

WATER SCIENCE & ENGINEERING

Underground Aqueducts Handbook

"*Underground Aqueducts Handbook* offers the first synthesis on aqueducts, including those conveying water and those tapping groundwater. This is the most comprehensive review of aqueduct technology as it concerns most continents and most periods, from prehistory to the present day, thanks to a multidisciplinary approach. It underlines the necessity to preserve and reuse, or redevelop, such sustainable technologies in the global context of aridification and increasing need for water supply."

— Julien Charbonnier, Laboratory ArScAn, Nanterre, France

"...the material is well documented and convincing. Any specialist and many common readers should be interested to have this book on their bookshelf."

— T.P. Tassios, National Technical University of Athens, Greece

In ancient times, urban development required that water be transported from distant springs to centralized locations, and this practice over time further advanced the evolution of increasingly complex aqueducts. Their design and construction required knowledge of mathematics, tunneling, geomechanics, hydraulic principles, and more. These technologies are the underpinning of modern achievements in water supply engineering and water management practices.

Written by leading experts from around the world, *Underground Aqueducts Handbook* presents the major engineering achievements in underground aqueducts throughout history. It examines the technological developments, hydraulic features, and management practices related to the underground aqueduct technologies worldwide, and presents case studies of aqueducts from nearly 30 different countries. This interdisciplinary work includes insight into the relevant engineering, hydrology, environmental sciences, and geosciences, as well as the archaeology and history of each example. It provides valuable insights into water technologies and management with respect to durability, adaptability to the environment, and sustainability, and compares the technological developments from several regions over several periods in time.

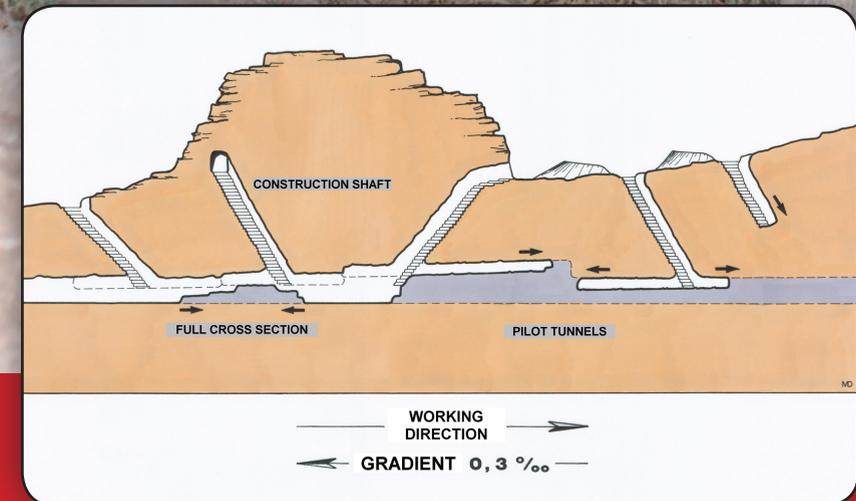
Paradigms of these technologies and practices (not widely known among engineers) have practical application to modern-day water engineering, and help address the issues of sustainability, cost-effectiveness, and decentralization. The book emphasizes that the future trends of underground aqueducts should consider the possibility and practicality of integrating older, proven technologies into today's infrastructure.

Angelakis
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Chiotis
•
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•
Weingartner

Underground Aqueducts Handbook

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Edited by
Andreas N. Angelakis • Eustathios Chiotis
Saeid Eslamian • Herbert Weingartner



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Contents

Preface.....	ix
Editors.....	xi
Contributors.....	xiii

SECTION I Introduction

Chapter 1 Underground Aqueducts: Types, Definitions, and General Conclusions.....	3
<i>Eustathios D. Chiotis</i>	

SECTION II Europe

Chapter 2 Roman Underground Hydraulic Structures in Dalmatia, Croatia.....	19
<i>Katja Marasović, Snježana Perojević, and Jure Margeta</i>	

Chapter 3 Roman Underground Aqueducts in Germany.....	37
<i>Constantin Canavas</i>	

Chapter 4 Updated Appraisal of Ancient Underground Aqueducts in Greece.....	43
<i>Panagiota Avgerinou, Eustathios D. Chiotis, Stella Chrysoulaki, Panos Defteraios, Theodora Evangelou, Nikos M. Gigourtakis, George Kakes, Yiannis Kourtzellis, Panagiotis Koutis, Nikos Mamassis, Maria Pappa, Giorgos Peppas, and Anna I. Strataridaki</i>	

Chapter 5 The Aqueduct of Eupalinos on Samos, Greece, and Its Restoration.....	63
<i>Costas Zambas, George Dounias, and George Angistalis</i>	

SECTION III Africa

Chapter 6 The Past and Present of Underground Aqueducts in Algeria.....	83
<i>Najet Aroua and Abdelkrim (Krimo) Dahmen</i>	

Chapter 7 The Water Supply History of Underground Aqueducts in Egypt.....	99
<i>Abdelkader T. Ahmed and Mohamed H. Elsanabary</i>	

Chapter 8 Qanāt Evolution and Use in Libya.....	109
<i>Abdulgader Abufayed</i>	

SECTION IV Middle East

- Chapter 9** Iranian Qanāts: An Ancient and Sustainable Water Resources Utilization..... 123
Saeid Eslamian, Alireza Davari, and Mohammad Naser Reyhani
- Chapter 10** Spring Tunnels (Niqba’): The Jerusalem Hills Perspective, Israel..... 151
Azriel Yechezkel and Amos Frumkin
- Chapter 11** Qanāt Fir’aun: An Underground Roman Water System in Syria and Jordan 173
Mathias Döring
- Chapter 12** The Aqueducts of the Sultanate of Oman: Sustainable Water-Supplying Systems Irrigating Oases Cities 197
Fairouz Megdiche-Kharrat, Rachid Ragala, and Mohamed Moussa
- Chapter 13** Aqueducts in Saudi Arabia..... 211
Abdulaziz M. Al-Bassam and Faisal K. Zaidi
- Chapter 14** Qanāts of Syria..... 229
Josepha I. Wessels
- Chapter 15** Groundwater Structures throughout Turkish History 241
Zekâi Şen
- Chapter 16** Aflaj Al Emarat: History and Factors Affecting Recharge, Discharge, and Water Quality, United Arab Emirates 261
Zeinelabidin E. Rizk and Abdulrahman S. Alsharhan
- Chapter 17** *Qanāt* and *Falaj*: Polycentric and Multi-Period Innovations: Iran and the United Arab Emirates as Case Studies 279
Rémy Boucharlat

SECTION V Eurasia

- Chapter 18** Ancient Aqueducts and the Irrigation System in Armenia 305
Marine Nalbandyan
- Chapter 19** Evolution of the Qanāt (Kahriz) Systems in the Arid Countries of the Caucasus and Central Asia..... 323
Alovsat Guliyev

Chapter 20 Ancient Water Mining in Tunnels and Wells in West Central Asia.....	333
<i>Renato Sala</i>	

SECTION VI Asia

Chapter 21 Underground Aqueducts in Japan	363
<i>Chikaosa Tanimoto and Iwanai Shimada</i>	

Chapter 22 Managing Drought through Qanāt and Water Conservation in Afghanistan	385
<i>Saifullah Khan and Saeid Eslamian</i>	

Chapter 23 Utilization and Contribution of Underground Aqueducts in the Turpan Oasis of China.....	403
<i>Gofur Nuridin Tolmbok</i>	

Chapter 24 Traditional Methods of Groundwater Abstraction and Recharge along the Windward Side of the Foothills of the Western Ghats of India.....	415
<i>Darren Crook, Sudhir Tripathi, and Richard Jones</i>	

Chapter 25 Historical Development of Qanāts: Underground Aqueducts in Pakistan.....	425
<i>Saifullah Khan, Mahmood-Ul-Hasan, and Muhammad Ishaque Fani</i>	

Chapter 26 Underground Aqueduct and Water Tunneling Development in Thailand.....	449
<i>Vilas Nitivattananon, Dollachet Klahan, Visnu Charoen, and Yin Mon Naing</i>	

SECTION VII Americas

Chapter 27 Puquios and Aqueducts in the Central Andes of South America	465
<i>Kevin Lane</i>	

Chapter 28 The Ancient Hydraulic Catchment Systems of the Tepeaca-Acatzingo Archaeological Zone, Puebla, Mexico	475
<i>Miguel Medina Jaen, Norma G. Peñaflores Ramírez, and Jay E. Silverstein</i>	

SECTION VIII Past, Present, and Future Trends

Chapter 29 Underground Aqueducts: Past, Present, and Future Trends.....	491
<i>Josepha I. Wessels, Sotirios Vardakos, Herbert Weingartner, Saeid Eslamian, and Andreas N. Angelakis</i>	

Index	511
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Preface

The rapid technological progress in the twentieth century created a disregard for past water supply management and sustainability. In the future, urbanization will continue to increase, and 80%–90% of the future world growth (~145,000 inhabitants/day) will be in urban areas. Thus, new specific water supply technologies need to be developed, based on sustainable principles, for serving different sizes of cities and peri-urban regions. Also, many unresolved problems related to the water management principles, such as collection and transportation of water by underground infrastructures, their durability, cost effectiveness, and sustainability issues, will be intensified to an unprecedented degree, especially in the developing world.

Traditional underground hydro-technologies presented major achievements globally in the scientific field of underground aqueducts throughout the millennia. This book provides valuable insights into various underground hydraulic works, for example, qanāts (which are referred to with a particular local term in various regions of the world), tunnels, and various types of inclined galleries, with and without shafts, which transfer ground and/or surface water from an area, usually mountainous, to the lowlands—sometimes several kilometers away for use. Management issues of their characteristics of durability, adaptability to the environment, and sustainability are also considered. In addition, a comparison of the water technological developments in several civilizations has been made. These technologies are the underpinning of modern achievements in underground aqueduct engineering practices. It is the best proof that “the past is the key for the future.”

This book focuses on the technological developments and management practices related to worldwide underground aqueduct technologies throughout the millennia. Paradigms of these technologies and management practices presented in this book (not widely known among engineers) may have some importance for water engineering even today. The hydraulic features of several categories of underground aqueduct technologies in numerous parts of the world are presented and discussed in this book. Finally, an attempt has been made to clarify the distinctive categories of such technologies through their historical development. In addition, potential future trends of underground aqueducts are considered including the possibility of combining old technologies with today’s available infrastructure (e.g., Tunnel boring machine).

About 66 authors from several disciplines and from 4 continents and 26 countries have collaborated on this book. The disciplines include archaeology, hydrology, history, engineering, life sciences, health sciences, environmental sciences, biology, and geosciences. The geographical coverage is very wide, and it is divided into 8 parts and 29 Chapters as follows:

Part I. Introductory (one)

Part II. Europe (Germany, Croatia, and Greece)

Part III. Africa (Algeria, Egypt, and Libya)

Part IV. Middle East (Iran, Israel, Jordan, Oman, Saudi Arabia, Syria, Turkey, and United Arab Emirates)

Part V. Eurasia (Armenia, Azerbaijan, and Kazakhstan)

Part VI. Asia (Afghanistan, China, India, Japan, Pakistan, and Thailand)

Part VII. Americas (Chile, Peru, and Mexico)

Part VIII. Past, Present, and Future Trends

Finally, we appreciate the efforts and contributions of the authors who have written about the labors of humankind to bring hydraulic works to the people and cities. We also acknowledge the assistance

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