15th International Conference

Water in Antiquity

Cura Aquarum in Israel **14-20 October 2012**

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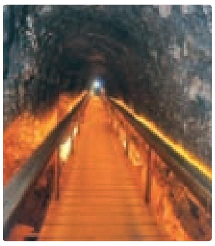
Water in Antiquity



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14-20 October 2012

Thanks are due to
Prof. Ronny Reich, Prof. Henning Fahlbusch, Yehuda Peleg and Miriam Webber who read this booklet and added important comments.

Photos: Cover – Doron Horovitz, all the others – Tsvika Tsuk

Preface

We take great pride in hosting the conference on Water in Antiquity *Cura Aquarum* in Israel for the third time. The first conference in Israel (*CA* 5) was initiated by Mr. Yehuda Peleg and organized in 1983 by the late Prof. Ehud Netzer together with Prof. Henning Fahlbusch on behalf of Prof. Garbrecht, under the auspices of the Hebrew University of Jerusalem and financed by the county of Niedersachsen. This conference led to a joint project on the ancient water systems to the Hashmonain and Herodian palaces near Jericho between the Hebrew University and the Leichtweiss-Institute for Water Research of the Technical University Braunschweig.
Later on there were another two joint initiatives. The first one was on the aqueducts to Sussita between Tel Aviv University and the Fachhochschule of Luebeck. This project was financed by the German Israeli Foundation. The second one was on the aqueducts to Beit Shean between the Hebrew university and again the Fachhochschule of Luebeck. This project was financed by the German Research Foundation.

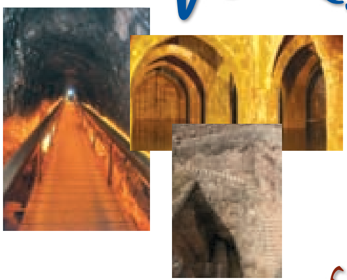
The second conference (*CA* 11), which took place in 2001, was organized by Dr. Tsvika Tsuk, Mr. Yehuda Peleg, Dr. Zeev Meshel and Dr. Yosef Porath together with Prof. Fahlbusch, under the auspices of the Israel Nature and Parks Authority, Tel Aviv University, the Israel Antiquities Authority and the German Water History Association (DWhG). 32 visitors from abroad participated in this conference and about 50 Israelis.

One of the best things about these conferences was that they lasted for seven days and differed from the other conferences in that the focus was on the excursions. In this conference (*CA* 15), we will follow the same format. The conference consists of one and a half lecture days and five and a half touring days. We decided to include very famous sites, some of which were visited in the previous conferences, but they have since been developed and new areas have been opened there.

We wish to thank all the participants in this conference and hope you will reap full enjoyment and success.

The Organizing Committee:

- Prof. Henning Fahlbusch - DWhG
- Dr. Tsvika Tsuk - INPA
- Prof. Jim Parker - NOBTS
- Prof. Ronny Reich - UoH
- Dr. David Amit - IAA
- Mr. Shimon Tal - TCCE
- Ms. Bella Dax - INPA
- Ms. Sylvie Witenberg - INPA
- Mr. Eli Dror - INPA
- Mr. Hillel Glassman - INPA



Water in Antiquity

A Pre-conference tour – Jerusalem: the city that is holy to 3 religions

Day 1 Sunday October 14, 2012 (from Neve Ilan Hotel and return)

Responsible persons:
Bus no. 1 – Eli Dror and Sylvie Witenberg

Bus no. 2 – Hillel Glassman and Bella Dax

Guides: Dieter Vieweger (in German) and Eyal Meiron (in English)

08:00 – 08:45	Drive to the old city of Jerusalem
08:45 – 12:30	Visit the Temple Mount, Western Wall and Holy Sepulcher
12:30 – 13:45	Lunch break in the old city (not included)
13:45 – 16:00	Visit the Mount of Olives and Gethsemane
16:00 – 16:30	Drive to Rockefeller Museum, the main office of the Israel Antiquities Authority
16:30 – 17:00	Short visit at the museum
17:00 – 18:00	Reception near the inner pool of the museum, organized by IAA

Greetings:

Mr. Shuka Dorfman	General director of the Israel Antiquities Authority (IAA)
Mr. Shaul Goldstein	General director of the Israel Nature and Parks Authority (INPA)
Prof. Henning Fahlbusch	Vice chairman of the German Water History Association (DWhG)
Prof. Jim Parker	Vice president of the New Orleans Baptist Theological Seminars (NOBTS)

18:00 – 18:45	Drive to the hotel
19:45	**Dinner at the hotel in Neve Ilan**

B List of lectures during Cura Aquarum in Israel 15-16/10/2012

Day 2 Monday October 15, 2012 (Neve Ilan Hotel)

08:00 – 08:30 Registration

08:30 – 09:00 **Greetings:**
Mr. Shaul Goldstein, general director of the Israel Nature and Parks Authority (INPA)
Prof. Henning Fahlbusch, vice chairman of the German Water History Association (DWhG)
Prof. Ronny Reich, Institute of Archaeology, University of Haifa
Dr. Tsvika Tsuk, chief archaeologist, Israel Nature and Parks Authority (INPA)

Session A ▪ 09:00 – 10:30
Ancient water systems in Israel 1

Chairperson Jim Parker

1. Is There Light at the End of the Tunnel? The Gezer Water System Project – Dan Warner, Tsvika Tsuk, Jim Parker and Dennis Cole
2. A New Assessment of the Upper Aqueduct to Jerusalem: its Date and Route – David Amit and Shimon Gibson
3. Dating and engineering of Siloam Tunnel, Jerusalem – Amos Frumkin and Aryeh Shimron

Coffee break 10:30 – 11:00

Session B ▪ 11:00 – 12:50
Ancient water systems in Israel 2

Chairperson Dennis Cole

4. The Inverted Siphon Pipelines to Tel Bet Yerah / es-Sinnabris – Yardenna Alexandre
5. The "'Otzar" in Ancient Ritual Baths: Second Temple Period Innovation or Anachronistic Interpretation? – Yonatan Adler
6. When were the Qanat Systems introduced to the Holy Land? – Yosef Porath
7. The Early Islamic aqueducts to Ramla and Hebron – Amir Gorzalczany and David Amit

Lunch break 12:50 – 14:15

Session C ▪ 14:15 – 15:15
Ancient and modern water systems in Israel 3

Chairperson Ronny Reich

8. Touring Israel's ancient water systems – Tsvika Tsuk
9. Water in Israel and in the Middle East – past, present and future – Shimon Tal

Coffee break 15:15 – 15:35

Session D ▪ 15:35 – 17:00
Turkey 1

Chairperson Werner Eck

10. Grundwassernutzung in der hethitischen Hauptstadt Hattusa um 1600 v. Chr. – Hartmut Wittenberg
11. Ancient Water Systems of the Lamas Çayi and the surrounding hinterland – Dennis Murphy
12. Die Datierung der römischen Kaikos- und Madradag-Kanalleitungen in Pergamon – Henning Fahlbusch

Coffee break 17:00 – 17:20

Session E ▪ 17:20 – 18:50
Turkey 2

Chairperson Henning Fahlbusch

13. Das städtische Abwassersystem von Pergamon - seine Entwicklung in hellenistischer und römischer Zeit – Kai Wellbrock
14. The aqueducts and water supply of Tralleis – Eddie Owens
15. Antike Wasserbauten von Antiochia (Tuerkei) – Mathias Döring

19:30 Dinner at the hotel

Day 3 Tuesday October 16, 2012 (Neve Ilan hotel)

Session F ▪ 08:30 – 09:30
The Military

Chairperson Mathias Döring

16. Das Heer und die Infrastruktur von Städten in der römischen Kaiserzeit – Werner Eck
17. Water as weapon and military target in Ancient Mesopotamian warfare – Ariel Bagg

Coffee break 09:30 – 09:50

Session G ▪ 09:50 – 11:20
Groundwater and Roman Aqueducts

Chairperson Eli Dror

18. Ground water use and understanding in ancient times: lessons for today and tomorrow – Michael Knight
19. Sinter deposits in Roman aqueducts – Gül Sürmelihindi and Cees Passchier
20. The Atlas Project of Roman Aqueducts (ROMAQ) – Cees Passchier, and Gül Sürmelihindi

Coffee break 11:20 – 11:50

Session H ▪ 11:50 – 13:15
Greece and Spain – sanctuaries, mills and aqueducts

Chairperson Dennis Murphy

21. The role of water in ancient sanctuaries. The Sanctuary of Amphiaraos – Anna Androvitsanea
22. When Ceres commands her nymphs – An investigation of the relation between mills and aqueducts in the antique Mediterranean – Stefanie Preißler
23. The Glass kiln (Horno de Vidrio), a drop tower in the water supply to the city of Toledo (Spain) during the Roman era – Marisa Barahona

Lunch break 13:15 – 14:30

14:30 Departure to Yad Vashem (from Neve Ilan Hotel to Jerusalem and return)

16:30 Departure to Israel Museum to visit the archeological section in Guiding groups Dan Warner, Dudi Mevorach and Tsvika Tsuk)

20:00 Dinner at the hotel

C The excursions during Cura Aquarum in Israel 17-20/10/2012

Day 4 Wednesday October 17, 2012 (from Neve Ilan to Masada, Jerusalem and return)

Guides: Uzi Dahari, Tsvika Tsuk, Ronny Reich and Eli Shukrun

08:00 – 09:45	Drive to Masada
09:45 – 12:00	Visit the site of Masada
12:00 – 13:00	Visit the new museum
13:00 – 14:00	Lunch at Masada (not included)
14:00 – 15:30	Drive from Masada to Jerusalem
15:30 – 17:30	Jerusalem: ancient water systems including the old drainage channel
17:30 – 18:15	Drive to the hotel
19:30	Dinner at the hotel

Day 5 Thursday October 18, 2012 (from Neve Ilan to Ramla, Gezer Eshkol and Acre)

(Check out)
Guides: Dan Warner, Amir Gorzalczany, Tsvika Tsuk and local guides at Eshkol site

Bus no. 1

08:00 – 08:30	Drive to Ramla
08:30 – 11:00	Visit Ramla and Gezer
11:00 – 12:30	Drive to Alonim
12:30 – 13:30	Lunch at Alonim (not included)
13:30 – 14:00	Drive to Eshkol site
14:00 – 16:00	Visit Eshkol visitors' center
16:00 – 17:00	Drive to Acre

Bus no. 2

08:00 – 08:30	Drive to Gezer
08:30 – 11:00	Visit Gezer and Ramla
11:00 – 12:30	Drive to Ein Hamifratz
12:30 – 13:30	Lunch at Ein Hamifratz (not included)
13:30 – 14:00	Drive to Naharia
14:00 – 17:00	Visit Acre's aqueduct, including the old city
19:00	Dinner and Overnight at Palm Beach Hotel, Acre

Day 6 Friday October 19, 2012 (from Acre to Tel Aviv)

(Check out)
Guides: Tsvika Tsuk, Dror Ben-Yosef and local guides at Eshkol site

Bus no.1

08:00 – 10:30	Visit Acre's aqueduct, including the old city
10:30 – 11:30	Drive to Sepphoris

Bus no. 2

08:00 – 09:00	Drive to Eshkol site
09:00 – 11:00	Visit Eshkol site
11:00 – 11:30	Drive to Sepphoris

both buses

11:30 – 13:30	Visit Sepphoris
13:30 – 14:00	Lunch (not included)
14:00 – 14:45	Drive to Megiddo
14:45 – 16:15	Visit Megiddo
16:15 – 17:30	Drive to Metropolitan Hotel, Tel Aviv
19:30	Dinner and Overnight at Metropolitan Hotel, Tel Aviv

Day 7 Saturday October 20, 2012 (from Tel Aviv to Caesarea and return)

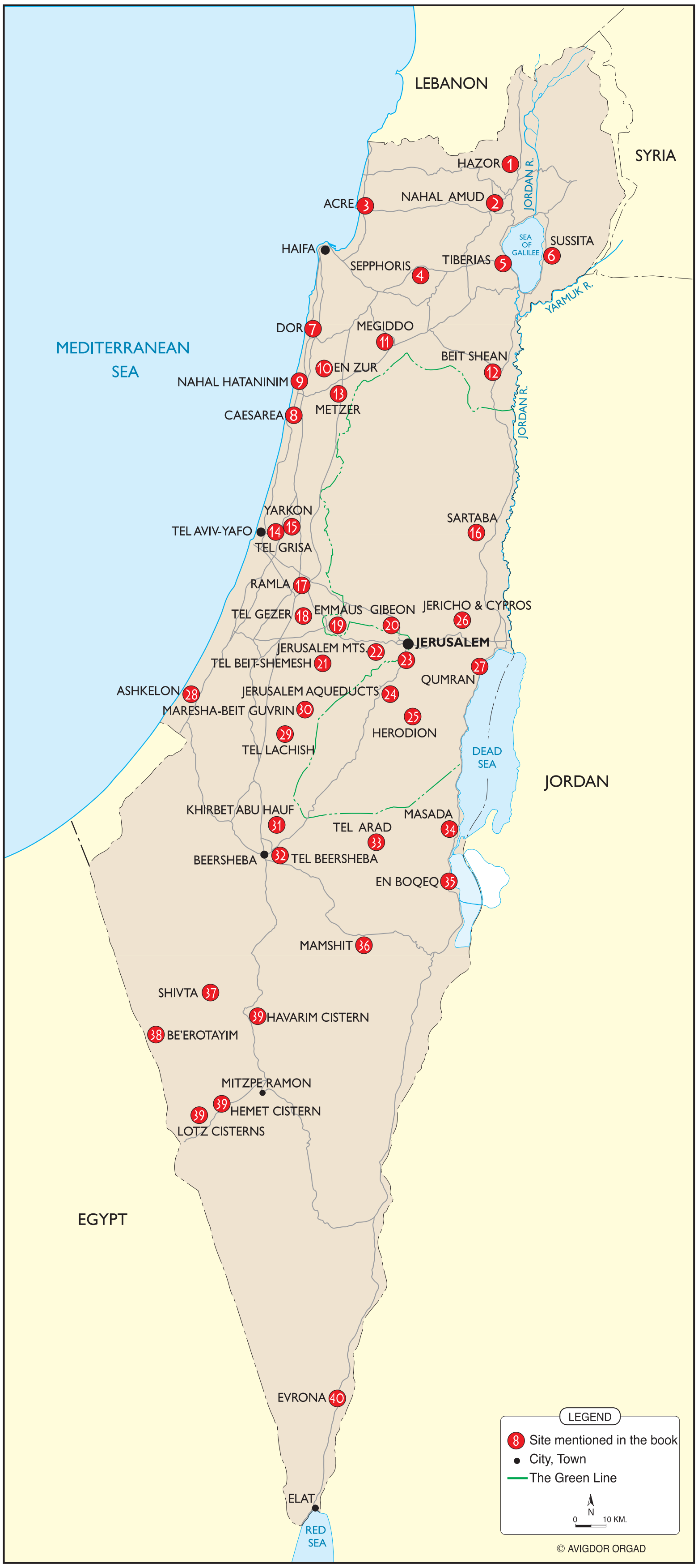
Guides: Yosef Porath, Yeshu Dray and Tsvika Tsuk

08:00 – 09:00	Drive to Mei Kedem
09:00 – 11:00	Visit Mei Kedem
11:00 – 11:30	Drive to Beit Hanania
11:00 – 12:00	Visit Beit Hanania
12:00 – 13:30	Visit Nahal Ha'Taninim Dam
13:30 – 14:00	Lunch (not included)
14:00 – 15:30	Visit Caesarea Aqueduct
15:30 – 16:30	Drive to Tel Aviv
16:30 – 19:00	Free time in Tel Aviv
19:00 – 22:00	Farewell Dinner at the Hotel

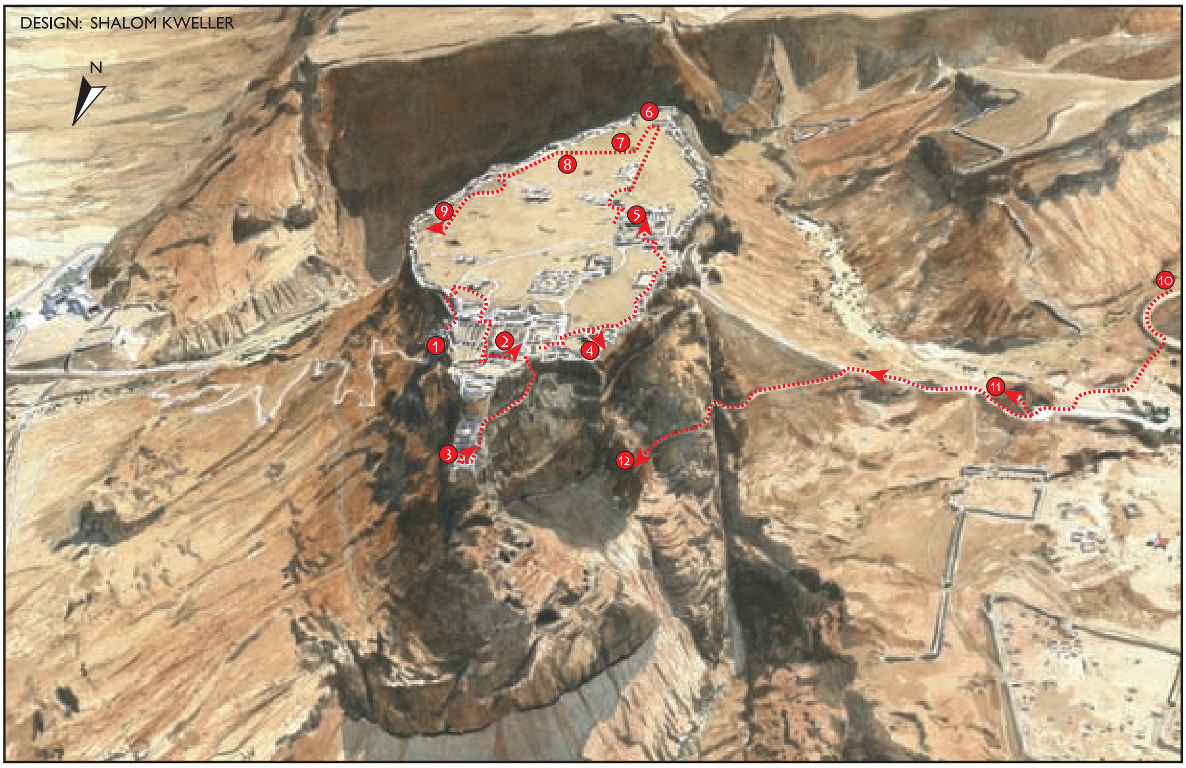
List of the conferences

1. 1975 Koblenz, Germany
2. 1977 Lyon, France
3. 1979 Istanbul, Turkey
4. 1981 Athens, Greece
5. 1983 Jerusalem, Israel
6. 1985 Cairo, Egypt
7. 1988 Rome, Italy
8. 1991 Merida, Spain
9. 1994 Pompeii, Italy
10. 1998 Syracuse, Italy
11. 2001 Jerusalem, Israel
12. 2004 Ephesus, Turkey
13. 2007 Petra, Jordan
14. 2009 Toledo, Spain
15. 2012 Jerusalem, Israel

Main Ancient Water Systems in Israel

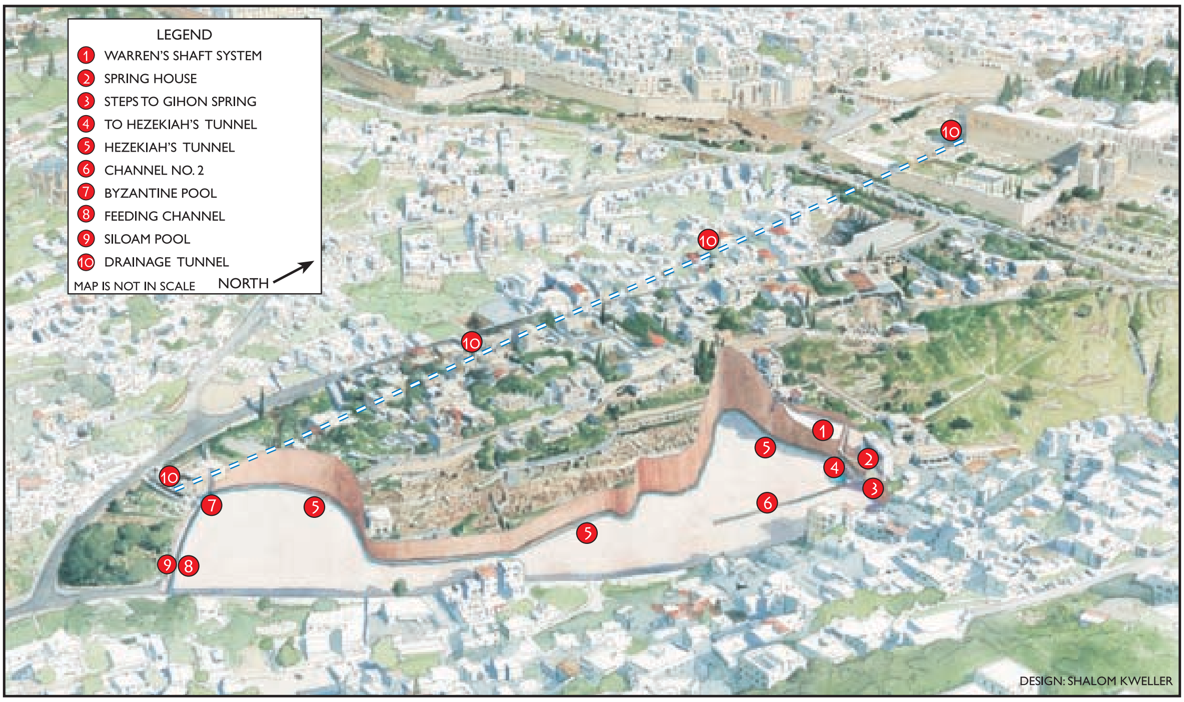


Masada National Park

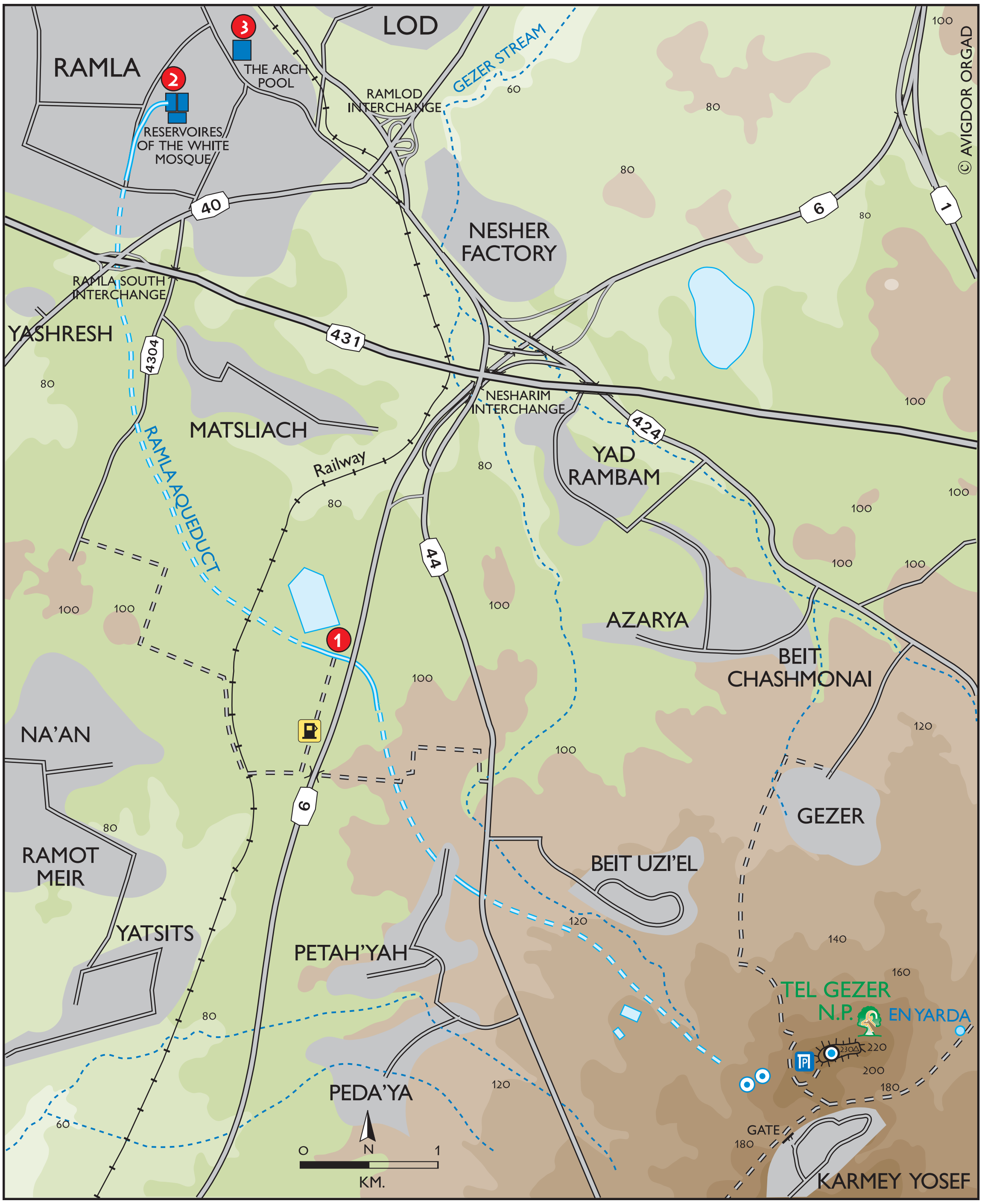


1. Cable Car's Reservoir
2. Big Bath house
3. Northern Palace, small Bath house
4. Synagogue's Cistern and Model of the Aqueducts and the Reservoirs
5. Western Palace
6. Swimming pool
7. Southern Reservoir
8. Southern Ritual Bath
9. Eastern Reservoir
10. Masada Stream's Aqueducts
11. Reservoirs' view point
12. Aqueduct and the upper Reservoirs

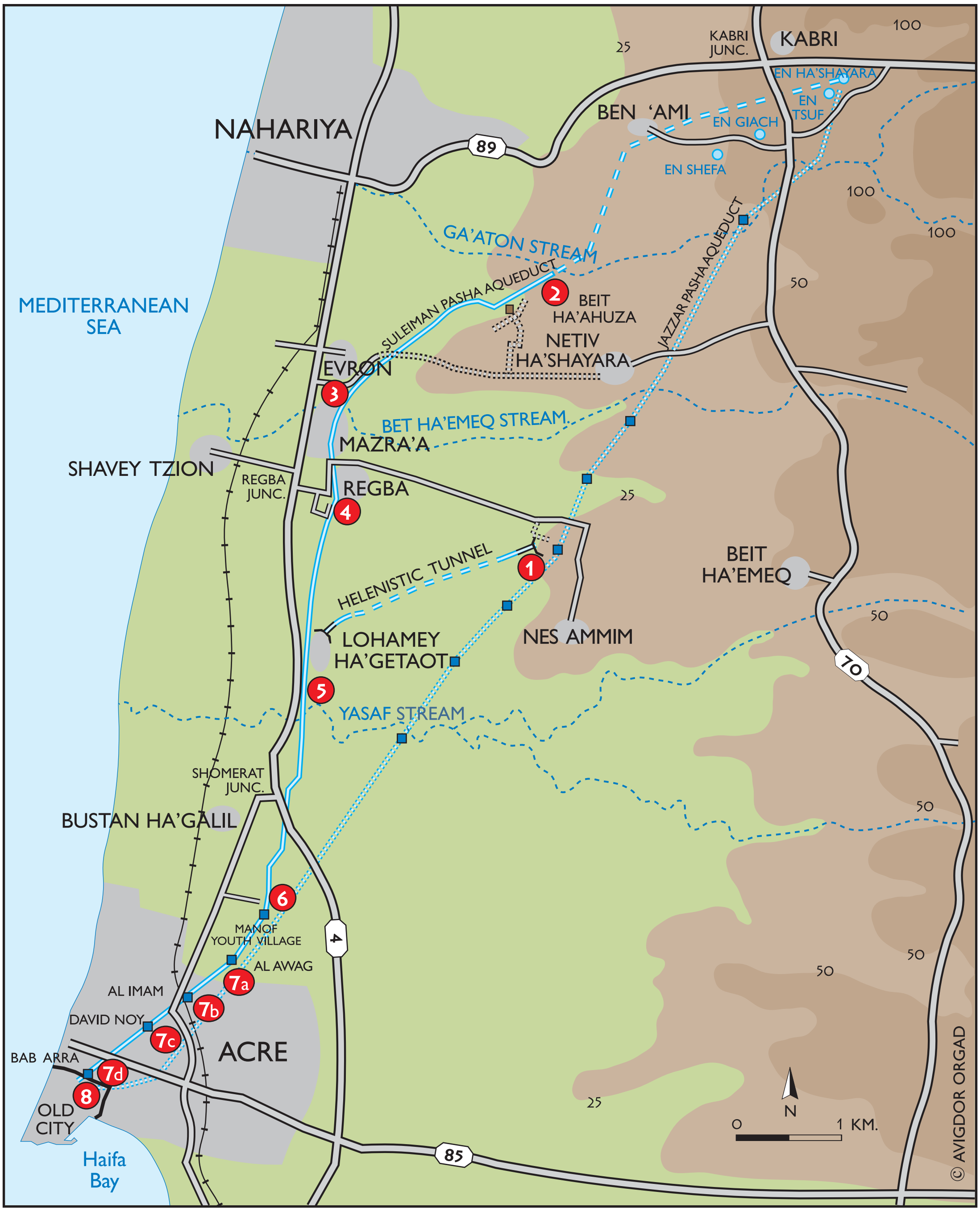
Jerusalem Water Systems - City of David National Park



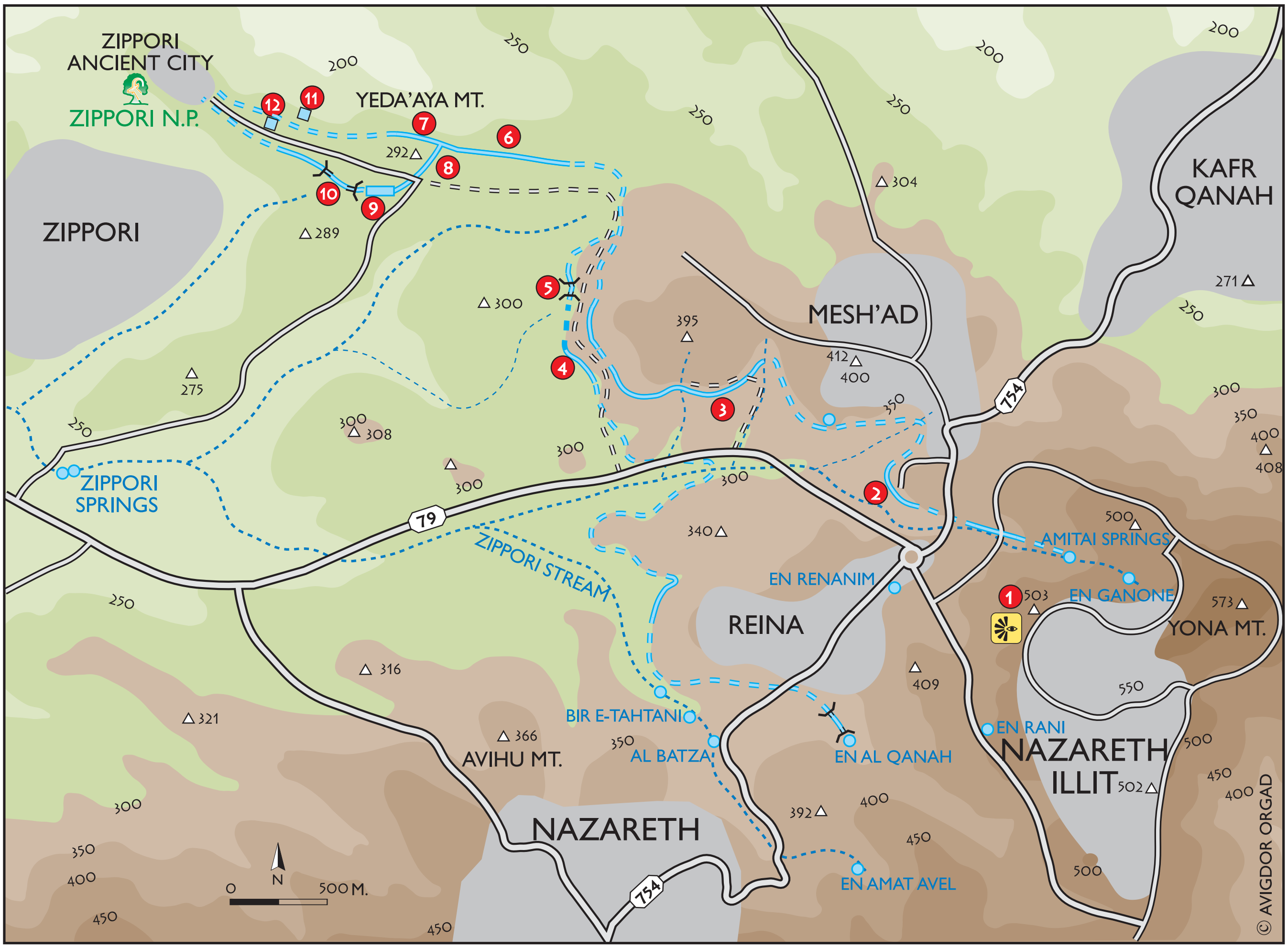
Tel Gezer National Park and Ramla



The Aqueducts to Acre

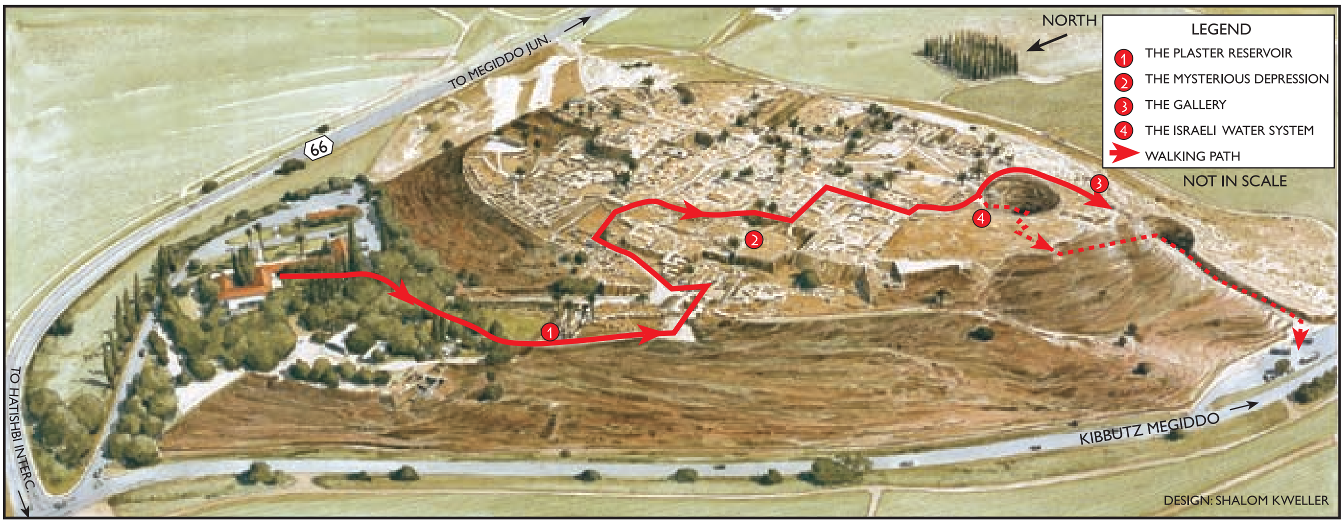


The Aqueducts to Zippori (Sepphoris)

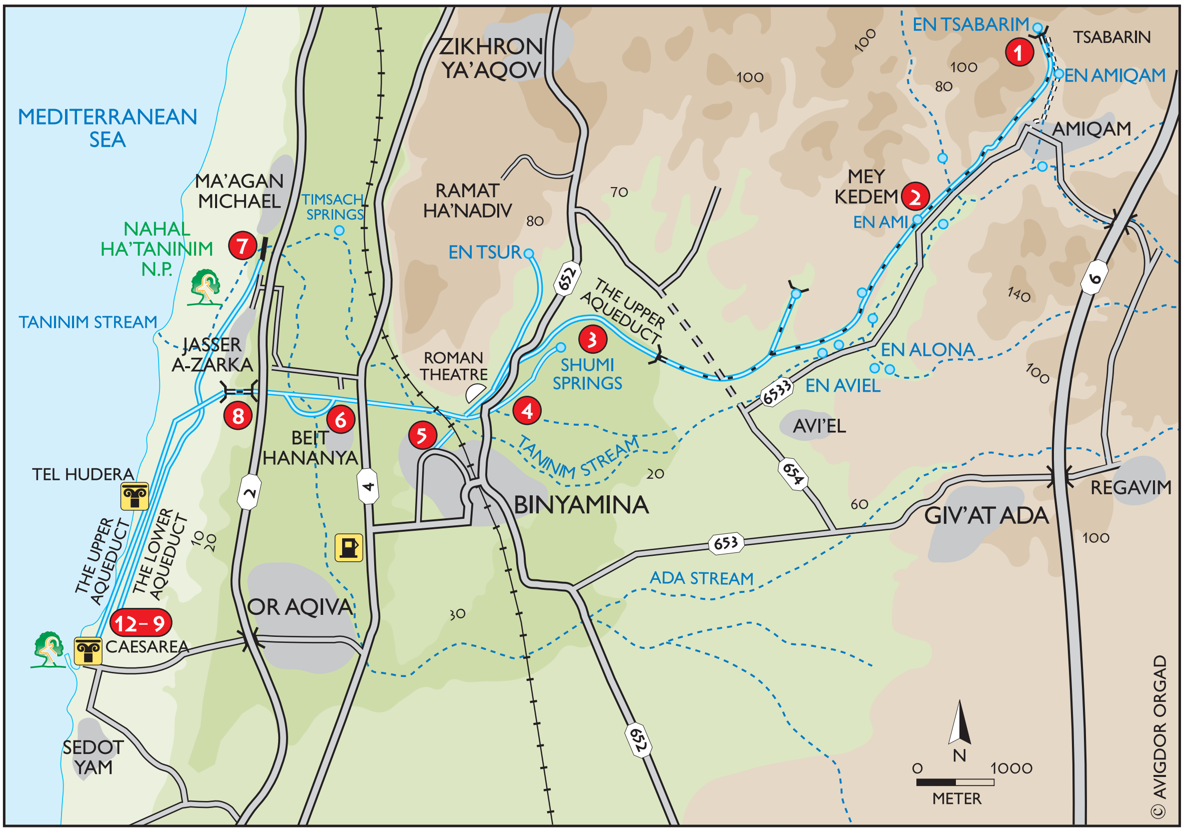


1. Mt. Yonah Viewpoint
2. Meshad's Aqueduct
3. Meshad's Aqueduct
4. Reina's Aqueduct
5. Ruin Tunnel (Destroyed)
6. Reina's Aqueduct
7. Pool's Aqueducts
8. Aqueduct before the Reservoir
9. The Huge Reservoir
10. Reservoir's Aqueduct
11. Mesh'ad pool
12. Arche's Reservoirs

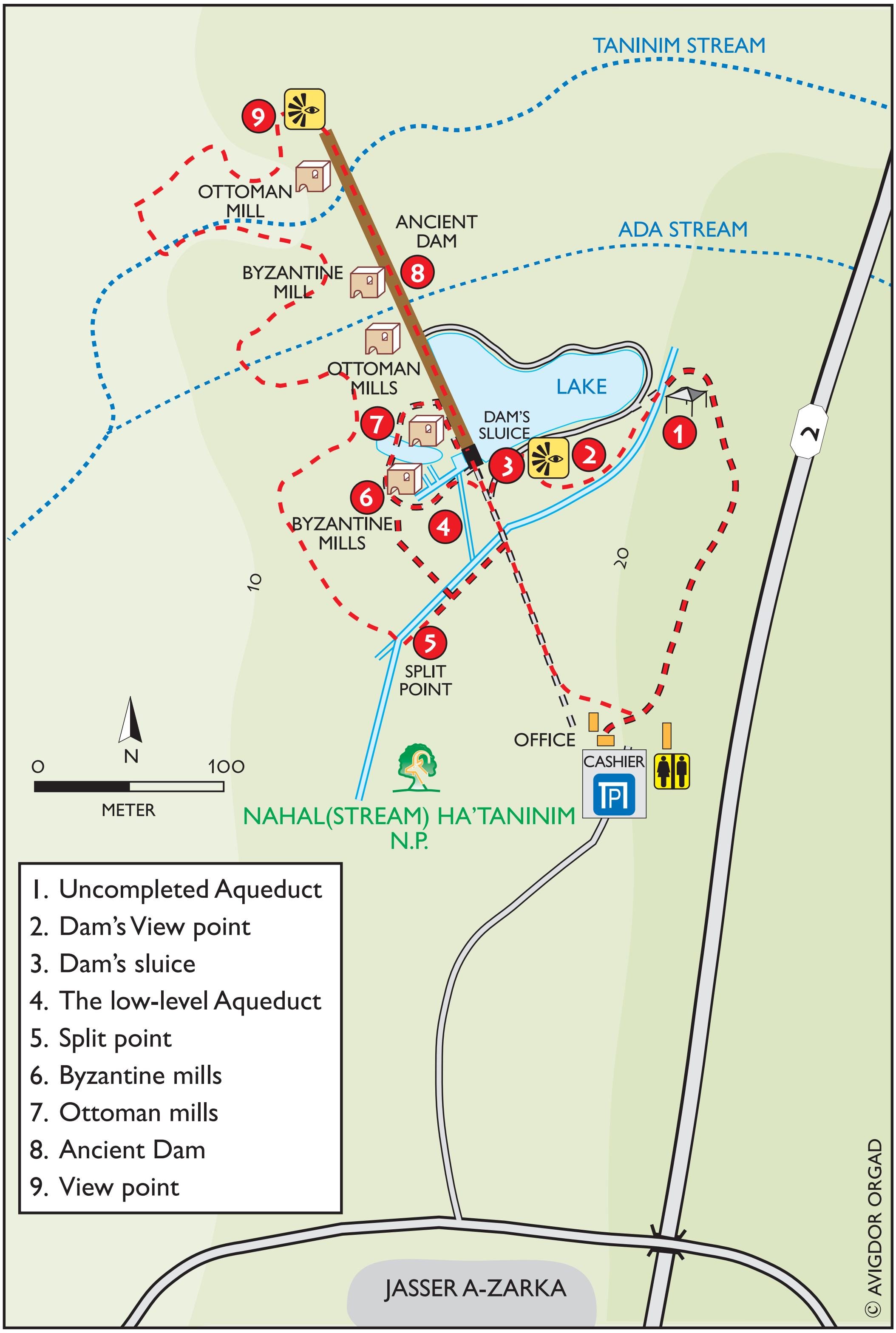
Megiddo National Park



The Aqueducts to Caesarea



Nahal Ha'Taninim Nature Reserve



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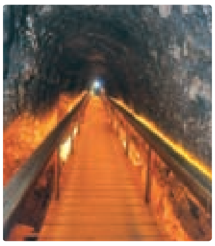

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14-20 October 2012

Abstracts

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1 Is There Light at the End of the Tunnel? The Gezer Water System Project

Dan Warner, Tsvika Tsuk, Jim Parker and Dennis Cole

This presentation will discuss the renewed excavations of the Gezer Water System from 2010-2012 sponsored by New Orleans Baptist Theological Seminary and the Israel Nature and Parks Authority under the auspices of the Israel Antiquities Authority. This presentation will focus on the latest archaeological information gleaned from the past three seasons of excavations clarifying some of the critical questions unanswered by its original excavator, the Irish archaeologist R.A.S. Macalister. Central to this presentation will be the examination of key features related to the three segments of the system exposed by Macalister. These sections include the keyhole shaped entrance, the central stepped water shaft, and the water cavern. This past season, the team was able to penetrate the cavern and examine it for the first time since Macalister's excavation. This breach into the cavern has assisted the team greatly in answering some critical questions about the system's function.

2 A New Assessment of the Upper Aqueduct to Jerusalem: its Date and Route

David Amit and Shimon Gibson

The sizeable urban expansion of Jerusalem in the Second Temple period, particularly at the time of Herod the Great (from 37 BCE), resulted in a growing demand for larger quantities of water, not just for the personal needs of its inhabitants, but also for those attending the extensive public and ritual areas of the Temple Mount, especially at times of festivals when Jerusalem filled up with thousands of Jewish pilgrims. Substantial quantities of water were needed, not just for basic drinking purposes, but also for the washing of the areas of sacrifice close to the Temple's altar. Additional large quantities of water were also necessary for the use of the fortified towers, service areas, residential buildings, and gardens belonging to the compound of the Palace/Praetorium situated in the area of the Upper City, built by Herod the Great (c. 25 BCE) and then re-used by a succession of Roman governors.

The pivotal urban changes occurring in Second-Temple period Jerusalem with the ever-increasing demand for an efficient supply of water, eventually led to the construction of two aqueducts, one situated on a low-level (the "Lower Aqueduct") and the second, running on a high-level (the "Upper Aqueduct"). These aqueducts conveyed a steady flow of water to the city from great distances in the south, from Ein Etam (below "Solomon's Pools") close to Bethlehem, and from Wadi Biyyar and Wadi Arrub, close to Hebron. Owing to the important function of the Lower Aqueduct as the chief supplier of water to the Temple Mount, scholars thought it to be the older of the two aqueducts, perhaps even from the days of Hasmonean rule. We may surmise that it was undoubtedly extant by the time of Herod the Great, since he was responsible for initiating major building works in the city, notably the construction of the Temple and Palace compounds, and it is unlikely that an efficient water supply to these areas would have been overlooked in his overall planning procedures. The Lower Aqueduct continued to be used over a lengthy period of time thereafter, in the Byzantine, Early Islamic, Medieval/Mamluk, and Ottoman periods. The Upper Aqueduct was regarded by scholars as the latest of the two aqueducts, with its use attributed to the time of the Tenth Roman Legion whose camp was established in the city following the destruction of 70 CE, and to the reign of Septimus Severus. The purpose of this lecture is: (1) to question the late date of the Upper Aqueduct; (2) to establish the route of both aqueducts within the modern part of Jerusalem; and (3) to present new information concerning the distribution of water channels within the Upper City extending from the Upper Aqueduct. We will rely on the results of recent archaeological excavations and surveys conducted at Mamila, on the west side of the city, within Jaffa Gate, in the area of the Pool of Hezekiah, beneath Christ Church, and in the Armenian Garden.

Our new analysis suggests that the Upper Aqueduct had to have had an antiquity earlier than scholars had previously assumed. Since the Upper Aqueduct was undoubtedly the chief supplier of water to the summit of the Upper City and to the area of Herod's Palace, extending southwards along the northern crest of the Western Hill, we assume the aqueduct must have existed by 25 BCE from the time of Herod the Great. In the present lecture we will demonstrate the reconstructed alignment of the Upper Aqueduct along the water divide, traced through the southern suburbs of modern Jerusalem (between Talpioth and Mamila), and finally ending at the Jaffa Gate where it entered the city and extended as far as Hezekiah's Pool. From this pool, water continued to be distributed southwards to the area of the Palace, and eastwards (beneath Christ Church) in the general direction of Wilson's Arch.

3 Dating and engineering of Siloam Tunnel, Jerusalem

Amos Frumkin and Aryeh Shimron

Being one of the longest ancient water tunnels lacking intermediate shafts, dating the Siloam Tunnel (ST) is a key in determining where and when this technological breakthrough took place. ST is also the best-identified biblical structure that can be entered today. We used geological, structural, and chemical features of ST and its internal deposits to show that it is an authentic engineering project, without any pre-existing natural conduit that could have guided its excavators. ST pinpoints the technological breakthrough in levelling techniques that was essential for the construction of such a long tunnel without intermediate shafts. A combination of geological and archaeological evidence demonstrates that the circuitous route of ST and the final meeting of the two excavating teams are associated with continuous modifications of the plan to allow acoustic communication between hewers and the surface teams. Hydraulic plaster was applied throughout the tunnel in order to seal pre-existing voids. We dated organic material accidentally entrapped in the plaster by carbon 14, and speleothems by U-Th. Both approaches corroborate the historic and epigraphic evidence attributing ST to the Judahite King Hezekiah ~700 BCE. This indicates that the biblical text presents an accurate historic record of Siloam Tunnel construction.

4 The Inverted Siphon Pipelines to Tel Bet Yerah / es-Sinnabris

Yardenna Alexandre

In January 2012 a salvage archaeological excavation was carried out by the Israel Antiquities Authority on the west bank of the old Jordan riverbed, directly opposite the site of Tel Bet Yerah, subsequent to damage caused to archaeological remains by earthworks laying down large water pipes to divert saline and sewage waters away from the Sea of Galilee. The excavation exposed a 20 m long section of a large water pipe built of interconnecting square basalt blocks, running downhill from the hill slope to the riverbed. About half a meter directly below the basalt pipe, a smaller terracotta pipe built of interconnecting cylindrical clay segments followed exactly the same line, running in the direction of the riverbed. These pipes were part of a water system that drew water off from the long 'Berenice' Yavneel to Tiberias open stone aqueduct, in order to supply water to the site of Tel Beth Yerah, a system that involved the implementing of the inverted siphon technology in order to transfer the waters across the low riverbed, and raise them again to the Bet Yerah tel. The lecture will present the two overlying channels, and the direct and indirect dating considerations available, to fix the date of this water system to the Early Islamic period, when an Umayyad palace and an elaborate bathhouse stood at the site. The relation of the terracotta and the basalt pipes is discussed, as well as the possibility that the stone blocks were originally part of the Hippos-Sussita water-supply system, and that they were secondarily transferred to the Bet Yerah water system.

5 The *"Otzar"* in Ancient Ritual Baths: Second Temple Period Innovation or Anachronistic Interpretation?

Yonatan Adler

The first installation to be identified as an ancient Jewish ritual bath (miqweh) was discovered by Yigael Yadin at Masada in 1963–64, and consisted of a stepped pool connected to an adjacent pool via a hole in the wall shared by the two installations. Yadin identified the first installation as an immersion pool, and the second as an `*otzar* (lit., "treasury"), used to ritually purify the waters in the immersion pool. In his groundbreaking 1990 study, Ronny Reich showed that an `*otzar* was in fact not a requisite element in ritual baths, an insight which allowed for the identification of hundreds of additional ancient stepped water installations consisting of a single pool with no adjacent `*otzar* as ritual baths. In the wake of Reich's study, scholars have debated the question of why only a minority of ritual baths make use of an adjacent `*otzar*, while the vast majority of ritual baths have no such adjoining installation, with some speculating a basis in late Second Temple period sectarian differences. The present paper argues that the `*otzar* was a concept invented only in late 18th century Europe, and that any attempt to identify an `*otzar* in ancient ritual baths is no more than an anachronism.

6 When were the *Qanat* Systems introduced to the Holy Land?

Yosef Porath

A *Qanat* system is a sophisticated method of obtaining underground water by gravitation. It was invented at the arid plateaus of Iran, in the first millennium BCE, in order to obtain flood water from the mountains that absorbed into the alluvial fans, before it got salted and lost its value for human use and for 'Irrigation Agriculture.' The typical Iranian *qanat* consists of a vertical well down to the water table ('Mother Well'), a conduit from the surface dug into the ground to the bottom of the well, and a line of vertical shafts from the surface to the conduit's tunnel. The conduit's gradient is lower than surface topography. The result was an artificial spring, which enabled the existence of an oasis.

The ancient Mediterranean civilizations also developed other methods of enriching water supply by digging into an underground water table; such as 'Spring Tunnels,' to intensify the supply of small mountainous springs, or 'Shaft Tunnels' (i.e. *cuniculi*) to collect water in underground aqueducts. *Qanat* systems of the Iranian type were surveyed in three sites at the Aravah, all in the western side, due to geological and topographical conditions. Several farm-houses were built adjacent to these *qanat* systems, all of which date to the Early Islamic period (late 7th to late 8th/early 9th century CE). The chronology of the remote artificial oases in the Aravah meets that of the rich residences supplied by *qanat*s' water of the Jordan Valley (Phasaelis and Shunet Nimrin) as well as the Syrian Desert (Qasr el Heir el Gharbi and Qasr el Heir el Sharqi). The study of the *qanat* systems of the Aravah and elsewhere suggests that the Iranian type was adopted, copied and spread in the countries controlled by the Umayyad rulers since the mid 7th century CE and later, then spread from China in the east to America in the west. *Qanat* systems are still functioning today in some under-developed arid zones such as Morocco.

7 The Early Islamic aqueducts to Ramla and Hebron

Amir Gorzalczany and David Amit

Two aqueducts from the early Islamic period were discovered in Israel. One conveyed water to Ramla, while the second supplied Hebron. Both are mentioned in literary sources and the records of researchers from the nineteenth century. Two parts of the aqueduct leading to Ramla (150 meters each), were systematically excavated, discussed and published. The remains are attributed to the Umayyad caliph Suleiman Ibn 'Abd al-Malik, founder of the city of Ramla (716 CE). This aqueduct seems to have led water from the Abu Shusha springs near Tel Gezer to the city of Ramla. The excavations allowed a thorough analysis of its constructive, historical and hydraulic features. The northern segment of the aqueduct is presumed to have been a secondary branch that bifurcated from the main channel, and to have conveyed water also to the large industrial area excavated near Moshav Matzliah, south of Ramla. The aqueduct in Hebron was never excavated but surveyed, and was also the subject of various studies. One of its most interesting features is a meaningful technological change, which consisted of the use of ceramic pipes to convey the water, rather than running them in open channels.

The construction of the aqueduct to Ramla during Umayyad period should not surprise us; its destination, the newly built city of Ramla, lacked natural water sources and the establishment of artificial means for water supply was mandatory. However, one could ask why a city of considerably greater antiquity such as Hebron did not construct such an installation before, i.e. during the Roman and Byzantine periods, when the needed technology was readily available. A possible explanation is that after the Islamic conquest the symbolic meaning of Hebron increased substantially, due to the traditions connecting the city to Abraham and the patriarchs. Those traditions encouraged a substantial increase in the volume of visitors and peregrines to the city. These visitors exhausted Hebron's water reserves and forced its residents to look for new sources in the vicinity.

8 Touring Israel's ancient water systems

Tsvika Tsuk

Hundreds of ancient water systems cover the whole of the state of Israel. Their dating begins at the 6th millennium B.C. and ends in the 20th century A.D. Their diversity is from a lonely cistern to a huge underground reservoir; from a simple well to a long aqueduct beginning at a spring. The semi-arid climate of the land, which meant a lack of water, forced the inhabitants to find solutions in order to bring water to their settlements.

Thus, some of the enormous water systems are local inventions of this country, such as underground hewn tunnels to the water table, as at Tel Gezer, Megiddo, Hazor, etc.

A year ago I published my book "Water at the End of the Tunnel," which recommended 40 tours to ancient water systems in Israel. There is an annex in the book, adding 80 more places, and there are even more.

In our conference we plan to visit 11 sites in the central and north-western parts of Israel as well as a site in the Judean Desert.

The sites are: Masada, Jerusalem, Tel Gezer, Ramla, Eshkol site (part of the Israel water carrier), Sepphoris, Acre, Megiddo, Mei Kedem, Nahal Taninim Dam and Caesarea.

Their dating ranges from the Middle Bronze Age to modern times, including the Iron Age, Roman, Byzantine and Early and Late Islamic periods. The sites are very diverse in their periods, hydrology, technology and regions.

In my lecture I shall describe the sites as a background to the tours.

9 Water in Israel and in the Middle East – past, present, future

Shimon Tal

Most of the Middle East is actually a desert. A wet strip of 80 km width along the coast of the Mediterranean Sea from Tel Aviv to the North is the source of most of the natural water resources. Natural water resources are necessary not only for basic needs but also to enable the existence of national interest, like agriculture. Conveyance of water from its origin to the places where it is consumed was necessary more than 2000 years ago and is necessary today. Needs for more water grow every day while natural water resources deteriorate constantly. In the past, the high cost and lack of proper technologies resulted in hostile disputes over water resources. Today we are not obliged to be content only with natural water resources. Desalination of sea water and reuse of sewage effluents can be easily achieved. Today creating new water resources is being done on a national level, but the regional need to increase the potential of the natural water potential will dictate regional solutions.

10 Groundwater use in the Hittite capital of Hattuša 1600 BC

Hartmut Wittenberg

From about 1650 until 1200 BC, Hattuša was the capital of the Hittite Empire in central Anatolia in today's Turkey. The steep and dry site of the ruined city appears unfavorable for a settlement of thousands of inhabitants, whose homes, workshops, cattle, gardens and places of worship had to be supplied with water. Large-scale ponds filled with sediments were found in the urban area since the 1980s and then partially excavated and studied.
The question remained how and from where the water was conveyed into the East Ponds (Ostteiche, 36000m^3) and South Ponds (Südteiche, 20000 m^3). A repeatedly discussed hypothesis has been the supply of the large volumes by long pipelines from outside the city. However, the study of the topographic, hydraulic and geo-hydrological conditions leads to the conclusion that a long distance supply would have been uneconomic and also unnecessary.
Even today, willow fountains in the region are fed by artesian groundwater. Our new assumption was that the ponds were cut into hill slope aquifers from where they were filled during the wetter winter months.
To verify this hypothesis, groundwater measuring stations were installed in the autumn of 2009 directly uphill of the ponds. Indeed, measured groundwater levels 2009-2011 show strong seasonal variations rising during winter above the former pond surfaces. The hydro-geological mechanisms of pond filling are demonstrated in the contribution. Obviously, the Hittites used exfiltrating groundwater also in their other reservoirs, to avoiding hefty and strongly varying surface inflows.

11 Ancient Water Systems of the Lamas Çayi and the surrounding hinterland

Dennis Murphy

The Lamas Çayi (River) marks the ancient boundary between Cilicia *Tracheia* (rough) and Cilicia *Pedias* (plain). It was also the primary water source for three different Roman water systems supplying the ancient cities of Elaiussa Sebaste/Korykos, Olba and Diocesarea. The three aqueducts transported water by an interesting combination of cliff side rock cut channels with galleries, above ground aqueduct channels, underground conduits, tunnels and arched bridges crossing valleys. Ancient engineers used local construction materials and many of the imposing aqueduct bridges have not only survived the test of time but are also artistically imposing structures. This study provides an excellent opportunity to look at how ancient water system can still be utilized in a modern environment and see how many of the technical problems faced by the ancient Romans are also experienced by today's modern engineers.
The hinterland included many small settlements and farmsteads which relied upon numerous cisterns to support agricultural activities and daily life. While the aqueducts primarily served to supply water to urban centers supporting such monumental public structures as *nymphaeums*, fountains and baths, there is also evidence that some of the water was diverted for private uses such as workshops, villas and in the later Christian era, the supply of monasteries. This division of water was accomplished by means of small *castellum aquae* and at least one instance of an in channel sluice gate water off take type device. This paper will look at the construction techniques employed in building these water systems, aqueduct bridges, arch construction, water off take devices and cistern design within the context of their continued use into the modern era.

12 The dating of the Roman Kaikos- and Madradaĝ aqueducts of Pergamum

Henning Fahlbusch

Two major channels were constructed in Roman times and supplied Pergamum with abundant water, i.e. the Kaikos-aqueduct from the east and the adradaĝ-aqueduct from the north. According to Garbrecht (2001) the discharge of the first channel was about 150 l/s and the one of the second probably 100 – 120 l/s. As there are no calcareous deposits in the Madradaĝ-aqueduct the discharge can only be estimated. Both channels were about 50 km long. However the one from the north followed more or less the existing line of the Hellenistic triple pipe-line. Only 3 bridges were obviously necessary in its course, i.e. a small one in the mountains a big and a small one directly north of the city.
As the elevation of the spring which supplied the Kaikos-aqueduct is little above its end in Pergamum, a thorough exploration of the line and the construction of 40 bridges and 5 tunnels were necessary. And the bridge across the ancient Karkasos river was obviously the highest built from opus caementicium in Roman times. The costs for the Kaikos-aqueduct therefore must have been extremely big.
The Kaikos-aqueduct is dated by Hecht (1979) into the early 2nd century AD. This opinion is supported by Garbrecht (2001). Assuming the destruction of most of its bridges due to the earthquake of 178 AD and an operation time of about 60 years, which was determined by an analysis of the sinter carried out by Prof. Passchier, this dating seems to be correct. The Madradaĝ-aqueduct was dated by Garbrecht into the era of Emperor Marc Aurel (161-180 AD) with reference to Jones (1991) who interprets a poem of Aelius Aristides and a coin found in Pergamum as evidence for the inauguration of an aqueduct. However, the order of the aqueducts doesn't fit to economical as well as engineering considerations. A new aqueduct normally was constructed when the water demand sharply increased and couldn't be covered by the existing supply. This was the case in Pergamum at the end of the 1st century AD. Choosing a new line for an aqueduct at that time it was important to reach the city on a high level, with a minimum effort for planning and construction and with low costs. The comparison of both aqueducts means that the Madradaĝ-aqueduct surely was constructed before the Kaikos-aqueduct. There is quite circumstantial evidence that the channel from the north was already constructed in the era of Emperor Trajan (98 – 117 AD) as it supplied the baths in the eastern part of the gymnasium which was most probably constructed at that time. The interpretation of the famous Astynomen inscription seems to indicate the construction of the channel even before the earthquake in 106 AD.
The poem of Aelius Aristides was therefore obviously written for another event and also the minting of the coin.

13 The urban sewage system of ancient Pergamum – How it developed in Hellenistic through Roman era

Kai Wellbrock

The ancient city of Pergamum, Turkey, is famous for its extraordinary water supply system which was intensively investigated during the last roughly 40 years. Nevertheless, since the ancient city was inhabited densely during its times of high prosperity, a sophisticated sewage system should be assumed, too. Several sewers were found during the first excavation, about 130 years ago. Mostly they were situated along the roads and alleys. Usually, they were constructed of hewn stones or cut into the bedrock. Most sewers were covered by means of flagstones. The main sewer is considered to be situated along the main road which led to the top of the Acropole Mountain.

Since Pergamum was a city which grew organically, no clear system or planning of the system is visible at first glance. Most likely the system grew in steps with the occupation of several quarters. Thus, a detailed investigation of certain junctions was conducted in order to determine the sequence of the system´s erection.
Furthermore, due to the steep terrain at the Acropole Mountain, certain problems regarding the hydraulics had to be solved. In many cases the sewers have been equipped with cascades in order to reduce the flow velocity and thus to prevent any damage during storm rain events.
Finally, the system was analyzed by means of a precipitation-runoff-model. Thus, the pertinent rainfall events to the sewer system could be determined. Further, based on recent rainfall statistics, the probability of flooding within the city could be evaluated. In addition the development of the sewer system could be checked due to hydrodynamic requirements.

14 The aqueducts and water supply of Tralleis

Eddie Owens and Rafet Dinç

This paper offers a preliminary examination of the water supply and distribution system of the ancient city of Tralleis. Tralleis is strategically situated on a flat, sloping spur overlooking the valley of the Meander river. According to Strabo, the city's wealth and importance were renowned and it flourished during the Hellenistic and Roman periods. Its growth was such that the city's water demands outstripped any local, natural water sources. Instead the city relied on a series of long distance aqueducts to meet the complex water demands of its inhabitants. At least two long distance aqueduct systems supplied the city. The water was carried in a series of underground and surface tunnels from sources up to 35 km away. The nature of the terrain was particularly difficult in places and impressive civil engineering structures, including multi-level bridges, arcades and at least one large, extra-urban storage facility, had to be constructed to ensure continuity of supply. The earliest identifiable remains date to the late Hellenistic/Augustan period. However, the importance of the aqueduct system to the continuation of the city is evidenced by the major renovations and extensions to the system which were constructed subsequently, and it is clear that the aqueduct systems still supplied the city into the Byzantine period and even beyond.
Excavations within the city are also beginning to reveal an equally impressive water distribution system, based on a complex system of terracotta pipelines. These provided water for public and private, essential and recreational use throughout the city.
The water supply of Tralleis is impressive. From at least the late Hellenistic period onwards, the city relied heavily, if not exclusively, on a piped water supply system, which provided for all the needs of the city's inhabitants.

15 The ancient hydraulic engineering buildings of Antiochia (Turkey)

Mathias Döring

Besides Rome, Alexandria, and Byzantium, Antiochia, (today's Antakya) was one of the most important metropolises of the ancient world with its population of more than 500,000 people. The water supply of the capital of the province Syria was assured with the help of two aqueducts, each having a length of 12 km, which were fed from major karstic springs. On their course, the aqueducts cross several valleys with the help of bridges up to 35 m in height, some of which are still completely preserved. However, the brick masonry of other bridges has disappeared to a large extent through weathering. Nevertheless, these bridges could be reconstructed. As a result of leaks in the water channel, the historic building substance was almost completely covered by calc-sinter, in which all details of the construction are visible as reversed impression. With the help of a bridge, the later aqueduct, presumably dating from the early 2nd century AD, crossed a torrent, whose high-water floods devastated the city centre again and again. When Antiochia had to be reduced in size because of several catastrophes, the bridge was broadened and the city wall passed over the bridge. The bridge arch was rebuilt and integrated into a reservoir and dam by closing it with a cylindrically curved wall made of Roman concrete (*opus caementicium*) such that the world's first dam wall with horizontal progression of forces was constructed as precursor of all modern arch dams. In spite of stone robbery and other damages, the reservoir and dam are still in operation to this day and care for the flood protection of a part of the modern town.

16 The army and the infrastructure of the cities in the Imperium Romanum

Werner Eck

The Roman army was an important factor in many provinces, especially in the province Iudaea/Syria Palaestina. Since Hadrian's time there were two legions and 18 auxiliary forces, under the command of the governor of this province – a much larger force than in any other province, in relation to the size of the province. Troops had to be kept busy, if they were not involved in combat. Therefore it is not surprising that troops or parts of the troops were also used to improve the infrastructure of a province or of cities in the province. In our documentation, it is not always easy to distinguish between activity for the army itself or for the inhabitants of settlements. Improvements of the infrastructure, like highways or bridges, were important for both the army itself and for the civilian mobility. It was different if soldiers, who were stationed in or near cities, were engaged in building projects there. The work the Legio X Fretensis had done for the aqueduct bringing water to Jerusalem was useful for both the legion and the citizens of Aelia Capitolina. It was not the same in Caesarea, where vexillations of several Legions had built the aqueduct; but in Caesarea itself no army unit was stationed there apart from the *officium* and the guard of the governor. The aqueduct was a real improvement of the infrastructure of the civilian world. This topic will be explored for the area of modern Israel, but also for the adjacent provinces in the east.

17 Water as weapon and military target in ancient Mesopotamian warfare

Ariel M. Bagg

Ancient Mesopotamia, the land between the rivers Tigris and Euphrates, was shaped by its relation with water. Water shortage, on the one hand, and water surplus on the other hand, challenged the skills of the earliest hydraulic engineers, who constructed elaborated canal and irrigation systems along the first three millennia BCE. Another constant of ancient Mesopotamian history is war, and also in this case water played a less known, but not less important, strategic role. Water served for defensive as well as for offensive purposes during military operations In the first case, canals and rivers were used for the transport of troops, civilians or provisions. The water supply of a besieged city needed to be safeguarded, and moat or swamps were created as obstacles for the enemy. Offensive forces could also be transported by water. Water supply was cut off, cities and grain fields were flooded, and irrigation systems were destroyed. The use of water for military purposes is amply attested in the cuneiform sources. The aim of the present paper is to present the written evidence of the different military uses of water in ancient Mesopotamia, focusing on the best documented cases of the first millennium, which are related to the Assyrian campaigns.

18 Ground water use and understanding in ancient times: lessons for today and tomorrow

Michael J. Knight

Over the period from 2.3 million years ago to 1600 AD there was a punctuated increase in conceptual understanding and use of groundwater. Springs were first used by *Australopithecine* and early *Homo* hominins in East Africa. At this stage, spring selection was probably a pragmatic response to drying climates that reduced surface water options, although some geological thinking was evident. From 1.8 million years ago, much of Africa and Arabia became arid, and hominins (*Homo erectus* initially) depended on springs during their migrations within, and out of Africa including into Jordan and Israel. The transition from hunter-gatherer to urbanized living, the development of agriculture, periods of varying climatic stress as well as trade, and the need for water security, were some of the significant drivers of the process that gave rise to groundwater understanding. The first well appeared at about 100,000 years ago and was probably excavated by *Homo sapiens*. From the beginning of Neolithic times (c. 10,000 years ago) in the Middle East, wells became abundant. During the Chalcolithic period (c. 4500-3300 BC), spring development and later water-table interceptions by tunneling were coupled with managed water transfers to population groupings and agricultural centers.

In the archaeological and historical record there is evidence of loss and relearning of groundwater knowledge and practice. Empirical models, in relation to groundwater were eventually conceived. Significant advances occurred in Greek and Roman times.

The conceptual understanding and practical use of groundwater that developed over time became the foundation for the emergence of modern Hydrogeology as a discipline. This occurred during, and following, the Scientific Revolution from the 17th Century onwards.

Some ideas and strategies of the Ancients, developed under conditions of severe climatic stresses have relevance for today. A more creative use of subsurface space (natural and excavated) in rocks beneath urban areas warrants some attention.

19 Sinter deposits in Roman aqueducts

Gül Sürmelihindi and Cees Passchier

Aqueducts are the largest and most spectacular archaeological monuments built, and their construction and maintenance is amongst the technologically most complex achievements of engineering in the ancient world. Most aqueducts were fed by large perennial karst springs which form at the outlet of cave systems that developed in limestone and marble layers in the Mediterranean. As a result, the water from such springs is "hard" and deposits calcium carbonate, also known as sinter, in the water supply system. Sinter deposits are commonly layered, and since the Mediterranean has a strong bipolar climate, with cool rainy winters and dry hot summers such layering is commonly assumed to be annual and is used to determine the duration of water flow in the channel. Unfortunately, not all layering is annual, and laboratory analysis is needed to check it.

The formation of layering depends on many factors such as water temperature, depth, flow speed, chemistry and the presence of biofilms of algae or bacteria on the walls of the aqueduct channels. This layering can be studied by field analysis of the arrangement of deposits in different channels, and by laboratory investigation of samples using microscopy, trace element analysis and investigation of oxygen and carbon isotopes. We use a new approach developed in Mainz that integrates all these techniques.

Once it has been established which layers are annual, a layer count on several places along an aqueducts can provide a relative dating of the lifetime of the water supply, and of any modifications to the system. High-resolution absolute dating, using U-Th is also possible in dense crystalline deposits, with an accuracy of up to 5 years.

Additional data that can be obtained from the sinter deposits are data on water quantities supplied; chemistry and microbiology of water and associated health aspects; changes in maintenance and reconstruction of the structures; climate and climate changes in antiquity and extreme weather events such as floods and draught; and earthquake damage to aqueducts. We are now working on several aqueducts in Greece and Turkey, and discuss first results from Patara and Aspendos.

20 The Atlas Project of Roman Aqueducts (ROMAQ)

Cees Passchier, Driek van Opstal, Wilke Schram and Gül Sürmelihindi

ROMAQ is a new database on Roman aqueducts which is presently being set up, and which will be complementary to the existing website on Roman aqueducts (http://www.romanaqueducts.info).

Aqueducts are an important archaeological heritage and are a unique data source on ancient engineering and hydrology, on economic prosperity of cities, through sinter and other deposits in the aqueducts, and on climate and earthquakes in Roman times. Aqueducts are narrow, ribbon-like structures in the topography, commonly away from centers of habitation, and are therefore much more likely to suffer damage than the remains of towns or sanctuaries that can be fenced in. One important reason that aqueducts are commonly damaged or destroyed is that there is no central database of the location of their remains. ROMAQ aims to improve this situation in the following manner:

1. By setting up a database of the presently known Roman aqueducts and the corpus of published literature on these structures. We presently have localized 4300 publications in 24 languages describing nearly 1400 major aqueducts in 40 countries. We aim to collect PDF's of all publications in our Digital Repository, where we presently have over 2000 PDF's stored on the subject.

Map of the presently known Roman aqueduct sites, as published by ROMAQ

2. By collecting all published topographic data on aqueducts and their elements and storing this information in a GIS platform
3. Through a public ROMAQ website which will give basic maps and technical information, linked to the references for each aqueduct.
4. By publication of a printed atlas of the known Roman aqueducts, including photographs, maps and detailed information which is more extensive than the website.

The website will show approximate traces of the aqueduct channels where known, and technical details such as the number and type of bridges, basins, siphons etc, and the basic construction method of the *specus*. Each aqueduct will be linked to the relevant publications, and each publication to the aqueducts described. The atlas will contain more technical details and detailed maps of all elements of the aqueducts, where known. The ROMAQ website can be used to localize and to obtain information on specific aqueducts, but can also be a comparative research instrument. For example, using ROMAQ it will be possible to identify differences in aqueduct design between different provinces of the Roman Empire, determine the distribution of certain types of siphons or basins, or do economic study about the total expenditure on aqueducts in a certain Province of the Empire. We hope that ROMAQ will contribute to the knowledge and preservation of Roman aqueducts as our common heritage.

21 The role of water in ancient sanctuaries. The Sanctuary of Amphiaraos

Anna Androvitsanea

Amphiaraeion was founded by the healer and seer Amphiaraos in the last quarter of the 5th century B.C. People arrived at the site to receive therapy or advice. After having bought a ticket, they entered the sanctuary in order to receive mental and physical purification and thereby go through the therapy process. At first, they had an animal sacrificed at the altar (an animel which they had brought themselves to the site), and had to sleep in the animal's skin over the night. During their sleep Amphiaraos appeared and gave the answer to their question or indicated the cure-method. After being healed, one would toss a coin into the sacred spring, whose water is not allowed to be used for cleaning or other purposes. The sanctuary was meant to be the central oracle of the Oropos polis and was more than once in possession of the Athenians or the Romans. It consists of many interesting buildings, deriving from different epochs and construction phases. Parallel to the evolvement of the site we can identify a change at the hydraulic installation, supplying water to all the buildings in need.

At the top of the hydraulic installations we find the water clock (*clepsydra*), a unique construction from limestone indicating the time by taking advantage of the constant outflow of water. It had a volume capacity of 1.070 lt, and was isolated against water by the use of 2 mm thick hydraulic mortar (*opus signinum*). The outflow takes place through a small opening of 1 mm made of bronze that is built at the lower part of the north wall.

At the north side of the sanctuary we find the public buildings like the theater, the *stoa*, the altar and the temple, but also the baths. These constructions necessitate the hydraulic network in order to be able to function. Therefore, we find an open channel, made of limestone, interrupted by a small basin of a ca. 15 lt. water capacity, used possibly to influence the microclimate at the area. In addition to that, we find a smaller channel of quadratic section made of stone, running parallel to the open channel, indicating another construction phase. Moreover, there is a network coming from the north west of the site, indicating possibly the origin of water, the spring. The channel coming from this direction turns off at least four times, in order to distribute the water to as many buildings as possible. So, we watch the first turn – off at the small temple where the one direction flows into a clay quadratic channel, possibly closed by a cover, and the second one parallel to the altar in a tunnel casted in the ground. The second channel turns off again in two different directions, in order for the water to be distributed both to the baths and the *stoa*.

The complexity of the system along with the expansion and evolution of the sanctuary provides us with very interesting information on the evolution of ancient hydraulic science and on the different techniques used to store and distribute water, in addition to influencing the microclimate of a site.

22 When Ceres commands her nymphs – An investigation of the relation between mills and aqueducts in the antique Mediterranean

Stefanie Preißler

An investigation of the relation between mills and aqueducts is desirable. This abstract, which originated from an archaeological campaign in Italy, focuses for the first time on this aspect with the help of historical sources, secondary literature and archaeological sites. There are no indications in the writings of Vitruvius and Frontinus, so the research is based on summary books about the history of techniques, mills and water. In Helmuth Schneider's publication the essential hint exists. He refers to the well-known water-mill complex of Barbegal and the Janiculum. Unfortunately, Schneider doesn't list further examples of mills in relation to aqueducts. However, archaeological documentations and reports, which focus on ancient water mills, have been published in the last few years only in English. This is especially true of the book by Robert Spain, who describes in detail over 30 sites with vertical-wheeled water-mills, but not focussing on the supply of water. With the help of his work, it was possible to locate two other sites in the Mediterranean. It now seems evident that water-mills with a connected aqueduct are situated in the vicinity of large settlements where a high and continuous demand for flour existed. For the chosen location, not the local sources of water, but rather its accessibility to the end-consumer or a transport system was essential. Because this research project is at the beginning and the actual listing doesn't claim to be complete, there is an opportunity to discuss any remaining issues. So, for instance, if a conventional water supply was used for driving the mill, there would be specific mill architecture on aqueducts, and it would be possible to prove a regional or periodic transfer of this technology.

23 The Glass kiln (Horno de Vidrio), a drop tower in the water supply to the city of Toledo (Spain) during the Roman era

Marisa Barahona

The building which is called The Glass Kiln in Toledo (Spain) is an ancient drop tower, which is situated in one of the Roman aqueducts, and was to supply water to the city of Toledo. The importance of this structure is twofold. Primarily, as far as we know, it is the only drop tower known in the aqueduct. Secondly, no other examples of such a tower, having the same characteristics as the Glass Kiln, are known, in Spain or throughout the Roman world.

The mechanism, which was regularly used in Roman aqueducts to reduce the speed of water rapidly, were cascades, step chutes and drop shafts. There are other examples where the drop in speed takes place exploiting the entrance of water from the aqueduct into the settling tank, or in the *castellum divisorium* in the city. However, the morphology of the Glass Kiln in Toledo does not match any of these cases.

It is a very solid and compact structure of about 6 meters in height, made mainly of *opus caementicium.* The channel was linked to the tower through a short stretch of *arcuationes* and covered the top of the Glass Kiln to reach its northern side. Once there, a vertical pipe with a circular section enabled the water to fall until it reached the lower section of the structure, which continued to Toledo. Inside the south side of the tower, there is a hollow space of about 2 square meters, 1.60 meters high, in which lies the part most difficult to interpret. The last archaeological researches and excavations undertaken have enabled us to identify different structures, some of which could be interpreted as traces of a previous building. Other elements and design features in the tower also suggest the existence of more than one chronological phase of the Glass Kiln. Therefore, we believe it is probable that the specific characteristics of this type of structure may be related to this particular building, with the possible reconstruction of the drop tower during its period of use.

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map: Eco-Geo Info. Center, GIS unit, Israel Nature & Parks Authority

1. NIMROD'S FORTRESS N.P.
2. HERMON STREAM N.R. (BANIAS)
3. TEL DAN N.R.
4. SENIR STREAM N.R.
5. HORSHAT TAL N.P.
6. IYON STREAM N.R.
7. HULA N.R.
8. TEL HAZOR N.P.
9. AKHZIV N.P.
10. YEHI'AM FORTRESS N.P.
11. BAR'AM N.P.
12. AMUD STREAM N.R.
13. KORAZIM N.P.
14. CAPERNAUM N.P.
15. BETIHA - BET TSAIDA N.R.
16. YEHUDIYA N.R.- Meshushim Stream
17. GAMLA N.R.
18. KURSI N.P.
19. HAMAT TVERYA N.P.
20. ARBEL N.P.
21. EN AFEK N.R.
22. ZIPPORI N.P.
23. HAI-BAR CARMEL N.R.
24. MT. CARMEL N.P.
25. BET SHE'ARIM N.P.
26. NAHAL ME'AROT N.R.
27. DOR HABONIM N.R.
28. TEL MEGIDDO N.P. (ARMAGEDDON)
29. KOKHAV HAYARDEN N.P. (BELVOIR)
30. MA'AYAN HAROD N.P.
31. BET ALFA N.P.
32. GAN HASHLOSHA N.P. (SAKHNE)
33. BET SHE'AN N.P.
34. TANINIM STREAM N.R.
35. CAESAREA N.P.
36. BET YANAY BEACH N.P.
37. SEBASTIA N.P.
38. APOLLONIA N.P.
39. YARKON N.P.
40. EN PRAT N.R.
41. THE MONASTERY OF ST. EUTHYMIUS
42. THE INN OF THE GOOD SAMARITAN
43. THE MONASTERY OF ST. MARTYRIUS
44. NEBI SAMUEL N.P.
45. JERUSALEM WALLS N.P.
46. CASTEL N.P.
47. EN HEMED N.P. (AQUA BELLA)
48. STALACTITE CAVE N.R.
49. ASHKELON N.P.
50. BET GUVRIN N.P. (MARESHA)
51. QUMRAN N.P.
52. QASER EL-YAHUD BAPTISMAL SITE
53. ENOT TSUKIM N.R. (EN FASHKHA)
54. HERODYON N.P.
55. EN GEDI N.R.
56. EN GEDI ANTIQUITIES N.P.
57. MASADA N.P.
58. TEL ARAD N.P.
59. TEL BE'ER SHEVA N.P.
60. ESHKOL N.P. (BESOR)
61. MAMSHIT N.P. (KURNUB)
62. SHIVTA N.P.
63. BEN GURION'S BURIAL PLACE N.P.
64. EN AVDAT N.P.
65. AVDAT N.P.
66. RAMON VISITOR CENTER & BIO RAMON
67. HAI-BAR YOTVATA N.R. (DESERT WILDLIFE)
68. CORAL BEACH N.R.