
Contents

Preface

1 Development of groundwater resources 1

- 1.1 Introduction 1
- 1.2 Establishment of the requirement 4
- 1.3 Desk feasibility study 4
- 1.4 Field investigation 4
- 1.5 Safeguard of supply 5
- 1.6 Approximate cost of groundwater development schemes 6
- 1.7 References 9

2 Groundwater: fundamentals 11

- 2.1 The origin and occurrence of groundwater 11
- 2.2 Porosity and permeability 14
- 2.3 Flow through soils and rocks 21
- 2.4 Fissure flow 25
- 2.5 Assessment of permeability 25
- 2.6 Assessment of flow in the field 34
- 2.7 Groundwater in igneous and metamorphic rocks 36
- 2.8 Groundwater in sedimentary rocks 38
- 2.9 References 41

3 Groundwater exploration 44

- 3.1 The desk study and preliminary reconnaissance 44
- 3.2 Remote sensing imagery and aerial photographs 45
- 3.3 Field exploration 48
- 3.4 Geophysical exploration 55
- 3.5 Logging of boreholes or drillholes 67
- 3.6 Maps 78
- 3.7 References 81

4 Assessment of aquifer recharge and potential well yield 83

- 4.1 Introduction 83
- 4.2 The hydrological cycle 83
- 4.3 Natural groundwater recharge 88
- 4.4 Natural groundwater discharge 92
- 4.5 Assessment of aquifer recharge and potential well yield 100
- 4.6 Location of wells for maximum yield – summary of factors for consideration 115
- 4.7 References 116

5 Groundwater quality 119

- 5.1 Introduction 119
- 5.2 Physical properties of groundwater 121
- 5.3 Biological character of groundwater 122
- 5.4 Chemistry of groundwater 123
- 5.5 Rock types and groundwater 129
- 5.6 Uses of groundwater 133
- 5.7 Investigation of groundwater quality 142
- 5.8 References 146

6 Well design and construction 148

- 6.1 Well design and construction 148
- 6.2 Well drilling methods 151
- 6.3 Well design for confined and unconfined aquifers 158
- 6.4 Selection of a suitable well diameter with respect to yield 165
- 6.5 Well screens 166
- 6.6 Well straightness, verticality, hole diameter and formation fillers 171
- 6.7 Pump selection and depth of setting 174
- 6.8 Details of well construction 178
- 6.9 Well development or stimulation 185
- 6.10 Artificially developed wells–gravel packing 193
- 6.11 Well sterilization 194
- 6.12 Other types of well construction and practice 195
- 6.13 References 199

7 Aquifer hydraulics and pumping tests 201

- 7.1 Introduction 201
- 7.2 Aquifer hydraulics 202
- 7.3 Well hydraulics 210
- 7.4 Well discharge equations and the prediction of the response of an aquifer to pumping 212
- 7.5 Planning a pumping test 221
- 7.6 The conduct of a pumping test 230
- 7.7 Correction of pumping test data prior to analysis 234
- 7.8 Boundary analysis using image wells 238
- 7.9 Extension of pumping test data 241
- 7.10 Examples of pumping test analysis 243
- 7.11 References 251

8 Groundwater pollution 254

- 8.1 Introduction 254
- 8.2 Rock type, pollution potential and attenuation of a pollutant 256 ↗
- 8.3 Faulty well design and construction 259
- 8.4 Leachate from refuse disposal sites 261
- 8.5 Induced infiltration 265
- 8.6 Saline intrusion 268
- 8.7 Nitrate pollution 271
- 8.8 Other causes of pollution 274
- 8.9 Detection of groundwater pollution 275
- 8.10 References 276

9 Groundwater management 280

- 9.1 Groundwater level considerations 283
- 9.2 Groundwater monitoring 292
- 9.3 Artificial recharge 296
- 9.4 Conjunctive use 300
- 9.5 References 304

10 Groundwater modelling techniques 307

- 10.1 Introduction 307
- 10.2 Development of modelling techniques and types of model available 310
- 10.3 General data requirements of groundwater models 315
- 10.4 Finite difference groundwater models 318
- 10.5 The finite element method 329
- 10.6 Other considerations and useful bibliography 335
- 10.7 References 336

Appendix I 339

Appendix II 340

Index 342