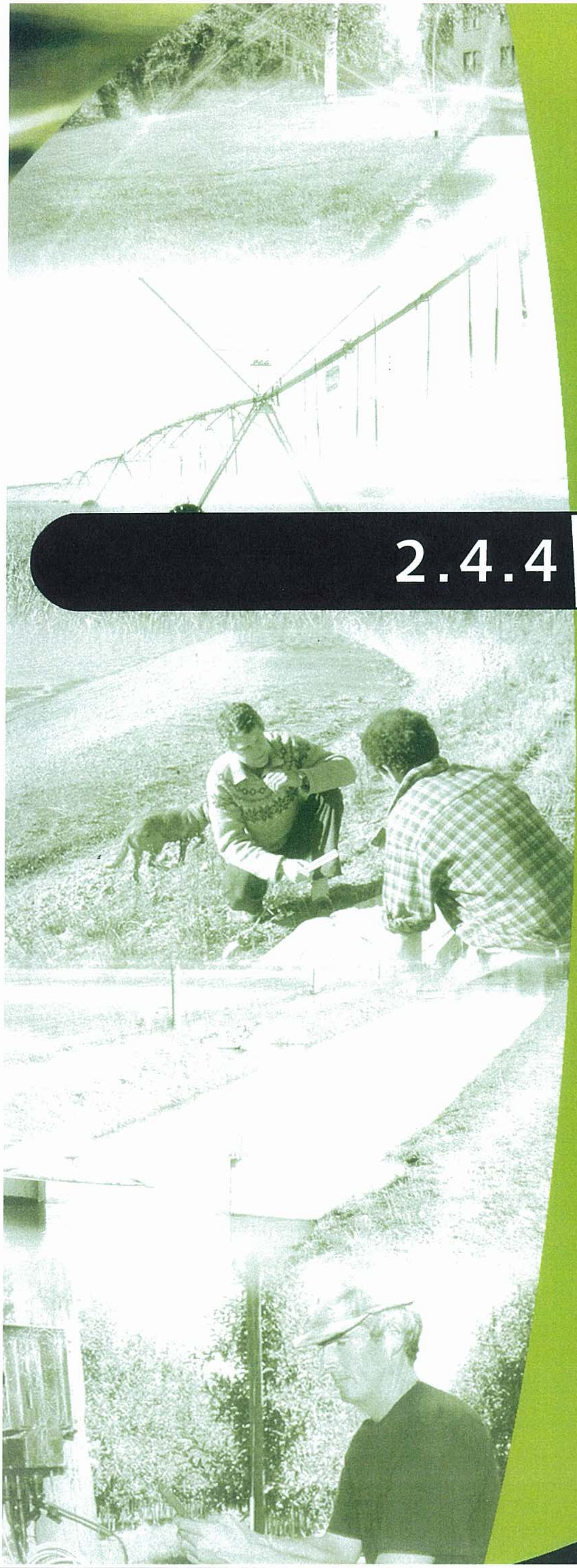


2.4.4 WATER SUPPLY

How to measure groundwater levels

In most groundwater-supplied irrigation areas in New Zealand, groundwater levels fluctuate within seasons or from season to season because of the effects of recharge or abstraction. Irrigation systems are designed to provide the correct amount of water at a fixed groundwater level. When levels rise, more water is pumped. When levels fall, less water is pumped. It is important to know groundwater levels in order to make the best irrigation management decisions.

Advantages of measuring groundwater levels

- An understanding of how water levels fluctuate in your own wells.
- Can indicate wrong size pump or pump depth in a well.
- Gain information to help predict possible water shortages in periods of low water levels.
- Possible reasons why your irrigation system is not performing as expected.
- An explanation for pump cutout during startup.
- An indication of well condition, when combined with flow measurement.
- An indication of pump condition, when combined with flow measurement.

Disadvantages of measuring groundwater levels

- Additional expense (small in comparison to total cost of system).
- It takes time to make the readings.
- Readings must be recorded.
- Measuring systems must be maintained.

Methods

Dip stick

For shallow wells, it may be possible to use a stick or a weight on a string, using a mirror to reflect light down the well to see what you are doing. This method can be accurate to within 1 or 2 mm if done carefully.

Polythene pipe

A very simple method is to use a length of 15 mm polythene pipe. Lower it into the well and, at the same time, blow gently into the top end. When the bottom end of the pipe goes below the water level, it becomes more difficult to blow into it. When that happens, mark the pipe at the top of the well, and remove it. The depth to water is the distance from the mark to the bottom of the pipe. This method is generally accurate to within 50 mm, which is sufficient for monitoring water levels, but not sufficient for detailed well testing. Its biggest advantage is that it does not get stuck in the well, as may happen with electrical probes and weighted strings.

Electrical probe

An electrical probe is lowered down the well through an inspection socket until a meter connected to the probe at the surface indicates the water level has been reached. The simplest version consists of light two-wire cable such as TV cable or twin TPS with a weight on the end, with distances marked with insulation tape. At the bottom end, the wires are bared for about 10 mm and arranged so they are kept separate. At the top end, a multimeter with a resistance setting or an ammeter is connected to the two wires to determine when the cable reaches water. Better systems include cable with pre-marked distances and a built-in meter. The advantage of this method is accuracy – it can normally be read to within 5 mm. The disadvantages are that it is normally not permanent (although there is no reason not to leave it in the well, above the water line), that there is sometimes insufficient room to get the probe down the well between the casing and column, and that the probe may become stuck in the well (quite common).

Air-line and pressure gauge

The air-line is plastic tubing, polyethylene pipe or galvanised pipe, usually strapped to the rising column when the pump is installed. It can be installed later, provided there is room between the well casing and column for it to slide down. The bottom of the tube is usually at the top of the pump. By pumping air into the line, the depth of water above the end of the tube (often, the height of water above the pump) can be read off the gauge. The accuracy of readings depends on the resolution of the gauge, and normally readings within 0.5 m or 1 m are possible. The advantage of the system is that it is a permanent installation. The disadvantages are limited accuracy and maintenance requirements, mainly due to damage to the tube or gauges.

Pressure gauge/vacuum gauge

Pressure or vacuum gauges are usually not as accurate as the other more direct methods described above. This method is used for surface pump installations where the pump is directly connected to the well casing, ie the well casing acts as the dip pipe. Where the well is under a positive artesian pressure, a pressure gauge calibrated in metres water and connected at the well head on the suction side of the pump or into the top of the well will indicate the equivalent height of water above the well head. Where the water level is below ground level, either before pumping starts or while pumping (because of drawdown), a vacuum gauge, preferably calibrated in metres water, will tell you how far the water level is being "sucked" down. If the gauges are calibrated in other units such as kPa, the measurements need to be converted into metres of water.

Suggestions/Precautions

- If you are using an electrical probe and there is a possibility of getting the probe stuck in the well, make sure that the weight at the end of the probe is copper rather than lead, and is something that is not going to jam between the pump column and casing.
- Install a polythene pipe in the well, running from the top of the pump to the surface, at the time of pump installation. The diameter should be at least 20 mm, with 25 mm being preferable. Make sure you can plug the top.
- If using an air-line, install a pressure gauge that displays depth of water in metres. Also, use a gauge that can measure the depth of water over the pump when the system is stopped, as well as when it is running.
- If using a gauge displaying water depth in something other than metres, you can approximately convert to metres as follows:

14 psi	=	10 metres	33 feet	=	10 metres
1 bar	=	10 metres	100 kPa	=	10 metres

June 2001

How much water can your well produce?

When a well is drilled by a reputable well driller, production figures, usually in the form of a pumping flow rate and drawdown will be provided. The irrigation system designer will use this information to select the correct pump for the system. However, water levels and well performances change over time. It is very useful to evaluate well performance to know if the well requires maintenance. It can also help to explain why problems are occurring with systems.

Basic terminology

When describing well characteristics there are some basic terms that are used:

Static water level (also known as standing water level)

This is the water level in the well relative to ground level when the well is not being pumped. Standing water level is often used for wells where the water level fluctuates significantly from season to season or within seasons. In most wells it is below ground level. In free-flowing artesian wells it is above ground level.

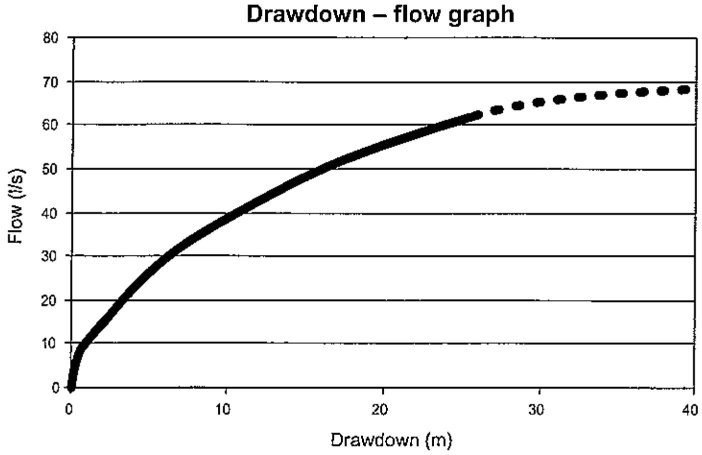
Pumping water level (or dynamic water level)

This is the water level when the well is being pumped. In most wells, the water level falls when the well is pumped and recovers when the pump is turned off.

Drawdown

This is the difference between the static water level and the pumping water level. It is the amount the water level "draws down" when it is pumped. Drawdown changes according to the characteristics of the well and the rate at which the well is pumped and is usually non-linear. A typical drawdown-flow relationship for a well is illustrated below.

Drawdown – flow graph



Maximum well flow rate

This is the highest flow that the system can be pumped at. It corresponds to the maximum drawdown and lowest practical pumping water level. It depends primarily on the performance of the well and is, in theory, the amount of water a well can produce given a specific static water level. In the above example, if the maximum available drawdown was 40 metres, the maximum well flow rate would be 68 litres/sec.

Predicting maximum flow rates given limited pumping

Often during testing, wells are not pumped at the maximum well flow rate or at the flow rate that the well is intending to be pumped at. This is usually because the test pumps that well drillers use do not have the capacity to pump the well at its maximum rate. The maximum flow rate then has to be predicted from the available data. There is no certainty in these predictions, and with the limited data that is usually available, the prediction is really only a best estimate.

The accuracy of the prediction can be improved by ensuring that the drawdown is measured for a range of flow rates so that a graph can be drawn to determine the drawdown-flow relationship. Where wells do not stabilise and drawdown significantly increases over time, pumping at longer time intervals is recommended.

The accuracy of the prediction can be further improved by carrying out a 4-6 hour step-drawdown test on the well. This involves pumping the well at a low flow rate for a known time, usually an hour and monitoring drawdown over that time. The flow rate is then increased slightly and the process repeated. Three or four steps are usually carried out, with the last step close to the maximum rate that can be pumped. The data is then analysed and drawdown calculated for any pumping rate and time.

Using the above graph as an example, assume that the maximum available drawdown was 40 metres and the well was only pumped at a maximum of 60 litres/sec for a drawdown of 25 metres (the solid line). Predicting the flow at the full 40 metres drawdown could be carried out by plotting the results of the test up to 60 litres/sec and extending the line (the dotted line). This indicates that the well may be capable of 68 litres/sec. However, this is only a prediction and actual results may differ significantly from this.

Practical pumping rates

Because of physical limitations such as pump size, pump depth (for submersible or deep-well pumps) or suction limits (for surface pumps), it is often impractical and usually not recommended to pump wells at the maximum well flow rate.

Surface pumps

The practical pumping rates of a surface pump are limited by the suction lift, which is approximately equal to the height difference between the pumping water level and pump. On most pumps, the recommended maximum suction lift ranges from 6-8 metres. If the lift exceeds this, performance drops and cavitation (a process that can cause severe damage to the pump) may result. The maximum flow that can be pumped is the flow at the drawdown that occurs at the maximum allowable suction lift. When static water levels fall, the allowable drawdown reduces and can significantly reduce pumping capacity.

Submersible pumps

The practical pumping rates of a surface pump are limited by the available drawdown in the well and the size of pump that can physically fit in the well. (See Section 3.1.3). Assuming that a well is large enough to accommodate a suitable pump, the pumping water level can in theory be drawn down to the top of the pump. It may be able to be taken further down if a shroud is fitted to the pump and the pump is designed not to cavitate at lower water levels.

Usually, low water level cutouts are fitted at the top of submersible pumps, stopping pumping when the water level reaches that point. In practice, it is difficult to operate pumps with the pumping level at that point because of instability in water levels and the difficulty of controlling pumping rates during startup.

It is more practical and recommended to operate submersible pumps at pumping rates corresponding to not more than 70-80% of the maximum available drawdown. This prevents cavitation, improves operating efficiency and adds a buffer for starting at higher flows. It also provides a safety factor for falling static water levels.

In the above example, 75% of the 40 metres of available drawdown is 30 metres. At this flow, the well is capable of being pumped at 65 litres/sec. Note that this is only 3 litres/sec less than the maximum flow of 68 litres/sec for the well despite the drawdown being 10 metres less. It is quite common for the last 20-30% of available drawdown to produce very little additional water. This is also why large falls in static water levels are needed before pumping flow rates change significantly.

Ongoing monitoring

Testing a well at the time of drilling or when a production pump is first installed will provide base information that can be used in the future to determine changes in well performance. A step-drawdown test is strongly recommended, especially if a production pump is in place.

Although annual testing would be ideal, carrying out a test when changes in performance are noticed can indicate whether the change in performance is due to pump wear or to a deterioration in well performance. If well performance has deteriorated, the test can quantify the reduction and indicate whether well maintenance is required.

June 2001

How to measure flow in channels or streams

Measuring flow in open channels is technically complex. Three less complex techniques are outlined below. For more precise determination of the flow, appropriate expertise should sought.

Float timing method

This method produces an approximate guide for the flow rate of a stream or waterway by multiplying the average stream velocity by the cross-sectional area of the stream.

To determine the average stream flow velocity a length of relatively uniform channel is required, ideally 10 — 15 metres. Surface flow velocity is determined by dividing the distance the float travels by the time taken. The average velocity of the stream is then determined by multiplying the surface velocity by 0.8.

Average stream velocity (m/sec) =

$$\frac{0.8 \times \text{Distance (m)}}{\text{Time for float to travel a set, distance (sec)}}$$

The float can be any number of objects e.g. tennis ball, polystyrene or a block of wood. However, the floating position of the device in water is very important. If the float sits up high in the water, the effect of wind blowing the float and therefore increasing its travel speed can have a significant influence on the final result. It is best to use a float that sits low in the water.

The cross-sectional area of the stream is determined by dividing the width of the channel into intervals and summing the individual areas of the segments. Determination of the area of a segment is calculated by measuring the depth of the stream flow at intervals and using the trapezium rule to calculate the area.

$$Area = \frac{a+b}{2} - h$$

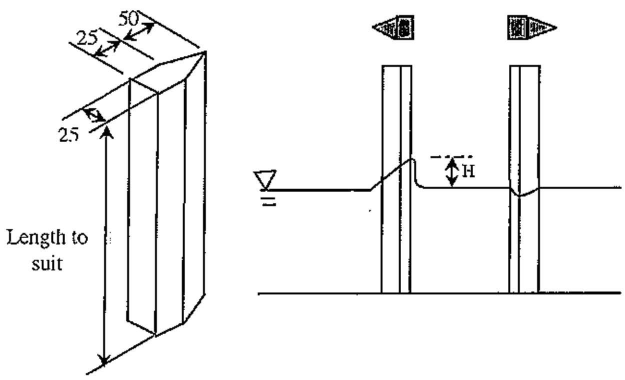
where h = width of the strip (m)
a = depth of flow (m)
b = depth of flow (m)

The flow is then determined by multiplying the calculated stream cross-sectional area by the average stream velocity.

Flow rate (m^3/s) =
cross-sectional area x average stream velocity

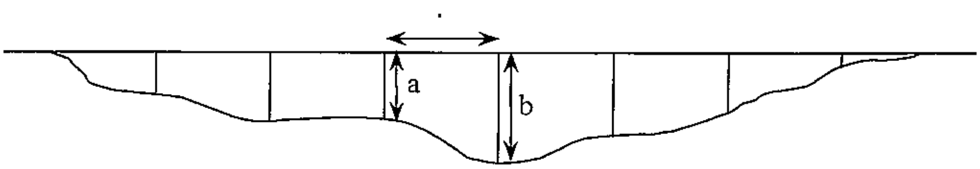
Velocity head rod method

This method uses a velocity head rod, which is a simple device that can be used to determine both the water depth and stream flow velocity. On one side of the rod, there is a sharp vertical edge and on the other side, a flat blunt surface. Care needs to be taken when using this method on streams with high velocities or great depth.



The stream depth may be directly measured from the velocity head rod by placing the rod into the stream flow with the sharp edge facing upstream. The stream depth is measured at regular intervals as done in the Float Timing Method.

The flow velocity is determined by rotating the rod so that the blunt edge faces upstream. The blunt edge creates a wave in front of the rod, whose height is proportional to the flow velocity in the stream. Measurements of the wave heights are taken at the same intervals as for the depth recordings.



The stream flow velocity is determined by the following equation,

$$V = 4.4\sqrt{h}$$

where V = stream flow velocity
h = height of the standing wave, m

To determine the flow rate through a segment, the stream flow velocity is multiplied by the stream depth. The total stream flow rate can be identified by summing all the segment flow rates.

Slope — area method

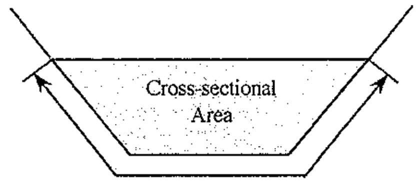
The slope-area method needs a channel section of 65 — 300m long, which is free from rapids, falls and sudden contractions and expansions. This method uses the stream cross-sectional area and the stream surface slope to calculate the stream flow rate by Mannings Equation.

$$Q = \frac{1.0}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

where Q = flowrate, m^3/s
n = roughness factor
A = cross-sectional area, m^2
R = hydraulic radius
S = stream surface slope

The surface slope of the stream is determined by dividing the difference in the water surface elevations at the two ends of the channel section by the length of the section.

The hydraulic radius, R is determined by dividing the cross-sectional area of the stream by the wetted perimeter length. When analysing an irregular stream bed, it is important to determine the cross-sectional area and wetted perimeter at several locations in the channel section in order to find average values which correctly represent the stream system.



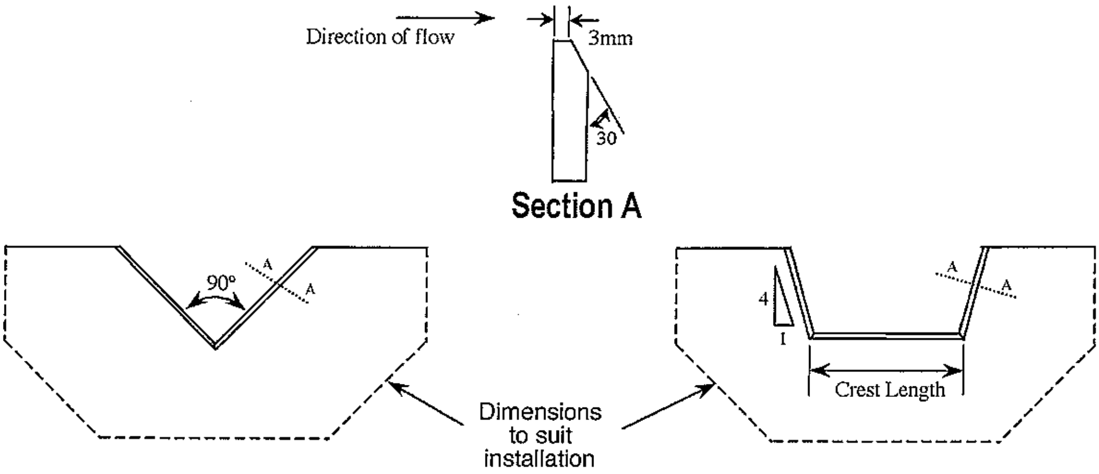
The roughness factor represents the friction between the streambed and the stream flow and is determined by the material make-up of the bed surface. Values for Mannings n can be determined from Table 1.

Table 1. Mannings n values

Description	Mannings n Values		
	Min	Design	Max.
Natural Streams			
Clean straight bank, no rifts or deep pools	0.025		0.033
Clean straight bank, some weeds and stones	0.03		0.04
Winding, some pools, no weeds	0.035		0.05
Winding, most ineffective slopes and sections	0.04		0.055
Winding, some pools, some weeds and stones	0.033		0.045
Winding, most ineffective slopes, stony sections	0.045		0.06
Sluggish river reaches, weedy or deep pools	0.05		0.08
Very weedy and winding streams	0.075		0.15
Earth Channels			
Earth bottom, no vegetation, large drainage ditches	0.028	0.032	0.035
Small drainage ditches	0.035	0.040	0.040
Stony bed, weeds on bank	0.025	0.035	0.040
Straight and uniform	0.017	0.0225	0.025
Winding and sluggish	0.0225	0.025	0.030

Weir measurement

The weir is the most common form of flow measuring device for smaller streams, as it is reasonably accurate, cheap to install and simple to use. The two main types of weir used for flow measurement are the v-notch weir and trapezoidal weir. Both weirs are sharp crested and free flowing.



When using a weir for the determination of flow rate, it is important that a number of conditions are met during the installation.

- The weir must be at right-angles to the direction of the flow.
- The crest of the trapezoidal weir must be exactly horizontal; for a v-notch weir a line bisecting the notch angle should be vertical.
- Flow depth over the crest of a trapezoidal weir should not exceed one-third of the crest length.
- Water immediately upstream of the weir should be calm and not travelling faster than 0.15 m/s.
- The crest of the weir should be at a sufficient height so that overflow will fall freely to the downstream flow level.
- The height of the weir crest about the upstream bed of the stream should be at least three times the maximum head over the weir crest.

To calculate the flow rate over the weir, the only measurement required is the head over the crest of the weir. This figure is then used in tables to find the corresponding flow rate of the stream.

When determining the head of water over the weir, do ***not*** measure the height of water at the weir itself. The height to measure is the difference between the bottom of the weir and the calm water upstream of the weir. The easiest way to do that for temporary installations is to install a peg or something solid at least 1m upstream of the weir with the top of the peg/item level with the bottom of the weir. The height of water above the peg can be measured with a tape measure. For permanent installations, a staff gauge should be used.

Table 2. Flow rate for 90... \Notch and Trapezoidal weir

Head over weir crest	Discharge (90 degree V notch)	Length of trapezoidal weir crest (mm)		
		300	600	900
mm	*l/s*	*l/s*	*l/s*	*l/s*
61	1.3	9.1	23.5	27.1
76	2.3	11.8	31.0	35.2
91	3.6	15.4	38.9	46.4
107	5.2		47.5	61.2
122	7.3		56.7	71.6
137	9.7		66.5	85.3
152	12.6		76.9	99.8
168	16.0		87.5	115.2
183	19.9		98.1	131.1
198	24.3		110.1	147.9
213	29.3			165.5
229	34.6			183.4
244	40.6			202.1
259	47.1			221.4
274	54.5			241.0
290	62.2			261.4
305	70.7			282.3
320	79.8			
335	89.5			
351	100.0			
366	111.1			
381	123.0			

How much water is in a dam?

There are two main categories of dam or reservoir that need to be identified; gully (embankment) and engineered. Gully reservoirs are created by damming a stream in undulating terrain, where water backs up and forms an irregular shaped reservoir. Engineered reservoirs can be either ring tanks, turkey nest tanks or square tanks. These reservoirs are constructed to a specified volume and maintain a regular shape no matter what depth the water is in the reservoir.

To determine the volume of water stored in a reservoir there are two main factors that need to be identified; the water surface area and the water depth.

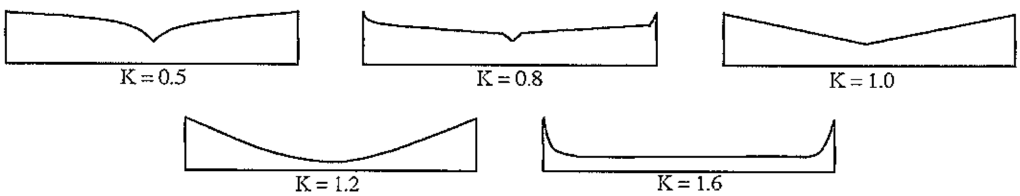
Volume of stored water in a gully reservoir

The volume of water stored in a gully reservoir depends on the height of the dam and the shape of the storage basin upstream of the dam site.

Coefficient method

This method calculates the natural water storage volume and the volume of material excavated from within the gully to form the embankment, which when combined, will determine the water storage capacity of the reservoir.

A coefficient is selected which most accurately represents the general gully shape.



- Natural water storage volume in the reservoir.

  $$Vs = 0.22 \leftrightarrow K \leftrightarrow W \leftrightarrow D \leftrightarrow L$$

- Volume of earthworks in the dam.

  $$Ve = 1.05 \leftrightarrow K \leftrightarrow B \leftrightarrow H \leftrightarrow (H + 1)$$

- Total storage of the reservoir.

  Total Storage* = *Vs* + *Ve

where ***Vs*** = natural storage volume, m^3.

Ve = volume of earthworks in the dam, m^3.

W = width of water across the dam wall, m.

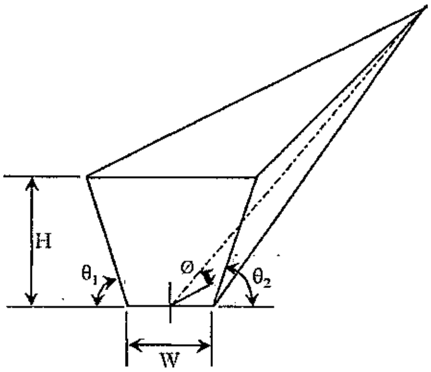
D = depth of water at the dam, m.

L = length of the longest stretch of water surface on the storage, m.

B = length of the dam across the gully, measured along its crest, m.

Mathematical model to estimate the storage

This method of determining the volume of water in a reservoir requires greater detail of the reservoir site, but will produce a more accurate result.



$$\textit{Natural Storage } (m^3) = \frac{H^2}{6 \tan fl} \leftrightarrow 2w \leftrightarrow \frac{H}{\tan \Theta_1} + \frac{H}{\tan \Theta_2} \surd$$

where

- ***H*** = height of water, m.
- ***w*** = bottom width at base of embankment, m.
- ***fl*** = bed slope of gully (degrees).
- Θ_1 Θ_2 = side slops of gully at position of embankment (degrees).

Contour method

Contours have limited use when determining the volume of water stored behind a dam. Since contours on topographic maps are typically spaced at 20 metre intervals, contour-volume determination can only be conducted for large dams and the results will still be very approximate.

Volume of water stored in an engineered reservoir

Due the fact that engineered tanks are regular shapes, calculation of the water stored in the reservoir is easier than for gully dams.

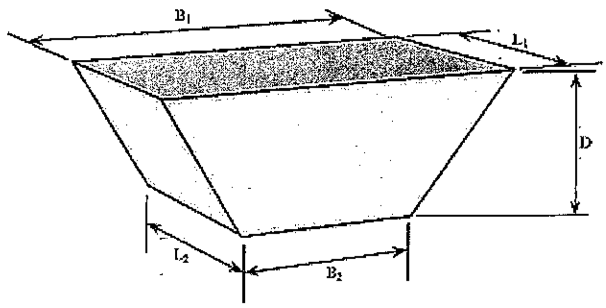
Ring Tanks

The water volume stored in a ring tank reservoir may be determined from the following tables.

Depth of water	Storage capacity (Megalitres = 1000 metres³) (m) Outside diameter				
	100m	*150m*	*200m*	*250m*	*300m*
2	15.6	32.4	53.7	81	113.2
3	26.4	54.4	92	139.6	196
4	37.5	77.8	130.5	197	275

Square/ Rectangular Tanks

When determining the water volume stored in a square or rectangular tank it is necessary to know the basic dimensions of the tank.



The formula to calculate the water storage volume is as follows:

$$V = (A + B + C) \leftrightarrow \frac{D}{6000}$$

where

- ***V*** = the storage capacity, megalitres (= 10^3 m^3).
- ***A*** = the top surface area (L_1 x B_1), m^2.
- ***B*** = the bottom surface area (L_2 x B_2), m^2.
- ***C*** = (L_1 + L_2) x (B_1 + B_2).
- ***D*** = the depth of the water in the tank

How to measure flow from a pipe

Bucket method

This method is ideal for pipes with low flows. It entails placing the bucket into the flow path for a specific time period e.g. 20 seconds and measuring the volume of water in the bucket. Alternatively, the time taken to fill a bucket of known volume can be measured. The flow rate is calculated by dividing the volume of water collected by the time period.

Flow rate (litres/sec) =

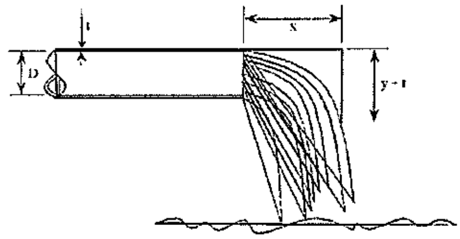
$$\frac{\text{Volume of water collected (litres)}}{\text{Time taken to collect water (seconds)}}$$

Note: m3/h = litres/sec x 3.6
gpm = litres/sec x 13.2

For higher flow rates, one of the following methods can be used.

Co-ordinate method — horizontally discharging pipes

This method determines the flow rate from a pipe by measuring the trajectory of the stream of water from the pipe. The pipe should be either perfectly horizontal, and if the pipe flow is greater than 80%, the jet stream needs to be measured by both horizontal and vertical coordinates from a fixed point on the pipe edge. For ease of calculation, a standard coordinate for either the horizontal or vertical component should be selected, e.g. y = 100mm.



Flow from the pipe is derived from tables using the known horizontal and vertical coordinates and the pipe diameter. If the pipe diameter is different from those listed in the table the following formula can be used to find the flow from the pipe.

$$Q = (5.25\,\chi \times D^2) \div 10^6$$

where **Q** = flow, l/s
χ = horizontal length, mm
D = internal pipe diameter, mm

Table 1. Table of flow rates for a horizontally discharging pipe.

Internal pipe diameter (mm)	75	100	125	150	200	250	300
Dimension X	**Discharge from pipe**						
mm	l/s	l/s	l/s	l/s	l/s	l/s	l/s
100	3.1	5.3	-	-	-	-	-
125	3.8	6.6	10.3	-	-	-	-
150	4.6	7.9	12.3	18	-	-	-
175	5.4	9.2	14.4	21.1	36.6	-	-
200	6.2	10.5	16.4	24	42	66.9	-
230	6.9	11.8	18.5	27.1	47.3	75.1	104.7
255	7.7	13.1	20.6	30	52.4	83.9	116.7
280	8.5	14.4	22.7	33.1	57.7	92.1	138.8
305	9.2	15.8	24.6	36	63.1	101	140.1
330	10	17	26.8	39.1	68.1	109.2	151.4
355	10.7	18.4	28.8	42.3	73.2	117.4	163.4
380	11.5	19.7	30.9	44.8	78.9	126.2	175.4
405	12.4	21.1	32.8	48	83.9	133.8	186.8
430	13.1	22.4	34.7	51.1	89	142.6	198.1
455	13.9	23.7	37.2	54.3	94.7	150.8	210.1
480	14.6	24.9	39.1	57.4	99.7	159	220.9
510	15.4	26.2	41	59.9	104.7	167.8	233.5
535	16.2	27.4	43.2	63.1	110.4	176.7	-
560	-	29	45.4	66.3	115.5	184.3	-
585	-	-	47.3	69.4	120.5	193.1	-
610	-	-	-	88.3	126.2	201.9	-

Co-ordinate method — vertically discharging pipes

The coordinate method for determining the flow from a vertical pipe uses the same principles as for the horizontally discharged flow. However for this set-up the measured height is the height of the water jet from the pipe (water crest).

With known pipe diameter and a measured crest height the flowrate can be determined from Table 2.

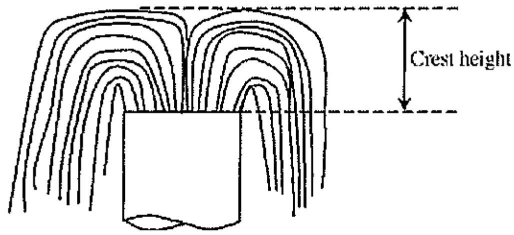
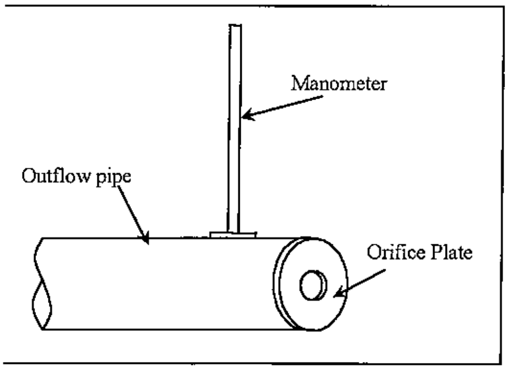


Table 2. Table of flow rates for vertically discharging pipe.

Crest height	Nominal Pipe Diameter					
(mm)	**50**	**75**	**100**	**125**	**150**	**200**
38.1	1.4	2.7	4.3	5.4	6.9	10.1
50.8	1.6	3.5	5.9	7.6	10.1	14.5
76.2	2.1	4.7	8.2	11.7	15.8	24.3
101.6	2.4	5.6	9.8	14.5	20.2	32.8
127	2.8	6.2	11.0	17.0	24.0	39.7
152.4	3.0	6.9	12.0	18.9	27.1	46.1
203.2	3.5	7.9	14.2	22.7	32.2	56.8
254	3.9	8.8	16.1	25.2	36.6	66.2
304.8	4.4	10.1	17.7	27.8	40.4	72.6
381	4.9	11.0	19.9	31.5	44.2	82.0
457.2	5.4	12.3	22.1	34.1	49.2	88.3
533.4	5.9	13.2	24.0	37.5	53.6	97.8
609.6	6.3	14.5	25.2	40.4	58.0	104.1

Orifice plate meter



Determining the flow rate from a pipe using an orifice plate meter is a more accurate method and is commonly used by well drillers. Although not commonly used by irrigators, an orifice plate meter may be able to be hired or borrowed.

For this method a flow outlet pipe needs to be fitted with an orifice plate and manometer. An orifice plate is a steel plate with a calibrated hole through its centre. This hole regulates the outflow from the pipe. The orifice plate (central hole size) needs to be correctly selected corresponding to the estimated flow rate through the pipe to ensure testing accuracy. The manometer is a device that records the pressure behind the plate and is usually constructed from a vertical clear plastic tube connected onto the side of the flow outlet pipe.

As the water flows through the orifice meter, the pressure in the pipe behind the plate builds up to a constant level. Due to the pressure, water enters the manometer tube and the water level height is recorded in metres above the outlet pipe.

To calculate the flow rate using an orifice meter, the following equation is used:

$$Q = 2.7A\sqrt{h}$$

where Q = flowrate, m^3/s.
A = area of the orifice hole, m^2.
h = height of water in tube, m.

Usually, tables listing flow rates have been prepared for orifice meters for a range of plate sizes and these should be used if possible.

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