THE DESIGN AND OPERATION OF 560 HECTARE OF DRIP IRRIGATION AT SIMUNYE SUGAR ESTATE (SWAZILAND)

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Abstract

Between January and October 1985 Simunye Sugar Estate designed and installed 560 hectares of drip irrigation on newly cleared land. The system was designed for the cultivation of a cotton and dry bean rotation with provision for conversion to sugarcane at minimum cost. The paper describes the rationale for the selection of the irrigation system, defines the design parameters and describes detailed features of the system when installed.

Introduction

Simunye Estate currently produces about 120 000 tons of raw sugar annually from 9 200 hectares of its own cane lands plus the production from one large scale commercial producer. Depressed world sugar prices over recent years have not encouraged any increase in sugar production, although the Simunye factory has additional built-in production capacity which can be utilized when market conditions change. Because of the lack of expansion potential for sugar, the company has implemented a new project to grow cotton and beans, thus utilising two remaining blocks of arable land and irrigation water from the Mnjoli Dam which is built on the Black Umbuluzi river.

The Project Area

Simunye Estate lies in the northern lowveld of Swaziland. The climate is sub-tropical, with an approximate annual average class A pan evaporation of 2000 mm and 800 mm of rainfall.

Soils in the new block developed for cotton and beans are generally clays, sandy clays and an area of black swelling clay; Table 1 lists the soil groups and area distribution. The new fields are on gently rolling topography with slopes of about 2,5 %.

Table 1
Soil groups - Impala main blocks and extension

Swazi classification	Extension	Impala main	SA classification
Kwezi deep	30,7	58,3 ha	Rensburg
Kwezi shallow	1,5		Arcadia
Kwezi mod deep	-	65,9 ha	Arcadia
Rondspring deep	30,9 ha	218,1 ha	Shortlands
Somerling	12,3 ha	51,6 ha	Genrosa
Shebani	-	92,7 ha	Mayo
Dark red brown intergrates	7,0 ha	14,9 ha	Mayo
Zwide/Habelo	1,6 ha	1,3 ha	Swartland/ Valsrivier
	84,0 ha	502,8 ha	

Total 586,8 ha = 560 ha nett area

Selection of Irrigation System

There has been limited experience in growing irrigated cotton and beans in the lowveld of Swaziland or in adjacent South Africa. The objectives of selecting drip irrigation were to maximise yield and minimise operating costs. Furthermore because Simunye would need to construct housing for additional permanent employees, the capital costs for drip irrigation were comparable with dragline sprinkler irrigation (see Table 2).

Table 2
Comparative costs - Drip vs Sprinkler irrigation

Note:
1. The following costs per hectare in South African rands compare only variable capital costs for the two systems. Costs common to both systems are excluded.
2. The comparison of irrigation equipment costs is based on detailed schemes worked out for drip and sprinkler irrigation.
3. Computer control and housing costs are based on requirement for 720 hectares of development.

Description	Drip	Sprinkler
Pumps, motors, filters, infield pipelines, valves and surface equipment	2 705	2 335
Filter stations, pipe installation, extra supervision etc.	209	101
Computer control	249	25*
Housing	498	1 085
Total	3 661	3 546

* Interlink between canal and booster station

Enhanced yield potential was anticipted as a result of precise water control and fertigation through the computer controlled drip system. Operational savings were anticipated, compared with conventional sprinkler systems, through reduced power use (lower head and more efficient water use), reduced insecticide application, as chemicals would not be washed off the plant, and reduced manpower requirement for irrigation.

Overall Design

The design was co-ordinated by Simunye with detailed irrigation equipment design and technical inputs from commercial suppliers.

Unit Layout

The system is designed to supply 7,8 mm per day gross irrigation through 2ℓ/h long path drippers at 1 m spacing along 12 mm diameter drip line. Drip line spacing is 2 m for cotton/beans with provision to convert to 3 m spacing if cane is planted in the future.

Dripper and drip line spacing was based on experimental and commercial experience on similar soils at Simunye. Long path drippers were selected in preference to compensating drippers because of the high cost of compensated dripper line (about double), and the increased power consumption needed for the higher working pressures. Dripper lines constituted nearly 30% of the capital cost for irrigation equipment, thus 12 mm dripper lines were selected as an economic necessity.

Unit size and layout is dictated by hydraulics with the objective to achieve a 90% coefficient of uniformity. The dripper line lengths are constrained by gradient and the laterals must be matched to the ground profile. A 50 mm diameter valve commands each unit. Typical unit size is 2 hectares.

Overall Layout

Figure 1 shows the overall layout and Figure 2 shows how a number of typical units are linked into the underground system of uPVC mains. The valve suffix of a, b or c designates to which irrigation schedule that valve will respond e g at peak irrigation schedule 'a' may operate midnight to 08h00, schedule 'b' 08h00 to 16h00 and schedule 'c' 16h00 to midnight thereby optimising the flow in the underground network.

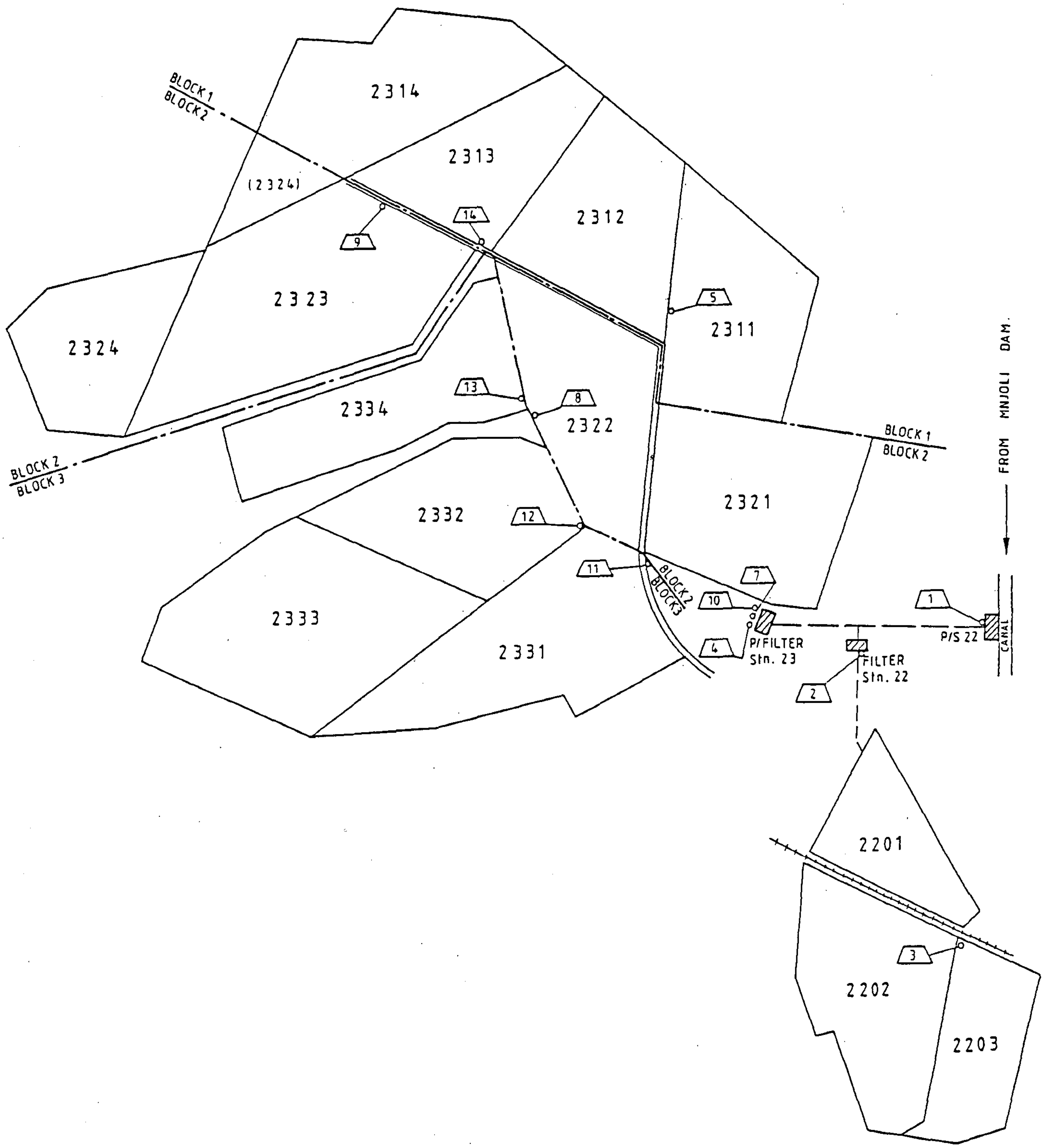


FIGURE 1 Impala Ranch overall layout

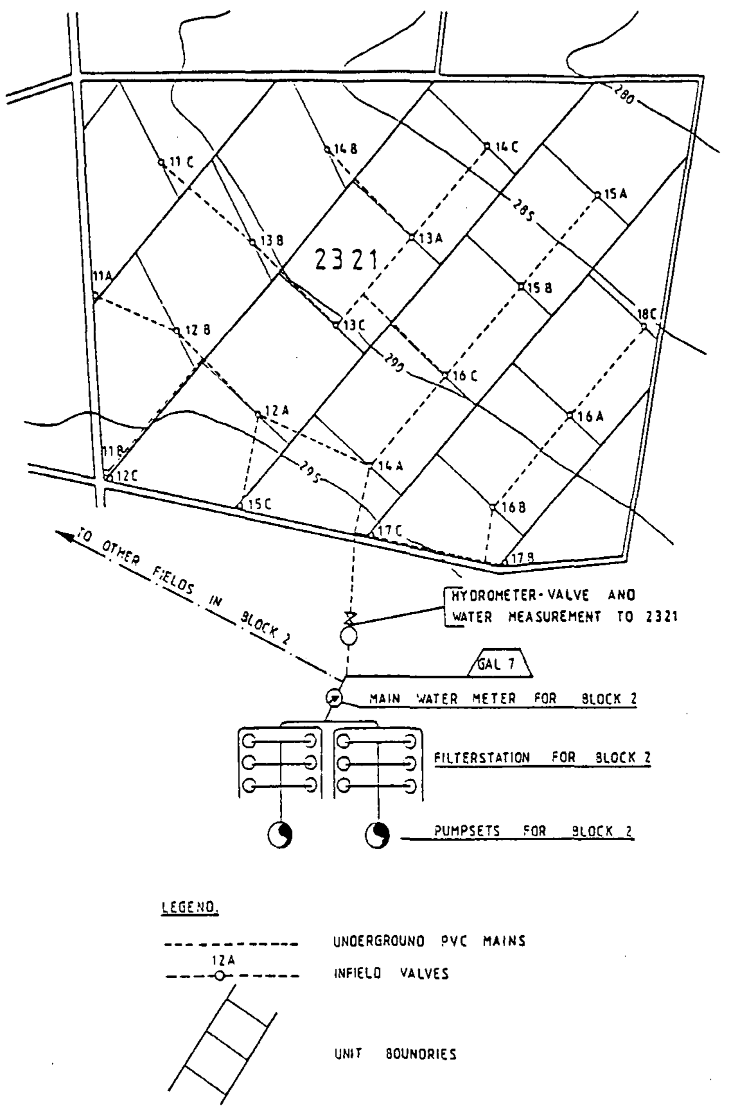


FIGURE 2 Irrigation layout and control field 2321

The detailed network for the underground mains was modelled on computer and optimised for hydraulic distribution, capital cost and power saving. The same programme provided the pipeline design and quantities.

Target crop row gradients were specified as follows: 1 to 0.5 % heavy black clays; 0.7 to 0.3 % other soils. Units were then grouped for management purposes into fields with similar soil types and topography to ease irrigation management and achieve efficient mechanised operation by ignoring unit boundaries for land preparation, planting and harvesting. The underground pipe network is arranged so that flow to one or two fields is monitored and controlled separately.

Water is pumped to the development area through a 500 mm diameter rising main 1 300 m long from a pump station sited on the main supply canal from Mnjoli Dam. This pump station contains seven identical 260 m³/h pumps. A branch from the rising main with a booster and filter station serves 70 hectare while a second booster and filter station at the end of the rising main serves the remaining 490 hectare. The latter is divided into three blocks with two pumps per block, impellers being matched to the varying head conditions.

The entire system is controlled by field micro-processors linked to a central IBM PC computer. Figure 3 shows a diagrammatic layout of the control system.

Detailed Features

Canal Pump Station (PS 22)

The seven identical pumps deliver into a common manifold which contains a surge anticipating valve with return discharge to the canal to protect the rising main.

The pump starts/stops are initiated by a micro-processor (GAL 1) which can be programmed to change duty sequences. Automatic hydraulically controlled pressure sustaining/non-return valves are installed downstream of each pump to facilitate automation.

Pump protection systems are installed for low water level via probes in the pump well, for power failure via relays in motor control centres and for motor temperature via thermisters in motors.

Booster Pumps (PS 23)

Each pair of booster pumps at pump station 23 is protected against power failure, overheating and low pressure in the manifold. Pump starts/stops are initiated by GAL 1.

Filtration

Each booster pump delivers to a bank of six sand filters each with a secondary disc filter. The connecting manifolds and hydraulically controlled valves facilitate sequential backwashing of each sand/disc filter unit. The purpose of the disc filters is to provide a final polishing and an added safety measure in case of sand filter failure and a means to visually check the effectiveness of the sand filters.

Delivery network

The PVC pipe supply network of each block contains a master water meter, infield hydrometers, and infield control valves to each irrigation unit. The hydrometers indicate flows via electrical pulses to adjacent GAL field units and also open or close water to sections of the network via a hydaulic control relay activated by a solenoid at the appropriate infield GAL.

The infield control valve assembly is illustrated in Figure 4. The Galid maintains the valve in a normally closed position until pressure is introduced into the hydraulic control tube by means of a hydraulic relay operated by a solenoid at the appropriate infield GAL. The valve then opens and supplies water to the lateral pipe and dripper lines.

Control system

Figure 2 shows the irrigation system and control for field 2321. GAL 7 controls water distribution to field 2321 and measures flow through the hydrometer. In order to initiate irrigation the sequence of events is as follows:

(1) The Manager programmes GAL 7 for a real time start to a set of irrigation cycles for schedules 'a', 'b' and 'c' in field 2321.

(2) GAL 7 recognises cycle start time and signals a pump start to GAL 1.

(3) GAL 1 starts a main pump at PS 22 and signals booster pump start to GAL 7.

(4) GAL 7 observes a pre-programmed delay for rising main to pressurise, starts booster pump at PS 23.

(5) GAL 7 holds field 2321 network in wait mode until the operating pressure is reached then opens the valves for the relevant schedule, say schedule 'a'. Irrigation is now taking place and the control system performs the following functions:

(a) GAL 1 monitors pressure at PS 22 and starts/stops pumps to maintain the correct pressure.

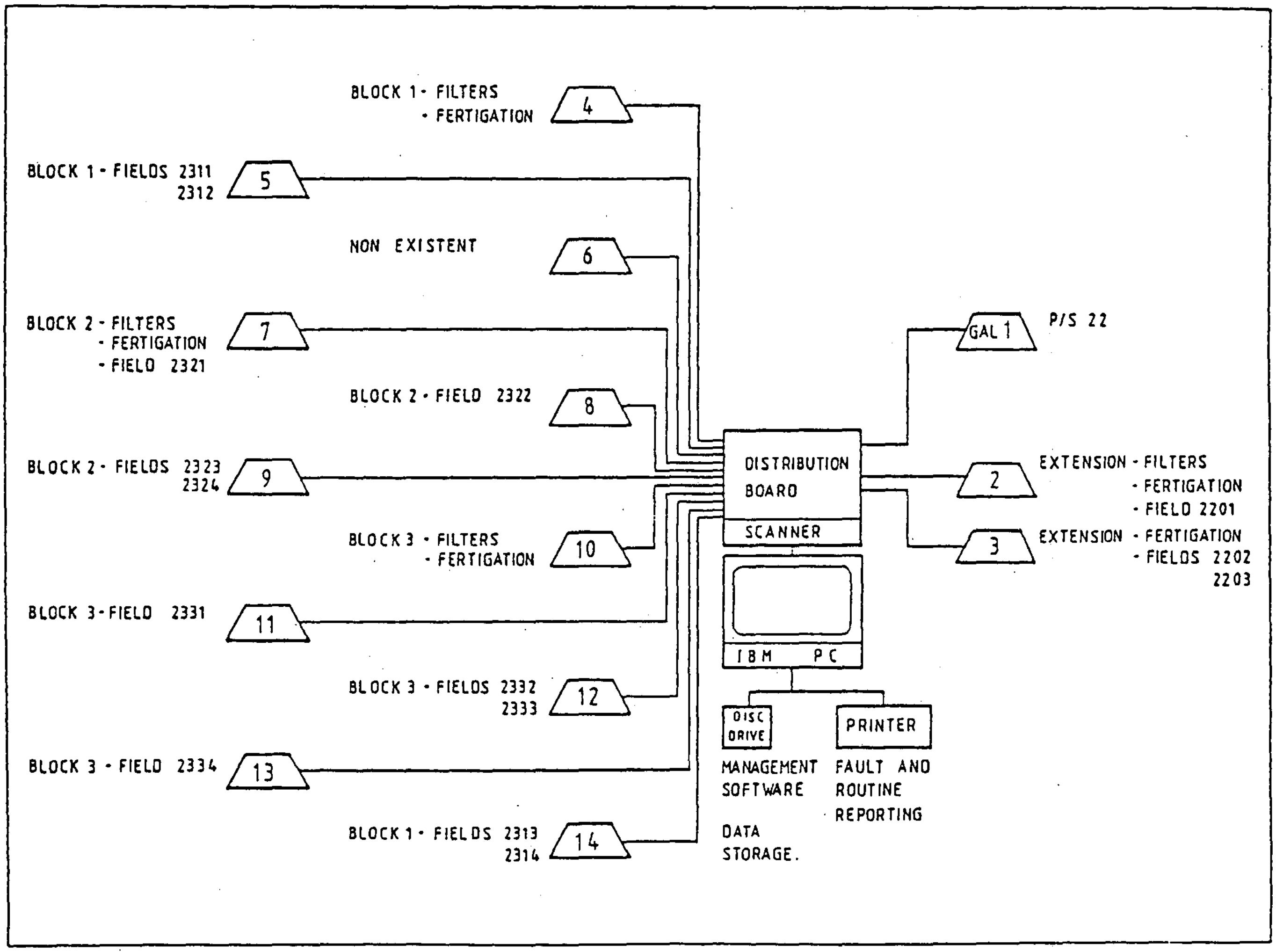
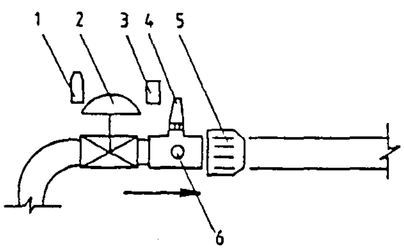


FIGURE 3 Irrigation control system



ITEM Nº	DESCRIPTION
1	MINI PILOT.
2	P R VALVE HYDRALICLY OPERATED
3	GALIT THREE WAY VALVE.
4	ANTI VACCUM VALVE.
5	HDPE MALE ADAPTOR
6	PRESSURE MONITORING POINT.

FIGURE 4 Infield valve assembly

(b) GAL 7 controls and measures injection of fertilizer and initiates backwashing of block 2 filters.

(c) GAL 7 monitors pressure in field 2321 network and shuts hydrometer, closing irrigation, if pressure falls, and re-opens provided pressure rises.

(d) Gal 7 closes schedule 'a' valves and opens schedule 'b' once programmed application (by time or quantity) has been applied.

On completion of irrigation the following sequence of events occurs:

(1) GAL 7 signals stop pump to GAL 1 and closes hydrometer and infield valves.

(2) GAL 1 signals stop booster to GAL 7 and initiates pump stop and valve close at PS 22.

All the above events are initiated and controlled by the GAL field units without reference to the central IBM PC computer. The central computer provides the following facilities:

- Centralised programming of each field unit through well organised tabular presentations.
- Constant monitoring, reporting and storage of all events throughout the system including records of water and fertilizer applications.
- Network protection for sections of the network upstream of areas controlled by infield units through aggregating measured system flows.

Operation of the System

Although the design of the automation system is complex, operation is simple and once the logic is understood fault finding is fairly easy. The system is operated at Simunye by the Section Manager responsible for the management of all the cotton operations, who received one weeks formal training, plus supervision and assistance from the supplier during commissioning work which took 3 to 4 weeks.

The system was installed in less than six months and apart from a few leaks in the 45 kilometres of underground PVC pipes and some minor commissioning faults the system came into use quickly. A particularly important point during commissioning is the need for thorough flushing of the system before fitting valves and control equipment.

Acknowledgements

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