The title of this book is intended to convey that it is devoted to illustrating the application of abstract methods from functional analysis to problems arising in the modeling of water flow in soils. In recent decades the need for increasingly sophisticated models for water flow in soils has led to correspondingly more difficult and interesting mathematical problems. The source of the mathematical difficulties is the extreme nonlinearity of the governing partial differential equations, that is, the two forms of the Richards equation:

$$\partial_t \theta = \nabla \cdot \left[ D(\theta) \nabla \theta \right] + \partial_z K(\theta)$$

and

$$C(h) \partial_h h = \nabla \cdot \left[ k(h) \nabla h \right] + \partial_z k(h)$$

Equation [1], the water content form of the equation, contains the following variables and coefficients: $\theta$, water content; $D(\theta)$, diffusivity; $K(\theta)$, hydraulic conductivity; $z$, vertical (gravity) direction. Equation [2], the pressure head form of Richards' equation, contains the following variables and coefficients: $h$, pressure head; $C(h)$, water capacity $d\theta/db$; $k(h)$, hydraulic conductivity.

As is well known, the coefficients $D$, $K$, $C$, and $k$ are descriptive of the hydraulic properties of the soil being modeled. The fact that they depend explicitly on the dependent variables $\theta$, water content, or $h$, pressure head, is what makes the equations nonlinear and precludes the discovery of any closed form solution to the equation (and auxiliary conditions), except in a few very special cases. As a result, flow problems are nearly always solved by numerical methods that are becoming ever more sophisticated and complex. Non-mathematicians often wonder about the need for, or purpose of the theorems on existence, uniqueness, and regularity for solutions to problems in partial differential equations. Correct implementation and interpretation of the numerical approximations is one of the principle motivations for such theorems. In addition, the abstract results oft en provide insight into unforeseen qualitative behavior of solutions to nonlinear problems. Finally, the fact that one is able to prove these theorems indicates that the problem is properly formulated, or conversely, if the mathematical model is not properly formulated, it will become evident in the course of trying to establish existence, uniqueness, and regularity of the solution.

This book is aimed at mathematicians who have an interest in developing models for water flow in soils. To see whether you have sufficient background to appreciate the content of the book, I would suggest reading Chapter 3, which contains a cursory outline of the abstract techniques the author intends to employ. If such notions as maximal monotone operator or Gelfand triple of function spaces are not foreign to you, then you probably will be able to benefit from reading this book. If Chapter 3 is not understandable to you, then the subsequent chapters will be even less so. If you are a soil scientist with only a modicum of mathematical training, this book is unlikely to be useful for you.