Groundwater Hydraulics

In this book the application of the boundary element method to the solution of the Laplace equation is examined. This equation is of fundamental importance in engineering and science as it describes different types of phenomena, inclu- ding the groundwater flow applications highlighted in this book. Special subjects such as numerical integration, subdi- visionof the domain into regions and other computational aspects are discussed in detail in the first chapters. To demonstrate the accuracy and efficiency of the boundary ele- ment method, results obtained when solving the Laplace equa- tion have been compared against known analytical solutions. Other chapters deal with problems such as steady and unstea- dy flow in addition to infiltration problems. The applica- tions demonstrate that the boundary element method provides a powerful solution technique which can be effectively ap- plied to solve this type of problem.

The groundwater science and engineering has been closely connected with various fields (1) Groundwater Hydrology, (2) Groundwater Hydraulics or Geohydraulics, (3) Fluid Dynamics in Porous Media, (4) Groundwater Quality Engineering, (5) Soil Physics, and (6) Hydrogeology or Geohydrology. The purpose of the book is to present an update textbook of groundwater hydraulics, which includes all of basic items in above-mentioned fields, to students (of graduate school), researchers and practitioners. The students and beginners who intend to specialize in groundwater

hydraulics through one semester will master contents of the book.

Mathematical models are powerful tools used in the prediction of pollutant movement. This book discusses the Finite Element Method (FEM) and Boundary Element Method (BEM), and takes a look at the advantages of these methods in groundwater hydrology. The combination of the BEM and the random-walk particle tracking method is also presented. The book includes computer programs, source code, and examples developed on the basis of the theoretical backgrounds of these methods. These Visual C++ programs are compatible with the Windows platform.

Groundwater Hydraulics

Due to the increasing demand for adequate water supply caused by the augmenting global population, groundwater production has acquired a new importance. In many areas, surface waters are not available in sufficient quantity or quality. Thus, an increasing demand for groundwater has resulted. However, the residence of time of groundwater can be of the order of thousands of years while surface waters is of the order of days. Therefore, substantially more attention is warranted for transport processes and pollution remediation in groundwater than for surface waters. Similarly, pollution remediation problems in groundwater are generally complex. This excellent, timely resource covers the field of groundwater from an engineering perspective, comprehensively addressing the range of subjects related to subsurface hydrology. It provides a practical treatment of the flow of groundwater, the transport of

substances, the construction of wells and well fields, the production of groundwater, and site characterization and remediation of groundwater pollution. No other reference specializes in groundwater engineering to such a broad range of subjects. Its use extends to: The engineer designing a well or well field The engineer designing or operating a landfill facility for municipal or hazardous wastes The hydrogeologist investigating a contaminant plume The engineer examining the remediation of a groundwater pollution problem The engineer or lawyer studying the laws and regulations related to groundwater quality The scientist analyzing the mechanics of solute transport The geohydrologist assessing the regional modeling of aquifers The geophysicist determining the characterization of an aquifer The cartographer mapping aquifer characteristics The practitioner planning a monitoring network

The purpose of this book is to bring together under one cover the principles of groundwater engineering. The concise format has produced a handy, comprehensive manual for professionals working in the groundwater industry. The author places emphasis on the application of theory and practical aspects of groundwater engineering. Well-cited references throughout the text guide you through the technology, scientific principles, and theoretical background of groundwater engineering. Exhaustive appendices contain quantitative data necessary for in-groundwater flow and contaminant migration equations. Principles of Groundwater Engineering is the state-of-the-art book that bridges the gap between groundwater theory and groundwater

problem solving.

This exciting new textbook introduces the concepts and tools essential for upper-level undergraduate study in water resources and hydraulics. Tailored specifically to fit the length of a typical one-semester course, it will prove a valuable resource to students in civil engineering, water resources engineering, and environmental engineering. It will also serve as a reference textbook for researchers, practicing water engineers, consultants, and managers. The book facilitates students' understanding of both hydrologic analysis and hydraulic design. Example problems are carefully selected and solved clearly in a step-by-step manner, allowing students to follow along and gain mastery of relevant principles and concepts. These examples are comparable in terms of difficulty level and content with the end-of-chapter student exercises, so students will become well equipped to handle relevant problems on their own. Physical phenomena are visualized in engaging photos, annotated equations, graphical illustrations, flowcharts, videos, and tables.

Modeling has become an essential tool for the groundwater hydrologist. Where field data is limited, the analytic element method (AEM) is rapidly becoming the modeling method of choice, especially given the availability of affordable modeling software. Analytic Element Modeling of Groundwater Flow provides all the basics necessary to approach AEM successfully, including a presentation of fundamental concepts and a thorough introduction to Dupuit-Forchheimerflow. This book is unique in its emphasis on the actual use of analytic element models. Real-world examples complement material presented in the text. An educational version of the analytic element program GFLOW is included to allow the reader to reproduce the various solutions to groundwater flow problems discussed in the text.

Researchers and graduate students in groundwater hydrology, geology, andengineering will find this book an indispensable resource. * * Provides a fundamental introduction to the use of the analytic element method. * Offers a step-by-step approach to groundwater flow modeling. * Includes an educational version of the GFLOW modeling software.

Published by the American Geophysical Union as part of the Water Resources Monograph Series, Volume 9. John Ferris's research has covered a broad range of hydrologic problems in groundwater, including pollution, storage, recharge, and pumping of groundwater; drainage design; hydraulics of aquifer systems; saltwater encroachment; and application of geophysics to groundwater development. These contributions have been made as a researcher and teacher of national and international renown during a career that has lasted more than four decades. During these four decades, the methodologies for application of hydraulics to solving groundwater problems have continued to evolve and improve. The development of aquifer test techniques and analytical solutions been coemonplace in the 1950's, 1960's, and early 1970's have increasingly been supplemented by the use of numerical methods and automated parameter estimation techniques.

Increasing demand for water, higher standards of living, depletion of resources of acceptable quality, and excessive water pollution due to urban, agricultural, and industrial expansions have caused intense environmental, social, economic, and political predicaments. More frequent and severe floods and droughts have changed the ability and resiliency of water infrastructure systems to operate and provide services to the public. These concerns and issues have also changed the way we plan and manage our surface and groundwater resources. Groundwater Hydrology:

Engineering, Planning, and Management presents a compilation of the state-of-the-art subjects and techniques in the education and practice of groundwater and describes them in a systematic and integrated fashion useful for undergraduate and graduate students and practitioners. The book develops a system view of groundwater fundamentals and model-making techniques through the application of science, engineering, planning, and management principles. It discusses the classical issues in groundwater hydrology and hydraulics followed by coverage of water quality issues. The authors delineate the process of analyzing data, identification, and parameter estimation; tools and model-building techniques and the conjunctive use of surface and groundwater techniques; aquifer restoration, remediation, and monitoring techniques; and analysis of risk. They touch on groundwater risk and disaster management and then explore the impact of climate change on groundwater and discuss the tools needed for analyzing future data realization and downscaling large-scale low-resolution data to local watershed and aquifer scales for impact studies. The combined coverage of engineering and planning tools and techniques as well as specific challenges for restoration and remediation of polluted aquifers sets this book apart. It also introduces basic tools and techniques for making decisions about and planning for future groundwater development activities, taking into account regional sustainability issues. An examination of the interface between groundwater challenges, the book demonstrates how to apply systems analysis techniques to groundwater engineering, planning, and management.

Investigating Groundwater provides an integrated approach to the challenges associated with locating groundwater. Uniquely, the book provides a review of the wide range of techniques that can be deployed to investigate this important

resource. Many of the practical examples given are based upon Australian experience but the methods have worldwide applicability. The book is published in colour and includes many original diagrams and photographs. Particular effort has been made to provide consistent terminology and SI units are used throughout the text Investigating Groundwater starts with an introduction to the historical significance of groundwater and gives an account of climate change. A description of the occurrence of groundwater in different rock types is then provided. A detailed account of surface water techniques is then followed by an account of the interconnections between surface water and groundwater. Four chapters describing groundwater hydraulics are then followed by four chapters describing the latest geophysical techniques. Once the best location of a borehole is determined using these techniques; chapters then describe appropriate drilling methods to use; provide a wide ranging review of geophysical logging, hydrochemical and isotopic techniques, before concluding with a detailed description of groundwater flow to a well. Written for a worldwide audience of degree level geology/engineering practitioners, academics and students involved in groundwater resource investigation methods; Investigating Groundwater is essential reading for those involved in groundwater research. Key Features: Presents the theoretical background and a detailed description of the techniques used in the investigation of groundwater. Describes the general occurrence of groundwater in different rock types; surface water hydrology and interconnected surface and groundwater systems. Provides detailed descriptions of geophysical techniques (seismic, electrical, gravity and heat) and an account of available geophysical logging methods. Reviews hydrochemical and isotope methods, followed by an account of drilling techniques. Gives a detailed account of radial flow

to a well, including appropriate modelling and pump-testing techniques and a consideration of non-linear flow. Of interest to anyone involved in the development of groundwater resources, either for domestic supply, for agriculture or for mining.

This book presents a unique and up-to-date summary of what is known about groundwater on our planet, from a global perspective and in terms of area-specific factual information. Unlike most textbooks on groundwater, it does not deal with theoretical principles, but rather with the overall picture that emerges as a result of countless observations, studies and other activities related to groundwater in all parts of the world. The focus is on showing the role and geographical diversity of groundwater—a natural resource of great importance in daily life, but poorly understood by the general public and even by many water sector professionals. The book starts by analysing groundwater in the context of the hydrological cycle. Subsequently, groundwater systems as physical units, with their boundaries mainly defined by geological conditions, are reviewed. The next chapter looks at groundwater as a resource, paying attention, among others, to its quantity and quality, to the differentiation between renewable and non-renewable resources, and to the techniques for withdrawing groundwater. This is followed by a systematic documentation of the quantities of groundwater withdrawn and used around the world, and of the corresponding shares of groundwater in each of the main water use sectors. After that, steadily growing needs for groundwater management interventions are identified, resulting from local human activities and global change (including demography, economic development and climate change). Finally, groundwater resources management is addressed and real-life cases are described that illustrate actions taken and experiences with different issues in different parts of the world. The authors attempted to write

this book in such a way that it is accessible to a wider readership than just groundwater professionals. It will also benefit non-groundwater specialists who work in groundwater-related fields (water managers, land use planners, environmentalists, agronomists, engineers, economists, lawyers, and journalists), by broadening their understanding of groundwater and making them aware of the huge variety of groundwater settings. Groundwater specialists will use the book as a convenient reference on the geographical diversity of groundwater. Part of the contents or interpretations offered may even be new to them or enhance their knowledge of some aspects. The many maps, tables, and references will save much time for those who would otherwise have to search elsewhere for basic information on the globe's groundwater.

Plus de 20 ans de développement des métiers liés à l'eau, un accroissement très significatif des travaux sur les ressources en eau et leur qualité, la nécessité d'une approche pluridisciplinaire de ces domaines ont montré la nécessité d'une révision et d'un enrichissement du lexique publié en 1972 par Jean Margat. Ce lexique axé sur l'hydrogéologie, l'hydraulique souterraine et l'hydrologie de surface comporte également des termes relatifs à l'évaluation et la gestion des ressources en eau, à l'environnement et à la conduite de projets, soit plus de 5 000 termes. Cet ouvrage s'adresse à l'ensemble des professionnels des milieux académiques et appliqués dans les techniques liées à l'eau ainsi qu'à tous ceux qui sont appelés à lire et à rédiger des textes dans ces domaines. The water-related sector has, over the past 25 years, undergone considerable development accompanied by increased awareness of our water

resources and their quality and of the need for a multidisciplinary approach. This called for a major revision and enrichment of the Glossary of Hydrogeology and Groundwater Hydraulics by Jean Margat that was published in 1972. The new Glossary, with over 5000 terms, focuses essentially on hydrogeology, groundwater and surface hydrology, but also includes entries related to water-resource assessment and management the Environment and project management. It is an essential reference work for all professionals in the water resource domain, whether academic or applied, and a must for all who read and/or write texts associated with hydrogeology and groundwater hydraulics.
Groundwater Resource Development describes the basic steps involved in the development of a groundwater resource in the search for productive aquifers. This book discusses groundwater exploration, construction and testing of water wells, water quality and pollution considerations, and groundwater management. This text is comprised of 10 chapters and begins by presenting the steps in the evaluation, development, and management of an aquifer for water supply. The reader is then introduced to the fundamentals of groundwater, with emphasis on their origin and occurrence as well as the influence of porosity and permeability on groundwater accumulation, migration, and distribution. The chapters that follow focus on groundwater exploration, assessment of aquifer recharge and potential well yield, and factors affecting the quality of groundwater. The issues to be considered in well design and construction are also highlighted, along with aquifer

hydraulics and pumping tests, groundwater pollution, and optimum management of groundwater resources. This text concludes with a chapter on techniques used in modeling the response of a groundwater reservoir. This book will be of value to geologists, civil engineers, environmental scientists, mathematicians, chemists, water well contractors, and others involved in the profession of water engineering.

Groundwater Science, Second Edition - winner of a 2014 Textbook Excellence Award (Texty) from The Text and Academic Authors Association - covers groundwater's role in the hydrologic cycle and in water supply, contamination, and construction issues. It is a valuable resource for students and instructors in the geosciences (with focuses in hydrology, hydrogeology, and environmental science), and as a reference work for professional researchers. This interdisciplinary text weaves important methods and applications from the disciplines of physics, chemistry, mathematics, geology, biology, and environmental science, introducing you to the mathematical modeling and contaminant flow of groundwater. New to the Second Edition: New chapter on subsurface heat flow and geothermal systems Expanded content on well construction and design, surface water hydrology, groundwater/ surface water interaction, slug tests, pumping tests, and mounding analysis. Updated discussions of groundwater modeling, calibration, parameter estimation, and uncertainty Free software tools for slug test analysis, pumping test analysis, and aquifer modeling Lists of key terms and chapter contents at the start of each chapter Expanded

end-of-chapter problems, including more conceptual questions Winner of a 2014 Texty Award from the Text and Academic Authors Association Features two-color figures Includes homework problems at the end of each chapter and worked examples throughout Provides a companion website with videos of field exploration and contaminant migration experiments, PDF files of USGS reports, and data files for homework problems Offers PowerPoint slides and solution manual for adopting faculty

This new edition adds several new chapters and is thoroughly updated to include data on new topics such as hydraulic fracturing, CO2 sequestration, sustainable groundwater management, and more. Providing a complete treatment of the theory and practice of groundwater engineering, this new handbook also presents a current and detailed review of how to model the flow of water and the transport of contaminants both in the unsaturated and saturated zones, covers the protection of groundwater, and the remediation of contaminated groundwater.

This rigorous and comprehensive text provides fundamental information geared to students in either engineering or natural sciences courses dealing with groundwater. The first four chapters consider subsurface fluid flow, while the remaining twelve chapters cover subsurface contamination and pollutant transport. Charbeneau views the application of groundwater hydraulics and pollutant transport as a quantitative field. Although quantitative methods are exact, the fields of study are usually homogeneous; laboratory and field

methods provide estimates for ideal (not real) fields. What impact does the use of ideal fields have on model predictions? The unknown answer places the study of subsurface flow of water and chemical mass transport in a prime position for continued researchand this readily accessible text opens the door to that research. Outstanding features include: Comprehensive, rigorous, and highly accessible coverageIncludes information on groundwater flow, well hydraulics, field methods for parameter estimation, hydrologic relationships between surface water and groundwater hydrology, mass transport of contaminants by advection, diffusion and dispersion, and special problems posed by nonaqueous phase liquids (oils). Strong focus on applicationsEmpowers readers with knowledge and methodologies that they can use in real, day-to-day practices. Includes 66 worked examples and 178 problems integrated throughout. Examination of standard software being used in the industry todayExposes readers to the USGS MODFLOW model (the most widely used numerical simulation model for groundwater flow) and the USGS MOC3D. These models, together with a user interface (MFI), can be downloaded from the Internet.

Increasing demand for water, higher standards of living, depletion of resources of acceptable quality, and excessive water pollution due to urban, agricultural, and industrial expansions have caused intense environmental, social, economic, and political predicaments. More frequent and severe floods and droughts have changed the resiliency and ability of water

infrastructure systems to operate and provide services to the public. These concerns and issues have also changed the way we plan and manage our surface and groundwater resources. Groundwater Hydrology: Engineering, Planning, and Management, Second Edition presents a compilation of the state-of-the-art subjects and techniques in the education and practice of groundwater and describes them in a systematic and integrated fashion useful for undergraduate and graduate students and practitioners. This new edition features updated materials, computer codes, and case studies throughout. Features: Discusses groundwater hydrology, hydraulics, and basic laws of groundwater movement Describes environmental water quality issues related to groundwater, aquifer restoration, and remediation techniques, as well as the impacts of climate change \ Examines the details of groundwater modeling and simulation of conceptual models Applies systems analysis techniques in groundwater planning and management Delineates the modeling and downscaling of climate change impacts on groundwater under the latest IPCC climate scenarios Written for students as well as practicing water resource engineers, the book develops a system view of groundwater fundamentals and model-making techniques through the application of science, engineering, planning, and management principles. It discusses the classical issues in groundwater hydrology and hydraulics followed by coverage of water quality issues. It also introduces basic tools and decision-making techniques for future groundwater development activities, taking into account

regional sustainability issues. The combined coverage of engineering and planning tools and techniques, as well as specific challenges for restoration and remediation of polluted aquifers sets this book apart.

This text explores the laws governing the flow and storage of groundwater in aquifers and provides all the necessary tools to forecast the behavior of a regional aquifer system. 1979 edition.

As we transition into the 21st century, it is apparent that this is an exciting time for environmental engineers and scientists studying remediation technologies. There has been a rapid development of new ways to clean-up polluted groundwater. Research activities of the past and next 10 years will have a dramatic impact on the quality of the subsurface environment for the next century. In 20, or even 10 years from now, our approach to subsurface remediation will probably be vastly different than it is today. Many of the emerging technologies presented in this book will form the basis of standard remediation practices of the future. Physicochemical Groundwater Remediation presents detailed information on multiple emerging technologies for the remediation of the contaminated subsurface environment. All of these technologies apply our knowledge of physical and chemical processes to clean up ground water and the unsaturated zone, and many (if not all) of these emerging technologies will help define standard practices in the future. These technologies include in situ sorptive and reactive treatment walls, surfactant-enhanced aquifer remediation, optimization analyses for remediation system design, chemical, electrochemical, and biochemical remediation processes, and monitored natural attenuation. You will learn how palladium catalyzes the dehalogenation of chlorinated solvents. You will find out how barometric pumping can naturally remove

significant quantities of volatile organic pollutants from shallow ground water and the unsaturated zone. You can learn about mobilizing non-aqueous phase liquids (NAPLs) without risking significant downward migration of the NAPL. You can find out how processes such as electroosmosis and electromigration can be exploited for groundwater remediation purposes and how zero-valent iron and zeolite treatment walls can be used in situ to treat and control contaminant plume migration. Contributors to this book are experts in groundwater remediation processes, and they represent industry, consulting, academia, and government. If your work involves the clean up of contaminated soil and groundwater, this book is an essential reference to keep you up to date on the most promising new developments in remediation research.

Prepared by the Task Committee on Hydraulics of Wells of the Groundwater Hydrology Technical Committee of the Groundwater Council and Watershed Council of the Environmental and Water Resources Institute of ASCE. Hydraulics of Wells: Design Construction Testing and Maintenance of Water Well Systems provides comprehensive treatment of the engineering issues related to the development and management of economical supplies of groundwater. Groundwater is a vital resource in nearly all parts of the world. Because groundwater is typically of high quality and dependability this vital resource is used to supply drinking water in nearly all parts of the globe. Demand for groundwater is expected to increase as population expands and technology advances. Yet groundwater is not free from costs and limitations including the construction and maintenance of wells and pumping equipment as well as storage and transmission infrastructure. Threats to well capacity and water quality rise from a variety of factors such as pollution overuse and drought. This Manual of Practice

codifies existing practices in the water well industry in order to improve the identification development and management of groundwater resources in the future. Topics include: fundamentals of hydrogeology; efficiency of water well systems; design of water wells; construction development and testing; corrosion; incrustation; wellhead protection; and maintenance. Appendixes include a detailed example of a system design for a water well and sample technical specifications for drilling constructing and testing of water wells. MOP 127 guides engineers and designers through the process of planning designing installing maintaining and troubleshooting water-well systems. Managers administrators and water-well operators at all levels of government as well as in the private sector will find it an indispensable reference to water wells assets.

This monograph is a practical guide to groundwater flow theory intended to serve students and practitioners by bridging the gap between basic hydrogeology and groundwater modeling. It synthesizes the mathematics of groundwater flow and provides information in an easily-accessible format for practicing groundwater professionals, consultants, and students that intend to become skillful and competent groundwater flow modelers.

Groundwater and Surface Water Pollution contains almost all the technical know-how required to clean up our water supply. It provides a survey of up-to-date technologies for remediation, as well as a step-by-step guide to pollution assessment for both ground and surface waters. The book defines groundwater, aquifers and surface water and discusses the physical properties of soils, liquids, vadose zones and aquifers. It emphasizes controlling nonpoint source pollution, best management practices, and an integrated management approach. The editors cover not only engineering but also legal, medical, agricultural,

meteorological, biological and other fields of study. They reach beyond the simplistic hydrological cycles usually addressed to the complexities encountered by rapidly-changing land-use patterns. In addition to focusing on causes, effects, and remedies, Groundwater and Surface Water Pollution stresses reuse, recycling, and recovery of resources. Nature does not cause pollution. Through total recycling, we can, like nature, make resources out of wastes. Béla G. Lipták speaks on Post-Oil Energy Technology on the AT&T Tech Channel.

The authors preceive a trend in the study and practice of groundwater hydrology. They see a science that is emerging from its geological roots and its early hydraulic applications into a full-fledged environmental science. They see a science that is becoming more interdisciplinary in nature and of greater importance in the affairs of man. This book is their response, and they have provided a text that is suited to the study of groundwater during this period of emergence.

CD-ROM contains: Complete FORTRAN source code for MODOFC -- Executable compiled using the Lahey F77L-EM/32 FORTRAN 77 Compiler -- Documentatiion for MODOFC -- Sample problems -- HTML files from the MODOFC Web site.

Artificial Recharge of Groundwater focuses on artificial recharge of groundwater basins as a means to increase the natural supply of groundwater, along with the technical issues involved. Special emphasis is placed on the use of reclaimed municipal wastewater as a source for artificial recharge of groundwater. This book is comprised of 26 chapters organized into five sections. After reviewing the state of the art of artificial recharge of groundwater, the discussion turns to the fundamental aspects of groundwater recharge, including the role of artificial recharge in groundwater basin management, recharge methods, hydraulics, monitoring, and

modeling. The next section considers pretreatment processes for wastewater and renovation of wastewater with rapid-infiltration land treatment systems and describes the health effects of wastewater reuse in groundwater recharge. A number of artificial recharge operations using reclaimed wastewater are then highlighted, focusing on cases in various countries including Israel, Germany, Poland, Japan, the Netherlands, and the United States. The remaining chapters look at the extent of contaminant removal by the soil system and the fate of micropollutants during groundwater recharge as well as the legal and economic aspects of groundwater recharge. Research needs for groundwater quality management are also explored. This monograph is written for civil and sanitary engineers, agricultural engineers, hydrologists, environmental scientists, and research scientists as well as public works officials, consulting engineers, agriculturalists, industrialists, and students at colleges and universities.

A thorough, up-to-date guide to groundwater science and technology Our understanding of the occurrence and movement of water under the Earth's surface is constantly advancing, with new models, improved drilling equipment, new research, and refined techniques for managing this vital resource. Responding to these tremendous changes, David Todd and new coauthor Larry Mays equip readers with a thorough and up-to-date grounding in the science and technology of groundwater hydrology. Groundwater Hydrology, Third Edition offers a unified presentation of the field, treating fundamental principles, methods, and problems as a whole. With this new edition, you'll be able to stay current with recent developments in groundwater hydrology, learn modern modeling methods, and apply what you've learned to realistic situations. Highlights of the Third Edition * New example problems and case studies, as well as problem

sets at the end of each chapter. * A special focus on modern groundwater modeling methods, including a new chapter on modeling (Chapter 9), which describes the U. S. Geological Survey MODFLOW model. * Over 300 new figures and photos. * Both SI and U.S. customary units in the example problems. * Expanded coverage of groundwater contamination by chemicals. * New references at the end of each chapter, which provide sources for research and graduate study. Student and instructor resources for this text are available on the book's website at www.wiley.com/college/todd.