Chapter 7: Water management in cities and towns

'…the city has water flowing all through it…We surpass the beautiful waters of other cities by the beauty of ours…' [Libanius *Orat.* II, 244]

7.1 Introduction

This chapter will consider what happened to aqueduct water once it arrived at the city. In the traditional model of water supply in Roman towns, the aqueduct would terminate at one of several structures: a *castellum divisorium*, where the water would be divided and channelled to various secondary points in the city such as fountains, bathhouses and private houses; a *nymphaeum* that flowed continuously; or a bathhouse. In this model, the aqueduct water flows continuously through the system and is not stored in significant quantities along its course: the constant-offtake principle (see Introduction and Chapter 4.3). More recently, it has been argued, contrary to this model, that reservoirs (open 'pools') and cisterns (covered storage installations) may also have provided terminal points and storage for aqueduct water.[1] In this chapter I will discuss the evidence from the East for *castella divisoria* (section 7.2.1), *nymphaea* (section 7.2.2) and storage reservoirs (section 7.2.3).

In addition to water supplied by aqueducts, this chapter will also look at the evidence for alternative sources of urban water supply from wells and rainwater cisterns (section 7.3). A brief survey of the internal distribution system, i.e. channels and pipelines, will follow in section 7.4. Section 7.5 will then consider how excess and waste water was removed from towns and cities across the Near East. Case studies looking at Jerash, Apamea and Caesarea will illustrate how these elements worked together in a composite system (section 7.6).

After an analysis of the construction and maintenance of these systems (section 7.7), I will then attempt to answer some of the questions posed by Bruun concerning water shortage and surplus in the Roman world (section 7.8).[2] These questions include: was there a system to provide buffer reservoirs or was it possible to turn off the water supply, was

[1] See for example Wilson 1997; Wilson 2001.
[2] Bruun 2000.

there a conscious policy for these matters and did the use of aqueducts lead to the neglect of rainwater cisterns and wells?[3]

Distribution and supply in baths and latrines is treated separately in Chapter 8. Water provision and storage in domestic urban contexts is also discussed separately in Chapter 9.

7.2 Destination and uses of aqueduct water in urban contexts

7.2.1 The castellum divisorium *and other distribution devices*

The *castellum divisorium* was a small tank usually located at the edge of the city. It acted as a distribution point where aqueduct water entered the tank as a single unit and exited in separate branches. Three paradigms of the *castellum divisorium* are most commonly referred to: the installations at Nîmes and Pompeii and the description by Vitruvius (VIII, 6) [Figs 7.1-2].

In the extant examples at Nîmes and Pompeii a water channel entered the tank, the water was then filtered through a grille or screen and then was split into the various branches leaving the tank.[4] At Pompeii it is often said that the *castellum* gave absolute priority to public drinking water. This theory, however, rests completely on Vitruvius' account, which suggests that some consumers (public fountains) were given priority over others (baths and private users), and is now refuted; in actual fact the destinations of the pipes leaving the *castellum* have never been traced and hydraulically there is no priority in the Pompeii castellum.[5] A third example at Thuburbo Minus in Tunisia had three lead pipes exiting, which are thought, though without secure grounds, to have fed the baths, the theatre and the reservoirs respectively; again these assumptions are partly drawn from Vitruvius.[6] Three other examples are known from North Africa: two from Carthage and one from Simitthus.[7]

Evidence for *castella* has been asserted at four sites in the Near East: Caesarea, Apamea, Auara and Scythopolis. The Caesarea *castellum* was at the end of the High Level

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[3] Bruun 2000.
[4] For a full account of these installations, see Hodge 1992, 281-292; Hodge 1996; Ohlig 1996; Ohlig 2001; Ohlig 2002.
[5] Hodge 1996, 18; Ohlig 2001; Wilson forthcoming (a).
[6] Hodge 1992, 289.
[7] Wilson 1997, 85.

aqueducts in front of the inner city wall [Fig. 7.3].[8] The device comprised a basin c. 1.9 m high whose external width was the same as that of both channels A and B (c. 4 m), which suggests that it was not part of the original conception when channel A was constructed. Its floor lay c. 0.3 m below these channel outlets; its length is uncertain. The water was diverted into several terracotta pipelines, but the method of this division has not been recorded. No mention is made of a grille or sluice.

A *castellum* in the form of a large cylindrical building (whose dimensions are not specified) has also been recorded at Apamea in the southern part of town 180 m from the colonnaded street.[9] The water entered from the base of the structure, issued through a central hole and then departed via 12 holes set in a circular formation around the central hole [Fig. 7.4]. Its find location in the southern part of the city suggests that this may have been a secondary *castellum* as recent excavations may have revealed the main *castellum* at the point where the aqueduct enters the city near the northern gate [Fig. 7.5].[10]

The third suggested device, at Auara, is a monolithic sandstone basin (c. 0.5 m long) that has traces of a channel cut through its walls.[11] It seems that this basin was found in several pieces and not *in situ*. In addition, it is unclear that it had any dividing function, which is integral to a *castellum divisorium*. It is difficult, therefore, to confirm its interpretation as a main *castellum*. A probable *castellum* has also been found at Scythopolis west of the hippodrome.[12] Excavations are planned to elucidate its nature, but at present all that is known is that there were five distributive systems in the vicinity of the installation.

A termination pool (2.5 m x 1.5 m x 1.7 m) fed by a terracotta pipe from the northern aqueduct has also been recorded at Dor.[13] There is no evidence for any dividing function in this installation, so it is unlikely that it was a *castellum*. Its size would suggest that it might have been a settling pool at the end of the aqueduct.

As the aqueduct entered Sbeiteh there was a sluice gate with three openings, two of which directed water to the settlement and one to the North Church.[14] The sluice gate was

[8] The description here is put together from: Porath and Yankelevitz 1989-1990, 131; Porath 1996, 112; Porath 2002b, 121-2.
[9] Lacoste 1941, 119; Balty 1987, 20.
[10] Thanks to Didier Viviers for the information on the recent discoveries at Apamea.
[11] Eadie and Oleson 1986, 63.
[12] Fahlbusch 2002, 62.
[13] Peleg 2002b, 151.
[14] Tsuk 2002c, 79.

made of stone blocks (0.25 m – 0.28 m high) with vertical grooves (40 - 45 mm wide and 25 – 55 mm deep). There does not seem to have been a tank at this point, so while the water was divided, this was not a true *castellum*.

A system of 17 small pools was built alongside the aqueduct to Banias at the edge of the city.[15] The pools were not distributed evenly along the course of the aqueduct [Fig. 7.6 A-E]. A group of eight were positioned where the aqueduct first approached the city (A). Two were 80 m further on (B), one was 70 m on from the second group (C), five were 35 m further on from the single pool (D) and the last pool was 14 m on from the previous group (E). There were no pools along the final 95 m of the aqueduct.

Dimensions of the pools were not provided, but they seem to vary from 1 m x 1 m x 1 m to 2 m x 2 m x 2 m [Fig. 7.7]. The pools were connected to the aqueduct either by an opening in the wall or by a terracotta pipe; three pools featured *calix*-like devices of lead pipes in conical holes at this point [Figs 7.8-9]. Each pool had a hole in its southern side (the side exiting the pool towards the city) for a terracotta pipe and two had a pair of pipes; these holes were covered with grilles to prevent debris entering the pipes [Figs 7.10-11]. The pipes seem to have been at or near the bottom of the pools.

The suggestion that these pools served as a substitute for a main *castellum* is convincing because they were not at the termination point of the aqueduct. Indeed, a termination pool (3.25 m long x 2.95 m wide) at the end of the aqueduct did exist from which two lines left [Fig. 7.12]. These pools seemed to function rather as a series of secondary *castella* or offtake points/draw basins.[16] Furthermore, they would appear not to have been built as part of the original scheme for the aqueduct, but rather to have been private, *ad hoc* ventures. This is because none of the pools was identical, but rather constructed out of an assortment of building materials: rooftiles, re-used ashlar blocks and bricks. If the pools were private, it also explains why the *calix*-like devices were at the entrance to the pool, rather than its exit, thus controlling the amount of water entering the pool from the aqueduct.

There are, therefore, only two realistic contenders (Caesarea and Apamea) for the title of *castellum divisorium*. This indicates that this technique did not make a large impact

[15] Hartal 1993, 1f; Tsaferis and Israeli 1995, 5; Hartal 1996, 6; Hartal 2002, 94-101.
[16] The depth of the installations from the original ground surface, evidenced by access shafts down to the pools, suggests that these were not drinking troughs.

on Near Eastern aqueduct water distribution, except in two of the most Romanised cities in the region. This is not a surprise as such devices were rare across the empire. This implies that there was a wide variety of practice. In addition, installations such as those at Banias point to the drawing of water directly from the aqueduct.

7.2.2 Nymphaea *and fountains (Gazetteer 8)*

In total, 22 structures claimed as *nymphaea* (ornamental structures comprising a public drinking fountain with a pool as part of its façade) across 17 sites have been recorded across the region (Gazetteers 8.1 and 8.2).[17] Scythopolis and Petra each had two *nymphaea*. Two other structures interpreted as fountain-houses or *nymphaea* were found at Zeugma, but a definite lack of water supply to these structures makes this interpretation highly unlikely.[18] Although originally identified as *nymphaea*, the examples from Susita and Na'arran have since been discovered not to be *nymphaea*.[19] In addition, it seems that the interpretation of the so-called *nymphaeum* at Amman is dubious. The interpretation is based solely on the proximity of the structure to several water sources, but no archaeological evidence for channels or pipes within or leading to this structure has been found to date, including in the 1990s excavations, which also seem to call the existence of the basin into doubt.[20] It is more likely that this structure is a *kalybe*, which has no equivalent in other parts of the Roman Empire.[21] The *kalybe* seems to be related to the *nymphaeum*, but was solely for display with no water provision element. These structures have also been identified at Bosra and Shohba [Fig. 7.13].

Therefore, 17 structures across 13 sites have been identified convincingly as *nymphaea* (Gazetteer 8.1). The sites were distributed evenly across the region and no regional bias could be discerned. In contrast, 8 of the 12 dated *nymphaea* were constructed in the 2nd century AD. Two *nymphaea* were dated to the 1st century AD, two to the 3rd century AD and one to the late Roman period. The construction dates must suggest that *nymphaea* were a Roman introduction to the region. The construction peak in the 2nd

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[17] Definition based on Segal 1997, 151.
[18] Early and Humphrey 2003, 15, 49-50, figs 3 and 41.
[19] The structure at Susita remains unidentifiable and that at Na'arran has been reinterpreted as a bathhouse: Dauphin and Gibson 1991, 177; Segal 2000, 13.
[20] Waheeb and Zubi 1995.
[21] Ball 2000, 291-2.

century AD must be related directly to the peak in aqueduct construction in the same century (Chapter 6, table 6.1). It also suggests that the euergetic culture intensified during this period, which would form part of a pattern of increased monumental construction, for example colonnaded streets and gates, in eastern cities from the end of the 1st century AD.[22] A similar boom in *nymphaeum* and fountain building occurred in 2nd-century Greece and Asia Minor: the *nymphaeum* of Herodes Atticus, Olympia; the exedra fountain next to the south-east fountain house, Athens; the Peirene fountain structure, near the agora in Corinth; the Castalia spring, Delphi (newly tapped); the Argos *nymphaeum*; the Kallichorus fountain, Sanctuary of Eleusis; the Library of Celsus, Ephesos; the *nymphaeum*, Miletus (possibly Flavian).[23] The lack of *nymphaeum* building in the East in the following centuries reflects a general downturn in building after the Severans. The pool at Scythopolis was a later addition in the second half of the 4th century,[24] which suggests that some continued in use for several centuries. It is also possible that the 3rd-century AD *nymphaeum* at Antioch [#331] was renovated by Justinian.[25]

Although aqueducts ultimately must have fed all of these installations, the water supply to *nymphaea* in this region, in general, has not been recorded, and is often neglected in favour of architectural descriptions. Two *nymphaea* were fed directly by aqueducts [Bosra and #360 Apamea] and three by terracotta pipelines [Caesarea, #331 Antioch and #335 Apamea]. A brick covering protected the pipeline feeding the *nymphaeum* at Antioch [#331].[26] The Gadara *nymphaeum* was associated with a barrel-vaulted cistern.[27] Similar arrangements of a storage tank and a *nymphaeum* have been found at Miletus and Pergamon.[28] Spouts for the fountain-heads were recorded at three sites [Jerash, Caesarea and #355 Scythopolis]; the spout at Scythopolis was fed by a lead pipe.[29] Pools and basins were recorded at seven installations [#297 and #355 Scythopolis, Jerash, #300 Petra, Caesarea, #331 Antioch, and #335 Apamea]. At Petra there were steps up to the outer pool (19 m long x 5 m wide) and a balustrade, so people could have stepped up to the pool and

[22] Segal 1997, 3.
[23] Glaser 2000.
[24] Tsafrir and Feorster 1989-1990, 122.
[25] Lassus and Stillwell 1972, 47.
[26] *Ibid.* 46.
[27] Weber 1988, 349; Segal 1997, 154.
[28] Stenton and Coulton 1986, 36-7.
[29] Bar-Nathan and Mazor 1992, 36.

leant over the balustrade to access the water [Fig. 7.14].[30] Two other pools had balustrades [Apamea and #355 Scythopolis], which suggests a similar manner of water access. The basin at Antioch was made of brick and had a hole in its side where a vertical pipe drained water off under a mosaic.[31] The use of lead pipes and brick reinforces the Roman nature of these installations.

Drainage provision was noted at four sites [Jerash, #331 Antioch, #335 Apamea and #355 Scythopolis]; in all four cases the water was directed underground.[32] It is not known whether this excess water entered the drainage system of the towns or whether it returned to the supply network as at Trajan's *nymphaeum* in Ephesos, where a channel may have led to the terraced houses;[33] presumably the latter would be the most sensible in an arid zone.

Less monumental street fountains, not classed as *nymphaea*, have been recorded archaeologically at Jerash, Jerusalem, Petra, Palmyra and Antioch (Gazetteer 8.3).[34] Literary evidence also attests to their presence at Ashqelon and Caesarea.[35] This is a strikingly low number and almost certainly represents an excavation or publication bias. I have also observed three possible street fountains at Apamea [Fig. 7.15]. These installations comprise stone blocks at street level into which a pair of pipes has been inserted. It seems possible that these pipes are the inlet (under pressure) and the outlet of a fountain base that has since been removed. A similar installation has also been found at Scythopolis [#680] [Fig. 7.16].[36] Fahlbusch suggests that this is a *colliviarium*, but it seems equally likely that it could also be the remains of a street fountain. Fountains at Priene, near the Tholos, Athens and on the Sacred Way at the Asklepieion, Pergamon also have this arrangement at their bases.[37]

Very little is known about the water supply and nature of these street fountains. The 2nd-century AD fountain in the centre of the *macellum* at Jerash [#315] was a pseudo-cross-shaped basin with small shafts [Fig. 7.17]. Traces of a spout and a perpendicular pipehole

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[30] Bachmann *et al.* 1921, 34; Segal 1997, 164.
[31] Lassus and Stillwell 1972, 46.
[32] Fischer 1938, 21; Balty 1987, 20; Bar-Nathan and Mazor 1992, 36.
[33] Wiplinger 2004-2006, 35
[34] Harding 1967, 94.
[35] Josephus *BJ* 1.21.11; Choricius of Gaza *Laudatio Aratii et Stephani* pars. 44-49.
[36] Fahlbusch 2002, 63.
[37] Stenton and Coulton 1986, 40, n. 73.

were found cut into the cylindrical limestone block of this fountain.[38] A stone pipeline possibly fed a fountain in Antioch [#573] in the Main Street Dig VII 16-0 South area, though no remains of a fountain were actually found.[39] At Petra a small fountain was fed by water from a cistern that collected water from an upper terrace in the Wadi al-Farasa.[40] At Palmyra there were two triangular fountains in the agora and an exedra fountain in the colonnaded street; pipelines fed the former.[41]

Segal believes that one of the main functions of a *nymphaeum* was to offer repose and a drink of water.[42] While he is no doubt right to point out the restorative and cooling effects of water in a hot, bustling town, are these really the only functions of a *nymphaeum*? It does not make sense that in an arid climate a *nymphaeum* providing large amounts of water would be used only for a drink, but rather was also a main drawing point. Indeed, we know from Josephus that when the fountain of Siloam in Jerusalem failed, prior to the arrival of Titus, water had to be sold in amphorae.[43]

In connection with this, surely, we should also include the power of the *nymphaeum* to impress and to display wealth and expertise; Segal himself points out that a *nymphaeum* in an arid zone would have made a 'strong and captivating impression'.[44] As has been noted in Greece, Asia Minor and North Africa, *nymphaea,* as well as smaller public fountains, were suited to lavish euergetic display.[45] This appears to have been the same in the East.

The *nymphaeum* from Pella is depicted on coins (under Elagabalus, 220AD) as having three stories and a façade with statues [Fig. 7.18].[46] The structure is identified as ΝΨΜΦ[ΕΩΝ] on the coins, which bear the inscription: 'Of the people of Pella Philippi at the *nymphaeum*'. Not only was the *nymphaeum* important enough for the city to be almost synonymous with it, but this is also the only instance of a building specifically named on a coin from the East and the coins were larger than usual so that the architectural details

[38] Uscatescu and Martin-Bueno 1997, 67.
[39] Lassus and Stillwell 1972, 92.
[40] Schmid 2000, 339-343.
[41] Crouch 1975, 16, fig. 14.
[42] Segal 1997, 166.
[43] Josephus *Wars* V.410. Adan 1979, 100.
[44] Segal 1997, 166.
[45] Walker 1987, 69; Wilson 1997, 149; Piras 2000, 252-3; Glaser 2000, 443.
[46] Dvorjetski 2001-2, 503.

could be clearly seen. Its architectural style would have made it similar to the façade *nymphaea* found in Asia Minor at Miletus, Aspendos, Perge and Side, though maybe not with such impressive dimensions. The basin at Caesarea (15 m long x 3 m wide) was also ornamental with marble-facing and a life-size marble statue.[47]

The dedications are also instructive here. We know of a *nymphaeum* at Suweida dedicated to the city in honour of Trajan, under a governor (either Julius Quadratus or more likely his predecessor Cornelius Palma; see Chapter 6.3.1).[48] The statue of Trajan was placed in a very prominent position: directly above the water outlet in a single storey *nymphaeum* façade.[49] Such an iconographic link between water supply and empire was also made in Volubilis, North Africa where the Arch of Caracalla (AD 216/7) had two fountains incorporated into two niches on each face of the arch.[50] Statues of the Imperial family also featured in the elaborate 2nd-century *nymphaeum* of Herodes Atticus at Olympia, which emphasised the donor's close link to the family.[51] Similarly in Argos a colossal statue of Hadrian was placed in the *nymphaeum,* probably in honour of the emperor's visit in AD 125.[52] The *nymphaeum* at Jerash [#298] was dedicated to Commodus in AD 191 (or AD 190) [Figs 7.19-20].[53]

The link between emperor and *nymphaeum* appears to be used for propagandistic purposes and demonstrations of loyalty to Rome. There seems to be an implicit connection between the emperor and the life-giving waters in the East, as well as elsewhere in the empire. The importance of the life-giving properties of water is also seen in bathhouse

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[47] Porath *et al.* 1998, 45.
[48] Le Bas and Waddington 1853, #2305 and #2308; Glaser 2000, 445; Di Segni 2002, 54. *IGR* III 1273, 1276.
[49] Glaser 2000, 445.
[50] Wilson 1997, 154.
[51] Glaser 2000, 440-1.
[52] Glaser 2000, 442.
[53] Welles 1938, 406-7, #69.

Ἀγαθῃ Τύχῃ. Ὑ[πὲρ τῆς σωτερίας καὶ τῆ]ς αἰωνίου διαμονῆς Αὐτοκράτορος [Καίσαρος Μάρκου Αὐ ρηλί]ου [Κομμόδου]Ἀντωνίν[ου] Σεβαστοῦ Γερμανικοῦ Σαρματικοῦ Βρεταν[νικοῦ] Εὐτυχοῦς π(ατ ρὸς) [π(ατρίδος)] δημαρχικῆς [ἐξουσίας τὸ ιf] ὑπάτου [τὸ f] κρατήσεος ἔτο[υς]
πεντε [και] δεκάτου [καὶ σύνπαντος αὐτοῦ οἴκου καὶ ὁμονοίας ἱερᾶς συνκλήτου] κα[ὶ δ]ήμ[ου τῶν Ῥ]ωμαίων [—] ἡ [πόλις Ἀ]ντιοχ[έων τῶν πρὸς τῷ] Χρυσορόᾳ τῶν [πρ]ότε[ρ]ον [Γερασηνῶν]. Ἔτ ους [τρίτου πεντεκοστοῦ] διακοσιοστοῦ μηνὸς Ξανδικοῦ [..]. 'With the good favour of the gods. For the safety and everlasting memory of the Emperor Marcus Aurelius Commodus Germanicus, Sarmaticus, Britannicus the prosperous, *pater patriae*, *tribunicia potestate,* consul in the 15th year of *imperium*, and all of the same house and the divine concord of the chosen and the Roman people, the city of Antioch on the Chrysoroas of the Gerasenes… (?built this?). In the 200th year of Xandikos on the third month of Pentecost…'

imagery and dedications, though not necessarily with the imperial overtones added here (see Chapter 8.5).

Presumably, the governors who donated fountains similarly wished to be viewed as magnanimous providers, as shown by the public display of their benefaction. An inscription from a fountain in Jerash records that Attidius, the *consul designatus*, set up fountains in AD 150 [Fig. 7.21].[54] In addition, Herod wished to prove his generosity by giving costly fountains (κρῆναι πολευτελεῖς) to Ashqelon.[55]

The historical background of most of these sites appears to provide the reason why they had *nymphaea*. Three of the cities were regional capitals: Bosra, Petra and Antioch. Five of the sites were Decapolis cities (Kanata, Gadara (Umm Qes), Scythopolis, Jerash and Pella), which have strong Hellenistic leanings. Of the other sites Apamea, Caesarea and Beirut are renowned for their Roman-style architecture and propensity to take on Roman-style monuments.

The *nymphaea* at these sites were on a notably less grand scale than those in Asia Minor, for example the elaborate and costly façade *nymphaeum* at Miletus. It seems possible that this difference in scale may be linked to a cultural difference in perception of water. There does not appear to have been a problem with ostentatious architectural display. Procopius of Gaza (c. AD 500), for example, describes a water clock at Gaza that was crowned by an eagle and had 12 doors, out of a different one of which Herakles appeared every hour to perform one of his labours.[56] The building (c. 8 ft wide and 19 ft high), which had a marble barrier with spikes at the front, marble pillars at the front and several large statues, was highly decorative and elaborate, not dissimilar in fact to a façade *nymphaeum.* The display element did not, however, come from the water itself (though it was powered by water). As noted above, the *kalybe* was a variation of the *nymphaeum* without water, i.e. it fulfilled the same display functions, but did not make ostentatious use of water. Is it possible then that *nymphaea* were not maybe as elaborate as one might expect because large

[54] Archaeological remains of these fountains have not been identified. Welles 1938, 404, #63.

Αἱ κρῆναι ἀφιερώθηνσαν πρεσβευτοῦ Σεβαστοῦ ἀντιστρατήγου ὑπατου ἐπὶ Λουκίου Ἀττιδίου Κορνελιανοῦ ἀναδεδεγμένου ἔτους γις Δειου...

'These fountains were blessed having been undertaken by Lucius Attidius Cornelius, legatus Augusti pro praetore, in the year AD 150.'

[55] Josephus *BJ* 1.21.11.

[56] Wilson 1983, 31; Sprague de Camp 1963, 257.

water displays seemed overly ostentatious and wasteful in a semi-arid climate? Similar arguments may also pertain in the use of water in bathhouses and domestic contexts (see Chapters 8.4.5 and 9.4).

7.2.3 Water storage (Gazetteer 9)

In total 46 water storage installations fed by aqueducts have been recorded in urban contexts (Gazetteer 9; see Gazetteer 14 for bathhouse reservoirs and cisterns fed by aqueducts). These water storage installations comprised reservoirs (open 'pools'), cisterns (covered storage with a volume less than 1,000 m^3) and reservoir-cisterns (covered storage with a volume greater than 1,000 m^3). There were 23 reservoirs (across 17 sites), 15 cisterns (across 9 sites) and 8 reservoir-cisterns, 2 of which were tunnel reservoirs (see below). A further four reservoirs and one cistern (not including those only used for irrigation) have been recorded from non-urban contexts (rural monasteries, rural settlements and forts). The majority of these installations from urban contexts dated to the late Roman period, notably including the majority of the reservoir-cisterns (Table 7.1); this will be discussed below in section 7.8.2. Analysis of the geographical distribution of these installations has been felt to be unproductive due to a large publication bias in favour of Israel (particularly due to the high number of reservoirs published in the *Excavations and Surveys of Israel/Hadashot Arkheologiyot* series).

Table 7.1: Aqueduct-fed urban water storage installations (including in bathhouses) by date.

Date	Reservoir	Cistern	Reservoir-cistern	Total
Roman	4	2	2	**8**
Late Roman	13	8	5	**26**

In terms of capacity, over 72% of the urban water storage installations were in the ranges below 2,500 m^3 (19 installations); there was a marked drop-off in numbers in the larger capacity ranges (Table 7.2). In general, with the exception of the massive open reservoir at Capitolias, larger volumes (2,500 m^3 and over) were, unsurprisingly, stored in covered installations rather than in open ones, which is probably due to lower evaporation and less risk of water contamination in covered installations (Table 7.2). The largest reservoir (Capitolias: 15,500 m^3) and reservoir-cistern (Resafe: 14,600 m^3) in the East were significantly smaller than the largest North African reservoir-cisterns from Carthage, Cirta and Zama (see Section 7.8).[57] This raises questions over whether the East had a system of buffer reservoirs, which will be discussed in detail below (section 7.8). With the exception of the occurrence of the three reservoir-cisterns in the late Roman period, there was no other clear pattern reflecting changes in capacity over time.

Table 7.2: Aqueduct-fed urban water storage installations by capacity (m^3).

Capacity (m^3)	Reservoir	Cistern	Reservoir-cistern
0-99	3	1	-
100-499	2	4	-
500-999	5	1	-
1,000-2,499	2	-	1
2,500-4,999	0	-	4
5,000-9,999	0	-	2
10,000 +	1	-	1

Whereas almost all North African aqueduct-fed sites were associated with storage facilities, only 18 aqueduct-fed sites had storage facilities in the East, leaving 23 urban sites fed by aqueducts that do not seem to have storage facilities.[58] At least 12 of these sites have only been partially excavated and this may offer a reason for this disparity. Another alternative is that these data reflect a publication bias. In spite of these possible explanations, the pattern still seems strong enough to warrant further investigation and will be discussed in detail below (section 7.8).

Information on the destination of outlet channels and their destination is lacking, so it is difficult to elucidate the exact role of these installations in the urban distribution network. Presumably, in many cases the water was led in channels or pipelines through outlet points to fountains, major public buildings and in some cases private buildings. Some reservoirs had steps leading into them and so it seems likely that in these cases water was drawn by hand.

[57] Wilson 2001.
[58] Sites with multiple aqueducts have been counted as one site.

Five urban reservoir-cisterns (Sepphoris, Capitolias, Beth Govrin and Resafe (two)), one urban cistern (Resafe) and one non-urban cistern (Qasr Wadi as-Siq) had holes in their ceilings. The Sepphoris tunnel reservoir-cistern had nine openings: five with steps, two side-openings without steps and two vertical openings in the ceiling.[59] In light of the openings with steps and the proximity of some of the side openings without steps to the stepped openings, it is probable that the openings without steps were for aeration and light rather than drawing water, which could be done from the stepped openings. The Capitolias tunnel reservoir-cistern had 3ft square holes over each 'compartment'.[60] As it is unlikely that this was the main storage area for water at Capitolias, it seems most likely that these were aeration holes.

The reservoir-cistern outside Beth Govrin (at Be'er Reseq) had a paved area near the western wall into which a 0.6 m^2 shaft was inserted [Fig. 7.24].[61] The easy access provided by the paving makes it likely that this shaft was used for drawing water. This reservoir also had a room (6 m x 4 m) to the south, which may have been used by a maintenance crew or may have been a tap outlet chamber. The holes in the Dome Reservoir-Cistern, Resafe seem to have been punched through later, so it is difficult to assess whether these were used as draw holes or aeration holes [Fig. 7.22]. It is more difficult to discern whether the holes in the Big Reservoir-Cistern, Resafe were contemporaneous with its construction [Fig. 7.23]. Whatever the case, as the Big Reservoir-Cistern had steps at its eastern end, it seems likely that the holes were for aeration (as is the case in large reservoirs elsewhere).

The holes (0.8 m^2) in the North-Western Cistern, Resafe were carefully built and seem to have been part of the original design, but their function is unclear [Fig. 7.22]. The cistern at Qasr Wadi as-Siq had three openings in between the arches, which are said to have been for drawing water; the steps down the east wall make this suggestion unlikely.[62] It appears then that although the holes in the roofs were used on occasion for drawing water, they were used more frequently for aeration.

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[59] Tsuk 2002a, 288-290.
[60] Schumache4r and Le Strange 1890, 162.
[61] Khalaily and Sagiv 1995, 93.
[62] *ESI* 1, 87.

Five cisterns and one, possibly two, reservoir-cisterns seem to have been associated with monasteries or churches. The reservoirs showed more varied locations (in an agora (a later build), alongside a colonnaded street, in a palace garden, near or in bathhouses, near a theatre and in a monastery). In non-urban areas, three of the reservoirs were on military sites (see below section 7.8.2). This discrepancy is probably largely due to the form of these installations, as well as a bias in buildings selected for excavation and survey; certainly there seems to be a plethora of monastery sites in Israel that have been subject to archaeological investigation. There may also have been, however, a close link between Christianity and water, which may have been a continuation of previous pagan beliefs.[63] There is some evidence from Palestine, for example, that in the late Roman period Elijah was venerated as a purveyor of rain, supplanting the earlier rain god cult of Baalshamin.[64] In addition, several Christian holy places were located on springs and/or aqueducts (see section 7.8.2 and Chapter 8.6).[65]

Five reservoir-cisterns and one cistern can be classed as similar in construction style to the chambered cisterns of North Africa. The reservoir-cistern underneath Nea Church in Jerusalem, with a capacity of 5,329 m^3, comprised six barrel-vaulted chambers with connecting transverse chambers [Fig. 7.25]. The late Roman, Big Reservoir-Cistern at Resafe had two parallel barrel-vaulted chambers with connecting transverse chambers (capacity 14,600 m^3); it also had settling tanks (see below) [Fig. 7.26].[66] The reservoir-cistern at Dara had ten parallel barrel-vaulted chambers [Fig. 7.27]. Each of these chambers was 4 m wide and 25 m long; assuming a depth of c. 5 m, this reservoir cistern would have had an estimated capacity of 5,000 m^3. The two other reservoir-cisterns at Resafe (the Small and the Dome Reservoir-Cisterns) were cross-vaulted chambers with their roofs supported on piers; hydraulically this type of reservoir is single-chambered [Fig. 7.28].[67] These

[63] Di Segni 2002, 66.
[64] Gatier 1986, 143-4, nos 145-6.
[65] Several were connected with St John the Baptist (Aenon, Sapsaphas beyond the Jordan, possibly Ain Karem and Ain al Ma'amudieh on the eastern Eleutheropolis aqueduct) [Avi-Yonah 1954, 35-36, no. 1; Bagatti 1983, 16-17, 20; Kopp and Stève 1946, 559-75.], others to Old Testament figures tradition: the miraculous spring of Mount Syna near Caesarea [*Itinerarium Burdigalense* 586.1]; Jacob's well near Neapolis; the spring of Elisha that watered Jericho [Avi-Yonah 1954, 44 nos 25-26]; the spring of Samson that watered Eleutheropolis [Antoninus of Placentia 32]; Ain Hanniya near Ain Karem [Bagatti 1983, 23-24].
[66] Brinker 1991, 126.
[67] Brinker 1991, 126, 130-2.

reservoir-cisterns had capacities of 2,050 m^3 and 3,400 m^3 respectively. The cistern at Dara was similar to these, though with a much smaller capacity (c. 390 m^3) [Fig. 7.29].

The installation at Scythopolis comprised two connected pools on different levels; the lower pool was barrel-vaulted and therefore functioned as a cistern. Water was directed between the two pools via a channel in the partition wall.[68] The 6th-century reservoir at Apamea, which was inserted into and blocked the agora to the north, was made up of three basins whose total dimensions were 22.9 m long x 5.86 wide m x 1.5 m (minimum) deep (total capacity of 200 m^3); nothing has been recorded about how water was transferred between these basins.[69]

Tunnel reservoir-cisterns were found at Capitolias (Beit Ras) and Sepphoris. The example from Capitolias was cut into the limestone and extended underneath the southern part of the city wall; it measured 275 m long, 2.5 – 4.5 m wide and 7.2 m high and had a capacity of 4,900 m^3 [Fig. 7.30].[70] It is described as being subdivided into small and large compartments by hollow walls; presumably these were piers supporting the roof and therefore the tunnel can be compared hydraulically to the cross-vaulted reservoir-cisterns above.[71] It delivered water via a channel inside the city walls to a reservoir with a 15,500 m^3 capacity, the largest in the Near East.[72] Due to the large size of this reservoir, in comparison with the capacity of the tunnel, we can surmise that the purpose of the tunnel was to regulate water supply to the reservoir and to act as supplementary storage if the reservoir was filled to capacity.

The Sepphoris tunnel reservoir-cistern, located 1 km east of the city, was very similar in form: it exploited a geological fault in the limestone and chalk, measured 250 m long, 3 m (average) wide and 10 m high and had a capacity of c. 4,300 m^3 [Figs 7.31-32].[73] Its regulating function is more clearly seen than in the Capitolias example. At the end of the tunnel a wall was built, into which a lead pipe (0.105 m diameter and 5.76 m long) was inserted [Fig. 7.33].[74] On the other side of the wall the lead pipe was broken, probably at the point where a stopcock had been. A bronze stopcock (0.3 m long and weighing 3.35 kg)

[68] Mazor and Bar-Nathan 1998, 8.
[69] Balty 1987, 22.
[70] Tsuk 2002a, 293.
[71] Schumacher and Le Strange 1890, 162-3.
[72] *Ibid.* 162; Tsuk 2002a, 293.
[73] Tsuk 2002a, 287.
[74] *Ibid.* 290.

has also been found installed in later phase reworking of the outlet point of the Nabataean reservoir at Humayma/Auara [Fig. 7.34].[75]

Two reservoirs (Capitolias and Dor) and a reservoir-cistern (Resafe) and two non-urban reservoirs were equipped with settling tanks. Schumacher refers to a rock-cut basin [125 ft x 77 ft x 26 ft] attached at its south-western end to a plastered cistern [77ft x 21 ft x 15 ft] at Capitolias.[76] If, however, one turns this around, one has a plastered settling basin attached to a large rock-cut reservoir. At Dor, reference is made to a re-used sarcophagus in one of the reservoirs; it seems plausible that this may have acted as a settling tank.[77] The Big Reservoir-Cistern at Resafe was the only storage installation on the site to be provided with settling tanks; they were located at the western end of the reservoir close to the inlet channel [Fig. 7.26].[78]

7.3 Non-aqueduct urban water supplies

7.3.1 Reservoirs and cisterns (Gazetteer 10)

In total 15 reservoirs (on 11 sites) and 48 cisterns (on 26 sites) that were fed by rainwater and runoff, rather than aqueducts, have been recorded from urban contexts (see Gazetteer 14 for bathhouse reservoirs and cisterns); a further 22 reservoirs and 14 cisterns (not used only for irrigation) have been recorded from non-urban contexts (primarily monasteries and churches, as well as three forts). Domestic cisterns will be discussed separately in Chapter 9. Most of the urban cisterns were rock-cut and, where recorded, were bottle-shaped, though examples from Jerash, Nessana, Serjilla and Moudjeleia were vaulted. At Tiberias the roofs of the cisterns were built of basalt and therefore corbelled. A non-urban example from the Monastery of St Euthymius had two narrow parallel vaulted chambers (28 m long x 2.4 m wide x 4 m deep and 16.9 m long x 3 m wide x 4 m deep; total capacity of 470 m^3); the excavator did not record a transverse chamber connecting the two parallel chambers.[79] A settling basin was found in the north-western corner of this cistern.

75 Oleson 1988, 123-4; Tsuk 2002a, 290-1.
76 Schumacher and Le Strange 1890, 165.
77 Stern 1985, 21.
78 Brinker 1991, 126.
79 Hirschfeld 1984, 81-2.

Water was supplied to these cisterns by a variety of channels and pipelines. Two cisterns at Jerash and Sepphoris were fed by lead pipes. The size of the mouth of only one of the cisterns was recorded: 0.5 m diameter (Jerash). One reservoir (6 m long x 3.5 m wide) in the piazza at Dor featured two plastered depressions (both 1.5 m long x 0.5 m wide) that contained water jars; it is likely that this was a central drawing point [Fig. 7.35].[80] The installation lies 20 m north of the aqueduct terminus, but no connection to the aqueduct was recorded.

The reservoirs, as one might expect, appear to have been in open areas, not associated with buildings. Cisterns, in contrast, were found beneath urban public buildings and spaces: ten were associated with bathhouses (see Gazetteer 14); eight were associated with monasteries or churches [Jerusalem, Tiberias, Jerash, Sbeiteh, Dor and Nessana] with a further three in areas of other religious significance [Petra (two in High Places) and Dura Europos (Temple of Atargatis)]; three were in basilicas [Tiberias and Resafe (two)] with a further one in a 'hall' [Sepphoris]; two were near the forum at Jerash; and one was in an unspecified public building [Sepphoris] (see Gazetteer 10.2). Again, in the late Roman period, monasteries and churches regularly appear to have had cisterns.

One of the most detailed surveys of urban systems has been undertaken at Sbeiteh/Shivta.[81] Tsuk identified 57 cisterns, of which 8 seem to have been in public areas of the town (6 in the 3 churches or their yards and 2 in streets) [Fig. 7.36]. Of the six cisterns in churches, only one (cistern no. 6 in Tsuk's numbering system) was excavated. This was the largest cistern in Sbeiteh/Shivta (9.7 m in diameter with a capacity of 162.5 m^3) and was aqueduct-fed (see Gazetteer 9.2). It was part of the design of the church and fit the configuration of the yard. The two rainwater cisterns in the central and southern churches, in contrast, were smaller and seem to have been in existence before the churches were built. The reservoirs at Sbeiteh/Shivta are discussed below (section 7.7).

Once again, the majority of these have been attributed to the late Roman period (Table 7.4). The particularly strong bias in non-urban reservoirs and cisterns must largely be due to the structures (monasteries and churches) selected for survey and excavation. Neither urban reservoirs nor cisterns had capacities beyond 900 m^3 (Table 7.5); this

[80] Berg *et al.* 2002, 162.
[81] Tsuk 2002.

probably reflects the fact that they are storing rainwater, which would not have been available in as great volumes as aqueduct water. The two large non-urban reservoirs were both associated with monasteries; their large volume is probably explained by a greater variety of uses for the water, including water for animals and irrigation as well as drinking water. In general, the urban cisterns were similar to their domestic (both urban and rural) counterparts (see Chapter 8) in both design and capacity, with the largest domestic cistern at Khirbet Mansur al-Aqab being 700 m^3.

Table 7.4: Reservoirs and cisterns (including those in bathhouses), not fed by aqueducts, by date.

Date	Urban reservoirs	Urban cisterns	Non-urban reservoirs	Non-urban cistern
Roman	3	8	1	1
Late Roman	7	15	12	12

Table 7.5: Reservoirs and cisterns (including those in bathhouses), not fed by aqueducts, by capacity (m^3).

Capacity (m^3)	Urban reservoir	Urban cistern	Non-urban reservoir	Non-urban cistern
0-99	1	6	0	2
100-499	1	5	2	3
500-999	1	2	0	0
1,000-2,499	0	0	0	0
2,500-4,999	0	0	2	0
5,000-9,999	0	0	1	0
10,000 +	0	0	0	0

7.3.2 Wells

Wells tapping groundwater resources are a simple and effective water technology. As such one would expect that they were used extensively in both rural and urban areas. In the East, however, wells have been recorded in suspiciously few urban centres and with very few details: Caesarea, Dor, Palmyra, Beirut, Eboda, Elusa, Kafr Neffakh, Ashqelon, Nessana, Ruheiba and Saadi.[82] Procopius also records that Justinian built wells at: the Monastery of St Samuel, Abbot Zacharias, Susanna, Aphelius, St John's on the Jordan and St Sergius on Cisseron mountain.[83] Finds of *saqiya* pots from Beth Govrin and Tiberias suggest that aqueduct water on these sites may also have been supplemented by water from wells.

The wells seem to have been predominantly cylindrical. Only four have been recorded with dimensions: the well at Beirut was 0.7 m in diameter; the well at Kafr Neffakh was 1.8 m diameter and the two wells near Ashqelon were both 2 m deep and 1.1 m diameter and 0.8 m diameter respectively.[84] In the Negev (at Nessana, Eboda and Ruheiba) deeper wells (between 60 m and 100 m) have been noted, which may have been necessary to reach the water-table. These exceptionally deep wells have been attributed to the Roman period, but no clear dating evidence was presented. Nabataeans, however, seem to have dug wells to a maximum depth of 15 m, which would suggest that they were Roman or later.[85] The construction technique of the wells was only described in detail at Ashqelon.[86] These wells were lined with dressed kurkar and beachrock blocks, not cemented together; a wooden log (Sycamore) underlay the lowest course of dressed stone in each well.

One well at Dor was in the Roman piazza; the dating of the other four wells recorded on this site is vague and none can be said with any certainty to have been used in the Roman or late Roman periods.[87] Wells have been recorded in the Temple of Bel and Diocletian's Camp at Palmyra.[88] In the first half of the 1st century AD at Caesarea almost

[82] Mayerson 1983, 251-2; Will 1983, 80, n. 29; Dauphin and Gibson 1991, 177; Shereshevski 1991, 59, 89, 93; Carmi *et al.*1994; Arnaud *et al.* 109-10; Berg *et al.* 2002, 157; Porath 2002b, 124-5.
[83] Procopius V.9.14-22.
[84] Dauphin and Gibson 1991, 177; Carmi *et al.*1994; Arnaud *et al.*109-10.
[85] Shereshevski 1991, 190.
[86] Carmi *et al.* 1994, 186.
[87] Berg *et al.* 2002, 127.
[88] Will 1983, 80, n. 29.

every building complex in the south-west zone possessed a well; no wells were dated to the 2^{nd} to 5^{th} centuries AD; almost every building complex in this zone returned to using well water in the 6^{th} century AD.[89] This seems to correlate with the history of the High Level aqueducts to Caesarea: channel A was probably constructed in the Herodian period; the water supply was increased by the construction of channel B in the Hadrianic period; both continued in use, though with increasing numbers of repairs, until the late Roman period. This pattern may point to a decline or collapse of the urban fabric and organisation of Caesarea in the later periods (see below section 7.6.3).

7.4 The distribution network: channels and pipelines

Pipelines and channels formed the network by which water from aqueduct and non-aqueduct sources could be moved from one part of the city, and from one building, to another. As with the wells, these elements must have been ubiquitous, yet information on pipelines and channels comes from only 16 sites: Banias, Caesarea, Dor, Susita, Jerash, Palmyra, Scythopolis, Jerusalem, Tel Dan, Apamea, Beirut, Sidon, Baalbek, Amman, Umm Qes and Antioch. In general, there is a lack of detail in the reports with only fleeting references made to pipelines that led to different sections of the city.[90]

Pipelines or sections of pipelines were recorded at 11 sites: Banias, Caesarea, Dor, Palmyra, Scythopolis, Tel Dan, Apamea, Beirut, Sidon, Amman and Antioch.[91] Sixteen ceramic pipes were recorded at Banias, Caesarea (four), Palmyra (three), Scythopolis, Tel Dan, Apamea, Sidon, Beirut (three) and Amman.[92] The pipeline at Banias had segments 0.35 m – 0.45 m long x 0.10 m – 0.12 m diameter; the pipeline in the Temple of the Standards was 0.25 m in diameter.[93] In addition a complex network of terracotta pipes and

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[89] Porath 2002b, 124-5.
[90] For example: Porath 1996, 112; Mazor and Bar-Nathan 1998.
[91] Kraeling 1938, 291; Lauffray 1944-1945, 64; Michalowski 1964, 25; Dunand 1967, 41; Daszewki 1972, 136; Lassus and Stillwell 1972, 27-9, 61, 70, 91, 92, 107-9, plan XIV, plan L; Hadidi 1974, 83, fig. 6 and pl. 26b; Wiemken and Holum 1981, 38-9; Balty 1987, 20; Raban 1988-1989, 39; Bounni and As'ad 1989, 131; Tsafrir and Foerster 1989-1990, 124; Abu Raya 1991, 135; Maeir 1993, 62; Biran 1994, 5; Finkbeiner and Sader 1997, 132; Saghieh-Beydoun *et al.* 1998-1999, 116, 121, fig. 36; Hartal 2002, 99-101; Porath 2002b, 122.
[92] Michalowski 1964, 25; Dunand 1967, 41; Daszewki 1972, 136; Hadidi 1974, 83, fig. 6 and pl. 26b; Wiemken and Holum 1981, 38-9; Balty 1987, 20; Raban 1988-1989, 39; Bounni and As'ad 1989, 131; Tsafrir and Foerster 1989-1990, 124; Biran 1994, 5; Finkbeiner and Sader 1997, 132; Saghieh-Beydoun *et al.* 1998-1999, 116, 121, fig. 36; Hartal 2002, 99-101; Porath 2002b, 122.
[93] Daszewski 1972, 136; Hartal 2002, 100.

channels has been excavated in several trenches along the main street of Antioch dating from the Augustan to late Roman periods [Fig. 7.37].[94] One cylindrical stone junction box was found along the course of one of the Justinianic ceramic pipelines in Antioch [Fig. 7.38].[95]

Four lead pipelines were recorded. Three were from Caesarea, one of which fed the 'governor's campus'.[96] The other example from Beirut was a lead and bronze pipe found south of the amphitheatre.[97] This pattern of preference for terracotta over lead is similar to a pattern noted by Jansen in towns first occupied by Greeks;[98] in this case it seems to point to lead pipes being a strongly Roman introduction into the Near East that did not spread widely. As suggested for inverted siphons (Chapter 6.2.5), this may be due to restricted access to lead supplies and/or a lack of willingness to change technology and construction techniques.

There were three stone pipelines from Palmyra, Antioch and Susita. The example from Palmyra was the Justinianic replacement of a ceramic pipeline fed by the Abu Fawares channel [Fig. 7.39].[99] The stone pipeline in Antioch was also Justinianic and may have fed a fountain; seven blocks, measuring 0.55 m long x 0.65 - 0.88 m wide with a central hole 0.22 m in diameter were found *in situ*.[100] In Susita a 50 m stretch of pipeline encased in a hard dark mortar was found inside the east gate. Blocks with holes 0.14 m – 0.16 m diameter in their tops were found at 1 – 2 m spacings, one of which was found with its original cover *in situ*; it is likely that these holes were used for cleaning the pipeline [Fig. 7.40].[101] Stone pipeline blocks as part of the internal distribution system are also known from Oinoanda and Ephesos in Asia Minor.[102] In these cases, however, the stone blocks were used to 'anchor' the ceramic pipeline in place (but were distinct from junction blocks), rather than being part of a continuous stone pipeline as seen in the East.

[94] Lassus and Stillwell 1972, 27-9, 61-70, 91-2, 107-9; Lassus 1983, 215-6.
[95] Lassus and Stillwell 1972, 61; Lassus 1983, 219.
[96] Porath 1996, 114; Porath 2000, 36*-37*.
[97] Lauffray 1944-1945, 64.
[98] Jansen 2000b, 119-121.
[99] Bounni and As'ad 1989, 131.
[100] Lassus and Stillwell 1972, 92, plan L.
[101] Tsuk *et al.* 2002, 208-9.
[102] Stenton and Coulton 1986, 38.

Eleven of the pipelines were found under pavements and streets: Banias, Caesarea (four), Scythopolis, Apamea, Beirut (two) and Antioch (two). Long basalt blocks protected one at Scythopolis; another pipeline under a street at Banias was set into a channel with ashes surrounding it for protection and/or ease of finding the pipeline at a later date.[103] A pipeline at Beirut was also set in a stone channel.[104] Manholes and inspection points were found along pipelines at Caesarea and Dor.[105] One pipeline at Banias was taken directly off the aqueduct and may represent illegal tapping of the aqueduct water at the site.[106]

A total of 32 channels, some of which carried pipelines, from 11 sites was recorded: Banias, Dor, Susita, Jerash (two), Palmyra (three), Jerusalem (three), Tel Dan, Beirut (seven), Baalbek, Umm Qes (ten) and Antioch (two). Sixteen of the channels (one at Susita, two in Jerusalem, nine at Umm Qes, and four from Beirut) were under pavements or streets and one at Tel Dan was an open channel.[107] Building materials were only specified for seven channels; stone was used in six cases and one was rock-cut.[108] The known dimensions of the channels are presented in Table 7.6. These are all relatively small, which suggests that maintenance would have to be carried out by removing the roof slabs. This may also be because some of these channels were designed to hold pipelines.

Table 7.6: Known dimensions of channels.[109]

Site	Width (m)	Depth (m)
Antioch	0.13	0.38
Palmyra	0.30	0.50
Susita	0.35	0.58
Tel Dan	0.60	0.60
Umm Qes	0.44	0.62

[103] Balty 1987, 20, Tsafrir and Foerster 1989-1990, 124; Porath 1996, 114; Hartal 2002, 100; Porath 2002b, 122.
[104] Saghieh-Beydoun *et al.* 1998-1999, 116.
[105] Porath *et al.* 1998, 42; Peleg 2002b, 151; Porath 2002b, 122.
[106] Hartal 1993, 2; Hartal 2002, 101.
[107] Lauffray 1944-1945, 64, fig. 12 and pl. VIIIe; Wagner-Lux and Vriezen 1984, 87; Diez 1995, 77; Finkbeiner and Sader 1997, 132; Tsuk *et al.* 2002, 208.
[108] Michalowski 1964, 34; Daszewski 1972, 130-6, 141; Lassus and Stillwell 1972, 69; Diez 1995, 77; Tsaferis and Israeli 1995, 5; Guinée *et al.* 1996, 208; *ESI* 2, 1983, 23.
[109] Daszewski 1972, 141; Lassus and Stillwelll 1972, 69; Wagner-Lux and Vriezen 1984, 87; Abu Raya 1991, 135; Biran 1998, 3; Tsuk *et al.* 2002, 208.

7.5 Drainage (Gazetteers 11-12)[110]

In total, 88 drainage elements were recorded across 20 sites. The various elements of the drainage networks have been classed according to a five-order classification (Table 7.7):

Table 7.7: Orders of drainage.

Order	Description
1	Drain within a building at the entry point to a system that leads waste water away; for example: gutters from roofs; channels from latrines.
2	Drain that combines 1st-order drains and forms a single exit from a building.
3	Drain that combines 1st or 2nd-order drains and runs under minor streets and alleyways.
4	Principal drain that combines 1st, 2nd or 3rd-order drains and runs under principal streets.
5	Large collector that can combine all previous orders (usually 4th) and discharges outside settlement.

This classification is based on the four-order classification of Bodon *et al.*, but sees the important division of the third order into two.[111] The four-order approach was felt to be overly simplistic and lacking in refinement for the classification of drainage in streets since it considered all drainage under streets as 'principal'. As will be seen below, there appears to be a lower order of drainage in streets. Due to their nature, the majority of 1st and 2nd-order drains have been dealt with in their respective chapters (Chapters 8 and 9).

As is to be expected, 82% of the drainage elements (71 features) were classified as either 3rd or 4th order; of these 34 drains were 3rd order and 28 were 4th order.[112] Two drain covers/grilles were recorded, one on a 4th-order drain at Palmyra and one on a 2nd/3rd-order drain at Humayma/Auara [Fig. 7.41].[113] Although dimensions were only available for nine drains, 3rd-order drains seem to have been under 0.2 m wide and 0.15 m deep and therefore

[110] The terms 'drain' and 'sewer' should not be confused; see Hodge 1992, 332. A sewer is used exclusively for the disposal domestic human waste. A drain, on the other hand, is used for the disposal of surplus or wastewater. In many cases this distinction has been hard to discern from the literature and the terms used here reflect the opinion of the present author over which terms should be used; in general 'drain' has been preferred over 'sewer' unless there was an overriding reason.
[111] Bodon *et al.* 1994, 391. This 4-order classification is the most commonly used, for example: Wilson 2000b. My orders 3 and 4 = Bodon *et al.* order 3 and my order 5 = Bodon *et al.* order 4.
[112] Nine drains may be 3rd or 4th order.
[113] Michalowski 1960, 97, fig. 7; Oleson *et al.* 1999, 420.

smaller than 4th-order drains, which varied from 0.23 m to 0.6 m wide and 0.23 m to 1.5 m deep.

Wilson suggests that drains, with particular reference to 'large drains', were not lined with waterproof mortar and sometimes had an unpaved floor in order to enable water percolation into the soil.[114] While this is generally true, there are exceptions where percolation into the soil may not be desired, for example some latrine (i.e. 2nd-order) drains were lined (Chapter 8.2). The underlying geology, for example on a basalt site, may cause the development of unwanted cesspools. In addition, there seems to be good evidence from levels data to suggest that the 3rd-order drainage system outside a building at Rujm al-Malfuf was designed to take groundwater away from the foundations.[115] This drain was plastered, presumably to facilitate the removal of water; percolation in this instance would negate the primary purpose of the drain. Another possible scenario, especially in an arid zone, is that the water may have a further purpose outside the settlement. The reuse of water from drains has been noted as a striking feature of Roman drainage.[116] It was proposed, for example, that the 5th-order collector in the *via Praetoria* at Auara discharged into the fields; the presence or absence of a lining was not recorded here.[117] For these reasons the identification of two 3rd-order [Caesarea and Rujm al-Malfuf] and four 4th-order drains [Banias and Sepphoris (three)] as plaster-lined drains by the excavators has been upheld.[118]

The majority of both 3rd- and 4th-order drains were masonry structures. Two 4th-order drains were built of brick and stone: Zeugma and Antioch.[119] A notable difference between the 3rd- and 4th-order drains seems to be the use of capstones; only one 3rd-order drain was recorded as having capstones in contrast to fourteen 4th-order drains. It is possible that this reflects a recording bias rather than a genuine difference in construction between the two orders; in a summary description the 3rd-order drains at Dor, for example, are described as being covered with ashlar.[120] One 3rd-order drain at Aqaba was lined with re-used ceramic vessels.[121]

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[114] Wilson 2000b, 169.
[115] Boraas 1971, 36-7.
[116] Wilson 1997, 217.
[117] Oleson *et al.* 1999, 420.
[118] Boraas 1971, 36-7; Strange and Longstaff 1987, 280; Porath *et al.* 1989-1990, 133; Ma'oz 1993, 6.
[119] Lassus and Stillwell 1972, 28; Abadie-Reynal and Ergec 1997, 357.
[120] Berg *et al.* 2002, 164.
[121] Parker 2000, 379-80.

Ten 5th-order collectors were recorded: Caesarea (three), Dor (two), Jerash, Zeugma, Jerusalem, Auara and Horbat Castra.[122] Caesarea may have had a fourth 5th-order drain; it is not clear if this drain discharges outside the settlement, but its depth (3 m) suggests that it is a 5th-order drain.[123] In general 5th-order drains were substantially deeper than any other drains on site, ranging in depth from 1.05 m to 4 m. The only exception to this is the example from Auara that measured only 0.3 m wide x 0.25 m deep, which may be explained by the smaller settlement size being drained.[124] This order of drain was usually stone-built and vaulted or capped with stone slabs; one exception at Jerusalem was rock-cut and capped with stones.[125] Three manholes were recorded all on 5th-order drains, which is unsurprising as only drains large enough for human access require manholes: Zeugma (0.46 m long x 0.40 m wide), Caesarea (0.65 m long x 0.65 m wide) and Dor [Fig. 7.42]. These large collectors discharged into a variety of contexts. The Zeugma example discharged into the Euphrates, Caesarea into the sea, Horbat Castra into a cesspool at the edge of the settlement and Auara possibly into the fields. This variety points to a flexible approach to how and where to discharge wastewater, an approach that is largely dependent on the local landscape and geology.

There is no clear chronological pattern for the installation and use of the drainage systems and they appear to be evenly spread throughout our period. The drainage systems at Jerusalem, Sepphoris, Tiberias and Banias seem to coincide with the period of aqueduct supply to the city and may therefore conform to a pattern of reliance on aqueduct water for drainage that is seen across the empire. One exception to this pattern is Dor. It has been proven stratigraphically that the construction of the drainage system at Dor actually preceded the aqueduct;[126] this was also the case at Timgad in North Africa. In addition, the drainage system went out of use before the aqueduct did.[127] In the period prior to the aqueduct, 3rd-order drains fed by roof gutters discharged into local sumps [Fig. 7.43]; it was

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[122] Harding 1967, 94; Wiemken and Holum 1981, 34-8; Gawlikowski 1986, 110; Stern and Sharon 1987, 209-11; Stern and Gilboa 1989-1990, 117; Stern *et al.* 1991, 49; Abadie-Reynal and Ergec 1997, 392, figs 13-15; Porath *et al.* 1998, 42, 55; Reich and Billig 1998, 90; Oleson *et al.* 1999, 420; Yeivin and Finkielsztejn 1999, 23*; Abadie-Reynal 2001, 251; Berg *et al.* 2002, 164-7.
[123] Bull and Toombs 1972, 180.
[124] Oleson *et al.* 1999, 420.
[125] Reich and Billig 1998, 90.
[126] Berg *et al.* 2002, 167.
[127] *Ibid.*

not until the next phase (AD 138-230) that Street I had a 4th-order drain installed. It appears, therefore, that at least at Dor drainage systems became more sophisticated with the provision of aqueducts. It also suggests that there was not always concern about the disruption caused by laying drains and changing the drainage systems after laying the streets.[128]

The relationship between aqueducts and drainage may also be seen from the three *nymphaea* that drain underground (see above: Section 7.4). It is commonly accepted that the constant washing of drains by overflow from aqueduct-fed fountains was a chief innovation of Rome.[129] It would seem that this technique was imported to the East at sites with *nymphaea* and fountains. Literary evidence from Josephus suggests that the tidal action of the sea flushed the drainage system at Caesarea.[130] On other sites we must presume that the systems were gravity controlled.

The quantity of excavation and publication at Dor means that we can postulate how the drainage systems would have worked across the site as a whole.[131] Drains were found under all the excavated streets and nearly every house appears to have been connected to the system. The water collected on the house roofs flowed down ceramic downpipes (1st and 2nd order). These fed 3rd-order drains in minor streets, which were usually 0.1 m - 0.2 m wide and deep, built from masonry with plastered bottoms and capped with stone. In turn, these 3rd-order drains fed 4th-order drains beneath major streets. These drains were 0.4 m wide and 0.4 m – 0.8 m deep, constructed from fieldstones and ashlar and capped by street flagstones. Finally, the vaulted 5th-order drains, 'large enough for men to walk through', were fed by the 4th-order drains and discharged outside the settlement (at an unspecified location).

It is also noteworthy that some sites took slightly different approaches to drainage. At Umm Qes, for example, a street was inclined to the north so that the unwanted water ran along the sidewalk. A channel was only provided through the north tower to avoid banked-up water in front of its threshold.[132] In addition, at Petra a depression in the middle of the street diverted runoff water, presumably through a grating, into the drainage system under

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128 See Hodge 1992, 340.
129 Wilson 2000b, 172.
130 Josephus *Ant.* 15.340.
131 The following description of the drainage system at Dor is based on: Berg *et al.* 2002, 164-7.
132 Kerner and Hoffmann 1993, 363.

the street.[133] While these techniques may seem ‘primitive’, they also represent a simple, but efficient solution to drainage issues. This is comparable to the situation at Pompeii where the pavements were raised high enough to avoid the surface water on the streets and stepping stones were provided so that one did not have to step in the water when crossing the road.[134]

7.6 Urban case studies

The three case studies aim to provide an overview of how the water supply of individual towns functioned. These studies will include installations and functions not explicitly discussed in this chapter, such as bathhouses and latrines, in order to illustrate how these installations fit into the wider water supply and management scheme of a particular site. The sites have been selected because there is a broad enough range of data from relatively large-scale excavation to make such an attempt worthwhile. Further details on the installations in these sites can be found in their respective chapters and gazetteers.

7.6.1 Apamea[135] [Fig. 7.44]

Apamea is located on a plateau on the eastern side of the fertile Orontes Valley. The site has a long history tracing back to the Chalcolithic period. The site was renamed several times, being Parnakka or Pharnake (Persian), Pella (Macedonian) and finally Apamea (Seleucid). In the Seleucid period it was renowned for being a stud farm, training area and supply centre for the army.

With the exception (probably) of the grid plan, virtually nothing survives of the Seleucid town. Although the citadel was destroyed in 64 BC by Pompey, the town continued as a prosperous centre, until it was severely hit by a massive earthquake in AD 115. This prompted an extensive rebuilding programme, including features such as the 2 km long colonnaded cardo. In the 3rd century Apamea became the winter quarters of the Second Parthian Legion. It continued as a prosperous centre into the 4th century, when it was an important bishopric. The town was destroyed in AD 540 by the invasion of Khusrau

[133] Zayadine and Farajat 1991, 286-8.
[134] Hodge 1992, 335.
[135] General information on Apamea: Balty 1981; Balty 1988; Millar 1993, 256-263; Ball 2000, 159-161; Butcher 2003 *passim*. Water supply information: Lacoste 1941; Shahada 1957; Rey-Coquais 1973, 41-46; Balty 1983; Schmidt-Colinet 1984; Balty 1987; Balty 1988; Leveau 1991, 154; Neudecker 1994.

I Parviz. Although Apamea was never a provincial capital, it had very strong associations with the Severan dynasty, which probably explains its wealth. The father of Elagabalus was from Apamea, Julia Domna (from Emesa/Homs) was a local woman, and Septimius Severus consulted the oracle of Zeus Belos at Apamea regarding his imperial destiny.

Due to the earthquake of AD 115, we know very little about the early water supply of Apamea, but bottle cisterns from the Hellenistic period have been excavated in the area of the colonnade and the churches. It would seem likely that this method of water supply continued until the aqueduct [Gazetteer 7] was constructed after the earthquake. The aqueduct, which came from springs at Salamiye and entered the city near the North Gate, was built by C. Iulius Agrippa in AD 116/117 (see section 6.3.1). Recent excavations in the North Gate area have made significant discoveries about the aqueduct water supply as it enters the city.[136] The aqueduct delivered its water to a *castellum divisorium,* just inside the city walls, which was presumably contemporary with the aqueduct. Close to this point, there seems to have been a bathhouse [#723; Gazetteer 14] and a *nymphaeum* [#335; Gazetteer 8], which may also have been contemporary with the aqueduct. It was not clear whether these buildings were fed directly from the aqueduct or from channels/pipelines leaving the *castellum*. To the west of the colonnaded street in the North Gate area, an extensive network of ceramic pipelines and a junction box have been revealed. The complexity of this area suggests that it was the hub of Apamea's water supply network, responsible for delivering water to the major users on the network: the bathhouses, *nymphaea* and latrines [Fig. 7.45].

To the south of this area, on the eastern side of the colonnaded street, a second bathhouse was located [#233; Gazetteer 14]. From Agrippa's inscription it would seem that this bathhouse was also part of the post-earthquake rebuilding phase and was connected to the aqueduct water distribution network to the north.[137] At the cardo/decumanus intersection, a second *nymphaeum* [#360; Gazetteer 8] and a connecting latrine [#210; Gazetteer 13] were constructed, also in the 2nd century AD. Both *nymphaea* in Apamea were located in highly visible and central locations in the cityscape. This is a common trait

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[136] The description of the area of the North Gate is based upon personal observations made on a site visit in September 2004. The excavations by Didier Viviers are so far unpublished, therefore, all interpretations and chronology must be treated as tentative.

[137] Agrippa's donation of baths is recounted in the same inscription that records his donation of the aqueduct (*AE* 1976, no. 678), as well as in another inscription (*AE* 1976, no. 677).

of *nymphaea* and reflects their propagandistic use as symbols of power and status, as well as loyalty to Rome. During this phase, there is no evidence for storage of aqueduct water.

The circular installation found in the south-eastern area of the city (see section 7.2.1) may also belong to this phase. It seems to suggest that a secondary division of the aqueduct water was needed in this area, but it is not clear why. A second latrine [#702; Gazetteer 13] has also been excavated on the western side of the colonnaded street; the latrine is undated, but is of better construction than the third latrine, which may suggest that it belongs to this earlier phase. A third possible bathhouse [#724; Gazetteer 14] was observed in 2004 on the eastern side of the colonnaded street further south than the two others; only the unexcavated brick vaulting was visible, so no comment can be made as to its date.

In the late Roman period, there seems to have been a change of emphasis in the management of water at Apamea. The aqueduct appears to have continued in use, but its water was stored in reservoirs in the centre of the city. Reservoirs [Gazetteer 9] were inserted at the cardo/decumanus intersection and in the northern area of the agora. It is possible that these reservoirs were associated with bathhouses as their capacities (201 m^3 and 144 m^3 respectively) would have been sufficient for this purpose. Bathhouses have not been excavated in these areas, however. In the case of the area of the cardo/decumanus intersection this may be due to a lack of excavation in the surrounding area, but this is less likely in the case of the northern agora area [Fig. 7.44]. The final destination of their water, therefore, is unclear. There seems to have been a clear encroachment on public space in the agora as a third latrine [#710; Gazetteer 13] was also inserted in the late Roman period into its eastern entrance, off the colonnaded street. In addition, one of the private houses had two small reservoirs inserted [#378; Gazetteer 15].

It is likely that a combination of factors was responsible for this change of emphasis at Apamea, but without a tighter chronology it is difficult to suggest which one of these may have been primary. It is possible that there was a population increase in the late Roman period caused by the use of the city as the winter quarters of the Second Parthian Legion, possibly as a response to the looming threat from further east. Its position as an important bishopric may also have brought higher numbers of visitors to the city. This may have prompted the construction of the third latrine and possible late bathhouses.

The seeming disregard for previously important elements of the city, such as the agora, appears to be part of a wider phenomenon at Apamea. This is illustrated starkly by the treatment of inscriptions related to C. Iulius Agrippa, the 2nd-century benefactor.[138] The inscription describing his benefactions, such as the aqueduct, was re-employed as a lintel for a window, ironically in his portico. In addition, a dedication to the same man was reused as a kerb stone in the colonnaded street. This change in water management, its apparent fragmentation and the encroachment on public space is discussed further below [section 7.8.2].

7.6.2 Jerash[139] [Fig. 7.46]

Jerash (anc. Gerasa) lies on both banks of the Chrysoroas River, which is a tributary of the Yabbok River in northern Jordan. The site is 42 km north of Amman on the road to Pella and Scythopolis and is surrounded by fertile agricultural land. Jerash has its origins in the Bronze and Iron Ages, but the earliest evidence for major settlement here is Macedonian ('Camp Hill' and the Temple of Zeus *temenos*). It was refounded under the name Antioch-on-the-Chrysoroas by one of Alexander's generals. The city was one of the Decapolis cities that came under direct Roman control during Pompey's annexation.[140] Although renowned for its splendid architecture, Jerash was not one of the most important towns in the area; it was not a provincial capital, nor on major trade routes.

In the 1st century AD the city underwent rapid expansion with the construction of the cardo and a theatre next to the Temple of Zeus. The 'Golden Age' of the city was in the 2nd century AD. In AD 130 Hadrian visited the city; a monumental arch to the south of the city walls, near the hippodrome marked this occasion. The city, with its two theatres and hippodrome, was a focus for athletic and theatrical festivals; an *agon* was established here for the Emperor Trajan. Jerash was also famous for the *maiumas* festival (see below). By

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[138] Butcher 2003, 265.
[139] General: Kraeling 1938; Harding 1967, 79-105; Zayadine 1986; Millar 1993 106, 411-412, 425; Ball 2000, 188-191; Butcher 2003 *passim*. Water management: Irby and Mangles 1845, 97; Fisher 1938b, 265-269; Kraeling 1938, 282, 291, pl. LVII.b; Harding 1967, 79-105; Kalayan 1981, 332; Browning 1982, 165, 168; Ball 1986, 391; Bitti 1986, 189; Fontana 1986, 181;Gawlikowski 1986, 110; Watson 1986, 359; Nielsen 1993, Vol. 2, 41; Segal 1997, 160-2; Uscatescu and Martin-Bueno 1997.
[140] By the end of the 1st century AD, there were 12 or 15 Decapolis cities (the exact number is disputed): Philadelphia (Amman), Gerasa (Jerash), Pella (Tabaqat Fahl), Capitolias (Beit Ras), Gadara (Umm Qes), Abila, Raphana, Dion, Scythopolis (Beth Shean), Hippos, Adra (Der'a), Kanatha (Qanawat) and Damascus (briefly).

the late 3rd century AD, the city reached its greatest extent and was surrounded by ramparts. The city never expanded as far as the Arch of Hadrian and the elaborate Temple of Artemis (begun in the 2nd century) was never finished.

With the defeat of the Sassanians (c. AD 300) a new phase of construction began in the area around the southern tetrapylon. In the late Roman period a large Christian community developed at Jerash and the cathedral was already functioning in the mid 4th century AD. Little else is known of 4th-century Jerash. In the 5th century, repairs to the fortifications were carried out and two churches were built, one of which was the Church of St Theodore. The high point of the late Roman period came under Justinian when at least seven churches were built. The end of Jerash was heralded by the Persian invasion of AD 614. The city was finally destroyed by a series of earthquakes in the 8th century.

Two springs are the main water providers for the site. Ain Qarawan is a perennial spring within the walls, but it lies too low in the valley to provide water for the western part of the city. Water was, therefore, channelled from a large double reservoir at Birketain, a spring (named after the double reservoir) at a higher level c. 1 km to the north [Gazetteers 7 and 9]. The aqueduct probably dates to the 2nd century. To the west was a small theatre that overlooked the reservoir and spring. This theatre seems to have been associated with the *maiumas* water festival, which was named after the port of Maiuma (Gaza), where it may have originated. The festival may have included mixed bathing, nocturnal displays and ritual feasting.[141] Libanius felt that the festival was licentious, which, alongside the increasing Christian emphasis at Jerash, makes it surprising that it was revived at Jerash in the 6th century AD.[142]

The 2nd century seems to have seen the main developments in water supply and management at Jerash, alongside the general development of the city during this period. The aqueduct water from Birketain fed several major installations on the western bank of the river, including the West Baths [#219; Gazetteer 14], the *nymphaeum* [Gazetteer 8] and one of the fountains in the *macellum* [Gazetteer 8], as well as (probably) the lion-headed fountain in the northern tetrapylon. The East Baths may also have been fed by Birketain rather than Ain Qarawan [#220; Gazetteer 14]. The aqueduct water seems to have been

[141] Coleman 1993, 71 n. 109.
[142] Libanius *Ad Timocr.* 16. Liebeschuetz 1972, 230-1.

supplemented by rainwater stored in cisterns, particularly in the areas of the Temple of Artemis, the south decumanus and the oval plaza [Gazetteer 10.2]. The drainage network, which had a 5th-order collector under the cardo, as well as lower order drains in the side streets, may also date to this period [Gazetteers 11 and 12]. Two other fountains were added to the *macellum* in the later 2nd/early 3rd centuries and 3rd-5th centuries AD respectively [Gazetteer 8]. Domestic water supply seems to have relied on wells and rainwater cisterns [Gazetteer 15]; no connection has been found to the piped distribution network.

Similar to the rest of the city, we know of no additions or changes to the water management system until the 5th century AD when the Baths of Placcus [#287; Gazetteer 14], including a public latrine [Gazetteer 13], were built between the Temple of Artemis and the Church of St Theodore. In this late Roman period, particularly in the 6th century, there seems to have been a change in focus towards water for industrial purposes with an industrial installation inserted into the hippodrome [Gazetteer 18], a dye-works inserted into the *macellum* [Gazetteer 18] and a water-powered sawmill in the Temple of Artemis [Gazetteer 17]. As was seen at Apamea, this appears to represent a large-scale encroachment on previously public areas, in particular those linked to pagan religion and entertainment (see section 7.8.2 below). The extreme change in purpose of the Temple of Artemis probably reflects the increasing Christian nature of the city, though this is at odds with the revival of the pagan water festival. In addition, the sawmill was being used to cut up *spolia* for veneer, which further illustrates the disregard for Classical architecture in this late period.

7.6.3 Caesarea[143] [Fig. 7.47]

King Strato of Sidon founded Straton's Tower, a harbour on the Phoenician coastline, in the 4th century BC. It was a relatively minor city until Herod refounded the site as Caesarea Maritima between 22 and 10 BC, one of several of his dedications named in honour of Octavian (Caesar). At this point it became the focus of an extensive building programme: the harbour was enlarged and the city furnished with a Temple to Rome and Augustus, a forum, baths, a theatre and an amphitheatre. This was a conscious attempt to make Caesarea a Roman city, 'a Roman implant on Palestinian soil'.[144] It was also a lavish and overt attempt to court Rome and so for a small kingdom and its client king to survive. It was at Caesarea that Vespasian was first hailed as emperor and so, early in Vespasian's reign, Caesarea was given the title *colonia*. From the 3rd century AD Caesarea was an important centre of Christianity: Origen taught there from the 230s to the early 250s and Eusebius was bishop from c. AD 313-339. In November AD 306, Caesarea's place in the Imperial state was marked firmly by the birthday celebrations of the Emperor Maximinus there. The city remained prosperous until the Arab conquest in AD 640. After a rise in fortunes in the 9th-13th centuries, Caesarea was abandoned finally in AD 1265 after the Mamluk conquest.

In its early phases Caesarea seems to have relied on rainwater stored in cisterns and well water that tapped the fresh water floating on top of the saline seawater. The Roman and late Roman city supplemented these resources with running fresh water from four aqueducts: Low Level, High Level channel A, High Level channel B and the Southern Pipeline [Gazetteer 7]. The main source for the High Level aqueduct channel A was Ain Shuni, c. 6 km northeast of Caesarea. This aqueduct may have been part of the Herodian remodelling of the city. Channel B, running parallel to the west of channel A, was a Hadrianic addition. At a later date part of channel B, to the west of the kurkar ridge, was infilled and a third channel (channel C) was constructed above it. The Low Level aqueduct, which was probably constructed before the 4th century AD, was fed by the swampy Nahal

143 General information on Caesarea: Millar 1993, 73, 200, 377-8; Ball 2000, 177-179. Water supply information: Bull and Toombs 1972, 180; Flinder 1976, 77-79; Ayalon 1979, 179; Wiemken and Holum 1981, 38-39; Porath and Yankelevitz 1989/90, 31; Raban 1988-89, 391; Porath, Neeman and Badihi 1989-90; Raban and Holum 1991, 110-112; Peleg and Reich 1992; Angert 1994, 138-139; Porath 1996, 112; Horton 1996, 177-189; Porath 1998, 45; Porath *et al.* 1998, 42; Porath 2000, 36*-37*; Mango 2002, 325; Porath 2002b.

144 Ball 2000, 52.

Taninim (Crocodilion River) that was dammed to raise the water into the aqueduct. In the 3^{rd}-6^{th} centuries the Southern Pipeline, which supplemented the High Level aqueduct resources for the southern area of the city, tapped the Ain al Assal spring c. 4 km southeast of the city. The High Level aqueducts provided the major source of running drinking water as the water delivered by the Low Level aqueduct, which was brackish and so unpalatable, may have been used for industrial purposes such as milling, not only at the dam, but also elsewhere on its course.

The wells and cisterns of the early Roman buildings in the south-western zone went out of use and/or were filled in the second half of the 1^{st} century AD. No wells in the south-western area have been dated to the 2^{nd}-5^{th} centuries AD and there seems to have been a reliance on aqueduct water during the Roman and late Roman periods until the 6^{th} century AD (see section 7.8.2). The two industrial installations on the southern promontory and to the south of the theatre [#488 and #584; Gazetteer 18] do not seem to have relied on aqueduct water. The following description focuses on the aqueduct water supply around the city in the 1^{st}-5^{th} centuries AD.

The High Level aqueducts entered the city close to the northern gate in the early city walls where, after the construction of channel B, they terminated at a *castellum divisorium*. We know little about how the water travelled from here to the central and southern parts of the city, which have been extensively excavated. We know that there was a series of drains in the northern area that drained towards the sea as well as a freshwater pipeline in this area. In the central and southern areas the water was distributed mostly in ceramic pipelines, over which there were inspection points and manhole covers. Occasionally lead was used for some sections of this pipeline network, such as the line west of the Temple of Roma and Augustus, a small section in the south-western area and a line feeding the Governor's Palace on the southern promontory. This distribution network fed the 1^{st}-century AD *nymphaeum* [Gazetteer 8] to the north of the western façade of the Temple of Roma and Augustus; notably, though maybe not unsurprisingly, one of the earliest *nymphaea* in the East. In general, from the small amounts we know, regular domestic supply must have been from wells and rainwater cisterns [Gazetteer 10], as only the 'palaces' were connected to the piped water distribution network.

The drains [Gazetteers 11 and 12] functioned much as at Dor. The 3rd-order drains in small lanes and alleyways fed 4th-order drains, which were usually constructed from ashlar and capped with stone. In some cases the 4th-order drains were stacked one on top of each other and received water from gutters along main streets; these gutters form a different kind of 3rd-order drain. The wastewater in the 4th-order drains was collected in the large, vaulted 5th-order drains that discharged into the sea off Caesarea.

From the 4th century onwards there appear to have been some changes made to the water supply system with more, albeit small, storage elements inserted into the network in the south-western area. A cistern was added to the Martyrium (the former Temple of Roma and Augustus) and a reservoir was fed by the pipe network in the south-western area [26 m^3; Gazetteer 9]. This reservoir was used to feed the 4th-6th-century AD baths [#695; Gazetteer 14] and their public latrine [#701; Gazetteer 13] in that area. A further reservoir (36 m^3) was needed for the 'Byzantine Palace' to the south of the baths.

In the 3rd-6th centuries AD, possibly then contemporary with the additional low capacity storage, the Southern Pipeline was deemed necessary to supplement supply in this area. The High Level aqueduct channel A must have been functioning to some extent in the 6th century AD as it fed a bathhouse and latrine [#288 and 286; Gazetteers 13 and 14] complex to the northeast of the city (excavated in 'Field E' to the northeast off Fig. 7.47). This suggests that the problem in the south-western zone was either that too much water was being drawn off the aqueduct before it could reach this area and/or the northern network (see below section 7.7), was in a state of disrepair. Indeed, Choricius of Gaza informs us that c. AD 535 the High Level aqueducts to Caesarea no longer brought enough water to the city's fountains because the channel was blocked (it is unclear which one).[145] Although Stephen, *consularis* of Palestina Prima, cleaned the aqueducts and added new fountains, it may have been this disruption that led to the decline of the water supply in the south-western zone. The problems with the aqueduct maintenance may have been caused, or exacerbated, by the insecurity brought on by the Samaritan revolt of AD 529 that continued up to Stephen's appointment.

[145] Choricius of Gaza *Laudatio Aratii et Stephani* pars. 44-49; Di Segni 2002, 61.

These case studies display the complexity of the distribution systems inside the cities. Their different topographic locations (on a plateau, on either side of a river, on the coast) display, for example, how different methods of supply can be utilised; wells, for example, which were a feature of early and late Caesarea, would not have been viable on a plateau site such as Apamea. Clear chronological developments have also been brought out, which seem to relate to the upturns and downturns in the wider fortunes of the cities. In particular there appear to have been distinct changes in water supply in the late Roman period (see section 7.8.2).

7.7 Construction and maintenance

In comparison to the amount of data known about the construction and maintenance of the aqueducts (Chapter 6.3.1), little epigraphic or literary evidence is available about other parts of the urban management system. The tax law (AD 137) of Palmyra tells us the caravan traders were charged 800 *denarii* per year for the use of the springs outside the city.[146] At Jerash the ‘devotees’ dedicated a stoa and reservoir (‘τὸν λάκκον’) in the Temple of Artemis.[147] With these exceptions (and the *nymphaeum* and fountain donations: section 7.2.2), the evidence relates to the late Roman period. It may not be viable to extrapolate this situation back because the situation in the late Roman period seems to have been quite distinct (section 7.8.2).

Only one imperial benefaction, other than those for fountains and *nymphaea* (see above section 7.4) is known. The reservoir under Nea Church, Jerusalem was undertaken by the munificence of Justinianus and under the care of Constantinius, priest and *hegumen* [Fig. 7.48].[148] An inscription from an *agraria statio* in Provincia Arabia shows military involvement in reservoir building: in AD 334 an officer who had seen many of his men killed in an ambush by Saracens while collecting water built a reservoir.[149]

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146 Matthews 1984, 177.
147 Welles 1938, 389, #28.
148 Avigad 1983, 241, 245.
149 Iliffe 1944; Di Segni 2002, 52.
CVM PERVIDISSET VINCENTIVS PROTE/CTOR AGENS BASIE PLVRIMOS EX AGRA/RIENSIBVS DVM AQVA<S> SIBI IN VSO TRANS/FERERENT INSIDIATOS A SARACENOS PE/RISSE RECEPTACVLVM AQUAR<VM> EX FVNDA/MENTIS FECIT’ OPTATO ET PAULINO VV CC CONSS. ‘Vincentius, who was acting as chief of the bodyguard of Basius, observing that many of the outlying pickets had been ambushed and killed by the Saracens while fetching water for themselves, laid out

There is more information about the upkeep and maintenance of the urban distribution and drainage network. Shopkeepers in Antioch were responsible for cleaning the drains, which Libanius suggests was dangerous work in which a man might be choked to death.[150] Work on replacement water pipes in Scythopolis in AD 521 was attributed to the *principalis* Silvinus son of Marinus and to the governor Flavius Orestes in two inscriptions set in the street pavement.[151]

Four 6th-century ostraca from Sbeiteh/Shivta point to villagers contributing a period of labour in the public reservoirs. The reservoirs were located in the centre of Sbeiteh/Shivta and both were an irregular trapezoidal shape [Fig. 7.36]. The surface area of the northern reservoir is 486 m^2 and the southern 324 m^2. Their total volume (given a depth of 2.5 m) would have been 2,025 m^3. They were supplied by a 2.5 km long aqueduct, fed by runoff, that entered Sbeiteh/Shivta from the north-east and also fed the northern church.[152] The ostraca show that the reservoirs were cleaned in October, which is appropriate as the rains resume at this time and the reservoirs would have had their lowest water levels.

The involvement of the Church is seen in two examples. An inscription from Jerash recorded that a bishop corrected the nuisance caused by bad odours from the sewer.[153] Secondly, Euthymius restored two large reservoirs in the vicinity of his monastery.[154] This is different from the aqueducts, where no involvement from the Church was seen (Chapter 6.3.1).

No renovation or maintenance seems to have been carried out under imperial orders, which is to be expected except under special circumstances such as repairing damage after natural disasters. Instead, maintenance seems to have been undertaken under the supervision of municipal authorities using a lower class workforce or under the supervision of the Church.[155]

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and constructed a reservoir for the water. He did this in the consulship of Optatus and Paulinus, both distinguished officials.'

150 Libanius *Orat.* xlvi.21; Liebeschuetz 1972, 219.

151 Di Segni 2002, 62.

152 Youtie 1936; Tsuk 2002c, 75-6.

153 The actual inscription could not be found by the present author, but reference is made to it in Fisher 1930, 9.

154 Di Segni 2002, 52 fn. 91. Cyril of Scythopolis *Life of Euthymius* 51:
῾Ως ἀπὸ σταδίων δύο τῆς τοῦ μεγάλου Εὐθυμίου μονῆς δύο λάκκοι μεγάλοι εἰσὶν πάλαι ὑπὸ Ἀμορραίων, ὡς λόγος, ὀρυχθέντες.

155 There is evidence about military involvement in the construction of rural reservoirs: Di Segni 2002, 52.

7.8 Urban water supply and storage and the constant-offtake principle

It was expected that due to similarities in environment and climate that the situation in North Africa would be mirrored in the eastern provinces (see Introduction) and that buffer reservoirs would have been provided in towns and cities, which could balance supply against usage, as has been convincingly argued for North Africa.[156] The picture, however, does not seem to be so straightforward. North Africa had markedly more installations with capacities greater than 2,500 m^3 than the Near East (Table 7.8). The Near East had no cities with reservoir-cisterns in the over 20,000 m^3 category, whereas North Africa had three: Carthage (Bordj Djedid: 20,000 m^3 and La Malga: 50,000 m^3), Zama (28,000 m^3) and Cirta (30,000 m^3). Even without including these exceptionally massive reservoir-cisterns, a large discrepancy between approaches to urban aqueduct water storage in the two areas of the Empire still appears. There is also the issue that 23 urban aqueducts were not furnished with storage facilities (section 7.2.3). The fact that a large majority of the dated storage installations were not contemporary with aqueduct construction, but were later additions to the water management system further compounds the difference.

Table 7.8: Comparison of urban aqueduct-fed water storage installations by capacity (over 500 m^3) in the East and North Africa.[157]

Capacity (m^3)	East	North Africa
500-999	6	1
1,000-2,499	3	4
2,500-4,999	4	7
5,000-9,999	1	8
10,000-19,999	2	5
20,000+	0	4

Is Peleg's theory correct, then, that:

'As it would never occur to the maidens who went to fetch water from the spring to turn it off, so the system in the town was not turned off.'?[158]

[156] Wilson 2001.
[157] Data on North African reservoir capacities is based on Wilson 1997, 79-80, table 4.
[158] Peleg 2000, 241.

In other words, did the constant-offtake principle, where aqueduct water was not stored in significant quantities along its course, apply to the Near East?[159] Firstly, I will address the question of how much the towns and cities in the Near East relied on an aqueduct supply (section 7.8.1). This will include an analysis of whether there were complementary resources. I will then assess to what extent there was a shift in approaches to water management in urban contexts in the late Roman period, how this might affect the constant-offtake principle debate and what may have been the motivations for this shift (section 7.8.2).

7.8.1 Complementary water sources in urban contexts

In order to answer the question of the extent to which cities and towns in the East relied on their aqueduct supplies, I will consider how many sites were supplied only by aqueducts and whether this is a reliable picture. I will also look at which sites were supplied by a combination of sources, such as aqueduct water, well water and rainwater.

Although the archaeological data for some installations, such as wells, are sparse, several observations can be made usefully about the complementary use of water sources and storage installations across the East. Table 7.9 presents the known data across 41 sites in the East. This does not include the 17 sites only fed by aqueducts without known public storage facilities or other complementary water sources.[160] Of these, however, 12 have not been subject to extensive excavation or survey, in most cases because of the overlying modern town, such as Damascus, Aleppo, Lattaqia and Tyre. The aqueduct at Lattaqia, for instance, is known only from literary evidence.[161] More is known about Emmaus and Susita/Hippos, but it is of course always possible that the other facilities have not been published or yet been found.

[159] This is a commonly expounded theory; see for example Hodge 1992, 3, 79, 89, 279, 280, 296, 303, 322; Forbes 1964, 172; Leveau and Paillet 1976; Shaw 1984, Cotterell and Kamminga 1990, 51.
[160] These are: Aleppo, Banias, Damascus, Edessa, Emmaus, Lattaqia, Neapolis, Samaria, Samosata, Si, Sidon, Susita, Suweida, Tripoli, Tyre, Umm Qes and Zeugma.
[161] Josephus *BJ* 1.21.11.

Table 7.9: Water sources and storage installations in the East.

		Aqueduct-fed storage			Rainwater/runoff storage		
Site	**Aqueduct (D=storage dam)**	**Reservoir**	**Cistern**	**Reservoir-cistern**	**Reservoir**	**Cistern**	**Wells**
Acco	X				X		
Antioch	XD						
Apamea	X	X	X				
Ar-Rabbah					X		
Ashqelon	X						X
Ba'eij					X		
Beirut	X						X
Beth Govrin	X			X			X
Bosra	X	X					
Burqa'ah					X		
Caesarea	XD	X	X				X
Capitolias	X	X		X			
Dafyaneh					X		
Dara	X			X			
Deir al Kahf					X		
Dor	X	X			X	X	X
Dura Europos						X	
Eboda					X	X	X
Elusa					X		X
Homs	XD						
Horvat Castra					X		
Horvat Zikhrin						X	
Irbid					X		
Jerash	X	X				X	
Jerusalem	X	X	X	X	X	X	
Kurnub						X	
Lejjun						X	
Nessana					X		X
Palmyra	X						X
Petra	X					X	X
Qanawat	X		X			X	
Qasr al-Hallabat						X	
Resafe	X		X	X	X		
Saadi					X	X	X
Sabkha					X		
Sabkhiya					X		
Sbeiteh	X	X	X			X	
Scythopolis	X	X			X	X	
Sepphoris	X	X	X	X		X	
Sumaqa						X	
Tiberias	X	X				X	X
Umm al-Jimal	X		X				
Umm al-Qetein					X		

Eight sites only had aqueducts and aqueduct-fed storage: Antioch, Apamea, Bosra, Capitolias, Dara, Homs and Umm al-Jimal. The lack of other resources at Capitolias and Dara is probably due to the low level of archaeological investigation at these sites; attention has focussed, therefore, on the larger, more monumental remains. More research has been undertaken at the other sites, which makes the lack of rainwater storage installations at these sites difficult to explain without suggesting that the aqueduct supplies were sufficient.

Information on rainwater storage and wells from Antioch and Homs may be lacking due to the overlying modern towns, which restrict archaeological investigation. Antioch and Homs also appear as two of the sites that did not have urban storage facilities. While this may be due to excavation bias, the fact that they both had dams may be significant (see Chapter 4.2) because this may have obviated the need for large-scale storage facilities inside the city. Although Caesarea did have storage facilities inside the town, they were small in scale: the known reservoir capacities were just 36 m^3 and 26 m^3. Dammed water storage may also explain this apparent anomaly.

The lack of wells at these sites may be due to environmental factors. Apamea, for example, was on a plateau above the Orontes valley and therefore digging wells may have been undesirable due to the depths necessary. Similarly, topography also dictated the water supply at Dura Europos on a plateau above the Euphrates, though unlike Apamea an aqueduct supply was not possible at this site (see Chapters 8.4.2 and 9.2.1). Both Bosra and Umm al-Jimal were in basalt areas, which would have made digging wells exceptionally difficult. The underlying basalt geology may also explain several of the sites that relied on stored cistern supplies: Ba'eij, Burqa'ah, Dafyaneh, Deir al-Kahf, Sabkhah, Sabkhiyeh, Umm al-Qetein and Irbid. Covered cisterns, rather than open reservoirs, must have been used on these sites because they were supplied by seasonal runoff water supplies, so long-term storage and prevention of evaporation would have been a high concern.

Evidence for the complementary use of aqueduct water, well water and rainwater only came from three sites: Dor, Petra and Tiberias. There were, however, 16 sites that showed a combination of two of these water sources. Seven sites are known to have used aqueduct and rainwater supplies: Acco, Jerash, Jerusalem, Qanawat, Sbeiteh, Scythopolis and Sepphoris. Given the propensity of other Negev sites for wells (see below), one might expect to have found wells at Sbeiteh. As the site has been subject to thorough survey, it is likely, therefore, that Sbeiteh was atypical because it was the only Negev town to have an aqueduct supply, which may have rendered wells unnecessary.

Five sites made use of aqueduct supplies alongside wells: Ashqelon, Beirut, Beth Govrin, Caesarea and Palmyra. As Palmyra was in an area with low rainfall under the 200 mm isohyet (see Chapter 1.1), the lack of rainwater cisterns should maybe be expected, but may also reflect under-reporting of cisterns. In addition, as an oasis site, well water would have been easily accessible, as evidenced by the qanat provision. Conversely, it would be reasonable to expect that the coastal sites (Ashqelon, Caesarea and Beirut) would have taken more advantage of the higher rainfall, especially Beirut, which would have benefited from the effects of the Lebanon and Anti-Lebanon mountain range (see Chapter 1.1). Beirut has, however, been subject to only limited excavation due to its troubled recent history. In the case of Caesarea, the use of complementary resources may be tempered by the idea that well water was only used when there was no aqueduct supply or when the aqueduct supply was in decline (see sections 7.6.3 and 7.8.2).

A further four sites used wells alongside rainwater storage to guarantee a stable supply: Eboda, Elusa, Nessana, and Saadi. Notably these sites are all in the Negev, none of which had an aqueduct supply due to their desert location (the single exception in this area was Sbeiteh, see above). Rainwater storage may also not have been a reliable, perennial source, so wells would have been a necessity. This is brought out clearly in a letter from Jerome to Procopius, which includes a complaint that the well water at Elusa was brackish and barely palatable.[162] This suggests that well water was relied upon when reservoir water was unavailable, for example in the middle of summer, or during drought years.

There is limited evidence for the use of river water in urban centres. It is unlikely that rivers would have been used to supply urban drinking water, but it is possible that river water may have been lifted to supply industrial installations. We know, for example, that fulling mills in Antioch were probably powered by the Orontes River (see Chapter 10.2).

While the lack of large-capacity aqueduct-water storage facilities in urban contexts seems to suggest that the constant-offtake principle applied in the East, i.e. that there was a wasteful approach to water management, this would seem to be an overly simplistic analysis. Firstly, dams creating large storage reservoirs outside the cities may have rendered

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[162] Mayerson 1983, 251. Procopius *Ep.* 2.

further large-scale storage inside the city unnecessary. In addition, many of the sites under consideration did not rely solely on aqueducts for their perennial water supply, indeed several had no aqueduct on which to rely. In the majority of cases complementary resources would have covered seasonal shortfalls in supply. Reliance was rarely placed on a single water source, be it an aqueduct or other source, the choice of which was often determined by topographic, geological and climatological factors. There is also evidence from taps, at Sepphoris and Auara, that, actually, the aqueduct supply could be turned off. In addition, the system at Capitolias that combined a large open reservoir with a tunnel reservoir-cistern, which could be used for back-up storage, suggests that the aqueduct supply could be more finely balanced than the constant-offtake principle would allow.

7.8.2 Urban water management and storage in the late Roman period

It is also interesting to look at the development of water storage and distribution in urban centres over time. One would expect to find that aqueduct and storage facilities were contemporaneous and this is the case for four sites: Sepphoris, Tiberias, Beth Govrin and Resafe. There are, however, several sites in which this is not the case. The late Roman period at Apamea, for example, in water supply terms, was typified by the building of small reservoirs, whereas the earlier period was concerned with the aqueduct.[163] A similar pattern of earlier aqueduct and later storage is also attested at Jerusalem, Acco, Caesarea and Dor. The fact that aqueducts and storage on the same site were not necessarily contemporary has obvious consequences for any theory of buffer reservoirs.

In the East, as was also shown in the urban case studies, there seems to have been a shift in approach to urban water management in the late Roman period. If the constant-offtake principle was ever used in the East, it seems not to have been the principle on which water management functioned in the late Roman period. This shift did not just affect how water was managed and, in particular, stored, but also where the new water management installations were placed in the urban landscape. This was particularly clear in Jerash and Apamea. It would seem that not only were there shifts in how water was managed in this

[163] Balty 1987.

period, but also in how urban centres functioned, so we need to ask what brought about these changes.

As shown by the encroachment of installations making use of water on public space, the monumentality of the city no longer appears to have been a major concern for its inhabitants. This seems to be related to changes in the power structure of cities that saw power held increasingly by individuals, in particular bishops, rather than by the *boule.* In this atmosphere the monumentality of cities no longer seemed to fit with cultural ideals, where wealth was used to enhance the status of the individual rather than that of the community.[164] This is illustrated by the treatment of C. Iulius Agrippa's inscriptions at Apamea noted above and by the building of shops and workshops in, for example, the colonnades at Scythopolis and Antioch.[165] Public entertainment came under state control in the 5th century, which also diminished the sense of a city's identity. The insertion of the vats into the Jerash hippodrome may reflect such a change in control over public entertainment. Furthermore, individuals were keen to gain heaven's approbation, thus bringing about a lowering in the number of donations made for public buildings and an increase in the wealth of the Church. Indeed, the number of water storage facilities, both reservoirs and cisterns, associated with church buildings strongly suggests that the Church was one of few institutions that could afford their construction and upkeep. It is also possible that the strong links between Christianity and water, as shown by the placing of Christian holy sites near springs and aqueducts, may have made it appropriate for the Church to concern itself with water provision (see section 7.2.3).

These changes in urbanism may explain the small-scale reservoirs at Apamea and Caesarea. These reservoirs are very different in scale from the massive, late, open reservoirs at Constantinople and Ptolemais.[166] What the Eastern reservoirs appear to represent is a more fragmented, less centralised approach to water management in this period. This seeming lack of any overarching water management plan may be attributable to the extensive administrative changes of the period. The decline in civic self-government with a

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164 Butcher 2003, 269; Liebeschuetz 1972, 101-105, 136, 259-260, 262.

165 Liebeschuetz 1972, 56.

166 Constantinople reservoirs: Aetius (5th century): 197,000 m^3; Aspar (5th century): 220,000 m^3; Mocius (6th century): 250,000 m^3: Ceçen 1996; http://longwalls.ncl.ac.uk/Water/Constantinople.htm. Ptolemais reservoirs: buildings 11 and 12 (52.5 m x 37.5 m and 118 m x 126 m (26 million gallons) respectively): Kraeling 1962, 71-2.

lack of effective power in the council and the rise in power of the church, or more specifically the bishop as city leader, did not just affect public munificence, but also appears to have had a significant impact on wider water management strategies. In the case of these small storage installations, it would seem that they might have been the result of private or small group enterprise. This may have been resorted to when municipal and provincial governing bodies were tied up with other more pressing issues, such as the Saracen revolt in Caesarea, which led to the disruption of the aqueduct systems.

The increase of storage *inside* the city walls in this period may also point to a fear of siege. The construction of a string of frontier cities, such as Dara, Resafe and Khan al-Manqoura, must be viewed as a deeply-felt concern over the increasing power from Persia. In addition, is it mere coincidence that Resafe and Dara were two of the cities with the largest storage facilities in the eastern empire? The inscription of the officer in AD 334 who had seen many of his men killed in an ambush by Saracens while collecting water and so built a reservoir (see section 7.7) also lends weight to the idea that water storage was closely allied to protection from external force.[167] These examples seem to indicate that the water management system worked effectively when ordered directly from the emperor, but otherwise strategies were implemented on a rather *ad hoc* basis.

Environmental factors may have governed how water was managed in the late Roman period as well. At Sagalassos in Turkey for example the 5th to 6th centuries AD saw the first construction of cisterns.[168] This may have been linked with the earthquake of AD 500 that may have damaged the six earlier aqueducts and thus led to the need for alternative water provision. There is also some evidence for climate change as the cessation of the formation of travertine deposits in the palaeoriver demonstrates that the large river almost disappears. Thus we see that environmental factors played a large part in the change in water supply techniques at the site.

Although we know little about climate changes in the Roman and late Roman periods (Chapter 1.1), there is evidence about the effect of earthquakes and the imperial provision of emergency aid in their aftermath (Chapter 6.3.1 and Chapter 7.7). In addition, in response to the drought in AD 520 in Jerusalem (see Chapter 1.1), we are told that

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[167] *Année Epigraphique* 1984, 136; Di Segni 2002, 52.
[168] These data were presented by M. Waelkens (Leuven) at the Late Antique Archaeology 2004 conference in the Ashmolean Museum, Oxford and are expected to be published shortly: Martens forthcoming.

'…the archbishop, worried at the unrest of the population, began a survey of the more humid places, putting a large number of hands to digging pits, expecting to find water, but could not find it. He went down to the Siloam valley near St Cosmas' Cave, beside the road to the Great Laura, and with the help of an engineer and a large number of labourers dug down to a depth of 40 fathoms [c. 70 m]. But the archbishop could not find any water, and was in great distress…'[169]

Not only does this illustrate that alternative solutions, such as wells, were looked for when there was a shortage of supply, but also highlights again the power of the Church in this period: it is an archbishop, not a city official, who responds to the crisis and takes on the responsibility of finding a solution in order to placate the population.

It appears then that several factors may have explained the move towards increased water storage in the late Roman period. These included internal changes to how cities functioned and were governed, which saw the rise of the Church and the decline of civic self-government, instability in the region (and so protection of the water supply in the event of a siege), and environmental factors that prompted emergency action.

7.9 Conclusions

The review of urban water management presented here has shown that the East was similar in many ways to other areas of the Empire. Aqueducts terminated at *castella divisoria*, *nymphaea* and storage installations. The water was distributed around the city via a network of channels and pipelines, supplying bathhouses, smaller storage installations, street fountains and houses. There was not, however, a total reliance on aqueduct supplies. Similar to North Africa, most cities and towns employed complementary water resources, such as wells and cisterns. This suggests, despite the low numbers of large capacity storage installations, that the basic wasteful premise behind the constant-offtake principle was not at work in the East. This may be backed up by the *nymphaeum* evidence, which seems to suggest that, unlike Asia Minor and Greece nearby, ostentatious (and, arguably, therefore, seemingly wasteful) use of water was limited.

[169] Cyril of Scythopolis, *Life of Sabas*, chap. 54.

The late Roman period in the East saw a change in approach to water management, with an apparent increase in water storage facilities. These changes seem to have been related to the general changes in urban life in the late Roman period, which saw the decrease in the monumentalisation of cities with the rise of the Church. This was concurrent with the decline of city and town governing bodies. Further pressure on urban water management was exerted by the threat from the East, as well as natural environmental disasters such as earthquakes and droughts.