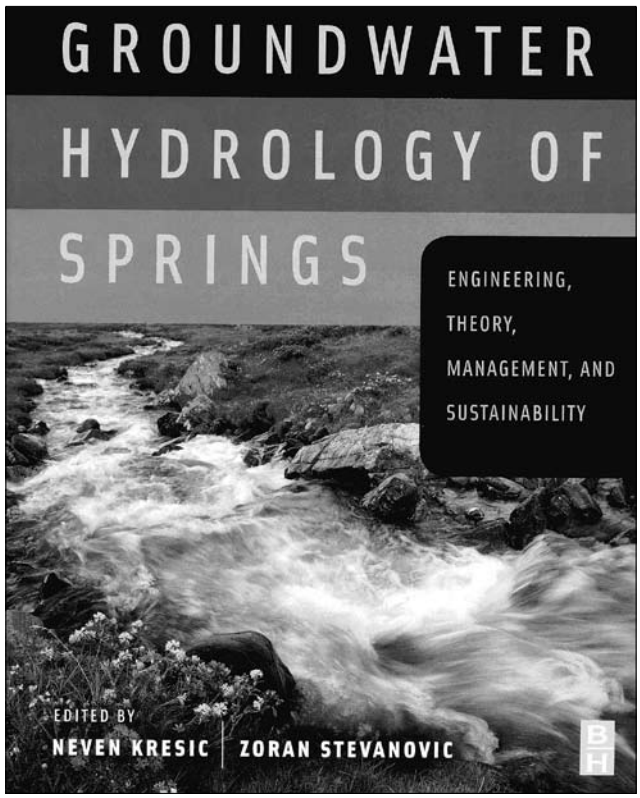
REVIEW OF KRESIC, N. AND STEVANOVIC, Z. (EDITORS) 2010. GROUNDWATER HYDROLOGY OF SPRINGS: ENGINEERING, THEORY, MANAGEMENT, AND SUSTAINABILITY. AMSTERDAM, BUTTERWORTH-HEINEMANN (ELSEVIER); 573 PAGES. ISBN 978-1-85617-502-9.



This volume is an initiative of the Karst Commission of the International Association of Hydrogeologists. The two editors are major contributors to the text and there are seventeen other authors from ten different nations. All are associated primarily with karst groundwater with the consequence that, although other sources for major natural springs (volcanic rocks, some sandstones and quartzites, some granular aquifers) are considered, the focus throughout the book is upon karst springs in carbonate rocks. This is not inappropriate because they are the majority of the world's higher magnitude fresh water springs.

The book contains a Foreword noting the historic importance of springs as foci for settlement in the ancient world that is followed by nine carefully sequenced systematic chapters. To conclude, a tenth chapter offers 175 pages of case studies. Chapter 1, on Sustainability and Management, opens with the UN Alicante Declaration (2006) that "groundwater constitutes more than 95% of the global unfrozen freshwater reserves..." and outlines policy requirements, citing examples of springs dried up by over-exploitation, others ruined by contamination – in some instances where 'characterisation' of the aquifer cost US $100 million or more before there was any remediation! Restoration is usually very difficult, in fact, full restoration impossible. Chapter 2 classifies springs, by topographic and geologic settings (gravity v artesian; perched, barred, submerged, submarine), by regime (perennial, seasonal, non-periodic, etc), by temperature (thermal; 'hot' or merely 'warm') and by discharge. The classical ordering by Oscar Meinzer (1927) of magnitude of spring discharges in the USA is adapted to metric First Order (mean $Q \geq 10\ m^3\ s^{-1}$) down to Eighth Order ($\leq$` $10\ cm^3\ s^{-1}$) but the great importance of variability about the arithmetic mean is also stressed. Chapter 3 focuses on delineating spring catchments, so it is largely devoted to groundwater tracing, presenting state-of-the-art reviews of artificial tracers (chiefly dyes) and the exploitation of natural environmental tracers; there is thorough explanation of applications of stable isotopes ($^{16}O/^{18}O$, D/H, N) for source depiction and for tracking contamination, and of radioisotopes (^{3}H, ^{14}C, ^{36}Cl) for groundwater residence times.

Chapter 4, Spring Hydrograph Analysis, is first formalised in budget terms (Q/area, Q/time) and then develops classical and current approaches to hydrograph separation, recession analysis and event analysis. These complex matters are very well explained, using 39 equations and good examples from southeastern Europe and the United States. Perhaps the contributions of Mangin in France (e.g. 1975, 1984) should have been noted here also. However, they receive fair exposure in Chapter 5, Modelling, which again is a masterful review. It begins with a solid outline of the problems of dealing with fractures and solutional voids that cause many still to adopt the Equivalent Porous Medium approach that can force Darcian solutions on to data series, with results that are often highly misleading. Empirical and deterministic mathematical models, probability models, auto-correlation, system analysis and transfer functions, time series, analytical and numerical model approaches are set out in well-ordered sequence with the essential equations and helpful examples of them at work. The American Society for the Testing of Materials (ASTM) guidelines for groundwater modelling where there may be legal implications are evaluated. Chapter 6, Spring Geochemistry, then takes the reader into the chemical world, dealing first with the low solubility silica and aluminosilicate minerals, then at appropriate length with the carbonate solutions that are quantitatively dominant in a majority of larger springs, briefly with gypsum, and concluding with hot springs that are often highly mineralised. The explanation is comprehensive, and well illustrated with data tables and site examples that are chiefly from the author`s own experience in the United States.

Together, Chapters 2-6 provide the careful reader with a comprehensive view of the present understanding of the physics and chemistry of freshwater springs. Chapters - 7-Springwater Treatment, - 8 Delineating Spring Protection Zones and – 9 Utilization and Regulation of Springs, then tell him or her how to handle them in practice. The US drinking water standards are explained in detail and there is a good review of physical and chemical water treatments. The combination of high population density, technical expertise and long experience places Europe generally in advance of the rest of the world in wellhead and spring protection and assessing vulnerability at present; competing hazard assessment acronyms (DRASTIC, EPIK, COP, even GOD) and the different approaches and methods they represent are clearly explained. In addition to drinking and irrigation, springs are used for power generation, therapy and thermal energy in different locations. The bottled spring water business is now reckoned to be worth more than $13 billion each year, and some secrets of such long-time winners as Apollinaris, Evian and Perrier are disclosed. How to capture all the water of a spring, to regulate its flow, and to exclude salt water, are demonstrated by many examples.

The concluding set of case studies of springs and ground water basins, Chapter 10, is uneven in scope and quality. It includes general summaries of the big springs (mostly karstic) known in southeastern Europe, in Turkey, in Iran and in China, mingled with studies of individual springs or clusters in Austria, Slovenia, Romania, Montenegro, Iran and Texas. The somewhat haphazard structure and content here contrast with the tight ordering of the material presented in the preceding systematic chapters. Nevertheless, readers will find plenty of points of novelty and interest in it.

As with any textbook compiled by multiple authors there is some repetition of material in Groundwater Hydrology of Springs. References cited are placed at the end of each chapter rather than in one bibliography at the end of the book, which is this reviewer's preference. The relevance and quality of the many line drawings that illustrate the text is uniformly high but the reproduction of photographs (black and white only) is poor. These are minor quibbles, however. This is a substantial and important contribution that every scientist and engineer dealing with karst should have on the bookshelf.

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