## **Contents**

	Preface to the Third Edition Preface to the Second Edition Preface to the First Edition	v vii ix
1.	FLOOD PROBLEMS	1–7
	1.1 Introduction	1
	1.2 Indian rivers and flood	2
	1.3 Causes of flooding and economic losses	2 3 4 5
	1.4 Flood management measures	4
	1.5 Flood control strategies	5
	1.6 Alleviation of flooding	6
2.	ESTIMATION OF DESIGN FLOOD	8–77
	2.1 Introduction	8
	2.2 Methods of design flood computations	9
	2.2.1 Observation of highest flood	9
	2.2.2 Empirical flood formulae	9
	2.2.3 Flood frequency study	14
	2.2.4 Derivation from storm studies and application of unit hydrograph principle	18
	2.2.4.1 Rainfall analysis—Mass rainfall curves	19
	2.2.4.2 Runoff analysis	21
	2.2.4.2.1 Infiltration approach	21
	2.2.4.2.2 By runoff percentage	23
	2.2.4.3 Soil Conservation service-US curve number method	25
	2.2.4.4 Rational method	26
	2.2.4.5 Derivation of regional flood formula	27
	2.2.4.6 Hydrograph and derivation of unit hydrograph	29
	2.2.4.6.1 Derivation of unit hydrograph	30
	2.2.4.6.2 Duration of unit storm period	31
	2.2.4.6.3 Limitations of the unit hydrograph theory	32
	2.2.4.6.4 Concentration of runoff near peak	32
	2.2.4.6.5 Synthetic unit hydrograph	33
	2.2.4.6.6 Changing the duration of a unit hydrograph	34
	2.2.4.7 Estimation of design storm and the design flood therefrom	35
	2.2.4.7.1 Estimation of design flood	36
	2.2.4.8 Design flood from IUH: basic concepts of instantaneous unit hydrograph	37

	2.2.4.8.1 Derivation of IUH from conceptual model	37
	2.2.4.8.2 Diskin's method of obtaining IUH from derivatives	40
	2.2.4.9 Design criteria for dams and embankments	43
3.	FLOOD ROUTING THROUGH RESERVOIRS AND CHANNELS	78–151
	3.1 Flood routing through reservoirs: General	78
	3.2 Basic Principles of routing	78
	3.2.1 Pul's method or inflow-storage-discharge method	78
	3.2.2 Cheng's graphical method	81
	3.2.3 Working value method	83
	3.2.4 Other methods	84
	3.2.5 Electronic analogue	85
	3.2.6 Mechanical flood router	86
	3.3 Routing through river channels	87
	3.3.1 Muskingum method	89
	3.4 Hydraulic flood routing	94
	3.4.1 Continuity equation of unsteady flow	. 94
	3.4.2 Dynamic equation of unsteady flow	′ 95
	3.4.3 Characteristics of flood waves	96
	3.4.3.1 Flood wave on steep slopes	97
	3.4.3.1.1 Kinematic wave	97
	3.4.3.1.2 Dynamic wave	98
	3.4.3.1.3 Monoclinal wave	99
	3.4.3.2 Flood waves on gentle slopes	99
	3.4.3.2.1 Rating curve for unsteady flow	100
	3.4.4 Characterization of flood waves by rating curve	101
	3.4.5 Flood waves in natural streams	103
	3.4.5.1 Simplified analysis	103
	3.4.5.2 Methods of characteristics	105
	3.4.5.2.1 Characteristics	105
	3.4.5.2.2 Method of finite difference	108
4.	DESIGN OF SPILLWAYS	152–166
	4.1 Functions of spillways	152
	4.2 Spillway classification	152
	4.3 Types of spillways	152
	4.3.1 Hydraulic design	153
	4.3.1.1 Discharge	153
	4.3.1.2 Discharge from gate controlled spillway	155
	4.3.2 Side channel spillways	156
	4.3.3 Chute spillway	158
	4.3.4 Shaft spillway	159
	4.3.5 Siphon spillway	160
	4.3.6 Emergency spillway	161

5.	FLOOD MITIGATION THROUGH PLANNING OF RESERVOIR CAPACITIES AND OPERATION OF RESERVOIRS	167–211
	5.1 Introduction	167
	5.2 General design factors	168
	5.3 Storage capacity determination	168
	5.4 Live storage capacity	169
	5.4.1 Mass curve	170
		170
	5.5 Flood storage	172
	5.6 Dead storage	173
	5.6.1 Reservoir silting	173
	5.6.1.1 Sediment outflow	174
	5.6.1.2 Trap efficiency	174
	5.6.1.3 Computation of unit weight	175
	5.6.1.4 Measurement of sediment yields	170
	5.6.1.4.1 Reservoir sedimentation surveys	
	5.6.1.4.2 Sediment load measurements	177
	5.6.1.5 Distribution of sediment in a reservoir	177
	5.6.1.5.1 Moody's method to find new zero elevation	179
	5.6.1.6 Useful life of reservoirs	180
	5.6.1.7 Environmental effects of dams and reservoirs	182
	5.7 Reservoir operation fundamentals	183
	5.7.1 Operation of reservoir with conventional rule	183
	5.7.2 Operation of reservoir with single rule curve	185
	5.7.3 Reservoir operation with zoning or partitioning	185
	5.7.4 Ideal reservoir operation for flood control	186
	5.7.5 Operation procedure of multipurpose reservoir	188
	5.8 Reservoir operation from practical considerations	189
	5.8.1 Based on annual storage capacity to the annual runoff	189
	5.8.2 Based on regulation of reservoirs	190
	5.8.2.1 Single-purpose reservoirs for flood control	190
	5.8.2.2 Conservation reservoir	192
	5.8.2.3 Multipurpose reservoir	193
	5.8.2.4 System of reservoirs	193
	5.8.3 Spillway gate operations schedules	193
	5.8.4 Operation to ensure maximum and minimum flow	194
	5.8.4.1 Single-purpose reservoir	194
	5.8.4.2 Operation of multipurpose reservoir	196
6.	FLOOD MITIGATION THROUGH RIVER PROTECTION AND	
	IMPROVEMENT WORKS	212–256
	6.1 Introduction	212
	6.1.1 Types of river	212
	6.2 Theoretical background in river engineering	214
	6.2.1 Types of flow	214
	6.2.2 Resistance laws	214
	6.2.3 Energy slope	216

	6.2.4 Gradually varied flow	218
	6.2.5 Three dimensional flow	220
	6.2.5.1 Circular and helicoidal flow	222
	6.3 River improvement works	225
	6.3.1 River and hydrographic surveying	225
	6.3.2 River training for flood protection	227
	6.3.2.1 Embankment	227
	6.3.2.2 Discharge capacity	228
	6.3.3 Design of river dyke or embankment	229
	6.3.3.1 Computation of wave heights	230
	6.3.3.2 Design of dyke section	231
	6.3.3.3 Stability analysis of the dyke	231
	6.3.4 Bank protection	233
	6.3.4.1 Causes of bank recession	233
	6.3.4.2 Classification of bank protection works	234
	6.3.4.2.1 Direct protection	234
	6.3.4.2.2 Indirect protection	237
	6.4 Channel improvement	240
	6.5 Cutoffs	240
	6.6 Diversion	242
	6.7 Flood relief or by-pass channel	243
	6.8 Intercepting of cutoff channel	243
	6.9 Floodways	243
	6.10 Flood-plain zoning or redevelopment	245
	6.11 Spreading grounds	245
	6.12 Soil conservation methods	246
	0.12 Soft Conscivation methods	240
7.	FLOOD FORECASTING, WARNING AND FLOOD FIGHTING	257–273
	7.1 General	257
	7.2 Basic data	259
	7.3 Communication network	260
	7.4 Forecasting techniques and procedures	260
	7.5 Forecasting rainfall	261
	7.6 Determination of runoff from rainfall data	262
	7.7 Method of forecasting stages	263
	7.7.1 The Relationship for the peak travel time	264
	7.7.2 Example on forecasts reporting	265
	7.8 Flood warning	268
	7.9 Engineering measures for flood fighting	272
8.	ECONOMICS OF FLOOD CONTROL, PROJECT	274–280
-	8.1 General	274
	8.2 Estimating flood damages	275
	8.3 Estimates of benefit of flood control	276
	8.4 Cost-benefit analysis for a flood control project	277
	8.5 Flood control planning through remote sensing	278
	1	270

		xv
	8.5.1 General	278
	8.5.2 Remote sensing technique	279
9.	DESIGN OF SUBSURFACE DRAINAGE SYSTEM	281–295
	9.1 Introduction	281
	9.2 Necessity for drainage	281
	9.2.1 Topographic factor	281
	9.2.2 Drainage factor	282
	9.3 Removal of drainage water: Under drains and their layout	283
	9.4 Design of closed underdrains	285
	9.4.1 Depth and spacing of drains	285
	9.4.2 Hooghoudt's equation for layered soil	287
	9.4.3 Determination of irrigation or rainfall rate	287
	9.4.4 Hooghoudt's equation in humid areas	287
	9.4.5 Leaching requirement	288
	9.4.6 Kirkham's formula	289
	9.4.7 Bureau of reclamation (USBR) formula	289
	9.4.8 Discharge capacity of drains	293
	9.4.9 Slopes of drain lines	293
	9.4.10 Gravel filter	293
	9.5 Design of open underdrain	293
	9.6 Design for leaching requirement	295
10.	DESIGN OF SURFACE DRAINAGE SYSTEM	296-322
	10.1 Necessity of surface drainage	296
	10.1.1 Surface drainage system for agriculture land	297
	10.2 Surface drainage channels design considerations	298
	10.2.1 Characteristics of a storm	299
	10.2.2 The design of storm	299
	10.2.3 Storm runoff	301
	10.2.4 Design of drainage channel	303
	10.3 General design consideration of outfall culvert	306
	10.4 Design consideration of tidal channels and outfall sluices	308
	10.4.1 Computation of discharges through the sluice	309
	10.4.1.1 Simplified approach	309
	10.4.1.2 Rigorous approach	310
	10.4.2 Fixation of sill level, clear width of the sluice and channel dimensions	311
11.	WATER-LOGGING AND SALINITY	323-336
	11.1 Introduction	323
	11.2 Causes of water-logging problem	323
	11.3 Causes of the salinity problem	. 324
	11.4 Salt water intrusion in coastal aquifers	324
	11.4.1 General	324
	11.4.2 Salt water intrusion in Coastal Aquifers	326
	11.4.2.1 Slope of the interface	327

	11.4.3 Method of control	329
	11.5 Causes of the drainage problem	331
	11.6 Remedial measures to combat water-logging and salinity	333
	11.7 Important drainage projects and a case study	333
	11.7.1 Case study: water-logging and reclamation of areas in Kerala State	334
12.	APPLICATION OF REMOTE SENSING TECHNOLOGY FOR FLOOD CONTROL	337–340
	12.1 Introduction	337
	12.1.1 Airborne sensing	337
	12.1.2 Satellite sensing	337
	12.2 Application for planning flood control measures	339
	12.2.1 Flood inundation mapping	339
	12.2.2 Information regarding flood plain landuse	339
	12.2.3 Indicators of flood susceptibility	340
	12.3 Flood warning	340
	12.4 Concluding remarks	340
13.	FLOOD PLAIN DELINEATION AND FLOOD HAZARD ASSESSMENT	341-348
	13.1 General	341
	13.2 Flood plain delineation from remote sensing	341
	13.3 Estimation of flooded area	342
	13.4 Flood plain delineation from digital terrain models (DTM)	342
	13.5 Geo-referencing of the water level points	342
	13.6 Creating a water surface	343
	13.7 Flood plain delineation	344
	13.8 Flood hazard assessment	345
	13.9 Flood hazard zone indexing: simplified approach	348
	SELECTED REFERENCES	349–351
	SELECTED BIBLIOGRAPHY	353
	INDEX	355-357