# LEARNER GUIDE

# Irrigation

## Level 3



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|---|---|---|---|---|---|---|---|
| **Title:** | | **Monitor the Operation and Maintenance of Irrigation Systems** | | | | | |
| **Applied Title:** | | **Monitor the Operation and Maintenance of Irrigation Systems in Citrus Orchards** | | | | | |
| **Field:** | | Agriculture and Nature Conservation | | | | | |
| **Sub-Field:** | | Primary Agriculture | | | | | |
| **SETA (SGB):** | | AgriSETA | | | | | |
| **Skills Area:** | | Irrigation | | | | | |
| **Context:** | | Citrus Production | | | | | |
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**Unit standard alignment and assessment tool development:**
Cabeton Training and Development

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# Table of Contents

# Directions

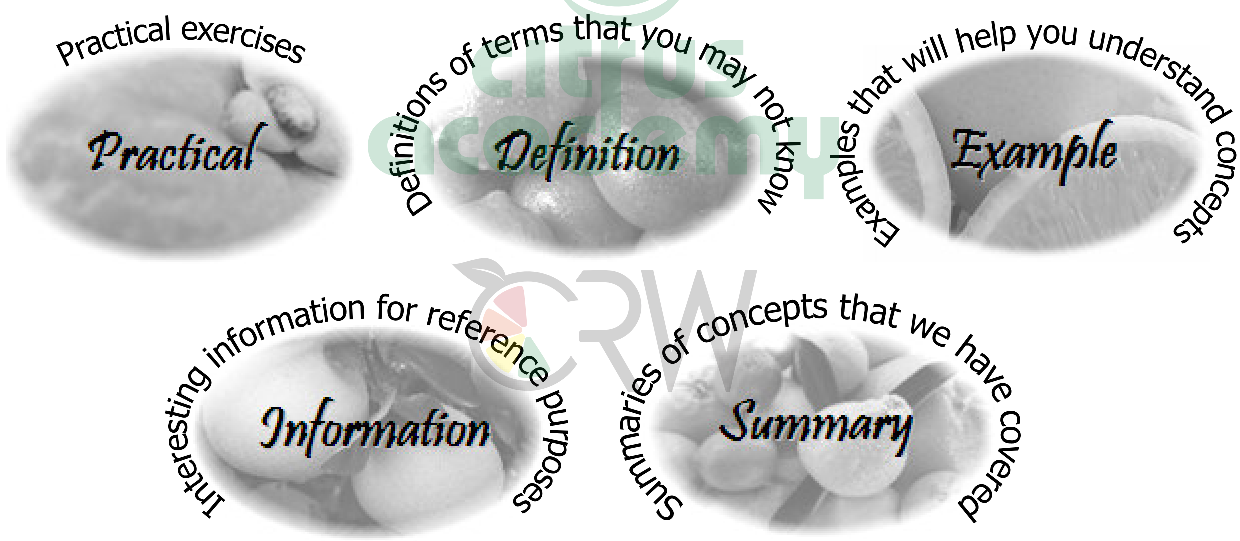
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

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, under superficial supervision, be able to irrigate a variety of crops and efficiently operate and maintain a variety of different irrigation systems.

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*** |
|---|---|---|
| NQF2 | Literacy and Numeracy | |
| 2 | 116066 | Operate and maintain specific irrigation systems |
| 3 | 116275 | Apply routine maintenance and servicing plans and procedures |

# Revision of Level 2

## 1. Pre-Start-Up Inspection

- An irrigation system consists of a pump system, filters, pipes, valves, lateral lines and emitters.
- Pump systems pump water from the water source into the pipes that lead to the orchards.
- Water passes through filters before passing into the pipes. The filters clean the water from suspended solids.
- Water is pumped through pipes to the orchards. There are various types of pipes, including mainlines, sub-mainlines, mother lines and lateral lines.
- Valves can open and close, thereby cutting water off or letting it through. Valves are also used to control the water pressure.
- Emitters deliver water to individual trees. Micro-jets and drippers are commonly used.
- During the pre-start-up inspection, the water level must be checked, and the pump, filters and valves must be checked and cleaned.
- The water level in the water source must be such that the pump will not run dry, as this can lead to cavitation.
- The pump must be checked for leaks, vandalism, loose bolts, etc., cleaned and oiled or greased (if necessary) before being started.
- Filters must be checked for leaks and other damage. Filters must also be cleaned through back-flushing if necessary.
- Valves must be checked to ensure that they open and close properly and that they are not leaking.
- A pre-start-up inspection checklist is completed before the pump is started.
- A pump must be primed before being started, meaning that it must be filled with water so that all air is expelled.

## 2. Start-Up and Shutdown Procedures

- Following proper start-up and shut-down procedures will ensure that the pump will work well and prolong its lifespan.
- Readings are taken from the amp meter, volt meter, pressure gauge and flow meter after the pump system has been started to ensure that it is working properly.
- If the amp reading is higher than expected, it is referred to as an overload situation, and if the amp reading is lower than expected, it is referred to as under-load.
- Pressure control valves are hydraulic valves that control water flow from the pump.
- Gate valves are opened and closed by turning the wheel clockwise or anticlockwise.
- Butterfly valves are opened and closed by turning the handle to be in line with or perpendicular to the pipe.

- In-field valves must be regulated to the correct water pressure, in accordance with the irrigation system design.
- Water pressure is measured on in-field valves by using either a hydromatic or pressure point.
- A pressure gauge is fitted in a pipette that is inserted into a hydromatic to measure pressure.
- A pressure gauge fitted with a special needle is inserted into a pressure point to measure pressure.
- Valves are opened or closed until the correct pressure is measured through the hydromatic or pressure point.
- Pressure is measured at inline filters using the same methods as is used for valves.
- The difference between the pressure reading taken before and after inline filters should not be more than 0.5bar. If it is more, the filter must be cleaned through back-flushing.

## 3. Irrigating Crop

- While a block is being irrigated the factors that must be monitored through a visual inspection are leaks, runoff, pressure, and delivery rate.
- The irrigation schedule determines how much water to apply and when to apply the water. The operating schedule prescribes when to open and close the irrigation to different blocks.
- The operational parameters are the parameters within which the irrigation system functions effectively.
- Operational parameters must be monitored, noted and reported on whenever the irrigation system is in operation.

## 4. Maintaining Equipment and Tools

- Filters must be back-flushed on a regular basis to clean them from accumulated debris.
- Depending on the water quality, inline filters must be opened and cleaned on a weekly to monthly basis.
- The pipeline must be monitored for leaks constantly and any leaks must be repaired as soon as they are detected.
- Mother-lines and lateral lines must be flushed on a regular basis.
- Hand tools must be cleaned and dried properly, and stored in a safe, secure place.
- Pressure gauges must be protected from shocks and protected from high temperatures.
- Grease guns and oil cans must be kept clean and free of sand and grit.
- All tools and equipment must be monitored for possible damage, which must be reported to the manager or supervisor immediately.

Definition

| |
|---|
| **Cavitation**<br><br>Cavitation is caused when there are air bubbles in the water. When air bubbles hit the impeller, the section of the pump that rotates and moves the water, they implode on the impeller and break the parts of the impeller. |
| **Water Hammer**<br><br>Water hammer occurs when if a pump is stopped abruptly, and the column of pumped water stops and flows backwards towards the pump because of the pressure inside the pipe line. |

# Chapter 1

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

**Modify and implement irrigation schedules for various crops**

## 1. Introduction

Irrigation scheduling refers to the timetables that are put in place for the irrigation of various orchards and blocks.

Most irrigation systems are designed in such a way that all orchards cannot be irrigated at the same time, because this will overtax the pump system and result in very low water-pressure in the system. The pump system also uses electricity while it is running and it is necessary to keep these costs as low as possible.

Citrus trees do not need to be irrigated all the time, as long as enough water is stored in the root-zone. The amount of water required by the tree depends on such factors as the climate, the season, the prevailing weather conditions, tree size, and tree condition.

Note that some specialised systems, such as open hydroponics systems, are able to irrigate all the blocks at the same time, in which case the irrigation design and pump selection is carefully matched.

Irrigation scheduling is about firstly ensuring that all trees receive the correct volume of water at the correct intervals, and secondly that the irrigation system is not overtaxed, does not use more than the necessary amount of electricity, and operates at optimum efficiency.

Always remember that the needs of the trees is the most important consideration - on a citrus farm, the tree is king. If proper scheduling means over-taxing the irrigation system, the system was not designed properly and should be redesigned. The tree should not adapt to the system, because this will have a negative impact on yield and therefore on profit.

## 2. Scheduling Requirements


**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.

The most appropriate and practical irrigation schedules are based on an irrigation cycle with a set standing time and variable intervals.

Because of changes in the weather, plants extract different volumes of water from the soil every day. Instruments, such as probes, tensiometers and evaporation pans, are used to determine the rate and volumes of water extracted. Data from these instruments are used to determine the soil-water balance. This is discussed in greater detail in chapter 2.

The soil-water balance is recorded in a logbook that keeps track of how many millimetres of water is extracted by the plant and lost to evaporation, and how many millimetres of water is replenished by irrigation and by rain. To understand the soil-water balance, certain properties of soil must be explained, and certain terms need to be defined.

Soil can be compared to a sponge. When you pour water onto a dry sponge, the sponge soaks up water until it is saturated. After it has been saturated, excess water will start draining from the bottom of the sponge. If no more water is poured onto the sponge, excess water will stop flowing from the bottom of the sponge after some time. At this point, no more free water is present in the sponge. If you want to get any more water out of the sponge, you have to extract it by for instance squeezing it.

The same principle applies to soil. Just like a sponge, dry soil absorbs water up to the point of saturation where no more can be accommodated. All extra water from this point upwards will drain down into the sub-soil. Once all the free water that cannot be accommodated has drained from the soil, a point is reached that is called **Field Water Capacity** (FWC). FWC is measured in millimetre (mm) of water per metre (m) of soil or as the water potential in kilo Pascal (kPa).

Note that field water capacity is not the same as saturation. When soil – or a sponge – is saturated with water, all the pores are filled with water. At field water capacity, some pores are still filled with air.

Definition

**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 ($m^2$)

Note that FWC, PWP, PAW can be expressed in mm/m, meaning millimetres of water per meter of depth of soil, or as the water potential in kPa.

Example

**Calculating Precipitation**

If 60 cubic meters ($m^3$) of water is applied to a 1 hectare (ha) area, the precipitation is calculated as follows (1ha = 10,000$m^2$):

P = V / A
P = 60$m^3$ / 10,000$m^2$
P = 0.006m
P = 6mm

The water content of the soil has increased by 6mm/m after the application of the water.

We can also see that: One mm per $m^2$ = 1 litre water, or one mm per ha = 10 $m^3$ water

Although the soil could be 1m deep or even deeper, only the water in the root zone, or at effective root depth, can be utilised by the plant.

Definition

**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.

If the plant requires more water than the easily available water, it has to use energy to extract the water. The tree will not immediately show visual symptoms of water stress, but production will already be compromised. Stress symptoms will only be visible once more water is extracted and not replenished. Stress symptoms appear as wilting of flowers and / or leaves.

Should the water-balance be restored, the plant will no longer be under stress and will recover. Note however that if water stress occurs during critical development periods, such as flowering or fruit set or cell division, it will have a negative affect on yield and fruit quality.

Effective irrigation scheduling ensures that the soil-water balance is corrected before the EAW is extracted. In chapter 2, more will be said about scheduling equipment and their role in the development of the irrigation schedule. For the purpose of this chapter, a set cycle and standing time will be used to explain the concept of irrigating with a schedule.

## 3. Implementing an Irrigation Schedule

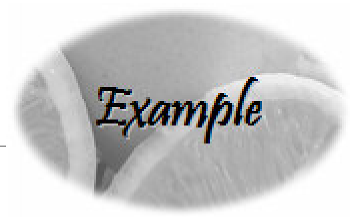
Most farms are divided into orchards. Orchards are in most cases again divided into irrigation blocks, each with it's own in-field valve. Irrigation can therefore be done for a block at a time.

To ensure that every orchard and block is irrigated sufficiently, a set schedule is implemented. In essence a schedule consists of three parts, namely:

- Operations table
- Pressure table
- Irrigation schedule

### 3.1. Operations Table

In the operations table, blocks are allocated to groups, referred to as operations. The operations table for the farm is compiled by the irrigation designer or irrigation manager and is based on the irrigation design and plan. Once the operations table is set, it does not change.




**Operations Table**

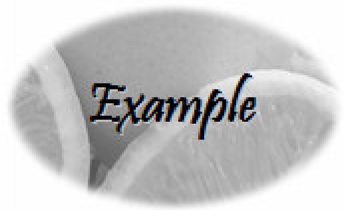
| Operation | Block | Block | Block | Block | Block | Block |
|---|---|---|---|---|---|---|
| 1 | 1.1 | 2.3 | 3.2 | 4.4 | 5.1 | 6.2 |
| 2 | 1.2 | 2.1 | 3.4 | 4.3 | 5.2 | 6.1 |
| 3 | 1.4 | 2.4 | 3.1 | 4.1 | 5.3 | 6.4 |
| 4 | 1.3 | 2.2 | 3.3 | 4.2 | 5.4 | 6.3 |

The blocks that must be irrigated at the same time are listed against the respective operations in the table above. This means that under operation 1, blocks 1.1, 2.3, 3.2, 4.4, 5.1, 6.2 will be irrigated, meaning that the infield valves for those blocks will be opened at the same time.

Blocks that share properties that influence their irrigation requirements are often grouped together in the operations table. For instance, low lying blocks, that are easily over-irrigated, are grouped together, as is blocks that have similar soil properties.

### 3.2. Pressure Table

The pressure table list the working pressure for each block. Where hydraulic valves are fitted, the values in the table are compared to the infield pressure. Where manual valves are used, the values in the table are used to set the infield pressure.

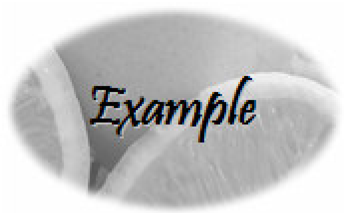



**Pressure Table**

| Block | Pressure | Block | Pressure | Block | Pressure | Block | Pressure |
|---|---|---|---|---|---|---|---|
| 1.1 | 2.0 | 1.2 | 2.2 | 1.3 | 2.2 | 1.4 | 2.0 |
| 2.1 | 2.0 | 2.2 | 2.0 | 2.3 | 2.2 | 2.4 | 2.0 |
| 3.1 | 2.2 | 3.2 | 2.0 | 3.3 | 2.0 | 3.4 | 2.0 |
| 4.1 | 2.0 | 4.2 | 2.2 | 4.3 | 2.0 | 4.4 | 2.2 |
| 5.1 | 2.2 | 5.2 | 2.0 | 5.3 | 2.2 | 5.4 | 2.0 |
| 6.1 | 2.0 | 6.2 | 2.0 | 6.3 | 2.2 | 6.4 | 2.2 |

## 3.3. Irrigation Schedule

The irrigation schedule dictates the day and time at which the different operations must be started and stopped.




**Irrigation Schedule**

| Day | Operation 07h00 – 11h00 | Operation 11h00 – 14h00 |
|---|---|---|
| 1 | 1 | 2 |
| 2 | 3 | 4 |
| 3 | 1 | 2 |
| 4 | 3 | 4 |
| 5 | 1 | 2 |
| 6 | 3 | 4 |
| 7 | - | - |

Note that this is a simple example of an irrigation schedule. Schedules for orchards with a variety of tree ages and cultivars will for instance require irrigation at various times during the day.

Where, in the example above, it says day 1, operation 1 from 07h00 to 11h00, it means that the valves for the blocks under operation 1 in the operations table must be opened on day 1 at 07h00 and closed at 11h00.

In practice, the following procedure will be followed using this example irrigation schedule:

- Start opening the valves for the blocks in operation 1 at 07h00.
- Once all the valves are open, go back and start regulating or checking the pressure as listed in the pressure table.

- At 11h00, start closing the valves for operation 1 in the order that they were opened.
- Start opening the valves for operation 2.
- Once all the valves of operation 1 are closed and the valves of operation 2 are open, go back and start regulating or checking the pressure for the blocks in operation 2 as listed in the pressure table.
- Start closing the valves for operation 2 at 14h00.

## 4. Adapting Irrigation Schedules to Ambient Weather Conditions

The implementation of an irrigation schedule must take into account the ambient weather conditions. On most farms, the standing time per operation is set, and is equal to the volume of water required to refill the soil water reservoir.

To compensate for seasonal changes, the intervals between two applications will be adapted. Where micro-jets are used, the intervals will change for instance from 8 days in winter to 3 days in summer. Where drippers are used, the standing time is also fixed and the number of applications might need to be changed from once every second day in winter to three times per day in summer in order to supply the required volume of water.

When it rains, for instance, it does not make sense to irrigate as much as otherwise and the irrigation schedule implementation has to be adapted. The irrigation manager decides on the minimum rain that will cause a change in irrigation, for instance 10mm. In this case, once it has rained 10mm irrigation will cease until further notice. The irrigation manager will adjust the irrigation schedule in the period after it rained depending on the amount of rain received. Note however that with drippers it could be required to irrigate in order to fertigate, even when it rains. In chapter 3, more is said about the actions taken in the event of rain.

During a heat-wave or dry wind spell evaporation increases, and it may be necessary for the irrigation to be increased, always keeping in mind that the soil reservoir for water is only so big, and too much water will simply drain beyond the ERD. Irrigation can be increased before such an occurrence to ensure that the deeper lying roots will have enough water to support the top roots. It is therefore essential to pay attention to weather forecasts from the Weather Bureau. Dry winds are mostly seasonal, and the irrigation schedule will make provision for increasing the water balance in the soil during this season.

In the next two chapters, the scheduling for these conditions is discussed in greater detail.

## 5. Improving the Irrigation Schedule

The person responsible for implementing an irrigation schedule is in an ideal position to observe the effectiveness of irrigation and to identify problems that can be resolved with improved scheduling. Mostly scheduling problems will result in either under- or over-irrigation, leading to water-logging or water-stress.

Problems that are observed during implementation must therefore be reported to and discussed with the irrigation manager immediately so that changes to the schedule can be made before lasting damage is done to the trees. In table 1.1 possible problems are listed with their causes and suggested solutions.

| ***Observation*** | ***Possible Cause*** | ***Suggested Solution*** |
|---|---|---|
| Mainline pressure is sometimes too low | Too many blocks in operation | Decrease number of blocks in operation |
| Pump continues tripping (mechanical fault is ruled out) | Overload, too many blocks in operation | Decrease number of blocks in operation |

| *Observation* | *Possible Cause* | *Suggested Solution* |
|---|---|---|
| Water standing in low-lying blocks | Over-irrigation in low-lying areas due to high mainline pressure or drainage of mainline to these areas after pump is switched off | Change prescribed infield pressure for low-lying blocks. Shorten standing time for low lying areas |
| Water standing in other blocks | Over-irrigation due to too high application rate or too low infiltration rate. | Correct application rate but if problem persists, take steps to improve infiltration rate. |
| Trees in high-lying areas shows signs of water-stress | Under-irrigation in high-lying areas due to lower mainline pressure and taking a longer time for mainline to fill | Consult the designer to split the irrigation blocks so that low and high lying areas are irrigated separately. |
| Water-stress symptoms in other blocks | Under-irrigation in ambient weather conditions | Adapt implementation of irrigation schedule to weather conditions |
| | Soil is rocky or sandy (more prevalent in high-lying areas) | Use shorter standing time and quicker cycles |

**Table 1.1: Possible Problems during and due to Irrigation**

Scheduling equipment log data as changes to the irrigation schedule are implemented and record the history of the water-balance of the soil. This data is used in conjunction with physical observations to make changes to the irrigation schedule. In the next chapter, the use of scheduling equipment is discussed further.


**Chapter 1**

- 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.

Practical

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

# Chapter 2

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

**Collect and record data in an agricultural field**

## 1. Scheduling Equipment

A variety of equipment is used to assist with irrigation scheduling. The most common is:

- Evaporation pans
- Rain gauges
- Tensiometers
- Probes

### 1.1. Evaporation Pan

Transpiration is a physiological process of all trees and plants as they grow.


**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.

The rate of transpiration is determined by climatic factors such as temperature, wind and humidity, and soil water status, and physiological factors such as growth stage and leaf area. The ratio between evaporation and transpiration is called crop factors. Crop factors are discussed in a later section of this chapter.

Climatic factors can be recorded by using an evaporation pan (E-pan). The E-pan contains a body of water that is not shielded from sun, wind and rain. The pan has a calibrated scale inside that is used to read the daily evaporation. Although there are other types of pans available in South Africa, the Class A E-pan is recommended by the Weather Bureau for use.

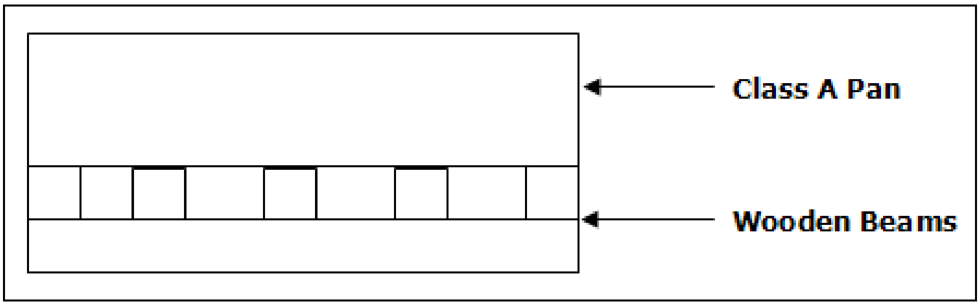



**Figure 2.1: Class A Pan**

### 1.2. Rain Gauge

The rain gauge is used to measure the volume of rain in millimetres (mm). This measurement is used to express the volume of water per area. Rainfall is recorded on a regular basis, usually for 24 hour periods, and the rain gauge is emptied. Historical rainfall records are kept to determine local trends.

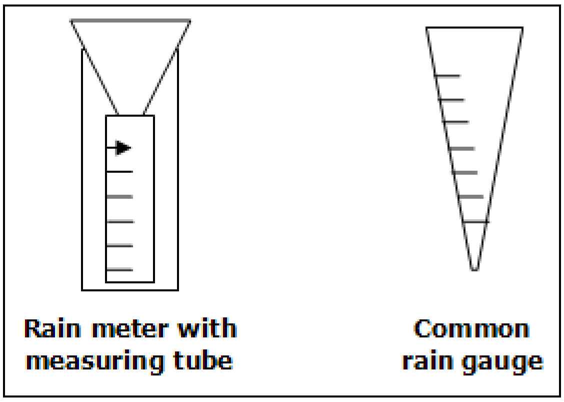



**Figure 2.2: Rain Gauges**

### 1.3. Tensiometers

Tensiometers are instruments that are inserted into the root-zone of trees. Tensiometers measure the water potential of the soil, which is used to determine the volume of available water in the soil.

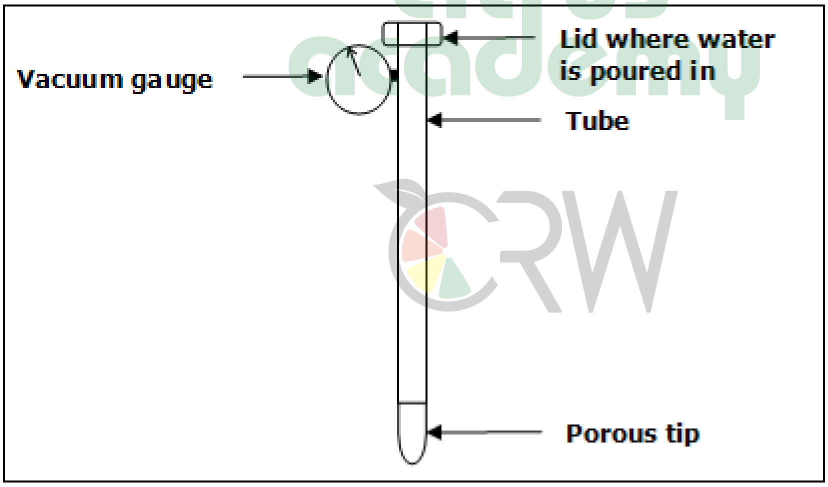



**Figure 2.3: Tensiometer**

### 1.4. Probes

Probes are electronic instruments that measure the volume of water in the soil directly or indirectly. Various types of probes are available, using waves, signals or neutrons to measure the amount of water in the soil. Probes are coupled to data loggers that record the readings from each sampling point. Computer software is supplied with the probe and is used to convert the data in to useful information.

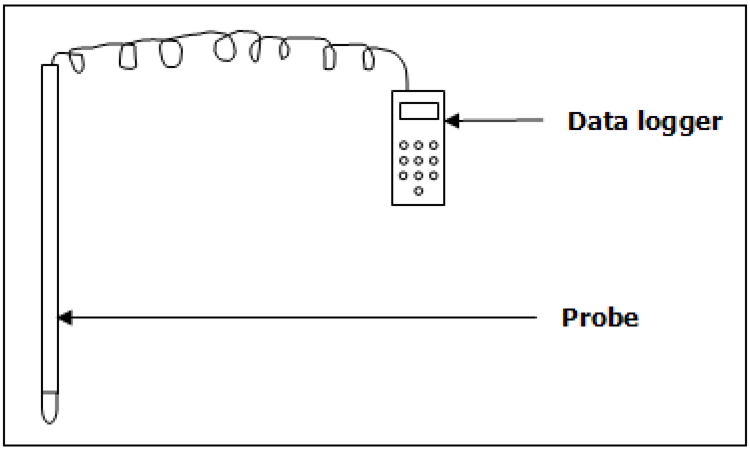



**Figure 2.4: Probe and Data Logger**

## 2. Installing Scheduling Equipment

In order for scheduling equipment to work effectively and provide accurate results, it is essential that it is installed in the correct manner.

### 2.1. Evaporation Pan

A class A evaporation pan is 1.22m in diameter and 250mm deep. The pan is installed 200mm above ground-level on wooden beams. The pan must be level and must not be shielded from sun, wind or rain, but it must be fenced in or placed in such a way as to make sure that animals do not have access to it.

Once the pan is installed, it must be filled with water and calibrated. On the inside of the pan is a measuring scale housed inside a still bowl that is used to record the evaporation. The still bowl is connected to the pan via a small hole.

When water is added or removed from the pan, it takes about a minute for the water level to equalise between the pan and the still bowl. Do not take readings or calibrate the scale immediately after water is added or removed.

The pan is filled until the water level is just over point A in figure 2.5. Point A must not break the water level. To calibrate the scale, adjust the screws at point B on the right-hand side of the scale until a value of 138 is shown on the scale at point C. The screws are then locked in place.

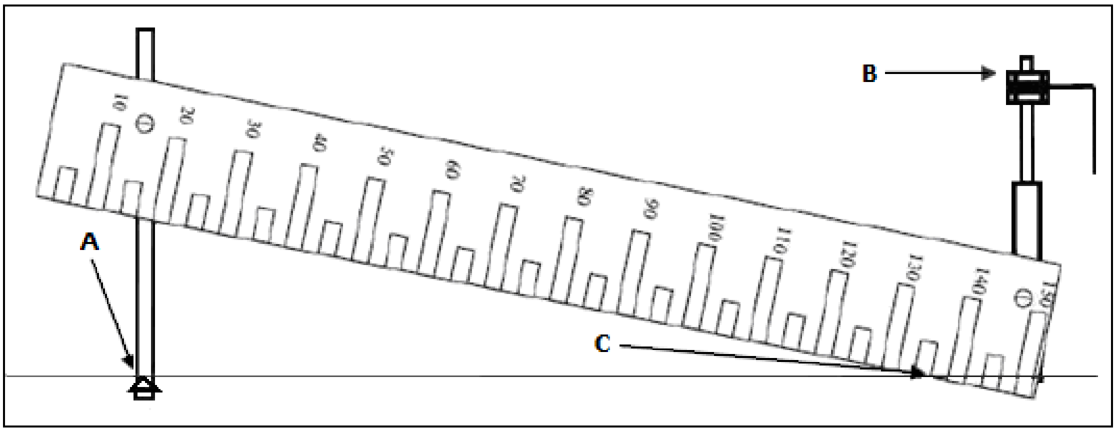



**Figure 2.5: Enlarged Scale inside an Evaporation Pan**

The pan is now filled with water up to 50 on the scale. In the E-pan logbook, this value is noted in the column ***Water Level After Regulating*** (see the example in section 3.1 of this chapter). The pan must be recalibrated every time it is moved or cleaned.

### 2.2. Rain Gauge

The rain gage must be installed in an open space where it is not obstructed, 1m to 1.2m above ground level. Ensure that the gauge is secure and that it is not screened by trees.

### 2.3. Tensiometer

Tensiometers are inserted into holes made by ramming a conduit pipe, such as a steel pipe with the same diameter as the tensiometer, into the soil to the required depth. The soil must preferably be damp and loose. The tensiometer is inserted carefully into the hole made in the soil. Care must be taken, as tensiometers can break easily.

In a citrus orchard, tensiometers are paired, with one being installed in the effective root-zone, at a depth of about 300mm, and one below the root-zone, usually at a depth of greater than 600mm. The data from the tensiometer in the root-zone is used to decide when to apply water. The tensiometer below the root-zone is used to detect over-irrigation, manage leaching, or to prepare for a heat wave. When the root zone is over-irrigated, the excess water drains to the area below the root-zone and the tensiometer at the lower level register the water. The irrigation manager decides where the tensiometers are to be placed.

### 2.4. Probes

Probes are inserted into tubes when a reading is taken. The tubes are installed by the company that supplies the probe, as the installation and placement is a specialised task.

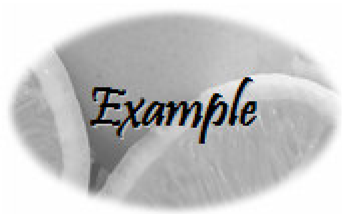
## 3. Collation and Recording of Data

Scheduling equipment is of little use if data is not recorded accurately and used to improve irrigation scheduling. Weather data is usually recorded at a set time, normally eight o'clock, every morning on every day of the week.

### 3.1. Evaporation Pan

A measurement from an E-pan is taken by reading the water level on the scale on the side of the pan. Before a reading is taken, the scale must be wetted by dipping a finger into the water and wetting the scale at the water level. The reading can then be taken on the scale, taking care not to make a parallax error. The reading is noted on the log in the ***Water Level Before Regulating*** column.

As the water evaporates from the pan, the water level drops and approaches a reading of 138. When the reading is near 138, the pan must be refilled to a level of around 50. When the pan has been filled by rain and the water level is above 50, water must be removed. This is referred to as regulating. If the water level has been regulated, the new reading must be recorded in the ***Water Level After Regulating*** column.




**Evaporation Pan Log**

| *Date* | *Rainfall* | *Water Level Before Regulating* | *Water Level After Regulating* | *Calculations* | *Evaporation ($E_o$)* |
|---|---|---|---|---|---|
| 2005/10/01 | | | 50 | | |
| 2005/10/02 | | 72 | 72 | (72-50)/2+0=11 | 11 |

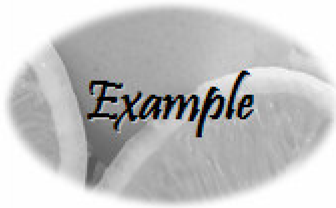
| | | | | | |
|---|---|---|---|---|---|
| 2005/10/03 | | 90 | 90 | (90-72)/2+0=9 | 9 |
| 2005/10/04 | | 108 | 48 | (108-90)/2+0=9 | 9 |
| 2005/10/05 | | 70 | 70 | (70-48)/2+0=11 | 11 |
| 2005/10/06 | 10mm | 64 | 64 | (64-70)/2+10=4 | 4 |

The columns in the log are used as follows:

- ***Date*** – The date on which the reading is taken.
- ***Rainfall*** – The daily rainfall is recorded in this column. The rainfall value is recorded from the rain gauge.
- ***Water Level Before Regulating*** – The daily readings are noted in this column, as explained above.
- ***Water Level After Regulating*** – This column contains the same values as the ***Water level Before Regulating*** column, except if the water level has been regulated manually as explained above.
- ***Calculations*** – The calculations to determine the evaporation is done in this column by using the following equation:

  **Evaporation ($E_o$) = (Water Level Before Regulating (current day) - Water Level After Regulating (previous day) / 2) + Rainfall**

- ***Evaporation*** – The result of the calculation, the evaporation, is noted in this column.




**Evaporation Pan Log Calculations**

Daily calculations in the example above were done as follows:

**Day 1:** The pan is filled with water to 50. The value 50 is entered in ***Water Level After Regulating***.

**Day 2:** A reading of 72 is taken. The value 72 is entered in ***Water Level Before Regulating***. Since there was no regulating, the value is transferred to ***Water Level After Regulating***. The evaporation is calculated as follows:

((72 - 50) / 2) + 0 = 11

The value 11 is entered in ***Evaporation***.

**Day 3:** A reading of 90 is taken. The value 90 is entered in ***Water Level Before Regulating***. Since there was no regulating, the value is transferred to ***Water Level After Regulating***. The evaporation is calculated as follows:

((90 - 72) / 2) + 0 = 9

The value 9 is entered in ***Evaporation***.

**Day 4:** A reading of 108 is taken. The value 108 is entered in ***Water Level Before***

***Regulating***. Since the water level is nearing the value of 138, the pan is filled and in this instance the new reading is 48. The value 48 is entered in ***Water Level After Regulating***. The evaporation is calculated as follows:

((108 - 90) / 2) + 0 = 9

The value 9 is entered in ***Evaporation***.

**Day 5:** A reading of 70 is taken. The value 70 is entered in ***Water Level Before Regulating***. Since there was no regulating, the value is transferred to ***Water Level After Regulating***. The evaporation is calculated as follows:

((70 - 48) / 2) + 0 = 11

Remember to use the previous day's value after regulating. The value 11 is entered in ***Evaporation***.

**Day 6:** A reading of 64 is taken. The value 64 is entered in ***Water Level Before Regulating***. Since there was no regulating, the value is transferred to ***Water Level After Regulating***. Note that 10mm rain fell and that this must be taken into consideration. The evaporation is calculated as follows:

((64 - 70) / 2) + 10 = 7

The value 7 is entered in ***Evaporation***.

### 3.2. Rain Gauge

The rain gauge reading is taken at a specific time every morning, most commonly 08h00. The volume of rain in millimetres is noted in the rain calendar and the evapotranspiration records. Ensure that the rain gauge is emptied properly after the reading has been recorded and that it is replaced in the correct position. Special attention should be paid when a large volume of rain is received in a short period of time. The rain gauge must not be allowed to overflow.

### 3.3. Tensiometer

To take a reading from a tensiometer is very easy. Located on the tensiometer is a dial gauge, resembling a pressure gauge. A reading is taken in the same manner as on a pressure gauge. Typical readings are between -10kPa and -60kPa.

### 3.4. Probes

The use of probes is specialised. Training, software, and online services of an agronomist are provided by the supplier. Data is collected in the field by inserting the probe into the tube, and the correct tube number is keyed into the data logger. Once the probe has logged the data, the probe is removed and the cap replaced on the tube.

After taking daily readings at all the tubes, the data is transferred to a computer via a data-cable. Specialised software creates a graph of the water balances, showing the FWC, PWP, PAW and EAW, and the current water content in the soil.

## 4. Using Scheduling Equipment Data for Irrigation Scheduling

To irrigate effectively, it is necessary to know the water requirements of the plant so that the right volume of water can be applied at the right interval. This is the essence of irrigation scheduling. The data recorded from scheduling equipment such as E-pans, rain gauges, tensiometers and probes, is used in irrigation scheduling. The data must be converted into information.

### 4.1. Evaporation Pan

An E-pan log is used in compiling the water balance sheet. The water balance sheet shows how much water is left in the soil, very much like a bank statement shows how much money is left in the bank. Every day plants use water from the soil reservoir as they transpire.

When the soil-water reservoir is low, being when the easily available water (EAW) has been extracted, the orchard must be irrigated. The amount of water that must be applied is calculated from the soil water balance.

The amount of water used by a plant is calculated by using evaporation, as calculated from the reading taken from the E-pan, and a crop factor. A crop factor is the ratio between evaporation from a free surface of water and losses of water through transpiration. By multiplying the evaporation with the crop factor, the evapotranspiration losses can be estimated.

Definition

**Evapotranspiration**

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

Crop factors are specific to crops, plant age, area and physiological stage. For example, crop factors will differ for maize and citrus, between old and young citrus trees, between northern and southern production areas, and between trees that are flowering or in fruit set. Crop factors are determined by years of research.

| *Region* | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *Jul* | *Aug* | *Sep* | *Oct* | *Nov* | *Dec* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addo | 0.87 | 0.76 | 0.75 | 0.73 | 0.74 | 0.82 | 0.94 | 1.10 | 1.25 | 1.20 | 1.10 | 0.93 |
| Adelaide | 0.42 | 0.43 | 0.63 | 0.69 | 0.70 | 0.83 | 0.82 | 0.94 | 0.79 | 0.62 | 0.50 | 0.41 |
| Citrusdal | 0.79 | 0.58 | 0.51 | 0.45 | 0.48 | 0.51 | 0.54 | 0.63 | 0.75 | 0.98 | 1.10 | 0.97 |
| Gamtoos | 0.84 | 0.72 | 0.87 | 0.92 | 0.81 | 0.88 | 0.99 | 1.10 | 0.98 | 1.00 | 0.90 | 0.75 |
| Hoedspruit | 0.54 | 0.50 | 0.63 | 0.76 | 0.79 | 0.91 | 0.94 | 0.93 | 0.96 | 0.74 | 0.71 | 0.57 |
| Komatipoort | 0.51 | 0.48 | 0.62 | 0.72 | 0.76 | 0.90 | 0.91 | 1.00 | 0.92 | 0.81 | 0.75 | 0.61 |
| Letaba Est | 0.62 | 0.60 | 0.75 | 0.87 | 0.94 | 1.03 | 1.11 | 1.14 | 1.00 | 0.88 | 0.79 | 0.67 |
| Levubu | 0.53 | 0.47 | 0.66 | 0.80 | 0.88 | 0.98 | 1.09 | 1.14 | 1.05 | 0.81 | 0.71 | 0.57 |
| Malelane | 0.62 | 0.58 | 0.72 | 0.85 | 0.90 | 1.03 | 1.05 | 1.12 | 1.05 | 0.93 | 0.79 | 0.67 |
| Marble Hall | 0.57 | 0.45 | 0.55 | 0.66 | 0.70 | 0.78 | 0.81 | 1.00 | 0.98 | 0.85 | 0.87 | 0.69 |
| Nelspruit | 0.59 | 0.51 | 0.68 | 0.90 | 0.94 | 0.98 | 1.00 | 1.10 | 1.10 | 0.93 | 0.82 | 0.67 |
| Pongola | 0.61 | 0.52 | 0.65 | 0.87 | 0.94 | 0.92 | 0.94 | 0.99 | 1.00 | 0.93 | 0.87 | 0.67 |
| Rustenburg | 0.54 | 0.44 | 0.51 | 0.64 | 0.73 | 0.88 | 0.99 | 1.06 | 1.07 | 0.93 | 0.87 | 0.67 |
| Zebediela | 0.44 | 0.38 | 0.48 | 0.60 | 0.67 | 0.81 | 0.83 | 0.91 | 0.82 | 0.71 | 0.64 | 0.53 |

**Table 2.1: Crop Factors for Citrus (Du Plessis, 1989)**

In the example below, we calculate the crop evapotranspiration using the formula:

**Crop Evapotranspiration (ETc) = Evaporation ($E_o$) x Crop Factor (f)**

**Calculating Crop Evapotranspiration**

Assumed Crop Factor: 0.50

| ***Date*** | ***$E_o$*** | ***Calculation*** | ***ETc*** |
|---|---|---|---|
| 2005/12/01 | 11 | 11 x 0.5 | 5.5 |
| 2005/12/02 | 9 | 9 x 0.5 | 4.5 |
| 2005/12/03 | 9 | 9 x 0.5 | 4.5 |
| 2005/12/04 | 11 | 11 x 0.5 | 5.5 |
| 2005/12/05 | 4 | 4 x 0.5 | 2 |
| 2005/12/06 | 8 | 8 x 0.5 | 4 |
| 2005/12/07 | 9 | 9 x 0.5 | 4.5 |
| 2005/12/08 | 11 | 11 x 0.5 | 5.5 |
| 2005/12/09 | 9 | 9 x 0.5 | 4.5 |
| 2005/12/10 | 10 | 10 x 0.5 | 5 |

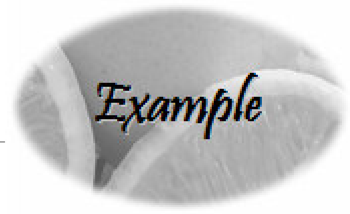
The cumulative water use is the amount of water that has been used since the last irrigation. The cumulative water use can now be calculated by adding the irrigation information.

**Calculating Cumulative Water Use**

| ***Date*** | ***$E_o$*** | ***ETc*** | ***Irrigation*** | ***Calculation*** | ***Cumulative Water Use*** |
|---|---|---|---|---|---|
| 2005/12/01 | 11 | 5.5 | | | 5.5 |
| 2005/12/02 | 9 | 4.5 | | 5.5 + 4.5 | 10 |
| 2005/12/03 | 9 | 4.5 | | 10 + 4.5 | 14.5 |
| 2005/12/04 | 11 | 5.5 | | 14.5 + 5.5 | 20 |
| 2005/12/05 | 4 | 2 | | 20 + 2 | 22 |
| 2005/12/06 | 8 | 4 | | 22 + 4 | 26 |
| 2005/12/07 | 9 | 4.5 | | 26 + 4.5 | 30.5 |
| 2005/12/08 | 11 | 5.5 | 30.5 | | 5.5 |
| 2005/12/09 | 9 | 4.5 | | 5.5 + 4.5 | 10 |
| 2005/12/10 | 10 | 5 | | 10 + 5 | 15 |

Note that the cumulative water use on day 7 was replenished through irrigation on day 8, and the cumulative water use on day 8 is therefore only the evapotranspiration for that day.

The soil-water balance, or soil water reservoir, can now be calculated by subtracting the cumulative water use each day from the EAW.




**Calculating Soil Water Reservoir**

Assumed EAW = 33mm, as calculated in the example in section 2 of chapter 1.

| ***Date*** | ***$E_o$*** | ***ETc*** | ***Cumulative Water Use*** | ***Calculation*** | ***Soil Water Reservoir*** |
|---|---|---|---|---|---|
| 2005/12/01 | 11 | 5.5 | 5.5 | 33-5.5 | 27.5 |
| 2005/12/02 | 9 | 4.5 | 10 | 33-10 | 23 |
| 2005/12/03 | 9 | 4.5 | 14.5 | 33-14.5 | 18.5 |
| 2005/12/04 | 11 | 5.5 | 20 | 33-20 | 13 |
| 2005/12/05 | 4 | 2 | 22 | 33-22 | 11 |
| 2005/12/06 | 8 | 4 | 26 | 33-26 | 7 |
| 2005/12/07 | 9 | 4.5 | 30.5 | 33-30.5 | 2.5 |
| 2005/12/08 | 11 | 5.5 | 5.5 | 33-5.5 | 27.5 |
| 2005/12/09 | 9 | 4.5 | 10 | 33-10 | 23 |
| 2005/12/10 | 10 | 5 | 15 | 33-15 | 18 |

On most farms, the amount of water that should be applied through irrigation is not calculated in this manner. A set schedule is used for irrigation. This means that certain blocks are irrigated on specific days for a specific period of time according to the irrigation schedule. The information from the water balance sheet is used to determine an average irrigation requirement. The intervals are simply extended or shortened when it becomes necessary to irrigate more or less.

In the example above it was calculated that the cumulative water use for 7 days was 30.5mm. This means that the irrigation schedule must be such that 30.5mm is replenished in 7 days. Since EAW is 33mm in the example above, the corresponding blocks must be irrigated back to FWC. The intervals in this instance will be 7 days. Note that in periods when tree water use is higher, the interval period will decrease, for example to 3 or 5 days, and when tree water use is lower, the interval period will increase, for example to 8 days or longer.

To determine the standing time, the system application rate is required. This is the rate at which the irrigation system applies water and is measured in mm/h. A micro-jet system for instance has an application rate of 2.6 mm/h. This means that for every hour the irrigation system is operating, it is applying 2.6 mm of water. The application rate is specific to each system and must be obtained from the irrigation design plan or the irrigation manager, taking into consideration factors such as system efficiency and wetted area.

Again taking the example above, the stand-time can now easily be calculated by dividing the application rate by the required irrigation. If 30.5mm water is required to refill the reservoir, then 30.5 ÷ 2.6 = 11.7, meaning 12 hours is required for the stand time.

## 4.2. Tensiometers

Irrigation scheduling equipment such as tensiometers and probes are used in a more indirect way. Both these instruments can take measurements that can be used to determine FWC and EAW.

For tensiometers FWC is at about -10kPa and EAW between -10kPa and -50kpa. Note that this figure is a general rule that does not apply to all soils. The tensiometer in the root zone should register readings of between -10kPa and -60kPa, while the tensiometer below the root-zone should register drier readings of between -25kPa and -60kPa. As with the water balance method, one can either irrigate when EAW is depleted, or the tensiometer readings can be used to determine the stand-time.

As using tensiometers is a direct method of measuring the soil water, it is necessary to develop a water retention curve for the specific soil. The water retention curve relates the tensiometer readings to the amount of water in the soil. Typically this curve will show the amount of water in the soil in mm/m for a certain reading, for example the curve would show a value of 66mm/m at a reading of -10kPa.

The process of developing a water retention curve can be quite scientific. For the purpose of this material, a simpler, widely-used method of using tensiometer readings for scheduling will be discussed.

With the tensiometers in place, the orchard is irrigated and the tensiometer readings are noted. With micro-jets, the aim is to let the tensiometer readings fluctuate between -10kPa (or FWC) and -50kPa. With drippers, a constant reading of between -15 and -30kPa is required.

When readings are tending to be above -10kPa it means that the block is over irrigated. The intervals must be increased. When readings reach values lower than -50kPa it is an indication that the block is under irrigated, and the intervals need to be decreased.

The same methodology is used for seasonal changes. During the summer the intervals may for instance be 3 days, but as the winter approaches and the water demand lowers, the tensiometers will register higher readings. The intervals need to be increased to prevent over-irrigation. The same applies to spring. When trees start flowering and it becomes warmer, trees will use more water. The tensiometers will register lower readings, thus the intervals needs to be decreased to provide in the higher water demand.

### 4.3. Probes

Scheduling with probes is done in the same way as with tensiometers, the only difference being that probes must be calibrated and a retention curve established. This is done with the assistance of the supplier of the probe or a consultant familiar with that particular type of probe.

Data from probes are captured using a portable data logger and transferred to a computer. Note the some probes do not have portable data loggers, in which case the data is stored in the probe itself and transferred to the computer. Software supplied with the probe is used to generate graphs. The graphs show the upper and lower limits of EAW. As with tensiometers, the aim is to stay between the two limits. As the water demands of the trees change, the graph also changes.

## 5. Maintenance of Scheduling Equipment

### 5.1. Evaporation Pan

Wind must be able to move freely through the top 100 mm of the beams on which the pan rests. To prevent shading of the pan, the area around the pan must be kept free of weeds and bush.

The pan must be cleaned regularly, and especially when algae is found in the pan. Remove the water from the pan and wash it properly with clean water. Refill it with water, and calibrate it again.

Regularly inspect the pan for leaks, which can be caused by rust or by the pan perishing due to exposure to the elements. Report such damage immediately to the irrigation manager.

### 5.2. Rain Gauge

Grass and weeds around the rain gauge must be kept short. Remember that the gauge must never be shielded from rain, or placed under plants that may cause water to run down into the gauge. If the rain gauge is dirty, remove it, and wash and rinse it thoroughly.

Rain gauges that are leaking, cracked or broken must be replaced immediately.

### 5.3. Tensiometer

If the ground dried to below a reading of –100kPa, the tensiometer must be reset after the soil is wetted. This is done by removing the lid on top of the tensiometer and filling it with water. The water level inside the tensiometer must be checked weekly. If the tensiometer is cracked or broken, report it to the irrigation manager.

### 5.4. Probes

Probes are mostly maintenance-free. The only maintenance required is removing water inside the tubes and replacing batteries in the data-logger when necessary. Note however that some types of probes, such as neutron probes, require to be serviced annually, according to the prescriptions of the manufacturer.

## 6. Faulty Scheduling Equipment

When readings from scheduling equipment starts varying greatly from the norm, and this cannot be ascribed to other factors, it is possible that the equipment is faulty or incorrectly calibrated. Reasonability can also be used to evaluate the accuracy of recording equipment, but one has to be familiar with the equipment and the manner in which it works.

Always employ a second cheap and quick method to check the main scheduling system. Feeling the soil and observing the condition of the leaves are good methods to evaluate the correctness of the scheduling system.

For instance, if it has rained during the night and the rain gauge does not contain any water, the reasonability test suggests that the rain gauge is not working properly. This can be due to a number of factors, such as the gauge not being stable and losing water, a leak in the gauge, or shading by plants around the gauge.

Comparing data from different devices is another method of measuring the accuracy of readings. If the E-pan readings are used to calculate the soil-water balance and it is found to be sufficient, and the tensiometer readings show dry conditions, one of the devices are not in proper working order. In the same way, the data received from tensiometers and probes can be compared to ensure that the equipment is accurate.


**Chapter 2**

- 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.


Complete activity 4 in the **Learner Workbook**.

# Chapter 3

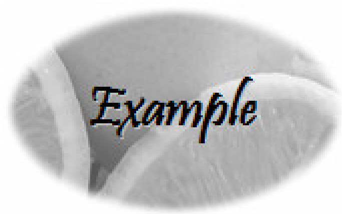
After completing this chapter, the learner will be able to:

**Supervise irrigation activities**

## 1. Implementing Irrigation Schedules

The implementation of irrigation scheduling was described in the previous chapters. A supervisor ensures that workers open and close the right valves at the right time, in line with the requirements of the schedule. It is thus important that workers have a thorough understanding of the schedule.

The best way to manage workers around scheduling is to use a work program. In a work program the names of the workers are listed, with their task description for each day. A row can be added for notes about the execution of the task.




**Work Program**

| Name | Task | | | | | |
|---|---|---|---|---|---|---|
| | **Monday** | **Tuesday** | **Wednesday** | **Thursday** | **Friday** | **Saturday** |
| **Tom** | Irrigate sect 1 | Irrigate sect 1 | Irrigate sect 1 | Irrigate sect 1 | Irrigate sect 1 | Irrigate sect 1 |
| **Comment** | | | | | | |
| **Dick** | Irrigate sect 2 | Irrigate sect 2 | Irrigate sect 2 | Irrigate sect 2 | Irrigate sect 2 | Irrigate sect 2 |
| **Comment** | | | | | | |
| **Harry** | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 1 | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 2 | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 1 | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 2 | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 1 | Start pump<br>Flush filters<br>E-pan reading<br>Probe readings for section 2 |

When the schedule is implemented, the supervisor controls the process. Control measures range from physically checking the workers and the opening and closing of valves, taking measurements with scheduling equipment, to scouting irrigation blocks for signs of over- and under-irrigation.

## 2. Adapting to Prevailing Weather Conditions

A supervisor must be able to adapt the irrigation schedule to the prevailing weather conditions by altering the intervals.

An E-pan is very useful to record the effect of weather factors, such as wind, cloudiness and heat-waves on the evaporation of water. During conditions that are hot, windy and dry, the daily evaporation will increase. Evapotranspiration can be lower due to the closure of the stomata. Using this data and the soil-water balance, the amount of time with which the intervals should be decreased can be calculated.

Tensiometers and probes will also give a reading associated with dryer conditions. When days are cloudy and drizzly, the evapotranspiration will be lower and hence the intervals should be lengthened. When rain of more than 10mm occurs, irrigation must be stopped. Once the rain has stopped, the soil water content is measured with a probe or tensiometer. As soon as the soil water content is about 10% below FWC, irrigation starts again.

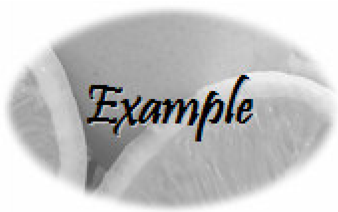
Where micro-jets are used and tensiometers and probes are used to assist with scheduling, the soil water content should fluctuate between FWC and -50kPa (EAW). With drippers the readings should be kept constant at a specific reading, such as -20kPa, usually between -15 and -30kPa. When the readings are more than -10kPa, the intervals should be lengthened. If the readings are constantly near -60kPa, the intervals should be shortened. The same principle also applies to probes.

## 3. Monitoring the Operation of the Irrigation System

The monitoring of the irrigation system is discussed at length in chapter 4, as well as understanding the operational parameters.

The irrigation supervisor is responsible for ensuring that the irrigation system is operated within the desired parameters. The most efficient way to accomplish this is by ensuring that records are kept by the workers that are responsible for starting up and shutting down the pump system. The person starting the pump must keep record of the volts, amps, pressure and flow-rate of the pump every day when the pump is started. Workers operating the infield irrigation must also keep records of infield pressures and flow-rates where applicable.

The supervisor evaluates the recorded parameters daily or a few times a week.




**Irrigation System Monitoring**

| Date | Volts | Amps | Pump Pressure | Flow |
|---|---|---|---|---|
| **Parameter** | **400V** | **120A** | **8.5 bar** | **210m$^3$/h** |
| 01/10/2010 | 402 | 125 | 8 | 220 |
| 02/10/2010 | 405 | 125 | 8 | 220 |
| 03/10/2010 | 402 | 118 | 8.7 | 205 |
| 04/10/2010 | 402 | 122 | 8.1 | 218 |
| 05/10/2010 | 402 | 120 | 8.4 | 215 |

## 4. Staff Safety Regulations

The following safety regulations must be adhered to:

- Treat pumps and motors with respect.
- Stay clear from moving parts as this can result in serious injury.
- Do not open electrical panels or distribution boxes.
- Never enter the restricted area around transformers even if the gate is open.
- Report damaged pumps, motors and electrical gear.

- Where chemicals are used, for instance in fertigation, wear the prescribed protective clothing. Wear a clean overall every day.

- Where chemicals such as phosphoric acid and chlorine are used, staff must be trained to comply with regulations.

## 5. Irregular Problems

Problems can occur that are not described in these chapters. An example is where the soil water balance is correct according to scheduling equipment, but the trees show signs of stress. A problem like this must be reported to the irrigation manager.

It is possible that scheduling equipment can give an incorrect reading because of incorrect calibration or a malfunction. Tensiometers especially are unreliable if not maintained properly and probes can become damaged by mishandling and falls. If a problem occurs and you are not confident in dealing with it must be reported to the irrigation manager.


**Chapter 3**

- ➢ 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.


Complete activity 5 in the **Learner Workbook**.

# Chapter 4

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

**Ensure the efficient operation of irrigation systems**

## 1. Irrigation System Checks

In unit standard ***116066 – Operate and Maintain Irrigation Systems Specific to Citrus Orchards***, ongoing maintenance tasks for the irrigation system is discussed. While these actions play an essential role in ensuring the effectiveness of the irrigation system, it is also important to perform major system checks and repairs on an annual basis.

Citrus is irrigated throughout the year. During the winter, the peak water demand is however lower, and the irrigation system can be switched off for short periods to do system checks and repairs. During periods of low water demand system checks and repairs can therefore be done so that the system can operate efficiently when water demand is high.

### 1.1. Pumps

Apart from the pre-start-up checks described in US 116066, pay special attention to the following points with regards to pumps and pump installations:

- Take a **pressure reading** of the pump with the valve closed to evaluate the state of the impeller. Find out from the irrigation manager what the closed valve pressure should be. If the closed valve pressure is less than what it is supposed to be, it is possible that the impeller is worn or blocked. Report this finding to the irrigation manager.

- While the pump is working, be attentive to **noise** and **vibrations**. This could be an indication that the pump is cavitating, which could be due to the impeller being blocked, the water level being too low, or a faulty suction pipe, or it could be that the bearings are beginning to fail. Report any noise and vibration to the irrigation manager.

- **Inspect pipe work**, paying attention to the foot valve, strainer and suction pipe. Ensure that the foot valve is operating correctly, that the strainer is clean and in a good condition with no holes, and that the suction pipe is in good condition with no leaks. Also check the general condition of the rest of the pipe work to ensure that there is no rust, holes or leaks.

- Visually **inspect the pump to motor couplings** with rubber tyres and rubber inserts for cracks and tears. Report suspect couplings to the manager.

- **Check and tighten mounting bolts** on the pump, motor and frame. It is recommended that the pump to motor alignment is checked once a year, especially on bigger pumps. Misalignment can also cause vibrations and bearing failure. The alignment is checked by a qualified person using special tools.

- **Inspect the electrical panels**. Employ an electrician to check the electrical connections and that the electrical panels and the fail safe systems, such as the motor protection relay, phase failure relay, and over and under voltage relay, are working properly. The person should pay attention to the cables, connectors, contactors, relays, timers, power supply, motor protection and motor operating parameters.

Winter is the ideal time for preventative maintenance on pump systems, and to replace worn bearings, seals, impellers and wear rings. This is not done every year, but is executed according to a maintenance schedule. The maintenance schedule is discussed in detail in chapter 4.

## 1.2. Filters

Perform the filter inspections as described in unit standard 116066. Pay attention to the following:

- On sand filters, open the filter and remove the sand once a year. If the same sand is going to be used again, wash the sand properly to break up any cakes that have formed and to clean out debris trapped in the sand. Wash the inside of the filter before replacing the sand. In some cases, the sand has to be replaced, which is also done when the filter is opened and cleaned. The irrigation manager will indicate when the sand must be replaced. If the quality of the water received on the farm is poor, the filter must be opened and cleaned more often. If the filter is not back-flushing properly, it is an indication that the filter needs to be cleaned.

- When the sand has been removed inspect from a sand filter check the inside of the filter. At the bottom of the filter are perforated pipes or buttons. Visually inspect these for wear and tear. The material between the perforations tends to break, thus letting sand into the irrigation system. Report any suspicious pipes and buttons to the irrigation manager.

- Most sand filters are fitted with secondary disc filters. These can be located on either inside the filter or at the filter outlet. Open and remove the disc filters. Clean and inspect the filter elements for signs of wear and tear. If the secondary filters are located outside the filter, inspect the housing for the presence of sand. If sand is present, it could be an indication that the perforated pipes or buttons in the sand filter are broken.

- Clean and inspect disc filters as described in US 116066, Chapter 4. Be attentive to wear on the discs and sealing rubbers. The grooves on the discs should not be flattened or chafed.

- Filter banks usually have hydraulic valves for filtering and back-flushing. Ensure that the valves are not leaking and that they are closing properly. Open these valves and inspect the rubber diaphragm for wear and cracks, and replace it if necessary. Be sure to reassemble the valve in the same way afterwards.

- Check lid seals and rubber tubing to see if it is perished or broken. Report this to the irrigation manager and replace damaged items.

## 1.3. Infield Irrigation

Besides the normal maintenance on infield irrigation, special attention must be paid to the items below. Repair and report problems and faults without delay.

- ***Valves*** – Check that valves open and close properly and that they do not leak. Check the gland packing for leaks and tighten it if necessary. Open hydraulic valves and inspect the rubber diaphragm for wear and cracks, and check the pilot valves. The pilot valves should regulate the pressure at the set value. Visually inspect the pilot valves for signs of leaks and wear.

- ***Emitters*** – The best evaluation of emitters is by means coefficient of uniformity (CU) test, which aims to ensure that all emitters are operating uniformly at the same pressure and delivery rate. Perform a visual inspection of the emitters and be on the look out for emitters that are spraying poorly or are blocked. Observe the spray pattern to see if it is overlapping or if dry spots occur. Micro-jets can be opened and cleaned, and drippers can be tapped lightly to loosen blockages. Do not hit or pierce the dripper as this will cause damage.

- ***Pipes*** – Visually inspect pipes for leaks and their general condition.

**Coefficient of Uniformity (CU) Tests**

A 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, five evenly-spaced lateral lines in a block and five evenly-spaced emitters on each lateral line are selected. The delivery of each sample emitter is measured by allowing the emitter to drip or spray into a measuring tube for a specific period of time, such as five minutes, and 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, and a tolerance level for the variance is 10%.

The manner in which CU tests are conducted and recorded is discussed in more detail in the learning material for unit standard 116317 (Irrigation level 4).

## 2. Start-Up and Shut-Down Procedures

The start-up and shut-down procedures are described in detail in unit standard 116066. Please take the time to revise these sections.

A pre-start-up inspection must be performed every time before a pump is started. Be attentive to vibrations and noise when the pump starts and runs. Remember to open the delivery valve slowly as soon as the pump operates normally. This will reduce the electricity cost at start-up. Before a pump is shut down, it is important to close the delivery valve to reduce water hammer.

Where two or more pumps are in the same pump station, the pumps must be started about 15 minutes apart. This is to lower the maximum demand of electricity, which will reduce the electricity costs.

Adhering to these procedures will prolong the life of the pump and motor, as it minimises the stress on the pump during start up and shut down, and will save on electricity costs.

Ensure that start-up and shut-down procedures are followed strictly at all times, and that the necessary records are kept in the prescribed manner. Ensure that the persons responsible for starting and shutting down pumps have the necessary skills to perform these procedures properly, and that they are aware of the importance of following the prescribed procedures. All workers must be aware of the proper reporting channels to ensure that problems and faults are reported and dealt with as soon as possible.

## 3. Operation of Irrigation System

At the pump installation, an amp meter, volt meter, pressure gauge and flow meter are installed. The various meters and gauges are used to monitor the pump working characteristics.

The amp meter measures the current that the motor uses. The harder the motor works, the higher the amp meter reading. The volt meter gives the voltage reading. Most pumps operate on 380V to 400V. If the voltage is too low, it can cause the motor to burn out, while the insulation inside the motor can be damaged if the voltage is too high. The pressure gauge is used to measure the pressure at the pump. The flow meter is used to measure the flow of water from the pump.

Pump-motor characteristics differ for each pump. The irrigation manager can assist with determining the pump-motor characteristics under normal conditions, meaning normal water levels, clean filters and the correct number of blocks open. The pressure and flow at the pump is checked against the irrigation design plan.

Overload conditions, which is when the amp meter reading is higher than the amps for the normal operating characteristics, should be avoided as this will cause the motor to burn out. The overload protection in the electrical panel should trip the power supply if this occurs. If the overload protection does not trip the power supply, report it to the manager. Under-load situations should also be avoided, as this can lead to pump malfunction that can destroy the pump if left unchecked.

During irrigation, ensure that the flows and pressures for each block are within limits. Take pressure readings and correlate it with the values on the irrigation design plan. Adjust the pressure accordingly.

Where hydraulic valves are used for pressure regulation, it may be necessary to adjust the pilot valve to increase or decrease the water pressure. To decrease the pressure, turn the nut on top of the pilot valve anticlockwise. This will close the valve thus reducing the pressure. To increase the pressure, turn the nut clockwise. This will open the valve and increase the pressure. Note that the actuation of the valve by the pilot takes a few minutes. Adjust the pilot only a little bit at a time and wait for the pressure to stabilise before it adjusting again.


**Chapter 4**

- 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.


Complete activity 6 in the **Learner Workbook**.

# Chapter 5

| |
|---|
| After completing this chapter, the learner will be able to:<br><br>**Prepare maintenance programs for irrigation systems** |

## 1. Life-Expectancy of Irrigation Equipment

When designing a long-term maintenance plan, it is important to take into account the life-expectancy of the equipment. The life-expectancy of irrigation equipment is influenced by two major factors, being:

- ***Quality*** – It is important to buy the best equipment one can afford when the original installation is done. The irrigation system is a major part of the capital investment when an orchard is established and constitutes a long-term commitment. The cost of replacing equipment of inferior quality that was chosen for the sake of saving money is often higher than the cost of superior equipment would have been in the first place.

- ***On-Going Maintenance*** – The ongoing maintenance required for the various components of the irrigation system is described in unit standard 116066. It is essential that equipment must be maintained as this will prolong their lifespan.

Citrus is a long-term crop, with a lifespan that varies between 17 and 30 years. An irrigation system is designed and installed when an orchard is planted and major changes are only made when the orchard is replanted after its economic lifespan. The life-expectancy of irrigation equipment is as follows:

- ***Pump System and Filters*** – Pumps and filters have the same life-expectancy as the lifespan of the orchard, and should only need to be replaced when the orchard is replanted.

- ***Mainlines*** – If mainlines are installed properly and correctly, they should have double the life-expectancy than the orchard's lifespan. It should be replaced every second time the orchard is replanted.

- ***Sub-Mainlines and Infield Valves*** – This equipment have the same life-expectancy as the lifespan of the orchard.

- ***Lateral Lines*** – Poly-pipe is used for lateral lines. The life-expectancy of poly-pipe very much depends on quality and ongoing maintenance. If the lateral lines are of good quality, and if they are maintained in the prescribed manner, they should have a life-expectancy of around seven years.

- ***Emitters*** – Emitters include drippers and micro-jets. Drippers have the same life-expectancy as poly-pipe, and are normally replaced with the lateral lines. Micro-jets should have the same life-expectancy as the lifespan of the orchard, but may wear out if the water quality is poor.

## 2. Long-Term Maintenance Plans

In designing a long-term maintenance plan, follow the guidelines below:

| | |
|---|---|
| **Monthly** | • Grease pump motors<br>• Clean discs on disc-filters<br>• Open and inspect sand-filters<br>• Check pilot valve settings |

| | |
|---|---|
| **Yearly** | • Replace filter sand<br>• Have electrical panel inspected by electrician<br>• Check pump alignment<br>• Replace oil inside the pump<br>• Inspect and, if possible, repair suction pipe |
| **5 Yearly** | • Overhaul pump by replacing bearings, seals, wear rings and impeller, if necessary<br>• Replace diaphragms on hydraulic valves |
| **5–7 Yearly** | • Replace micro-jets, drippers and poly-pipe, depending on the type |

**Table 5.1: Guidelines for Designing a Long-Term Maintenance Plan**

## 3. Contingency Planning

Contingency plans for emergency situations are extremely important and can save money and disruptions in the operation of the irrigation system. Although the contingency plans will be different for each farm, the basic principles remain the same. The contingency plans must be worked out well in advance, specific tasks must be assigned to specific members of personnel, and drills must be practised to ensure that each person knows what to do.

### 3.1. Floods

Floods are a major threat to pump stations, and can cause flooding of the pump station or literally sweep away the pump installation. When heavy rains occur it must be considered that a flood can occur. It is important to be in contact with the local water-users association as they issue flood warnings.

Use the following guidelines when developing a contingency plan for floods:

- Stop the pumps and isolate the main electrical circuit. Keep the key to the main distribution box in a place that is easily assessable in an emergency. If possible, contact Escom to isolate the transformer if there is a danger of it flooding.

- When the pump is installed in a place that is exposed to flooding, such as on a riverbank, install the pump in such a way that it can be easily removed, by placing it for example on a trolley, rails or a sledge. Use quick-release couplings and connections.

- If the pump installation has been flooded, never switch on the main isolator until the pump and panels has been inspected by a qualified electrician. Wet motors and panels are extremely dangerous.

### 3.2. Fire

Fire can be devastating to trees and irrigation systems. It is important to have firebreaks around orchards and to keep the grass short between the rows. The area under trees should be free of weeds and grass. Some farmers mulch organic material under the trees, in which case the mulch must be kept moist.

A fire fighting unit must be kept handy and filled with water at all times, especially during the dry season when fires are more prevalent. Before the advent of the dry season, inspect and physically test the fire fighting unit. Inspect the condition of the pipes, nozzle, pump and engine, and the fire fighting brooms. The rubber flaps must be in a good condition.

A back-up plan must be in place to ensure that water will be available to fight a fire, even if the pumps cannot operate. A small diesel or petrol pump to fill up fire fighting units is one option that can be considered. A stand-by generator or water stored in a tank or dam that can fill fire fighting units through gravitation are other options.

### 3.3. Pump Breakdown

Large pump installations usually consist of a number of pumps. Should one of the pumps fail, the capacity of the system will decrease, but with the other pumps still operating, there will be water available.

A contingency plan for pump failure should focus on ensuring that high value crops receive priority. These orchards should be irrigated first, and other orchards can then be irrigated if water is available. The number of pump hours per day can also be extended to 24 hours, in which cases changes to the irrigation schedule will be required.

The other part of the contingency plan must focus on repairing the broken pump as soon as possible. This can be done by either keeping spares on the farm or by selecting a pump and motor that are widely-used and for which spares are readily available. When only one pump is used, this will be the only strategy to follow.

### 3.4. Pipe Bursts

Burst pipes, especially on main- or sub-main lines, can cause interruptions in irrigation to sections of the farm, which is especially dangerous in summer when the water requirement of trees is high.

When preparing a contingency plan for burst pipes, the irrigation plan is used to identify the pipe sizes and the types of materials that were used. Replacement pipes and repair couplings are kept on the farm so that pipes can be repaired as soon as possible.

Note that asbestos and fibre cement pipes are still used on some farms for main- and sub-main lines. These pipes and their fittings are not manufactured any more. Collars that fit on these pipes can be made by engineering firms, but the manufacturing can take up to two weeks. It would be wise to keep some of these fittings handy on the farm.

### 3.5. Chemical Spills

Chemical spills pose a danger to the irrigation system in that the irrigation water or water sources on the farm may be contaminated. If it is suspected that a chemical spill has caused such contamination, all irrigation must be suspended immediately.

Inform the irrigation manager of the situation.

## 4. Preparing Budgets for Purchases

Before a budget is prepared, a list is made of the required equipment. This list may consist of spares that are frequently used and spares that are needed for preventative maintenance or replacement. When a new development is being planned a list of the required materials, also referred to as a Bill of Quantities, is generated based on the irrigation design.

To the list of requirements, the dates on which the items are required must be added, together with the approximate prices of the items. If the prices are not known, quotations are requested to give an indication of the prices. From this information a monthly budget can be generated.

Example

## Bill of Quantities and Monthly Budget

### Bill of Quantities

| *Item* | *Allocation* | *Order Frequency / Date Required* | *Quantity* | *Price per Unit* | *Total* |
|---|---|---|---|---|---|
| Joints 15 mm | Maintenance | Monthly | 500 | 0.15 | 75.00 |
| Joints 20 mm | Maintenance | Monthly | 500 | 0.20 | 100.00 |
| Joints 25 mm | Maintenance | Monthly | 500 | 0.25 | 125.00 |
| Poly-pipe 15/3 | Maintenance | Monthly | 250m | 0.30 | 75.00 |
| Poly-pipe 20/3 | Maintenance | Monthly | 250m | 0.50 | 125.00 |
| Poly-pipe 25/3 | Maintenance | Monthly | 250m | 0.70 | 175.00 |
| Micro Complete | Maintenance | Monthly | 100 | 3.50 | 350.00 |
| Diaphragm (50mm) | Capital | 31/07/2006 | 5 | 25.00 | 125.00 |
| Filter lid seal | Capital | 31/07/2006 | 5 | 30.00 | 150.00 |
| Cascade clamp 200 | Capital | 31/07/2006 | 2 | 150.00 | 300.00 |
| Cascade clamp 250 | Capital | 31/07/2006 | 2 | 200.00 | 400.00 |
| Filter sand | Maintenance | 3 Monthly | 20 bags | 50.00 | 1,000.00 |

### Monthly Irrigation Budget

| *Month* | *Maintenance* | *Capital Expenditure* | *Total* |
|---|---|---|---|
| March 2006 | 1,025.00 | | **1,025.00** |
| April 2006 | 1,025.00 | | **1,025.00** |
| May 2006 | 2,025.00 | | **2,025.00** |
| June 2006 | 1,025.00 | | **1,025.00** |
| July 2006 | 1,025.00 | 975.00 | **2,000.00** |
| August 2006 | 2,025.00 | | **2,025.00** |
| September 2006 | 1,025.00 | | **1,025.00** |
| October 2006 | 1,025.00 | | **1,025.00** |
| November 2006 | 2,025.00 | | **2,025.00** |
| December 2006 | 1,025.00 | | **1,025.00** |
| January 2007 | 1,025.00 | | **1,025.00** |
| February 2007 | 2,025.00 | | **2,025.00** |
| **Total** | **16,300.00** | **975.00** | **17,275.00** |

## 5. Procurement of New Equipment and Spares

Once the materials have been budgeted for and the budget has been approved, the materials can be procured as needed.

With procurement it is very important to make sure that you are comparing apples with apples. Poly-pipe, for instance, is available in a wide variety of grades and classes, with great variations in price.

Although better quality equipment is more expensive, it pays in the long run to use products of good quality. The guarantee that is given on equipment must also be taken into account.

It is good practice to obtain three quotations for equipment, especially when purchasing the equipment for a new installation. A preferred provider of equipment for monthly maintenance is normally identified, but the prices of this supplier must still be compared with what other suppliers can offer on a regular basis. Evaluate suppliers on price, quality and service.


**Chapter 5**

- 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.


Complete activities 7 and 8 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