LEARNER GUIDE

Irrigation

Level 4

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Title:	**Schedule the Operation and Maintenance of Irrigation Systems**						
Applied Title:	**Schedule the Operation and Maintenance of Irrigation Systems for Citrus Production**						
Field:	Agriculture and Nature Conservation						
Sub-Field:	Primary Agriculture						
SETA (SGB):	AgriSETA						
Skills Area:	Irrigation						
Context:	Citrus Production						
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Based on the Production Guidelines of:

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Unit standard alignment and assessment tool development:
Cabeton Training and Development

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Directions

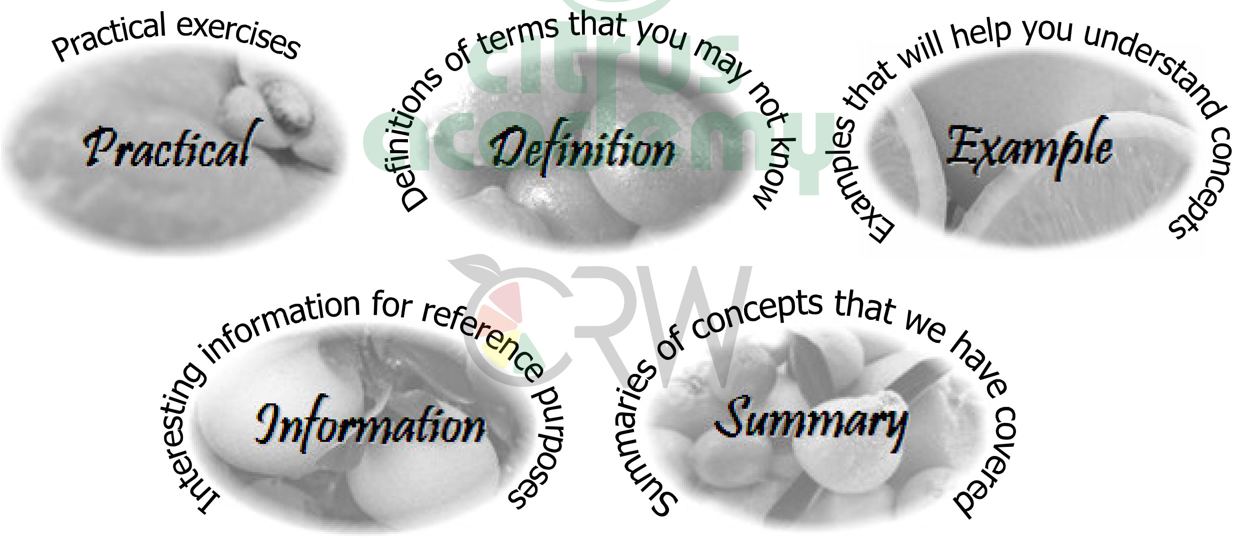
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

Although this learner guide contains all the information required for attaining competency in this unit standard, references to additional resources, both printed and electronic, are provided for further study by the learner.

Information in boxes is indicated by tags that show:



Introduction

1. Purpose

A learner achieving this unit standard will be able to effectively supervise the installation, operation and maintenance of irrigation systems of agricultural crops.

Learners will gain specific knowledge and skills in irrigation and will be able to operate in a plant production environment implementing sustainable and economically viable production principles.

They will be capacitated to gain access to the mainstream agricultural sector in plant production, impacting directly on the sustainability of the sub-sector. The improvement in production technology will also have a direct impact on the improvement of agricultural productivity of the sector.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF3	Literacy and Numeracy	
3	116266	Monitor the operation and maintenance of irrigation systems
4	116290	Establish a plan for the monitoring, safe use and maintenance of equipment, implements, technology and infrastructure

Revision of Level 3

1. Modifying and Implementing Irrigation Schedules

- Operation scheduling refers to timetables that are used to determine when crop should be irrigated because all the orchards cannot be irrigated at the same time.
- Irrigation scheduling refers to how much water needs to be applied at what intervals.
- A well-developed irrigation schedule ensures that all plants receive an equal and sufficient volume of water.
- The irrigation cycle refers to the number of times in a week that blocks are irrigated, while stand-time is the number of hours that a block is irrigated for at a time.
- The soil-water balance is determined to ensure that plants are receiving enough water and to ensure that the irrigation schedule is effective.
- Soil absorbs water much like a sponge. When all free water has drained from the soil, it is at field water capacity (FWC), measured in mm/m or kPa.
- Permanent wilting point (PWP) is the water content of the soil, measured in mm/m or kPa, at which most plants will wilt permanently.
- Plant available water (PAW) is the difference between the FWC and PWP.
- Precipitation is the volume of water applied to the soil and is usually measured in mm.
- Effective root depth (ERD) means the depth where 70% of the feeder roots are present. The ERD for citrus plants is between 300mm and 600mm but usually around 300mm.
- Easily available water (EAW) is the amount of water that is easily available to the plant, which is usually considered as being 50% of the PAW in the root-zone. However, with citrus it is the volume water available between FWC and -50kPa.
- The operations table, pressure table and irrigation schedule is required to implement a schedule.
- The operations table shows which irrigation blocks are irrigated at the same time.
- The pressure table indicates the pressure at which in-field valves should be set.
- The irrigation schedule indicates the cycle and stand-time for the different operations.
- In order to ensure that plants are not over- or under-irrigated, the irrigation schedule must be adapted to ambient weather conditions by changing the intervals.
- Various problems can be caused by incorrect scheduling. When symptoms of such problems are detected, the irrigation schedule must be changed to ensure that irrigation remains effective.

2. Collecting and Recording Data

- The scheduling equipment that is used most commonly in irrigation scheduling is evaporation pans, rain gauges, tensiometers and probes.

- An evaporation pan measures the daily evaporation due to climatic factors, and is installed 200mm above ground level.
- A rain gauge measured daily rainfall in mm, and is installed in an open space around 1m above ground level.
- Tensiometers measure the water potential of the soil and are inserted at depth of the root-zone and below the root-zone.
- Probes are specialised equipment and measure factors related to the volume of water in the soil.
- Evaporation pan data is recorded in a log in which the daily evaporation is calculated.
- Rainfall as recorded by the rain gauge is recorded in a rain calendar and evaporation pan log.
- Tensiometer readings are taken from a special dial gauge mounted on the tensiometer.
- Readings from probes are recorded with a data logger and processed on special software.
- The daily evaporation and crop factor is used to calculate the crop evapotranspiration and from that the daily soil-water balance, or ground water reservoir, is calculated, which is used to assist with scheduling.
- From the soil-water balance, the weekly water requirement is calculated, which is used to determine the irrigation intervals.
- Tensiometer and probe readings are used to determine the EAW. Irrigation can be applied when the EAW is depleted.
- The areas around the evaporation pan must be kept clear, it should be cleaned regularly and checked for damage.
- Rain gauges must be in a clear area and should be replaced when cracked or broken.
- Tensiometers must be reset if the soil has dried out and checked for cracks.
- The accuracy of readings from scheduling equipment can be determined by comparing readings from different equipment and applying reasonability tests.

3. Supervising Irrigation Activities

- Supervising the implementation of an irrigation schedule is easiest done by compiling a work program for the field workers and monitoring them.
- The irrigation schedule is adapted to ambient weather conditions by using information from scheduling equipment to determine whether intervals must be increased or decreased.
- The operation of the irrigation system is monitored through keeping records of readings when the pump system is started up.
- Workers must all be aware of safety regulations.
- Irregular problems must be reported to the irrigation manager immediately.

4. Efficient Operation of Irrigation System

- Major irrigation system checks and repairs are performed on an annual basis, normally during the winter when irrigation is required less often.

- The following checks are made on the pump system:
  - Pressure readings
  - Pipe work
  - Pump and motor coupling
  - Mounting bolts
  - Electrical panels

- Be attentive to noise and vibration from the pump whenever it is working.

- The following checks are made on filters:
  - Filtering material (sand, discs, screens, etc.)
  - Hydraulic valves
  - Pressure differential over the filter
  - Lid seals and rubber tubing

- In the infield irrigation system, the valves, emitters and pipes must be checked regularly.

- Pre-start-up inspections must be performed every time before the pump is started, and start-up and shut-down procedures must be strictly followed.

- The pump installation is equipped with an amp meter, volt meter, pressure gauge and flow meter. Readings from these meters are used to determine the working characteristics of the pump and pump-motor.

- The normal pump-motor working characteristics are determined by the irrigation manager and based on the irrigation design.

5. Irrigation System Maintenance

- The lifespan of irrigation equipment is determined by the quality of the equipment that was originally installed and the ongoing maintenance of the irrigation system.

- Pump systems, sub-mainlines and filters should only need to be replaced at the end of the lifespan of the orchard, while mainlines should have a life-expectancy of twice the lifespan of the orchard.

- Good quality and well-maintained lateral lines should have a life-expectancy of around seven years, at which time drippers should also be replaced. Micro-jets should last for the lifespan of the orchard, but may deteriorate sooner if water quality is poor.

- A long-term maintenance plan describes the tasks that should be performed on a monthly, yearly, 5 yearly and 5-7 yearly bases.

- Contingency plans should be in place to deal with emergency situations such as floods, fire, pump breakdowns, pipe bursts, and chemical spills.

- In case of floods, pumps must be removed from vulnerable positions as soon as possible. The electricity must be shut down and not be switched on again before the system has been inspected by a qualified electrician.

- The risk of fire must be limited as far as possible, and a fire fighting unit must be kept at hand and in good working condition.

- When pump breakdown occurs, high-value crops must receive priority for the available water and the pump must be repaired as soon as possible.

- Equipment must be kept on hand to repair pipe burst as soon as possible.

- If the irrigation water has been contaminated as a result of a chemical spill, all irrigation must be halted immediately and the irrigation manager must be informed.

- A monthly budget can be developed from the list of irrigation equipment requirements.

- Irrigation equipment should be bought from dependable suppliers that provide good quality equipment.

Irrigation Cycle

The irrigation cycle refers to the intervals at which a set volume of water must be applied to the trees. For example, if the cycle for a block is three days a week, it will be irrigated on for instance Monday, Wednesday and Friday.

Standing Time

Standing time is the number of hours for which water needs to be applied to a block at the intervals stipulated by the irrigation cycle. If a block has a cycle of three days a week with a standing time of four hours, the block will be irrigated on for instance Monday, Wednesday and Friday for four hours at a time.

Field Water Capacity (FWC)

Field water capacity (FWC) is the condition of a soil when all free water has drained under gravitational forces from a water saturated soil. The FWC can be measured in mm/m or kPa. FWC is not a fixed point and varies from soil to soil. This is sometimes referred to as the *full* point of the water reserve in the soil.

Permanent Wilting Point (PWP)

The Permanent Wilting Point (PWP) is the condition of a soil where plants cannot obtain any water and will wilt permanently. This is also referred to as the *empty* point of the water reserve in the soil. PWP is experienced at a water potential of -1,500kPa.

Plant Available Water (PAW)

Plant Available Water (PAW) is defined as the difference between Field Water Capacity and Permanent Wilting Point, i.e. **PAW = FWC – PWP**

Precipitation

Precipitation refers to the volume of water applied. As a result the water content of the soil may increase by the same magnitude provided all the water infiltrates the soil and no evaporation or runoff occurs. Precipitation is calculated as follows:

Precipitation (m) = Volume of water (m^3) / Area of land (m^2) : **P = V / A**

Or

Precipitation (mm) = Volume of water (m^3) x 1,000 / Area of land (m^2)

Effective Root Depth (ERD)

Effective Root Depth (ERD) refers to the depth where 70% of the feeder roots are located. The ERD for citrus is usually 300mm-600mm. The average root depth for orchards in South Africa is in fact 300mm, as few roots are found below this level due to the depth of mechanical working and compaction. ERD is assessed by digging profile pits and observing the root distribution.

Easily Available Water

The general assumption is that Easily Available Water (EAW) refers to the amount of water that is easily available to the plant, being 50% of Plant Available Water. The easily available water in the soil is determined as follows:

Easily Available Water (mm) = Plant Available Water (mm/m) x Effective Root Depth (m) x 50%

Or

EAW = PAW x ERD x 50%

However, in citrus production especially fruit size is limited when the water potential in the soil exceeds -50kPa. Therefore, easily available water is only the volume available between FWC and -50kPa. This is the volume of water a tree can absorbed without using energy.

Note that the FWC and PWP, from which the PAW is calculated, differ for each type of soil and must be determined by the irrigation manager or an irrigation consultant.

Transpiration

Transpiration refers to the process whereby water that is absorbed by the roots and translocated to the leaves, is lost to the atmosphere in the form of water vapour. These losses of water vapour from a plant's surface happen through minute pores on the leaf surface, called stomata.

Evapotranspiration

Evapotranspiration is the combined loss of water by means of evaporation from the soil and transpiration by the trees.

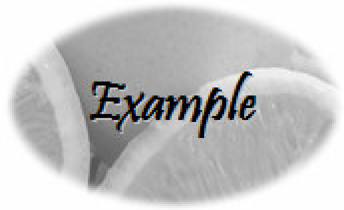
Chapter 1

After completing this chapter, the learner will be able to:

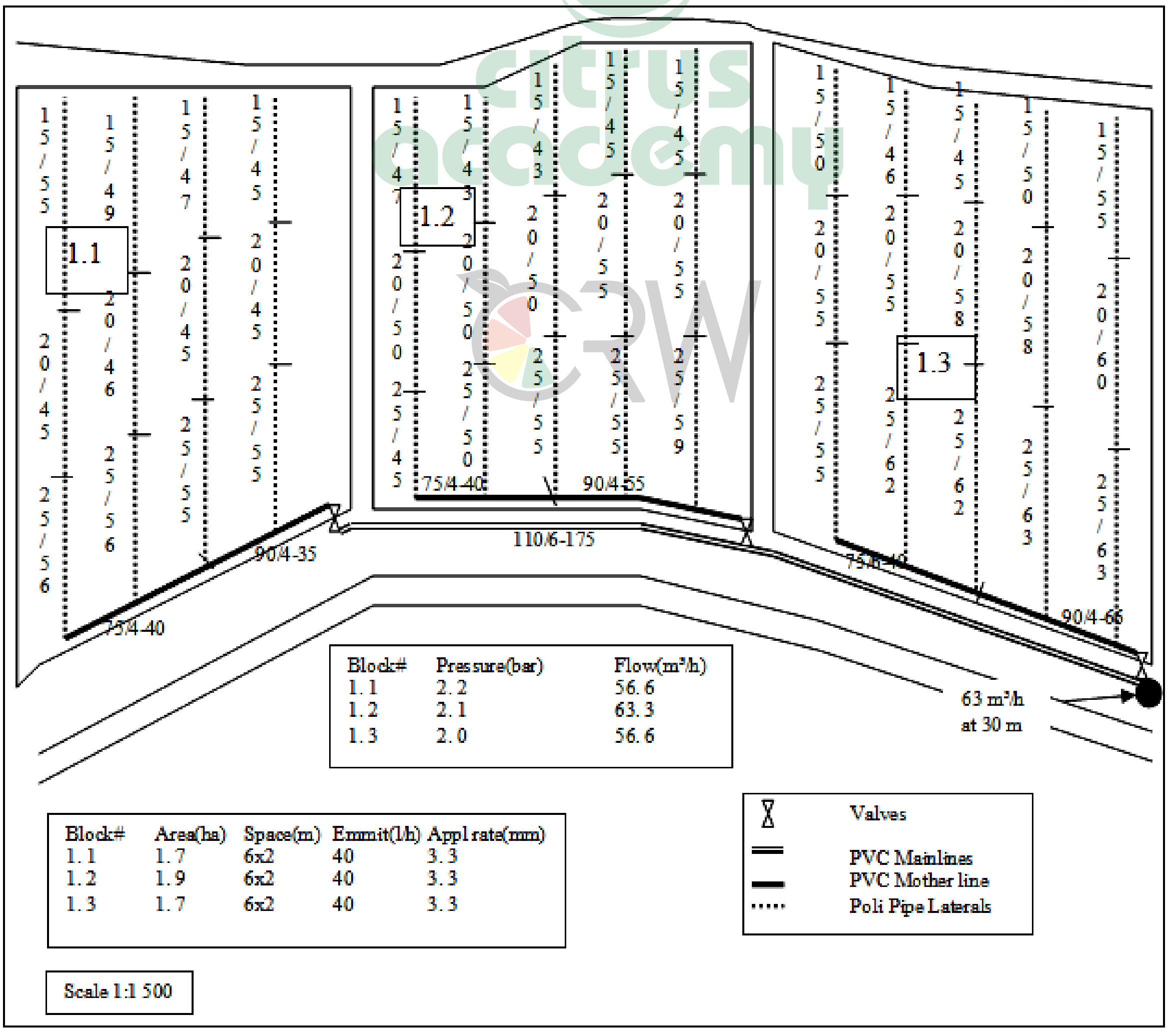
Install an irrigation system

1. Interpreting an Irrigation Design Plan

The foundation of a reliable irrigation system is based on adequate data on the crop, soil and root system being incorporated in a good irrigation design plan. The irrigation system is usually designed by a qualified irrigation consultant. Below is an example of an irrigation design plan for three adjacent blocks.



Irrigation Design Plan



1.1. Orientation

When reading an irrigation design plan, the first step is to get the orientation right. The plan must be turned so that landmarks on the plan agree with the actual landmarks, such as dams, canals, koppies, or any other distinguishable feature that is shown on the map. Familiarise yourself then with the block and pipe layout on the plan and compare it with the actual block and pipe layout.

1.2. Symbols

On an irrigation design plan symbols or different colours are used to depict the various pipes, valves and other features. Usually, a key is provided with the symbols and their meaning. In table 1.1, the symbols and keys that are used on the irrigation design plan above are explained.

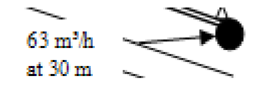
Symbol	*Description*	*Example of Use*	*Details*
●	Pump		The best place to start on an irrigation plan is at the pump station or the beginning of the mainline. The pump station is marked on the plan with a dot and the pump duty point is noted (63m^3/h at 30m in this case).
═	Mainline		The mainline can be traced from the pump station. On some plans there may also be sub-mainlines, which are pipes that branch off the mainline to take water to blocks that are further off the mainline.
⧗	Valve		On the mainline and sub-mainlines are the valves for the blocks. Valves feed directly into the mother lines.
▬	Mother Line		There is a mother line for each block. The lateral lines branch off from the mother lines.
·····	Lateral line		Lateral lines run from the mother line along the tree rows. The emitters are located on the laterals.

Table 1.1: Symbols and Keys Used on Irrigation Design Plan

1.3. Pipe Notations

The notations next to the different sections of pipes indicate the pipe size and class for that particular section of pipe, and the length of the pipe.

Using the notation of 110/6-175 for the mainline in the table above as an example, the 110/6 indicates the pipe size and class, meaning the pipe will have a nominal diameter of 110mm and will be PVC class 6 pipe. The second part of the notation indicates the length of the pipe in meters, meaning that this pipe will be 175m long. Note this is the total length and includes the bends in the pipe.

Pipe sections are indicated by a short line (/ or -). In the example above, the different sections of the lateral lines are marked in this way. The first lateral for block 1.3 has the numbers 25-63, 20-60 and 15-55. This means that in the first section, 25mm poly-pipe is laid for 63m. In the second section, 60m of 20mm poly-pipe is laid, and 15mm poly-pipe is laid for 55m in the third section.

Classes are usually not specified for the laterals, because class 3 poly-pipe is used as a rule. If drippers are used, the drip line would be specified.

The class of the pipe indicates, for plastic, PVC and poly-pipe, how much pressure in Bar the pipe can withstand. The class notations for asbestos and cement pipes are more complicated and have to be verified with the supplier.

Below is information on the commonly used pipe sizes and classes.

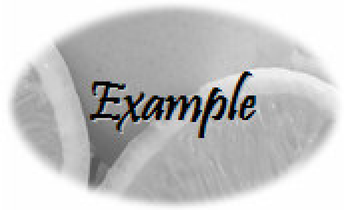
Popular Pipe Sizes and Classes for Irrigation Pipes

Pipe	***Number***	***Nominal Diameter (mm)***	***Class***	***Working Pressure (bar)***
Poly-pipe	15/3	15	3	3
Poly-pipe	20/3	20	3	3
Poly-pipe	25/3	25	3	3
Poly-pipe	32/3	32	3	3
Poly-pipe	40/3	40	3	3
Poly-pipe	50/3	50	3	3
Poly-pipe	32/6	32	6	6
Poly-pipe	40/6	40	6	6
Poly-pipe	50/6	50	6	6
Poly-pipe is available in sizes 65mm, 80mm, 100mm and in classes 3, 6, 9. Note that this for LDPE (low density pipe).				
PVC	50/4	50	4	4
PVC	50/6	50	6	6
PVC	63/4	63	4	4
PVC	63/6	63	6	6
PVC	75/4	75	4	4
PVC	75/6	75	6	6
PVC	90/4	90	4	4
PVC	90/6	90	6	6
PVC	110/4	110	4	4
PVC	110/6	110	6	6
PVC	140/4	140	4	4
PVC	140/6	140	6	6
PVC	160/4	160	4	4
PVC	160/6	160	6	6
PVC	200/4	200	4	4
PVC	200/6	200	6	6
PVC pipe is available in sizes up to 500mm and up to class 20.				
Asbestos Cement	150/6	150	6	3

Asbestos Cement	150/12	150	12	6
Asbestos Cement	150/18	150	18	9
Asbestos Cement	200/6	200	6	3
Asbestos Cement	200/12	200	12	6
Asbestos Cement	200/18	200	18	9
Asbestos Cement	250/6	250	6	3
Asbestos Cement	250/12	250	12	6
Asbestos Cement	250/18	250	18	9

1.4. Irrigation Block Information

On the irrigation design plan information with regard to each block is given in a table that shows the block number, area, spacing, emitter delivery and application rate.

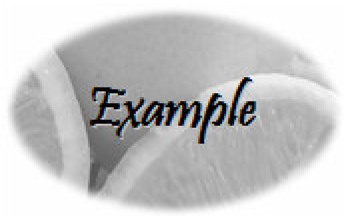


Block Information on Irrigation Design Plan

Block#	Area(ha)	Space(m)	Emmit(l/h)	Appl rate(mm)
1.1	1.7	6x2	40	3.3
1.2	1.9	6x2	40	3.3
1.3	1.7	6x2	40	3.3

The area of each block is indicated in hectares (ha). In the ***Space*** column, the plant spacing is indicated. In the example the spacing is 6m x 2m, meaning that the plant rows are 6m apart and the trees are planted 2m apart in the rows. Remember that plant spacing varies according to the cultivar and the production area.

The plant spacing is used to calculate the number of plants per hectare, and therefore the number of emitters that is required. The plant spacing is multiplied to calculate the area per plant, and area in hectare is divided by the area per plant, which will give the plant population per hectare. Remember that 1 hectare equals 10,000m^2.



Calculating Plant Population per Hectare

Plant spacing: 6m x 2m

Calculating Area per Plant

6m x 2m
=12m^2 per plant

Calculating Plant Population per Hectare

Area of a hectare / Area per plant
10,000m^2 / 12m^2

=833 plants per hectare

Calculating Plants per Block

Plants per hectare x Block Area
833 plants x 1.7ha
=1,416 plants in block number 1.1

This is useful when plants are ordered or when the plants are allocated per block.

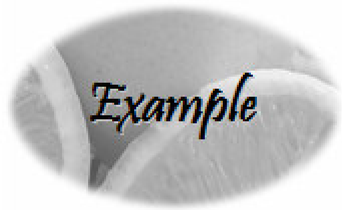
The emitter delivery in the table is used to calculate the precipitation and to check the emitters. The precipitation is used in the scheduling of the irrigation.

The irrigation design plan also contains a table with the pressure and flow per block. This information is used in the irrigation scheduling.

1.5. Bill of Quantities

When a system is designed from scratch or if new blocks are designed, a bill of quantities is supplied along with the irrigation design plan.

If the company that designed the system is delivering the materials as well, the bill of quantities is used to check and verify all the materials that are delivered. If the designer is not delivering the materials, the bill of quantities is used to obtain quotations for the materials and for budgeting.



Bill of Quantities

Item	*Unit*	*Quantity*
Poly-pipe 15/3	m	1,200
Poly-pipe 20/3	m	1,300
Poly-pipe 25/3	m	900
25 mm nylon couplings	Each	90
20 mm nylon couplings	Each	130
15 mm nylon couplings	Each	120
Reducer 25x20 mm	Each	80
Reducer 20x15	Each	85
Grommet fitting and rubber	Each	85
Micro 40 l/h, spreader, peg, tube, barb	Each	8,250
PVC 50/4	m	300
PVC 63/4	m	200
PVC 75/4	m	180
PVC 90/4	m	150
Reducer boseng 63x50	Each	6
Reducer boseng 75x63	Each	6

Reducer boseng 90x75	Each	5
RO bend 80x90	Each	6
Valve cluster 80mm hydraulic valve, pilot	Each	6
Saddle 110x50	Each	6
Reducing socket 50x80	Each	6
Nipple 50 mm nylon	Each	6
Glue on bend 50mm	Each	12
Glue on ball valve	Each	6
End cap 110	Each	1
Air valves 25 mm	Each	6
Risermatic short 25 mm	Each	6
Bend boseng 110mm	Each	2
PVC 110/6	m	800
Pipet	Each	1
Pressure gauge 0 – 4 bar	Each	1
Pipe punch	Each	2
Hole saw	Each	1
Pipe lubricant	Bucket	1

2. Laying Out the Irrigation System

Now that we have developed an understanding of the irrigation design plan, the blocks can be pegged out in the field. The assumption is made that the land has been cleared and soil preparation has been done, and that other infrastructure items, such as roads and waterways, has already been demarcated.

Care must be taken when laying out the irrigation blocks that it is done correctly and precisely. It may take a day or two longer to get it right, but remember that the result will be visible for the lifespan of the orchard.

The following tools and equipment are required for pegging out the blocks:

- Pegs (one per tree in the block)
- Hammer
- Dumpy level or other surveying instrument
- Measuring tape
- Wire or rope

Blocks are laid out as follows:

- Marking the corners of the blocks
- Marking the rows
- Marking the plant positions

2.1. Marking the Corners of the Blocks

The corners of the blocks are first pegged out roughly to see the relation of the blocks to one another. The lengths of the sides of the blocks are now measured on the irrigation design plan, and the scale of the plan is used to calculate the actual length.

The **scale** is a ratio that shows the relation between the measurement on the plan and the actual distance on the ground. The scale of the plan in the example is 1:1500, meaning that for every centimetre on the plan, the distance on the ground would be 1,500cm or 15m. If the side of a block measures 10cm on the plan, it equals a distance of 15,000cm or 150m on the ground.

The corners of the blocks can now be marked precisely. Make sure the corners are in the right spot and that the pegs are hammered in well. These corners will be the markers used to lay out the rest of the block, so if they are wrong, the rest of the layout will also be wrong.

2.2. Marking the Rows

Start by measuring the rows on the side of the block with the mother line, using a measuring tape. Remember that poor-quality measuring tapes can stretch and expand. Use a good quality measuring tape made of fibre.

If the plant spacing on the irrigation design plan is for example 6x2, it means that there must be a 6m space between rows, and a 2m space between the plants in the rows. The row spacing is the bigger number.

Set the dumpy level up at one of the corners of the block. To set up the dumpy, the legs of the tripod is extended and secured. The base of the dumpy is fastened to the tripod by means of the attachment screw on the base the tripod.

On the dumpy is a spirit level, located on the eye-piece or the base of the dumpy. By moving one leg of the tripod at a time in or out, adjust the level of the dumpy until it is almost in the middle. On each of the three corners of the base of the dumpy is an adjusting screw. Adjust these screws until the spirit level shows dead centre. In the case of the spirit level being located on the eye-piece, the dumpy has to be turned to face the leg that is being adjusted. Rotate the dumpy trough all three legs after it is levelled to check the levelling.

When you look into the dumpy level you will note crosshairs on the inside. Turn the dumpy towards the other corner of the block. If the other corner is out of sight due to elevation, have an assistant hold a long pole or staff at the other corner. Plant pegs between the corners at about 20m to 30m intervals. Make sure the pegs are in the vertical crosshair and therefore in line with the other corner. These preliminary pegs give a straight line along the side of the block for the measuring of the rows.

Use a tape measure to mark the end of each row with a peg. Make sure the straight line is followed. Check the pegs with the dumpy. They should all be in one straight line from the dumpy to the other corner. Move the pegs perfectly into line, and check the row spacing again with the measuring tape.

Keep the dumpy at the corner it is and swivel it to mark a line perpendicular to the one on which the rows have been marked. Apply the same method as above, and put down two marking pegs at about 50m to 100m intervals on this line. Move the dumpy to the first peg and level as set out above. Turn the dumpy back to the first corner and zero the degree scale, by adjusting the degree plate on the dumpy so that 0 degrees shows to the first corner. Now swivel the dumpy trough 90° and lock.

Peg out a line to the opposite end of the block, and use the same method as above to mark the rows at six meter intervals on this line as well. Repeat the procedure for the remaining pegs that run parallel to the rows. When the rows are marked the pegs in the rows must be checked to see that they are in line.

Citrus orchards are ridged in many cases. This means that the ground is cropped up into the row to improve the soil depth and drainage. Once the rows are marked, the ridges must be made. Once the rows have been ridged, the rest of the land can be pegged.

After ridging the row markers must be checked again as the grader could have moved the pegs. Check the rows by using the same method that was used to lay them out.

2.3. Marking the Plant Positions

Set up the dumpy at the end of a row and look at the other end. Use the tape measure to measure the inter-plant spaces. If the plant spacing is 6x2m, this would be 2m. Plant pegs at every spot where a tree must be planted.

Check the pegs visually to see that they are in line. Check them also at an angle, meaning from one corner to the corner diagonally opposite, to see if they are aligned.

3. Conveyance System Trenches

Conveyance system trenches are the trenches into which the pipelines are buried. Before the trenches are dug, they must first be pegged out. The centre of the trench can be pegged with pegs about 50m to 100m apart. Tie a wire or a rope to the pegs to mark out line between them, and use ordinary lime to mark out the line of the trench. When the trenches are dug, the chalk line must be in the centre of the trench.

Trenches are dug about 400mm to 600mm wide, depending on the size of the pipe. Trenches are usually about 600mm deep. Trenches for pipes that go through lands and roads, such as mainlines and sub-mainlines, should be 1,000mm deep. Trenches for mother lines can be a bit shallower, at about 400mm. Trenches must be free of protruding rocks on the bed since these rocks can break the pipes.

Trenches can be dug by either using manual labour or a back-end loader, also called an excavator. Manual labour may be cheaper, but will take longer, while using a back-end loader will be faster but more expensive. Keep in mind that back-end loaders are also more suited for rocky terrain. The choice will depend on the budget.

4. Installing Irrigation Equipment

In table 1.2 below, various items of irrigation equipment is discussed in greater detail.

Pipes	
Asbestos Cement (AC) Pipes	Asbestos cement pipes are not manufactured any longer due to health concerns regarding the manufacturing process. It is however not uncommon for these pipes to be used second-hand. Many older systems also use these pipes for mainlines and sub-mainlines. AC pipes are hard but very brittle, so care must be taken when they are handled and transported. The trench must be free of protruding stones and the pipe must be laid on a bed of clean sand. AC pipes are joined by collars. Triplex couplings are made out of asbestos cement and have three seal rings. The pipe slides into this socketed joint. The other method of joining AC pipes is with the short collar, which is a coupling with two iron rings that are tightened around an iron collar. Each ring contains a rubber ring that is compressed around the pipe when the collar is tightened, preventing the collar from leaking. AC pipes come in COD (constant outside diameter) and CID (constant inside diameter).
PVC Pipes	This is the most commonly used pipe for irrigation. PVC is a plastic material and these pipes are more flexible and tolerant to movement. The one end of the pipe is chamfered and the other end is socketed. The chamfered end slides into the socketed end. Trenches must free of stones, but do not need to be lined with sand for smaller pipe sizes of 200mm and smaller. Fittings are either steel or PVC and are also socketed. Inside the sockets are lip-seals that seal the pipe.

Steel Pipes	Steel pipe is very expensive but very reliable and durable. Steel pipes are used more often for suction pipes, delivery pipes, risers, and filter manifolds, where the line must go trough or over unsuitable terrain. Steel pipes can be threaded at the end (up to 150mm) or flanged (from 50mm and bigger). Threaded pipes are connected using screwed sockets. Flanged pipes are bolted together with a packing in the middle. Steel pipes rust, so they must be coated with a rust-proof coating such as paint, coupon, galvanizing or powder coating.
Poly-pipe	Poly-pipe is used for the lateral lines. Class 3 LDPE pipe (low density pipe) is used most often, but HDPE (high density pipe) is also available. HDPE pipe is used more often in boreholes and shade houses.
General Fittings	
Reducers	A reducer is used to connect pipes of different sizes.
Bend	A bend is used to allow a pipe to change direction. Bends are available in 90° and 45°.
End Cap	An end cap is used to plug the end of a pipe.
Air Valve	An air valve expels air from the system, preventing air locks. Some air valves have a vacuum function (see below).
Vacuum Valve	A vacuum valve prevents the formation of a vacuum when the pump system is switched off.
Non-return Valve	A non-return valve prevents the back-flow of water.
Gate and Butterfly Valve	Gate and butterfly valves open and close the pipeline, thereby decreasing and increasing the water flow. They are used to regulate the water pressure in a block manually.
Hydraulic Valves	Hydraulic valves are also used to decrease or increase the water-flow, thereby regulating the water pressure in a block.
Infield Fittings	
Grommets	A grommet is a fitting that is used to connect lateral lines to the mother line.
Nylon Couplings	Nylon couplings and reducers are used to connect poly-pipe.
Micro-jets and Drippers	Micro-jets and drippers are the emitters that supply water to each individual tree. They are installed on the lateral lines.

Table 1.2: Irrigation Equipment

4.1. Installing Pipes

Pipes are installed in trenches as follows:

- Before installing pipes in trenches, ensure that the trenches are free of stones and sharp edges.
- Asbestos cement pipes and large PVC pipes must be laid down on a bed of sand.
- Place the first pipe into the trench and secure it by backfilling the trench near the ends of the pipe.
- Place a collar over the end of the pipe. Make sure the collar and the end of the next pipe is clean.
- Lubricate the inside of the collar and the end of the next pipe with pipe lubricant or soap water. Do not use oil because this will cause the rubbers to perish.

- Insert the end of the second pipe into the collar.
- Place a wooden block over the other end of the second pipe and tap the block with a hammer to force the pipe into the collar. The force that is required depends on the size of the pipe.
- Drive the pipe in up to the depth marked on the pipe. Take care not to pinch the rubbers.
- If the pipe refuses to go into the collar, remove the pipe and inspect the collar, as the rubbers may have shifted.
- Ensure that there are no foreign objects inside the pipes that can cause blockages in the irrigation system.
- As the pipes are laid they can be backfilled near the edges. Joints must be left open to check for leaks.

Where bends or end caps are fitted there is always the possibility that the joints can kick out, except in the case of steel joints. Bends and end caps must be anchored either by driving Y-standards in and tying them down, or by casting trust blocks. Trust blocks can be 600x600x300 and cast in ordinary concrete.

It is good practice to flush the pipes as the work continues. First flush the mainline before the valves are fitted. Then flush the mother lines before the laterals are fitted. Next, the laterals can be flushed before emitters are fitted.

After the system has been tested (see section 5) the trenches can be backfilled. The backfilling around and above the pipe for about 100mm must be stone free and compacted. The rest of the backfill does not need to be compacted.

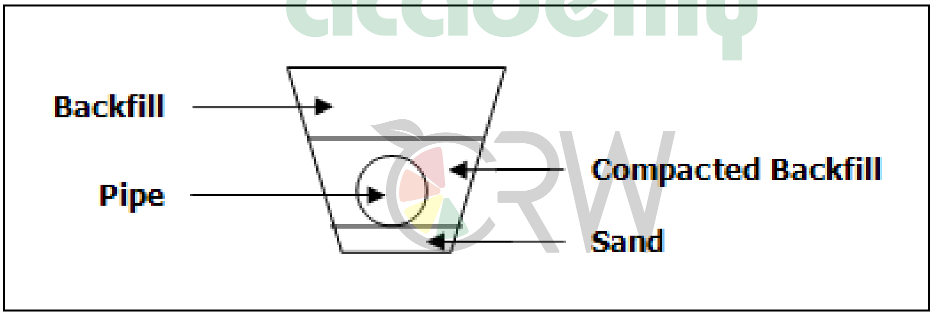


Figure 1.1: Cross Section of a Backfilled Trench

4.2. Installing Filters and Valve Clusters

Pump and filter bank installation is a specialised job that should be carried out by a competent contractor.

Inline filters can however be installed very easily. The filter is attached to risers so that it is above ground. At the bottom end of the risers are riser outlet bends, which are spigoted to slide over the pipe. At the back of each riser leg, a Y-standard is hammered in and tied down to the riser to keep the leg from popping out. The valve clusters are installed in the same way.

4.3. Installing Infield Fittings

Grommets are installed by sawing a hole in the mother line, and inserting a rubber ring into the hole. The ring has a groove that fits into the sides of the pipe. The coupling is inserted into the lateral and then pushed into the rubber ring. There is also another type of grommet that is pushed into the hole and the retaining nut on the grommet is tightened.

Nylon couplings and reducers are pushed into the poly-pipe. No clamps are needed as long as the working pressure is within limits.

Micros have a tube that is fitted with a barb and drippers have the barb moulded onto them. A hole is punched in to the poly-pipe and the barb inserted into the hole.

5. Testing the Irrigation System

The various components of the irrigation system are tested as they are installed, and the performance of the entire system is tested once the installation is complete.

As the pipes are laid and flushed, joints are inspected for leaks. Once the pipes are partially backfilled with the joints exposed, the system is brought up to working pressure. The blocks that are grouped in operations are opened. Pressure readings are taken before and after the valves, and these are compared with the values noted on the irrigation design plan in the ***Pressure and Flow at Nodes*** table. If the readings are not correct, it may be an indication of wrong pipe size, incorrect hydraulic valve settings, or pump or filter malfunction.

Hydraulic valves are calibrated at this time. The pressure gauge is inserted downstream after the valve and the valve is opened. Note the pressure reading. Once the block is filled, the valve is switched to automatic. If the pressure reading drops, the screw on the pilot is turned slowly in a clockwise direction. If the pressure rises, the screw on the pilot is turned anticlockwise. The process is repeated by adjusting the pilot, checking the pressure again after a while, and adjusting the pilot again if necessary.

Once the hydraulic valves have been calibrated, the pressures in the lateral lines can be checked. Check the pressure at the end of each lateral, which should be close to the pressure that the valve is set at. Alternatively, each lateral can be assessed visually, and the pressure of the laterals measured that appears to have a different distribution pattern than the other lines.

Emitter delivery can also be checked to see if it corresponds with the irrigation plan. Place the emitter in a suitable container. After 15 or 30 minutes, remove the container and measure the volume of water. Multiply the volume of water by four for 15 minutes and two for 30 minutes to calculate the emitter delivery per hour. When this test is done with a representative sample for the whole block, it is called a CU (Coefficient of Uniformity) test. For further information, see section 3.1 in chapter 2.

After this test is done and the system has been operating for a couple of days, inspect joints for leaks. If no leaks are found, the trenches can be backfilled completely.

Chapter 1

- The foundation of a reliable irrigation system is converting soil, tree and rooting data into a good irrigation design plan.
- The first step in reading an irrigation design plan is to orientate the plan according to landmarks.
- Symbols are used on the irrigation design plan to indicate positions of pipes and other components of the irrigation system.
- Notations next to pipes indicate their size, class and length.
- A table on the irrigation design plan provides information on the individual irrigation blocks, including the size, tree spacing, emitter delivery and the application rate.
- A bill of quantities indicates the equipment that is required to install the irrigation system.
- Blocks are laid out by first marking out the corners of the blocks, then marking the rows, and lastly marking the position of each tree.
- The lengths of the blocks on the irrigation design plan are used in conjunction with the scale of the plan to determine the position of the corners of the blocks.

- A dumpy level is used to ensure that rows is straight, starting at the row closest to the mother line of the block.
- A measuring tape is used to determine the positions of trees in each row.
- Conveyance system trenches are dug for all pipelines, and the width and depth of the trenches depend on the size of the pipe.
- The manner in which irrigation equipment is installed depends on the type of equipment.
- Components of the irrigation system, such as pipes, are tested while being installed, and the entire system is tested once the installation has been completed.

Practical

Complete activities 1, 2 and 3 in the **Learner Workbook**.

Chapter 2

After completing this chapter, the learner will be able to:

Maintain and evaluate an irrigation system

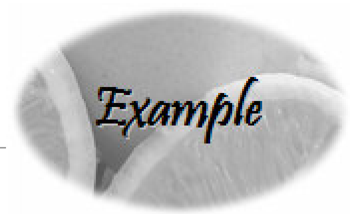
1. Introduction

Irrigation systems that have been installed correctly, and that are operated within the set parameters should never require major maintenance under normal circumstances, meaning circumstances that do not include for instance a flood or a fire.

A sound preventative maintenance plan ensures that minor problems do not turn into major problems, and constant evaluation and monitoring of the system ensures that the system operates within the required parameters, and that problems are picked up and dealt with when they occur.

2. Maintenance Planning

Below is an example of a fairly comprehensive maintenance plan, which also includes essential monitoring actions.



Irrigation Maintenance Plan

Frequency	***Item***	***Task and Action***
Daily	Block pressures	Check that block pressures are within prescribed limits.
	Emitter operation	Check for clogged, broken or misplaced emitters. Repair, replace, unclog or reposition emitters.
	Leaks	Check for leaks in pipes and other equipment and other water wastage, and repair if found.
	Primary filter	Flush primary filters as prescribed.
	Fertigation application	Check that fertigation applications are within specifications.
Weekly	Lateral lines	Flush lateral lines as prescribed.
	Secondary filters	Flush secondary filters as prescribed
	System pressure and flow	Check that system pressure and flow are as per irrigation design plan.
	Pump operation	Check that pump operation is within prescribed parameters.
	Block pressures for automated valves	Check that block pressures are as prescribed where automated valves are used.
	Pump oil levels	Check pump oil levels as prescribed.
	Fertigation plant	Inspect fertigation plant.

Monthly	Valves, water meters, and gauges	Visually check valves, water meters and gauges and look for damage and / or vandalism.
	Filters	Open and inspect filters as prescribed.
	Pump pipe work	Check for leaks at pump pipe work through which water is lost and for leaks through which the pump can suck air.
	Pump motor	Grease pump motor as prescribed.
	Coefficient of Uniformity (CU) tests	Perform CU tests
Annually	Valves	Service valves and physically check correct operation.
	Filters	Thoroughly clean filters. Replace sand in sand filters.
	Pump	Change oil in pump.
	Water sampling	Take a water sample at the end of lateral lines and send it for analysis.
2-10 years	Pump	Replace bearings and other wearing parts, such as bearings, on pump and motor every five years.
	Hydraulic valves	Replace diaphragms on hydraulic valves every three years.
	Poly-pipe and emitters	Replace poly-pipe and emitters every seven to ten years.

Citrus has a continuous irrigation cycle, and therefore has no pre- or post-season period as such. During the winter, the peak water demand is however lower, and this is the ideal time to perform maintenance and repair operations that require a system shutdown for a few days. It is with this in mind that a continuous preventative maintenance plan is implemented and carried out. A good maintenance plan focuses on daily, weekly, monthly and yearly actions.

Water quality is a very important factor in planning preventative maintenance. Water quality differs widely from farm to farm and it is essential to keep records of lateral flushing, filter flushing and water quality. This data is used to determine whether flushing should be done more often or whether water treatments are required.

In general terms, physical water quality is worse during the summer than in winter. In summer rainfall areas, the higher rainfall during the summer means that water sources carry more suspended solids, usually clay, silt and sand. Algae are also more prevailing during the warmer months, which increases the biomass that has to be filtered out of the water. However, the soluble salt content of the water, which is a chemical water quality factor, is usually lower during the rainy season.

Pump hours are also increased during summer, resulting in filters having a bigger filtering load. The higher pump hours also cause the levels of the water source to drop. Water quality usually suffers because of the lower water level, as pumps tend to suck more dirt and there is little time for the silt and sand to settle out of the water. When water quality is poor, filters must be flushed more often.

Note that the physical water quality, which relates to the suspended solids in the water, plays a role in how frequently filters are flushed and cleaned.

The above plan is merely an indication of the tasks that has to be performed. The objective should be to use this plan and decide how the intervals should be changed in each individual case. Use the following as a guideline:

- If the physical water quality is poor, increase the frequency of flushing and cleaning for laterals, mother lines, filters and filter rings.

- CU test can be performed less often in a well designed system.
- The frequency of the inspection for air leaks can be decreased on new suction pipe work.
- Replace bearings and wearings as soon as the pump can not deliver the original duty.
- Replace diaphragms when valves do not close properly.
- Replace poly-pipe when the pipes become brittle and burst easily.
- Replace emitters as soon as CU test show a deviation form the design specifications and the flow rate per block increase.

3. Evaluating the Functioning of Irrigation System

Evaluating the functioning of the irrigation system is important in that it ensures that the system operates within the set parameters, which protects the components of the system. It is furthermore essential for ensuring that the correct volume of water is delivered to the trees.

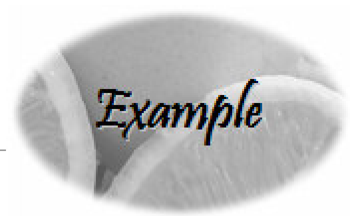
All the data required to monitor and evaluate the operation of the irrigation system is provided on the irrigation design plan, including the list of operations, a table with pressures and flows at valves and at nodes, and a table with the plant spacing and precipitation for each block.

3.1. Coefficient of Uniformity (CU) Tests

The coefficient of uniformity (CU) test is used to determine the variance in the performance of equipment, for instance the uniformity in delivery rate of the emitters across an irrigation block.

To perform a CU test on the delivery rate of emitters, select five evenly-spaced lateral lines in the block. Use for instance the 1st, 5th, 9th, 13th and 17th line in the block. Select five evenly-spaced emitters on each lateral line. Use for instance the emitter at the beginning of the line, an emitter about one quarter of the way along the line, one about half-way along the line, one about three-quarters of the way along, and the one on the end.

The delivery of each sample emitter is measured by allowing the emitter to drip or spray into a measuring tube for 5 minutes. The volume of water expelled by the emitter is noted on a data table. The delivery of each emitter in litres per hour is calculated from the data that has been gathered. The average delivery is calculated and the difference between the highest and the lowest emitter delivery is expressed as a percentage of the average. This tolerance level for the variance is 10%. If it is more than 10%, the block must be examined and the fault repaired.



CU Test Data Table

Emitter Delivery in l/5min					
Lateral	**Position on Lateral**				
	Beginning	***¼***	***½***	***¾***	***End***
1	3.30	3.30	3.16	3.16	3.16
5	3.30	3.30	3.30	3.25	3.30
9	3.40	3.30	3.30	3.30	3.30

13	3.30	3.25	3.25	3.25	3.16
17	3.30	3.30	3.30	3.25	3.25

Emitter Delivery in l/h					
Lateral	**Position on Lateral**				
	Beginning	***¼***	***½***	***¾***	***End***
1	39.6	39.6	37.9	37.9	37.9
5	39.6	39.6	39.6	39.0	39.6
9	40.8	39.6	39.6	39.6	39.6
13	39.6	39.0	39.0	39.0	37.9
17	39.6	39.6	39.6	39.0	39.0

The average emitter delivery is 39.48l/h. The emitter with the largest delivery is 40.8l/h and the emitter with lowest delivery is 37.9l/h. This is a deviation of 7.5% and, with the tolerance level being 10%, the system can be considered to be in order.

Note that the same procedure of the coefficient of uniformity (CU) test can be used to determine the uniformity of the pressure at the emitters.

3.2. Evaluation Irrigation System Performance

The irrigation system is evaluated as follows:

- Open the blocks as per the list of operations
- Check and correct, if necessary, the block pressures
- Note the pump operating parameters
- Note the pressures at nodes
- Perform a CU test
- Repeat the procedure for all the operations
- Evaluate the data

The following is indicative of the system flow being higher than specified:

- **Pump:** Amp reading is higher than expected
- **Pump:** Pressure reading is the same or lower than expected
- **Pump:** Flow meter reading higher than expected
- **Pressure at Nodes:** Lower than expected
- **Pressure at Blocks:** Lower than expected
- **CU Test:** CU might be good, but the flow per emitter can be higher

The most probable cause is worn nozzles on the emitters, especially if the water has a high silt and sand content. The system pressure is lower due to the higher flow in each block. The pump is trying to compensate by pumping more, which is why the amp reading will be higher. The CU should be acceptable, since wear will occur on all the nozzles.

The following is indicative of the system flow being lower than specified:

- **Pump:** Amp reading is lower or higher than expected
- **Pump:** Pressure reading is higher or lower than expected
- **Pump:** Flow meter reading is lower than expected
- **Pressure at Nodes:** Higher or lower than expected
- **Pressure at Blocks:** Lower or higher than expected
- **CU Test:** Poor CU with low emitter delivery

Lower flow can be caused by a worn pump or by blockages. When the pump is worn, the symptoms will be low pressure and flow but a high amp meter reading. In this case, the pump must be serviced and repaired, or replaced. Blockage can occur at various places with differing symptoms. The pressure reading before the blockage will be abnormally high, but pressure readings after the blockage will be very low. Amp meter readings will also be lower. Consider the following examples:

- **Blocked Impeller:** Low pressure reading at pump and in the rest of the system
- **Blocked Filter:** High pressure at pump, but low pressure after filter bank
- **Blocked Pipeline:** High pressure up to the filter and some nodes, but at other nodes the pressure is low

Chapter 2

- A preventative maintenance plan ensures that minor problems do not turn into major problems.
- Constant evaluation and monitoring of the system ensures that the system operates within the required parameters and that problems are picked up and dealt with when they occur.
- In citrus production irrigation is used all year round, but during the winter the water requirement is lower and therefore major maintenance is done during the winter.
- Physical water quality impacts on the frequency with which certain maintenance actions will be performed.
- A maintenance plan include actions that has to be performed on a daily, weekly, monthly, annual and two- to ten-yearly basis.
- The coefficient of uniformity (CU) test is used to determine the variance in the performance of equipment.
- The irrigation system is evaluated by opening the blocks as per the list of operations, checking and correcting, if necessary, the block pressures, noting the pump operating parameters and the pressures at nodes, performing a CU test, repeating the procedure for all the operations, and evaluating the data.

Complete activities 4 and 5 in the **Learner Workbook**.

Chapter 3

After completing this chapter, the learner will be able to:

Efficiently operate an irrigation system

1. Irrigation Scheduling

In this section, we will look at how the irrigation schedule can help you to manage and operate the irrigation system more efficiently.

The aim of scheduling is to maintain the soil water balance at the optimum levels, being for micro-jets to fluctuate between FWC and -50kPa and for drippers to be constant at a soil water potential in the order of -15kPa to -25kPa. In other words, the soil must not be too wet, in which case anaerobic conditions and water logging will inhibit plant performance, or too dry, in which case the plants will suffer from water stress. The correct stand time and irrigation frequency, or cycle, must be determined and maintained.

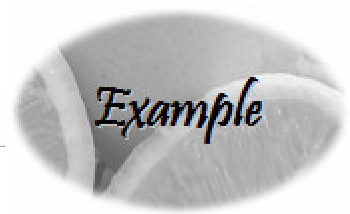
An irrigation operations schedule consists of:

- The ***table of operations*** lists the different operations and the blocks involved in each operation.
- The ***irrigation schedule*** lists the date and stand time for each operation. The longer the stand time the more water is applied, which would apply during hot periods.
- ***List of pressures and flows***, which is used to set the pressure for each block.

For the irrigation system to operate effectively, these three components must all be managed properly.

2. Monitoring the Irrigation Schedule

Various aids are available to monitor the implementation of the irrigation schedule. These aids include E-pans, rain meters, tensiometers, and probes. This equipment provides information that assist with the calculation of the soil-water balance, thereby enabling one to determine the effectiveness of the irrigation.



Irrigation Scheduling

Farmer Brown has a citrus farm. The micro-jet irrigation system has an application rate of 2mm/h. With the current schedule, each block is irrigated for 4 hours every second day. There is no irrigation on day 7. This means that farmer Brown applies 8mm of water during every operation, irrigating a total of 24mm a week.

According to the E-pan, the average evaporation (E_o) is 3.4 mm/day, being 23.8 mm/week. The irrigation intervals are therefore adequate for the moment. He would also observe an adequate water balance according to the readings from the tensiometers and the probes. These instruments will show that the soil-water balance is kept between FWC and -50kPa or the refill point.

Should the climate become warmer, the daily E_o will rise. The probe and the tensiometer readings will also start to indicate the soil-water balance is nearing -50kPa or the refill point quicker. The intervals must now be decreased until the tensiometer and probe readings show the soil-water balance to be in the correct range. The same principle would also apply for cooler seasons, when the scheduling equipment would indicate a lower evapotranspiration and the intervals will have to be increased accordingly.

3. Determining the Effectiveness of Irrigation

The effectiveness of irrigation can be assessed by means of a holistic approach that considers factors such as:

- The Coefficient of Uniformity (CU) test
- Scheduling equipment data
- Visual inspection of profile pits
- Tree health
- Crop yield data

Not one of the factors to determine the irrigation effectiveness should be viewed in isolation. For instance, if the CU and profile pits show a high effectiveness, but the yield is low, other factors influencing yield must be investigated. On the other hand, if tree health is poor in certain areas and the profile pits data vary greatly, the cause of poor irrigation effectiveness must be investigated.

3.1. The Coefficient of Uniformity

In the previous chapter, we discussed CU tests and how it can be used to determine the effectiveness of the irrigation system and the performance of irrigation equipment. For this reason, we focussed on the deviation in delivery between emitters that the test indicates. The CU test however also indicates the delivery rate of the emitters, which is critical in determining the exact volume of water that is delivered to the trees and whether there is a uniformity of delivery.

3.2. Scheduling Equipment Data

Data obtained from scheduling equipment, especially equipment such as probes and tensiometers, also indicates the volume of water being put down in the soil as well as the depth of the wetted profile. This data can be compared to the actual water meter readings for the specific block. In this manner, the effectiveness can be determined as it indicates losses due to evaporation and misting during irrigation.

3.3. Profile Pits

Digging and inspection of profile pits helps to determine irrigation effectiveness. Although no readings can be taken, it offers the opportunity to determine the depth and width of the wetted profile as well as in situ inspection of root growth and health. Good root growth and health indicate that the profile is wetted correctly and consistently, while bad root health can be attributed to poor irrigation (under- or over-irrigation).

Profile pits are also useful to determine if water logging occurs, especially at subsoil-levels. Profile pits evaluate the effectiveness of the stand time and irrigation cycle. Too long stand times generally causes water logging and wetting the profiles below the root-zone. Short stand times will show as shallow wetting of the upper crust.

Too long cycles are more difficult to detect, but can manifest as a dryer profile with deep roots and dry subsoil. Too short cycles will result in either a too wet profile or salt accumulation due to lack of leaching. Evaporative losses will also be higher.

3.4. Tree Health

General tree health is a subjective method of determining irrigation effectiveness. Although some skill is required in assessing tree health and the general condition of the trees, it is none the less a method where the whole orchard can be assed for over- or under-irrigation. It must however be kept in mind that three health is influenced by a wide range of production factors and that trees usually show only symptoms of over-irrigation when the problem is in an advanced stage and difficult to correct.

It is also possible to identify problem areas in a specific orchard by assessing variances in tree health. Symptoms such as wilting, colouring and turning of the leaves can be indicative of poor irrigation practices.

3.5. Crop Yield Data

Yield data can indicate if irrigation effectiveness is poor or good, but is also influenced by a wide range of production factors making it difficult to isolate the effect of irrigation. Yield is influenced by other factors such as fertilising, pruning and pest control, but can also be indicative of irrigation effectiveness over a longer period of time. Too small fruit is often an indication of poor irrigation management, provided that plant nutrition is ruled out as a cause.

Chapter 3

- Irrigation scheduling should ensure that the soil-water balance is maintained at optimum levels, being between FWC (or full point) and -50kPa (or refill point) for micro-jets and a constant water potential for drippers.
- An irrigation operations schedule consists of a table of operations, the irrigation schedule and a list of pressures and flows.
- Various types of equipment are used to monitor the effectiveness of the irrigation schedule by monitoring the soil-water balance.
- The effectiveness of irrigation is assessed by taking a holistic approach and taking into account CU tests, scheduling equipment data, visual inspection of profile pits, tree health and crop yield.
- The CU test indicates the uniformity of the irrigation system and measures the actual delivery and pressure at the emitters.
- Scheduling equipment data indicates the soil water balance.
- Profile pits are used to visually assess the water balance throughout the profile, especially in the subsoil-levels.
- Tree health and crop yield data is subjective methods to measure the effectiveness of irrigation, as it can be influenced by many other production factors.

Complete activities 6, 7 and 8 in the **Learner Workbook**.

Chapter 4

After completing this chapter, the learner will be able to:

Collate data pertaining to the long-term efficient management of an irrigation system

1. Irrigation Data Records

Collecting and recording data is extremely important, because it helps to establish a history of events thereby assisting with the management of the irrigation. There is a saying that says that there is no management without measurement. It is equally important to record measurements.

The soil-water content is measured to determine if the stand time is adequate. By recording the soil water content over a period of time, the soil characteristics can be determined and the irrigation schedule can be fine tuned.

Here is a list of possible records:

- ***Daily records*** are the records of block pressures, flow-rates, amp meter readings, hour meter readings, start-up and shut-down inspections and readings, fertiliser levels, readings linked to fertigation like pH and EC, and system performance checks such as CU tests. Records like these are contained in a logbook for the irrigation system. The recorded data is useful to identify trends, for instance, water use per week and an increase in flushing cycles, which can help to make decisions proactively.

- ***Weather station and scheduling equipment data*** is recorded to assist with irrigation scheduling. It is essential that these records at the very least are kept on every farm.

- ***Yield data*** is used to determine if the irrigation was effective or not during the season.

- ***Labour records*** include labour used for irrigation, clock-in and -out times, job descriptions, and records of work done by each worker. The recording of this data helps to effectively manage workers, because the man-hours spent on a task can be determined.

Most data is initially captured by hand, for which a logbook, or a form that has been designed for that specific purpose, is used. Other data is captured electronically, such as from weather stations and probes, and must be downloaded onto a computer.

Below are some forms as examples. When adapting the examples for use on a farm, keep the following in mind:

- One sheet can be used to record all the labour working in your section. The description of the day's work can be more abbreviated or in more detail.

- The daily record must preferably include the daily checks. This will vary between farms. Again the record can be more detailed or more abbreviated.

- The fields in the weather and scheduling equipment record depend on the equipment on the farm. Obviously you can only record readings from the equipment that you have.

- The irrigation manager or supervisor would prescribe the fields required in the various records.

Example

Labour Record

Labour Record			
Name:		John	
Job Description:		Irrigate blocks – Section 1	
Date	***Clock-In Time***	***Clock-Out Time***	***Description***
1	07h00	17h00	Irrigate operation 1
2	07h00	17h00	Irrigate operation 2
3	07h00	17h00	Irrigate operation 1
4	07h00	17h00	Irrigate operation 2
5	07h00	17h00	Irrigate operation 1
6	07h00	17h00	Irrigate operation 2

Daily Report

Daily Report		
Date:	07/08/2005	
Block	***Pressure***	***Comments***
1.1	2	
1.2	1.9	
1.3	1.9	
1.4	2.1	
1.5	2	
1.6	2	
1.8	1.8	
Readings		
Water Meter	15,008	
Amp Meter	120	
Volt Meter	400	
Pump Pressure	7	
EC	1.2	
pH	6.5	
Action		
Pre start-up Inspection	Y	

Start-up Inspection	Y	
Shut-down Inspection	Y	
Filter Flushing	5	

Weekly Activities

Weekly Activities		
Date:	09/08/2005	***Comments***
Weekly Inspection	Y	
Filter Flushing	Y	
Completed By:	John	

Weather Data

Weather Report	
Date	07/12/2005
E-pan	5
Rain	0
RH	60
Max Temp	34
Min Temp	17
Block	***Tensiometer***
1.1	-30
1.2	-20
1.3	-22
1.4	-24
1.5	-28
1.6	-40
2.1	-30
2.2	-25
2.3	-28
2.4	-30
2.5	-10
2.6	-12
2.7	-15
2.8	-18

2. Recording Data in Electronic Format

Once data has been recorded on paper, it is captured in electronic format. With the advancement in computer technology, computers have become cheaper and more powerful, with the added benefit that data can be transferred electronically to anywhere in the world through the internet. Computers also help to convert data to useful information.

Data is captured in either a database or in spreadsheets. The use of a database has advantages because they can store masses of data and are very powerful in converting data into information. Operating databases however requires skilled personnel and they are used mostly by large farms and estates. The use of spreadsheets finds a wider application as they are easy to use, more assessable, and adequate for most tasks.

In the simplest form, the hand-written document is simply recorded on an identical spreadsheet with the same fields as the paper format. Alternatively, the spreadsheet can be altered to sort and filter some of the data. Once the data is keyed into the spreadsheet it can be linked to other spreadsheets that sort and filter the data, thereby converting it into information, including the calculation of averages, averages over time, and so on.

The data from equipment with electronic loggers, such as probes and automated systems, is downloaded from the logger to a computer. Usually, an interface and program is supplied to download the data to the computer. This program has an option that converts the data to formats that are commonly used.

Software and hardware are improved continuously, and new versions of software are released from time to time. As older programs are replaced by new programs, it is necessary to save the data in a format that is supported by the new program. New hardware also becomes available from time to time and it is wise to save data on newer storage media.

3. Evaluating Data

Even the most sophisticated equipment is not fail safe. Electronically collected data is sensitive to instrument drift and even failure. Instruments must be recalibrated from time to time and reasonability checks done on the data to verify the accuracy and precision. The principle is the same as a clock that needs to be corrected when it loses time. We will however only discover that it is losing time when we compare it to another clock.

In the simplest form, reasonability checks can be done by taking readings in set conditions. This applies especially to EC and pH meters where readings can be taken with the use of standard (for EC) or buffer (for pH) solutions. If the value is different from the test value for a standard or buffer solution, the instrument must be recalibrated or serviced. It is recommended that one refers to the owners manuals of such equipment.

Some probes can also be tested in the same manner. It is however best to correlate data with other scheduling equipment, if available, or even the general condition of the trees and observations from profile pits. Even if different types of scheduling equipment are used, they should all point to the same tendencies. If one set of data contradicts another set or sets of data, this set must be retaken and verified.

The importance of checking and verifying data cannot be overstated. It is always better to rather believe the tree conditions than a set of data. It would make no sense at all to stop irrigating when a probe for instance shows that the soil water content is sufficient, but the trees shows signs of wilting.

4. Preparation of Reports

Reports are developed from records, and in some cases, such as daily records, the records itself is sufficient for reporting purpose. In some cases, it is however necessary to develop reports based on recorded data. A report is a summary of the relevant information, reflecting the information that is relevant to the issue under review. In the example below, a weekly report has been prepared based on daily reports.

Example

Weekly Reports

Date and Day	*Daily Report*	*Comment on Daily Checks*
Monday	All workers present, workers irrigated and did CU test on blocks in operation 1 and 2, results within limits	All checks OK Water level at pump suction reaching minimal level.
Tuesday	All workers present, continue to perform CU test on rest of operations (3 and 4). Shifted pump suction down into water.	All checks OK ETC more.
Wednesday	All workers present, repaired leak on sub-mainline. Schedule affected, pump operation extended	All checks OK ETC rising
Thursday	All workers present. Took reading with the probe, data downloaded.	All checks OK ETC rising
Friday	All workers present, probe readings processed, increased stand time from 3 hours to 3½ hours. Clean filter elements.	All checks OK ETC constant
Saturday	Team A present (weekend off for team B), irrigated	All OK

When preparing a report keep the following in mind:

- Keep the report short and to the point, but not too abbreviated.
- Report mainly on deviations from acceptable standards or norms. It is senseless to report that the pump was pumping the correct volume. The manager is only interested in when the pump is not performing to specs.
- Give all the details that management requires.
- Write the report in neat hand-writing or type it out.

Summary

Chapter 4

- Data collection and recording is essential for proper management.
- Records that are kept for irrigation management include daily records, weather station and scheduling equipment data, yield data and labour records.
- Data is mostly first recorded by hand and then transferred to a computerised recordkeeping system.
- Databases or spreadsheets are used to collect data and convert it into information.
- Data must be evaluated as equipment can be incorrect or measurements can be taken incorrectly.

- The best way to evaluated data is through reasonability tests.
- Reports are developed for specific purposes from data that has been collected.

Complete activities 9 and 10 in the **Learner Workbook**.

Bibliography

Irrigation Operation Manual, F.H. Koegelenbergh, 2003, ARC Institute for Agricultural Engineering, ARC-ILI

Irrigation Design Manual, J.H. Burger et al, 2003, ARC Institute for Agricultural Engineering, ARC- ILI