On-Farm Water Reticulation Guide

pipingit

for our kids' future

Rob Caris

GWMWater

On-Farm Water Reticulation Guide

Disclaimer

This guide has been prepared for landowners receiving a water supply from the Wimmera Mallee Pipeline and is intended for use as a guide only. While every effort has been made to ensure the accuracy of information within the manual, GWMWater does not guarantee that it is free from error, or wholly appropriate for any particular circumstance. Mention of companies, products or trade names does not imply recommendation, and any omissions are unintentional. The water authority recommends that users of this document make their own enquiries, including obtaining professional technical, legal and financial advice before relying on any information and to form their own view as to whether the information contained in this document is applicable to their circumstances. This manual is a guide only and is not intended to stand alone as a textbook.
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Much of the information in this guide has been drawn from existing publications produced by various authors and state agencies from across Australia. The original source of some concepts is unknown. Therefore the contributions of all in this area, both known and unknown, is acknowledged. Those sources used in preparation of this manual are listed as further reading at the end of the guide.

The valuable input of other GWMWater staff and the FARM steering committee consisting of Darryl Phillips (Chairman), Warren Goad (Deputy Chairman), Don McAllister, Lyn Boyle, John Burns, John Russell, Brian Barry, Terry Lewis, Rob Caris, Richard Van Den Bosch, Steven Briggs, Trevor Dedini, John Powell, Max Burns and Karen Stewart are also recognised. Bill Pyke of Land Technology provided engineering examples. We would also like to acknowledge the valuable input of mpmedia, Canon Industrial Design and Artisan Design.

Foreword

Water transported in open channels to farm dams has been the life-blood of farming families in the Wimmera and Mallee regions of Western Victoria for many years. The system of channels and dams carved into the landscape has been an integral part of the farming way of life for this region.

Almost 85 per cent of the water that is released into this system is lost through evaporation and seepage. The prolonged drought that the region has endured over recent years has served to remind us that this inefficiency in supply is not sustainable.

The Wimmera Mallee Pipeline Project is a key regional water initiative that will achieve major water savings and deliver the benefits of a more reliable supply and improved water quality with the introduction of a piped system servicing an area of approximately two million hectares.

The new water supply heralds a fundamental change in the way that water is both supplied to and managed on farms. The Wimmera Mallee Pipeline Project is more than just replacing farm dams and channels with tanks, troughs and pipelines. It is about a new way of life and it presents new technical and management challenges for farmers.

With this in mind, the Farm Advisory Reticulation Methods (FARM Project) was initiated in 2003 to promote the benefits of piped water supplies to the community.

The overall aim of the FARM Project has been to provide advice and guidance to landholders in establishing high quality, cost effective and efficient on-farm piped systems for their properties, when making the transition.

This publication titled "On-Farm Water Reticulation Guide" has been delivered by the FARM Project, and is a well-documented and comprehensive guide that covers all aspects of piped on-farm water systems. The document is broad in content and provides practical technical advice to assist farmers in the planning, design and installation of piped systems connecting to the Wimmera Mallee Pipeline system. A DVD/video titled 'Piping your Property', that complements this guide, is also available.

The FARM Project was directed by a steering committee that comprised primary producer, community, Department of Primary Industry and GWMWater representatives. I extend my sincere thanks to that committee, which was led by Darryl Phillips, for the contribution to the project. I also wish to acknowledge the support and assistance by Rob Caris as the project manager and author of this guide. The efforts of those involved have been considerable and invaluable in the development of this important tool for water management.

I also acknowledge the funding contribution for the FARM project, which was provided by the Victorian Government through the 'Water for Growth' program.

Piped on-farm water systems represent a major local investment by farmers, and it is very important that the planning of these works is based on sound advice and that good practices are employed during installation. I encourage farmers and rural producers to use this guide in preparing to connect to the Wimmera Mallee Pipeline system to ensure that we maximise the benefits that this new system provides to our region.

Barry Clugston
GWMWater Chairman

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Water is the Source of Life

Since time beyond imagining, humans have wandered and settled at its reaches

The people of Australia living in one of the driest continents on earth are no exception to this rule

Here we cling to our beaches and turn our gaze to the sea

But if we ask ourselves what it means to be Australian – our gaze suddenly shifts

We turn our backs to the sea and focus inland.

'Pipe Dreams' 2000.

Farm Project

The Wimmera Mallee Pipeline (WMP) will change the way domestic and stock supply water is delivered to private properties. Through the scheme, GWMWater is responsible for transporting water to the boundary of rural properties throughout the region. It is the landowner's responsibility to provide infrastructure to distribute water to its points of use across the property. The success of the WMP will be influenced by the quality of the design and installation of on-farm water reticulation systems.

The design and quality of on-farm infrastructure will significantly affect the performance and customer satisfaction of the WMP. Recognising the importance of these changes on rural lifestyle and farming operation and the significant investment needed for on-farm infrastructure, GWMWater initiated an advisory and technical support service aptly named FARM (Farm Advisory Reticulation Methods).

FARM's aim has been to help Wimmera Mallee landowners plan and implement high-quality, practical on-farm infrastructure during the period of transition from a channel supply to a piped supply. The key focus of this guide has been on quality, durability and low maintenance of on-farm systems. This incorporates the requirements of system design and accommodates foreseeable on-farm needs and demands.

FARM has been managed by a steering committee represented by primary producers and people with technical and specialist skills in water management. The State Government has provided funding for FARM through the 'Water for Growth' program. The On-Farm Water Reticulation Guide has been prepared under the auspices of this project.

Landowners have a number of choices and will make decisions concerning the type, size and location of tanks, pipes and troughs and how they should be best interconnected to provide optimal results for water delivery on farms. If the new system is carefully and thoughtfully designed for current and future requirements, it will last for many years and minimise long-term operation and maintenance costs. This will help farming enterprises maximise the benefits and take advantage of the opportunities arising from a piped water supply.

FARM steering committee:
Darryl Phillips (Chairman)
Warren Goad (Deputy Chairman)
Don McAllister
Lyn Boyle
John Burns
John Russell
Brian Barry
Terry Lewis
Rob Caris
Richard Van Den Bosch
Steven Briggs
Trevor Dedini

FARM
Farm Advisory Reticulation Methods

Table of Definitions

CFA	Country Fire Authority
DSCS	Domestic and Stock Channel System
EC	Electrical Conductivity
GPS	Global Positioning System
ha	hectare
HGL	Hydraulic Grade Line
kl	kilolitre
km	kilometre
kPa	kilopascal
L	litre
L/day	Litres per day
L/s	Litres per second
mg/L	Milligrams per litre
min	minute
ML	megalitre
mm	millimetre
m/s	metres per second
NMP	Northern Mallee Pipeline
NMPP	Northern Mallee Pipeline Project
pH	incidence of acidity/alkalinity
PN	Pressure Number
ppm	parts per million
PSI	pounds per square inch
PU	Pressure Unit
sqkm	square kilometre
sqm	square metre
SR&WSC	State Rivers and Water Supply Commission
uPVC	Unplasticised Poly Vinyl Chloride
WMP	Wimmera Mallee Pipeline
WMPP	Wimmera Mallee Pipeline Project
UV	Ultra Violet

1. Introduction

The Wimmera Mallee Domestic and Stock Channel System (DSCS), covering 2.9 million hectares (ha), is one of the largest water supply systems in the world. It originally extended from the Grampians in central western Victoria to Ouyen and Manangatang in the north, Underbool in the west and Korong Vale in the east. Water is supplied through approximately 17,500 kilometres (km) of earthen channels, supplying 36 towns and about 20,000 farm dams.

GWMWater delivers this water to approximately 60,000 people for industrial, agribusiness, household, stock and garden use. By the time this water reaches the very extremities of the system, up to 85% has been lost through seepage and evaporation – clearly an intolerable waste of a scarce resource.

Proposals for piping the Wimmera Mallee DSCS date back many years. The earliest recorded call for piping was in 1928 in Patchewollock. The first pipeline scheme, introduced in the 1950s, was a gravity pipe system. It supplies a small area of 9,700ha west of Rainbow. This was necessary because of sandy soil and undulating topography in the area. The Eureka pipeline, covering 25,000ha, was built in the late 1980s as a pilot for the much larger piping system proposed for, and now built, in the Northern Mallee by Wimmera Mallee Water.

Construction and implementation of the Wimmera Mallee Pipeline (WMP) will significantly change the landscape and the way in which water is managed across the region, to the benefit of all landowners, towns and the environment.

Above: drift sand
Below: channel breakout

1.1 History and Background

The existing Wimmera Mallee DSCS began in the 1860s when the region's pioneers attempted to harvest water from rivers and creeks with diversion weirs. In about 1856 the Wilson Brothers of Longerenong diverted Wimmera River water into Ashens and Yarriambiack creeks. This not only marked the first step towards establishing the water supply system, but was also the first water conservation effort in Victoria.

With farmers transporting water from up to 50km away, shire councils helped by constructing dams, weirs and other works needed to store and supply water. The first storage was Wartook Reservoir, which was built on the MacKenzie River in the mid 1880s by the Wimmera Shire. The main sources of supply for the system were the Wimmera River and Mount William Creek.

Water shortages and crop failures resulted in the construction of Lake Lonsdale in 1903. Although water supply to the area was improved, divided control of the headwaters caused difficulties, which were only overcome when the State Rivers and Water Supply Commission of Victoria (SR&WSC) took control of all water supplies to the region in 1906.

Men and horses worked side by side to build the early channels and dams. Over time, this gravity-fed system expanded to include 12 storages that divert water from the Wimmera and Glenelg rivers and various lakes. More than 17,500km of open earthen channels deliver water from these storages to over 20,000 dams.

Using natural watercourses for the initial distribution of water caused heavy water losses, channels were rapidly extended between 1906 and 1931. The channel system increased from 1,600km serving 8,550 square kilometres (sqkm) to 9,600km serving 28,500sqkm. New channels included the Glenelg River Diversion Channel, which was constructed in 1930 to divert Upper Glenelg winter flows into the Wimmera storages.

Lake Fyans and Taylors and Pine lakes were constructed during this period, with Moora Reservoir built in 1933 to store flood waters of the upper Glenelg River for diversion into the system. In an effort to keep pace with regional development, the largest reservoirs, Rocklands and Toolondo, were completed in 1953. The final storage to be constructed, Lake Bellfield on Fyans Creek in the Grampians, was completed in 1967.

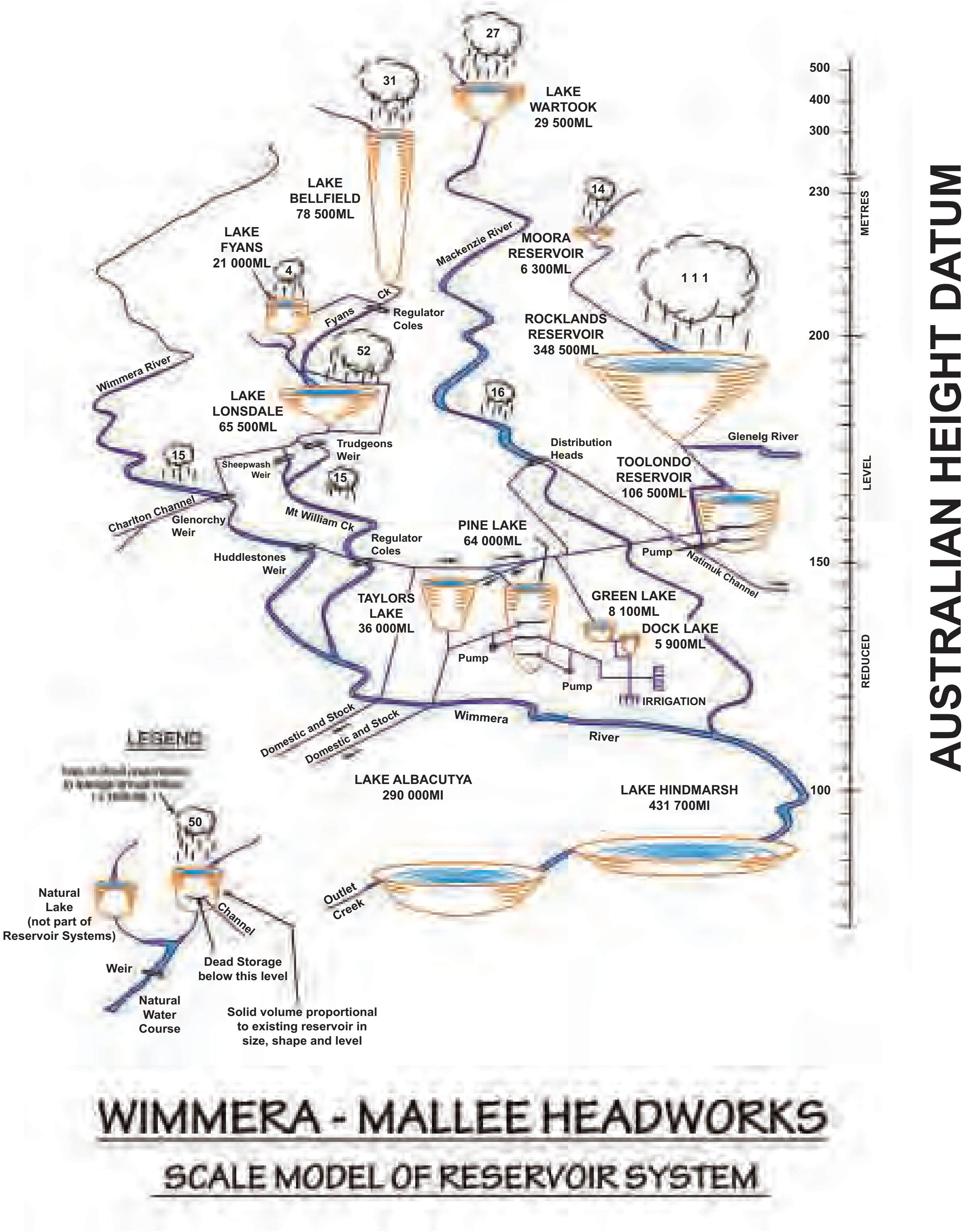
Grampians storages provide most water for consumers across the region. Water from streams and rivers can be diverted in winter to boost the supply and ensure that the maximum amount of available water is conserved in storages for drier periods. Water from the Murray River is now the source of supply for towns and farms in the Northern Mallee Pipeline area of the region.

Over decades, what initially were small changes to the landscape eventually amounted to serious problems for the community and environment. Over-commitment of the system was confirmed by computer modelling in the 1980s. Increasing outbreaks of blue green algae, ageing infrastructure, salinity and ongoing water losses continue to present challenges for managing this supply system.

On 1 July 2004, Grampians Water and Wimmera Mallee Water merged to form Grampians Wimmera Mallee Water Authority. On April 11, 2005 the new authority officially became GWMWater.

Lake Wartook, Grampians, Victoria

Wimmera Mallee Headworks
Scale Model of Reservoir System



2. Wimmera Mallee Pipeline Project

The Wimmera Mallee Pipeline Project (WMPP) is a community-driven initiative that represents an integrated water vision for the region for at least the next 100 years.

Significant water savings generated through this project provide the basis for community wellbeing and regional development; resulting in a highly-sustainable water management program. The project will eventually replace 17,500km of existing open channels with a reticulated system through 2.1 million ha of the region. The system has the capacity to deliver 27,000 megalitres (ML) of water each year to 9,000 customer service points and 36 towns.

Trunk pipelines transmit water continually from the Grampians headworks and Murray River to balancing storages which service distribution pipeline networks that supply water to on-farm tanks, households and stock troughs.

Overall, the pipeline system comprises approximately 8,800km of new pipeline, 45 trunk pump stations and additional booster pumping stations.

2.1 Key benefits

Key benefits of the WMPP are:

> A more reliable and better quality water supply to farms, towns and businesses across the Wimmera Mallee.

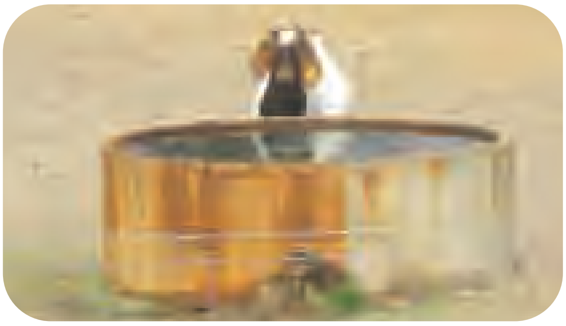
> Restoration of the aquatic life of the Wimmera and Glenelg river systems.

> Increased frequency of flows to the region's nationally-significant terminal lakes system, including lakes Hindmarsh and Albacutya.

> Increased water for recreation purposes, with substantial flow-on tourism benefits.

The water-saving benefits address many of the major problems being experienced across the Wimmera Mallee such as curtailed agricultural productivity, 'stressed' rivers, loss of ecosystems in dry terminal lakes, limited water for lakes and industry and restricted recreation and tourism.

Regional economic development opportunities will also become more widespread through new industries and on-farm diversification.



Examples of on-farm diversification in the Wimmera-Mallee

3. Water Quality on the Farm

Water quality is determined by the amount of dissolved and suspended materials present and is defined in terms of a number of parameters. Salinity, turbidity, pH and hardness are key water quality parameters for a farm water supply. Undesirable levels of these can adversely affect domestic reticulation systems, and the effectiveness of chemicals, stock health and other water uses.

Although the quality of water delivered into the open channel system is generally acceptable for most purposes, it can be highly variable and deteriorates on its journey from reservoirs to farm dams. Water quality further declines in farm dams as evaporation causes a concentration of salt and nutrients.

The quality of water collected in the headworks of the Grampians catchment is very high. A piped system ensures water quality is maintained through the system, providing many benefits to landowners.

3.1 Salinity

Salinity refers to the content of dissolved salts in water. Salts occur naturally in all water; the most common being sodium, magnesium and calcium salts. Salinity is measured in milligrams per litre (mg/L), parts per million (ppm) or electrical conductivity (EC) units.

EC is now the most commonly used salinity measure and can be approximately converted to ppm by multiplying by a factor of 0.6. For example, 1,000EC approximately equals 600ppm.

Salt can be tasted in water above about 500EC, with levels below 800EC regarded as good quality. Town drinking water guidelines have a maximum of 1,200EC.

In general, salinity has little effect on performance of most herbicide formulations. Saline water will break down triazine herbicides at a faster rate than non-saline water and will affect the performance of emulsifiable concentrate formulations of herbicides.

3.2 Hardness

Hardness is caused by the presence of calcium and magnesium salts and is expressed in terms of mg/L of calcium carbonate. Hard water does not readily form a lather with soap. Hardness levels between 60 and 200mg/L are acceptable for most uses.

Herbicides most susceptible to hardness include formulations of glyphosate and 2,4-D amine, when calcium carbonate concentrations in the water are above 250mg/L.

3.3 pH

The pH of water is a measure of acidity or alkalinity (basic) on a scale from 0 to 14. Measurements less than 7.0 are acidic with near to 0 being the most acidic. Measurements above 7.0 are alkaline with a pH of 14 being the most alkaline. Distilled water has a pH of 7.0 and is called neutral. Each one unit change in pH is equivalent to a tenfold change in concentration.

The pH of water can affect the performance of some chemicals. Glyphosate and amine-based formulations are susceptible to breakdown in alkaline conditions.

3.4 Turbidity

Turbidity is a measure of the transmission of light through water. Turbidity is caused by suspended particles of soil and organic matter, giving a cloudy or muddy appearance. The turbidity of water in Grampians reservoirs is low.

Suspended material can cause staining when washing clothes and can interfere with the action of detergents and chemicals. Clay and silt suspended in water can absorb and bind some herbicide's active ingredients and reduce their overall effectiveness. This is particularly the case for glyphosate, paraquat and diquat. Contaminants also block nozzles, lines and filters, and reduce the performance and life of spray equipment.

4. Whole Farm Property Planning

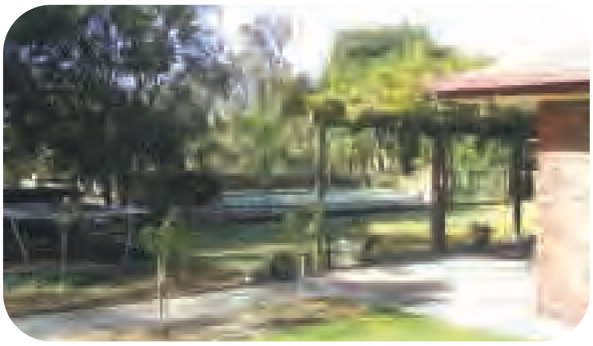
Water supply has been a major factor in determining farm layout across the Wimmera Mallee. Catchment and channel-filled dams are predominately located on the lower parts of farms. The channel cannot always service high ground, resulting in fencing on low ground, a less than ideal situation for stock management. The channel network has caused division and inconvenience, particularly to cropping and stock operations. A reticulated on-farm water supply system allows flexibility in locating water outlets on the farm and virtually eliminates the property management problems the channel system presents.

Whole-farm planning integrates the economic, family and environmental aspirations of the farming operation with the physical capacity of the farm's land and water resources. With a new on-farm water supply system, it is opportune to review or develop a whole-farm plan.

Planning an on-farm water reticulation system incorporates decisions on:

> how the water will be used
> where the water is required
> how much and at what rate water is required at each location
> how the water will get to these locations
> material and installation costs
> suiting design to individual needs
> sharing resources, equipment and purchasing power with neighbours and community organisations to install systems
> an implementation program to suit financial circumstances and farming priorities

Properties needing more detailed solutions should access experienced reticulation system designers.



Above: home and garden use

Existing dam systems should not be the deciding factor for future water requirements and locations. Dams are usually located in the lowest lying land, whereas piped water will provide water at any location around the farm including high points such as natural rises or dam banks.

Long-term thinking is required to make farming activities easier in terms of reducing travel time around paddocks and walking distances for stock, and sensible access to fire-fighting water. Polyethylene pipe and taps are relatively cheap one-off expenses – petrol, diesel and time are expensive and represent ongoing costs.

Above: troughs utilised for stock

Reviewing or starting a whole-farm plan is a valuable process in creating a sustainable, functional and profitable farm environment. It involves a critical and holistic view of current and future needs of the farm, family and the land. The result will be a flexible, functioning system and significant reduction in future on-farm costs.

A whole-farm plan recognises that farms consist of a range of land classes such as flats, slopes and hilltops. Most landowners are aware of the capabilities and limitations of different areas of the farm. The channel network limits the ability to manage these areas and accordingly, some paddocks have no water supply. Often one large paddock may represent three different land classes. By replacing channels with a reticulated supply, the farm can be managed to best utilise the different soil types and slopes across the farm.

4.1 On-farm benefits: family and farm business operation

The range of benefits and possibilities from a piped supply and on-farm water reticulation system include:

> Improved water quality for home and garden. Properties will be more manageable, flexible and efficient with the piped supply not exposed to contaminants en-route or through surface runoff.

> Improved results with washing and extended life of home appliances. Results from the Northern Mallee Pipeline Project (NMPP) have shown that gardens thrive, providing a more comfortable environment for families.

> Improved effectiveness and performance of herbicides and chemicals for crop spraying. Paddock results will improve with costs also being lowered. Superior results have been achieved with stock in the Northern Mallee Pipeline area.

> Greater reliability and security of supply.

> The provision of water through piping to points on the property, irrespective of previous locations of dams.

> Inbuilt fire-fighting features include fire plugs located along trunk lines and distribution lines. Where fire hydrants are not practical, dedicated water tanks will be located along distribution lines and usually on road reserves at strategic locations. Additional access to stored water will be available on private land with on-farm water reticulation systems and water storage tanks. (below)

Typical roadside fire plug

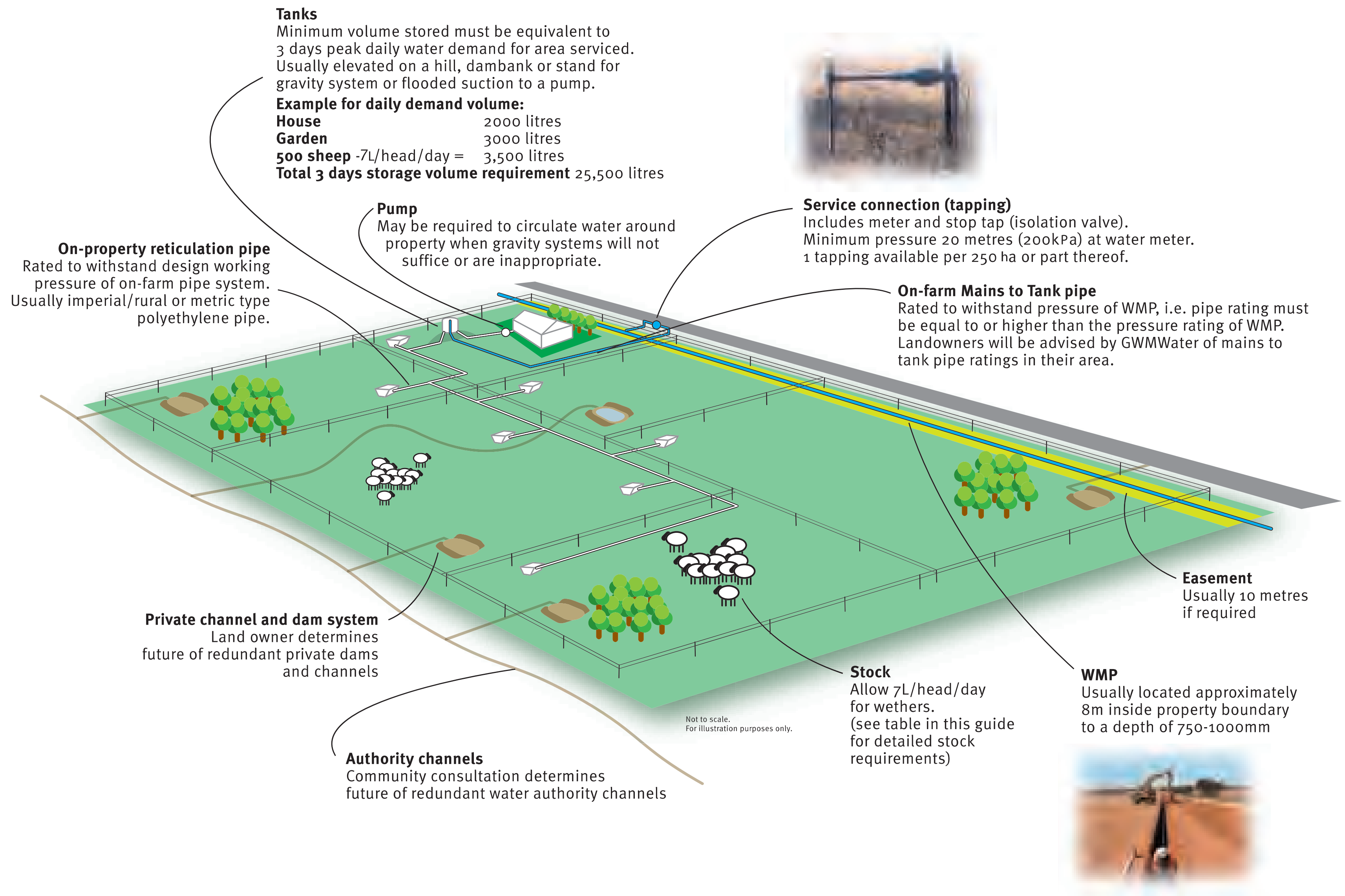
Typical roadside fire tank

5. Conditions of Supply

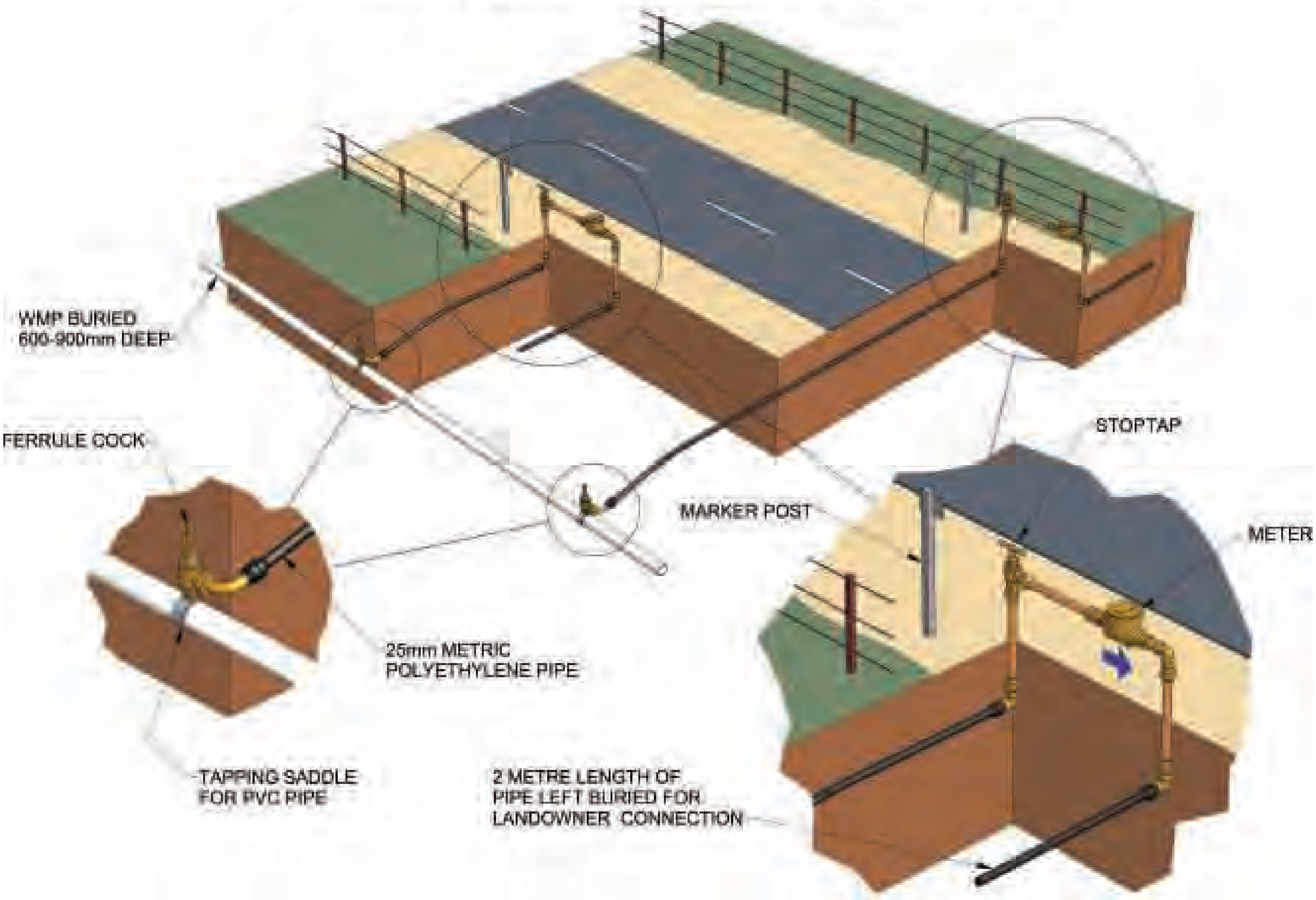
5.1 Design and operation of the Wimmera Mallee Pipeline

The WMP will provide water to property boundaries, with landowners being responsible for providing infrastructure to store and deliver water around the property. Landowner responsibilities also include design costs, purchase, installation and maintenance of all pipe work and fixtures downstream of the water meter.

The pipeline is designed to provide a flow rate equal to the peak month average daily demand to rural properties. To balance system capital and operating costs, on-farm storage of water is a critical and inherent part of the system design. This enables the on-farm water demand at peak usage times (e.g. a hot summer day) to be met from tanks, which will be replenished over the whole day at an average flow rate. This system provides an equitable level of service to all properties.



Wimmera Mallee Pipeline Service Connection Arrangement (Typical)



5.2 Pipe work

Pipes from each service connection must feed directly into a tank via a float valve located at the top of a tank. The float valve must be positioned at least 50mm above the level of the tank overflow pipe, so that the float valve outlet always discharges water above the water level in the tank. This is to ensure there is always an air gap between the float valve discharge and the surface of the water in the tank. The air gap prevents water from the tank siphoning back into the pipeline if system pressure is lost. Piped water cannot enter into the bottom of the tank.

The pipe from the meter to the tank must have a pressure rating equal to or higher than the rating of the pipeline in the area of the meter. The operating pressure and associated pipe class of the pipeline can vary. To enable the appropriate size and pressure rating of the pipe connecting the meter to the on-farm tank, each property owner will be notified of the minimum and maximum operating pressure of the pipeline by GWMWater.

5.3 On-farm requirements

To receive water from the WMP, landowners must comply with the following conditions:

> Each service connection (tapping or meter) must be coupled to a tank located on the property serviced.
> The on-farm storage volume must provide at least three days' storage for the serviced area to accommodate any prolonged system downtime or maintenance requirements.
> Three days' storage is defined as the peak daily water demand at any time multiplied by three. Generally a house needs a 20,000 to 30,000L tank. A mob of 500 sheep needs a standard 13,500L tank.
> Service connections will only be provided when on-farm storage tanks are in position.

5.4 Water pressure

The WMP has been designed to provide a minimum pressure of 20m or 200kPa of water head at the water meter. This is the pressure available to allow for head losses of approximately 1m in the tapping and water meter, 2m for tank depth and the balance for on-farm pipe and fitting losses.

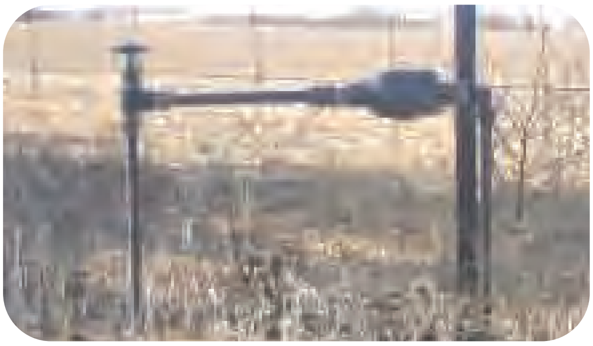
Tapping on Wimmera Mallee Pipeline

5.5 Service connections

Service connections commonly referred to as 'tappings' consist of an isolating valve, water meter and length of 25mm polyethylene metric pipe. Water is delivered from the WMP to the property, via this arrangement. The water authority's pipe is usually located on private property 8m in from the fence line. Tapping assemblies are usually located just outside the property boundary.

The location of the tapping is determined through consultation between the water authority and landowner. Property owners usually have considerable choice in the location of the tapping along the pipeline. The meter can be installed along the boundary of an allotment which is 'fronted' by a distribution pipeline. An allotment is 'fronted' if the pipeline route is parallel with the property boundary and located either inside the allotment or in the allotment on the opposite side of the road reserve.

> It is undesirable to locate tappings in areas of thick vegetation or near other obstacles often found in road reserves. This may create access difficulties for reading meters or maintenance.
> Service connections that have to cross roads or railway lines may not be approved if other options exist.
> GWMWater will contact each property owner to establish tapping location requirements.
> The number of service connections provided by the water authority, at no cost to the landowner, is determined by dividing the area of the farm by 250ha and rounding up to the nearest whole number.
> Trunk lines will only be tapped where no other option exists.



Example of service connection meter

5.6 Service connection availability

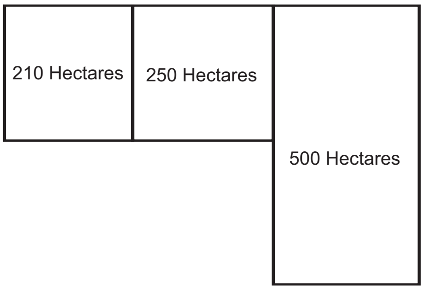
Supply will be provided from the pipeline to every property. A property is defined as follows:

'Property' means all adjoining lands that are operated as one entity by the one person or by several persons jointly, and may comprise one or more Crown Allotments, and includes leased Crown Land. However, if a property is divided into two or more portions by a fenced public road or railway line, each portion may be regarded as a separate property.

Service connections are provided free for a period of two years following the last dam fill in the area prior to commissioning of the WMP. Charges are applicable for service connections after this two-year period expires. Additional service connections can be installed at the landowner's expense at any time.

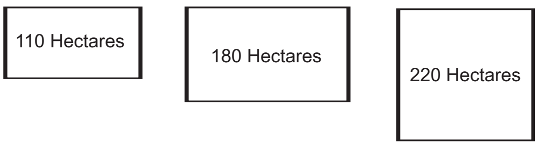
PROPERTY SIZE hectares	SERVICE CONNECTIONS
1-250	1
251-500	2
501-750	3
751-1000	4
1001-1250	5
1251-1500	6

Contiguous allotments



Free service connections: 4

Non-Contiguous allotments



Free service connections: 3
(1 per property)

5.7 Service connection location

Unless other arrangements are made, GWMWater will provide a service connection to the property at a location which will be no greater than:

> 2.3km from the most distant point on the property;

and as close as possible but no greater than:

> 1.6km from the largest water demand on the property, such as the tank supplying the homestead.

The standard size for supply points on the WMP is 20mm in diameter. Larger supply points to meet special requirements will be considered on a case-by-case basis.

5.8 Direct connection

Direct connections to homes, gardens, pumps and troughs from the pipeline are not allowed under any circumstances.

5.9 Planning approvals

Implementation of farm reticulation systems can potentially require a large range of works including pipe ripping and trenching, disturbance of vegetation and decommissioning of channels and dams.

Landowners should seek advice from planning authorities such as municipal councils, Department of Primary Industries, Department of Sustainability and Environment and catchment management authorities when planning earthworks on land where native vegetation, cultural heritage and waterways may be impacted.

5.10 Location of system pipelines

System pipelines will commonly be installed parallel to road reserves, 8m inside the freehold land. This land has usually been cleared for cropping and other agricultural activities, and locating system pipelines inside private property minimises the disturbance of native vegetation associated with road reserves. Pipes are typically buried about 750mm in the ground. Where an easement is required, it is usually 10m wide over the freehold land. Service connections, air valves and other associated pipeline components are located outside the property fence line where practicable.

When designing the on-farm pipe system, considerations should be given to land that may be sold in the future. Landowners may consider installing separate reticulation systems on land proposed to be sold or sub-divided at a later time

6. Water Requirements and Demand

This section provides information on typical water demand, storage requirements and flow rates applicable to Wimmera Mallee farms. Consideration needs to be given to water requirements for all activities on the property, including a realistic allowance for future changes and development.

6.1 Water consumption on the farm

When designing a farm reticulation system, peak demand is considered to be the maximum expected flow rate that a section of pipe must supply. Flow rates much higher than the yearly average must be accommodated, and the daily rate should not be confused with the annual water consumption divided by 365 days in a year. The typical once-a-year dam fill will be replaced by on-farm water storage tanks replenished by the WMP every day of the year.

There are a number of important water flow rates to consider when designing and planning an on-farm reticulation system. Actual consumptions can vary widely depending on farming enterprises.

Average peak daily demand is the amount of water a farm operation may need during a 24-hour 'worst-case' scenario period. Although the peak load may only occur on a small number of days in any year, it is this worst-case scenario that the system needs to be designed for. This figure helps determine how much stored water is required on-farm and therefore determines tank size.

Instantaneous demand is the flow rate required to service a water point(s) at any one time. This is the flow rate that ensures there is enough water to operate the shower and dishwasher while stock are being watered in a nearby paddock. Pumps and pipes must be sized to accommodate this flow rate.

It is necessary to be practical and realistic with estimates of existing and future water consumption. The components of the reticulation system are designed and sized on these estimates and will cost accordingly.

Areas affecting consumption include:

6.1.1 Domestic

> Household demands require water for kitchen, bathroom, laundry, shower and toilet. Evaporative air conditioners perform well in low humidity and during dry Wimmera Mallee summers, can consume up to 40 litres per hour.

> Rainwater will continue to be used for drinking and cooking purposes, and could service all or parts of the whole house depending on the season and on-farm storage capacity.

> In most situations homes and gardens are already piped from existing dams or tanks, and may only require minor re-plumbing to connect to the new supply.

The house pressure pump must be able to deliver enough water for the required number of outlets to be used at one time. The table above outlines household water supply needs.

PEAK WATER CONSUMPTION
SEPTIC SYSTEM / NUMBER OF HOUSEHOLD RESIDENTS

NUMBER OF HOUSEHOLD RESIDENTS	1	2	3	4	6
Litres per day (household)	180	250	320	340	380
Kilolitres per year	66	91	117	124	139
Evaporative Air Conditioner	Up to 960 litres per day				

Source: State Electricity Commission of Victoria-Rural Stock and Water Domestic Supplies, June 1991

PEAK DOMESTIC WATER SUPPLY NEEDS

Shower/bath/laundry	14L/minute
Kitchen sink	11L/minute
Toilet	7L/minute
Garden hose outlet	14L/minute
Evaporative air conditioner	0.7L/minute

The pump is selected by determining how many outlets must operate at any time without a significant drop in pressure. Flow rates for all outlets are then combined to give the peak flow rate, with pumps and pipes selected to deliver the required peak flow rate.

Through the hottest days of summer for example, two garden hoses may run for extended periods. While hoses are running, toilets need to refill and the washing machine, shower and dishwasher could also be in use. In addition to house and garden usage, stock and other uses may place additional demands on the reticulation system.

Peak flow rate of the home and garden for this situation is:

2 x 14 + 7 + 14 + 14 = 63L/min or 1.05L/sec

Typical mid to large pressure pumps provide a flow of around 80L/min.

The pressure pump should be capable of providing for this flow at its lowest operating pressure, usually around 140kPa.

Evaporative air-conditioners consume around 0.7L/min, so have little influence on the design of the pressure pump peak load relative to other outlets. With extended usage periods of 10 hours per day over summer, 400L of water could be used, which will impact on the storage tank volume required. Larger pressure tanks on pumps can minimise stop/start cycling of pumps with the low flow rates required by evaporative air conditioners.

6.1.2 Garden

Gardens contribute enormously to creating a pleasant living environment. Water requirements of gardens depend on:

> The type of garden and plants, ranging from native trees and shrubs to well-watered ornamental plants and lawns. Allow around 3000L per day for an average garden with a mix of plants.

> Rainfall and evaporation rates.

> The size of the garden. Urban blocks have an average garden size of 500sqm after allowing for roof and paved areas. Rural settings average 600sqm of garden area.

> For garden and lawns larger than 600sqm, divide the actual area of garden by 600 and multiply by 3000L per day.

These figures are a guide only. Actual garden water use can vary considerably with garden sizes and types. Rainwater from buildings and catchment dams will continue to be a valuable source of water.

6.1.3 Sheds and workshops

> Determine water requirements at sheds for stock and for other incidental uses.

> Shearing sheds may require water for general hygiene, cleaning or suppressing dust in sheep yards.

> Washdown facilities may be required at workshops or a separate supply for the boomspray if filled at this location.

6.1.4 Fire fighting

Locate facilities to enable convenient filling of fire-fighting units, ensuring easy access to tanks and appropriate fittings are available. Contingency plans should be in place in case of power outages.

Water for fire fighting has typically been reserved in dams close to houses and farm buildings. Up to 50,000L may be required to protect a homestead and sheds from fire. Guidelines for reserved volumes are given below.

RESERVED VOLUME: FIRE FIGHTING LITRES / SQUARE METRE	
BUILDINGS	40 -120
GRASS AREAS	25 — 75

Source: 'Managing Farm Dams' - Wimmera Mallee Water

6.1.5 Stock

Peak demand needs to be calculated for each watering point as well as the system as a whole. An accurate estimate is required to determine the size of the pipe and head required to deliver water to the watering point.

Systems need to be designed for a possible 'worst-case' scenario or the maximum peak load in any year, such as hot summer conditions when stock are on dry feed.

If peak demand is not met, even for a short time, some animals will become stressed. If water flows to a trough too slowly, stock will fight to get to the trickle of water at the float valve as the water level lowers, with possible damage to the trough, float valve or the stock themselves. Ensuring the trough is replenished at least at the same rate that stock are drinking will avoid this situation. A slightly lower flow rate can be acceptable as the trough holds a reserve of water.

Stress is exacerbated during extreme conditions, and will continue until water is accessed. Livestock mob behaviour may also dictate watering patterns. Dominant stock may empty the trough and lead submissive stock away without drinking.

The main factors affecting stock water consumption are:

Stock type: Older, pregnant or lactating animals require more water than dry animals.

Weather/Climate: Humidity, temperature, wind and rain will affect stock drinking requirements. Demand will be higher if there is high temperature, low humidity and a strong wind. Variations to these climatic conditions occur on a day-to-day, season-to-season and year-to-year basis.

Shelter: Access to shade and protection from the elements can help reduce stock water requirements and boost productivity.

Feed type: Demand for water varies with dry or green feed, grain pellets or grass. Stock grazing on plants containing salt will drink more water.

Water quality: Different stock tolerate different levels of salinity. Stock will require more water if it contains high levels of dissolved salts.

Water temperature: Animals prefer to drink water at or below body temperature and may avoid warm water, especially in hot weather.

Peak demand may occur at particular watering points, for example, at holding yards where there may be high water consumption by a semi-trailer load of thirsty cattle or sheep that have just arrived.

When sizing pipelines that connect tanks to stock troughs, reticulation designers have developed 'rules of thumb' to characterise the sometimes unpredictable drinking habits and behaviour of stock. Daily water requirements of a wide range of stock are well documented. It is recognised that from a practical point of view, stock do not drink at troughs at an average rate all day long. In reality, large numbers or the whole mob can converge on a watering point at once. If a good quantity of water is not provided, and the trough goes dry, some stock may move away with the rest of the mob without getting a drink.

To allow for this scenario, the accepted design standard for delivering water to stock troughs is supplying the equivalent of the daily demand for stock over a four-hour period. This is a 'rule of thumb' figure that reticulation designers have tested and proven to work in the field over many years.

The table on the next page provides additional information on livestock water requirements.

STOCK	DAILY USE Litres/head		ANNUAL USE Kilolitres/head
	Summer Oct-March	Winter Apr-Sept	
SHEEP			
Lactating	9	7	2.88
Dry	7	4.5	2.07
Irrigated pasture	3.5	2	0.99
LAMBS			
Dry pasture	2.5	1	0.63
Irrigated pasture	1	0.7	0.31
CATTLE			
Grazing (<550kg)	45	30	13.5
Grazing (>550kg)	67.5	45	20.7
Lot feeding	94	60	27.2
Calves	25	15	7.2
Dairy lactating	70	45	20.7
Dry	45	30	13.5
HORSES			
Working	54	37	16.4
Grazing	36	27	11.3
PIGS			
Sows lactating	23	18	8.20
Sow and litter	45	21	
Growers – 70kg	10	8	3.24
Growers – 25kg	5	3	
POULTRY			
Laying	32 L/100		12
Pullets or Broilers	18 L/100		7
Turkeys	54 L/100		20

Source: State Electricity Commission of Victoria - Rural Stock and Domestic Water Supplies, June 1991

6.2 Spraying crops

To ensure adequate on-farm water storage requirements, you should consider the large volumes of water required for use with chemicals for crop spraying. For many cereal operations, crop spraying generally takes place from April to October. This covers pre-sowing knockdown sprays, pre-emergent and post-emergent weed sprays as well as insecticides and fungicides. Heavy summer rains often lead to a need for significant spraying for weed control, with higher spray rates often used at this time of year.

The trend has been to use low water volume application. Some typical crop spraying benchmarks for a single tractor operation are:

> 40-200L/ha
> 30-40ha/hr
> 1200–8000L/hr

Consideration needs to be given to likely future machinery trends such as higher capacity spray units or contractors with more than one machine.

6.3 Liquid fertilisers

High water use with liquid fertilisers is often required during periods of low stock demand for water. With an anticipated increased use of liquid fertilisers in the future, landowners will need to consider the effect on their reticulation system design. Early research suggests that liquid fertilisers utilise 150-200L of water per ha.

Hydraulic theory and principles are complex subjects. This guide aims to improve the reader's knowledge of engineering principles and application to reticulation design. Pressures, flow rates, pressure drop and headloss, and pipe sizing are all parameters that need to be understood and considered in any reticulated system.

7.1 Hydraulic principles

The aim in reticulating water around the property is to ensure all stock have adequate, high-quality water available when required. To achieve this, pipes must be large enough to deliver the required flow.

Pressure is required to deliver the water through the pipe. The pressure will come from either a pump or gravity from an elevated tank. Most of the pressure available is required to overcome the friction that exists between the flowing water and the inside surface of the pipe, fittings and any elevation differences from tanks to end use. A small amount also remains within the flowing water itself.

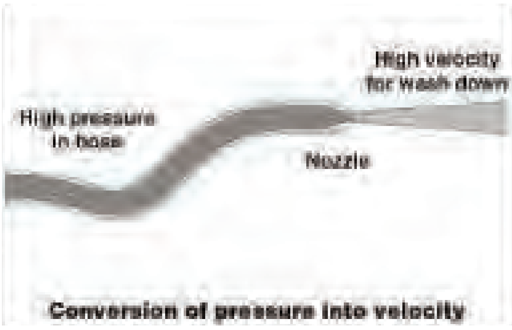
The free water surface in the tank and at the trough is always at atmospheric pressure. Water in the pipe is under pressure.

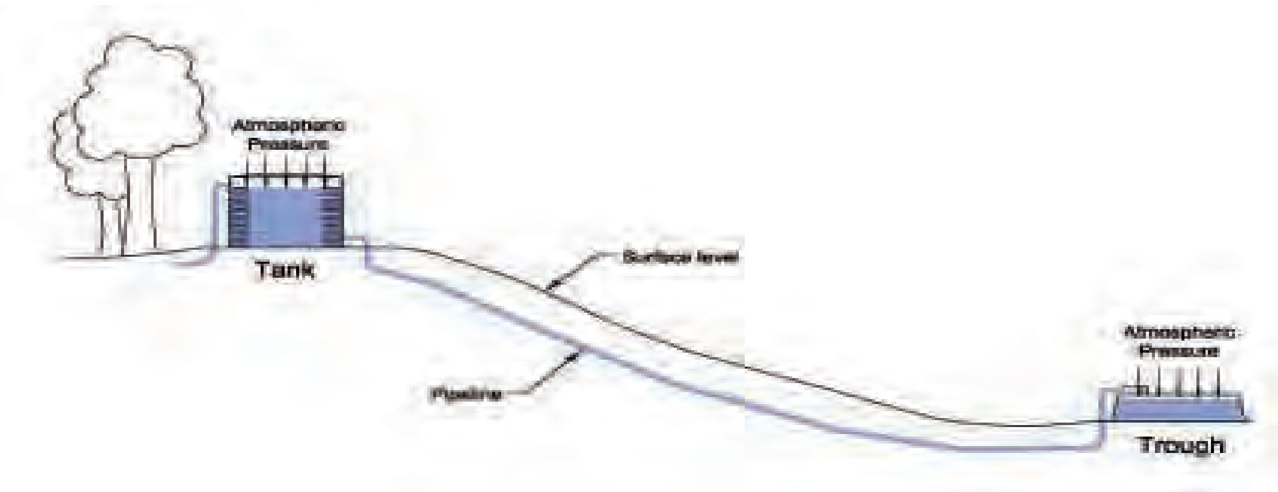
When designing a pipeline, whether for the farm or even the entire WMP scheme, the pressure available needs to be balanced with the frictional loss. The amount of friction will depend on the pipe diameter, its length, number of fittings used and the speed of flow and any buildup of foreign materials within the pipe.

The flow will regulate itself so the higher the pressure, the greater the flow through the pipe. When water reaches the end of the pipe, no extra pressure will remain. Water will leave the pipe at atmospheric pressure.

The pressure acting on the surface of the water in a tank is atmospheric. The water as it flows through the pipe is under pressure provided by gravity. At the trough, the pressure at the water surface is again atmospheric.

Water is discharged from fire hoses, garden hoses, irrigation sprinklers or other jets at high velocity and atmospheric pressure. As the water leaves the hose or nozzle, the only opposing pressure around the jet is atmospheric pressure. It is the high velocity of the jet that gives the impression of high pressure.





7.2 Pressure and head

If the outlet valve at the end of the pipe was turned off, the water level would be the same in each of the clear tubes. When the outlet valve is open the water level will drop in each successive tube as indicated.

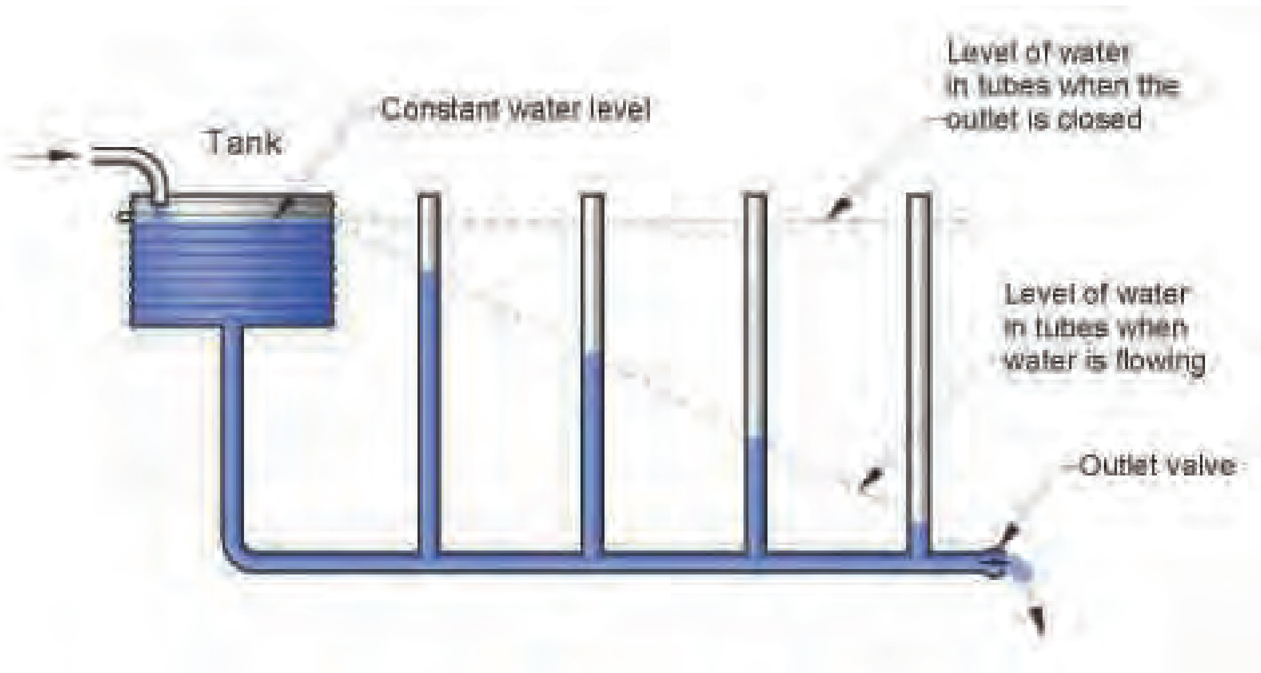
The pressure will vary along the length of the pipe, as indicated by the depth of water in the tubes. This pressure will gradually decrease due to friction between the water and the pipe wall until it reaches atmospheric pressure at the end of the pipe.

The term ‘head’ is often used instead of pressure in water hydraulics. This has remained from the early days of water wheels and steam power. A pump may be specified to have an operating head of 50m, or alternatively 500kPa. The safe working pressure of a pipe may be quoted as a head of 60m or 600kPa.

The diagram below, depicts a tank with a constant water level and a pipe running from it. Water levels in the clear tubes rising from this pipe indicate the pressure of the water flowing in the pipe.

For every metre of depth in fresh water the pressure increases by approximately 10kPa.

The pressure and depth rule is:
1m water = 10kPa = 1.4PSi



7.3 Flow rate and velocity

Flow rate is the volume of water passing a given point in a given time. The basic unit for measuring flow rate is cubic metres per second - m^3/s.

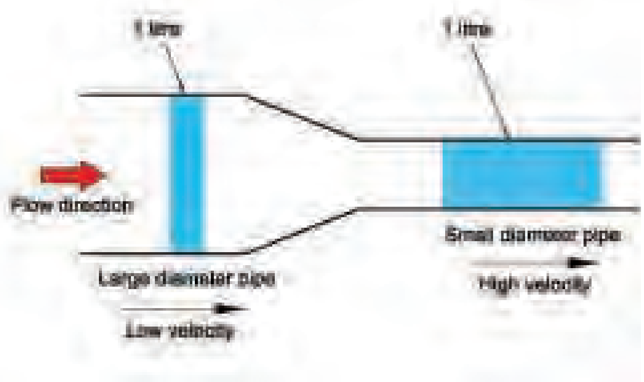
Unfortunately this unit is quite often too large so consequently non-standard units are frequently used. These include:

> L/s
> L/min
> ML/day

Water is incompressible, and although the shape of a litre may vary, the volume will not. If a litre of water flows into a pipe every minute, a litre will come out the other end every minute, due to its incompressibility.

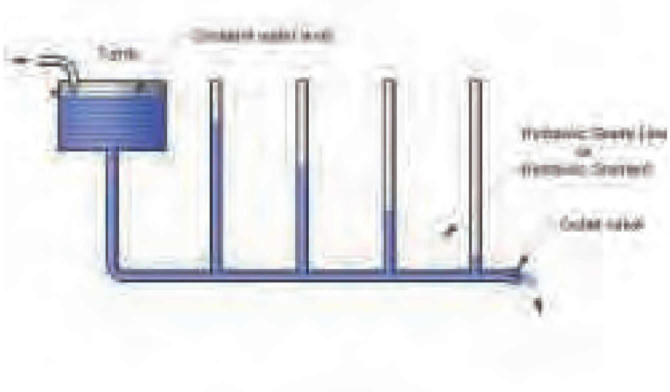
If a pipe carrying liquid changes shape as shown in the diagram below, it will take the same time for the litre to pass A as it does to pass B. While the flow rate remains constant, the velocity of the liquid particles will increase

Flow rate is constant through the pipe, so the velocity of water is higher in the smaller diameter section of the pipe and lower in the larger diameter pipe.



For a given flow rate the smaller the cross-sectional area, the higher the velocity and therefore the higher the friction loss.

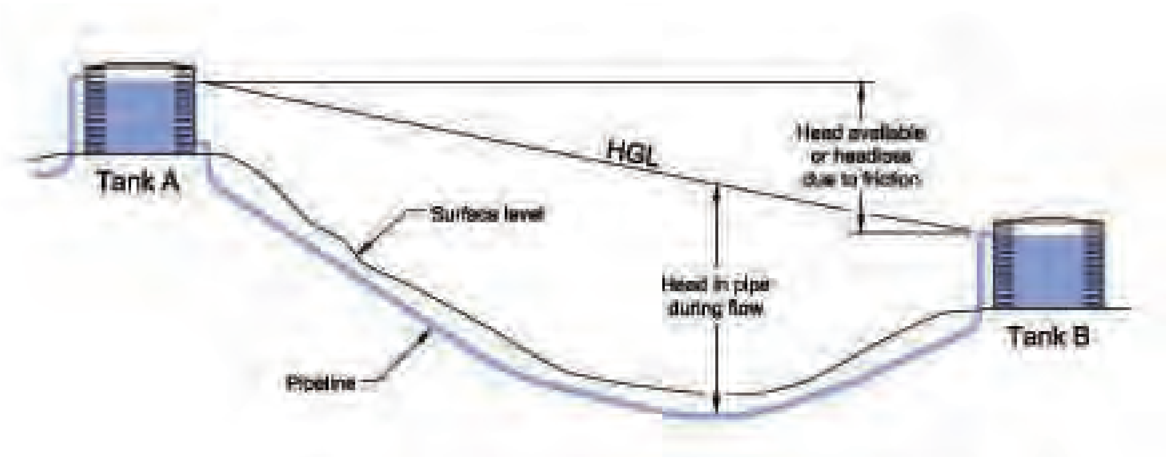
7.4 Friction loss and the hydraulic grade line



In the model shown above, a straight line can be drawn from the water surface at the tank through the water level in each clear tube to the outlet.

This line is known as the Hydraulic Grade Line (HGL) or the Hydraulic Gradient. The HGL that links points of atmospheric pressure can be drawn for any hydraulic system, whether it be several hundred kilometres of pipeline or a relatively short stock water supply line.

The HGL represents the pressure, expressed in metres of water (or head) at any point in the pipe, and the amount of head lost in overcoming friction up to that point. The pressure is given by the distance from the pipe up to the HGL, and the loss is the distance from the water level at the source down to the HGL.



In the diagram (above) a tank on a hill has been used to provide the pressure to create flow. A pump may replace an elevated tank, particularly in flatter country. The pump raises the HGL in the same way as the elevated tank.

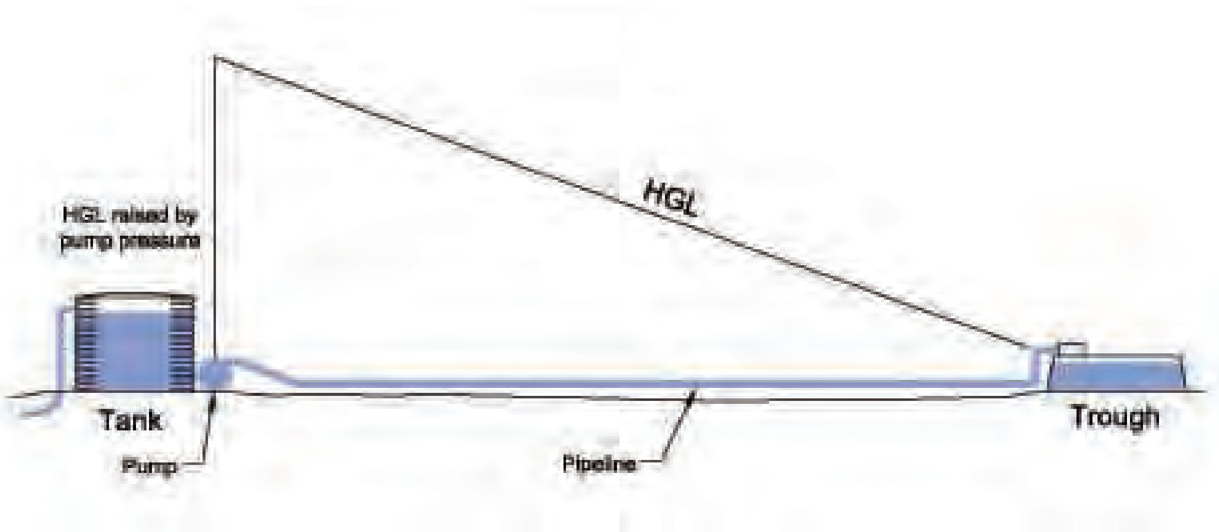
For example, if a pump produces a pressure of 200kPa (20m) then the HGL will be raised by 20m at the pump as shown below. This has the same effect as raising a tank 20m above ground level.

Almost all of the head available at the start of the pipe is used in overcoming friction.

When the HGL is drawn, the amount of head at the start equals the amount of head lost by the end.
A small amount of the head available at the start is converted into velocity energy. This is nearly always so small that it can be ignored.

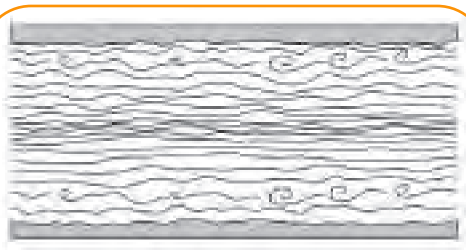
The total head loss due to friction is approximately equal to the difference in elevation between the water level at the pipe inlet and the pipe outlet.

This explanation is intentionally simple. Further details can be found in hydraulics engineering text books.



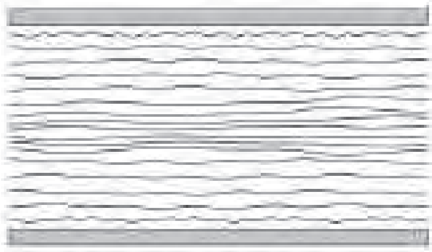
7.5 Pipe friction

Two surfaces rubbing together create friction and generate heat. Fluid moving in a pipe creates friction and pipe friction transforms pressure energy into heat energy. The amount of friction in any pipe will depend on its diameter, internal surface roughness, length and flow rate.



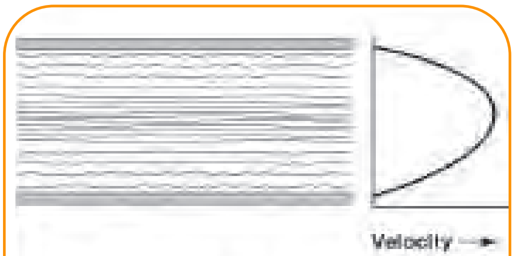
Pipe Friction In Rough Pipe

If the inside of a pipe is rough, the turbulence created restricts the velocity of water close to the pipe wall. Using a smooth bore pipe, this pipe friction results in lower flows and higher pressure drop along the length of the pipe.



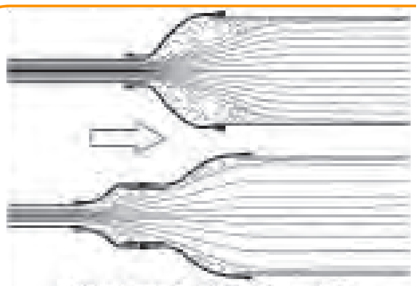
Pipe Friction In Smooth Pipe

If a smooth bore pipe like PVC or polyethylene is used, there is less turbulence created and water velocity close to the pipe surface will be high; resulting in less friction and increased flow.



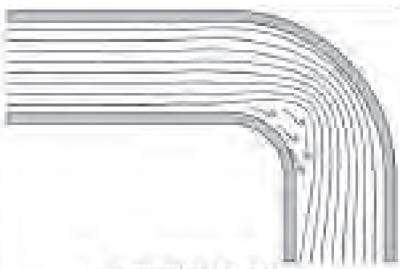
Velocity Of Water Across Pipe

Because of friction created between water and the inner surface of a pipe, water across a pipe does not flow at even velocity.
At the walls of the pipe the flow is close to zero, whereas at the centre the flow is the maximum. This can be likened to a river, where at the edge the flow is virtually zero due to friction created by the riverbank. The fastest flow will be in the middle of the river. This illustration shows a graph of velocity in relationship to pipe cross section.
As pipes get older, material tends to build up on the inner wall of the pipe causing roughness and less cross-sectional area, resulting in increased friction and less flow.



Turbulence In Pipe Expansions

When a pipe is being increased or decreased in size, turbulence is experienced adding to pipe friction. Generally, keep expansion and reduction of pipe sizes to a minimum or at least in small steps if unavoidable.

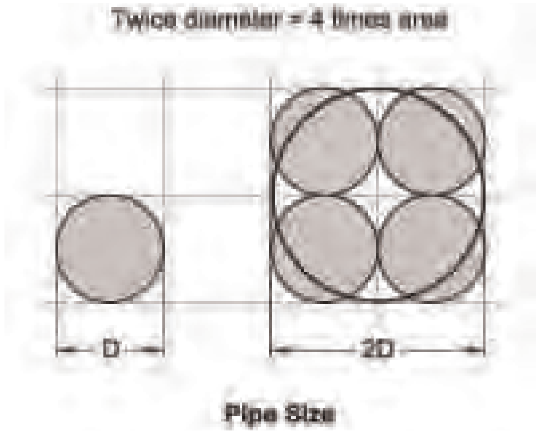


Flow Of Water In Elbows

Due to centrifugal force and the shape of the elbow, the fluid flow is higher on the outside of an elbow. As the water is thrown to the outside surface, this effectively reduces the area in which the water flows. Sharp elbows create more centrifugal force increasing pipe friction, so it is good practice to use gradual radius bends where possible and keep the number of bends in any pipe system to a minimum to reduce the effects of friction.

7.6 Water flowing from a pipe

The amount of water flowing from a pipe in a given time depends on the pressure available, the diameter of the pipe, pipe length and the roughness of the inside of the pipe.



A small increase in pipe size increases the internal area of the pipe significantly. If the pipe diameter is doubled, the cross-sectional area increases by a factor of 4.
If everything else remains constant, flow rate is also increased by a factor of 4.

7.7 Pressure rating or PN

The Pressure Rating of the pipe represents the safe working pressure of the pipe.
This is expressed as the 'PN'. The number of the PN multiplied by 10 gives the safe working pressure in metres of water at 20ºC.

A PN10 pipe has a safe working head of 100m, and PN12.5 has a safe working head of 125m. Rural 'B' or imperial class pipe has a safe working head of 60m or 600kPa at 20ºC.

7.8 Low pressures developed in pipelines

Pressure less than atmospheric pressure is commonly referred to as negative pressure. Negative pressure may occur in reticulation systems in certain situations and will generally be present in most pump suction lines.

In water hydraulics, if the pressure is less than atmospheric it is generally referred to as a negative pressure or negative head. For example, a negative head of 30kPa would be an absolute head of 70kPa.

7.8.1 Absolute pressure and gauge pressure

Most pressure gauges when disconnected and open to atmosphere give a reading of zero, even though they are registering air pressure. If the air pressure acting could be reduced, the needle would move back beyond zero to a negative value.

A total vacuum has zero pressure. It is impossible to get a pressure less than zero at total vacuum.

'Absolute Pressure' is displayed on gauges that have zero at total vacuum while 'Gauge Pressure' is indicated on those with their zero at atmospheric pressure.

Absolute pressure is therefore equal to gauge pressure plus atmospheric pressure.

Average atmospheric pressure at sea level is 100kPa. Absolute pressure readings are therefore about 100kPa higher than gauge pressure readings.

7.8.2 Negative heads in farm water supplies

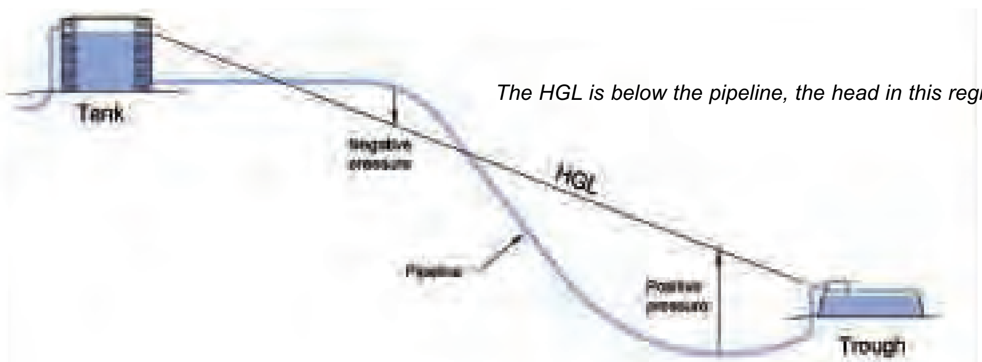
Negative heads occur where the HGL is plotted below the pipeline. The distance from the pipeline to the HGL on a plot drawn to scale represents the pressure in the line. If the HGL is below the pipeline, the distance down from the pipeline to the HGL represents the amount of negative head (see figure below).

Although it is possible to graphically represent a negative head so that it appears to be more than 10m, it is impossible to get a negative head greater than 10m, as this is equal to total vacuum.

Negative heads greater than 3m should be avoided in pipelines. Negative heads have been observed to cause pulsating flow in pipelines and may even stop the flow altogether.

Negative heads occur on the suction side of pumps. Pumps do not 'suck'; they produce a negative pressure at the inlet. Atmospheric pressure then forces the water into the centre of the pump

A large negative head in a pump suction line can lead to damaging cavitation in the pump.



The HGL is below the pipeline, the head in this region is negative.

7.9 Pipe sizing and pipe friction charts

The practical use of pipe friction charts in designing on-farm systems is shown through the examples on the next two pages:

Engineers have put the relationship between pipe length, diameter, flow rate and head loss for different types of pipe on a graph known as the pipe friction chart.

Most friction charts show the friction loss for a constant length of pipe, either for 100m or 1,000m of pipe.

Friction charts for two different types of polyethylene pipe are shown on the following two pages.
The axes of these charts are:

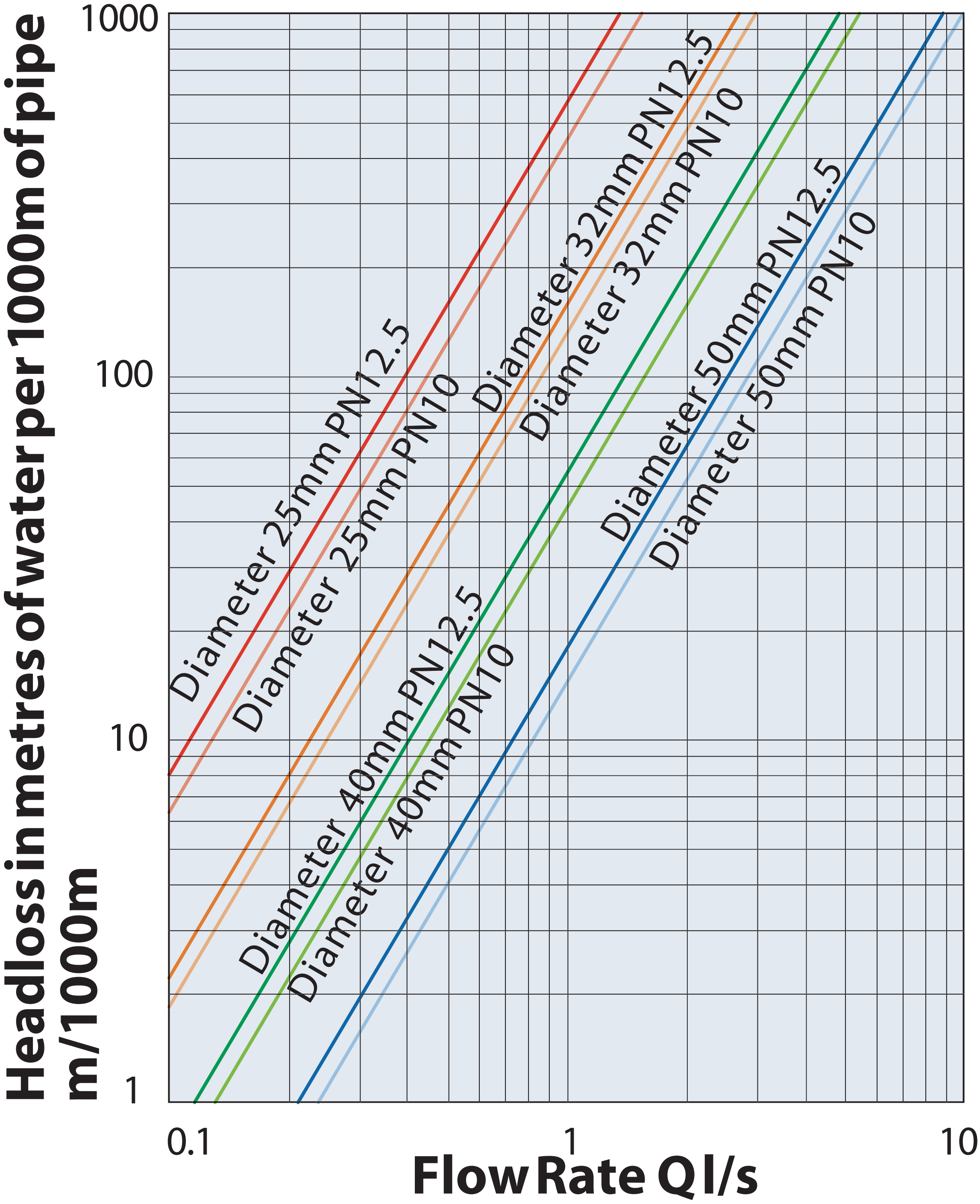
> Horizontal axis-flow rate Q, in L/s.
> Vertical axis-head loss due to friction Hf, in m of water per 1,000m of pipe.

Pipelines are seldom exactly 1,000m long so the friction loss for the known length of pipe has to be calculated from the loss of head shown for 1,000m of pipe.

Some friction charts also show velocity of flow. The formula on which the chart is based only holds for velocities below 5m/sec. High water velocity in pipes contributes to poor flow and higher pumping costs and may aggravate water hammer. To reduce complication, water velocity is not shown on the charts.

Metric Flow Chart for Polyethylene Pipe

PE80B complying to AS4130

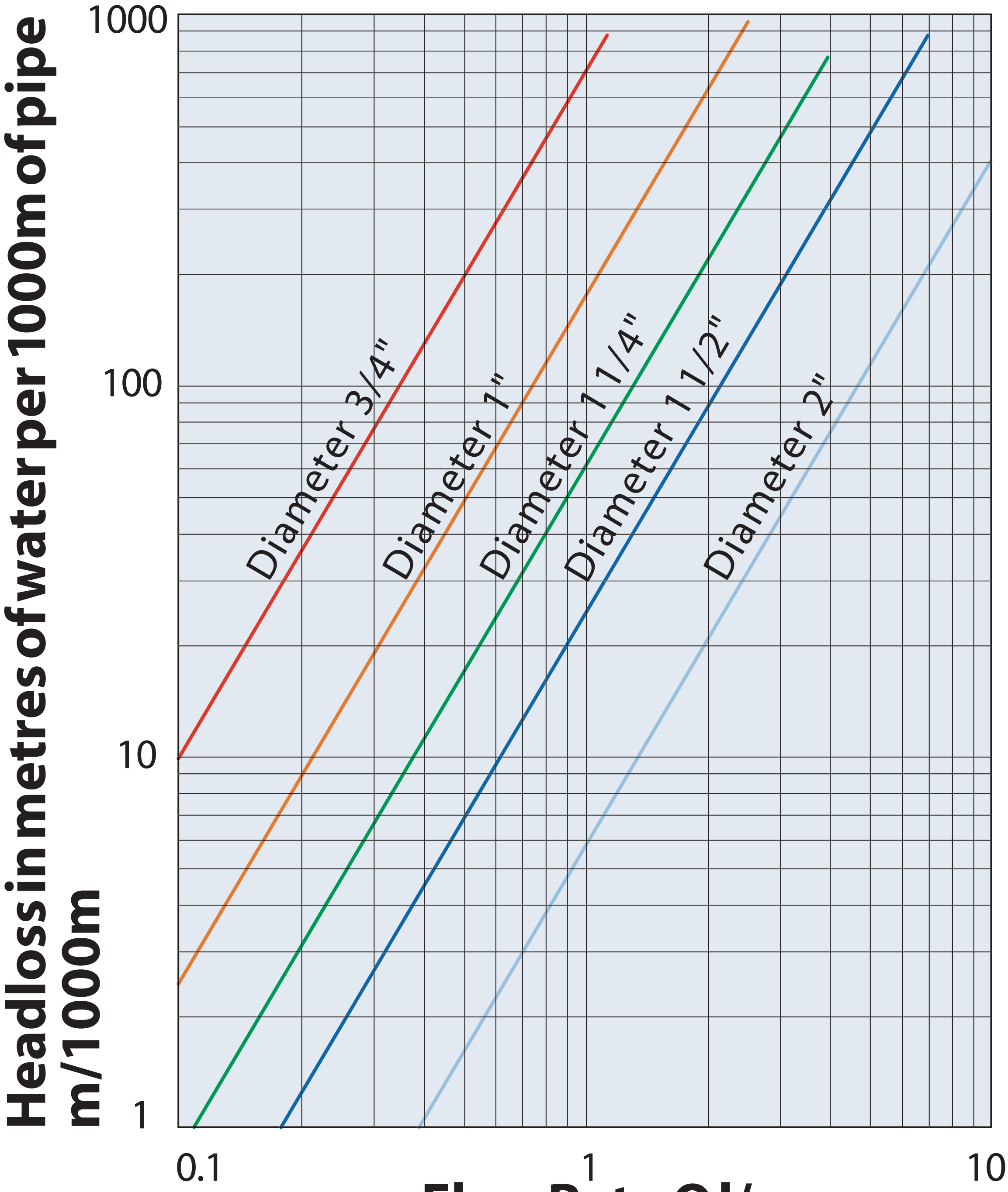


Based on Hazen-Williams Formula

$Q=4.03x10^{-5}D^{2.65}H^{0.54}$

Imperial Flow Chart for Polyethylene Pipe

PE80B complying to AS4130



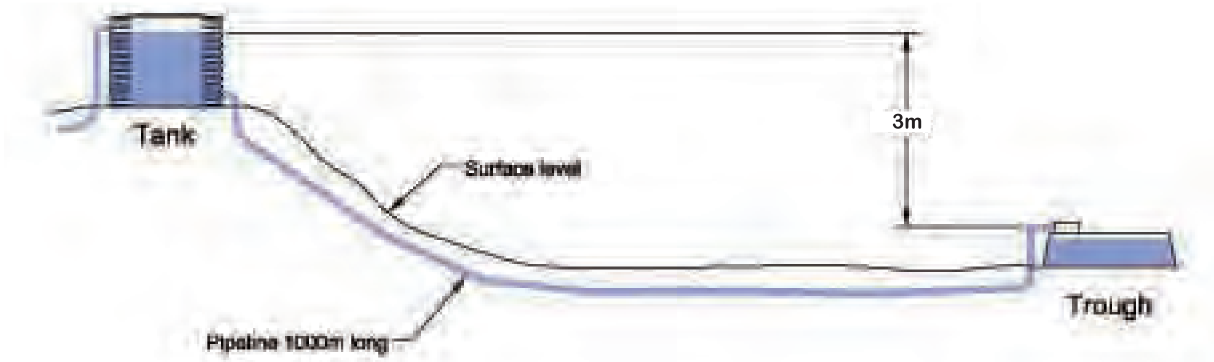
Based on Hazen-Williams Formula

$Q=4.03x10^{-5}D^{2.65}H^{0.54}$

7.10 Examples

7.10.1 Example 1

Determine what size rural polyethylene pipe is required to carry 0.2L/s from a tank to a trough 1,000m away with a head of 3m as shown below.

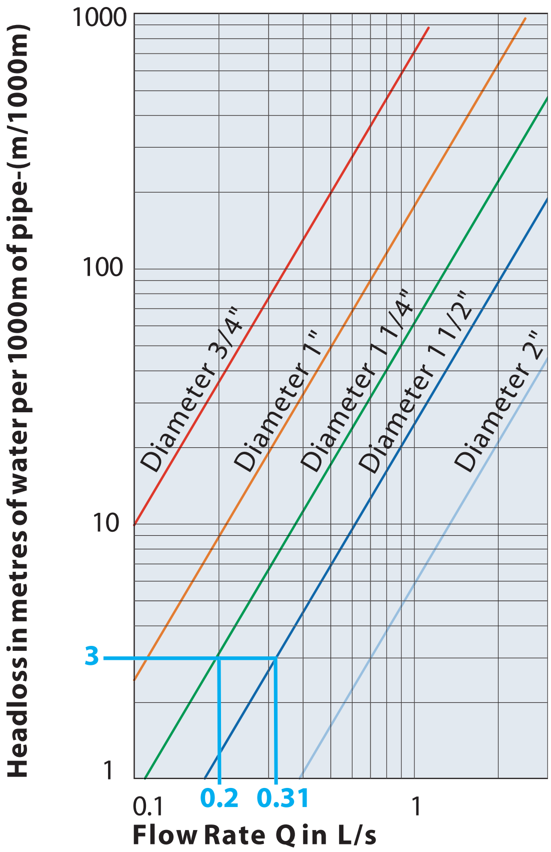


The trough is 1,000m from the tank; the available head is 3m. The HGL for this system is a straight line from the water surface in the tank to the outlet.

Initial drawing of the HGL is a useful exercise. The HGL (above) shows that 3m of head is available to overcome friction losses in the pipe. This 3m is lost uniformly over a pipe of 1,000m in length. Therefore the head loss per 1,000m is 3m.

hf/1,000m = 3m and
Q = 0.2L/s

The maximum pressure in the system will be 3m. This will occur when the outlet is closed. A rural class pipe will be adequate as it can withstand a head of 60m.



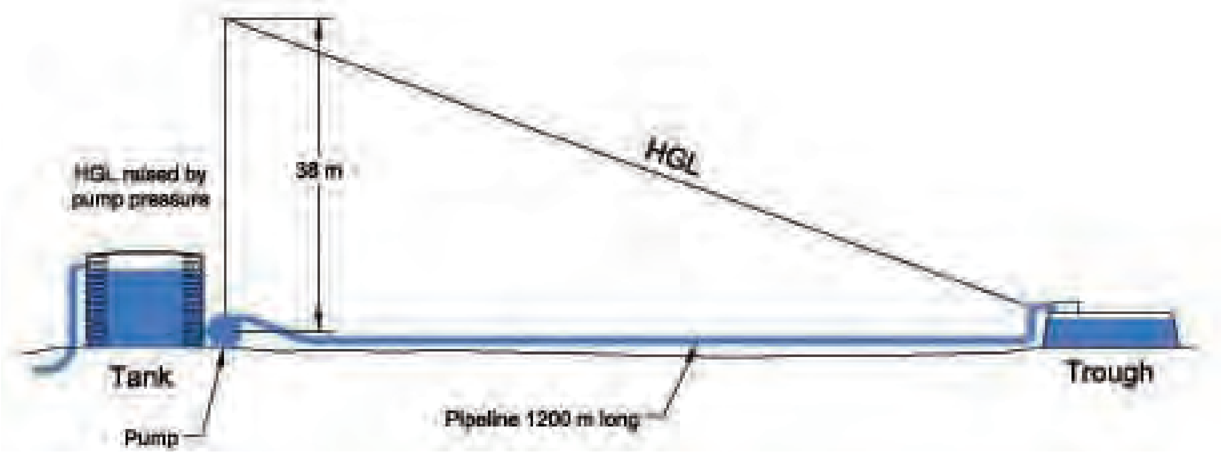
Under these conditions a $1\frac{1}{4}$" pipe would give a flow rate very close to the required 0.2L/s. A $1\frac{1}{2}$" pipe would give a flow rate of 0.31L/s.

If the pipeline was not 1,000m long, it would be necessary to determine what the head loss per thousand metres would be in order to use the vertical axis on the chart. If for example the head loss was 3m for a 500m length of pipe, the equivalent loss per 1,000m is 6m. i.e. 6m/1,000m, the maximum head would still be 3m.

Alternatively, if the head loss was 3m on a pipe 2,000m long, this would be equivalent to a loss of 1.5m per 1,000m; the maximum head still being 3m.

7.10.2 Example 2

Determine the diameter and PN of a metric pipe necessary to deliver 0.8L/s through a pipeline 1,200m long if the head available is 38m.



Available head is 38m, length is 1,200m, the flow rate is 0.8L/s.

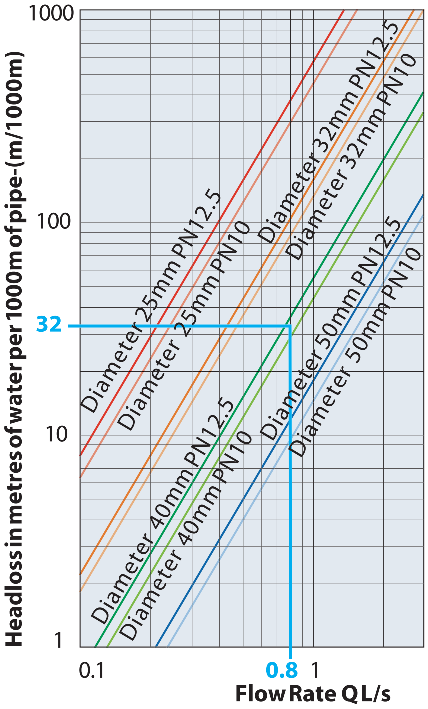
Maximum head is 38m, therefore PN10 is acceptable (head <100m, either PN4 or PN6.3 would also be suitable, depending on availability).

Head loss is 38m over 1,200m.

To determine the equivalent head loss over 1,000m, divide 1,200 by 1.2 to obtain 1,000. 38m must also be divided by the same amount.

$$\frac{38}{1,200} = \frac{38/1.2}{1,200/1.2} \quad \text{approximately} \quad \frac{32}{1,000}$$

head loss is 32m per 1000m or 32/1,000
desired flow rate is 0.8L/s



This chart shows that the nearest PN10 pipe to carry the desired flow rate of 0.8 L/s is a 40mm diameter pipe.

7.11 Designing a system

Designing a system involves selecting all pipe diameters, tanks and pumps if needed.

How do you determine the most economic diameter of pipe? Water requirements, distances, heights and pressures all have to be considered together to determine the best diameter of pipe for a given application.

The simplest case is to determine the pipe diameter where only one water source and one outlet exist. This may be all that is needed to complete a design if all stock were to run in one mob, even though the pipeline may have multiple troughs coming from it. In this case, the stock would only ever be drinking from one trough. All that is needed is to ensure that stock receive sufficient water no matter what trough they drink from.

7.11.1 Example 3

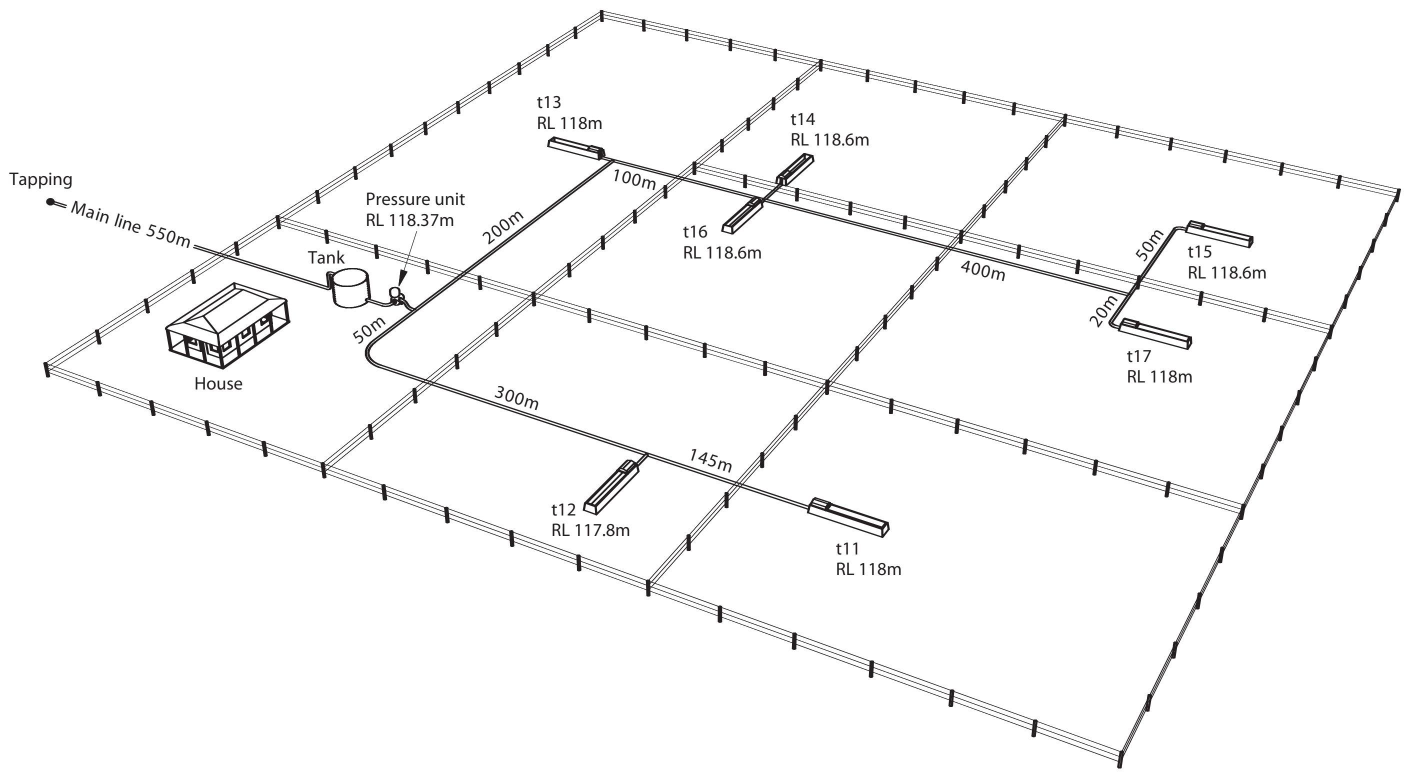
A reticulation plan on part of a broadacre property.

In this case there are seven troughs shown on the property, but sheep will only be drinking from one trough at a time.

Water is pumped by the pressure unit in the shed. The tank and pressure unit are at a height of 118.37m. Trough ***t15*** is at 118.09m, and this will be the most difficult to service because it is the highest (the highest of a number that are almost the same in height). It is also the furthest trough from the pump, at a distance of 750m. If the water reaches this point satisfactorily it will also reach all other points.

Trough ***t11*** is on another system and will also have to be checked. If water gets to ***t11*** it will also get to ***t12*** because ***t12*** is closer to the pump. This section of the pipeline also services the farm house and therefore extra capacity is needed to allow for watering the garden.

There are two systems for which the pipe sizes must be determined. One is the line from the mains to the tank; the other is the reticulation system around the property. Tank capacity must also be selected.



7.12 Tank size

The proposed daily allowance on the WMP is currently designated at:

Location	Litres
house and garden	5000
stock	2903
growth	4271
TOTAL	**12,213**

The tank has to be able to contain three days' supply of water.

Tank capacity is
12,213 x 3 = 36,396L

The tank that has the closest capacity to this measurement is a 45,000L tank.

7.12.1 Mainline from tapping to tank

Measurements and calculations required are:

Distance from tapping to tank	550m
Difference in elevation of meter and inlet to highest tank (allowing 2m for tank height)	3.7m round to **4m**
Pressure at meter	200kPa or **20m**
Head available to overcome friction loss	**16m** (20-4=16m)
Head loss per 1,000m	$\frac{16 \times 1{,}000}{550}$ = 29.3m/1,000m round to **29m/1,000m**

For a daily allowance of 12,213L in a 24-hour period, the daily or 24-hour flow rate per second will be:

$$\frac{12{,}213}{24 \times 60 \times 60} = 0.14\text{L/s}$$

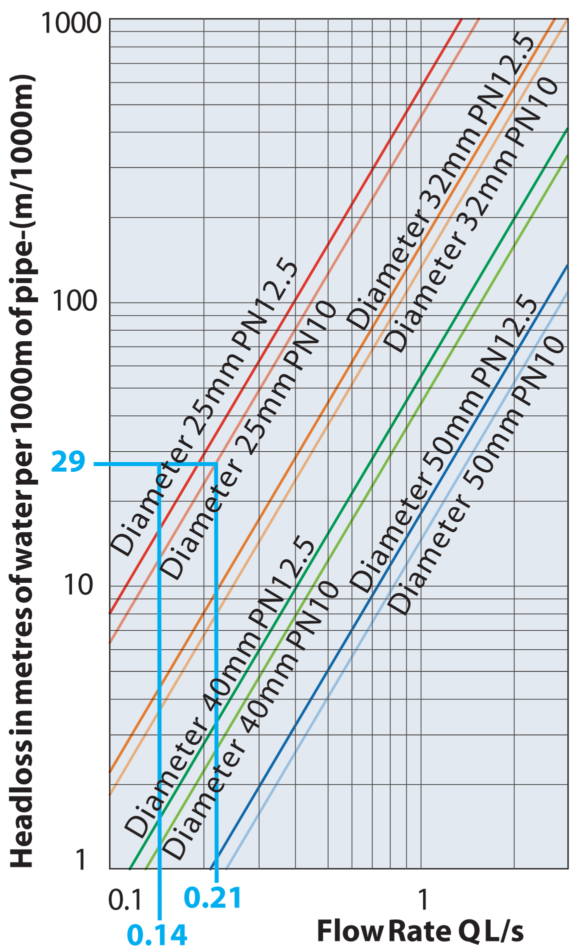
The metric friction chart below, details the pipe necessary to deliver this amount of water from the mainline to the tank.

In this example, Q is 0.14L/s and Hf is 29m/1,000m.
From this chart it can be seen that the best available pipe is a 25mm pipe.
Maximum head is 20m.

A rating as low as PN4.5 could be used, but to meet the requirement of matching the farm mainline and the WMP mainline rating it is assumed that PN10 will be necessary.

The chart shows the actual flow rate from a 25mm PN10 pipe will be just over 0.21L/s.

Consideration may also be given to next pipe size up to encourage a higher than required flow rate for replenishing the tank.



7.13 Property reticulation

The following parameters are required either as measurable or calculated from.

Note: heights and distances are shown on *7.11.1, (example 3: property plan)*

Flock size:	500 wethers
Household requirements:	two garden taps
Flow rate required:	To be determined from stock numbers. Rule of thumb for stock water requirements suggests that all stock should be watered in a four-hour period.
	This rule has been used by designers for many years, giving reliable, if conservative, figures.
	(Burton, John R. 1965. *Water Storage on the Farm. Bulletin No 9, Vol 1.* Water Research Foundation of Australia)

The water requirement for wethers is 7L/head per day. This is the maximum expected and therefore allows for the most severe conditions.

Flow rate:
500 head x 7L/head/day = 3,500L/day
This amount is to be supplied in four hours or 240 minutes

The required flow rate will be:

$$\frac{3,500}{240} = 14.58 \text{ or } 15\text{L/min}$$

or

$$\frac{14.58}{60} = 0.243 \text{ or } 0.25\text{L/sec}$$

In this example the pressure is supplied by a pressure unit, with much choice of how much pressure is available.

Typical pressure unit operating ranges are:

140 – 280kPa
210 – 350kPa
280 – 420kPa
350 – 560kPa
420 – 630kPa
490 – 700kPa

Pressure ranges may be higher than this with some makes and models of pressure units.

In this example the pressure unit range is set at 140–280kPa. The system needs to operate satisfactorily at the lowest pressure. It has to operate at 140kPa or a head of 14m.

'Rural' polyethylene pipe is to be used. The figures required from the pipe friction chart to determine the pipe diameter are:

total length of pipeline
from the pump to trough t15: 750m
head available: 13m

The trough is at 118.09 and the float valve is at 118.69; the outlet of the pressure unit is 0.3m higher than the pump level at 118.37 + 0.3 *i.e.* 118.67. The pump and trough can be assumed to be at the same height in this example. To build in a safety factor an extra 1m may be added to the trough height, making the head available 14-1 *i.e.* 13m.

To use the pipe sizing charts in this guide, it is necessary to convert head loss in m/m to head loss in metres/1,000m.

the headloss is 13m over a distance of 750m

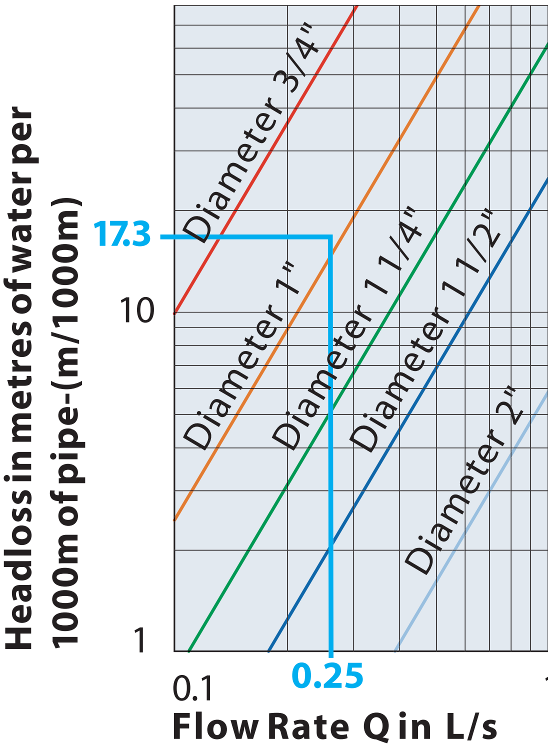
$$\frac{13}{750} = 0.0173\text{m/m}$$

If the head loss is 0.0173m per metre, for a 1,000m length of pipe the head loss will be:

0.0173 x 1,000 = 17.3m

This figure is to be used on the friction chart:

hf = 17.3m/1,000m
The flow rate Q = 0.25L/s



The friction chart above, shows that the nearest pipe size is 1 inch.

The entire length of pipe from the pump to all troughs could be 1 inch. Some larger diameter pipe will be needed to service the garden.

When the answer lies within two pipe sizes go to the larger size.

7.13.1 Example 4

Although ***example 3*** was straightforward, landowners may have a number of different mobs. If there are three mobs of 500 head many questions can be asked:
Where are they running?
What will be the most difficult troughs to service?

Designing with unknown factors in mind requires a different approach.

Difficulty arises from knowing where the sheep will be and when they will drink. Two options exist for determining the pipe size:
a) To assume that all the sheep will drink in the same four-hour period. This generally gives an economic result and is very reliable.
b) The other option is to use a rule of thumb which has been found to be appropriate and reliable for multiple troughs, while giving an economic pipe design. This allows 0.1L/s per outlet and 0.2L/s to the end trough. This is more appropriate when there is a large number of mobs and troughs with flock sizes of 200-250 head.

Designing with unknown factors is best managed using a table as shown below. Some trial and error is necessary; using different diameter pipes to ensure the HGL is always greater than ground level.

Location	Outlet	Pipe flow	Distance	Pipe dia	Head loss	H_f	HGL	RL
	L/s	L/s	m	mm	m/1000m	m	m	m

Table heading definitions

Location	lists the components of the system e.g. trough t11, tank T2.
Outlet	flow rate from a given outlet e.g. the flow rate required from t11 may be 0.25L/s. The location and outlet figures are entered on the same line and at every second line.
Pipe flow	contains the flow rate within the pipe between two features e.g. the flow between t11 and t12 may be 0.5L/s. The value of the flow rate is entered in the row between the outlet rows.
Distance	distance between the features or the length of the pipe section.
Pipe dia	nominal diameter of the pipe, in inches for 'Rural' pipe and mm for metric pipe.
Head loss	loss per 1,000m determined from the pipe chart.
H_f	head loss for the length of pipe for the distance shown in the 'Distance' column.
HGL Hydraulic Grade Line	height of the HGL at the given location, calculated for a given line by subtracting the H_f from the row above from the HGL figure in the next row above.
RL	reduced level of the point or location as shown on the farm plan ***(example 3)***. RL is a surveyor's term for the level of a point that has been calculated, or 'reduced' from survey figures to give the height relative to a given baseline or datum.

7.14 The design procedure

Assuming that all stock will drink during the same four-hour period, the first part of this table is filled in with known figures or data.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	Hf m	HGL m	RL m
PU							132	118.37
			0					
J1	1.4							119
			200					
t13	0							118
			100					
t14, t16	0.25							118.6
			400					
t17	0.25							118
			50					
t15	0.25							118.6

Table 1: The design procedure

Step two is to fill in the flow rates in each section of the pipe and estimate the pipe sizes necessary to carry the water. When filling in the pipe flow section, start at the bottom of the table, as shown in red on *Table 2*.

Then fill in the line above which carries the water to both t17 and t15, 0.25 + 0.25 i.e. 0.5L/s as shown in blue, continuing up the table, adding each flow rate from the pipe below, as shown in green.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	Hf m	HGL m	RL m
PU						132	118.37	
		2.15	0					
J1	1.4						119	
		0.75	200	1				
t13	0						118	
		0.75	100	1				
t14, t16	0.25						118.6	
		0.5	400	1				
t17	0.25						118	
		0.25	50	1				
t15	0.25						118.6	

Table 2: The design procedure

In the first trial, a 1-inch pipe has been tried. In *Table 2* the RL figures do not exactly match those on the map. An allowance has been made for the height of the trough above the ground, usually at least 0.6m. The pressure unit height remains the same as its stated RL. The minimum pressure the pressure unit meets is 140kPa or 14m. When the pressure drops to this amount the pressure switch turns the pump on. This means that the HGL at the pump will be:

118.37 + 14 = 132.37 or 132m

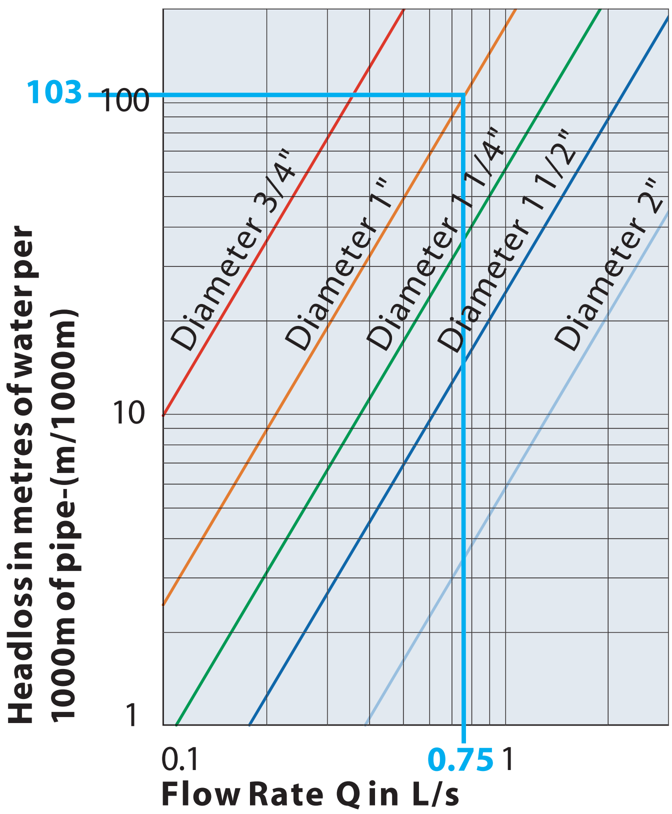
Figures are rounded up or down to ensure the most reliable outcome. For example, the outlet RL is rounded up, while the pump RL is rounded down. J1 in the tables is junction 1. This is the 'tee' at the pressure unit that delivers the water to the farm house and eastern troughs. The next step is to utilise the pipe friction loss chart to determine the head loss per 1,000m of pipe. This figure is shown in red in *Table 2*. This has to be done for each line of the table using the method outlined in *(7.10.1, example 1).*

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.15	0		0	0		
J1	1.4							119
		0.75	200	1	103	20.6		
t13	0							118
		0.75	100	1	103	10.3		
t14, t16	0.25							118.6
		0.5	400	1	48.6	19.4		
t17	0.25							118
		0.25	50	1	13.5	0.7		
t15	0.25							118.6

Table 3: The design procedure

From this, head loss per 1,000m for each length of pipe and its appropriate flow rate H_f must be determined as shown in blue on *Table 3*.

For example, the 200m of 1-inch pipe between J1 and t13 carries 0.75L/s and from the friction chart the head loss will be 103m/1,000m.



Use of the friction chart to determine head loss per 1,000m.

The head loss, H_f, for 200m will be given by:

$$\frac{100}{1,000} \times 200 = 0.103 \times 200 = 20.6\text{m}$$

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.15	0		0	0		
J1	1.4						132	119
		0.75	200	1	103	20.6		
t13	0						111.4	118
		0.75	100	1	103	10.3		
t14, t16	0.25						101.1	118.6
		0.5	400	1	48.6	19.4		
t17	0.25						81.7	118
		0.25	50	1	13.5	0.7		
t15	0.25						81	118.6

Table 4: The design procedure

The calculation of head loss/1,000m (red) and head loss H_f for each length of pipe is calculated (blue).

Finally the HGL is determined as shown in *Table 4*. This is done by subtracting the head loss H_f from the HGL on the line above it, starting at the top as shown in red, and then following down as shown in blue and continuing on in green.

From completed *Table 4*, it can be seen that the 1 inch diameter pipe has been a bad choice, as the HGL is less than the RL at t13 and beyond. This means that the water will not flow at the rate required.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.15	0		0	0		
J1	1.4						132	119
		0.75	200	$1\frac{1}{2}$	14.1	2.8		
t13	0						129.2	118
		0.75	100	$1\frac{1}{4}$	34.7	3.5		
t14, t16	0.25						125.7	118.6
		0.5	400	$1\frac{1}{4}$	16.4	6.6		
t17	0.25						119.1	118
		0.25	50	$1\frac{1}{4}$	4.5	0.2		
t15	0.25						118.9	118.6

Table 5: The design procedure

A larger diameter has to be tried which includes some $1\frac{1}{2}$ inch pipe and some $1\frac{1}{4}$ inch as shown in *Table 5*.

Results in *Table 5*, show the HGL is always higher than the RL and therefore the system will operate satisfactorily. The fact that the HGL is higher than the RL at the end, t15, indicates that the flow rate will be slightly higher than expected.

This result is conservative and experience will tell the designer that perhaps further investigation may allow the first 300m of $1\frac{1}{2}$ inch pipe to be replaced by $1\frac{1}{4}$ inch. This only amounts to a saving of about $50 on the pipe and fittings together, so may not be warranted when compared with the reliability of the proposed system.

Further information can be put into *Table 5*. Different pipe lengths of alternative diameters can be assessed; for example the distance between J1 and t13 becomes 150m of $1\frac{1}{2}$ inch and 50m of $1\frac{1}{4}$ inch, changing at P1 in *Table 6*. Negative heads can be checked; these show up when the HGL is less than the RL as shown *Table 6*.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.15	0		0	0		
J1	1.4						132	119
		0.75	150	$1\frac{1}{2}$	14.1	2.1		
P1							129.9	124
		0.75	50	$1\frac{1}{4}$	34.7	7.0		
t13	0						122.9	118
		0.75	100	$1\frac{1}{4}$	34.7	3.5		
t14, t16	0.25						119.4	118.6
		0.5	400	$1\frac{1}{4}$	16.4	6.6		
t17	0.25						112.8	118
		0.25	50	$1\frac{1}{4}$	4.5	0.2		
t15	0.25						112.6	118.6

Table 6: The design procedure

From *Table 6*, it can be seen that incorporating a further 50m of $1\frac{1}{4}$ inch and reducing the $1\frac{1}{2}$ inch will not allow the system to work at the desired flow rate because the HGL is too low at t17 and t15. This does not mean that the system will not work; it means that the flow rate will be less than desired.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.0	0		0	0		
J1	1.4						132	119
		0.6	150	$1\frac{1}{2}$	9.3	1.4		
P1							130.6	124
		0.6	50	$1\frac{1}{4}$	23	4.6		
t13	0						126	118
		0.6	100	$1\frac{1}{4}$	23	2.3		
t14, t16	0.2						123.7	118.6
		0.4	400	$1\frac{1}{4}$	10.8	4.3		
t17	0.2						119.4	118
		0.2	50	$1\frac{1}{4}$	3	0.2		
t15	0.2						119.2	118.6

Table 7: The design procedure

Tables 1-9 make the assumption that the flow rates will be as shown. This is not necessarily the case. What occurs in practice is that the water takes the line of least resistance and flows out the easiest outlet first. The water in the trough acts as a buffer to ensure that all stock are watered satisfactorily.

In *Table 7* the water will flow out the nearest trough first. If the capacity of the float valve is less than the pipe capacity then some water will be available for other outlets downstream. The pipe chart will tell us that the flow to trough t14 on its own will be approximately 0.8L/s .

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		2.2	0		0	0		
J1	1.4						132	119
		0.8	150	$1\frac{1}{2}$	15.9	2.4		
P1							129.6	124
		0.8	50	$1\frac{1}{4}$	39.1	7.8		
t13	0						121.8	118
		0.8	100	$1\frac{1}{4}$	39.1	3.9		
t14, t16	0.8						117.9	118.6
		0	400	$1\frac{1}{4}$	0	0		
t17	0						117.9	118
		0	50	$1\frac{1}{4}$	0	0		
t15	0						117.9	118.6

Table 8: The design procedure

Water will flow into trough t14 at a quicker rate than assumed in the design. If sheep are drinking from the other troughs and are starved for flow they will quickly have flow resumed because t14 will be filled much quicker than expected.

The storage in the other troughs is available to the stock while the flow is interrupted and the upstream trough is filling.

The 'free flow' at the end trough should be checked to see that no negative heads develop when all the flow is going to the end trough.

The end trough is not always the trough that will give the greatest negative head. In hilly situations, checks for negative heads should be done on hills immediately upstream of troughs that are in hollows.

The requirement of the pressure unit to meet these conditions is to be capable of at least 2.15L/s, i.e. 130L/min at 140kPa.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m
PU							132	118.37
		1.9	0		0	0		
J1	1.4						132	119
		0.5	150	$1\frac{1}{2}$	6.7	1		
P1							131	124
		0.5	50	$1\frac{1}{4}$	16.9	3.3		
t13	0						127.7	118
		0.5	100	$1\frac{1}{4}$	16.4	1.6		
t14, t16	0						126.1	118.6
		0.5	400	$1\frac{1}{4}$	16.4	6.6		
t17	0						119.5	118
		0.5	50	$1\frac{1}{4}$	16.4	0.8		
t15	0.5						118.7	118.6

Table 9 The design procedure

A blank copy of the table is provided for reference purposes.

Location	Outlet L/s	Pipe Flow L/s	Distance m	Pipe dia inches	Head loss m/1000m	H_f m	HGL m	RL m

When evaluating how to reticulate water on a property, it is important to have an open mind to all methods. There are many workable solutions but there is usually a preferred or optimal design for each property. It is important to seek the views of others, including:

> landowners who have installed good quality reticulated systems
> experienced on-farm system reticulation designers
> GWMWater's free video: *Piping our Property Video/DVD*
> relevant textbooks, manuals and articles in agricultural journals

The WMP has been designed to provide water at a minimum pressure of 20m or 200kPa on the discharge side of the meter at the service connection location of each property. In many cases, the pressure available may be higher. The pressure available at the service connection is important when locating tanks in terms of distance and elevation and diameter of the connecting pipe. Contact GWMWater's pipeline office for more precise information for your location.

Consider locating tanks on hills or other high spots such as a dam bank or tank stand so that water can gravitate to troughs and other water points, eliminating the need for pumps. If a trough needs to be located some distance from the WMP service connection, consider locating the tank near the trough and use the pressure available from the WMP system to deliver water to the tank. If a trough must be located at a distance from the WMP service connection, the lowest cost method of supplying the trough may be to place it near the tank. Running a pipe from the meter to the tank will utilise the pressure available from the system. Dams are usually located on the lowest ground, whereas with a piped system, tanks can be placed on elevated ground.

Most rural homes and gardens in the Wimmera-Mallee source their water from nearby dams using electric pressure pumps. These pumps usually operate in the range of 140-275kPa. Common pressure requirements for a home are a minimum of 150Kpa and up to around 300kPa. Unless there is a hill or tank stand with an elevation 15-20m above the meter service connection, pumps are usually the best option to achieve satisfactory pressure.

8.1 Typical requirements of a reticulation system

Tanks should be located to minimise total pipe length around the property. Pipe costs will usually be minimised when the tank is placed centrally among the troughs it serves. If the tank only supplies one trough, it should be situated close to that trough.

The pipe from the water meter to the tank can deliver the daily demand over a 24-hour period. In addition, there is at least a 20m head of water to push this relatively small flow rate. As a result, the pipe from the meter to the tank will be smaller in diameter and will cost less.

It is recommended that the pipe from the tank to the trough be designed to deliver the daily demand in four hours. The available head required for this is the difference in elevation of the tank outlet compared with the trough inlet. Because this may be as little as 0.5-1m, the pipe needs to be either short, or large in diameter, to minimise the losses due to friction.

8.2 Pressures required

> Trickle or drip irrigation of plants requires a pressure of at least 100kPa or 10m, which may be achieved by gravity.
> 'Soak-it' hoses will operate satisfactorily on 150kPa or 15m.
> In general, sprinklers will need a minimum of 200kPa or 20m for good performance; this pressure is usually only achievable from a pump.
> Flows to single trough systems may operate with only a few metres of head.

8.3 Tank stands

In flat situations where power is unavailable, a tank stand may be the best method of achieving enough head to deliver water to the troughs. This can be an existing dam bank, an earthen bank or steel tank stand which can be fabricated.

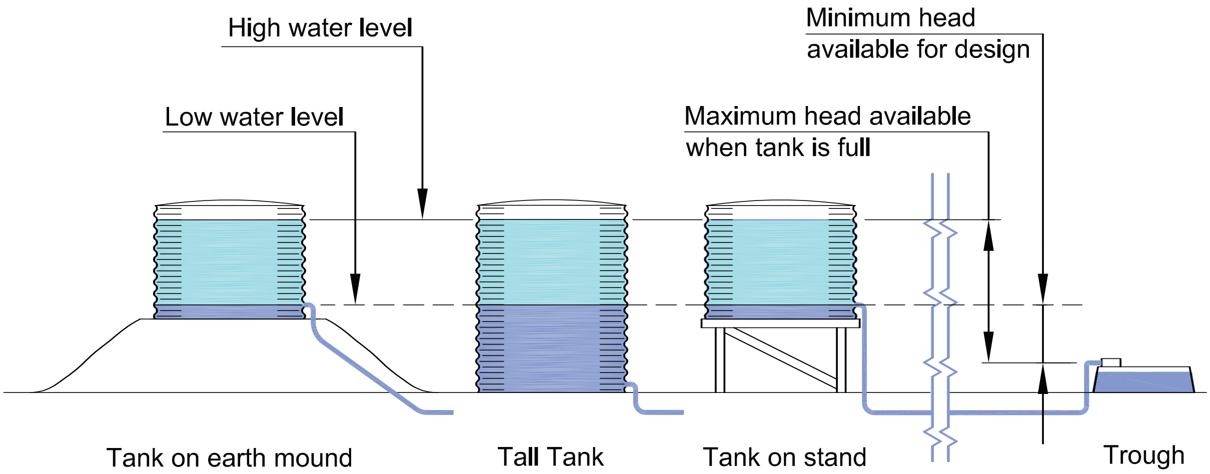
Fabricated tank stands should be the last option due to construction cost, difficulty in placing the tank on the stand and the safety aspect of climbing the stand for maintenance.

A three to four metre stand will give adequate pressure for troughs which are not too far away. In general, it is cheaper and safer to construct an earthen bank this size than to fabricate a stand of the same height. Each litre of water weighs 1kg; there is 22.5 tonnes of water in a 22,500L tank. The stand has to be able to support the water, the weight of the tank, the wind load and any other identified loads.

Occupational health and safety regulations require access ladders on the stand to have suitable caging and be locked to ensure safe access only by approved persons. These factors tend to make the cost of using a tank stand prohibitive. Tank stands can be high in capital costs, but gravity systems are cheap and reliable to operate.

To make the best use of gravity it may be cost-effective to place an oversized (height) tank on the ground. If this is done there must be sufficient water stored in the tank above the height of the trough inlet to ensure a three-day storage requirement.

For example, a tank stand may be required to supply water to one trough from which 500 wethers will be watered in very flat country. The daily requirement at 7L/head is 3,500L. The three-day storage will be 10,500L. As tanks are unlikely to be manufactured in this exact size, the closest size up should be selected, which in this case is 13,600L. The trough is 50m away and requires a minimum of 1.2m head for the water to be safely delivered.



The dimensions of such a tank are based on the formulae at the end of this guide.

diameter 3.1m
height 2.02m

The alternatives are to place this tank on a 1.2m stand, preferably an earthen bank. To obtain a larger tank that will store 10,500L above 1.2m, a 22,500L tank with the following dimensions is required:

diameter 3.56m
height 2.42m

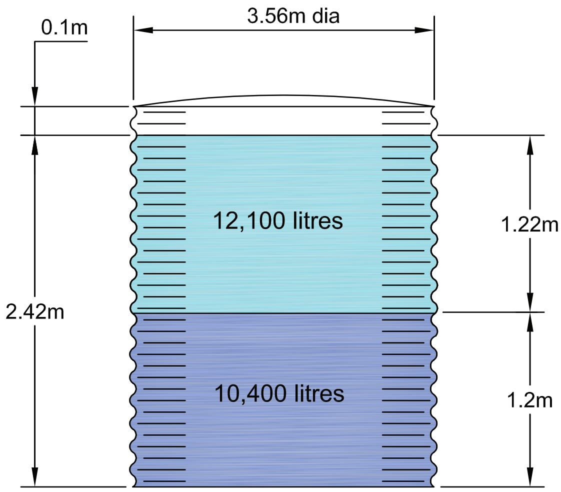
If the lowest 1.2m cannot be used there will be 1.22m of water available to supply the trough. The volume stored above 1.2m will be given by the cross-sectional area.

pi x Diameter x Diameter divided by 4 x tank usable height.
3.1416 x 3.56 x 3.56 divided by 4 x 1.22 = 12m^3

Using the conversion tables at the end of this guide, to convert m^3 to litres $12m^3$

12 x 1,000 = 12,000L

The difference in price between a 13,600L tank and a 22,500L tank is about $500. This has to be compared with the cost of constructing a 1.2m tank stand. This ensures there will always be at least 10,400L available for emergency use such as fire fighting.



A 22,500L tank stores 12,100L above 1.2m when full

8.3.1 Head loss

The diagram (below) shows a tank delivering water to a trough on level ground, if the trough waters 500 wethers and is located 50m from the tank.

The peak daily requirement is 500 head x 7L/head/day = 3,500L/day

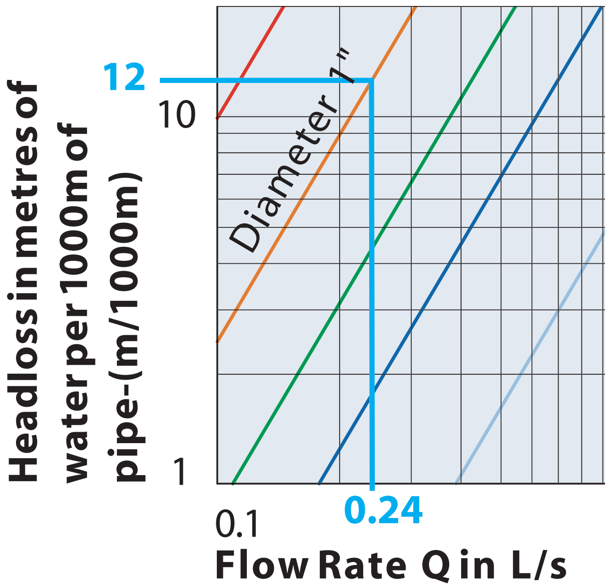
The required flow rate should be delivered in:

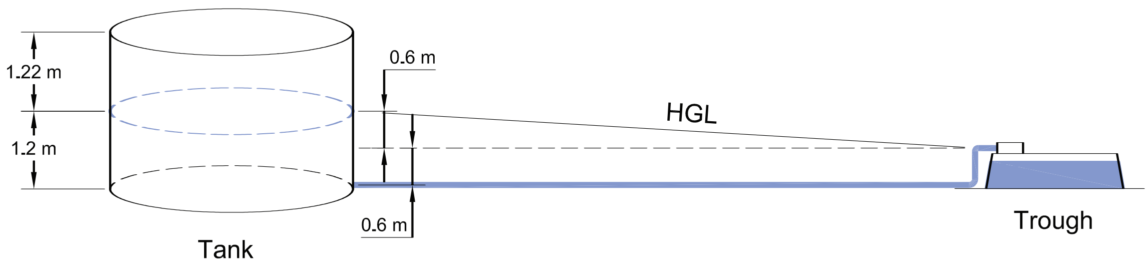
4 hours, 240 minutes or 14,400 seconds i.e. 3,500 divided by (240 x 60) = 0.24L/sec

This has to be achieved when there is still 1.2m of water in the tank. The trough inlet is equivalent to 0.6m above the ground, so the head available is 0.6m as shown in the diagram below.

A head loss of 0.6m over 50m is equivalent to 12m/1,000m.

The pipe chart (below) indicates the pipe required to deliver 0.24L/s with a head loss of 12m/1,000m is a 1-inch Rural polyethylene pipe.





8.4 Pump or gravity flow

Pressure is required to move water through pipes. This must come from either a pump or via gravity from a tank, generally positioned in a raised location relative to where the water will be used.

Delivery of water to the troughs by gravity is generally the best option when elevation is available, because of reliability and minimal operating costs. The negative aspect is that pipe diameter from the tank may need to be greater than for a pumped system, but usually the increased cost of the pipe is minimal in comparison.

Most properties with dams currently have a pressure unit to pump dam water around the house and garden. This is the preferable method for the higher flows required in these situations. Pumps provide good pressure and flow for all water purposes. Adequate pressure for the garden as well as all other reticulation requirements can be obtained from elevations over 15m.

The topography in many parts of the Wimmera Mallee does not allow tanks to be placed at sufficient height to service all pressure requirements of homes and gardens. Consideration should be given to inconvenience and risks of a power failure, especially on hot days. Well-designed gravity systems are unaffected by power failures.

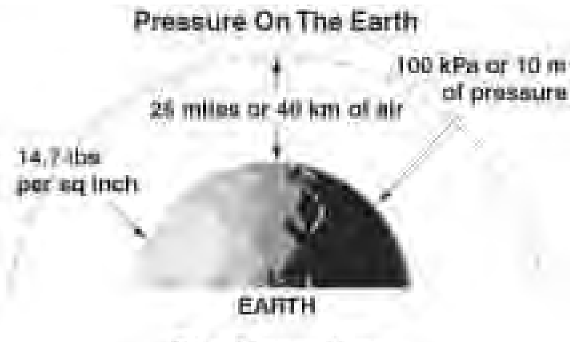
8.5 Summary of pump and gravity systems

In country with minimal slope, troughs should be kept as close to the tank as possible, even if this means additional high pressure pipe between the tapping and the tank. If troughs must be distant from tanks, first consideration should be given to earthen tank-stands, particularly in flat regions, while utilising the existing pressure unit as much as possible.

Pipelines that run away from tanks will normally be subject to the head of water in the tank. Imperial pipe rated to 600kPa is suitable in this situation.

Type of System	Comments
Gravity only	- utilise as much as possible for reliability and the cheapest running cost - pressure from gravity: every 1m elevation of water surface gives 10kPa - may not be suitable around house, garden and sheds
Pump and pressure units	- 100kPa required to lift water 10m - must be enough pressure to overcome friction in the pipe - pumps have maintenance and power costs - utilise existing pressure unit as much as possible - specifications may require checking - jet and venturi may require changing to meet new duty - pipe sizes can be minimised with higher pressures - the safe working pressure for Imperial class pipe is 600kPa
Pump and Gravity	- same pressure requirements as for pump and pressure units - to achieve gravity flow, requirements may include pumping into a high tank - advantage over a pressure unit: added reliability in the case of power failure - pipe sizes have to meet all requirements of pump and gravity
Pump power:	Electric: cheapest but subject to power failures Wind: expensive, high maintenance. February often a calm month Solar: most expensive; best performance in summer when needed. Reliable and low maintenance - additional cost over pump or gravity to achieve required flow and reliability

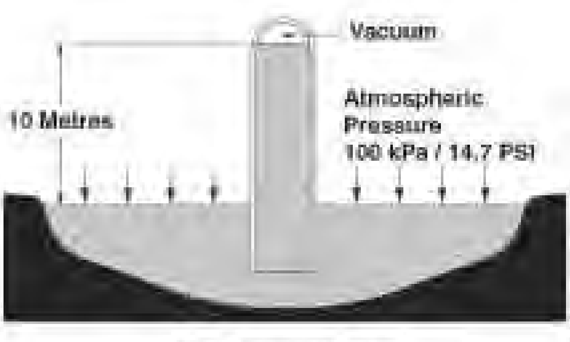
Pumps do not 'suck'. Pumps create a partial vacuum or negative pressure at their inlet. The pressure differential of atmospheric pressure acting on the surface of the water entrains the water into the impeller to fill the vacuum.



The Atmosphere

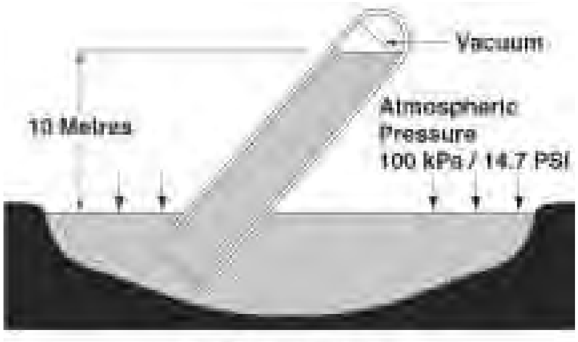
The surface of the earth is surrounded by an 'ocean' of air commonly referred to as the atmosphere. Pressure in a liquid is caused by the weight of liquid above the area in question. The atmosphere exerts pressure on the earth's surface (and water bodies) due to the weight of the air above.

At sea level, this ocean of air exerts a pressure of approximately 100kPa (101,325kPa) which is approximately 10m water head or 14.7 pounds per square inch.



The Atmosphere

If a perfect vacuum is created in an inverted vertical tube, the atmospheric pressure on the surface of the water would push the water into the tube to a height of 10m.



The Atmosphere

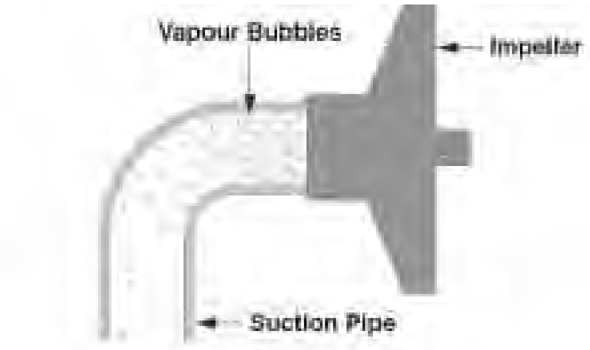
If this same tube is laid on an angle and again creating a perfect vacuum within, the atmospheric pressure would again push the water up the tube to a height of 10m.

Irrespective of total length of the tube, water will rise to a height of 10m with a perfect vacuum, and this indicates there is a maximum pump suction limit.

When the impeller of a pump rotates, it creates a partial vacuum and allows atmospheric pressure to push the water into the vacuum.

Water pumps are incapable of creating a perfect vacuum, so the maximum suction lift of the pump is considerably less than 10m. The maximum suction lift for centrifugal pumps is approximately 6m for self-priming and reliable continuous operation.

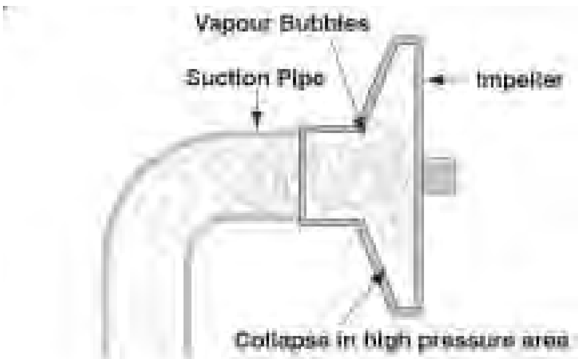
9.1 Cavitation



Pump Suction Lift

Water flowing in the suction pipe and entering the pump impeller can be extremely turbulent, releasing water vapour which can destroy the partial vacuum created by the pump.

In the suction of the pump, water vapour bubbles are released due to a combination of a vacuum, temperature and turbulence. The vapour bubbles enter the impeller and collapse as they reach the high pressure area at the outer edge. The sound of pumping gravel or ball bearings is technically referred to as cavitation. The cavitation noise heard is the collapsing or imploding of the bubbles against the walls of the impeller.



Cavitation

The vapour bubbles causing cavitation reduce the efficiency of the pump and can cause pitting and erosion of the impeller or casing of the pump.

9.2 Temperature

Pump Suction Temperature

The temperature of water can affect the suction performance of a pump, and in the most extreme cases can even cause cavitation.

Water boils at a lower temperature on a mountain than it does at sea level. This is because the air pressure high on a mountain is less. The partial vacuum (low pressure) created by a pump, together with elevated temperature of the water, can cause the boiling temperature of water to lower. This can cause cavitation problems and the pump can lose prime.

For this reason, it is important to avoid situations where long lengths of suction pipe are exposed to the sun causing hot water to enter the pump. This is also why it is desirable to draw water into a pump from a tank that is elevated or is under flooded suction conditions.

9.3 Pump considerations

When connecting to the WMP system, minor to major modifications may be required to your existing on-farm reticulation system.

If your new reticulation design requires a pump, consideration may need to be given to whether:

- > An existing pump can be used.
- > Modification to an existing pump is required. This may involve increasing flow rates or delivery pressures to suit the probable increased demands of troughs.
- > A new pump is required.

A new design may require evaluation of pump location and suitability.

It is probable that the most cost-effective approach with regard to pumps is to check if you can utilise your existing pump that draws water from a dam for domestic home requirements and the farm operation.

Compromises will need to be considered. The availability of power will often influence the siting of an electric pump. The cost of running power to a new pump location can be expensive. It is usually cheaper to install new water pipes to a pump rather than connect power to a pump.

The new on-farm reticulation design and the WMP may allow a pump to be located close to your residence. If there is access to power, the WMP is usually able to deliver water to a tank near a pump. Previously the pump may have been located near the dam which may have been some distance away, with potentially a significant suction lift.

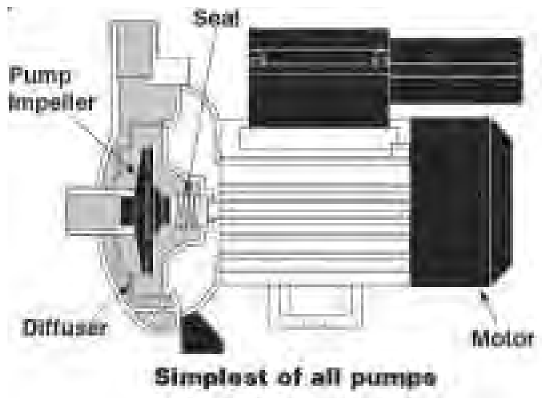
There may also be opportunity to remove power lines that supplied power to the pump if they are causing a safety hazard or hindering farm operations.

It is good practice to locate tanks as close to the pump as practical, and locate tanks in an elevated position to provide flooded suction conditions to the pump. Even a small head will ensure the availability of water in the advent of a power outage.

9.4 Types of pumps

There are many different types of pumps purpose-designed for specific applications. The following are a few common types that will have application for farm reticulation systems.

9.4.1 Centrifugal



Centrifugal pumps are efficient, simple to maintain and are one of the most common pumps available.

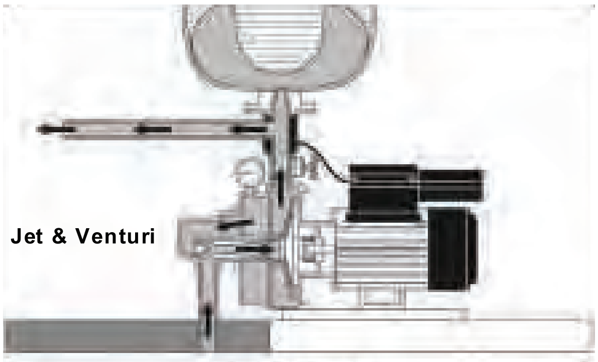
Centrifugal pumps consist of five basic components:

- > motor
- > mechanical seal
- > impeller
- > stationary diffuser
- > casing

The motor rotates the impellor, generating centrifugal force that transforms mechanical energy into kinetic energy as the water velocity increases. The kinetic energy imparted into the water increases as the water moves towards the outside of the impeller. At the vane tip, the water velocity is almost equal to the peripheral velocity of the impeller. Therefore, the greater the diameter and velocity of the impeller, the faster the water will be moving.

Centrifugal pump impellers operate within a volute casing or diffuser, which adds to the efficiency of the pump converting water discharging from the impeller to pressure.

9.4.2 Jet Pumps



Jet Pumps

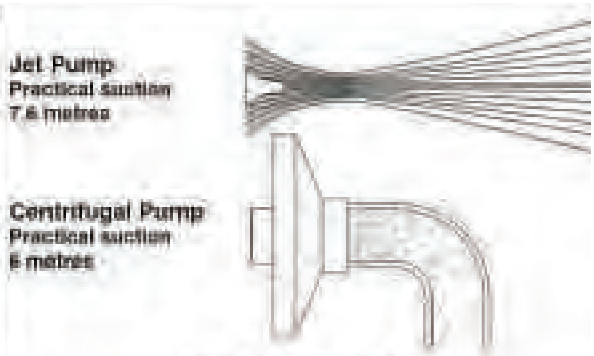
An injector containing a jet and a venturi added to the suction of a centrifugal pump increases the suction lift to between 7-8m and is known as a jet pump.

Dams are often located at lower parts of properties. Typically, pumps have been located near the home or shearing shed where power is connected. This can also be some distance from the dam.

The combination of drawing water from a dam much lower than the pump and the distance from the pump creates requirements for large suction lifts. Centrifugal pumps have been modified to improve their suction characteristics.

In operation, some of the water processed by the pump impeller is re-circulated and enters the jet and venturi assembly. High velocity water passing through the jet causes a low pressure region in front of it, inducing more water from the source. The combined stream is then re-pressurised in the venturi tube and fired into the eye of the impeller.

Jet pumps are very common on Wimmera-Mallee properties because they can produce greater suction and delivery heads than conventional centrifugal pumps of the same power input. This improves the self-priming ability of the pump, but is at the expense of flow performance and pump efficiency because some of the water is circulating within the pump itself.



Suction Comparison

The jet pump is also versatile. By changing the venturi and jet assembly combination within the pump, the head and flow performance can be altered to suit the application.

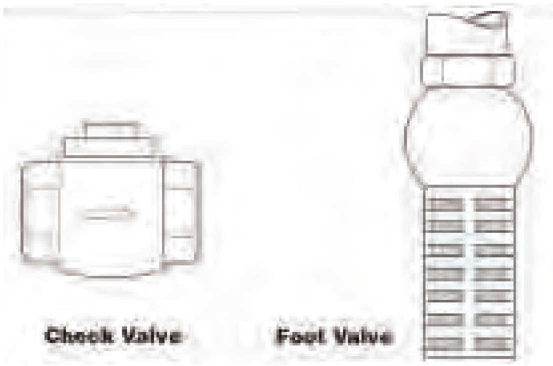
This is an advantage in situations where pipe work on existing systems is being extended, or suction lines reduced in length and lift as is the case when switching from drawing water from dams to tanks.

When connecting to the WMP, it is likely that tanks will be able to be located much closer to the pump and perhaps in an elevated position relative to the pump by utilising the inherent pressure of the WMP in the local area. Reticulation systems designed for the WMP may have pumps with flooded suction conditions, or at least have significantly reduced suction lifts and suction line length.

When connecting to the WMP, pumps will most likely draw water from tanks. The tanks will preferably be located higher than the pumps, utilising the pressure from the WMP to fill them. It is also likely they will be closer to the pumps than dams have been in the past.

If the jet pumps are in good condition, rather than purchase a new pump it is preferable to modify the design of the jet pump to suit the new reticulation design and application.

9.4.3 Check valves (foot valves)

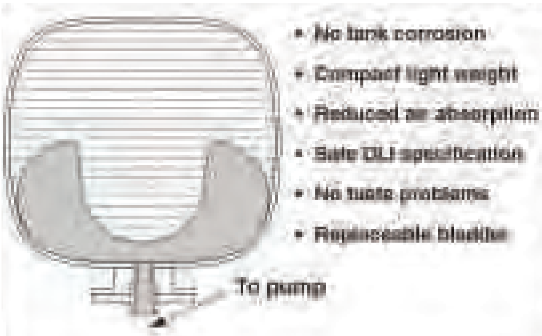


The check valve is also known as a one-way or non-return valve. The sole function of this valve is to stop any reverse flow.

Check valves are required in pressure systems to prevent water pressure buildup in the system from flowing backwards through the suction line when the pump switches off.

Most modern pumps for stock and domestic purposes have the check valve built into the pump suction port, although they can be installed anywhere in the suction line and usually at the water source (foot valve), ensuring the pump is primed even when idle.

9.4.4 Pressure tanks



Pressure tanks serve two purposes.

1. The tank provides a volume of water that the system can draw from before the system pressure falls to the cut-in setting of the pump to minimise pump cycling.

Air pressure tanks utilise the ability of air to be compressed to apply continuous but variable pressure to the water stored in the tank. This air cushion is formed by pumping water into the base of the tank; trapping and compressing the air occupying the remainder of the tank volume until a predetermined pressure is reached. Pressure tanks operate best when rubber bladders are positioned inside them. This eliminates water coming into contact with air and dissolving in solution. It also prevents the inside of the tank from rusting.

Their main purpose is to minimise pump cycling when small volumes are drawn off by the reticulation network. If a tap is turned on, or a float valve opens on a stock trough for a short time, water can be drawn from the tank without triggering a pump cycle and can save many cycles over the lifetime of the system.

2. The tank also acts as a control to the pump. If there were no tank, or if the tank had no air pressure, the pump would build and lose pressure instantaneously because water is incompressible and would cause the pump motor to rapidly cycle.

Monitor the air pressure in the tank, as over a period of time the system operating conditions may change.

A general guide to maintaining a pressure tank is:

> turn power off at the pump
> open a tap and drain off all water pressure. Leave the tap open
> using an air pressure gauge, check the air pressure
> adjust air pressure to 10% less than the cut in pressure. For example if the cut in pressure is 140Kpa, the pressure tank air charge should be about 126Kpa.
> turn power back on; turn off tap

When checking air pressure and recharging the pressure tank, an incorrect reading is obtained unless it is completely drained of water.

Pressure tanks are pressure vessels, and only those manufactured to Australian standards should be used. Manufacturer’s instructions should be followed at all times to avoid an accident of any kind.

9.4.5. Pressure switches

Pressure switches are located on the discharge side of the pump. They sense the discharge pressure of the water pressure system and control the on-off operation of the pump motor.

The operating pressure, cut-in and cut-out, is set to the system operating requirements. The cut-in pressure is the lower system pressure; the pressure at which the motor is started by the pressure switch contacts closing the electrical circuit. The cut-out pressure is the higher system pressure at which the pump motor is stopped by the pressure switch contacts opening the electrical circuit.

The cut-in pressure is set to suit the application the pump is supplying water to. The cut-out pressure should be set to prevent the pump from cycling during operation.

In practice, pressure switches usually have an adjustable cut-in pressure, and a separate adjustable differential pressure which effectively sets cut-out pressure. They should only be set by qualified and trained personnel, as the adjustments are often under a cover that could provide an exposure to mains power.

9.4.6 Pressure system operation

An automatic pressure system consists of an electric motor driving a pump, pressure tank, preferably a check valve or foot valve on the suction, pressure switch supplying water to a pressure tank and the reticulation network.

The pressure switch controls the operation of the pump by allowing the pump to operate between maximum and minimum settings. Every time a pressure system turns on or off, it wears out one cycle. The art of designing a quality pressure reticulation system is to maximise the performance of the whole system and the operating life of all components. It is important that the pump is sized to suit the application. An oversized or undersized pump may rapid-cycle, causing undue wear and tear of the equipment resulting in premature failure or unreliable operation.

While pressure-switch operated systems are widely used for domestic and stock water supply, they suffer some disadvantages. If they run out of water they cannot build sufficient pressure to switch off, which means they may run without water until failure. If they are used in low flow applications they can tend to cycle, producing fluctuations in flow and pressure.

To counteract these disadvantages, manufacturers have designed various ‘constant pressure’ systems. These can be a wise investment to help minimise a motor failure and increase system reliability.

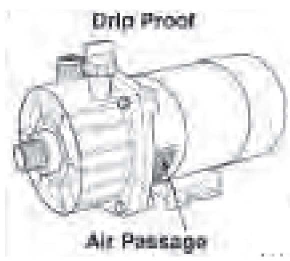
‘Constant pressure’ technology assists in providing more even pressure over a wider range of flows.

9.4.7 Electric motor and pump protection

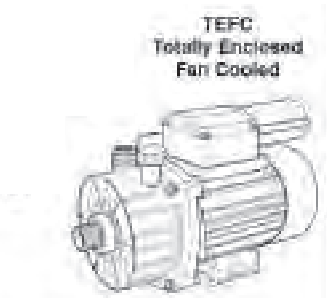
Consideration should be given to supplying the pump with power.

Questions you need to ask are: should the pump be installed at the house or shed where power is already connected, or are new mains required to suit a new pump location?

There are two types of motor enclosure commonly used on pumps.

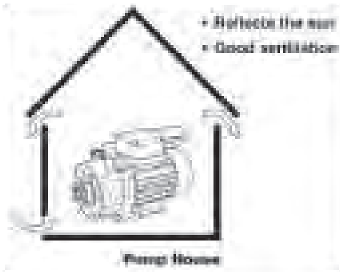


Drip Proof: usually quiet in operation, but dust, dirt, mice, snakes, frogs and other vermin can get into the motor through the cooling slots and cause it to fail.

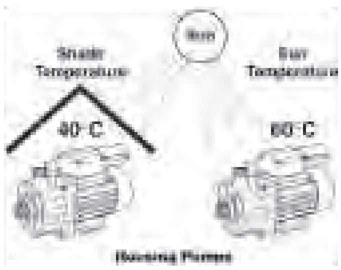


Totally Enclosed Fan Cooled (TEFC): the most common motor used to drive pumps. A more expensive motor to manufacture, but much more reliable.

The motor housing is totally enclosed with an external fan blowing air over the outside to dissipate heat. The motor windings are well protected from dust, dirt, insects and vermin, and although not waterproof, offers some protection if exposed to the weather from time to time.



All pumps should be adequately housed to protect them from sun, weather and dust. Pump houses should be constructed to provide ventilation to the motor for cooling so the motor runs as close to air temperature as possible. There should not be any buildup of heat in the pump house and pumps should be easily accessible for servicing.

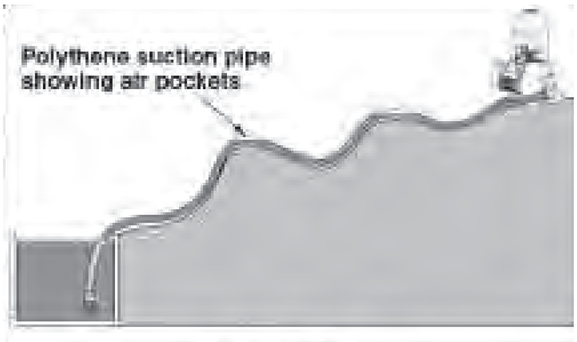


Motors need be kept cool to protect electrical insulation. They should not operate in temperatures above 40ºC for long periods. A motor exposed to direct sun could operate at up to 20ºC hotter than one housed in a properly-designed shed or cover.

Covers will also protect motor and pumps from excessive cold conditions and frosts which could crack pipes or pump housings as water freezes.

Consider wiring a light into the pump electrical circuit to indicate when the pump is operating and mounting it above the pump or on the pump housing. This will allow monitoring of the pump from a distance and can be particularly useful at night.

9.4.8 Suction lines



Suction Pipe

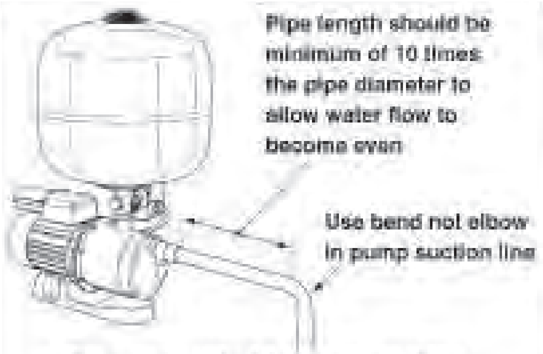
No effort should be spared to ensure a leak-proof suction pipe, including installation of suction lines to minimise air pockets.

Use only high-quality fittings on suction lines and seal any threads with either Teflon tape or paste. Gate valves may be installed between pump and water source to allow isolation for servicing and repairs when flooded suction conditions exist. When there is a suction lift to the pump, air can be drawn into the suction line through the spindle of the valve, causing the pump to lose prime. Use high grade pipe only and minimise the number of fittings because they all contribute to additional friction losses and reduce pump performance.

Suction Pipe

It is critical for reliable pump operation that suction pipes are completely airtight. Air leaks destroy the vacuum created by the pump and can cause failure.

Avoid installing elbows directly onto the pump suction inlet because this creates turbulence in the water entering the pump impellor, reducing pump efficiency. As a general rule of thumb, a straight length of pipe equivalent to 10 times the diameter of the pipe prior to entering the pump. For example, a 50mm suction line should have a 500mm length of straight pipe before entering the pump.

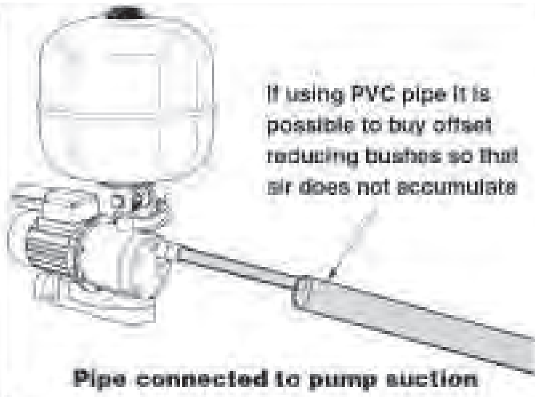


Pipe connected to pump suction

In theory, if the water source is lower than the pump, the suction line should rise gradually without humps and hollows to the pump suction port. The pipe should be free of any sharp elbows, expansion or reducing fittings.

Pipe connected to pump suction

If reducing the suction pipe size at the pump, be careful not to create cavities for air pockets as this may cause the pump to lose prime when operating.



Pipe connected to pump suction

It is preferable to use an offset reducer as this keeps the top of the pipe flat and reduces the possibility of forming air pockets in pump suction.

9.5 Automatic pressure units (jet pump)

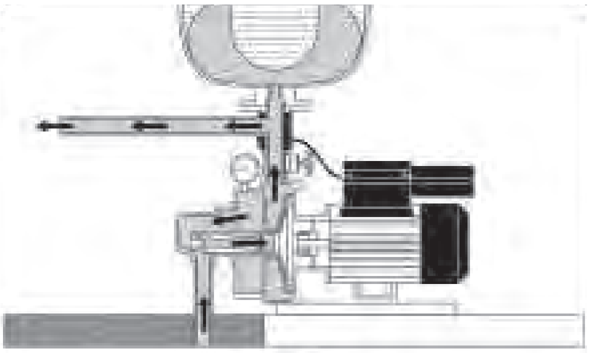
Existing farm pressure pumps may not be set up correctly for a reticulation system, especially if the new layout is greatly different from the existing one.

For example, if a pump is to be relocated from a site on a dam bank below the house to a new site adjacent to tanks, the required pressure setting on the pump may need to be changed.

The suction will be changed from a depth of 4.5m to a flooded suction. Flooded suction refers to water in the suction line entering the pump impellor under positive pressure.

Changing the settings should result in improved performance for the new location and will require:

> a new jet and venturi
> resetting the pressure switch range
> adjusting the air pressure in the pressure tank



Jet Pumps

> Operation

To achieve versatility, economic production and to maintain efficiency, most pressure units incorporate a jet and venturi. With this arrangement some of the water delivered from the pump is diverted to a jet which is directed to a venturi on the inlet side of the pump. All water drawn into the pump passes through the venturi. The combination of the jet and venturi aids suction and improves efficiency over a given range of pressure and flow. If pressure and flow are to be changed on the unit, a different jet and venturi combination may be required.

> Injector

In most cases the jet and venturi, which are often referred to as the injector, are made from plastic. Both the jet and venturi are easily accessible and cheap. Your pump agent or manufacturer will specify which combination is required for a given range of pressure and flow requirements. Injector kits may be removed and identified by either colour coding or number identification.

The pressure switch will need to be adjusted by a suitably-qualified person to enable the correct cut-in and cut-out settings (210-350kPa).

> Air pressure

Air pressure in the pressure tank should be set with the pump turned off and a tap open to ensure no water is in the tank. The pressure should be set the same as the pressure switch. Cut-in pressure in this case 210kPa.

> Check the pressure unit

The pressure unit should have the correct pressure switch settings and the injector kit number identified on it. It should also have a pressure gauge. If there is no identification tag, the pressures at cut-in (pump start up) and cut-out (pump shut down) should be determined using the pressure gauge. The pressure switch will have to be adjusted if the settings are incorrect.

> Check the gauge accuracy

Turn the pump off, expel all water from the tank and check that the gauge registers zero. The gauge should also appear to be in good condition.

A tap should be inserted between the pump and the gauge so that it can be turned off most of the time. Constant cycling over the years causes wear on most gauges which can cause inaccuracy. Suspect gauges should be replaced and a valve installed at the same time.

9.6 Existing pressure pumps

The most cost-effective way to set up homes and gardens when they are connected to the WMP system is to use the same pressure pump that drew water from dams. Tanks can be installed next to the pressure pump, or on a high spot such as the dam bank, and connected to the pump inlet. Check with your pump service provider to check if modifications are required to the pump for the changed service conditions.

For homes utilising an electric pressure pump, tanks need only be located on a site higher than the pump inlet to ensure a flooded suction. A small head will ensure the availability of some water when mains power is not available. A pump that always has positive pressure at its inlet is said to have a 'flooded suction' and is desirable to minimise pump operational problems and cost.

9.7 Relocating pumps

If original dams are some distance away from the residence, consideration should be given to relocating the pump closer to the home; ensuring power is available in the new location. It may be possible to decommission power lines previously servicing a pump near a dam, especially if they hinder farm operations or are a safety hazard.

The availability of power will often influence the siting of a pump. It is usually cheaper to install new pipes to a pump than connect power to a pump.

A tank supplying water to a pump can be located some distance from the pump. Priming problems can be avoided if the connecting pipe is designed so there will be positive pressure at the inlet to the pump.

9.8 Replacement pumps

When designing the new on-farm system for the WMP, new pressure pumps may be required if existing units are reaching the end of their useful life or if they don't suit the new operating conditions and duty of the reticulation system.

10. Rural Residential Properties

The channel and dam system delivers and stores water on many different types and sizes of properties. Regardless of the type of property, the fundamental requirements of connecting to the WMP do not vary.

There are a number of small properties on the outskirts of townships, often referred to as hobby farms or rural residential properties, and other small parcels of land that rely on water from dams supplied by channels.

Water reticulation systems on properties that have a home, garden and other water uses would typically comprise the following elements:

> A pump drawing pipe water from a dam and distributing it directly to a garden and home. Home toilets use dam water, particularly when rainwater is in short supply.

> A pump that draws water from tanks that capture and store rainwater from roof areas, supplying water for drinking and cooking purposes. If tank storage capacity is particularly large and rainfall has been plentiful, rainwater may also be used in other areas of the home such as showers, toilets and baths.

Properties with such scenarios will need to make a number of minor modifications to receive a water supply from the WMP.

The system must satisfy the 'Conditions of Supply' (see Section 5).

In the most simple case, a tank(s) must be installed which is capable of storing a volume of water equivalent to at least three days' supply. This ensures the property always has water in the event of the WMP system being unable to supply water for a period of time.

In practical terms, a supply line will need to be installed from the WMP meter location at the boundary of the property to the tank. A float valve at the top of the tank will need to be installed.

A pipe is required to connect the tank to the inlet of the pump, preferably under flooded suction conditions, which effectively replaces the original suction line from the dam to the pump. The original pump may be able to be used and may need relocation.

There are many options worthy of consideration that may help keep cost and modifications to a minimum. When connected to the WMP, higher quality and ample water will be available to the property. If the property already has multiple and large rainwater storage volumes, it will be useful to determine if all rainwater storage is still required. For example, two large rainwater tanks that had previously supplied the whole house may not be required when water is available from the WMP. One of these tanks might be retained for drinking and cooking purposes which frees up the other tank for connection to the WMP (providing it satisfies the three-day storage requirement). This tank might be set up to supply other areas of the house such as showers, toilets and garden, avoiding the need to purchase another tank.

11. Surveying Methods

In addition to water requirements and demands, other key information essential in designing a property water reticulation system is property elevations. For each separate system, the elevation (and relative location) of components such as pumps, troughs, tanks and the proposed pipe route are essential to a comprehensive design. Elevation data can be difficult to determine, and depending on the method selected, this information will have varying levels of accuracy.

Accuracy can be more critical as the terrain becomes flatter especially if a gravity system is either desired or is the only option. Generally, Wimmera and eastern Mallee flat plains provide a greater challenge for reticulation design under gravity than do the steeper and undulating country in the Wimmera's north and northwest. Flat terrain can require more sophisticated surveying equipment to determine the rise and fall information required for reticulation design.

Do not be tempted to guess or estimate relative height differences as elevation changes can be deceiving.

Surveying methods are explored below.

11.1 Global Positioning System (GPS)

> Requires specialised dual-frequency GPS equipment. Current hand-held GPS technology is unable to achieve required accuracy and repetition with elevation.

> Provides quick and accurate readings for position coordinates (Northings and Eastings) and elevation.

> Utilises specialised computer programs for best interpretation of results.

> Some yield monitoring equipment currently available on harvesters is equipped with GPS similar to surveying grade GPS, and may be a useful alternative for those with access to this equipment.

> Is most appropriate for complex reticulation systems on large properties, especially if there non-contiguous areas connected by pipes.

> Requires sophisticated equipment and specialist-trained operator, making it relatively expensive.

> Some GPS systems installed on tractors may be able to provide information on levels and distances around the property. It is important to check with the manufacturer for accuracy expectations.

11.2 Total Station

> Uses a theodolite and reflecting target(s).

> Is an accurate means of determining height and distance, especially for complex systems over flat terrain.

> Requires an experienced operator and often an assistant with equipment that is relatively expensive.

> Is not as quick as GPS.

> Elevation results are transferred onto a property map.

11.3 Surveyor's level

> Requires a less sophisticated (less costly) instrument, but requires two operators, one at the instrument and one holding a graduated staff.

> Essential that the instrument is accurately set up and calibrated.

> Yields accurate results of height only, which must be transferred onto a property map.

> Is suitable for flat country and less complex reticulation systems.

> Requires distances to be measured separately, which may be done by:
- direct measurement using a tape, measuring wheel or vehicle odometer,
- closely following the path of the proposed pipeline,
- scaling from an accurate topographic map or aerial photo, and
- counting steps; having first counted normal strides over a measured distance to calibrate the length of stride.

11.4 Rotating laser beam

> Uses a rotating beam and staff with receiver to determine relative level.

> Operating range depends on the sophistication of the unit, ranging from 150m radius with cheaper units to 300m radius for more expensive units.

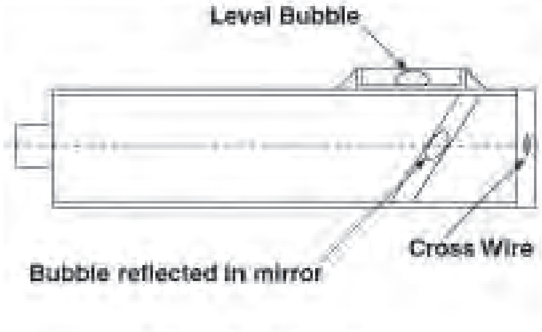
> Is not practical for gathering elevations over large distances or areas typical of Wimmera-Mallee properties as the instrument needs to be relocated to extend its range and a change of setup procedure needs to be done.

> Is convenient for level information over a short distance such as around the homestead or sheds, for assisting with location of pumps or tanks.

> Requires a line of sight and can have limitations if there are obstacles such as trees, sheds or rises.

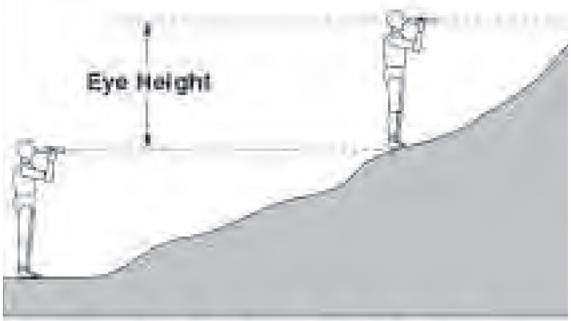
> Units such as these have become more affordable in recent times.

11.5 Quicksite



Quicksite Level

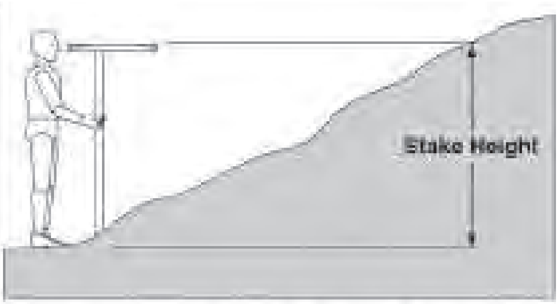
> Uses an instrument consisting of a tube with an inbuilt cross wire and level bubble.
> Instrument is inexpensive, simple to use and can be purchased from irrigation/pump outlets.
> Eye height can be measured on a rise in increments as illustrated in the diagram below.



Application of quicksite

11.6 Carpenter's spirit level

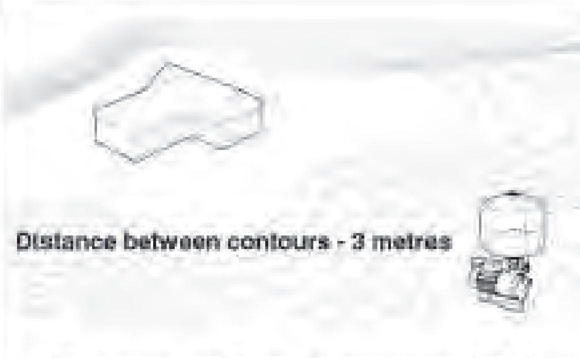
> Can provide satisfactory elevation information over short distances.
> Consists of a spirit level attached to a stake at about eye level or any other comfortable height, and set horizontally.
> Looking along its length, sight a point on a target such as a tree, pole or post on the rise in front. This point is stake height above the viewing level.
> This process can be repeated if necessary for steeper rises.
> Suits single tank and trough systems.



Carpenters level to check height

11.7 Contour Maps

Some properties may have access to contour maps which can be an accurate method of determining vertical height from one point to another on the property.



11.8 Services available

Large properties requiring a reticulation system with numerous troughs and tanks would benefit from consultation with a designer. The cost of a survey and design will be a small proportion of the overall cost of the job. It will save time and cost of materials purchased.

Components of a design service may include:

> surveying to determine heights and distances
> developing a property plan and reticulation design
> detailing reticulation layout and options
> an estimate of cost
> itemising all components required for quotation and ordering purposes

12.1 Tanks

Consideration may be given to the following system components when determining the most suitable tank types.

12.1.1 Material

Development in resin and moulding technology during the last decade has seen extensive use of polyethylene to manufacture tanks due to lower cost and longer life.

Polyethylene tanks are manufactured in various storage volume capacities ranging from 100L (22 gallons) to 31,700L (7,000 gallons), with some manufacturers offering 45,000L tanks (10,000 gallons).

To achieve total storage volume requirements, consideration should be given to combinations of tank sizes to provide flexibility, and allow for maintenance and treatment if required. Currently, the tank that yields the best cost per litre is the 22,500L polyethylene tank, which is a practical size for on-farm storage systems.

Polyethylene tanks are popular because of their resistance to corrosion and cracking and their flexibility. They are manufactured as a singular one-piece item, including the roof. They are UV-stabilised, have a comprehensive colour range, are reasonably priced, lightweight and can be relocated easily.

If larger storage volumes are required and there is a preference for a single tank, modular kit tanks are available. Modular tanks consist of a prefabricated steel shell that gives structural strength and a plastic liner, usually polyethylene, to hold the water.

Fire resistance of tanks varies according to the material from which they are fabricated. Concrete and steel tanks offer good resistance to fire while polyethylene tanks generally offer the least resistance. A polyethylene tank full of water should resist a low-intensity grass or stubble fire but would collapse during an intense fire.

It is essential to minimise fuel build up around tanks by removing straw, roly polys and dry vegetation matter. Ensure that polyethylene tanks are not used in situations where they are likely to be subject to fire and intense heat.

Roofing on tanks is desirable to maintain water quality by preventing entry of birds and animals, leaves and dust. By reducing sunlight, algae growth is also minimised.

12.1.2 Siting and access

Larger tanks will often be transported to properties by a large and heavy combination truck and trailer. Typically, these truck and trailers are 20m long, 3.5m wide and 5m high. They may have a turning circle of around 20m, so a reasonably large and firm area is required.

Inspect the route the truck will take near and on your property. Pay particular attention to width and height clearances at crossings, gateways, trees and buildings.

Make sure there is plenty of help available when unloading and positioning tanks.

At the time of ordering it is important to discuss and specify with suppliers the location of outlets, float valve, overflow and access covers on the tanks.

12.1.3 Installation

Tank manufacturers recommend the tank be located on a hard, flat, stable foundation suitable for the weight and size of the tank and protected from erosion by wind, water, stock and rabbits. In the event that a float valve is stuck open, the tank overflow should be piped well clear of the tank to avoid any undermining of the base.

Polyethylene tanks can expand and contract with temperature fluctuations. Over time, any hard objects in contact with the base of the tank could cause wear and eventual penetration of the tank.

Most manufacturers recommend at least 75mm of sand is placed underneath tanks, extending out from the tank sidewalls by around 300mm. This may have warranty implications.

Exposed sand should be covered with 150mm of sandstone, limestone or road base to prevent wind or rain erosion. Tanks are often placed on the top of hills to make the best use of gravity. Avoid locating tanks on top of hills where soil is subject to wind erosion. Perhaps locate slightly away from the top of the rise if there is flexibility with elevation requirements.

12.1.4 Tank management

Managing the area around tanks sometimes requires compromises and will come down to personal preferences. Issues to consider are:

> Stock access
The possibility of stock knocking or disturbing fittings and pipe work and causing erosion to the fill or ground area near the tank.
Stock will keep weed growth to a minimum.

> Vegetation growth
Vegetation growth around the tank will help prevent erosion but may also be a source of fuel in the event of fire.

> Maintenance
A fence constructed around the tank can minimise the potential for stock damage to fittings and pipe work. Although weeds and other vegetation are a maintenance issue, they have the advantage of holding the ground together and reducing effects of wind and rain. Sprinkling a little water around the tank occasionally can maintain this cover.

> Location
Tanks should not be located near trees because roots can break through the bottom or move the soil beneath, causing cracks or tank movement that affect outlet pipe work and fittings.

Tanks should be located to ensure easy access for equipment such as boomsprays and fire-fighting appliances which may need to utilise the tank for water. New tanks should be securely fastened or filled with 25-50mm of water to avoid displacement by strong winds.

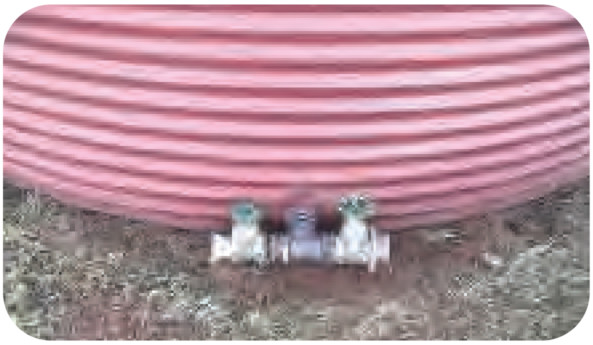
12.1.5 Tank fittings and connections

A number of basic fittings should be considered for each tank.

> 50mm (2-inch) British Standard Pipe (BSP) outlet is a practical size that can be reduced to smaller diameter supply lines straight to troughs or pump inlets if necessary.

> A second 50mm BSP outlet for spraying and fire fighting (refer Section 16).

There are many possible configurations for fittings. Consider an arrangement where a T-piece is inserted into the tank outlet. This allows the permanent set-up of end connections.



A spray cart fitting can be installed on one connection and a CFA fitting on the other (above).

> The boom-spray outlet may be located slightly higher than the outlet for pipes supplying pump inlets and/or troughs. This will ensure a reserve of water is always available for stock troughs and minimises the chance of pump motor burnout. Consider mounting all outlets higher than the CFA outlet to ensure fire-fighting appliances always have a reserve to draw on.

> The float valve on the inside and top of the tank should be of high quality to minimise maintenance and service requirements. It should preferably be located as close tothe manhole as practical, so that maintenance is safe and easy.

> The tank should have a drain plug for use when cleaning out the tank.

> A valve should be used on all pipe outlets so the tank can be isolated if maintenance is required. A lever action ball valve is often preferred because it only requires a 90-degree turn for full actuation.

> When plumbing the tank, any pipe work and fittings installed on the tank outlet should be well supported to avoid excessive strain on tank walls. A flexible length of pipe about 300mm long should be installed after the isolation valve to absorb any movement or shock loads transmitted to the tank walls. This will also avoid pipe work from pulling away from the tank outlet, particularly with fibreglass tanks. Tank walls should never be used to support the pipe.

> Inlet or outlet pipes should enter the ground as close to the tank and its connection as possible to minimise the amount of exposed pipe that can be knocked or damaged by stock or equipment.

> Most manufacturers locate outlets in accordance with customer requirements at time of ordering. They should be at least 50mm above the bottom of tank to ensure some water always remains in the tank to prevent the tank from blowing away.

> Installing a hose bib or garden tap adjacent to the tank, or tank outlet, offers a number of convenient and safe benefits. Tanks are often used to fill boomsprays and mixing chemicals often occurs nearby. Access to readily available fresh water under pressure is an important safety aspect worth considering.

> Fittings positioned slightly above the bottom of the tank ensure any sediment remains in the bottom of tanks to allow clean water to be accessed at all times.

12.2 Troughs

When determining the most suitable trough type, consideration may be given to the following:

12.2.1 Stock trough valves

There are a large number of stock trough valves on the market, with various levels of quality, reliability and price.

Quality and durability of valves is most often reflected in the price. At the lower end of the market, valves can be made of plastic and be of a disposable nature if failure occurs. More robust and durable valves with carefully selected materials such as pot brass and marine grade cast brass can be more reliable, with parts replaceable if needed.

Float valves are often included in the purchase of tanks and troughs. The quality of these valves and other fittings, if included in the sale, can be of low quality to maintain competitiveness with other suppliers.

When selecting float valves, the following issues should be considered:

> The consequence of float valve failure.
> The impact on the operation or the domestic situation if the water supply is interrupted.
> Will the home or stock go without water for a period of time and is this acceptable?
> What is the inconvenience caused by an unplanned failure?
> Will more time need to be spent checking a system with lower quality valves?

Water is a valuable commodity. The cost of leakages or wastage if an inferior product fails can incur additional cost in repairs. One or two failures causing loss of water and the associated cost of that water can be the difference between the initial cost of a low quality valve compared with a high quality valve.

Consideration also needs to be given to the consequence of a valve becoming blocked. It is important for valves to be easily protected from damage by stock or other external forces.

It is important to use reliable and high quality valves when tank or troughs are in remote locations, due to infrequency of checking.

Consideration should be given to how much time is spent repairing and troubleshooting valves. Demands on the landowner’s time to conduct repairs, particularly at busy times of the year such as harvesting or sowing, are also important when deciding on valve quality.

12.2.2 Material

The most common construction materials used in the manufacture of troughs are concrete, recycled plastic and polyethylene. Galvanised iron and fibreglass have also been used to good effect but are now found less frequently.

12.2.3 Shape

Large circular troughs are mainly used for cattle and horses to provide adequate storage for peak demand periods. Round troughs have the advantage of being more stable. If soil or fill material is lost from around a trough, a circular trough is unlikely to tip or crack.

Rectangular troughs made in sections that sit on pedestals are prone to developing leaks or overflowing when the soil underneath erodes.

12.2.4 Weight

Concrete troughs are heavy and require a forklift or front-end loader for handling and placement. Due to their high mass, they are better insulated and experience less water temperature fluctuations.

Polyethylene troughs are lightweight and easily relocated by one person. Water in polyethylene troughs cools at night and heats up when exposed to high air temperatures and direct sunlight, which can promote algae growth. Cattle and rams will often push lighter weight troughs with their horns.

In flood-prone areas, concrete troughs provide greater stability and are preferable to the lighter weight plastic troughs unless the latter can be fastened securely. Polyethylene troughs may run dry if the water supply has been turned off or due to isolation or malfunction of a float valve. In these cases the trough could easily move or blow away in a severe wind.

12.2.5 Colour

Black poly troughs absorb more heat than those of lighter colour, which can contribute to water temperature fluctuations and algae growth.

12.2.6 Size

Sheep troughs should generally stand about 300mm high and cattle troughs about 500mm high. Although cattle can drink from sheep troughs, sheep may struggle to comfortably drink from cattle troughs. Combination troughs are available to suit sheep and cattle, standing 400mm high.

> Rectangular troughs: allow 1m of length for every 30 head of cattle or 100 head of sheep.

> Circular troughs: allow 1m of circumference for every 15 head of cattle or 65 head of sheep.

12.2.7 Size guidelines

They are based on the need to fit enough heads around the trough and avoid aggressive behaviour by dominant stock.

It is impractical to have exactly the right size trough to match varying stock numbers and stock types. However, if stock numbers are low, water in the trough may tend to foul more quickly. If there are multiple troughs in a paddock and only low stock numbers it is sensible to turn water off at one of the troughs.

If troughs are too long or too large for the number of stock they serve, the water furthest from the inlet valve may stagnate, become more easily contaminated with algae or be unpalatable to the stock. The trough must be large enough to fit a reasonable number of stock around its perimeter and hold an initial volume of water to meet peak demand. If necessary, two troughs may be needed or the water inlet located at the midpoint. Many plastic troughs include this feature.

RECTANGULAR TROUGH

Length Metres/Feet (m/’)	Volume stored (litres) 300mm depth 600mm width	Sheep numbers per trough	Cattle numbers per trough
2.4m/8’	430	310	70
3.6m/12’	650	360	110
4.8m/16’	860	620	140

CIRCULAR TROUGH

Diameter Metres/Feet/Inches (m/’/”)	Volume stored (litres) 300mm depth	Sheep numbers per trough	Cattle numbers per trough
1.3m/4’4”	400	260	60
1.4m/4’9”	460	290	70
2m/6’8”	940	410	90
3m/10’	2,120	610	140

The tables above represent average figures and should be used as a guide only.

12.2.8 Water volume

The volume of water stored in troughs acts as a reserve which effectively reduces the flow rate required to meet peak demands, and therefore the required pipe diameter.

Theoretically, circular troughs will collect more sunlight than rectangular models. A rectangular trough 3.6m long and 600mm wide has a perimeter of 8.4m and water surface area of 2.2m^2. A circular trough providing the same perimeter for stock to assemble would have a diameter of 2.7m and a water surface area of 5.6m^2 - at least twice the area. Larger water surface areas may cause increased algae growth.

When designing the reticulation system, consideration should be given to watering a large number of thirsty stock at one time. It is common practice in Wimmera-Mallee areas for large mobs to be placed in paddocks during summer to graze stubble. Stock may only be in each paddock for days or weeks, however peak drinking rates need to be accommodated to ensure animals are not stressed.

12.2.9 Trough placement and location

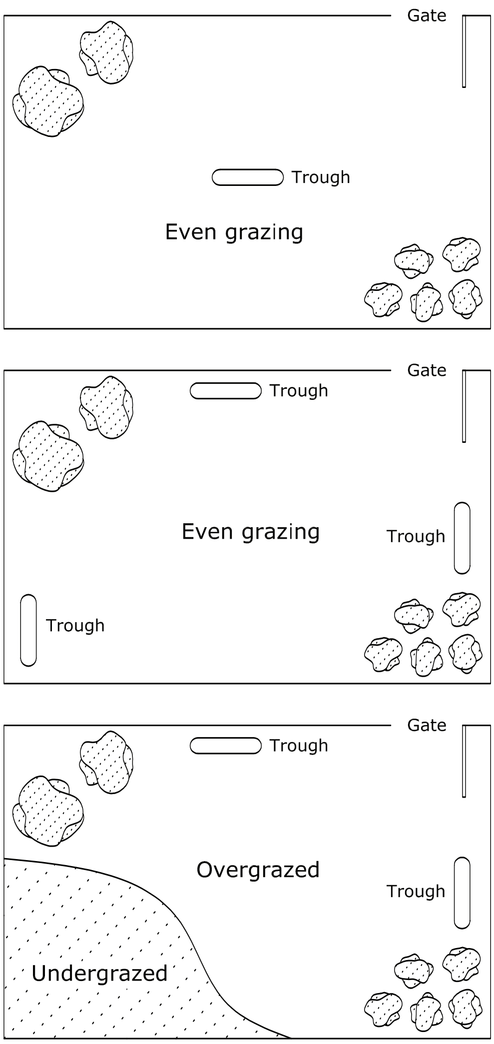
Location of troughs requires an informed decision based on the best compromise of a number of considered factors.

> Location of water supply and fences has a strong influence on how grazing pressure is spread across paddocks. Ideally, stock should not have to walk more than 1.5km to water as increased distances may cause uneven grazing, erosion, compaction, damage to fresh pastures and may affect stock condition. Newly-purchased stock should be driven to troughs when first introduced to a paddock because they may be accustomed to watering from dams and could fail to locate the trough.

> Watering points should be located centrally in the areas they serve. Frequently it is required for one watering point to serve more than one subdivision for economic reasons. This is usually false economy because in large subdivisions, stock neglect good pastures in more distant locations and denude areas around the water point.

> Water in troughs can also be used to administer feed additives where special needs exist such as the supply of vitamins or minerals.

> From a grazing aspect the most appropriate location for troughs in a large paddock is in the middle. Central trough location ensures even grazing and minimises walking distance for stock.



- Alternatively, from a trough inspection and maintenance perspective, troughs can become obstacles for farm machinery and large broadacre machinery. Troughs in this case may be more conveniently located close to fences, or at least a machinery-width away from the fence line to enable ease of cropping.

- If troughs are located close to a fence line, the fence should be reinforced with a solid rail, barrier or sheets of welded mesh because stock may jump fences. In grazing situations, as opposed to cropping, the best location for troughs is minimum 20m away from any fence to prolong the life of the fence.

- Troughs should be kept clear of gateways to avoid obstructions during mustering and to give easy access for large machinery.

- Troughs should be located away from areas where stock are likely to camp. More dung and dust are created where stock camp, contributing to algae growth in a trough.

- It is desirable to place a trough near trees to protect stock from the elements because they are more likely to camp in this area in summer. Troughs should not be placed within trees, as sheep will then lie down around the trough. This will prevent much of the mob, especially timid animals, from accessing the water. Placing troughs on the shady side of trees or tanks can reduce algae blooms developing, but extra maintenance may be required to keep the troughs free of twigs and leaves.

- Locate troughs on the leeward side of vegetation or tree clumps to protect stock from prevailing winds and dust being dumped in troughs. This also minimises leaves and tree debris being blown into the trough.

- The most practical location for a trough is near tracks or roads for ease of access, monitoring and maintenance. If this is not possible or is undesirable, consider a large, highly-visible float attached to the float valve to allow observation of water levels from a distance.

- To prevent soil degradation troughs should not be placed in depressions, steep gully banks or areas prone to erosion. Troughs should not be located where constant stock traffic could cause lighter soils to drift. They should be placed on heavier ground that is less subject to erosion.

- The direction in which rectangular troughs are placed can affect stock behaviour. Some landowners locate troughs in an east-west orientation because lambs have been known to use the trough as a source of shade in the morning. The area is cooler due to the insulation provided by the water but problems can arise because this restricts easy access to the water by other stock.

- One long trough passing under a fence can provide water to two paddocks. The trough can be placed at right angles to the fence with the float valve and the float cover in the middle of the trough up against the fence. Although larger troughs provide a greater reserve of water they should not be too large such that they make water stagnant and unpalatable. Installation costs are lower because the trough only requires one float valve and cover and one set of risers and fittings. Maintenance is also reduced.

- It may be necessary to strengthen the fence near the trough to minimise the chance of stock jumping over if the trough is crowded. Pipe work should also be arranged so that it cannot be knocked, squashed, tugged or hooked by stock.

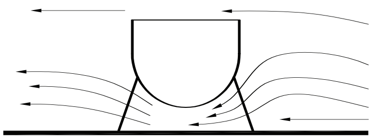
- Shade structures positioned over troughs will limit sunlight and its effect on algae growth. Shade also reduces evaporation and helps keep water in the trough cool. Too much shade and the stock may be encouraged to camp around the trough which is undesirable.

12.2.10 Contamination and cleaning

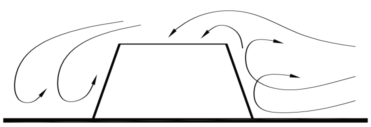
Water in troughs can become contaminated by algae, dust, dung, bees, bird droppings and dead birds. Stock troughs should be cleaned periodically to remove contaminants and deoxygenated water. If trough cleaning is time consuming other measures such as trough design, location or water maintenance may need to be considered. Stock covers are available for protection during the non-stock period.

Trough design needs to allow air to flow underneath to reduce the chance of wind-borne debris being dumped in the trough. Troughs that allow for the free flow of air both around and under are less likely to have deposits of dust, dirt or manure on the water surface when windy.

Algae is unlikely to grow in troughs fed through a reticulated system. If dung and dust contaminate the water in a trough nutrients levels will be raised, increasing the likelihood of algae. Round troughs have a larger water storage volume than rectangular troughs for a given perimeter, and can help with temperature variation and minimise algae growth.



Free air space under trough allows windbourne debris to flow through unobstructed.



Wind containing manure and soil particles can stall and deposit material in and around trough.

Troughs should have large drain bungs, with threaded bungs of at least 50mm in diameter recommended. When cleaning or changing the water in a trough, the quicker the water escapes through the drain bung hole, the more chance of contaminants escaping with the water rather than adhering to trough walls and floor.

Large drain bungs minimise idle time waiting for the trough to empty and prevent water wastage if the float valve is allowed to let more water in. The drain bung should be easily accessible and is best located on the side wall of the trough, not underneath.

A broom or other scraping device can be shaped to match the profile of troughs and can make cleaning troughs quick and easy. This can be particularly important in feedlot situations where stock are fed grain that may contaminate trough water when animals drink.

12.2.11 Bees

Bees, like many other birds and animals, need to access water in troughs. Large numbers of bees congregating at a trough at one time can be undesirable. Bees may drown in trough water if they slip in or a ripple dislodges them into the water. If bees become a problem, work out ways of giving them safe and easy access and egress to the water. Rough surfaces on troughs at the water level provides grip for the bees to safely drink or exit from the water if they fall in. A plastic container partially filled with water and covered by a rough durable material such as a stocking can be placed in the trough. This floating object provides bees something to cling to while drinking and has proven to be a successful technique.

12.2.12 Installation

Water spillage around troughs can exacerbate pugging, making stock dirty and creating slippery and possibly unhygienic conditions. Eroded areas around the trough also become muddy after rain. Troughs should ideally be positioned on a concrete apron. This may only push eroded areas from around the trough to around the apron but a benefit of the apron is the height at which stock stand to the water level in the trough remains constant. This can cause problems for smaller animals that may not be able to reach the water and ensures they have a firm and more hygienic base when drinking.

The area around each trough can be protected from erosion by placing road base material such as compacted gravel or crushed rock to a depth of 150mm. This should be maintained regularly. It is often preferable to backfill with imported gravel after stock have accessed the trough and caused a depression. Further reinforcement can be achieved by laying old car tyres around the trough and filling them with road base.

A high quality lever action ball valve or gate valve should be installed at each trough to isolate the water while cleaning and maintaining, or to turn the trough off when water is not required. Only high quality isolating valves should be installed, as frosts can lead to splitting of lesser quality valves, which will cause water wastage. Handles should be removed from valves so stock cannot accidentally shut off water supply.

12.3 Air valves

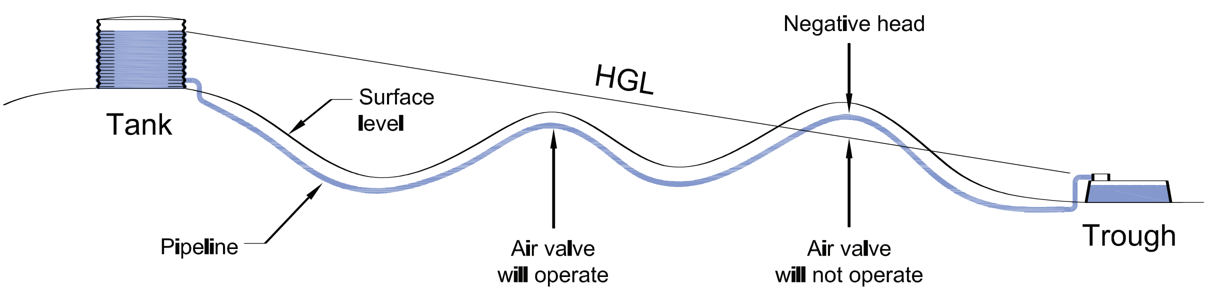
When water is reticulated over undulating country, air can accumulate in the pipe at high points in the line. Air valves automatically expel air from the pipe, preventing interruption to flow.

The air valve, which is placed on a tee at the highest elevation of the pipeline, has a small float in it. For most of the time, water is present in the line and this causes the float to close the outlet of the valve and prevents water from escaping from the vent at the top of the valve. When flow stops, entrained air moves to the highest point in the pipeline. If air is present in the line there is no flotation for the float, it drops and opens the valve to the atmosphere. The pressure in the line expels the air from the pipe until water arrives, activates the float and closes the outlet to the valve.

Care needs to be exercised with air valves, particularly where gravity is used for reticulation. If a negative head occurs in the pipeline, as may occur in gravity systems in undulating terrain, the air valve may open and allow air into the line, therefore not operating in the automatic way intended. This is much less likely to occur if the farm system is pressurised using a pump. Designers are able to assess the potential for negative heads. Having awareness of this possible problem can assist in troubleshooting the on-farm reticulation system.

The alternative to using automatic air valves on the farm is to bleed air from the pipe at regular intervals as part of normal farm maintenance. To do this, a tee and valve should be inserted in the line wherever it crosses a hill top. This valve can then be opened periodically to purge any air from the line. Purging the line should be completed before a reduced flow to the trough has become evident, particularly in hot weather.

The valve should be easily accessible but also protected from machinery and stock and well-marked to prevent damage during cropping and harvest. Protection from frost is also important. It is important to research valve resistance to frost prior to purchase. Many cheaper valves may split when water freezes on a frosty night, causing a leak when the ice thaws, and should ideally be placed underground in a valve box. Again this should be well marked, particularly to avoid damage during cropping. Keep in mind that the location of troughs on high points of the pipeline can facilitate purging of accumulated air.



12.4 Pipes

Modern pipe materials such as polyethylene and unplasticised poly vinyl chloride (uPVC) have revolutionised the way water can be conveyed around the farm. Due to their resistance to corrosion and ease and speed of installation, these materials have eliminated many previous problems associated with galvanised steel pipe, except in situations where high physical strength is required.

Polyethylene is the most economical for long pipe lengths and has a variety of fittings and joiners to suit different applications.

uPVC is an alternative for shorter runs around homes and sheds where numerous fittings are required. Flanged joints are used which must be solvent-welded to the pipe, or using a rubber ring joint. uPVC is a rigid pipe and so must be laid in an excavated trench where the join can be made. Some expertise is required when assembling uPVC fittings and pipe which require consumables such as cleaners and solvents to make joins.

Polyethylene has all the design, installation and maintenance characteristics necessary for efficiently conveying water around farms and will easily satisfy the range of flows and pressure requirements for properties connecting to the WMP delivery system.

Polyethylene pipe has been well accepted and is popular with the farming community for the following reasons:

- lightweight for transport and handling
- more cost-effective than other pipe material
- long life expectancy if laid below ground level
- easy to lay with mechanical pipe layers (rippers)
- available in long rolls, allowing join numbers to be minimised
- easy to cut, join and repair
- good flow characteristics due to smooth internal surfaces
- durable if installed correctly

Polyethylene pipe is manufactured in long lengths and is available in roll lengths ranging from 50 to 100, 150, 200 and 300m. It can also be custom ordered in longer lengths.

It is sensible and cost-effective to standardise the pipe type to minimise the number of spares that may need to be kept. Check pipe quality if acquiring at clearing sales.

12.4.1. Comparisons between rural and metric polyethylene pipe

For rural applications, the two standards of polyethylene pipe available are Metric and Imperial pipe (referred to as Rural, Rural B, Class 6 and more recently Economy pipe). They have both been designed to suit very different markets and applications and are manufactured to different standards including size and quality. There are various qualities of pipe on the market, often reflected in the price.

By understanding parameters that affect pipe quality, an educated decision can be made on what is best for individual situations. Quality can be affected by using reprocessed (recycled), reground or substandard polymers and pipe that has not been manufactured to a recognised standard. By assessing risks and consequences of pipe failure within the reticulation system and the importance of water to stock, home garden and other uses, landowners will usually conclude that pipe quality is important for the long term.

12.4.2 Metric

Metric pipe is used extensively in engineering infrastructure including town water supply, mining, industrial applications and where high reliability is essential. It is manufactured to *AS4130-2003 Polyethylene Pressure Pipes*. This standard in turn specifies that polymers used for pipe manufacture have to comply with *AS4131*. Metric pipe is specified by its outside diameter in millimetres and Pressure Number (PN) which is expressed in the unit of ‘bars’. One bar is equivalent to 100kPa. Metric pipe is available in diameters from 16mm up to 1,000mm and in a large range of pressure ratings from 320 to 160kPa or PN3.2 to PN16. Water for human consumption should only be conveyed in pipe complying with *AS4130*.

Metric Joiner Cutaway

12.4.3 Pressure number

Metric pipe should be used in applications such as the suction or inlet side of pumps, heavy duty conditions or when surge conditions may be experienced. At meter locations on the WMP where pressure is above 600kPA, metric pipe is needed to convey water to the on-farm storage tanks.

The internal working pressure that a pipe can safely withstand is called the Pressure Rating or Pressure Number (PN), and has been previously known as pipe Class. PN is the rated pressure of the pipe (at 20°C) divided by 100 therefore PN8 is rated to 800kPa. The maximum internal working pressure of the pipe must not exceed 800kPa.

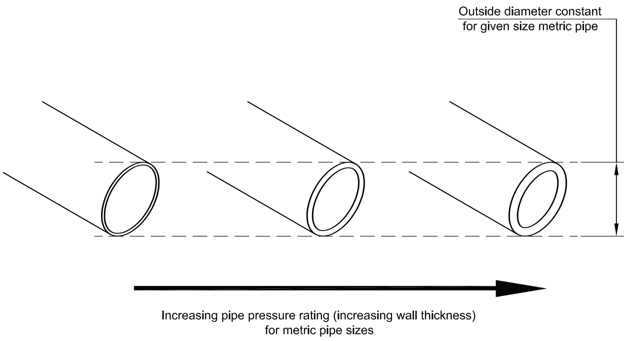
Pressure Number (PN)	Class	Safe working Head M	Pressure kPa	Mpa
	4.5	45	450	0.45
	6	60	600	0.6
	9	90	900	0.9
10		100	1,000	1
	12	120	1,200	1.2
12.5		125	1,250	1.25

Higher safe working pressures or PNs are achieved with metric pipe by increasing the wall thickness of the pipe. For metric pipe, the outside diameter is kept constant with the inside diameter, reducing as the wall thickness increases. Metric pipe is almost always more expensive than imperial pipe because more material is required to manufacture thicker walls and manufacture to Australian standards. For those sizes of pipe most commonly used, scales of economy can also strongly influence the cost of manufacture. Limited amounts of metric pipe have been utilised in reticulation systems in the Wimmera-Mallee for this reason.

Each size of metric pipe is available in a number of PN ratings. The higher the PN for a given size of metric pipe, the greater the wall thickness of the pipe. As a result, the cross-sectional area of the pipe will be smaller, reducing the flow rate due to higher friction for a given pressure.

Each pipe size requires one set of fittings irrespective of the PN, with the fitting matching the outside diameter of the pipe.

Metric Pipe – as the pressure number, or initial working pressure increases, so too does the pipe wall thickness while the outside diameter remains unchanged.



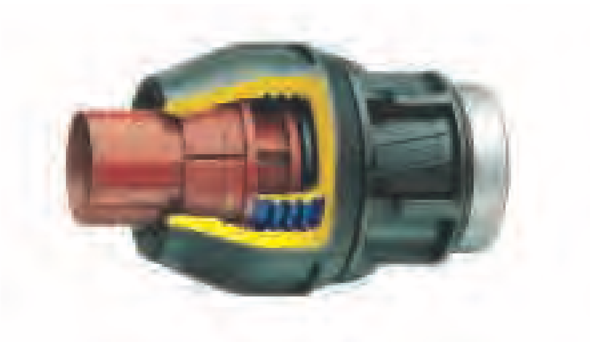
12.4.4 Imperial

The polyethylene pipe most commonly used for conveying water for stock and domestic purposes in this region is imperial or Rural pipe.

Imperial pipe is only manufactured in $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 inch diameters with a single pressure rating of 60m of head or 600kPa. The size in inches refers to the internal diameter of the pipe. The Australian Standard that applies to imperial type pipe is *AS2698.2-1985 Polyethylene Rural Pipe*. This standard in turn specifies that polymers used to manufacture this pipe should comply with *AS4131*.
A 2-inch Imperial pipe has a 2-inch (50mm) interior diameter.

It is important to ensure that *AS2698.2*, the PN and Diameter are visibly stamped on the pipe.

As an example, the internal diameter of 1-inch Rural B Pipe is 1-inch. The internal diameter of 25mm metric polyethylene pipe is about 20mm. For a given flow, there will be a higher pressure drop in a 25mm metric pipe than for a 1-inch imperial pipe due to the smaller diameter creating a higher friction. In reality, and from a flow rate perspective, 1-inch imperial pipe is a closer comparison to 32mm metric pipe than 25mm metric pipe.



Rural Joiner Cutaway

12.4.5 Fittings

Fittings for metric and imperial standard pipes are not interchangeable for the reasons explained above, although conversion kits are available. Imperial pipe is controlled by the internal diameter. An insert or barb is placed into the bore of the pipe and a seal is made. Metric pipe is controlled by the external diameter with the sealing and gripping mechanism on joiners acting on the outside of the pipe.

12.4.6 Temperature

Pressure ratings apply to a pipe temperature of 20°C. Polyethylene pipes exposed to the sun heat up, with the higher temperatures reducing the pressure rating. The pressure rating of imperial polyethylene pipe reduces substantially as pipe temperature increases as indicated in the table below.

Pipe diameter	Temperature °C 20	25	30	35	40
19	600	600	570	490	420
25	600	530	460	400	340
32	600	520	460	400	340
40	600	520	460	400	330
50	600	520	450	390	330

12.5 Installation of polyethylene pipe

Polyethylene pipes should not be laid above ground because of the effects of temperature and physical damage.

12.5.1 Fitting and joining pipe

There is a wide range of polyethylene pipe and fitting products designed for applications with varying quality and costs.

Imperial fittings are found most commonly on farms, being easily identified by the male barbed arrangement that inserts tightly inside the pipe. Metric polyethylene pipe sizes refer to the outside diameter of the pipe, with all associated fittings located over the pipe.

There are three methods of joining polyethylene pipe.

1. Joiner:

The most common method is to use a fitting or joiner. The joiner consists of a number of pieces which lock and seal the pipe ends together using a threaded fitting. Joining pipes is generally a simple task but procedures as shown in diagrams on the following page will ensure joins are effective and lasting.

2. Electrofusion:

Heating coils moulded into plastic fittings are placed over the pipe. An electrical current is passed through the fitting and fuses the two pieces together. Electrofusion machines are expensive ($2,000-$5,000) or $100 day to hire, fittings cost about $25.

3. Butt Welding:

Also involves electrofusion but uses an external heat source to melt both faces of the pipe. The molten ends of the pipe are then pushed together under pressure to ensure fusion of the two pipe faces until cooled.

Joining Poly Pipes

1. The tools required to mend a damaged Imperial pipe or to join two Imperial pipe ends are: a hacksaw, small knife or preferably pipe cutters, block of wood, a joiner.

2. & 3. The two most common methods of cutting pipe is with a hacksaw or using pipe cutters. It is important to cut the pipe squarely. If joining two lengths of pipe, ensure the ends are also square.
It can be difficult to obtain a straight cut with a hacksaw. It is important to clean any burrs or plastic filings from inside and outside the pipe end.

4 & 5.
Pipe cutters give the best results, making it easy to cut the pipe square without leaving burrs.

6. Place the threaded collar and tapered locking ring on the pipe before pushing the O-ring insert into place. These inserts not only have a barbed profile but are also slightly tapered to ensure a tight fit. The rings also have internal barbs to ensure the pipe cannot slip out.

7. It is important the fitting is assembled in the correct order (above). Push both ends of the O-Ring into the threaded joint, ensuring O-ring sits firmly and is not twisted or rolled as this is crucial to the integrity of the joint.

8. Hand tighten the locking collars over the threaded joint before using two pipe wrenches or multigrips (inset) to tighten the joint.

12.5.2 Pipe laying – above or below ground

In the majority of situations, pipes are best buried in the ground. Above-ground pipes are exposed to the elements and external forces. Sometimes landowners may have opted to lay pipe on the ground near a fence line to protect the pipe from vehicles and avoid the cost associated with ripping and trenching. Below-ground pipes have many more advantages than above-ground installation.

> UV radiation in sunlight does not degrade polyethylene of below ground pipes.

> Underground pipes are not affected by temperature variables, and are therefore not prone prone to cracking or becoming brittle.

> Rodents cannot gnaw at below-ground pipes.

> Stock are not able to tread on, crush, puncture or kink below ground pipes.

> Underground pipes are not susceptible to frosts and high temperatures.

> Underground pipes are not affected by bushfire or uncontrolled stubble fire.

> Regular vehicle traffic does not affect below-ground pipes.

Locating polyethylene pipe above ground is poor practice, reducing life expectancy and reliability. A long working life will be achieved from well installed pipe laid below ground.

12.5.3 Pipe installation

The two most common techniques used to install pipe underground are ripping and trenching. Determining which approach is most suitable will be achieved by considering:

> equipment and resource availability
> quality of pipe and installation requirements
> quality, durability, reliability and life of the system installed
> pipe route - soil type and conditions, fences, trees
> affordability

Pipe must be buried deeper than all current cultivation depths and have an allowance for future changes in farming practices or any deep ripping operations that may be undertaken. Allowance should also be made where surface erosion may occur, particularly around troughs, tanks, gateways and along tracks on lighter ground. For applications in the Wimmera-Mallee, at least 450mm depth is recommended. However, if drifts are likely, slightly deeper burial is recommended. Depths greater than 450mm may make initial installation awkward and cause difficulty identifying and repairing leaks.

To minimise the effects of underground pipe movement caused by expansion and contraction, connection to the trough should provide some degree of flexibility. Options are to terminate the long line with an elbow following approximately 2m of pipe continuing underground or gently curving the pipe to an elbow leading to the standpipe at the trough.

Polyethylene pipe is supplied in long rolls and assists in keeping the number of joints to a minimum and enabling easy installation. Correct installation techniques are required to ensure a trouble-free, leak-free reticulation system that will stand the test of time.

Pipes should not be laid on hot days. If trenching is undertaken, it is more advantageous to locate the pipe in the trench and backfill in the cool of the day. If there are no options to installation during the heat of the day, consideration should be given to filling the pipe with fresh water to help keep the pipe cool and minimise the effects of pipe expansion and contraction.

Some manufacturers can provide pipe in lengths to suit. This may save in joins but transport and handling of large coils can be difficult.

Important considerations prior to pipe laying:

> Ensure pipes that are stored for installation at a later date are blocked at each end as rodents may get into the open pipe and cause a blockage that will be difficult to find once installed.

> Mark a clear route free of obstacles.

> A marker should be placed at each joint when laying pipe or amended on pipe route plans. This will make leaks at joins easier to find. Leaks often do not show up immediately above the joint but instead, they appear down the slope after running along the newly-formed trench. Some landowners replace material around and above joins with road base or similar. This enables easier location as there is no growth around the road base.

> Areas of limestone or other loose rock should be avoided if possible. The risk of a hard or sharp object contacting the pipe needs to be avoided during installation. Movement of the pipe once in the ground from expansion and contraction from temperature changes, ground movement, shock waves from pump cycling and float valves on tanks and troughs can lead to abrasion, wear and eventual leakage.

> If the path of the pipe is in a stony or limestone/gravel area with no alternative route, trenching is most likely the preferred technique. The ripping method does not allow the final resting place of pipes and the material around the pipe to be observed and controlled. If the pipe is placed in a trench, the final resting place of the pipe can be observed, and if necessary, a bedding material (e.g. sand) can be located around the pipe to protect against hard materials.

> Polyethylene pipe expands as it gets hot and contracts as it cools. Pipe should not be installed while hot or on a hot day because joins can pull clear as the pipe cools, particularly if the pipe is anchored at each end such as risers to troughs or connections to pumps. A sudden rush of cold water can cause significant and sudden contraction of the pipe, compromising the joins and even pulling clear the risers from the troughs. To prevent pipe from absorbing too much heat, limit the time pipe is exposed to the sun. It may be necessary to keep coils of pipe under a shed, cover with a tarp, under a shady tree or lay the pipe in cool conditions. As a minimum, run water through the pipe before making the final join so the pipe can contract before the final connection is made.

12.5.4 Ripping

Ripping is a widely practised, easy and cost-effective method of laying pipe in the ground for on-farm reticulation systems.

A pipe ripper can be made from attaching a curved steel tube to the back of a ripper tyne attached to the three-point linkage on a tractor. They can often be hired from the retail outlet where pipe is purchased.

Polyethylene pipe is fed down through the steel tube as the tyne is pulled through the soil by the tractor.

There are a number of commercially-available pipe rippers with various features such as spinners (to hold the pipe coil) to avoid manual feeding of the pipe. The coil still needs to be manually lifted into the spinner.

There are also a number of soil/tree and rabbit rippers owned by Landcare groups, which can or have been converted to pipe layers.

The type of ripper will have a significant bearing on the ease and effectiveness of pipe installation. Access to a ripper with a pipe guide large enough to allow the largest joiner size to pass through comfortably will improve efficiency of the laying process by allowing each coil to be joined prior to laying. Otherwise, the pipe needs to be dug up manually and joining the pipe at the laid depth can be an awkward task. The tube feeding pipe into the ground should be inspected to ensure there are no sharp edges or points that could score the pipe. Teflon is often used to line the inside of the steel tube to minimise friction.

There are some disadvantages with laying pipes using rippers. It is not possible to observe the pipe in its final resting place, making it difficult to know if the pipe has been stretched as it was installed, especially when using powerful equipment. Installing the pipe at depths below 300mm can take a lot of additional work such as pre-ripping and the use of a heavy-duty ripper driven by a powerful tractor.

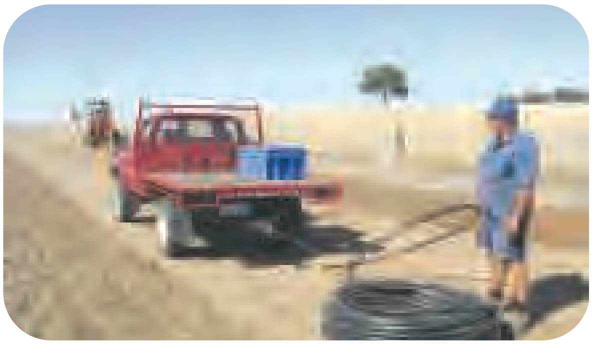
Depending upon soil conditions, pipe may need to be manually assisted into the pipe layer tube to prevent the pipe's tendency to rise due to the loose soil overhead. This technique will also help remove stress on long stretches of pipe.

> Some rippers will ride up out of the trench. Tractors, preferably four-wheel drive that can apply a downward pressure on the three-point linkage, can alleviate this problem. This will avoid high spots in the pipe that could cause airlocks or be hooked by machinery.
> Ripping is best undertaken when there is soil moisture The pipeline route should be pre-ripped at least once, twice is preferable, as this will help ensure machinery is working correctly and the tyne is reaching an even depth. Dry, large clumps or sods can cause pipes to crease or squash while embedded stones or sharp objects can rupture or score the pipe. Avoid the need to reverse with the pipe ripper.
> As the tractor moves along the line, pipe can be manually fed up and then down into the ripper tube, with care taken to avoid kinking and stretching.
> The tractor and pipe layer should be positioned at the start of the line with enough pipe passing through the ripper tube to reach the connecting pipe fitting and be firmly anchored.
> With slow movements, the three-point linkage should be gradually lowered to the required depth. Maintaining alignment to the pre-ripped trench is also important. More than one person needs to be involved in laying the pipe to ensure the pipe feeding into the layer doesn't kink or damage. After completing the first section, the end of the pipe to connect to the next fitting can be uncovered.

It is probably best to cut fence lines along the pipe route to allow the equipment through and the process to be continuous. Otherwise, there is a lot of manual digging required or a mechanical trencher may be appropriate.

Some contractors who install pipe are reluctant to rip in pipe because it is difficult to guarantee workmanship as the final resting place of the installed pipe in the rip line cannot be observed. Ripping can place stress and stretch the pipe during laying which can cause problems down the track. Some contractors may only agree to rip in metric pipe because it less likely to cause problems because of its superior strength, resistance to penetration and quality. Metric pipe is usually more expensive than imperial pipe.

Soil types and condition impact on the quality of pipe installation. Sometimes the pipe route needs to be pre-ripped a number of times. This may result in large clods rising to the surface. It is good practice to breakdown the clods by running machinery wheels over them before the final pass of inserting the pipe.



Pipe can be unrolled along one side of the route by anchoring the outside end of the roll, tying the inside end to a vehicle with about 3-5m of rope and driving away very slowly.
As pipe unrolls it should be observed for kinks. Ends should be tied down to avoid recoil.

12.5.5 Trenching

Digging a trench, laying pipe into the trench and backfilling provides a sound method of burying polyethylene pipe and ensures a high quality, reliable and long-lasting system. The initial cost of laying pipe in trenches is more expensive than ripping, but this may be offset against maintenance and reliability costs factored over a period of time.

Trenching is more practical than ripping around homes, sheds, fences and other areas where access is difficult or services may be encountered. Manual digging may be the only practical option in confined areas or where the risk of damage to services is possible.

Trenching enables the final resting place of pipe to be easily observed, ensuring no sharp objects are against it and it is laid loosely in the trench. It is a particularly favourable technique when ground conditions are stony or abrasive. A layer of fine sand can be placed in the trench to provide a barrier between the pipes and the abrasive or stony ground if required.

Pipes are easily joined at ground level and just dropped into the trench with a snake effect, allowing the pipe to move in the trench as conditions change. Trenching also allows the pipe to be fully pressure tested prior to backfilling.

Pipe route plans should be clearly documented or amended to reflect 'as-built' conditions. Leaks or other problems can then be easily traced at a later time and the chance of a pipe being inadvertently damaged during farming activities can be minimised.

12.5.6 Farm safety

Farms are among the most dangerous workplaces in Victoria. Farming fatalities account for one-third of workplace deaths annually, despite the industry having only about 5% of the state's total workforce.
The farm is an environment in which there is a high risk of injury and illness to you, your workers and others on the property such as children.

As is the case in all workplaces, farm safety begins with performing simple assessments of work practices and putting steps in place to reduce risk.

Implementing a water reticulation system on your property will potentially require property owners and assistants to use machinery and equipment, as well as perform new tasks they may not be familiar with. A risk assessment process will identify potential hazards and help you put appropriate controls in place to minimise the risk of an incident.

Prior to any digging, ripping or trenching, carefully identify any services on your property such as electricity, gas, telecommunications and water. If in doubt, ring 'Dial Before You Dig' on **1100** before you start work.

While the WMP construction work is in progress around your property, landowners are requested to keep all personnel well away from the construction zone.

WorkSafe Victoria has created a campaign to raise awareness of farm safety and has also developed a farm safety pack to provide farmers with important safety advice.
WorkSafe Victoria can be contacted on **1800 136 089**. Relevant information on farm safety can also be obtained from WorkCover's website at **www.workcover.vic.gov.au**

13. Costing and Revision of Design

13.1 General

Once a reticulation system with all pipes, tanks, and troughs has been designed, it is a good idea to carry out a costing of the proposed system. If the calculated cost exceeds expectations some design changes or cheaper options may require consideration. Bulk purchases of reticulation materials can yield better pricing. Consider making larger orders by combining with other purchasers, such as neighbours.

In addition to the capital cost, future operational costs should be considered. Additional costs will be incurred to locate and repair leaks, and for other rectification works over time. Landowners need to assess the cost of wasted water as a result of a poorly-installed system against investing in a well-designed system of quality materials and sound installation techniques.

For example, saving on a storage tank may require long distances to refill the boom-spray, which has ongoing equipment and labour costs. If there is only a narrow envelope of time when conditions are suitable for spraying, time wasted on travelling for water could delay the next spraying period. Similarly, quick access to water for fire fighting should also be considered.

Situations that require thought and discussion include:

> Optimising tank and trough location to make best use of gravity.

> Tank location and balancing more expensive high pressure pipe from the meter to the tank, compared with changes in the length of low pressure Rural B pipe from the tank to the trough.

> Utilising feeder tanks at the trough to minimise the diameter of pipe from the main tank to the trough site.

It is recognised that the capital outlay required to implement a reticulation system on properties will be high. The system constructed will provide water to the whole property for many years, so it should be considered as a long-term investment with anticipated benefits and service life.

Locating and repairing leaks and other rectification works will incur costs over the years. Landowners need to asses the cost of wasted water and maintenance as a result of a poorly-planned and poorly-implemented scheme against investing in a well-designed system of quality materials and sound installation techniques.

Incorporating the design of a reticulation system into the property's whole-farm plan will help ensure the system is compatible with priorities for family, the farming operation and cash-flow. If a long-term property plan is in place, the reticulation works can be staged to suit finances and programs of other farm works.

13.2 Costing reticulation systems

To help with the preliminary costing and review stage, information in the tables below provides an approximate guide to cost of the various components of a reticulation system. Once design and estimated cost of the system are confirmed, suppliers can provide firm quotes.

13.3 Pricing tables

Please note the following prices are provided as an approximate guide only.

(Feet is abbreviated with ' and inches with ")

POLYETHYLENE PIPES	AVAILABLE IN	PRICE	
25mm PN 12	200m coils	$0.78/m	$156/roll
32mm PN 12	200m coils	$1.23/m	$245/roll
$\frac{3}{4}$" Rural B	200m coils	$0.35/m	$71/roll
1" Rural B AS	200m coils	$0.47/m	$95/roll
$1\frac{1}{4}$" Rural B AS	150m coils	$0.68/m	$102/roll
$1\frac{1}{2}$" Rural B AS	150m coils	$1.01/m	$152/roll
2" Rural B AS	100m coils	$1.61/m	$161/roll

STOCK TROUGHS	SIZE	PRICE
Poly sheep trough including float valve/cover	1.5m/5' long	$274
Poly sheep trough including float valve/cover	2.7m/9' long	$366
Poly sheep trough including float valve/cover	3.7m/12' long	$525
Poly Round trough 600L	1.4m/4'7" diameter	$349
Poly Round trough 1200L	1.7m/5'9" diameter	$488
Poly Round trough 2400L	2.4m/7'10" diameter	$720
Concrete sheep trough including float valve/cover	2.4m/8' long	$280
Concrete sheep trough including float valve/cover	3.6m/12' long	$380
Concrete sheep trough including float valve/cover	4.3m/14' long	$460
Concrete sheep trough	3.0m diameter	$450
Concrete cattle trough	1.3m diameter	$140
Concrete cattle trough	2.0m diameter	$290
Concrete cattle trough	3.0m diameter	$495

POLYETHYLENE TANKS	PRICE	$/100 L
2250L/500 gal	$510	$22.70
4500L/1000 gal	$765	$17.00
9000L/2000 gal	$1300	$14.40
13,600L/3000 gal	$1600	$11.80
22,500L/5000 gal	$2100	$9.30
31,700L/7000 gal	$2800	$8.80
45,500L/10,000 gal	$4300	$9.45

Note: Tank prices include

> inlet including float valve

> outlet including 2-inch lever action valve

> 65mm Male CFA coupling

> garden tap for fresh water and safety while using chemicals

Manhole Cover: Fittings	Price $
1" plastic float valve with float	33.00
1" brass float valve with float	70.00
1" high quality brass and stainless steel float valve	99.00
$1\frac{1}{4}$" & $1\frac{1}{2}$" high quality brass and stainless steel float valve	140.00
1" joiner	7.00
$1\frac{1}{4}$" joiner	10.00
$1\frac{1}{2}$" joiner	12.00
2" joiner	23.00
1" poly riser	7.00
CFA 65mm coupling 2" outlet and gate valve	26.00
Installation	
Contractor trench, lay pipe, backfill	1.50/m
Contractor trench, landowner lay pipe, contractor backfill	1.00/m
Contractor rip and lay metric pipe	1.00/m

14. Staging the Works

Not all on-farm costs are incurred during the first year. Experience with pipelines in the Northern Mallee system indicates that installation and associated costs have often been spread over five years and depend on:

- timing of the last dam fill to the area
- reliability of the water holding ability of the dam
- current stocking rates
- cropping rotations
- farm financing
- extent/development of farm planning

14.1 Installation costs

There are large variations in installation costs due to the different ways landowners operate and manage their properties and how they choose to install their systems.

Some landowners will choose to use contractors to design, supply and install their water reticulation system; others will complete some or all of these functions themselves. Landowners have different approaches to valuing their own labour, plant and equipment cost and the sharing of plant and labour between neighbours.

Researching installation techniques should determine what best suits the operation, affordability, quality, features and future reliability of the system.

A combination of specialised contractors, sharing labour and equipment with colleagues and co-ordination of the works by the landowner is often the best case scenario.

In 2005, contractors fees are within the vicinity of $1.50/m of pipe to trench, lay and backfill pipe. If the landowner helps the contractor with pipe laying, the contractor’s cost may be reduced to approximately $1.00/m of pipe.

14.2 Helpful hints

The cost of tanks can be in the order of about 40–50% of the total material cost of the entire reticulation system.

Alternatives could include:

- One larger tank may provide water to a number of paddocks.
- The introduction of a high quality, secure water supply may free up surplus rainwater tanks that can be utilised elsewhere on the property.
- Keep troughs as close to tanks as practical with gravity systems to minimise pipe diameter.
- Minimise the length of high pressure pipe from the mains to the tank by placing tank and troughs closer to the meter if practical.
- Incorporate the use of gravity flow where practical to eliminate the need for a pump.
- Standardise pipe sizes where appropriate to minimise spares and replacement components.
- Identify the best balance between initial costs, quality, future maintenance, operating cost and system life.

> Make best use of the pressure/head available at the water meter by locating tanks on nearby highest points. This will maximise the opportunities to utilise gravity.

15. Tax Deductability of On-farm Water Reticulation Works

This section outlines possible options that may exist for landowners to seek tax concessions for the capital cost of on-farm water reticulation works associated with the WMP.

15.1 Water conservation concessions

Section 75B of the Income Tax Assessment Act (1936) allows landowners accelerated depreciation on capital expenditure over a three-year period, where the expenditure is incurred primarily and principally for the purpose of conveying or conserving water.

This includes expenditure on items such as dams, water storage, tanks, bores and irrigation channels.

Providing the business is primary production, capital costs in relation to:

"the construction, acquisition manufacture or installation of plant or structural improvement for the purpose of conserving or conveying water for use in carrying on that business on that land", (Section 75B)

a deduction under Section 75B would be allowable.

The on-farm reticulation works associated with piping are covered under the term:

"*plant or a structural improvement"* which is defined in the Act as including *"a dam, earth tank, underground tank, metal tank, stand for a tank, bore, well, irrigation channel or similar improvement, pipe, pump, water tower and windmill"*, (Section 75B)

15.2 Land degradation measures

Section 75D of the Act provides for an outright deduction for certain land degradation prevention measures and there may be aspects of the total expenditure incurred by individual landowners that qualify as an outright deduction.

The costs associated with:

- > filling in existing open channels
- > land levelling or grading
- > contour banking
- > fencing (to exclude livestock or vermin or separate land as part of an approved land management plan)

On-farm reticulation works which are principally designed to:

- > prevent land degradation
- > soil erosion
- > improve drainage
- > destroy weed and other detrimental plant growth, remove animal or vegetable pests
- > control salinity

may also be considered as outright deductions.

In developing this information GWMWater sought advice from the Australian Taxation Office and a senior taxation consultant. It is presented to ensure that landowners are aware of the possible tax benefits associated with pipeline works. While all reasonable efforts have been made to verify the accuracy of this information, GWMWater cannot be held responsible for any inaccuracies or misinterpretations. It is essential that landowners provide adequate details of any proposed works to their tax agent or accountant, to ascertain their correct tax position.

16. Fire Fighting

As the transition is made from channels and dams to a fully-piped water supply, authorities, communities and landowners need to assess the impact of changes with regard to fire fighting. Over time, the WMP will make most farm and community dams redundant, with the exception of water collected in catchment dams and perhaps a small number of environmental dams.

A sufficient supply of water should always be readily available for fire fighting around the property. Tanks should be fitted with a tee piece and an extra valve at the outlet for quick access. A standard CFA fitting might also be included. All tanks should be kept full for fire fighting and other emergency purposes. As they are sealed there will be no loss.

The WMP will consist of about 1,200km of trunk lines and several thousand kilometres of distribution lines. The fire-fighting water supply will consist of fire hydrant plugs installed along the trunk mains and dedicated fire water tanks located throughout the distribution area.

Fire plugs will be installed on the pipeline at strategic locations. Where the flow rates are insufficient to fill fire appliances in a reasonable timeframe, static tanks will be installed at similar intervals. These tanks will ensure water is always available when needed. Fire plugs and static tanks will also be a source of water for shire and council road construction and maintenance activities as well as other community uses.

Generally, fire-fighting tanks will be 22,000L capacity, level controlled by a float valve, with hydrants consisting of twin Victorian CFA Standard couplings so that two fire appliances can be filled simultaneously.

All customers serviced by the pipeline are required to ensure they have at least three days' supply of water stored on-site to provide security of supply if the system should fail. These on-site storage tanks are an additional source of water for fire fighting that will supplement the many hydrants and tanks throughout the district. The on-farm storage tanks will partially replace farm dams as a source of fire-fighting water.

The CFA makes the following recommendations to ensure that water can be reliably, conveniently and quickly accessed from storage tanks in the event of a fire.

Design of the reticulation system should include:

> Provide all-weather entry and exit access to tanks for fire-fighting appliances. A drive through or past is preferred, being mindful of fences, drains and gates.

> Tank outlet connections should be permanently set up with a Victorian CFA Standard Coupling. These are 64mm ($2\frac{1}{2}$ inch) diameter, with round threads and a thread pitch of 3 threads per inch. This will ensure that CFA quickfill tankers and pumps can be easily connected and draught the water into the appliance.

Other possible alternatives to eliminate the use of a T-Piece include:

> permanent installation of CFA fittings for fire-fighting appliances

> fitting spray cart with appropriate female connections to suit the CFA adaptor

> maintaining separate tank outlet and fittings dedicated for each application

The outlet for the boomspray and fire-fighting water should be raised slightly higher than the outlet and pipes supplying pump inlets and/or troughs supplied by gravity. This will ensure a reserve of water is always available for stock troughs for emergencies and will minimise pump motor burnout.

It is recommended that couplings, valves and fire-fighting pumps be checked regularly, by turning on and off to ensure they are in good working order. This process also ensures there is enough good quality hose available and helps prevent corrosion. Fire prevention works should be done regularly to protect the tank, pipe and valves from possible fire damage.

17. Remote Monitoring

In the past, landowners could place stock in paddocks with a dam and be confident they would have access to water for a certain period of time. Troughs have a small water storage capacity and rely on the reticulation system being constantly topped up. If there is a problem with the reticulation system or supplying water to a trough, stock may be without water in a very short period of time. Manually checking the various components of a reticulation system can be time consuming. Landowners need to know as soon as possible when a leak has occurred, if a trough or a tank has run dry or if a pump has failed.

With constant changes in farming operations it is increasingly difficult for landowners to regularly inspect their stock. Primary producers are often away from the property for long periods of time, properties are significantly larger and land is non-contiguous and often located some distance away from the main residence.

Telemetry is remote monitoring and control through telecommunications. For example, remote monitoring might enable the water level in a trough or tank or the status of a pump to be checked from many locations including family home, business functions or if away on holidays.

Technologies such as remote monitoring are becoming increasingly affordable to the broader community. Early telemetry systems used radios and fixed telephone lines; newer systems are using mobile telephone networks, the internet and satellite systems. While farm, labour and transport costs have risen in recent years, data transmission and hardware costs are steadily reducing.

There are a number of different types of telecommunication technologies available to help landowners manage a water reticulation system.

17.1 Radio

A typical radio remote monitoring system consists of the following:

> **Base Station** usually located centrally and consists of a processor and display, VHF transmitter/receiver, aerial and a modem if required for transmitting the signal from the farm.

> **Field Units** are mounted on posts near each sensor at each monitored site and consist of a radio receiver/transmitter, aerial, solar panel and rechargeable battery; for those sites without access to power such as a trough in a paddock.

> **Sensor** to monitor the status of the item being measured such as water level.

The base station regularly ‘talks’ to the field units and checks the status of the sensor, battery level and signal strength at the same time to ensure the integrity of the system.

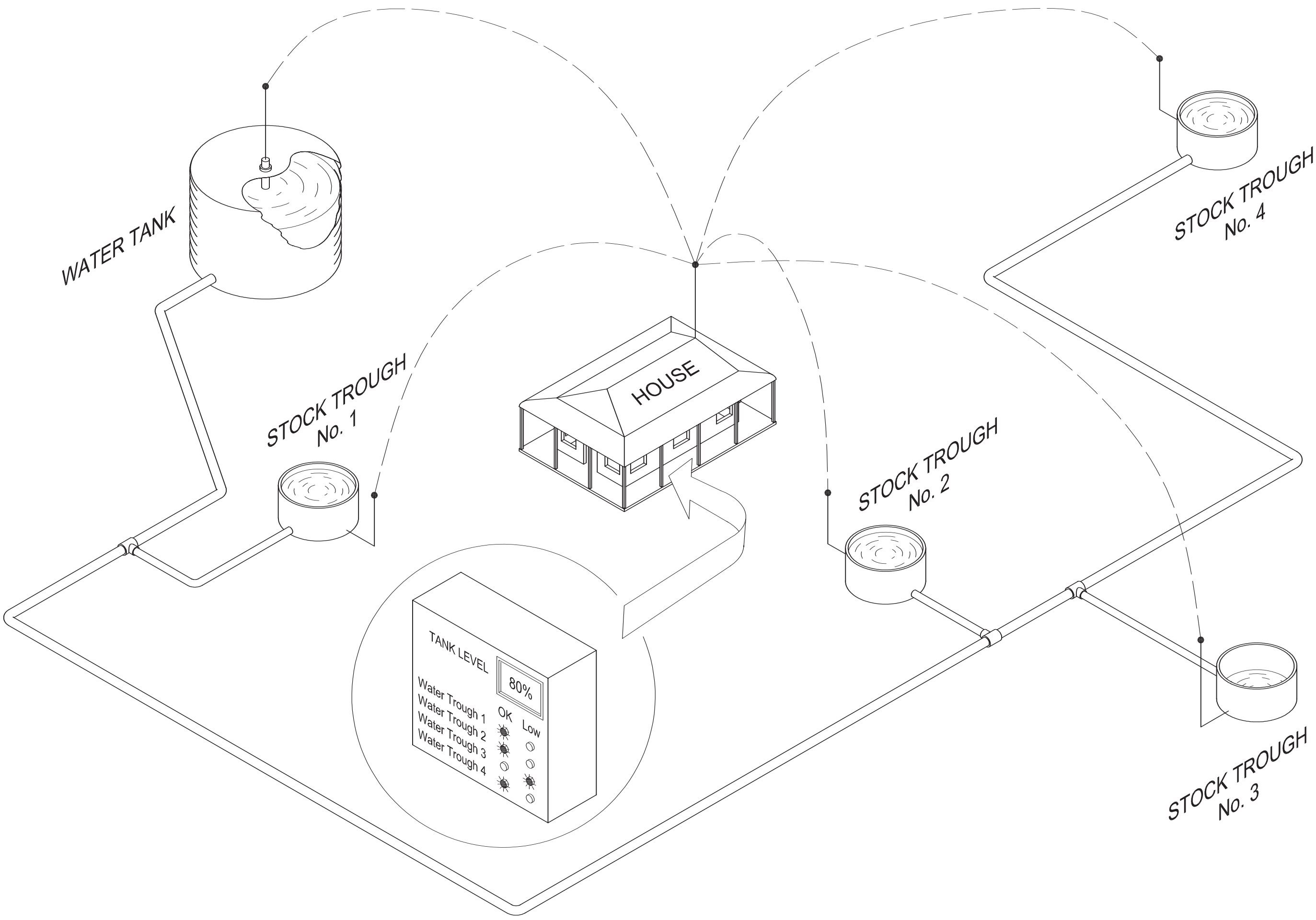
The system utilises a license-free band on the VHF radio spectrum for transmitting and receiving signals with a range of 10km. Repeater stations can be installed to expand the signal range.

At the base station, the reporting requirements can be configured to suit the specific requirements of the landowner. It can be as simple as one warning light indicating a fault or low water level, or a more complex and larger number of monitored sites. Signals can be further transmitted from the base station to a fixed line or mobile phone and deliver a pre-recorded message to provide verbal notification of the problem as soon as it is detected, regardless of landowner location.

The system can also be easily modified to control as well as monitor. This can be useful for turning pumps on or off as well as other required functions.

There is no limit to what can be monitored and controlled in the field with many other possible applications for the farm operation. Weather station instruments can relay information on temperature, wind, humidity and rainfall on the property. Remote monitoring can be used to open and close gates, security and video imaging and identify pressure and flow sensing.

Radio Remote Monitoring System (Typical)



17.2 Technological advancements: Internet, SMS, satellite

The Internet has now consolidated as an ever-present, low-cost transport system for data. Mobile phone access costs are much lower than the cost of fixed lines. Newer technologies are incorporating packet switching, i.e. you pay only for the data that is sent, not for the time you are online. Remote monitoring is more feasible and accessible than in the past.

SMS is used for remote activation of pumps, with users receiving SMS alarms when certain conditions are reached or identified. SMS messages can also be sent and received to a personal computer via the Internet. Some land owners incorporate web cameras at the remote site which upload images to the Internet for viewing.

Typical farm telemetry configuration

The technology selected to carry information will depend on factors such as distance, availability, type and frequency of data transmission required, and finally an analysis of fixed and variable costs.

TECHNOLOGY	GENERAL USE
Radio	Shorter distances: 'line of sight' applications
Fixed telephone lines	Established sites: using existing infrastructure
Mobile phone networks	Unmanned sites: remote sites
Satellite	Remote areas: no mobile coverage

GLOSSARY	DEFINITION
Bandwidth	The maximum speed a communication link is capable of.
Bit	Fundamental unit of data.
CDMA	Code Division Multiple Access. A newer digital mobile technology offering increased coverage over GSM.
CDMA 1X	A high speed data component of the CDMA network with speed of up to 144 kbit/s.
Coverage	The geographic area within which a given service will operate.
GPRS	General Packet Radio Service. A high speed data component of the GSM network.
GSM	Global System for Mobiles. A digital mobile phone network launched in 1993 in Australia.
kbit/s	Unit of speed of data transmission, in thousands of Bits per second.
Packet	A small parcel or Packet of Data Bits.
Packet Switching	A method of data transmission which charges by the volume of data moved, rather than by the time the service is online.
SMS	Short Messaging Service. A text-based messaging service of up to 160 characters between mobile handsets and over the internet.

18. Water Catchment on the Farm

The dry and variable climate of the Wimmera Mallee means it is vital to maximise opportunities to collect rainfall runoff from buildings and natural catchment areas. Extremes of dry seasons encouraged many landowners to install tanks to capture every available drop.

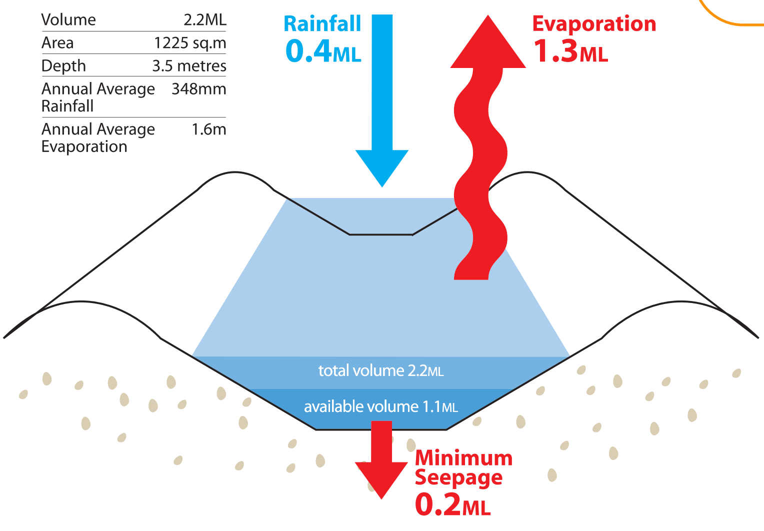
Rain can be captured from homes and sheds to provide safe water for drinking, cooking and other domestic uses. The performance of some herbicides and other chemicals used for crop spraying and other activities is reliant on the purity of water used. Sometimes this water may have been used as a supplement to that provided by channels.

The fully-piped water supply will provide high quality water that is more than adequate for spraying and other uses. Water will be far superior with a higher level of security than the channel supply system. It will still be necessary to capture rainwater for drinking and cooking purposes.

Farm dams have long been part of the landscape on farms in the Wimmera-Mallee. Originally constructed to store water delivered by the channel system for stock and domestic purposes, farming families and friends have also become accustomed to dams as a source of recreation and a pleasant part of their environment.

18.1 Farm dam losses

18.1.1 Water efficiency comparisons with a southern Mallee dam



INFLOW LESS OUTFLOW

Volume available (2.2 + 0.4) - (1.3 + 0.2) = 1.1ML

Channels and farm dams will not be required as part of a piped water supply scheme. The cost to provide water to a traditional dam from the new system may be prohibitive. Some landowners may maintain a smaller open water body on their farm for aesthetics, recreation and biodiversity. There are many affordable alternatives and opportunities to capture water around properties and direct it to areas where it can be enjoyed by family members.

18.2 Buildings

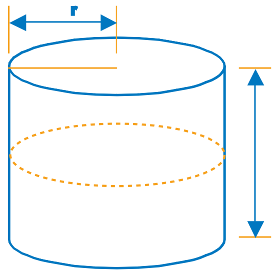
The volume of rainwater collected depends on the area of roof catchment, the season, the amount of water storage capacity and the amount of stored water on the farm. Rainwater can be a high quality source of water for the home and spray applications, with the added benefit of reducing metered consumption from the piped domestic and stock supply system.

Landowners will continue to catch rainwater with the advent of a piped water supply.

18.3 Calculating the volume of a rainwater tank

The volume of a circular rainwater tank can be calculated as follows:

$V = \pi \times r^2 \times H$
Where
V is the volume of the tank
π is 3.142
R is radius of tank
(half the diameter)
H is the height of the water in the tank



All dimensions are in metres

1m^3 (cubic metre) = 1000L = 1kL
1,000kL = 1ML

Most rain falling on roof areas can be captured and directed to storage tanks. Although small amounts splash off, overflow or evaporate, they are considered negligible for the purpose of this manual.

The amount of runoff from a roof can be calculated as follows:

Runoff (in litres) = A x R
where
A = the area of the roof in square metres
R = the rainfall falling on the roof in millimetres

Rainwater can be collected from hard surfaces at a rate of:

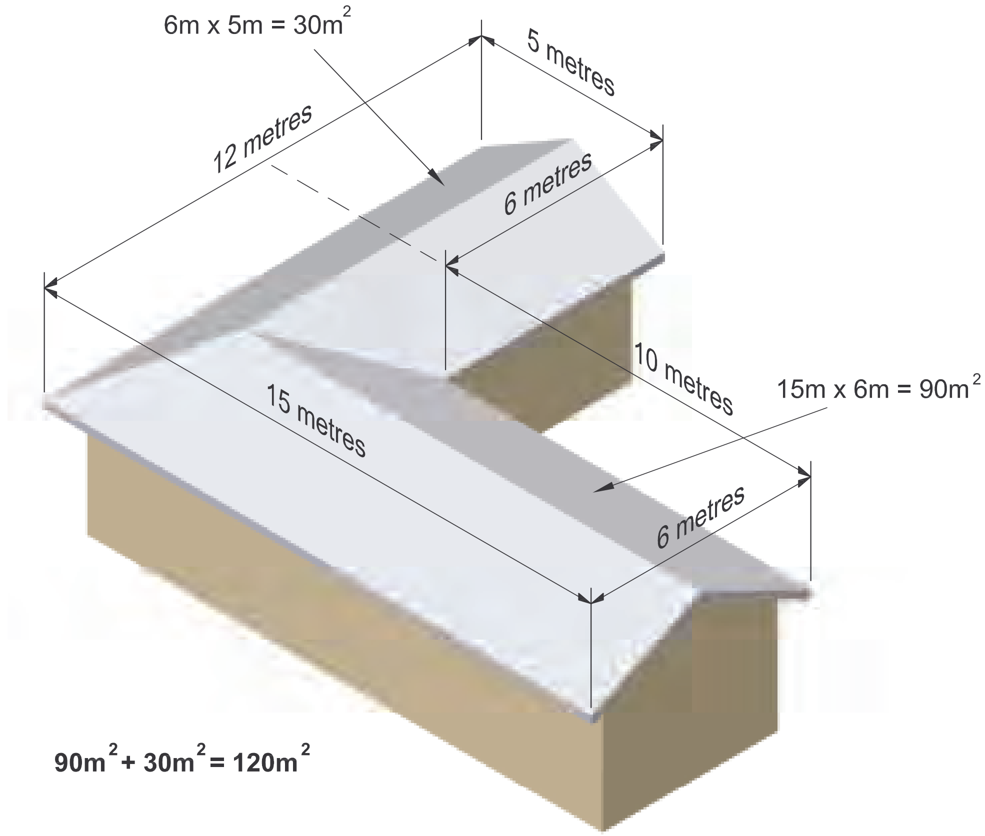
1 litre of water for every 1mm of rain falling on 1sqm of roof

If the roof area is 120sqm and there was a rainfall event of 25mm, about 3,000L of water could be captured in a tank.

The same principle can be applied to determine how much water can be collected in a year based on annual rainfall figures.

Rain is a highly variable phenomena which cannot be relied on to fall in a predictable way from season to season. Personal knowledge of local rainfall variation or the Bureau of Meteorology may provide detailed data. This will give a more reliable estimate of the amount of water that can be collected in most years and help determine the most appropriate-sized tank required.

There is little to be gained by directing water from roof runoff to a tank connected to the piped water supply. The tank will be full most of the time, unless the float valve is set low, which is inefficient use of tank capacity. Most captured water will just exit the tank through the overflow pipe. To make use of runoff water, stand-alone tanks should be provided, and could be plumbed into the reticulation system if desired.



Roof area square metres	squares	ANNUAL RAINFALL 250mm/10"	375mm/15"	500mm/20"	625mm/25"
36	3.9	9,000	13,500	18,000	22,500
50	5.4	12,500	18,750	250,000	31,250
100	10.8	25,000	37,500	50,000	62,500
200	21.5	50,000	75,000	100,000	125,000
300	32.3	75,000	112,500	150,000	187,500
400	43.1	100,000	150,000	200,000	250,000

18.4 Roads and drains

It can be quite simple to construct a drain from the road and surrounding road reserve and direct water into a dam. Removing water from the road drain will also help prolong the life of the road. Dams need to be located sufficient distances from roads to avoid water damage to the road foundation and create a hazard for vehicles. These possibilities should be discussed with your local municipality.

18.4.1 Roaded catchments

Roaded catchments are common in low rainfall areas, such as Western Australia, where water for stock and house dams is required. It involves inverting the soil profile so clay from underneath is brought up to seal the normally permeable soil.

The first step is to form the area so there is a gentle slope towards a dam. A grader is often used to make a series of 'roads' along the fall by mounding the topsoil to expose the clay underneath. The clay is then graded up and laid over the top and compacted.

The clay forms an impervious layer which acts like concrete so that even light rain normally soaked up by dry ground will run off. Roaded catchments are ideal for low rainfall years when runoff is limited. A runoff occurs when the roaded catchment reaches a threshold of 4-10mm of rain, compared to a threshold of 20-25mm for normal soils.

18.5 Private land

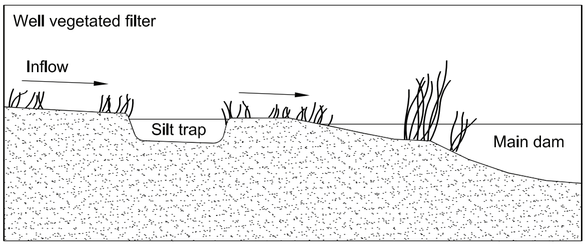
Where water runoff from land areas exists, consideration should be given to redirecting to channels or drains supplying dams.

Earthworks can be done around picturesque dams, perhaps pushing banks back to allow a larger catchment area to be secured. Clay lining, thin asphalt or road base compacted on these areas will help improve run-off efficiency.

These options might be compared with building a shed, which provides a collection mechanism for rain and protection from the elements for equipment, machinery or stock feed.

Estimating property catchment yields is not an easy task, and there are many factors that can influence the yield. The amount of runoff that can be captured depends on rainfall intensity, soil permeability, vegetation cover and ground slope.

Previous applications of gypsum can also affect water absorption rates significantly and may result in less available runoff.



SILT TRAP

Silt traps, physical or vegetative, can be effective in catchments where erosion and siltation are a problem. By trapping incoming silt, organic matter and nutrients such as manure and fertiliser, the life and water quality can be maximised. A good cover of pasture and native grasses, sedges, trees and shrubs throughout the dam catchment will maintain a good quality of water entering the dam. A silt trap is about one-tenth the size of the dam.

Stock should have restricted access to dams. Fencing will protect the area from erosion and eliminate or at least control damage to vegetation and water quality.

The amount of runoff from a catchment can be estimated using the following formula:

Runoff (in Megalitres) = (A x R x Y)/10,000
Where
A = the catchment area above the dam in hectares
R = the average annual rainfall over the catchment in millimetres, and
Y = catchment yield in per cent (%)
A typical value of Y for average annual rainfalls between 250 and 500mm is 5%

Runoff in the drier Wimmera-Mallee areas is more likely to occur in wetter years, extreme rainfall events or when there is good rainfall on a wet catchment.

Experienced and long-term landowners are often the best judge of areas suitable for efficient collection of runoff.

19. Enhancing Your Environment with Water

There are a vast number of possibilities for capturing water on and around the farm to enhance the environment. Enhancing your environment may be associated with aesthetics, biodiversity, vegetation or open water. Often dams are already surrounded by mature trees, especially if it is a home-supply dam.

19.1 Vegetation

Strategically-planted vegetation around catchment dams can fulfill a variety of functions such as shade for stock and habitat for wildlife. It can also reduce evaporation loss from dams and provide an aesthetically-pleasing outlook. The amount of vegetation cover will also affect the quality of water from the catchment area into the dam.

It is desirable to have a mix of aquatic plants such as milfoils, pond weeds sedges and reeds. Specialised advice should be sought because some species may spread and choke dams.

Water quality is affected by contaminants such as silt, fertiliser and animal manure washing into dams from banks and catchment areas. Stock accessing dams cause pugging and erosion, which adds further silt and nutrients to the water.

Erosion, damaged caused by stock can be reduced by fencing a buffer zone around a dam. This area can be planted with trees, shrubs, and under-storey plants. Dense tussock plants such as rushes and grasses protect areas from erosion and filter sediment and pollutants from runoff. Once established, these areas can provide shelter for stock and may be grazed for short periods.

19.2 Use of piped water

If dam beautification opportunities are not available, a small open water feature could be established using piped water. There are many options to keep water consumption to an affordable minimum.

Recognising the loss of open water bodies such as dams may create a significant change on the rural landscape, the WMP project planning group did a small trial in early 2003 to see what might be achieved. The objective was to create an environment, monitor water requirements and beautify the surrounds of a pond.

19.3 Environmental pond (example)

19.3.1 Purpose

A bobcat excavated earth to form the shape and profile of the pond. The floor was lined with a layer of heavy duty black builders plastic. One end was formed with a shallow incline to allow small birds and animals to wade in and out easily. The bottom of the pond could have been lined with soil to develop a more realistic environment. Fully-moulded fibreglass or polyethylene ponds would be ideal as they would completely eliminate seepage.

Pond Size Details

Volume 28kL Area 65sqm Depth 0.4m

Trial environmental pond constructed on the 4th hole of the Brim Golf Course.

Several small rocks and logs were positioned in the pond for small birds and insects to perch on. Pots filled with clay, planted with cumbungi, umbrella sedge or other plants which are often found around dams, would also help to create homes for small insects which in turn would attract birds to the pond.

To achieve a high level of ecological or biodiversity ideally the pond would have a:

- range of native vegetation species and types such as aquatic cumbungi, grasses, shrubs and trees
- range of habitats such as submerged woody debris, rock, timber, water of variable depth and perching areas

Consideration should be given to the pest and animal harbour, management (slashing if required) and fire access.

A water meter was installed at the Brim pond in the water delivery line to monitor water consumption. Results detailed the average daily consumption of water as 185L. Peak daily consumption was 530L in January, with total annual water consumption being 66kL or 66,000L.

20.1 General

The WMPP has been funded and constructed with the primary objective of saving water.

Approximately 80% of the water released from the Grampians headworks is lost to evaporation, seepage and leakage from the old system of channels and dams. Farm dams are extremely water inefficient with 40-60% or over one metre of water evaporating annually. At least 5-10% of water is lost to seepage through the dam floor, with annual water losses attributing to half the volume of each dam. Pipeline systems hardly waste a drop from the headworks to your trough.

More water can be saved once it has arrived at its point of use on the farm.

20.2 Check for leaks

Once the farm water supply system is installed it is important to check for leaks. The system may be tested by installing a pressure gauge then pressurising the system from the Rural Pipeline System or with a pump. The system should then be isolated from the mains system by shutting off the meter tap and monitoring the gauge for any drop in pressure. If there are no leaks the pressure should hold for many hours.

Alternatively, once the system is connected but prior to the introduction of stock, observe the flow meter. If there is a flow at this stage a leak is evident. Regularly inspect fibreglass, galvanised steel and concrete tanks and troughs for cracks, repair leaks as required.

A leaking joint or fitting can waste thousands of litres if unnoticed. Regular checks should be made of supply meters, joints, troughs andfittings and connections at tanks to ensure there are no leaks in the system.

20.3 Regularly read meters

Meters should be read regularly and diary records kept of the reading, the date and the number of stock being watered. The pattern of consumption i.e. litres/head/day can then be calculated for different times of the year. If a reading does not fit this pattern then there may be a problem in the system.

All meters have a display in kL (or thousands of litres) shown in black numbers, however, not all meters are read in the same way.

20.3.1 Reading the meter

The first four black digits record the volume of water that has passed through the meter in kL.

Some meters also have three or four red digits following the black digits. These represent parts of a kL.

When determining water consumption in kL, ignore the red numbers. Read only the black numbers.

1kL = 1,000 L
1000kL = 1ML

If the meter (below) reads:
0013.951kL: consumption has been 13.9kL

Other examples:
0139.510kL: consumption has been 139kL

1395.100kL: consumption has been 1395kL or 1.395ML

20.3.2 Check your supply system

> The water meter requires regular checking to ensure it has not been damaged or turned off. Record readings and monitor water use at the same time.

> The pipeline from the meter to the tank should be checked regularly. This pipeline is under high pressure after the tank is filled and shut off from supply. If the pipe leaks, a large volume of water may be lost and the amount of water supplied to the tank will also be reduced. A significant leak could prevent the tank filling.

> Tanks should be checked regularly for available inflow and water level. A float indicator water level gauge can be fitted to tanks to make monitoring quicker and easier.

> When checking troughs do not assume full troughs mean everything is okay. The tank may be empty, with only the water in troughs available for stock use.

> The meter should be turned off when there is no demand for supply in a particular area e.g. no stock in an area. This system will require you to frequently check that the meter is not turned off. The possibility of undetected leaks and water wastage will also be r educed.

> If GWMWater staff are planning work on meters, landowners will be advised immediately to ensure they are aware who has been at the meter site and the status of supply to the property.

21. Using Water Wisely

Water is a limited resource in the Wimmera and Mallee regions. The following measures can help conserve water around the farm.

21.1 In the house

Laundry

> A washing machine uses 100-200L of water per load. Wash a full load or reduce the water levels for smaller loads.

> Laundry water can be recycled. Catch the rinse water in a trough and use it for the next load.

> Consider a front loader when your washing machine needs to be replaced because they use a lot less water than a top loading machine.

Kitchen

> Don't fill the sink or run the dishwasher for a small number of dishes. Wait until there is a full load.

> When buying new appliances, select water-efficient models. The highest efficiency appliances are indicated by AAAA water use ratings.

Bathroom

> Keep showers to five minutes. 10 to 20L of water is wasted every minute.

> Installing water-saving showerheads or a flow restrictor is a cheap and effective way of saving water.

> A full bath uses 200L; don't fill to the brim. Save 20L by reducing the water level 5cm. A partially-filled bath uses less water than a long shower.

> Don't leave the tap running while cleaning teeth; only turn it on to rinse.

> Place the plug in the basin when washing face and hands instead of letting the tap run.

Toilet

> Check toilet for leaks. A leaking cistern can waste thousands of litres per year.

> A normal toilet uses about 11L per flush. A duel-flush toilet means a half flush can be used. Alternatively, the amount of water used to flush can be reduced by gently bending the float arm on the cistern down or by placing a clean brick or a plastic bottle filled with water into the cistern.

21.2 In the garden

Lawns

> Lawns areas should be kept to a minimum. Select a hardy lawn species.

> Lawns should be watered deeply weekly, fertilised lightly and the soil aerated.

> Grass should not be mown shorter than 3cm. Use a timer system with sprinklers.

> Bark chips, paving or groundcovers are effective lawn substitutes.

Garden beds

> Soil should be loosened and organic matter such as lawn-clippings, compost or straw added to help absorb and retain moisture.

> Mulch such as straw, newspaper, lawn clippings, bark or well-rotted compost will improve soil structure. Mulch should be placed away from the trunks of trees and shrubs to prevent collar rot. Mulch also reduces weeds, which compete with plants for moisture.

> Plants suited to the region and soils with low water requirements such as natives should be selected.

> Tall trees, shrubs and fences can be used as windbreaks to prevent water loss from plants and soil. They also provide shade and shelter.

Watering

> Watering systems with drippers provide mist sprays for young plants and timers prevent over-watering.

> Concentrated watering reduces work and water use when you group plants with similar water requirements.

> Watering should be done at night or in the cooler part of the day. Plants do not absorb water effectively during the heat of the day, with some plants suffering damage if watered in hot weather.

> A water gun ensures no wastage if watering by hand. Ensure taps aren't leaking or left on when watering is completed.

Car washing

> Cars should be washed on the lawn so grass can be watered at the same time.

> The hose, fitted with trigger gun, and bucket of warm soapy water should always be used to wash cars.

21.3 Around the farm

Looking after your farm's water reticulation system not only protects an investment but saves precious water.

Gate valves should be fitted to all T-pieces, troughs and outlets from tanks. This allows paddocks to be isolated if there is a leak to repair or if it is not required for stock. Troughs should be turned off when not in use.

22. Measuring Units and Useful Conversions

When studying engineering principles, hydraulic theory and water reticulation systems, it is important to understand units of measure. They can be confusing and complicated at times. Confusion and complication can occur when some people are familiar with the metric (SI) unit system and others with the imperial system. The SI system is the adopted standard for Australia and many other countries throughout the world and therefore has been used throughout this guide. The SI system is a much simpler system to use than the imperial system because it is based on increments of 10.

The conversion tables easily convert different types of pressure. As an example, when converting from kilopascals (kPa) to pounds per square inch (PSI), simply go down the kPa column until you find the number one, and then across to the corresponding PSI column and recognise the multiplication factor is 0.145. Therefore, 100kPa is 14.5PSI.

Square Measure:

1 Sq mile	= 640 acres, 259 hect.
1 Sq km	= 247 acres, 100 hect.
1 Acre	= 4,840 sq. yards
	= 4 roods
	= 0.4047 hectare
1 Rood	= 40 perches, rod, pole
1 Perch	= 30.25 sq.yards
1 Hectare	= 10,000 sq. metres
	= 107,640 sq. feet
1 Sq metre	= 10,764 sq. feet

Circle Formulas:

Circumference of circle	$= \pi D$
Area of circle	$= \pi D^2 \div 4$
Surface area sphere	$= \pi D^2$
Volume of cylinder	$= \pi D^2 H \div 4$
Volume of sphere	$= 1/6\pi D^3$

D = diameter   H = Height

$\pi = 3.142$

Temperature:

Water boils at 100°C or 212°F

Water freezes at 0°C or 32°F

Centrigrade	= (F-32) x 5/9
Fahrenheit	= (Cx9/5) + 32

Heat and Energy:

1 kW/hour	= 3.6 Megajoule
	= 3412 BTU/hour

Power:

1 HP	= 746 watts
	= 33.000 ft lbs per min
	= 550 ft. lbs per sec

Water Catchment Volume:

Collection area in mm x rainfall in mm = litres

Salinity:

1 EC (Electrical Conductivity Unit)	0.64 milligrams/Litre	0.64 parts per million
1.67 EC	1 milligram/Litre	1 part per million
1000 EC	640 milligrams/Litres	640 parts per million

Fluid Equivalents:

1 gallon	= 4 quarts
	= 10lbs (Water)
1 quart	= 2 pints
1 pint	= 4 gills
1 gill	= 5 ozs

Length Equivalents:

1 league	= 3 miles
1 mile	= 8 furlongs
1 furlong	= 40 poles
1 chain	= 4 poles
	= 66 feet
	= 100 links
1 fathom	= 6 feet

PRESSURE

psi	Foot of Water	kPa	Kilgram Per Square cm	Atmosphere or Bar	Metre of Water	Millimetre of Mercury	Inch of Mercury
1	2.31	6.895	0.0703	0.068	0.704	51.87	2.042
0.433	1	2.986	0.0305	0.03	0.305	22.45	0.884
0.145	0.335	1	0.0102	0.01	0.102	7.52	0.296
14.223	32.85	98.09	1	0.98	10	737.9	29.05
14.7	33.50	100	1.02	1	10.21	752.1	29.61
1.42	3.281	9.797	0.1	0.098	1	73.66	2.900
0.019	0.044	0.131	0.0014	0.0013	0.014	1	0.039
0.491	1.134	3.377	0.034	0.0339	0.345	25.4	1

1mm Hg is also known by the name "torr" (1kPa = 1kN/m2).
The international standard atmosphere (1 atm) - 101 325 pascals or 1.013 25 bar. This is equal to 1.033 23 kgf/cm^2 or 14.6959 lbt/in^2.
In meteorology 1 milibar = 100pascals (1mb = 100Pa).

FLOW

Gall Per Minute	Galls Per Hour	Litres per Second	Litres per Minute	US Gals Per Minute	Cubic Metre Per Hour	Cubic Metre Per Minute	Cubic Feet Per Minute
1	60	0.076	4.546	1.2	0.2728	0.00455	0.1605
0.01667	1	0.00127	0.07578	0.02	0.004547	-	0.00268
13.2	792	1	60	15.84	3.6	0.06	2.119
0.22	13.2	0.0167	1	0.264	0.06	0.001	0.0353
0.833	50	0.063	3.787	1	0.227	0.0038	0.1337
3.656	220	0.278	16.667	4.400	1	0.0167	0.5886
220	13200	16.68	1000	264.0	60	1	35.31
6.23	373.8	0.472	28.32	7.48	1.699	0.0283	1

LENGTH

Inch	Foot	Yard	cm	Metre	Mile	Km	Chain
1	0.0833	0.02778	2.54	0.0254	-	-	-
12	1	0.3333	30.48	0.3048	0.000189	0.0003048	0.01515
36	3	1	91.44	0.9144	0.0005681	0.0009144	0.04545
0.3936	0.0328	0.010931	1	0.01	-	-	-
39.37	3.2808	1.0936	100	1	0.00052	0.001	0.0497
63,360	5,280	1760	160.934	1609.4	1	1.6093	80
39,371	3280.9	1093.6	100,000	1000	0.6214	1	49.71
792	66	22	2011.68	20.115	0.0125	0.0201	1

VOLUME

Imp Galls	Litres	US Galls	Cubic Feet	lbs Water	Cubic Metre	Acre Feet	Cubic Inch
1	4.546	1.2	0.1605	10	0.00455	-	277.34
0.22	1	0.264	0.0353	2.2	0.00100	-	61.02
0.833	3.785	1	0.1337	8.333	0.00379	-	231.06
6.23	28.317	7.48	1	62.3	0.02832	-	1728
0.1	0.4546	0.12	0.0161	1	0.00046	-	27.820
220	1000	264	35.32	2200	1	0.00081	61.032
271,379	-	325,828	43,560	2,713,788	1234	1	-

WEIGHT

lbs	oz	gms	Kg	Ton	Tonne	cwt	Stone
1	16	453.6	0.4536	0.0004464	0.00004535	0.008929	0.07143
0.0625	1	28.35	0.02836	-	-	-	-
0.0022	0.03527	1	0.001	-	-	-	-
2.205	35.274	1000	1	0.000984	0.001	-	-
2240	35,840	1,016,064	1,016	1	1.016	20	160
112	1792	50,803	50.8	0.05	0.0508	18	-
14	224	6350	6.35	0.00625	0.0064	.125	1

Glossary

air valve	A device allowing air to escape from a pipeline. The valve comprises a chamber containing a float. When the chamber contains water the float rises to the top and seals against a small hole. When water in the chamber is displaced by air from the pipeline, the float drops down, uncovering the small hole. The water pressure in the pipeline then expels the air in the chamber and re-fills with water. Once the chamber is full of water again the float rises and closes the hole.
available head	The maximum possible head difference between two ends of a pipeline.
back flow prevention	Devices or methods used to prevent water flowing from the farm pipe system back into the main pipeline supply system in the event that the head in the main system drops below the head in the farm pipe system. One-way valves and air gaps are the most common methods of preventing back flow.
ball valve	A valve that can be turned by hand to open or close a pipeline. A 90° turn of the handle takes the valve from fully open to fully closed and vice versa.
design capacity	The quantity of water required. Pipeline components are selected so that they meet or exceed the design capacity.
domestic and stock	A description used by water authorities for the classification of certain water supply systems. Water classified as domestic and stock is used for washing, toilet flushing and garden watering in and around homes and for stock to drink. This classification and quality does not include water used for commercial irrigation or drinking water.
float valve	A valve with a float attached to an arm that shuts the valve once the water in a tank or trough reaches a certain level.
flooded suction	The condition where the water at the inlet of a pump is under positive pressure.
flow rate	The volume of water delivered through a pipe in a given period of time.
gate valve	A valve that can be turned by hand to open or close a pipeline. Several turns of the hand wheel are required to take the valve from fully open to fully closed and vice versa.
Head	The total energy of water at a particular point. It represents the sum of water pressure in the pipeline and elevation difference between the supply and delivery points. Pressure is converted to metres of head by dividing kPa by 10.
hydraulic gradient l	The head loss along a section of pipe divided by the length of the pipe.
peak daily demand	The maximum volume of water required over a 24-hour period.
pressure	The compressive stress within water, defined by units of kilo pascals (kPa).
pressure pump	A pump with a control system that holds the pressure of water on the discharge side of the pump within certain limits by starting and stopping the pump.
pressure rating	The safe long-term operating pressure for a pipe.
Rural Water Commission	A former Victorian statutory authority responsible for the provision of water supply and drainage across rural Victoria. This organisation was replaced by five rural water supply bodies in 1994.
service connection	The point where the farm water system is connected to the WMPP system, including a water meter, filter and valve.
tariff and charge	The tariff defines the structure used by the water authority to calculate water charges for each property. A water tariff commonly comprises a service, area and volumetric component. The tariff structure is reviewed frequently and involves customer consultation. Charges are reviewed annually by the water authority's board and relate to the prices assigned to each of the tariff components.
whole-farm planning (property management planning)	An approach to planning the physical layout of a farm and farming operations that takes into account landforms, soil types, economic and productive returns and sustainable farming principles. The term 'property management planning' is also used to describe the same approach.

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About the author

Rob Caris BEng (Mechanical Engineering) has held engineering, operational and management positions in multinational food companies, local government and the water industry.

He was the GWMWater project manager of an on-farm advisory and technical support service known as the FARM Project which was established to assist Wimmera Mallee landowners implement reticulation systems on their properties when receiving water from the Wimmera Mallee Pipeline.

Rob is now the Wimmera Regional Operations Manager for GWMWater, and maintains a close interest in the Wimmera Mallee Pipeline project as it is implemented over an anticipated ten-year period.

Rob's aim in preparing the On-Farm Water Reticulation Guide has been to help landowners understand complex pipeline information in an engaging, comprehensive, informative and easy to read manner. The key focus of this guide is to encourage thoughtful design, installation and material selection that will provide landowners with low maintenance, cost-effective and efficient on-farm reticulation systems for their properties and ensure landowners are able to maximize the benefits of a piped water supply.

The FARM project also produced Piping your Property available in both video and DVD format for landowners and farmers seeking advice and practical information on installing tanks, troughs and connection pipes.

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