Design and optimization of irrigation distribution networks

by

Y. Labye

Consultant CEMAGREF, Antony, France

M.A. Olson

Consultant Harza, Chicago, USA

A. Galand

Consultant Société du Canal de Provence, France

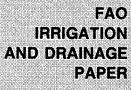
N. Tsiourtis

Consultant Ministry of Agriculture and Natural Resources Nicosia, Cyprus

and the set of the set	
Techn, Hochschu	le Darmstadt
Institut für W Fachgebiet Konstruk	
	Virtschoff
VP-7 199	3
Inv Nr R	13.507
	<u> </u>
Inv. Nr. R	13.507

SCHULE DARA

Bibliothek Wasser und Umwelt (TU Darmstadt)



44



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, 1988 CONTENTS

				-			
1.	TYPES	OF DIST	RIBUTION NETWORKS	1			
	1.1 1.2 1.3 1.4	 Definitions of Network Components Definitions of Network Parameters 					
		1.4.2	Classification according to source of supply Classification according to type of conveyance system	4 4			
		1.4.3	Classification according to pressure availability Classification according to origin of pressure	5 5			
			Classification according to mode of distribution	6			
2.	BASIC	HYDRAUL	ICS AND ECONOMICS	9			
	Α.	HYDRAU	LICS	9			
	2.1 2.2 2.3		action teristics of Water E Water in Pipes	9 9 9			
		2.3.2 2.3.3	State of flow Flow relationships Head loss due to pipe friction Minor losses	9 10 12 15			
	2.4	Flow o	f Water in Open Channels	15			
		2.4.2	Types of flow State of flow Channel geometry Velocity distribution and measurement of	15 17 17			
		2.4.5	discharge Flow relationships The hydraulic jump Flow resistance due to friction	19 19 27 29			
	Β.	ECONOMICS 40					
	2.5 2.6 2.7	Phases of a Project Appraisal Study40General Methods: Multi-criteria Analyses43Economic and Financial Analysis of Agricultural43Projects43					
		2.7.2 2.7.3 2.7.4	Economic analysis Shadow prices	43 45 46 47			
		2.7.6	Final stage of economic analysis: calculation of the internal rate of return Discount Calculation of the internal rate of return	49 49 50			

Page

3.	NETWOR	RK LAYOU	T AND DESIGN DISCHARGE	55		
	3.1 3.2 3.3	Struct	uction ure and Layout of Open Channel Systems ure and Layout of Pressure Distribution Networks	55 55 59		
			Design of a network for on-demand irrigation Design of a network for irrigation by rotation Optimization of the layout of branching networks	59 61 62		
	3.4	Water	Supply by Rotation and Determination of Flows	69		
		3.4.1	Fixed stream size rotation Reduction of constraints associated with	69		
		3.4.3 3.4.4	distribution by rotation Case of pressure networks operated by rotation			
	3.5	Flow i	n Pressure Networks Operating On-demand	77		
		3.5.2	Flow at farm outlets The demand formula Field of application of on-demand irrigation	78 78		
			networks Limited on-demand irrigation	82 84		
	3.6	Discha	rge in Continuous Flow Systems	84		
4.	DESIGN NETWOR		TIMIZATION TECHNIQUES OF PRESSURE DISTRIBUTION	89		
	4.1 4.2					
		4.2.2	Introduction Principles of rational numbering Example of network numbering Use of the network description table	90 90 92 94		
	4.3	Conten	ts of the Table of Suitable Pipes	96		
		4.3.1 4.3.2 4.3.3	Application of the table of suitable pipes	96 97 99		
	4.4	Minimu	m Price of a Section	99		
		4.4.3	Not more than two pipes per section Practical application of the list of pipes suitable for a given section	99 99 101		
	4 F	4.4.4	Special cases	103		
	4.5		Steps for the Calculation of the Minimum etwork	108		
		4.5.1 4.5.2 4.5.3	Introduction Adding sections in derivation Adding sections in series	108 109 111		

F١

4.6	Determi	ination of the Minimum Cost of a Network	114		
	4.6.1	First step: ascending the network	114		
	4.6.2	Determination of the upstream piezometric head Second step: descending the network	117 121		
	4.6.4	Case where a single diameter is allowed	121		
4.7	Specia	l Features	123		
	4.7.1	Limiting the number of segments on the lower			
		envelope curves	123		
	4.7.2	Installation of a booster	126		
4.8	Regulation of Pumping Stations Supplying Pressure Networks				
			128		
		Introduction	128		
		Manual regulation Automatic pump regulation	128 130		
		Variable speed pumps	141		
		Conclusions	142		
DESTON	AND OP	FIMIZATION TECHNIQUES OF OPEN CHANNEL			
		NETWORKS	147		
5.1	Introdu	iction	147		
5.2		and Optimization of Conveyors	147		
	5 2 1	Open channel conveyors	147		
	5.2.2		186		
5.3	Design	and Optimization of Distribution Networks	195		
	5.3.1	Open channel systems	195		
5.4	Regulat	tion of Canal Networks	201		
	5.4.1	Tataoduction	201		
	5.4.1	Introduction Regulation of small canals	201		
	5.4.3	Regulation of pumping stations supplying	201		
		irrigation canals	207		
CDECTAI	CONST	NEDATIONS - WATED HAMMED CYDSEOUS SOILS			
SPECIAL CONSIDERATIONS - WATER HAMMER, GYPSEOUS SOILS, CORROSION, MATERIALS AND EQUIPMENT					
6.1	Water H	Hammer	211		
	6.1.1	Introduction	211		
	6.1.2	Protection against the effect of water hammer	214		
	6.1.3	Equation for determination of volume of the			
	6.1.4	pressure vessel Description and operation of the air-pressure	217		
	0.1.4	vessel for protection against the effect of			
	_	water hammer	218		
	6.1.5	Ancillary protection	219		
6.2	Gypseou	us Soils	221		
	6.2.1	Introduction	221		
	6.2.2	Design Criteria and Treatment Procedures	222		

5.

6.

vii

6.3 6.4	Agression of Irrigation Networks by Water and Soils Materials and Equipment				223 223	
	6.4.2 6.4.3 6.4.4	Introduction Pipes Pump protection equipment Reservoir valves Open canals				223 223 230 230 230
Annex	Use of	the programme				233
References						245

.