Estimating Groundwater Recharge

Understanding groundwater recharge is essential for the successful management of water resources and modeling fluid and contaminant transport within the subsurface. This book provides a critical evaluation of the theory and assumptions that underlie methods for estimating rates of groundwater recharge. Detailed explanations of the methods are provided – allowing readers to apply many of the techniques themselves without needing to consult additional references. Numerous practical examples highlight the benefits and limitations of each method and provide guidance on the selection and application of methods under both ideal and less-than-ideal conditions. More than 800 references allow advanced practitioners to pursue additional information on any method.

For the first time, theoretical and practical considerations for selecting and applying methods for estimating groundwater recharge are covered in a single volume with uniform presentation. Hydrogeologists, water-resource specialists, civil and agricultural engineers, earth and environmental scientists, and agronomists will benefit from this informative and practical book, which is also a useful adjunct text for advanced courses in groundwater or hydrogeology.

For more than 30 years, Rick Healy has been conducting research for the US Geological Survey on groundwater recharge, water budgets of natural and human-impacted hydrologic systems, and fluid and contaminant transport through soils. He has taught numerous short courses on unsaturated zone flow and transport, and groundwater flow modeling. He first presented a short course on methods for estimating recharge in 1994, and over the intervening 15 years the course has been presented to several hundred professionals and students. The material in that course has been expanded and refined over the years and forms the basis of *Estimating Groundwater Recharge*. Rick has authored more than 60 scientific publications and developed the VS2DI suite of models for simulating water, solute, and heat transport through variably saturated porous media. He is a member of the Soil Science Society of America, the American Geophysical Union, and the Geological Society of America.

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Richard W. Healy
US Geological Survey
Lakewood, Colorado

With contributions by
Bridget R. Scanlon
Bureau of Economic Geology
Jackson School of Geosciences
University of Texas, Austin

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Preface

Groundwater is an integral part of natural hydrologic systems. Humans have used groundwater for thousands of years. Its use has increased greatly over time, but only in the last few decades has our appreciation of the limitations of its supply and its vulnerability to contamination grown to the point where steps are being taken to protect this valuable resource. One of the most important components in any assessment of groundwater supply or aquifer vulnerability is the rate at which water in the system is replenished – the rate of recharge.

A number of textbooks are devoted to hydrogeology, groundwater flow, and contaminant transport (e.g. Freeze and Cherry, 1979; Domenico and Schwartz, 1998; Todd and Mays, 2005). The importance of recharge is cited in all of these textbooks, but only limited information is provided on the description and analysis of techniques for estimating recharge. Similarly, undergraduate and graduate courses on hydrogeology, groundwater flow, and contaminant transport are offered at many universities, but we know of no university level courses specifically devoted to groundwater recharge. This book attempts to fill these gaps by providing a systematic and comprehensive analysis of methods for estimating recharge.

The book is aimed at practicing hydrogeologists who are actively involved in groundwater studies. The material contained in the text should also be useful to water-resource specialists, civil and agricultural engineers, geologists, geochemists, environmental scientists, soil physicists, agriculturalists, irrigators, and scientists from other fields that have an elemental understanding of hydrologic processes. The book can be used as an adjunct text or reference in an advanced undergraduate or graduate groundwater or hydrogeology course; it can also serve as a primary text in courses on groundwater recharge. Theoretical as well as practical considerations for selecting and applying techniques are discussed. Theoretical analysis of the methods allows the evaluation of assumptions inherent in each method. Practical examples of applications provide guidance for readers in applying methods in their own studies.

Over the years, hydrology has become a diverse field with the development of many new topic areas. Few hydrologists can claim expertise in all areas of hydrology; specialization in groundwater, surface water, unsaturated-zone flow and transport, geochemistry, or other subfields has become more the norm. We anticipate that most readers will have a background in groundwater hydrology. However, application of many of the methods described herein (e.g. streamflow hydrograph separation, the zero-flux plane method, and watershed modeling) requires knowledge of areas outside of groundwater hydrology. A challenge in writing this text was to bring together a number of methods that are drawn from fields outside of groundwater hydrology, fields such as surface-water hydrology, flow and transport through the unsaturated zone, geophysics, remote sensing, and water chemistry. Unsaturated-zone processes, in particular, are described in some detail. Many methods for estimating recharge require assumptions about the mechanisms by which water moves through the unsaturated zone; insight into unsaturated-zone processes provides a basis for evaluating the validity of those assumptions.

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