
Contents

<i>Preface</i>	ix
<i>About this book</i>	xi
<i>Acknowledgement</i>	xiii
<i>Authors</i>	xv
0 Basics of groundwater flow	1
0.1 Hydraulic head	1
0.2 Darcy's experiment	2
0.3 Representative elementary volume	2
0.4 Hydraulic conductivity and porosity	3
0.5 Aquifers and aquitards	4
0.6 Storage and transient flow	5
0.7 Darcy's law for groundwater modeling	6
0.8 Dupuit and Forchheimer	7
0.9 Groundwater models	7
1 Steady one-dimensional flow with constant transmissivity	9
1.1 Flow between two rivers	10
1.2 Areal recharge between two rivers	13
1.3 Areal recharge between an impermeable boundary and a river	18
1.4 Flow through two zones of different transmissivities	22
2 Steady one-dimensional semi-confined flow	25
2.1 Flow from a canal to a drained area	26
2.2 Flow between a lake and a drained area	29
2.3 Flow to a long river of finite width	32
2.4 Flow to a river in a two-aquifer system	35
2.5 Areal recharge between two rivers in a two-aquifer system	39
3 Steady one-dimensional unconfined flow with variable saturated thickness	43
3.1 Areal recharge between an impermeable boundary and a river	44
3.2 Flow over a step in the aquifer base	48
3.3 Combined confined/unconfined flow with areal recharge	50

4 Steady one-dimensional flow in coastal aquifers	55
4.1 Confined interface flow	56
4.2 Unconfined interface flow	60
4.3 Combined confined/semi-confined interface flow	64
5 Transient one-dimensional flow	69
5.1 Step changes in surface water level	70
5.2 Periodic changes in surface water level	77
5.3 Areal recharge between two rivers	80
5.4 Solutions with Laplace transforms	87
5.5 Unconfined flow with variable transmissivity	91
6 Steady two-dimensional flow to wells	95
6.1 Radially symmetric flow on a circular island	98
6.2 Wells near rivers and impermeable boundaries	102
6.3 Wells near an inhomogeneity boundary	108
6.4 Wells in a semi-confined aquifer	110
6.5 Wells in a two-aquifer system	113
7 Steady two-dimensional flow to wells in uniform background flow	117
7.1 A single well in uniform background flow	117
7.2 Well capture zones	122
7.3 A well in uniform background flow near a river	124
7.4 A well in uniform background flow near a river with a leaky stream bed	129
7.5 A well in uniform background flow near the coast	134
8 Analytic element modeling of steady two-dimensional flow	137
8.1 Uniform flow and wells	137
8.2 Line-sinks for modeling rivers and streams	144
8.3 Area-sinks for modeling areal recharge	148
9 Transient two-dimensional flow	151
9.1 Wells in confined and unconfined aquifers	152
9.2 Wells with a periodic discharge	158
9.3 Wells in a semi-confined aquifer	160
9.4 Wells with wellbore storage and skin effect	164
9.5 Wells in a two-aquifer system	167
10 Steady two-dimensional flow in the vertical plane	171
10.1 Vertical anisotropy	172
10.2 Flow to a partially penetrating stream	174
10.3 Flow over a step in the base	181
10.4 Spatially varying head at the top of the aquifer	185
10.5 Interface flow towards the coast	190
10.6 Interface flow below a strip island	194

A Python primer	199
A.1 Basics	200
A.2 Loops and if statements	203
A.3 The <code>numpy</code> package and arrays	205
A.4 The <code>matplotlib</code> package for visualization	210
A.5 Functions	213
A.6 The <code>scipy</code> package for scientific computing	216
<i>Numerical answers to selected problems</i>	219
<i>Bibliography</i>	221
<i>Index</i>	225