THE INFRASTRUCTURE OF A GREAT CITY: EARTH, WALLS AND WATER IN LATE ANTIQUE CONSTANTINOPLE

James Crow

Abstract

By the later 5th c. A.D., Constantinople was the greatest urban centre in the Mediterranean world. This paper considers three associated aspects of the infrastructure of the city, each of which applied aspects of ancient technology: a first theme will consider the system of terraces which have only been studied in detail for the area of the Great Palace, but which represent a massive investment in the transformation of the built topography of the city; a second theme will examine the new Theodosian fortifications and suggest that these reflect a new level of innovation more often associated with the religious and civic architecture of the city; the third theme will briefly review recent research on the water supply and will identify major areas of continuity and innovation into the Middle Byzantine period.

Introduction

The essential disorder of cities has at least two main origins. First, great cities are big cities, and bigness implies complexity. Villages get their water from wells or small streams, small towns from small rivers that happen to flow through them; they dispose of their wastes into the soil or into those same watercourses, without much bother. But big cities need much more water than that, more water than can ever be supplied by local sources; so they must impound their rivers to build huge upstream storage reservoirs, or bring water from distant river basins, or both. And then if they are not to be racked with epidemics, they must channel their wastes for long distances downstream, to distant purification plants well out of contamination’s way.

(Hall, P. Cities in Civilization, Culture, Innovation and Urban Order (London 1998) 612)

The ultimate ‘new city’ of Late Antiquity was Constantinople; but in modern Istanbul we can hardly expect to experience that ‘evocative ‘late antique' experience”, described by Luke Lavan when recalling the

excavated cities of the eastern Mediterranean, “where the site is preserved as it was in the closing years of antiquity”. Unlike, for instance, Justiniana Prima, history and change have not left Constantine’s city alone. For the urban archaeologist, the fragmentary state of current knowledge and the prospects for future investigation are depressing. A further difficulty for both archaeologists and cultural historians is that the traditional approach to the historical topography of the city has privileged texts over structures and their spatial context within the “existing fabric of the city”. This paper is concerned with three aspects of the urban archaeology of late antique Constantinople—terraces, walls and aqueducts—all three of which can be described as part of the infrastructure of the city. They are examined to reveal the distinctive character of the new city as a rival and a successor to the old imperial capital. It will be argued that the scale and magnitude of these works reflects not merely a massive imperial investment but that they also draw attention to the innovative and distinctive technologies driven by different circumstances of time and place.

The term ‘infrastructure’ has a wide and developing range of meanings. It is most simply defined as the “underlying base or foundation for an organisation or system”; alternatively, it describes the basic facilities, services and installations such as transport and roads, and similar public works needed for the functioning of a community or society. In this paper the latter definition is preferred, although the breadth of the former meaning is implicit throughout. Studies of ancient technology have often focused on technological progress and inventions, which are seen to have demonstrated new scientific knowledge and their influence on novel mechanical devices and their applications. Ancient writers, such as Vitruvius, who provide some of the key sources for our understanding of ancient technology, however, present a broader picture of ‘infrastructures’ under the heading of opera publica or ‘public works’.

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5 See, however, Greene (2004) for a more nuanced consideration of technology in the ancient and medieval world. For the recreation and development of the hydraulic infrastructure in early modern Rome, see the important recent study by Rinnc (2005).
Terraces

Barely a century after the fall of Constantinople in 1453, Pierre Gilles provided the first ‘modern’ description of the Byzantine remains, which until today remains fundamental in understanding its topography and buildings. In the introduction, he draws attention to the differing topographic settings of Rome and Constantinople:

It was not very difficult to distinguish the Roman hills, because they were entirely separated by valleys, but it is not as easy to distinguish those of Constantinople because they are joined at the top. Besides, their backs do not project in so mountainous a way as they do in the front; so I cannot better describe them than by calling them a continued ridge of hills, each divided by valleys.\footnote{Gilles (1988) 19; see now Byrd (2002).}

In contrast, the physical setting of Rome provides level ground or broad slopes for the major public spaces of the Forum, the later imperial fora and the developments on the Campus Martius, and a limited number of precipitous hills for temples and imperial residences, such as the twin peaks of the Capitol, or the Palatine. As Gilles clearly describes, Constantinople possesses a single high ridge extending from the Bosporus and the acropolis of Byzantium to the west. The ‘mountainous’ backs are the north-facing slopes falling steeply towards the Golden Horn, broken by a series of short parallel valleys, and the equally steep banks cut by the Lycus, falling towards the Sea of Marmara. A close-contour plan of the city (fig. 1) shows these features very clearly. In comparison, fig. 2 reproduces the map of the terraces within the city published in Raymond Janin’s Constantinople Byzantine,\footnote{Janin (1964) 7–8; map 6; a detailed plan of terraces in the area of the Tekfur Saray has recently been published by Stephan Westphalen (1998) fig. 2, based on Pervititch’s map it shows for example the association of the terraces with the church of the Pammacharistos.} the principle record of a system of ancient land retention. It is largely based on the observations made by Ernest Mamboury and others throughout the physical transformation of the Ottoman city in the first half of the 20th c. They are represented on fig. 2 by a series of thick black, parallel lines across the steep slopes.

There are no ancient descriptions of these structural features of the city, and a recent account of the Byzantine street system dismissed much
Fig. 1 Contour map of Constantinople showing the projected course of the two main water channels (Richard Bayliss).
of this evidence as being largely Ottoman in date. But in contrast, Bardill’s detailed analysis of the brick-stamp evidence from the city specifically draws attention to the possible early date of brick terraces in the Forum Tauri, clearly demonstrating that terracing was an aspect of the urban layout from its earliest phases. Certainly as presented in Mamboury’s plan, it is possible to recognise potential areas of Ottoman activity, especially around the Eski Saray (the first Ottoman palace, now the area of Istanbul University) and the great Covered Bazaar. However, it is worth noting that they are included in the same area as the Sixth and Seventh Regions of the late antique city where the Notitia urbis attests to the highest density of domestic housing in the city and there is as good a reason to assume that the terracing Mamboury shows may in origin derive from Late Antiquity. Our limited understanding of the urban archaeology of the city has already been noted in the introduction, so that much of what follows concerning the terrace systems is by nature ‘informed speculation’. However, in some places, there is sufficient evidence for a secure late antique or Byzantine date for specific terraces associated with particular structures. On the basis of this secure evidence it is possible to predict that a very extensive programme of terrace construction formed part of the layout of the city from the 4th c. onwards.

In some areas, especially for the rectilinear alignment noted around the Column of Marcian and at the east end of the peninsula, in the areas of the Topkapı Saray and the Great Palace, it is clear that the majority of retaining walls were late antique in origin, and represent a major effort in urban configuration. Two accounts by Mamboury provide some insight into the observations made by Janin: in 1951 Mamboury divided the system of terraces into the maritime terraces above the Sea of Marmara and the Golden Horn and a central zone.

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9 Berger (2000) 163; also Berger (1997) 404, n. 284; see however the reservations of Dark 2004, 104–05. Mango (1990) fig. 4 reproduces Janin’s map of the Forum Tauri but does not comment on the terraces shown.

10 Bardill (2004) 28. It is worth noting that much of this corpus is based on Mamboury’s collection.


12 See n. 4 above.

13 For the arrangement of terraces around the Column of Marcian, see Janin (1964) map 6; the forum is discussed by Mango (1990) 46; for the Topkapı Saray, see Tezcan (1989) and for the Great Palace, see a recent assessment of the evidence in Bolognesi (2002).
He further noted “D’autre part, dans la limitation de 14 régions et des 3 zones, la connaissance des terrasses, dont beaucoup abritent encore des citerne et de sous-sols, facilitera énormément l’étude de la topographie Byzantine”. Mamboury also considered the wider significance of the terraces and their broader urban context in his *The Tourists’ Istanbul* (last edition published in 1953). His evocation of the form and structure of the Byzantine city may seem at odds with more recent studies of the historical topography—such as the current interpretation of the important term, *gradus*, which he understood only in its literal meaning of ‘stairs’. But his account of the process of urban creation gives the reader both an insight into the problems faced by the builders of the new city and also a realisation of the impact of the topographic setting on the infrastructures of the new city, just like Lanciani’s description of the rediscovery of ancient Rome in the late 19th c.

They (the great avenues of the city) were, as in ancient Rome, provided by sewers, which have been discovered at several points. To lay out these great roads the tops of the hills were lowered and considerable engineering works were carried out. Much levelling was done and strong containing walls were built to contain level esplanades. Most of the highest ground was taken by cisterns or reservoirs, open or covered, or by a forum, in the midst of which there usually stood a column, or a church. Unlike modern Istanbul, old Constantinople had few side streets or modern lanes, but on the other hand there were numerous steep streets of stepped slopes, which have attracted the attention of topographers in recent years. In the division of the town into fourteen regions in *Notitia urbis Constantinopolitanae* 52 arcades or avenues with porticoes are shown and 117 stepped streets. We are entitled to suppose that since the chronicler has given this information it means that these stepped ways played

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14 Mamboury (1950) 445–46; the feature of the Byzantine cisterns abutting the terraces is illustrated in Tezcan (1989) endpaper; Müller-Wiener (1977) fig. 601; the association of terraces as impluvia for cisterns is noted by Wilson for Carthage (1998) 69.
15 Lanciani (1897); for the context of these new urban excavations across Europe, see Çelik (1986) xvi.
16 See Bardill (2004) 77–78, 110–11; Müller-Wiener (1977) fig. 288, shows the sewers A A and B B in cross section at the Forum of Constantine. The main literary reference to sewers is in the late text of the *Patria* 1. 69–70; ed. Preger II, 149, ‘He (Constantine) also brought the aqueducts from Bulgaria, and he built sumptuous vessels (karabos ektur昂íoua) all over the city that are as deep as the porticoes are high in order that there be no stench and no occurrence of many disease but rather that the stinking substances run through and run down to the sea. These as has been said were built by the praepositus Urbicius and the prefect Sallastius and the others, (Constantine) having left them six hundred kentenaria of gold for the porticoes and aqueducts and the walls.’ (trans. Krausmüller).
a preponderating (sic!) part in the circulation of the city. To obtain an idea of the topography of the city in the days of Theodosius II or of Justinian we must figure to ourselves a whole series of high and medium terraces running along the slopes of the seven hills like contour lines, arranged according to the locality in four, five and six levels laid out in the form of an amphitheatre. We must imagine that these terraces, often ten meters high, communicating with each other by means of stairways cut along the line of the steepest slope, connecting one main street on a lower level with one on a higher level. In this way, in spite of the often vertical steeply sloping ground, all private property was on horizontal ground and only the stairways were sloping.17

The 117 ‘stepped streets’ or gradus as they are referred to in the Notitia urbis, cannot be identified with flights of stairs linking the parallel terraces Mamboury envisaged; these are better understood as locations for the distribution of the annonae and the bread dole.18 Yet even if this textual connection is excluded, the evidence for the terraces still represents an important component in the creation of the distinctive urban fabric of Constantinople between the 4th and 6th centuries. As Mamboury’s account makes clear, the public spaces and colonnaded streets, with the exception of the harbours and associated structures such as granaries, need to be located on the principle ridges.19 Furthermore, given the size of many public structures, a system of terracing must have played an important role in the positioning of the major avenues and fora. They would also have been necessary to ensure the effective use of the urban space for domestic housing; a factor which may explain the long lines of terrace to the West, which are probably ancient, as they make little sense in terms of the layout of the Ottoman city.

On the terrace plan (fig. 2), the major concentrations are found in between the Forum of Theodosius and the Column of Marcian, on the steep, south-facing slopes near the Sea of Marmara. These include the 10th c. church of the Myreliaon, which was partly built on a pre-existing terrace, beside the site of a late antique palace.20 A second group can be seen to be aligned around the Forum of Arcadius, extending a little way beyond the presumed line of the Constantinian Walls. Both

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17 Mamboury (1953) 69–70.
18 Dagron (1984) 533, Themistius Disc. 32, 292 a., uses the term ἐκράναι, translated as fence; see also Janin (1964) 45, n. 3. In Rome, however, the term gradus has the meaning of stairs, see Steinby (1995) 372.
Fig. 2 Terraces in Constantinople (after Janin 1964).
groups represent up to four rows of parallel terrace walls, each extending over a kilometre and a half.\textsuperscript{21} The walls near the south end of the Hippodrome and around the promontory have already been noted as part of the substructures of the Great Palace. These retaining walls can be seen to continue around the ‘Acropolis’ of Byzantium, later occupied by the Topkapı Saray.\textsuperscript{22} Despite the later works above many of these examples, they can be shown to be integrated with pre-existing Byzantine structures, including several cisterns, which are likely to be late antique in origin; a recent study of one terrace wall has identified it with part of the garden of the 11th c. emperor Constantine Monomachos at the Mangana Palace.\textsuperscript{23} On the slopes facing the Golden Horn, the evidence is less secure and could well belong to the Ottoman buildings, as noted before. But in the vicinity of the Pantocrator monastery, beyond the broad valley crossed by the Aqueduct of Valens, further terraces survive, which may also be associated with the 5th c. cistern below it, near Unkapanı.\textsuperscript{24} The external wall of this cistern indicates a close structural relationship between these retaining walls and the cistern, although the precise date of the terraces is not certain. From here to the west the only terrace walls marked are those around the Eski Imaret Camii and in the neighbourhood of the Blachernai.

Although some of the terrace walls may belong to Middle Byzantine and later Ottoman structures, it is possible to suggest that a significant number reflect the layout of the main southern and central areas of the Constantinian and Theodosian city. While it may not yet be possible to exactly relate the known terraces with road alignments, the terraces need to be recognised as a major element of the new city. Even if Mamboury was mistaken about his interpretation of the term \textit{gradus} as connecting stairs, such stairs are still likely to have been a key element of the terraces overlooking the Sea of Marmara. Indeed, on his plan, a series of returns in the terraces, either cross-roads or steps, can be identified.\textsuperscript{25} A recent survey of the archaeological evidence for

\textsuperscript{21} Dark and Özgümir (2004) 40–42, describe evidence for terraces at Cerrahpaşa, behind the harbour of Eleftheros.

\textsuperscript{22} Müller-Wiener (1977) figs. 263, 601; Tezcan (1989) endmap.

\textsuperscript{23} Maguire (2000) 261–62, identifies Middle Byzantine style brickwork in the retaining wall.

\textsuperscript{24} See map and illustration in Müller-Wiener (1977) figs. 237, 244.

\textsuperscript{25} See fig. 2, see also the plan reproduced in Mango (1990), fig. 4, showing Janin’s attempt to relate these features to the Mesc. This rather inelegant solution is not accepted in Mango’s or Berger’s discussion of the city’s main avenue (2000).
domestic housing in Constantinople reminds us how very little we know compared to many other ancient and medieval cities. Documents like the *Notitia urbis* only provide evidence for the concentration of housing in certain districts, not for their nature or extent.\(^{26}\)

In a subject where the topographical and historical reality is to a large extent grounded in the written sources, the absence of any reference to terrace construction has clearly inhibited their study. The sources on Rome differ and celebrate building achievements rarely matched in Constantinople\(^{27}\) since comparable terrace works were not required because of the physical setting of the former city.\(^{28}\) One extensive operation of earthmoving is known for the largest of the imperial fora, that of Trajan. In order to create a level site of such magnitude it was necessary to dig and quarry the spur of the Quirinale Hill, an operation which was demonstrated graphically in a recent study.\(^{29}\) The construction of Trajan’s Forum was the culmination of a process in the monumentalisation of Rome as the imperial capital. Such massive programmes may not have been the Roman Republican way, in contrast to the major terraced sanctuaries of the late 2nd c. B.C., in mid-Italy, at Praeneste and elsewhere.\(^{30}\) Indeed, one of the causes for Julius Caesar’s fatal unpopularity with the Senate was his grandiose scheme to remodel the Capitol as a great Hellenistic theatre, a project reminiscent of Pergamon and its terraced acropolis.\(^{31}\)

But by the time of Trajan, Roman values had changed and such projects could be the cause for epigraphic celebration. Thus, the final line of the inscription at the base of the column in Trajan’s Forum

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\(^{26}\) See the discussion of housing in Dark (2004); for the *Notitia urbis* and a German translation, see Berger (1997); most accounts of domestic architecture are concerned with stone and brick structures, but both stone and timber houses are noted in Agathias’ account of the earthquake of 557, *Histories* 5.3.1–11.

\(^{27}\) See the recent analysis of ‘exceptional construction’ in the Roman world by Delaine (2002).

\(^{28}\) Exceptions are the terracing along the banks of the Tiber, on the slopes of the Palatine and the major terraced platforms of the temples of Claudius and Venus and Rome. The works associated with Nero’s Golden House will have involved extensive terracing, Steinby (1995) fig. 18. The most complex terraced structures were in Trajan’s Markets and the great imperial baths, Delaine (2002) 211.


\(^{30}\) See Zanker (1989); Delaine (2002) 210, argues for Republican monumental construction although Praeneste does not figure in the examples she cites; Ganzert (2000) 46–47, provides an instructive sequence of sketches to illustrate the build up of the core monumental area of Rome from the 2nd c. B.C. to the time of Trajan.

has been interpreted to read, “in order to declare how deep were the rock and earth excavated for the great work”. While its meaning remains ambiguous, it is possible to recognise that Trajan’s monument combined a cenotaph, a tropeum and a celebration of the engineering achievements, and however much historians might prefer the first two interpretations, it is the last that the inscription asserts.

In Constantinople, a comparable text exists, celebrating both imperial military triumph and technological prowess. On the base of the Theodosian obelisk in the Hippodrome, the bilingual inscription in Greek and Latin is combined with a well-known relief depicting the triumphant erection of the monument. In translation the Latin text reads:

Of lords serene a stubborn subject once, bidden to bear the palm to tyrants that have met their doom—all yields to Theodosius and his undying issue—so conquered in thrice ten days and tamed, I was under Proclus’ governorship raised to the skies above.

Unlike the Greek inscription, which is more prosaic, this Latin text celebrates Proclus’ ingenuity, as well as Theodosius’ recent victory over usurpers, the same event (over the British usurper, Magnus Maximus) also celebrated on the Golden Gate in the Land Walls. Both the imperial inscriptions of Trajan and Theodosius demonstrate the importance of the practical act of major engineering feats as a source of imperial prestige. Although the citizens could witness the performance of imperial triumphs and might even benefit from imperial largesse, these events persisted only through memory and artistic and literary commemoration. By contrast, the practical achievement of great monuments and buildings in an urban setting were a continuous reminder of imperial action and patronage; they were the essential features of the townscape, experienced daily by the dwellers of the late antique city. Underpinning such works were major achievements of engineering and physical effort, terraces which sculpted the very ground of the city, and provided the settings for its hippodrome, palaces, piazzas and avenues.

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34 ‘Only the emperor Theodosius dared to raise this ponderous square column, ever prone on the ground. Proclus was summoned and so it was erected in 32 days.’ See Dagron (1984) 310–12.
36 The main avenue, the Mese, was longer than any other colonnaded street in the empire. Although Haas (1997) 29, 81–83, has rightly drawn attention to the Via
The Land Walls

Apart from Justinian’s Great Church of Hagia Sophia and the ‘Aqueduct of Valens’, the most prominent surviving late antique monuments in modern Istanbul are the Land Walls, which suffered two decades of ‘Disneyfication’ by excessive clearance and over-enthusiastic restoration, with the notable exception of the project directed by Professors Zeynep and Metin Ahunbay. Although the Byzantines later claimed that Constantinople was a city “Well guarded by God”, thanks to the legacy of Theodosius I and his successors, it possessed the most elaborate and complex urban fortifications in the ancient world. The work on the extension of the city under Theodosius I commenced with the construction of the Golden Gate. It was completed by the time of the emperor’s victory procession in November A.D. 391, and as Mango has observed, “it seems obvious to me that the gate, with its massive pylons, was planned in the context of the new land walls, which for all I know, may have been on the drawing board already in the time of Theodosius”. The walls extend for 6.5 km from the shore of the Sea of Marmara to the Golden Horn. They were completed between A.D. 405–13, although the complete line of the Sea Walls would not be finished for another 25 years, probably in A.D. 439. The chronology of the Land Walls has been subject to an extensive but sterile debate, which has centred on the interpretation of written texts, with little or no reference to the structural remains. From east to west the Land Walls comprise four main elements: an inner wall, an outer wall with an inner terrace, a second outer wall alongside the ditch and the wide ditch (figs. 3, 4).

Canopica in Alexandria, the colonnaded streets of Constantinople were far longer, although the exact extent of the stoa is not precisely known. Recent work south of the Golden Gate under the direction of Professors Z. and M. Ahunbay (2000); unlike the walls of Galata which were demolished in the 19th c. A.D., the Land Walls were preserved despite major threats over the past two centuries. For changing attitudes to restoration and demolition, see Çelik (1986) 70, n. 97; for a sympathetic and innovative appreciation of the walls, see Costa and Ricci (2005), see especially 121, to indicate the radical restorations of the last twenty years.

The date of the Land Walls has been recently discussed by Bardill 2004, 122; for the Sea Walls, see, Müller-Wiener (1977) 308–319; Mango (2000) 179, n. 41; the date is given in Chron. Pasch. 583.

Fig. 3  The Land Walls of Constantinople showing the inner wall, outer wall and ditch (Conway Library, Courtauld Institute of Art, London).

Fig. 4  Cross-section through the Land Walls (Richard Bayliss after Müller-Wiener 1977).
The inner wall rises h. 9.8 m above the outer terrace formed between the inner and outer walls; on the inside, the inner wall rises up to 13 m above the ground within the city. The wall is w. 4.5–4.85 m, with towers 175–181 m apart, h. 19 m and projecting 6–11 m. On the ground floor are high vaulted chambers which normally had no access to the tower above. These last are specifically mentioned in a law of Theodosius II demonstrating that they were allowed to remain in private usage as compensation for the land appropriated for the Land Walls. Presumably this can also explain the hypogeum recently discovered close to the Silivri Kapi (see fig. 5). More important for understanding the structural

Fig. 5  The Land Walls, Tower 37, north of the Silivri Kapi and the level platform behind the outer wall (to the left). Recent excavations have revealed the Hypogeum buried against the base of the tower in the inner terrace (see p. xxx). (Sir Ian Richmond c. 1930).

\[42\] Cod. Theod. 15.1.51; for the hypogeum see Deckers (1993). The site of the hypogeum before excavation is shown in fig 5.
chronology of the wall system are the postern gates in the lateral walls of the projecting towers, which open onto the terrace located behind the main outer wall.43 This terrace was built against the west face of the inner wall and is recorded as being w. 16.4–21 m, with an arced wall to the west. This is the main outer wall and the parapet is supported on arcades (see below), the wall itself has a thickness between 0.6–2 m and rises 9 m above the outer terrace. The wall walk with parapet is w. 3.4 m, and rises 4.4 m above the inner terrace; there are interval towers located midway between the towers of the main inner curtain and, in some towers, posterns give access to the lower outer terrace. This is w. 20 m with a parapet overlooking the ditch.44 The ditch is square in section, w. 20 m, with a maximum depth of 7 m near the Golden Gate, and side walls th. 1.6 m, with buttresses.45

In total, the difference in height between the bottom of the ditch and the parapet of the inner wall is ca. 30 m. But the distance from the outer face of the main curtain to the outside edge of the ditch is even more impressive, at ca. 60 m.46 Without accurate measurements based on excavation, it is difficult to be certain of the relevance of the apparent ratio of 1:2, but it seems likely that it was a factor in the overall design. The presence of the postern gates in the inner and outer towers does however allow greater certainty about the unity of the plan. Far from representing a system of fortifications which evolved over three decades and more, as has been suggested from a historical analysis of the epigraphic sources,47 it is clear from structural evidence that the construction of the main inner wall came first.

The terrain varies considerably across the peninsula, from the high ground at the Edirne Kapı to the depression across the valley of the

43 Ahunbay and Ahunbay (2000) figs. 25, 31 shows the postern gate opening onto the inner terrace.
44 The arrangement of a low parapet fronting the ditch compares with most examples of outer walls (proteichismate) known from Late Roman fortifications; see Smith and Crow (1998) 66–69 for a discussion of outer walls in the Balkans and the Roman east.
45 The dimensions are derived from Van Millingen (1899) 51–55, see also Meyer-Platt and Schneider (1943) and Müller-Wiener (1977) 268–311.
46 See the cross section and elevation published by van Millingen (1899) facing 106, 107; these form the basis for all subsequent studies, despite all the recent restoration work no excavated archaeological section through the wall and terraces has been undertaken.
47 See Bardill (2004) 122–24; although this is not to ignore the very extensive evidence for later restorations, see the results of careful survey and excavations: Ahunbay and Ahunbay (2000).
Lykus, but if we can generalise from van Millingen’s section,\textsuperscript{48} it would appear that the ground level on the inside is lower than on the outside. This was the result of a terrace constructed against the outer face of the main inner wall. We may suggest that the construction sequence commenced with the building of the main inner wall, but more or less contemporary with it came the digging of the ditch 40 m to the west. The cross section of the ditch is approximately 140 m\textsuperscript{2}, and the terrace between the inner and outer walls can be estimated to have a cross section of 80–85 m\textsuperscript{2}; clearly the upcast from the ditch would have been more than sufficient to create the terrace fronted by the outer wall (see fig. 4). Since the postern gates in the towers of the inner curtain open at the level of the terrace between the inner and outer walls, this demonstrates that the outer wall was always part of the original scheme, despite the apparent difference in construction technique between the two walls. To suggest that the outer wall was added at a significantly later date, as has been frequently inferred from the historical sources, presumes that these primary posterns originally opened above the original ground surface at a high level, which is both impractical and highly unlikely. The position and the chronology of the hypogeum close to the tower also make sense. It is likely to have been built after the construction of the inner wall when soil from the ditch was being heaped up against it, as part of the creation of the inner terrace. The building of the tomb could be a little later, but it certainly postdates the process of the creation of the Land Walls.

It is however salutary that, over a century after the publication of van Millingen’s original study of the Land Walls, we have hardly advanced in our understanding; only as a result of the recent study of the curtain do we at last recognise that, like on other late antique walls, there were two levels of firing platform on the inner curtain, comparable to the main outer wall. In the first phase, evidence survives for a regular sequence of internal buttresses, set behind the merlons, located 2.5 m apart and projecting 0.8 m internally. This matches the similar arrangement of the outer wall.\textsuperscript{49} Within the structure of the primary wall top,

\textsuperscript{48} The essential details are confirmed by the most recent study, which records the inner curtain as w. 4.83 m, rising to a maximum height of 12 m and with projecting towers located 30 m apart; the outer wall is located 16 m to the front of it: Ahunbay and Ahunbay (2000) 229, 238.

\textsuperscript{49} The evidence for the phases of the inner curtain is described by Ahunbay and Ahunbay (2000) 233, figs. 21, 23, with a reconstruction fig. 24; for the outer wall, see (2000) 235–36, figs. 31, 32.
A number of flagstones with large rectangular sockets were discovered, which could be located in the primary embrasures. They provide valuable evidence for the use of torsion artillery (ballistarii) as part of the original scheme of defence. It has further been suggested that this arrangement of a two-tier wall-top defence matching that of the outer wall was later replaced by a single row of substantial T-shaped battlements. Comparison with other Late Roman defences strongly suggests that this second scheme is very similar to other systems of embrasures and upper parapet walls. However, Professors Ahunbay and Ahunbay are certainly correct in drawing attention to the vulnerability of the primary scheme to earthquake damage. It is quite possible it only survived until the massive earthquake of A.D. 447, which is known to have extensively damaged the Land Walls.

By way of comparison, fig. 6 shows a photograph of the walls of Amida (modern Diyarbekir), taken in 1907. This is the best-preserved example of a 6th c. fortress from late antique Mesopotamia. Although the city’s defences underwent extensive medieval and later restorations, the essential elements date from the time of Anastasius and Justinian. In front of the main curtain wall and towers, remains of the outer wall, typical of late antique defences, are preserved. In contrast, fig. 4 shows a recent photograph of an un-restored section of the Land Walls of Constantinople. All the main elements as outlined above are apparent, but the comparison reveals the difference that is created by the Constantinopolitan outer wall and inner terrace. Despite numerous attempts to associate the design of the walls with the works of Hellenistic

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50 Ahunbay and Ahunbay (2000) 236, fig. 23. These important discoveries contradict Foss’s suggestion that the absence of inner loopholes necessitated building the outer wall (1986) 45.
51 The evidence for the second phase is discussed in Ahunbay and Ahunbay (2000) 235, and fig. 21 shows phase one as a dark-grey stipple and the phase two T-shaped battlements (marked A-C) in outline. These later ‘battlements’ are substantial in size, w. 1.65 m and project internally from the outer face of the curtain by 2.2 m, and are comparable with similar features known from Actia Nicopolis, Silivri and elsewhere, see Crow (2002) 343–44, fig. 4; on these walls instead of a wide two-storey parapet, see the illustrations of the Silivri walls by Covel (1998), 48–50, figs. 11–12; a more detailed study of the walls of Silivri will form part of our forthcoming monograph on The Anastasian Wall. See also recent work on Late Roman wall tops in France, see Wood (2002), Foudrin (2002) and Dutert, Bardie and Malmary (2002), all three articles discuss the evidence for traverses in the merlons.
52 See the recent critical discussion of the evidence for the earthquake of A.D. 447 in Bardill (2004) 123.
53 See Gabriel (1940).
writers, especially those of Philo of Byzantium,\textsuperscript{54} it is clear that their construction was an entirely novel response to the requirements of the new capital. They represent not only the most massive fortification in the ancient world, but surely the most successful. In terms of the infrastructure of the city, whatever the actual costs, the benefits—with the exception of the sack of A.D. 1204—lasted for over a millennium.

**WATER SUPPLY (fig. 7)**

Within the city of Constantinople, the vestiges of the urban water supply are among the most impressive structures to be seen, including the aqueduct of Valens\textsuperscript{55} and more than 150 covered cisterns and

\textsuperscript{54} See the cautious comments in Ahunbay and Ahunbay (2000) 237, n. 21; see also Crow (2001) 92, esp. n. 16; and note the reservations expressed by Spieser (1986) 365.

\textsuperscript{55} Recent studies often prefer to describe the Bozdoğan Kemeri, the Turkish name for the long arched bridge between the Third and Fourth Hills, Müller-Wiener (1977), as the *so-called* aqueduct of Valens. Archaeological evidence, however, indicates that the structure does in fact date to 4th c. A.D. (see note 73 contra Mango (1990) 20; see the discussion of Valens’ building programme in Lenski (2002) 278, 393–401, esp. 399.
Fig. 7 Map of Thrace showing the lines of the Byzantine water supply systems and the Anastasian Wall. Note the first phase of the Long-Distance Water Supply is shown west of Gümüspinar. (Richard Bayliss)
reservoirs.\textsuperscript{56} Recent research, however, has concentrated beyond the city’s limits, and over the past decade fieldwork has finally revealed something of the complexity and scale of the aqueducts and water channels built between the 4th and 6th centuries. In the 6th c., several chroniclers refer to an aqueduct of Hadrian, a legacy from the former Greek colony of Byzantium. More reliable and informative are the accounts of the 4th c. orator Themistius: he praises Valens for inaugurating the city’s aqueduct in A.D. 373 and also Constantius II, who in A.D. 345 began the construction of his eponymous baths, located in the Tenth Region of the city, between the Church of the Holy Apostles and the west end of the Aqueduct of Valens. Moreover, the same account records that in the same year the emperor initiated the search for springs and more abundant water, and clearly the two actions can be associated.\textsuperscript{57} Themistius stresses the importance of the new water provision by commenting that, whatever Constantine and Constantius II had given the city by embellishing it with statues and public buildings, it remained nothing more than a sketch that was ‘girdled by gold but dying of thirst’.\textsuperscript{58} As with so many other aspects of the expansion of Constantinople during the 4th and early 5th centuries, the process of development took time. It is, however, worth noting that the new aqueduct system was initiated only 15 years after Constantine’s inauguration and may have always been part of the plans for the new city.

Written accounts are much more concerned with the creation of the water supply system in the 4th c. than with its maintenance or extension; from Theodosius I onwards, texts concerning the aqueducts become sporadic and limited. A law of A.D. 396 mentions an aqueduct \textit{Theodosiacus},\textsuperscript{59} and although it is not clear which part of the system this refers to, it is likely to refer to the extension and re-building of the long-distance line in Thrace. In the 6th c., Hesychius reported that the source of this aqueduct was at Bizye (modern Vize), at a distance much further than the 1000 \textit{stades} given by Themistius,\textsuperscript{60} and as we shall

\textsuperscript{56} Mango (1995) provides an authoritative summary of the literary and topographical evidence; the results of recent fieldwork are summarised in Romey (2003), and Crow and Bayliss (2003).

\textsuperscript{57} Themistius \textit{Or. IV} 58a.

\textsuperscript{58} Themistius \textit{Or. XI} 151a; Dagron (1984) 90; Mango (1995) 13.

\textsuperscript{59} \textit{Cod Theod.} 6.4.29–30.

\textsuperscript{60} Mango (1995) 13.
see, this was an accurate assessment of the final extent of the system. Although 5th and 6th c. sources are less concerned with activities outside the city, there are increasing references in either contemporary or later chronicles to a developing pattern of open-air and closed cisterns. In ca. A.D. 500, three great open-air cisterns were constructed in the west part of the city enclosed by the new Theodosian Land Walls, together with an increasing number of large closed cisterns, including the Basilica Cistern (Yerebatan Saray) and the Binbirdirek ('1001 columns'), built by the time of Justinian. In assessing the differences between Rome and Constantinople, a major distinction between these two imperial capitals was the extensive use of water storage within the walls of the later city. Whilst Rome from Augustus onwards relied on the frontier armies for its security, Constantinople acquired increasingly complex systems of fortifications. Thus the large number of cisterns and reservoirs was necessitated partly by the needs for security but also by the different character of the water sources available to the city. Constantinople lies at the south-eastern extremity of the Thracian peninsula, and local geology dictated that the spring sources with the best hydraulic potential were located at a considerable distance to the west of the city, in the metamorphic range of the Istranca massif.

Until recently, very little systematic fieldwork had been carried out on the late antique water-supply system beyond the city walls, and significantly, the important article by the Turkish archaeologist, Feridun Dirimtekin, published in Cahiers Archéologiques, does not figure in any of the major studies on Roman aqueducts, perhaps a reflection of the divide between classical and late antique/Byzantine studies. Our own work on the Anastasian Wall and the water supply system commenced in 1994, but Professor Kâzim Çeçen had already begun a detailed reconnaissance of the water channels and aqueducts to the west of Istanbul to complement his important studies of the water supply of the Ottoman city. This research provided the first coherent interpretation of the Thracian water supply for Constantinople. His study was provocatively, but correctly, entitled The Longest Roman Water Supply Line. He estimated that the system, from Istanbul to Vize, where

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61 Earlier studies are summarised in Mango (1995) 14–17; the dates of many of the open and closed cisterns have been recently reassessed in Bardill (2004).
63 Dirimtekin (1959); for recent aqueduct studies, see Hodge (1992); (2000).
64 Crow and Ricci (1997); Çeçen (1996a).
he had traced channels, was 242 km in length. Subsequent research has suggested that it was some 8 km longer, but whatever distance is accepted, it is still over twice the length of any previously known Roman supply system. The water provision of Constantinople can be divided into two principal water supply lines.

The Long-Distance Channel

At its maximum extent, this system drew water from over 120 km away in the region of Bizye (modern Vize), and in total, between the furthest source and the city, its sinuous channel runs for more than 250 km. This was not the first aqueduct constructed in the 4th c. and completed under Valens, but an extension dating to the early 5th c. The first channel supplying the Aqueduct of Valens in the city began at the major springs in the valley of the Karamandere, near the village of Danamandira, a distance which coincides with Themistius’ claim of 1000 stades (185 km). We now also know of a second major source and channel from this primary phase of the system, beginning at the springs at Pınarca. The western extension to Vize commences at the Balligerme aqueduct. Its most distant source is located on the outskirts of the village of Pazarlı, north-west of Vize, while another major spring is located at the source of the Ergene river, 6 km east of the town. It is now clear that there was not a single line of water channels, but a more complex dendritic pattern of main channels and tributaries throughout its length, with at least two major periods of development; closer in practice to the system of multiple aqueducts that developed around Rome.

The main surviving elements of the system as a whole are the bridges, built to carry the aqueduct channel across the steep-sided valleys and through the forested hill country of the Istranca range. Around 60 aqueduct bridges have been identified within the system as a whole, and 19 of these are more or less in tact with high, massive stone piers and great vaulted arches. The channel was constructed by ‘cut and cover’ techniques and was roofed with a rough stone vault. In many places the hydraulic lime-mortar lining of the sides of the channel survives,

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65 Mango (1990) 42, n. 33.
66 For illustrations and the location of the bridges, see Cecen (1996a); Crow and Ricci (1997); Romey (2003); and Crow and Bayliss (2005).
often with later accretions of distinctive travertine or sinter deposits that had accumulated with the passage of water. The vaults and the channel walls are constructed of metamorphic or limestone blocks, with some distinctive variation in construction technique depending on period, locality and scale of the channel. Distinct widths of channels have been noted in different parts of the system. The primary channels from around Danamandar and Pınarca are narrow with a width of 0.6 m and a maximum height of 1.6 m, but to the east of the Balkisturma aqueduct, in the same region where the two systems converge, the Vize line flowed in a much broader channel 1.6 m wide and nearly 2 m in height.

Where the two lines run parallel, the broad channel is located over 6 m below the narrow channel above. With this new channel, a new set of aqueduct bridges were built, including the great bridges at Kürşunlugerm and Büyükgerme. In some places, the earlier bridges continued in use, but elsewhere they were abandoned. The two lines gradually converge in height by the time they reach the aqueduct at Büyükgerme, near Ciftlikköy; but despite extensive exploration, no evidence has been found of a junction between the channels, and it remains likely that both reached the city as individual, unconnected channels at more or less the same height. Despite the clear differences in tunnel size which can be seen in the area between the villages of Gümüşpinar and Ciftlikköy, further west towards Vize, the channel is mostly observed at a narrow gauge, and towards Istanbul evidence for the broad channel is also absent.

The last third of the channel is rarely evident in the open ground, but covered by the extending modern city of Istanbul. On its final approach to the city, this system followed the western edge of the Alibey Valley, although its remains are now lost beneath the damned waters of the Alibey Baraj. The channel(s) would have passed the line of the later Theodosian Walls close to where the Edirne Kapı was later built. At this point their elevation would have been 63–64 m, which is confirmed by the 971 m long aqueduct bridge, the Bozdoğan kemeri, or Aqueduct of Valens.

Consequently, much of the line of the channel, proposed first by Çeçen, and subsequently by Bayliss and Crow, is hypothetical, created by joining the positions of known bridges and sections of exposed conduit. Implicit in the projected line are a number of tunnels up to 1.5 km in length, although the physical evidence for these is very limited. But the sinuous nature of the supply line, as it followed the
four major valleys in the Istranca hills between Vize and the city, is recalled in Themistius’ oration to Valens when he colourfully describes the Thracian nymphs ‘who undeterred by rocks, mountains or ravines, skirted these obstacles, burrowed under them or flew through the air’. The physical undertaking of this project was huge, and today we can only marvel at the surveying skills which made it possible to lead water across hundreds of kilometres of difficult wooded terrain, into the city of Constantinople. Far from being the work of an empire in decline, this possibly ranks as the greatest engineering achievement in the ancient world, comparable to the Land Walls of Theodosius and to Justinian’s Great Church of Hagia Sophia.

The Forest of Belgrade and Halkali

Other water sources are located much closer to the city and it could, therefore, reasonably be assumed that they were the first to be exploited by the colony of Byzantium. These springs were extensively re-developed by the Ottomans from the late 15th c. onwards, so it is often difficult to define the surviving Roman and Byzantine features of the system. Soon after the Ottoman conquest of Constantinople in 1453, Mehmet II ordered the restoration of the Byzantine water supply channels, most probably those to the north-west of the city, in the Forest of Belgrade. Following the establishment of this first supply line, a more extensive network, the Kırkeşme (‘Forty Springs’) system, was developed, maintained and expanded throughout the Ottoman period, with a multitude of lines drawing water from such different sources as springs, streams or substantial dams. Ottoman sources refer to earlier structures, and traces of structurally earlier late antique and Byzantine work have been noted at a number of places in the Belgrade forest.67

The closest aquiferous zone to the city is located some 15 km to the west, in the region of Halkali near modern Küçükçekmece. This area was also extensively exploited for its water resources in the Ottoman period, and several scholars have assumed that it was from here that the first aqueduct channel for the city ran. The elevation of the principal springs is significant because, unlike the Çeşeciköy and Kırkeşme sources, they were located high enough (55–65 m at the Land Walls) to provide for the whole area of the city. Dalman, Eyice, Çeçen and, most

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67 Crow and Bayliss (2005); Çeçen (1996b) 169–73.
recently, Mango, have argued that the surviving aqueduct bridge known as the Maz’ulkemer is most likely the last surviving element of the Roman and Byzantine system in this area. However, the Halkali springs can only supply a relatively limited amount of water; in 1922 its output volume was only half of that of the Kırkçeşme springs. Furthermore, there is no direct evidence for Roman or late antique interventions to this line. Indeed, it is possible that Constantius’ prospectors disregarded the source as insufficient for the ambitions of the capital.\textsuperscript{68}

Water Distribution within the City

One of the major problems affecting the water provision for Constantin's new city was not simply the volume of water available, but also the problems created by a gravity-based water-supply system. Quite simply, many of the new parts of the city were at a higher elevation than the core of old Byzantium at the east end of the peninsula, and any pre-existing water supply could not be expected to be able to effectively provide running water for fountains and baths. It is for this reason that earlier studies needed to invoke at least the Halkali springs. The main Ottoman channel, the Cebeçiköy/Kırkçeşme line, entering the city at a height of 35 m, was adequate for the requirements of the early Greek and Roman settlement.\textsuperscript{69} Only as the city expanded up and beyond the Second Hill, in the early 4th c., was a higher water provision required.

Having established the two main water main supplies beyond the city walls, it is possible to develop the following model to investigate the water-distribution system inside the city based on the following elements (see fig. 1):

- Water from the Belgrade Forest (Kırkçeşme) supply line could only have provided water to cisterns and reservoirs in the city lying at an elevation below 35 m.
- Water from the long-distance supply line could only have provided water to cisterns and reservoirs in the city lying at an elevation below 64 m.

\textsuperscript{68} Mango (1995) 10; see now Crow and Bayliss (2004).
\textsuperscript{69} Çeçen (1996b) 143–44.
The lines of the channels within the city are not known, but in order to investigate this hypothesis, Bayliss established a computer-based model which reconstructs the course of the two water channels into the city: one from a point north of Edirne Kapı at an elevation of 64 m, and the other from just north of Eğri Kapı at an elevation of 35 m, with an assumed regular gradient of 1 m per km (fig. 1). Plotted onto a topographical map of the city, it becomes apparent that there is a correlation between the two projected tracks and the location of many of the known cisterns. The projected course for the upper channel passes close by the Aetios and Aspar reservoirs, maintaining the correct elevation to cross the Valens Aqueduct, which it must have done before turning south towards the Forum Tauri and proceeding along the line of the Mese and finally terminating at the Binbirdirek Cistern, on the promontory of the Second Hill. Other clusters of cisterns lying away from this line, but situated above 35 m, must also have been supplied by a channel of this altitude.

The line of the water channel from Çebeciköy and the Forest of Belgrade was similarly projected through the city from a height of 35 m at the Land Walls. Once again, Bayliss has been able to establish a close correlation between the path of the channel and the positions of known cisterns. The projected channel hugs the steep hillsides above the quarters near the Golden Horn, a route that ultimately would have taken it right to the heart of the old city. A branch in the channel between the Fourth and Third Hills, as in the Ottoman system, could have then passed along the south side of the Third and Second Hills to the area of the Imperial Palace. Along its route, the proximity of Ottoman fountains to many surviving Byzantine cisterns underlines the correlation between the two systems. Indeed the Byzantine line can reasonably be assumed to have entered the 5th c. city in the vicinity of the surviving Ottoman Kırkçeşme distribution centre, situated just outside the Eğri Kapı at the north end of the Land Walls. Significantly, there are no substantial cisterns until the channel crosses the assumed line of the Constantinian walls. Rounding the north side of the Fourth Hill it then follows the contour immediately behind the large Unkapanı cistern, situated on the west flank of the Atatürk Bulvarı and below

70 See the illustration of stone water pipes in Müller-Wiener (1977) figs. 303, 305.
71 A full concordance of all known and recorded cisterns within the city will form part of our forthcoming monograph on the Water Supply of Constantinople.
the Pantocrator monastery. After running along the north side of the Third and Second Hills, the projected line of the channel passes close to the Basilica Cistern (Yerebatansaray), which is situated sufficiently deep beneath the modern ground surface to have been fed by it. From here, a branch possibly turned to the north-east to run along the flank of the First Hill, probably supplying the cisterns known in and around the Topkapı Palace, and then onto cisterns in the vicinity of the Imperial Palace and Sphendone of the Hippodrome, all apparently situated at an appropriate elevation.

This summary has presented some of the archaeological and topographical evidence for the two water supply lines of different heights and origins. The lower line—originating to the north of the city—supplied the area of the Imperial Palace and most probably also the Basilica Cistern. The upper line—originating deep within Thrace—supplied the baths of Constantius II and the Cistern of Modestus (and Arcadianus) before crossing the Aqueduct of Valens and terminating at a castellum divisorium, situated near to or south of the eastern end of the aqueduct. The line was later extended to supply the grand nymphaeum on the Forum Tauri, while a substantial expansion of the entire system to springs near Vize in the 5th c. was probably necessary to serve the three massive intra-mural reservoirs located in the new area of the city between the Constantinian and Theodosian Land Walls, as well as the many new cisterns constructed in the 5th and 6th centuries.

Textual evidence for the existence of two supply lines comes from the following passage in Malalas, where he refers to restorations undertaken by Justinian in A.D. 528: “He built the central hall of the Basilica cistern, intending to bring the water of Hadrian’s aqueduct into it. He also reconstructed the city’s aqueduct”.\footnote{Malalas 436–6; Jeffreys et al. (1986) 252.} A clear distinction is drawn between the aqueduct built by Hadrian and the city’s aqueduct, and since we can identify the Basilica Cistern, we can therefore associate the Hadrianic Aqueduct with the lower level supply line. From this we can infer that what Malalas describes as the ‘city’s aqueduct’ was the higher line which entered at a height of ca. 64 m and flowed across the great aqueduct bridge of the Bozdoğan Kemer. The date of this structure has been long debated, since in its current state it reveals
numerous phases of repairs and restoration.\textsuperscript{73} There is, however, independent and limited, but valuable, archaeological evidence\textsuperscript{74} suggesting a 4th c. date for the structure. With a maximum height of 29.1 m and length of 971 m, it is certainly the longest aqueduct bridge (as distinct from arcades) in the Roman world.

Such a complex system required continual maintenance\textsuperscript{75} and The Secret History records disrepair to the aqueduct and a water shortage in the time of Justinian. Characteristically, Procopius claims that: “it was not the desire to save money but the set purpose of destroying his fellow-men that led him to neglect the re-building of the aqueduct”.\textsuperscript{76} However, the recent discovery of an inscription questions this claim: it records repair work by a certain Longinus, ex-consul and prefect, on a small aqueduct bridge at the valley of Elkafdere, near Belgrat Köy, where the two long-distance channels run parallel.\textsuperscript{77} The only prefect of the city with this name is recorded under Justinian, and the form of the building work is quite different from the main bridges constructed during the major building phases in the 4th and 5th centuries. For instance, at the springing of the vault of the arch, a distinctive form of moulding is used, where the string courses are angled towards the top rather than towards the bottom as is usual. At Elkafdere, this feature is seen at the springing of the vault of the archway. Elsewhere, the same element is found at a number of major bridges where there is a very substantial re-building, either a complete re-construction or an extensive cladding of the structure of the earlier bridge. This sequence of re-building was first observed by Dirimtekin at Talas,\textsuperscript{78} and it is also known from Cevizlikkale, Lukadere, Leylekkale and Ortabel, all four of which have

\textsuperscript{73} Mango (1995) 12; Striker and Kuban (1997) fol. 31. provides a detailed elevation of piers 77–78.

\textsuperscript{74} Harrison (1966) pl. 61.1 notes 4th c. A.D. pottery from the lowest levels of sounding next to pier 45, 4.5 m below the modern ground surface; note that Ward-Perkins (1958), in his study of Early Byzantine construction, accepted the date of A.D. 968 for the Aqueduct of Valens, p. 65, pl. 17 A. Striker and Kuban (1997) observe that there is little difference in ground surface between Late Roman baths at Kalenderhane and the adjacent aqueduct piers; a chrismen decorated key-stone is known from the south elevation, Crow and Bayliss (2005).

\textsuperscript{75} A law of Leo required new consuls to provide 100 pounds of gold for the maintenance of the aqueduct instead of the ‘vile practice of scattering the money among the populace’ Cod. Just. 13.3.2.

\textsuperscript{76} Procop. Anecdot. 26.23.

\textsuperscript{77} Longinus is known to have been prefect from A.D. 537–ca. A.D. 542, PRLE III s 1 Longinus 2; see also Feissel (2000).

\textsuperscript{78} Dirimtekin (1959) 230–32.
distinctive buttresses and blockwork construction. A further use of the distinctive string course is also found at the raised embankment east of Büyükgerme. By analogy with the dated example from Elkafdere, we can suggest that this work may be attributed to the period of Justinian. They were possibly the result of very specific seismic damage, since all but one of the renewed bridges are located in a 10 km length west of the villages of Belgrat and Çiftlikköy. The work of repair was not noted in Procopius’ De Aedificiis.

**Conclusion**

Each of the three examples discussed in this paper reveals something of the uniqueness of the late antique city of Constantinople. Recent research has shown the scale and complexity of the water supply system, which in less than a century became as long as the eleven aqueducts of Rome. Precise figures are lacking, but if we combine the length of 242 km Çeçen suggested, with the original 4th c. line of ca. 185 km, plus the re-built and extended aqueducts of the Belgrade Forest, the total figure approaches the combined length of 502 km estimated for imperial Rome.79 Within the city, the aqueduct bridge of the Bozdoğan Kemeri provides an iconic statement of Late Roman water engineering,80 and the extensive system of water storage in closed cisterns and open reservoirs is unmatched elsewhere. Large cisterns are rare in Rome itself, although other cities, notably Carthage and Alexandria, used them extensively, for storage and distribution.81 They are a distinctive feature of Constantinople, where there is clear evidence that the nature of the rainfall and discharge from the springs influenced the decision to build large cisterns; but instead of using the normal barrel vaults and concrete piers to support the vast roof span, they were monumentalised by the

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80 The Valens Aqueduct (Bozdoğan Kemeri) passing between the Third and Fourth Hills is certainly the longest known Roman aqueduct bridge at 973 m, matched only by the arcade/bridge in Segovia which is 723 m long and 28 m. high, Hodge (2000) 75, fig. 6.
81 In the later 1st c. B.C., Strabo describes how ‘almost every house in Rome had cisterns and service pipes’ (*Geography*, 5:3.8) although these are not reflected in the urban archaeology, see now Rome and Italy: Blake and Bishop (1973) 276–78; De Kleijn (2001) esp. 84–97; Taylor (2000) 64–66; Sear (2004) 165–66; for Carthage, see Wilson (1998) esp. 71–77.
use of columns of capitals.\textsuperscript{82} Resources and security became intertwined themes in the city’s history. The size and location of the open reservoirs within the newly-constructed Theodosian Walls reminds us that in A.D. 378, less than 50 years after Constantine’s foundation of the city, and only five years after Valens welcomed the new waters into the city, it was directly threatened by the Goths. But Constantinople did not just match Rome in scale; there is also evidence for innovation; not only in the use of cisterns and reservoirs, but also in the provision of water towers to balance water flow, known from the open cistern of Aspar in the city, and from the Fildami, near the palace at Hebdomeni.\textsuperscript{83}

To achieve the infrastructure discussed here required massive investments of time, manpower and resources. It is easy to dismiss the modern estimates of time for ancient projects as futile musings,\textsuperscript{84} but it is important to recognise that the main period of building of the aqueducts, cisterns, terraces and walls was between \textit{ca.} A.D. 350 and 450. To take one example from these undertakings, just to excavate the ditch for the Theodosian Wall would have involved digging out 910,000 m\textsuperscript{3} of soil and clay, and that does not even begin to estimate the amount of stone and brick required at this time for the walls and other projects. The ditch alone, based on comparisons with Romania in the 1930s, would have taken over 600,000 days of labour.\textsuperscript{85} But this was just one component in the creation of the great city during the 5th c. The laying out of the colonnaded streets, piazzas and terraces, the excavation of the massive open reservoirs, the construction of harbours, defensive walls and water supply were all completed within less than 150 years from the death of Constantine to the time of Anastasius.\textsuperscript{86}

\textsuperscript{82} Hodge (2000) 93–94; he provides figures to incorrectly show that the Yerebatan Saray is ten-times the size of the largest Carthaginian cistern, the Bordj Djedid! Note he confuses the names of the Binbirdirek (1001 columns) and the Yerebatan (Basilica) cisterns, n. 30.

\textsuperscript{83} For the date of the cisterns, see Bardill (2003) 39, 61. The dating of these towers is uncertain, since they are structurally later than the main structure of the cistern walls. They are different from the circular taproom known from the Dar Saniat cistern at Carthage, Wilson (1998) 71.

\textsuperscript{84} See the discussion of the costs and financing of Roman aqueduct building by Leveau in Blackman and Hodge (2001) 85–101, esp. 99.

\textsuperscript{85} Squarriti (2002) 41; that is approximately 1000 men working for two years, taking in to consideration holy days and poor winter weather.

\textsuperscript{86} See the fictionalised account of the impact of the building of the Aurelianic Walls of Rome, quoted by Christie (2001).
The opening quotation concerning ‘great cities’ reminds us that “bigness implies complexity”. Constantinople by the 5th c. had become both ‘great’ and ‘big’. The citation is taken from Peter Hall’s study of *Cities in Civilisation*. Most of his examples and discussion are drawn from the early modern or modern western world. In the part entitled “The Establishment of Urban Order”, Hall contrasts ancient Rome, and especially its water supply, with the developing cities of London and Paris in the 19th c., as they sought to accommodate increasing urban populations and create new infrastructure. In late antique Constantinople we can recognise developments of a similar scale and complexity. The Byzantine city was able to sustain a large part of this infrastructure throughout the Early Middle Ages. In the ancient world, ambition and innovation did not end with the Antonine Golden Age; in the East, they were maintained, albeit with a new ideology and in Greek rather than Latin. John Ward-Perkins in his study of the building materials and techniques of the late antique city wrote:

Where Constantinople differed from all its predecessors was in the unique and unqualified success that attended the new enterprise. Out of the dust and confusion of the third and early fourth centuries there emerged a new pattern, a pattern which was to influence every aspect of human thought and activity, and which inevitably found expression in the architecture of the new age.

These observations can be extended beyond the architectural achievements of Constantinople, and if its practices of urban space and order do not fully match those classical ideals of the ancient world, it was to become a civilization unique in early medieval Christendom; a centre of technological and artistic achievement recognised by the Arab-Islamic world, which, as Michael Lewis’ paper in this volume shows, was recognised as a scientific and technological equal by the distant Chinese empire.

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87 See the important discussion by Cameron (2003) about western attitudes and prejudices to Byzantine culture and history. A recent study of hydraulic technology in medieval Europe is limited to a very western perspective. See, however, the evidence for continuity in ancient water technology in Italy; Magnusson and Squatriti (2000).
88 Ward-Perkins (1958) 102.
89 See the instructive comparisons with ‘great’ Islamic cities in Northedge (2005).
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