lower end of the bay.

Siphons are not recommended in permanent systems because of the labour required to operate them. However, they can be attractive for furrow irrigation, or where irrigation from a new unconsolidated channel is required.

Pipes and siphons should be set so that both ends are submerged when the water is flowing. This will minimise head loss.

Size of Outlets

The size of the outlet is determined by the head available (after the channel has been designed), and the flow rate required, which is determined from the bay design. See Tables 6, 7, 8 and 9 for recommended dimensions, and Figures 6, 7, 8 and 9 for illustrations of the terms used.

The available head loss through the outlet will vary with the depth of water (or depth of flow) on the bay. This depth depends on the flow rate, the slope of the bay and the height and density of the crop or pasture on the bay. It can vary from 50 to 150 mm, but is commonly between 80 and 120 mm. Such variation has most effect on flow through the outlet where limited head is available.

Where conditions outside those given in Tables 6, 7, 8 and 9 occur, advice should be sought. Similarly, where automation is planned, advice should be sought.

Design Water Level

The "design water level" at various points along the channel system can be calculated, given the Supply Level and allowing for the various head losses.

Where the Supply Level limits the area of land which can be irrigated, the aim is to keep the design water level as high as possible by minimising head losses. Where command is not limiting, the aim should be to maintain design water levels so that the available head over the bay is perhaps 0.20 m.

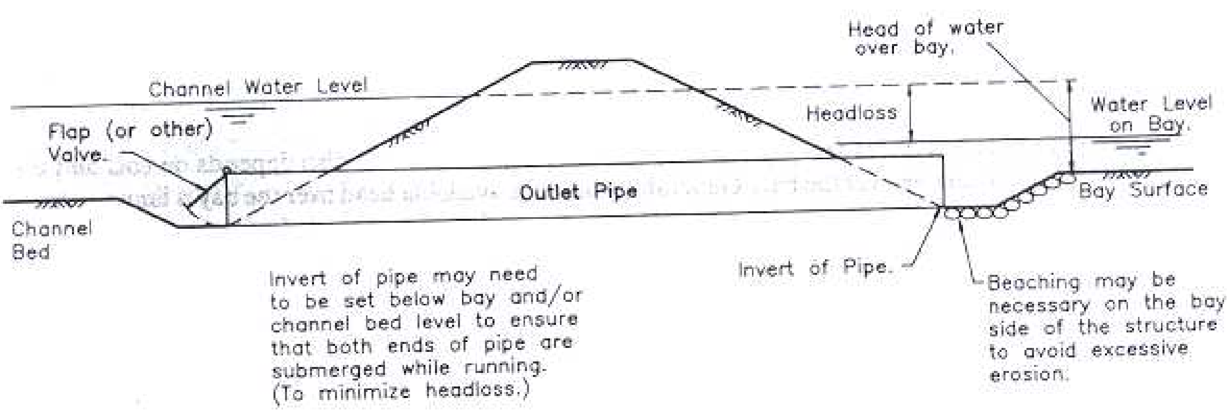

Figure 6. Pipe Outlet

TABLE 6 - PIPE OUTLET SIZE				
Head of water over the bay (m)	Pipe Diameter (mm)			
	Flow ML/d			
	5	10	15	20
0.12 - 0.14	1 x 380 or	1 x 525 or	1 x 600 or	2 x 525 or
(Low head loss	2 x 300	2 x 380 or	2 x 450	3 x 450
- 20-40 mm)		3 x 300	3 x 380	
0.15 - 0.20	1 x 300 or	1 x 380 or	1 x 525 or	1 x 600 or
(Typical head loss	2 x 225 or	2 x 300 or	2 x 300 or	2 x 450
- 50-100 mm)	4 x 150	4 x 225	3 x 300	3 x 380
0.21-0.30	1 x 300 * or	1 x 380 * or	1 x 450 * or	1 x 525 or
(High head loss	2 x 225 or	2 x 300 or	2 x 300	2 x 380
- 110-200 mm)	3 x 150	3 x 225		3 x 300
> 0.30	1 x 225 or	1 x 380 or	1 x 380 or	1 x 450 or
(High head loss	2 x 150	2 x 225	2 x 300	2 x 380
- > 200 mm)			3 x 225	3 x 300

* Commonly Used.

Notes:

1. The table assumes a depth of flow on the bay of 100 mm. Where deeper flows on the bay are expected, advice should be sought. Flow depths may be greater than 100 mm with relatively flat slopes, dense pasture and/or high flow rates. Varying the depth of flow will have most effect where limited head is available.

2. Pipes should be set so that both ends are submerged, for minimum head loss conditions. For example, a 380 mm pipe should be set with the invert of the pipe 280 mm or more below the surface of the bay, with 100 mm depth of flow on the bay.

3. Where a flow of 2.5 ML/d is required, use one pipe of 300mm diameter (instead of 2 x 300mm) for low head loss, or 1 x 225mm (instead of 2 x 225mm) for typical head loss.

TABLE 7 - DOOR OUTLET SIZES				
Head of water over the bay (m)	Total Sill Width m			
	Flow ML/d			
	5 ML/d	10 ML/d	15 ML/d	20 ML/d
0.12 - 0.14		2.5	4.0	5.0
(Low head loss	1.2	eg. 2 x 1.2	eg. 3 x 1.2	eg. 4 x 1.2
- 20-40 mm)				
0.15 - 0.20	0.7	1.5	2.0	3.0
(Typical head loss		eg. 2 x 0.7	eg. 2 x 1.0	eg. 3 x 1.0
- 50-100 mm)				
Commonly Used	0.6	1.2	1.2	1.8
0.21-0.25				
(High head loss	0.45	0.9	1.2	1.8
- 110- 150 mm)				eg. 2 x 0.9
> 0.25	0.45	0.6	0.9	1.2
(High head loss				
- > 150 mm)				

Notes:

1. The sill widths given assume a depth of flow on the bay of 100 mm. Where deeper flows on the bay are expected, advice should be sought. Flows deeper than 100 mm may occur on relatively flat bays, with dense pasture and/or high flow rates. Variation in the depth of flow on the bay has most effect where limited head is available.

2. This assumes that the sill level is set at or below bay level, and that the channel bed level is at or below bay level.

3. The total sill width can be made up by a number of sills whose total width approximates the figure given. Eg. 2 x 0.9m = 1.8m.

4. The depth of door required is given by adding the required freeboard to the head-of-water-over-the-bay figure (where the sill is at bay level). (0.10 m for structures in channels of up to 10ML/d capacity, 0.20m for up to 20ML/d).

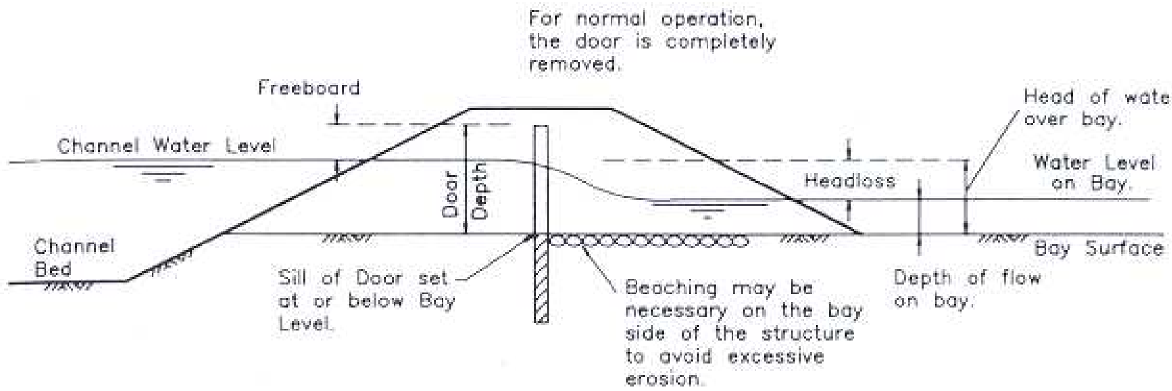

Figure 7. Door Outlet

TABLE 8 - SILL WIDTHS FOR FREE OVERFALL				
Head over the sill (m)	Total Sill Width (m) Flow			
	5 ML/d	10 ML/d	15 ML/d	20 ML/d
.02	11			
.04	4	8		
.06	2	4	6.5	8.5
.10	1.0	2.0	3.0	4.0
.15	0.5	1.1	1.6	2.2

Note:

1. "Free overfall" occurs where the sill level is above the depth of flow on the bay; not "drowned" as in Table 7. Hence, the sill should be 100 mm or more above bay level where 100 mm depth of flow occurs.

2. Where automation by channel level control is required, the minimum sill elevation difference between subsequent sections is the head over the sill figure used, plus head loss through any structures, and an allowance for head loss along the channel. The minimum practical difference between sections is 100 mm.

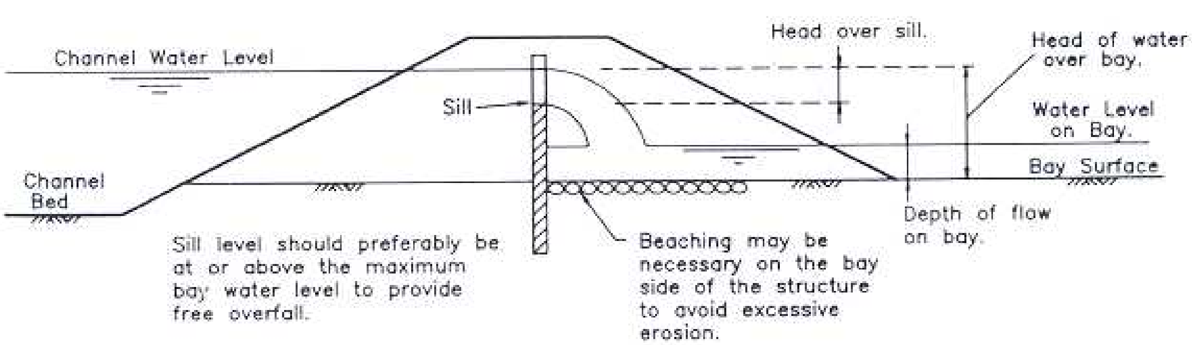

Figure 8. Sill Outlet

Head (m)	TABLE 9 - SIPHON SIZE				
	Number of siphons for 10 ML/d				
	Pipe Diameter				
	50 mm	80 mm	100 mm	150 mm	200 mm
0.05	92	37	27	11	6
0.075	76	31	19	9	5
0.10	66	27	16	7	4
0.15	54	23	14	6	3
0.20	46	20	12	5	3
0.30	38	17	9	4	2

Note:

The head is the difference in elevation between water in the channel and water on the bay (or furrow). That is, these figures do not assume a depth of flow on the bay (as distinct from Tables 6 and 7). For example, a 100 mm depth of flow on the bay and a head over the bay of 0.25 m (250 mm) results in a head of 150 mm (0.15 m).

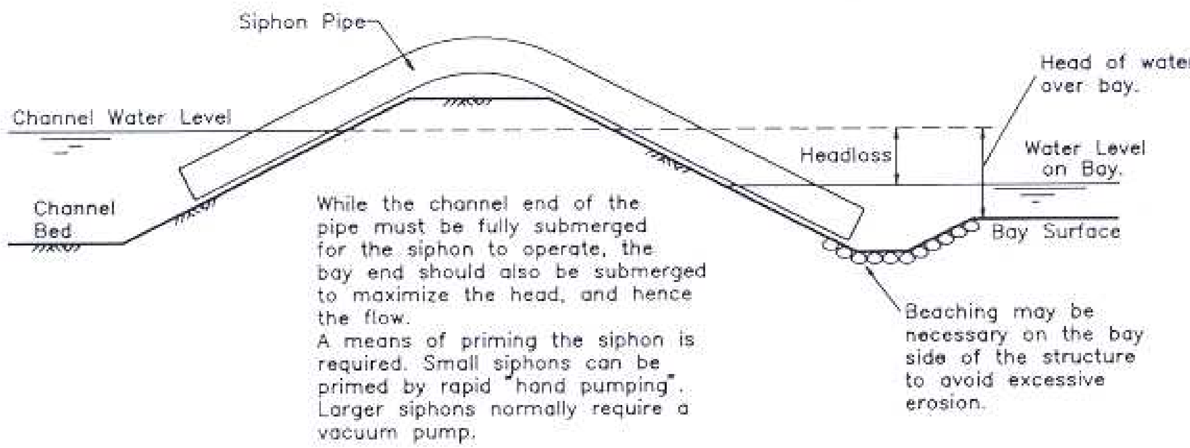

Figure 9. Siphon Outlet

Diagrammatic Summary

Figure 10 is a diagrammatic representation (not to scale) of the main components of the farm system, showing the respective head losses and their relationships.

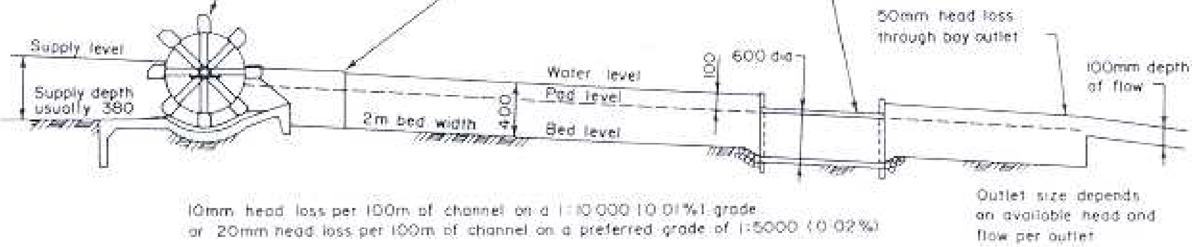

Figure 10. Typical design for a farm channel with Dethridge meter delivering 12 ML/d; the diagram is not drawn to scale.