



# **DEVELOPMENT OF TECHNICAL AND FINANCIAL NORMS AND STANDARDS FOR DRAINAGE OF IRRIGATED LANDS**

Project K5/2026//4

# Scope of Presentation

## 1. Introduction

- Project details
- Problem definition

## 2. Methodology

## 3. Project Progress

## 4. Summary

# Introduction



## Project Details

- 1. WRC – KSA**  
Water Utilisation in Agriculture
- 2. Thrust**  
Water resources protection and reclamation  
in agriculture
- 3. Title**  
Development of technical and financial  
norms and standards for drainage of  
irrigated lands
- 4. Duration**  
Start date: 2011  
End Date : 2015

# Introduction

## Project Details



### 1. Lead organisation

- Agricultural Research Council, Institute for Agricultural Engineering

### 2. Collaborating organisations

- University of KwaZulu-Natal, School of Bio Resources Engineering and Environmental Hydrology
- OABS
- University of the Free State
- Bio Resources Consulting

### 3. Supporting organisations

- Department of Agriculture
  - Directorate engineering – KZN North Region

# Introduction

## Problem Definition

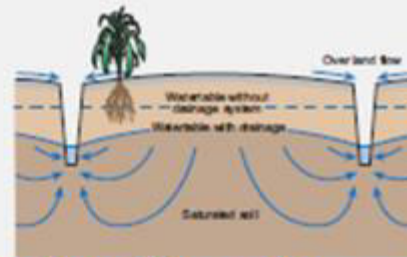


In some soils, the natural drainage processes are sufficient for crop growth but in many other soils, artificial drainage is needed for efficient agricultural production

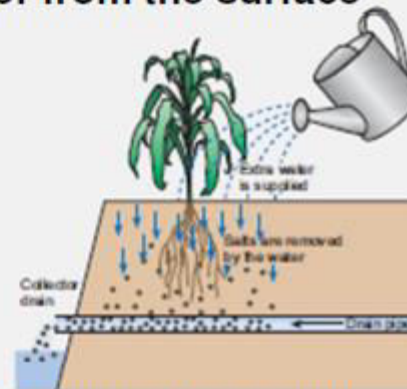
The purpose of agricultural drainage is to remove excess water and salts from the soil profile in order to enhance or maintain crop production

# Introduction

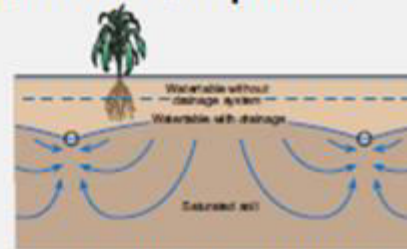
## Problem Definition



a. To remove excess water from the surface



b. To remove excess salts from the profile



c. To maintain groundwater at a desired level

# Introduction

## Problem Extent



### Worldwide

500 000 ha of the total world's agricultural land is becoming unproductive every year due to poor drainage

### South Africa

240 000 ha are affected by rising water tables and salinisation and this problem appears to be increasing



# Introduction

## Problem Extent

### Drainage % of total irrigated area (%) in different countries

| Country         | Area irrigated (ha) | Area drained (ha) | Drainage % of total irrigated area (%) |
|-----------------|---------------------|-------------------|--|
| Egypt           | 3 246 000           | 3 024 000         | 93                                     |
| India           | 90 000 000          | 5 800 000         | 12                                     |
| The Philippines | 1 530 000           | 1 500 000         | 96                                     |
| South Africa    | 1 500 000           | 150 000           | 10                                     |

# Introduction

## Problem Extent



In South Africa :

- The areas along the Orange River, especially at Vaalhartz, Douglas and Upington
- Winter Rainfall area at Robertson, Worcester, Swellendam, Ceres and Wellington
- KwaZulu Natal Region – Pongola and Nkwalini
- Eastern Cape – Gamtoos valley, Sunday River valley and Fish River valley
- Limpopo – Loskopdam and Hartbeespoortdam Irrigation schemes
- Potentially where there is a concentration of irrigation activity

# Introduction

There is a need to revise and publish up to date norms and standards for South Africa that could form guidance for practitioners

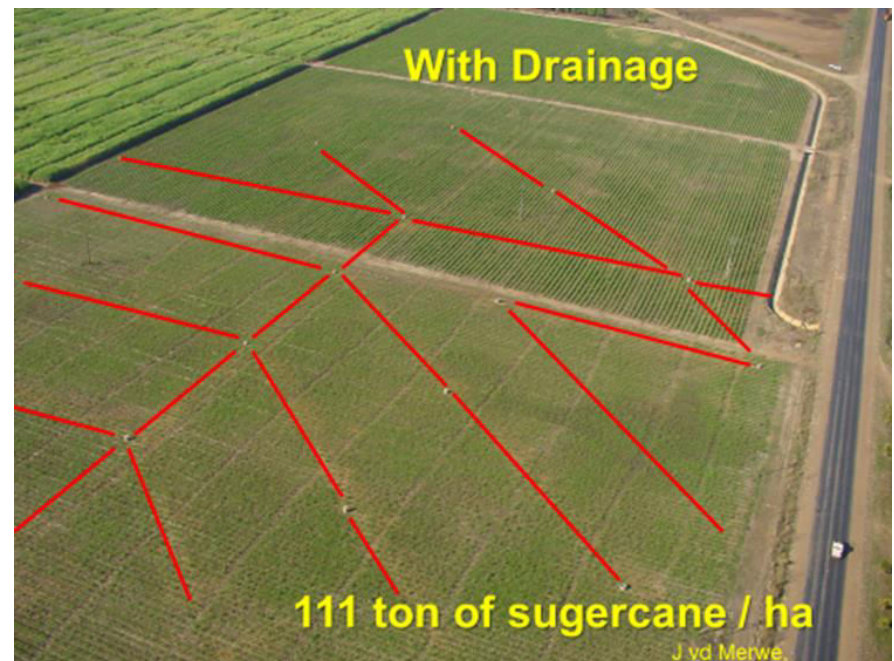
- Internationally and locally available research outputs and modelling approaches are assessed for applicability in South Africa

# Introduction



## Overall Objective

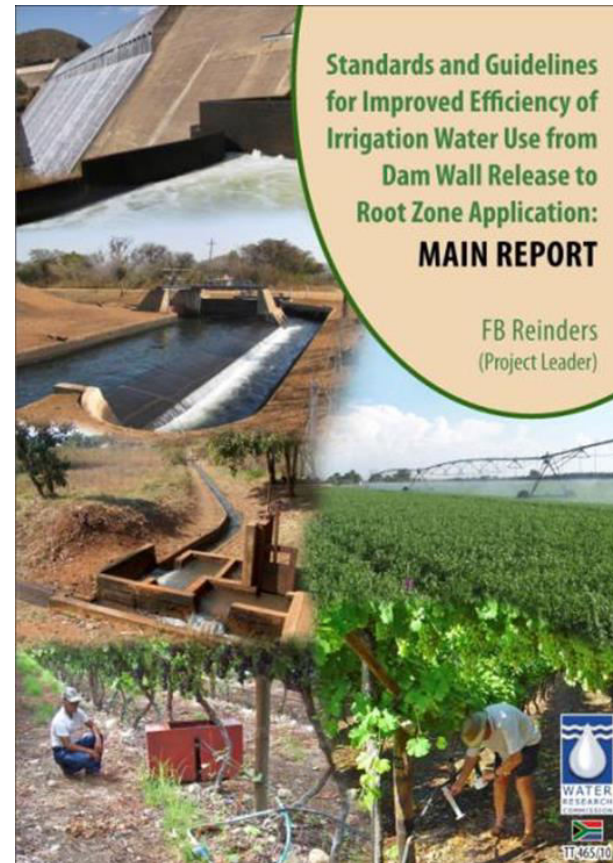
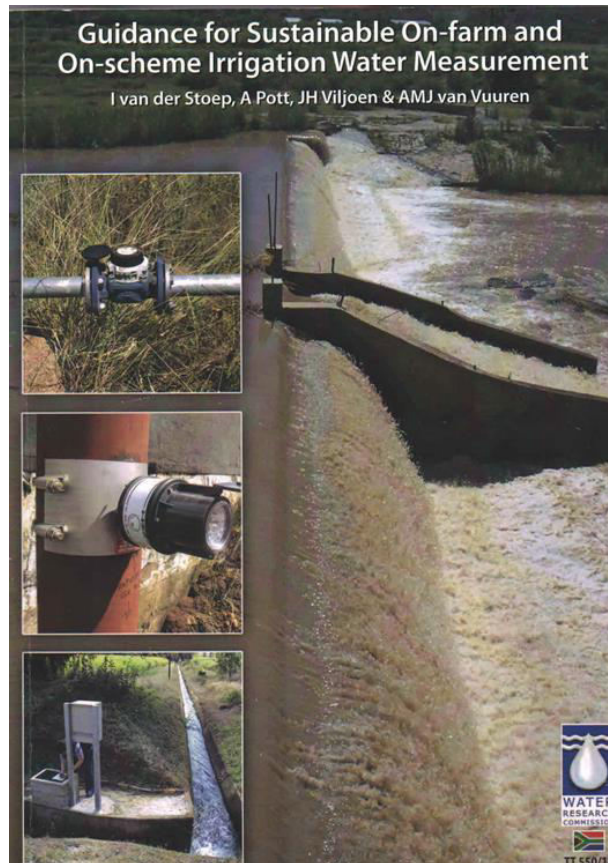
“To develop technical and financial standards and guidelines for assessment of the feasibility of surface and sub-surface drainage systems under South African conditions”



# Introduction

## Project Output

“Guidelines and manual for design, installation, operation and maintenance of drainage systems”



# Methodology



1. Conduct a desktop study to assess the terminology, definitions, practices and technology of drainage
2. Evaluate and measure drainage in selected areas for the refinement and development of standards
3. Apply the tools at selected locations to finalise the technical and financial standards

# Methodology



The major reason for installing drainage is to improve the productivity of the farmland.

- Reduced productivity of farm land = waterlogged soils – anaerobic microbial activity (bad bugs)
- Improved land productivity = aerated soils stimulate aerobic microbial and fungi activity (good bugs)

In South Africa drainage was introduced in the late 50's and early 60's

Various approaches and techniques have been used and are still been used to drain agricultural fields in South Africa

The Conservation of Agricultural Resources Act, Act 43 of 1983 makes provision for soil conservation measures to be implemented and enforced if deemed necessary

Control measures as stated in the Act

- Cultivation of virgin soil
- Cultivation of land with a slope
- **Prevention of waterlogging and salinisation of irrigated land**



# Project Progress

# Materials and Installation Techniques



# Project Sites



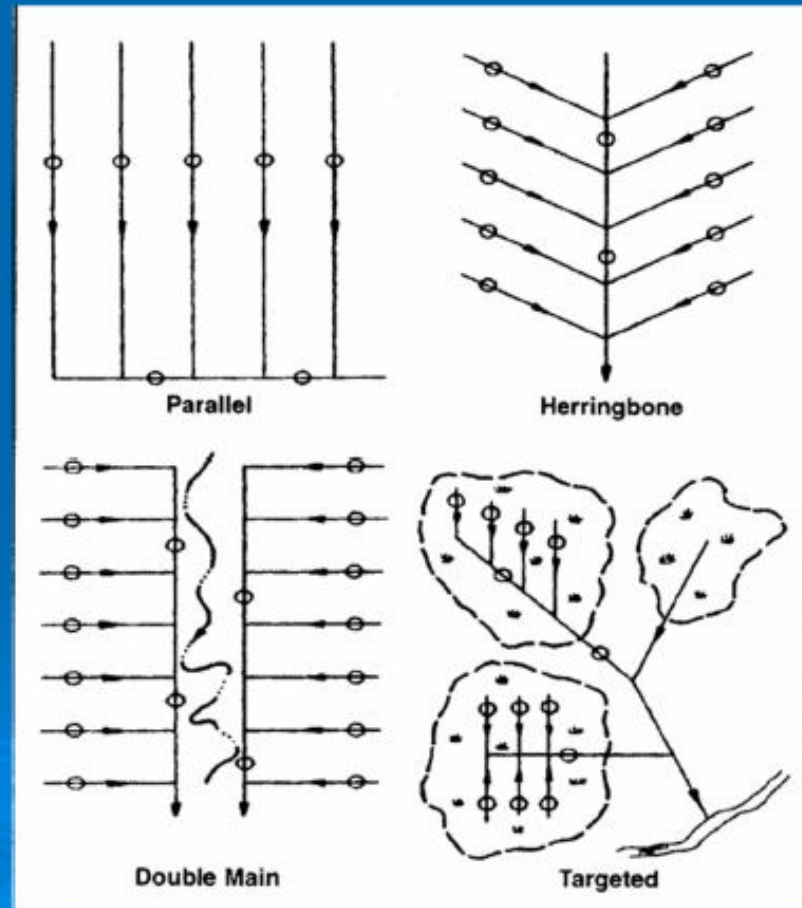
Three schemes were selected for drainage evaluations during the WRC project:

- Vaalharts Irrigation Scheme (Jan Kempdorp/Hartswater)
- Breede River Irrigation Scheme (Robertson)
- Impala irrigation Scheme (Pongola)



# Drain types

- System of drains
- Cut off drains
- Targeted drains



■ Goddoudt formula:

$$L^2 = \frac{4kh^2}{q} + \frac{8kdh}{q}$$

Where: L= Drain spacing (m),

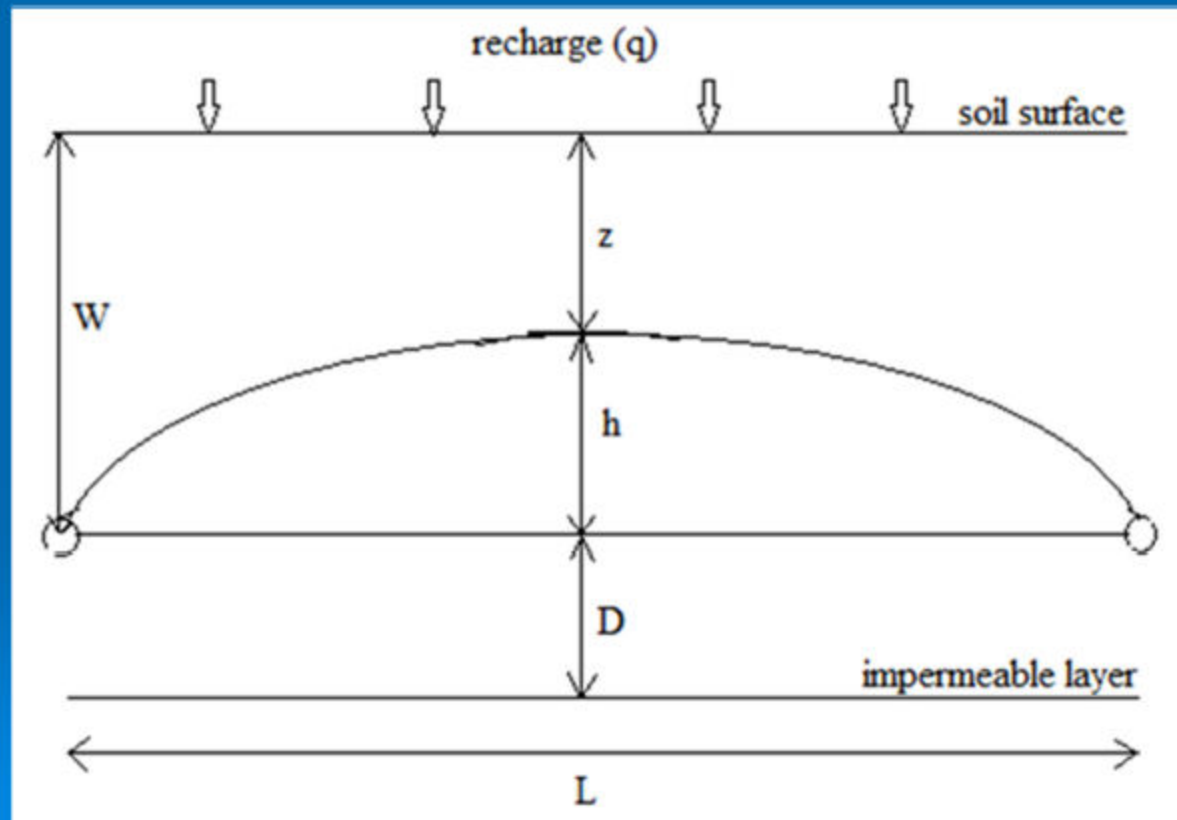
K= Hydraulic Conductivity (m/d),

h= Water table elevation (m),

d= Elevation of the water level in the drain (m), and

q= Discharge (m/d).

## Main variables in groundwater drainage design

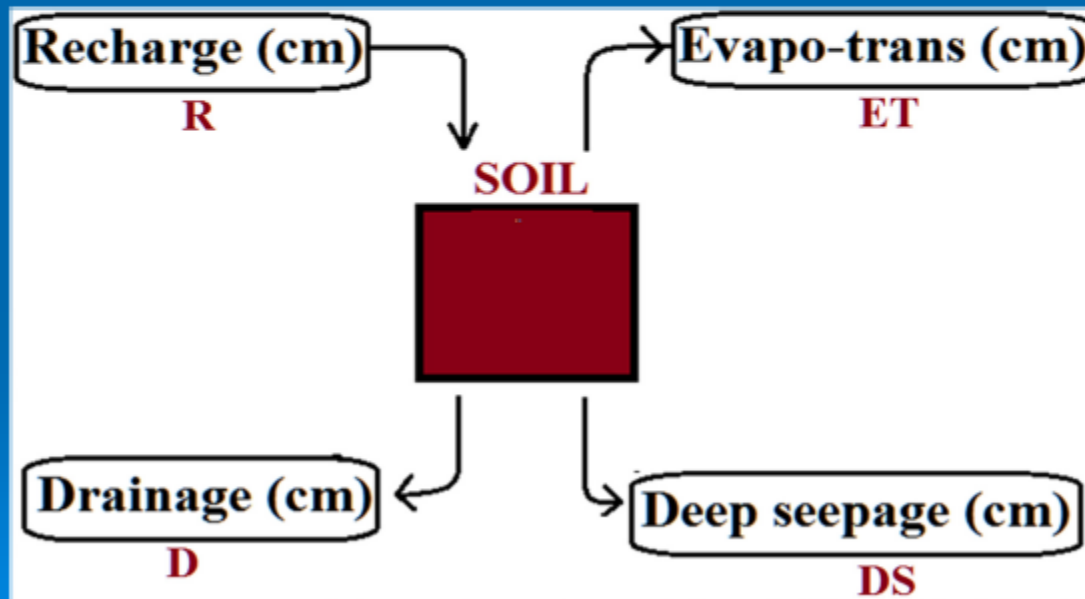


## DRAINMOD Model

Drainmod (Skaggs, 1999),

The water balance for a time increment ( $\Delta t$ ) are expressed as:

$$-\Delta V_a = D + ET + DS - R$$



## **DRAINMOD model**

**DRAINMOD is a hydrological model developed at the North Carolina State University (NCSU) in the department of Biological and Agricultural Engineering.**

**The model is reported to have been initially developed for analyzing field scale watershed management scenarios for poorly drained soils, but it has now been updated and used on both field- and watershed-scale**

DRAINMOD model is one of the most widely applied of the water balance models in subsurface drainage system design

$$\Delta Va = D + ET + DS - F$$

Where:

$\Delta Va$  is the change in the water free pore space or air volume, cm;

D is the drainage from the section, cm;

ET is the evapotranspiration, cm;

DS is the deep seepage, cm;

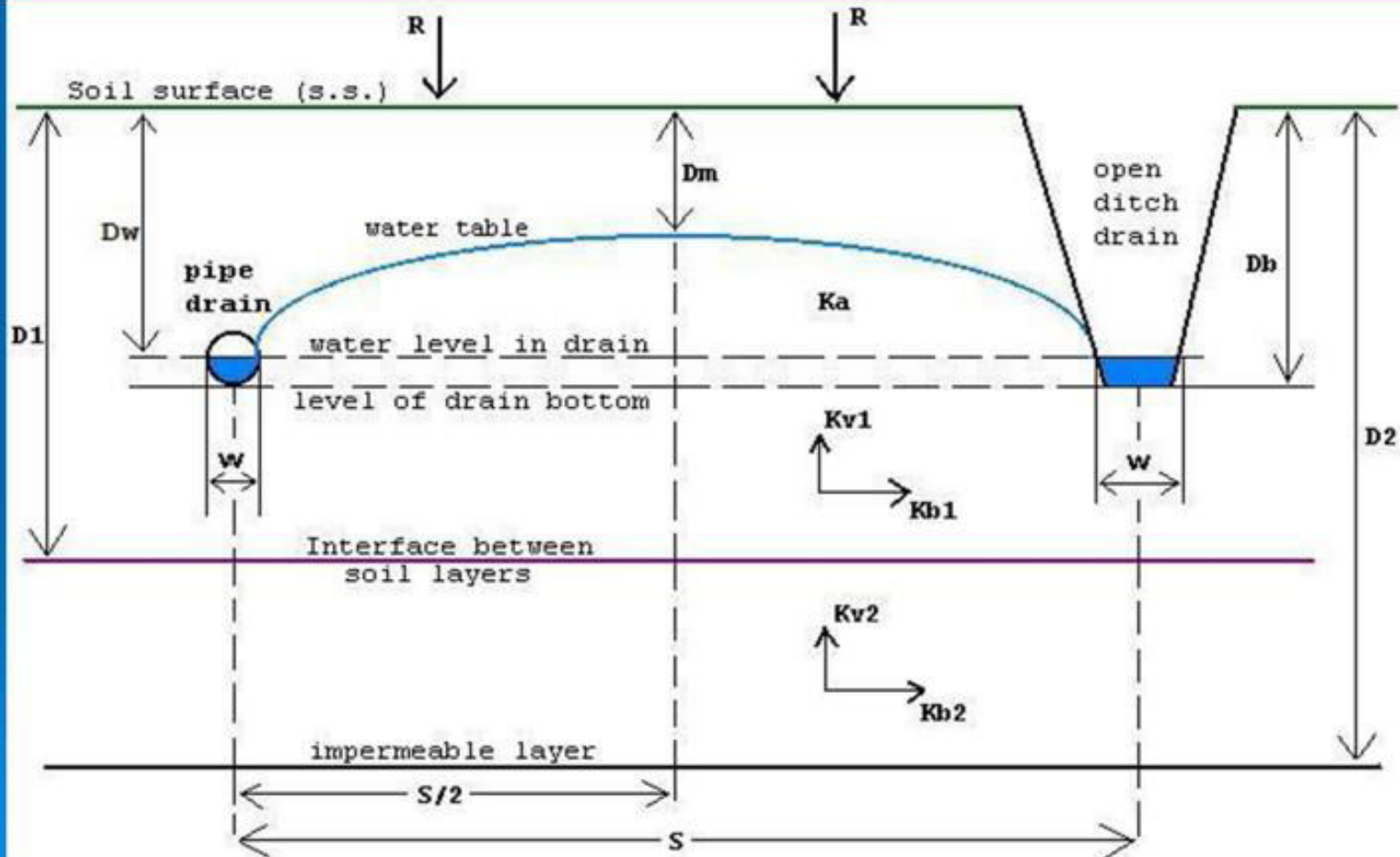
F is the infiltration entering the soil profile

# EnDrain

- Application of the energy balance of groundwater flow to pipe drains leads to lower elevations of the water table or, if the elevation is fixed, to a wider drain spacing
- Gives the shape of the water table
- Further, it can take entrance resistance and anisotropy of the soil's hydraulic conductivity into account
- Calculations with the energy balance need be done on a computer because of the cumbersome iterative, numerical procedure required.

# EnDrain

## Design approach Definition of inputs for the Endrain model



# EnDrain



EnDrain, groundwater drainage by pipes and ditches

File Edit

Intro | Figure | Input | Output | Graphics

File C:\Users\User\Documents\WRC ARC drainage\literature\Endrain model\DATA\I  
Title1 Rouzelle  
Title2 Designed Inputs  
Options The drain discharge is to be calculated  
Method Use the new energy balance method

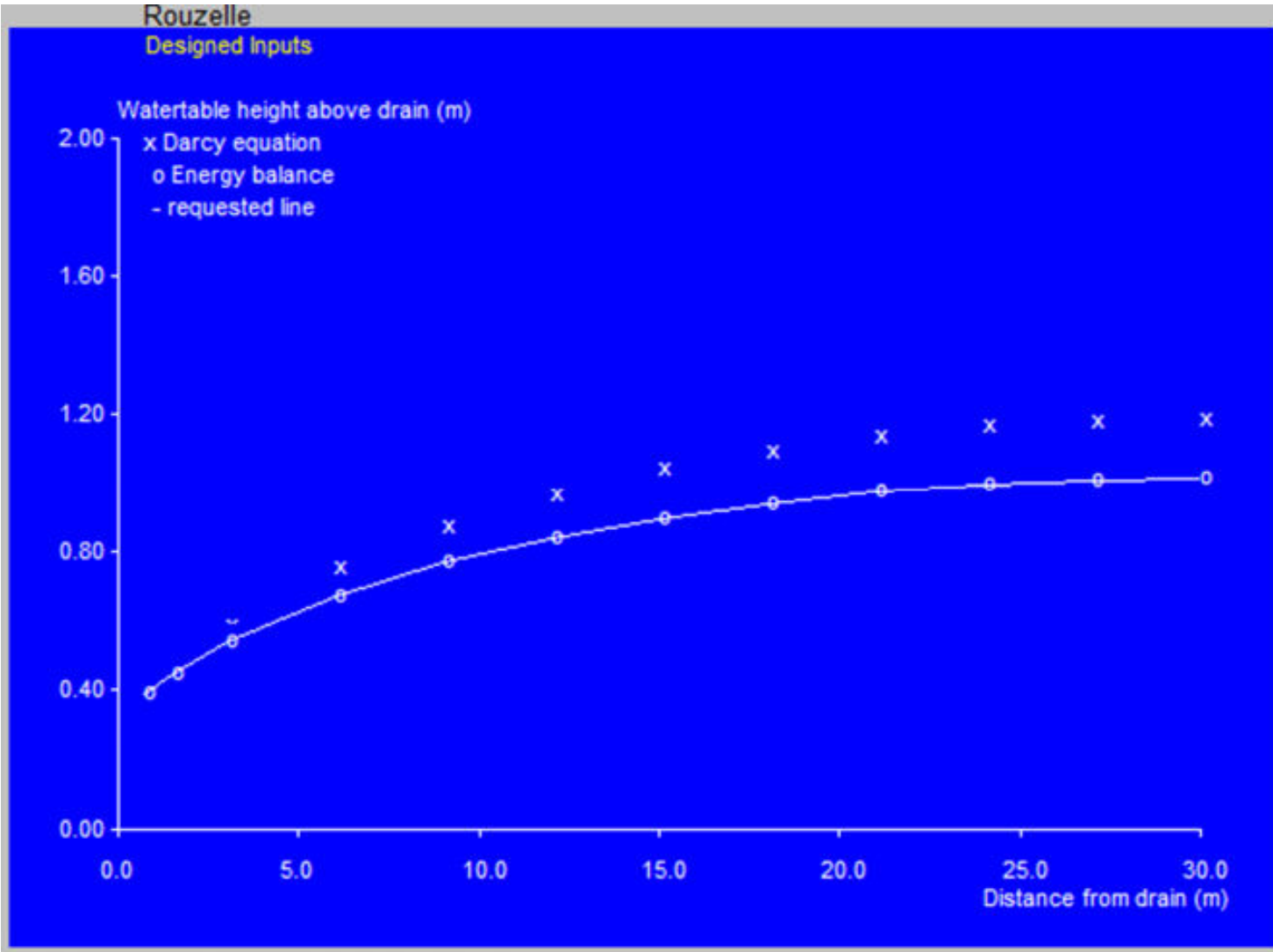
|   |     |           |       |
|---|-----|-----------|-------|
| Depth watertable midway between drains *) | Dm  | (m) :     | 1     |
| Bottom depth of 1st layer below s.s.      | D1  | (m) :     | 2.2   |
| Bottom depth of 2nd layer below s.s.      | D2  | (m) :     | 2.2   |
| Depth water level in drain below s.s.     | Dw  | (m) :     | 2     |
| Depth of the drain bottom below s.s.      | Db  | (m) :     | 2.036 |
| Entrance resistance at the drain          | E   | (day/m) : | 0.83  |
| Max. width of water body in the drain     | W   | (m) :     | 0.075 |
| Hydraulic permeability, above drain level | Ka  | (m/day) : | 4.1   |
| Horizontal permeability, 1st soil layer   | Kb1 | (m/day) : | 0.5   |
| Vertical permeability, 1st soil layer     | Kv1 | (m/day) : | 3.9   |
| Horizontal permeability, 2nd soil layer   | Kb2 | (m/day) : | 0     |
| Vertical permeability, 2nd soil layer     | Kv2 | (m/day) : | 0     |
| Spacing between the parallel drains       | S   | (m) :     | 60    |

\*) Time average

Help (E) | Figure | Save/Run | Open input

Enter data or use "Open" to see examples under "Data" or to edit existing files. Thereafter use "Save/Run".

# EnDrain





*ARC • LNR*



## ARTIFICIAL DRAINAGE INSTALLATION COSTS (2014)

|  | <u>Unit</u> | <u>Minimum spacing</u> | <u>Average spacing</u> | <u>Maximum spacing</u> |
|--|-------------|------------------------|------------------------|------------------------|
| <b>Inter row spacing distance (meters) of different soil types for effective drainage:</b> |             |                        |                        |                        |
| Heavy soils (>35% clay)  | m           | 20                     | 25                     | 30                     |
| Medium soils (15-35% clay)   | m           | 40                     | 45                     | 50                     |
| Light soils (<15% clay)  | m           | 70                     | 75                     | 80                     |
| <b>The total meters of drainage required per hectare :</b>                                 |             |                        |                        |                        |
| Heavy soils (>35% clay)  | m/ha        | 500                    | 400                    | 330                    |
| Medium soils (15-35% clay)   | m/ha        | 250                    | 220                    | 200                    |
| Light soils (<15% clay)  | m/ha        | 140                    | 130                    | 125                    |
| <i>Cost of installing drainage</i>   | <b>R/m</b>  | <b>200</b>             | <b>200</b>             | <b>200</b>             |
| <b>Total cost per ha of drainage on different soil types:</b>                              |             |                        |                        |                        |
| Heavy soils (>35% clay)  | R/ha        | 100 000                | <b>80 000</b>          | 66 000                 |
| Medium soils (15-35% clay)   | R/ha        | 50 000                 | <b>44 000</b>          | 40 000                 |
| Light soils (<15% clay)  | R/ha        | 28 000                 | <b>26 000</b>          | 25 000                 |

# Summary



Soil health and productivity can be obtained and maintained through efficient drainage which leads to well-drained soils and potentially higher yields

Higher yields translate into greater returns. So the investment decision is based on whether the higher crop returns will justify the investment in drainage

Project outputs will assist the farmer in the decision making process of whether or not to install an artificial drainage system which is **technically** sound and **financially** viable

# Acknowledgements



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