AGRICULTURAL RESEARCH COUNCIL

INSTITUTE FOR AGRICULTURAL ENGINEERING

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CLIENT REPORT

RECOMMENDATIONS, DESIGN REPORT AND SPECIFICATIONS

FOR THE IRRIGATION SYSTEMS AT PLOT 23 ONDERSTEPOORT, PRETORIA

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1. Introduction

The NRE-IrAIEng was requested by the API to give design recommendations and specifications for an irrigation system at Plot 23 Onderstepoort, Gauteng. The location of the plot is found at 25.549595 S and 28.143694 E.

1.1. General Description

The area to be irrigated is approximately 0.4 hectares in extent (the boundaries are presented in Table 1 and also shown in Figure 1 in green).

Table 1: Coordinates of key boundary points on the plot

ID	LATITUDE	LONGITUDE
A	-25.549389	28.142643
B	-25.54988	28.142634
C	-25.549872	28.143096
D	-25.54975	28.143241
E	-25.549732	28.143367
F	-25.549368	28.143335
TANK	-25.549381	28.143616
BOREHOLE	-25.550557	28.143108

The following are the client's preferences:

1. A micro sprinkler/sprayer irrigation system
2. Supply pipeline as well as the infield lateral pipelines should be moveable.
3. The sprinklers/sprayers should be removable.
4. The plot should be divided into distinct beds which are 5 m wide and separated by 1 m wide pathways
5. The overall design should put issue of theft into consideration
6. The plot is for leafy vegetable production including cabbage, spinach, etc.

Figure 1: The area that is to be irrigated

2. Legal compliance

The end user is to comply with all relevant local environmental and water use legislation.

3. Design Elements

3.1. Soil

3.1.1 Soil analysis

No detailed soil analysis was carried as literature and experience was used to characterize the soil on the plot as follows:

Soil type: Assumed as sandy loam

Soil depth: approximately 0.5 m

Water Holding capacity: 120 mm/m

3.2. Crop water requirement

Cabbage was selected as design crop to determine crop water requirements. Reference was made to a weather station in Pretoria to ascertain evaporative demand due to climatic data (over 30 year period of weather data). The water requirements of cabbage to be produced in this plot are presented in Table 2.

Table 2: Crop water requirement for cabbage

	Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**
	Average daily ET_o [mm/day]	6.4	5.2	4.5	3.6	2.9	2.4	2.7	3.6	4.8	5.3	5.5	6
1	ETo [mm/month]	198.4	145.6	139.5	108	89.9	72	83.7	111.6	144	164.3	165	186
2	Rainfall (mm/month)	107	99	88	40	17	7	3	7	18	65	92	118
	R [mm/day]	3.5	3.5	2.8	1.3	0.5	0.2	0.1	0.2	0.6	2.1	3.1	3.8
3	kc	0.99									0.58	0.93	0.99
4	ET_c [mm/month]	196.416	0	0	0	0	0	0	0	0	95.294	153.45	184.14
	ET_c [mm/day]	6.336	0	0	0	0	0	0	0	0	3.074	5.115	5.94
5	R_e [mm/month]	43.5	39.5	34	10	-1.5	-6.5	-8.5	-6.5	-1	22.5	36	49
	R_e [mm/day]	1.4	1.4	1.1	0.3	0.0	-0.2	-0.3	-0.2	0.0	0.7	1.2	1.6
6	NIR[mm/month]	152.916	-39.5	-34	-10	1.5	6.5	8.5	6.5	1	72.794	117.45	135.14
7	NIR[mm/day]	4.9	-1.4	-1.1	-0.3	0.0	0.2	0.3	0.2	0.0	2.3	3.9	4.4

In analyzing the crop water requirements in Table 2 above 1, the peak crop water requirement for irrigation system design purposes is 4.9 mm/day for cabbages. It should be note that effective rainfall has been taken into account.

3.3. Micro-sprinkler Irrigation system

3.3.1. Irrigation system design

3.3.1.1. Overview

An area of 4 000 m² is to be irrigated by means of a micro-sprinkler irrigation system. The area is to be divided into 3 blocks, each comprising of 4 beds 5 m x 52.55 m. Each block will have 4 laterals placed at the middle of each of the 5 m-wide beds.

The water source that will be used for irrigation is from an existing water tank which is situated 30.8 m (25.549381 S; 28.143616 E) away from near northern corner of the plot. Water is pumped from the tank to the irrigation system with its own dedicated pump. The general layout is shown in Figure 2.

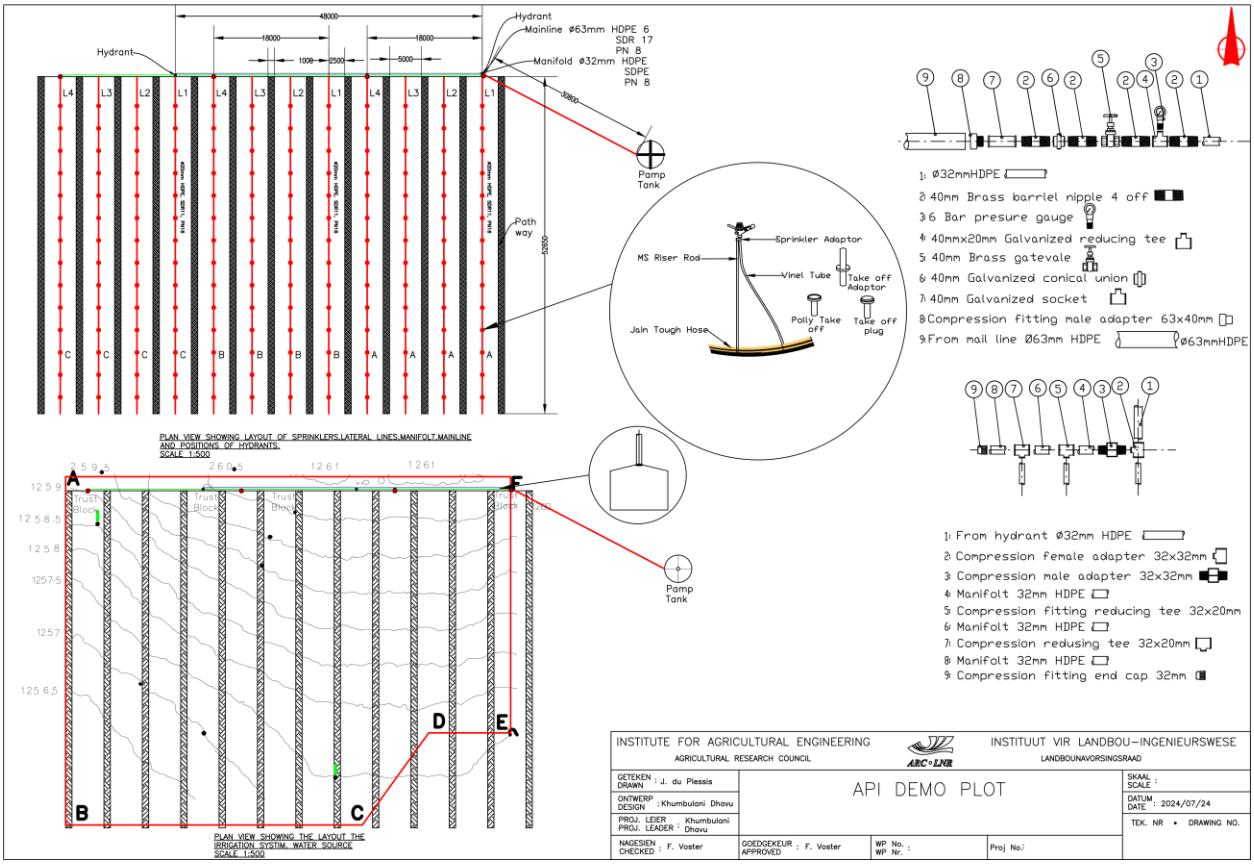

Figure 2: General layout of the irrigation blocks for the irrigation systems

3.3.1.2. Irrigation Practice for the Irrigation System

It is recommended that Rain Bird Sprinkler LFX 300 discharging 66 liter/hour spaced 3.5 m apart on 20 mm HDPE SDR11 PN16 lateral pipelines. The lateral pipelines should be placed at the center of each bed which is 5 m wide.

Based on the calculations shown in Table 2 and 3 below it is recommended that the following be adopted:

- Cycle length: The cycle length is 5 days at peak crop water requirement. The cycle length is the actual time lapse between the commencements of two successive applications of 29.4 mm on the same area.
- Standing time: The standing time is the time that a block is irrigated, before the next block is irrigated. At peak daily crop water requirement, the standing time is 5 hours.
- The system is designed in such a way that 29.4 mm of irrigation water can be applied during a cycle. In the peak growing season, the system will be able to deliver 5.28 mm of water per hour, which assuming a system efficiency of 85 %, will satisfy the peak crop requirement of 4.9 mm/day.
- Operating pressure: The micro-sprinkler irrigation system is designed to operate at 150kPa - 240kPa. Therefore, the pressure at the hydrant manifold is to be set at 240kPa.

Table 2: Emitter design

Water Holding Capacity100 (0-300)mm	120	mm/m
Effective root depth (cabbage)	0.5	m
Total Available water in soil	60.0	mm
Allowable water depletion	40	%
Readily Available water (RAW) =	24.0	mm
Net Irrigation Requirement	4.9	mm/day
Lateral Spacing	2.5	m
Emitter spacing	3.5	m
Wetted area	70	%
Cycle length	5	days
No. of working days per week/cycle	5	days
No. of working hours per day	8	hours
Standing time	5	hours
System Efficiency	85	%
Gross irrigation requirement per cycle	29.4	mm
Gross application rate	5.3	mm/hour

Table 3: Practical Emitter Selection

Rain Bird Sprinkler:	**LFX300**	
Primary nozzle size:	1.01	mm
Operating Pressure	240	kPa
Emitter flow rate: (qe)	66	l/h
Spacing: (S x L)	3.5 x 2.5	m x m
CU:	95.3	%
DU:	93.3	%

A summary of key hydraulic calculations of the irrigation system design are shown in the tables below.

Table 4: Calculation of flow rate per block

Sprinklers	Rain Bird LFX300 1.01 mm nozzle size	
Length of laterals	52.65	m
Lateral spacing	2.5	m
Sprinkler spacing	3.5	m
No. of sprinklers per lateral line	16	
No. of lateral lines per block	4	
No. of sprinklers per block	64	
Flow rate per sprinkler	0.066	m^3/hour
Flow rate per block	4.48	m^3/hour

Table 5: Constants and assumptions for lateral and manifold design

Sprinkler working/operating pressure: Pave =		24	m
Distribution tubing length =		0.91	m
Friction loss in Distribution tubing =		0.23	m
Allowable pressure variation: ΔP		4.8	m
Pressure loss in manifold:	**0.5ΔP**	2.4	m
Pressure loss in lateral:	**0.5ΔP**	2.4	m
Slope per segment (Lateral)		0.194	m
Slope per lateral		2.5	m

Table 6: Design parameters of the lateral lines

Block	Lateral number	No. of sprinklers on lateral	Lateral length (m)	Chosen pipe diameter (mm)	Chosen pipe type
A	L1	16	52.65	20	HDPE SDR11 PN16
	L2	16	52.65	20	HDPE SDR11 PN16
	L3	16	52.65	20	HDPE SDR11 PN16
	L4	16	52.65	20	HDPE SDR11 PN16
B	L1	16	52.65	20	HDPE SDR11 PN16
	L2	16	52.65	20	HDPE SDR11 PN16
	L3	16	52.65	20	HDPE SDR11 PN16
	L4	16	52.65	20	HDPE SDR11 PN16
C	L1	16	52.65	20	HDPE SDR11 PN16
	L2	16	52.65	20	HDPE SDR11 PN16
	L3	16	52.65	20	HDPE SDR11 PN16
	L4	16	52.65	20	HDPE SDR11 PN16

Table 7: Design parameters of the manifold lines

Block	Manifold section	Length of manifold section (m)	Chosen pipe diameter (mm)	No. of outlets in manifold	Chosen pipe type
A	L1-L4	18	32	4	HDPE SDR17 PN8
B	L1-L4	18	32	4	HDPE SDR17 PN8
C	L1-L4	18	32	4	HDPE SDR17 PN8

Table 8: Design parameters of the main pipeline

Pipe segment	Maximum flow rate per segment (m^3/h)	Length of pipe segment (m)	Cum. Length of pipe (m)	Chosen pipe diameter (mm)	Chosen pipe type
TANK - A	4.48	30.8	30.8	63	HDPE SDR11 PN10
A - B	4.48	24	54.8	63	HDPE SDR11 PN10
B - C	4.48	24	78.8	63	HDPE SDR11 PN10

Table 9: Calculation of the required pumping capacity

Block	A	B	C
Pressure (m)	36.13	36.13	36.13
x 1.05	37.94	37.94	37.94
Flow rate (m^3/h)	4.48	4.48	4.48
X 1.1	5.42	5.42	5.42
Required pumping capacity	**5.42 m^3/h @ 37.94 m**		

3.3.2. Pipes and fittings

The layout of the pipes is also shown in Figure 2. Individual fittings are not all shown. All pipes and fittings are listed in the Bill of quantities.

The whole pipeline system will be above ground to allow for removal to store them at a safe place to avoid theft.

3.3.3. Pump Station

The duty point of the pump is 5.42 m^3/h at a pressure of 370 kPa. A pump with similar characteristics as the KSB ETANORM 04-025-200 at 2900 rpm should be used to pump water from the tank to the irrigation system. The impeller of the pump should be trimmed to 201 mm diameter to meet the above duty point requirements.

The size of the 2-phase electric motor required by this pump is 3.0 kW. An electric motor with characteristics as the GMYL-100L-2 3.0 Kw at 2800 rpm MOTORELLI ELECTRIC MOTOR should be used

The details of the pump house must be designed by the supplier according to the guidelines as outlined in the ARC-IAE Irrigation Design Manual, Chapter 16.

3.4. Electrical work

3.4.1. Transformer

A 50 m electric cable of 10 mm^2 cross-sectional area must be used to connect the electric motor to the nearby transformer which 200 V (at least 21 kVA single phase).

4. Bill of quantities

4.1. Micro-sprinkler Irrigation System

Refer to Table 3 below. Extra stock (in length) has been added to avoid procurement glitches. On number items, 2 or 3 items additional may also be added during procurement.

Table 3: Bill of quantities of the Irrigation system

Item number	Description	Size	Quantity	Unit	Rate (R)	Amount (R)
Main pipeline:						
1	HDPE SDR17 PN8 pipe	63 mm	50	m		
Mainline Fittings:						
2	Compression fitting: Male adaptor	63 mm x 40 mm	1	No.		

Hydrants:						
3	Galvanized socket	40 mm	3	No.		
4	Galvanized conical union	40 mm	3			
5	Brass gate valve	40 mm	3	No.		
6	Galvanized reducing tee	40mm x 20 mm	3	No.		
7	6 Bar pressure gauge	20 mm	3	No.		
8	Galvanized barrel nipple	40 mm	12	No.		
Manifold pipeline:						
9	HDPE SDR17 PN8 pipe	32 mm	70	m		
10	Compression Fitting: female adaptor	32 mm x 32 mm	3	No.		
11	Compression Fitting: male adaptor	32 mm x 32 mm	3			
12	Compression Fitting: Reducing Tee	32 mm x 20 mm	12			
13	Compression Fitting: End cap	32 mm	3			
14	Compression Fitting: End cap	20 mm	12			
Item number	**Description**	**Size**	**Quantity**	**Unit**	**Rate**	**Amount**
Laterals:						
15	HDPE SDR11 PN16	20 mm	650	m		
16	Micro-sprinkler riser rod	8 mm diameter and 54 cm length	192	No.		
17	Feedtube (76 cm)	Universal (with barb and universal riser adapter	192	No.		
18	Poly take off	universal	192	No.		
19	Take off plug	universal	192	No.		
20	Take off adaptor	universal	192	No.		
21	Sprinklers	Rain Bird LFX300 1.01 mm nozzle diameter	192	No.		
Miscellaneous:						
22	PTFE Tape or similar thread sealant	Enough to seal all the threaded fittings to prevent leakage				