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A Section of the Gezer–Ramla Aqueduct (Qanat Bint al-Kafir) and a Mamluk-Period Cemetery near Moshav Yashresh

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Introduction

For the past sixty years, archaeologists and farmers have been exposing sections of the Umayyad-period aqueduct between Gezer and Ramla (Fig. 1; Gorzalczany 2011). In July and August 2006, a further segment of this aqueduct was uncovered during salvage

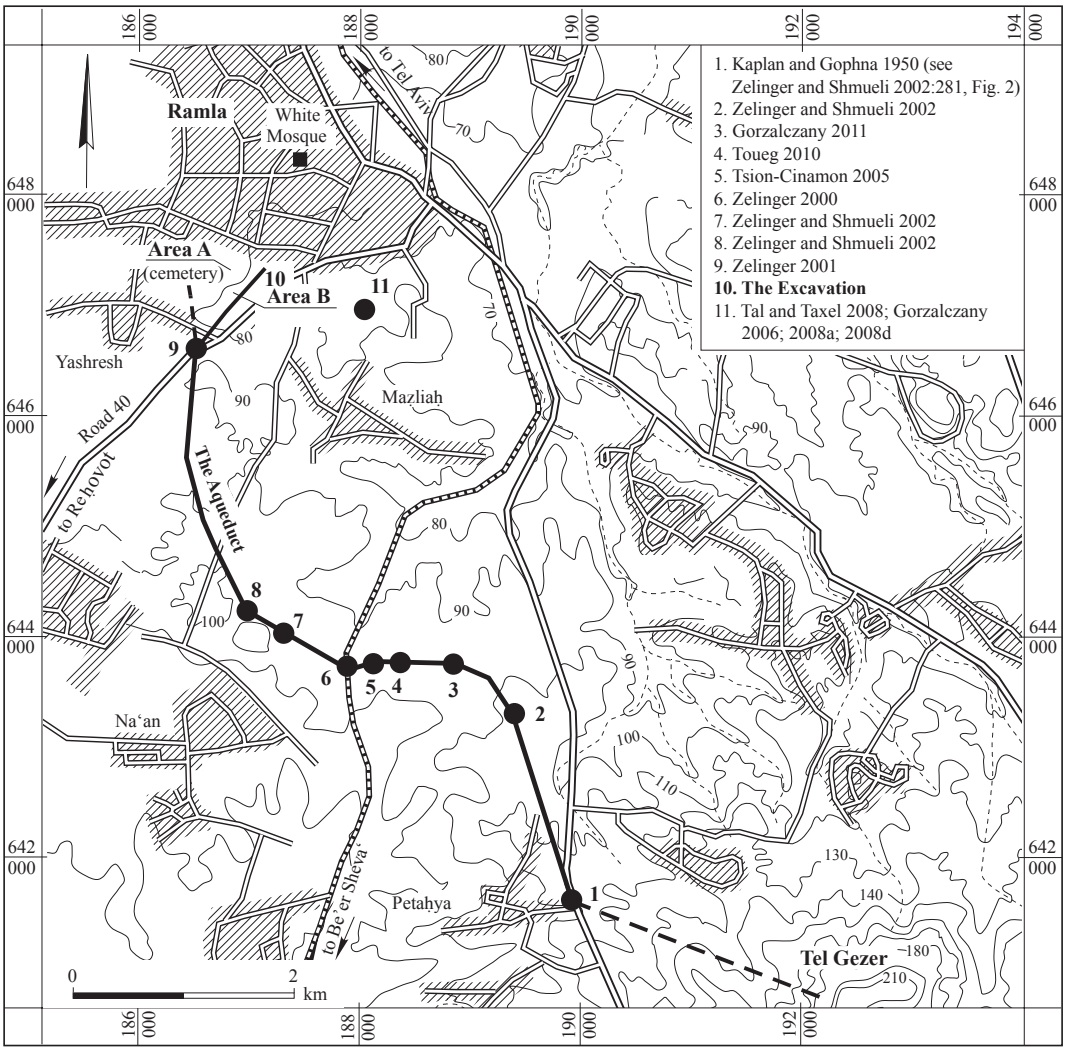
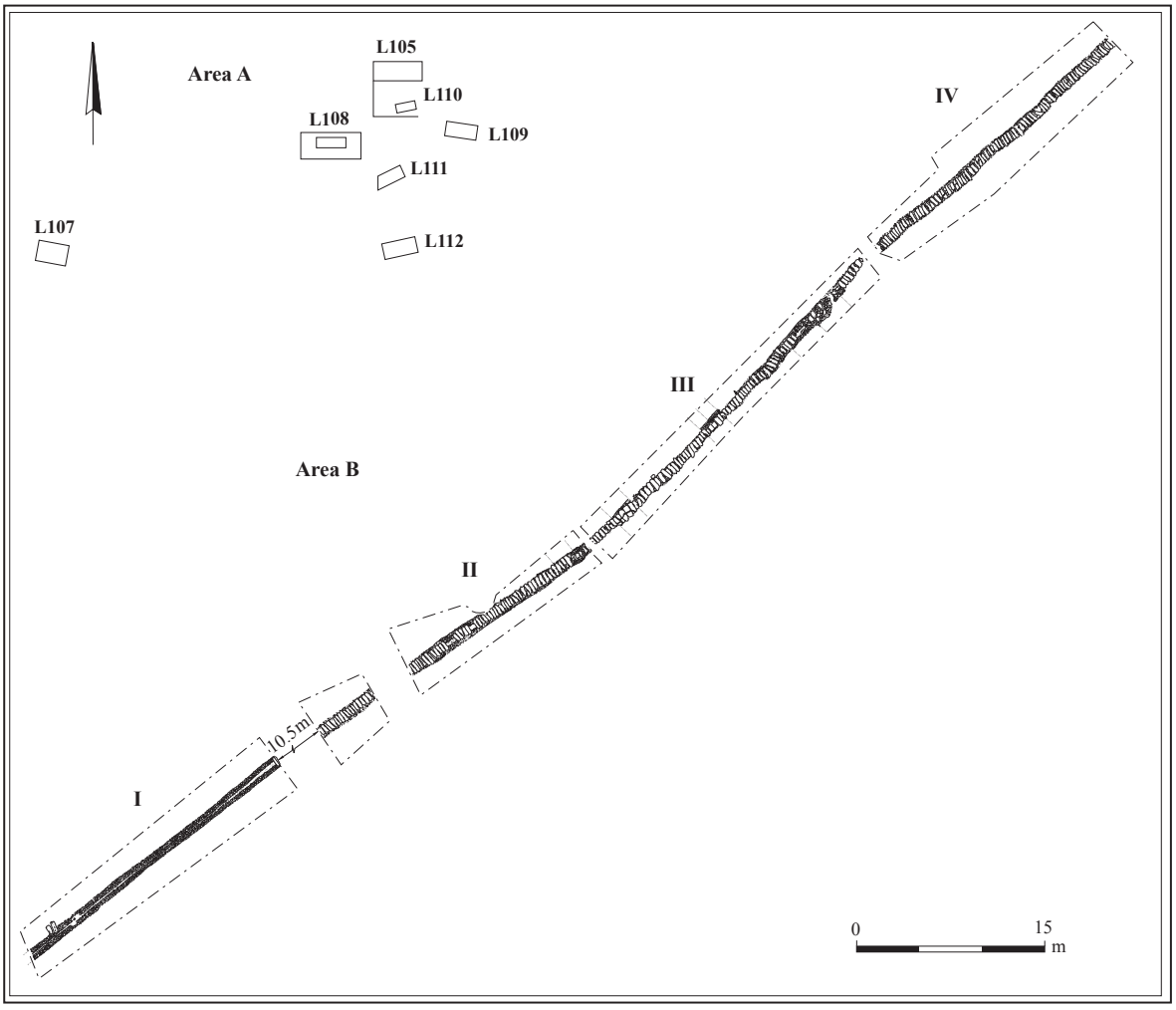


Fig. 1. Location map showing the current excavation areas (10; Areas A, B), the reconstructed course of the aqueduct, the cemetery, and previous excavations and surveys.



Plan 1. General plan of the excavated areas: the aqueduct (Area B), plan and sections, and the general plan of the cemetery (Areas A and B).

excavations carried out south of Ramla and northeast of Moshav Yashresh (map ref. NIG 18650–66/64729–42; Fig. 1) prior to the paving of Highway 431.[1] It lies within the boundaries of an olive-tree grove, known locally as the 'Kakunda Compound', owned by a well-known Ramla family of this name.

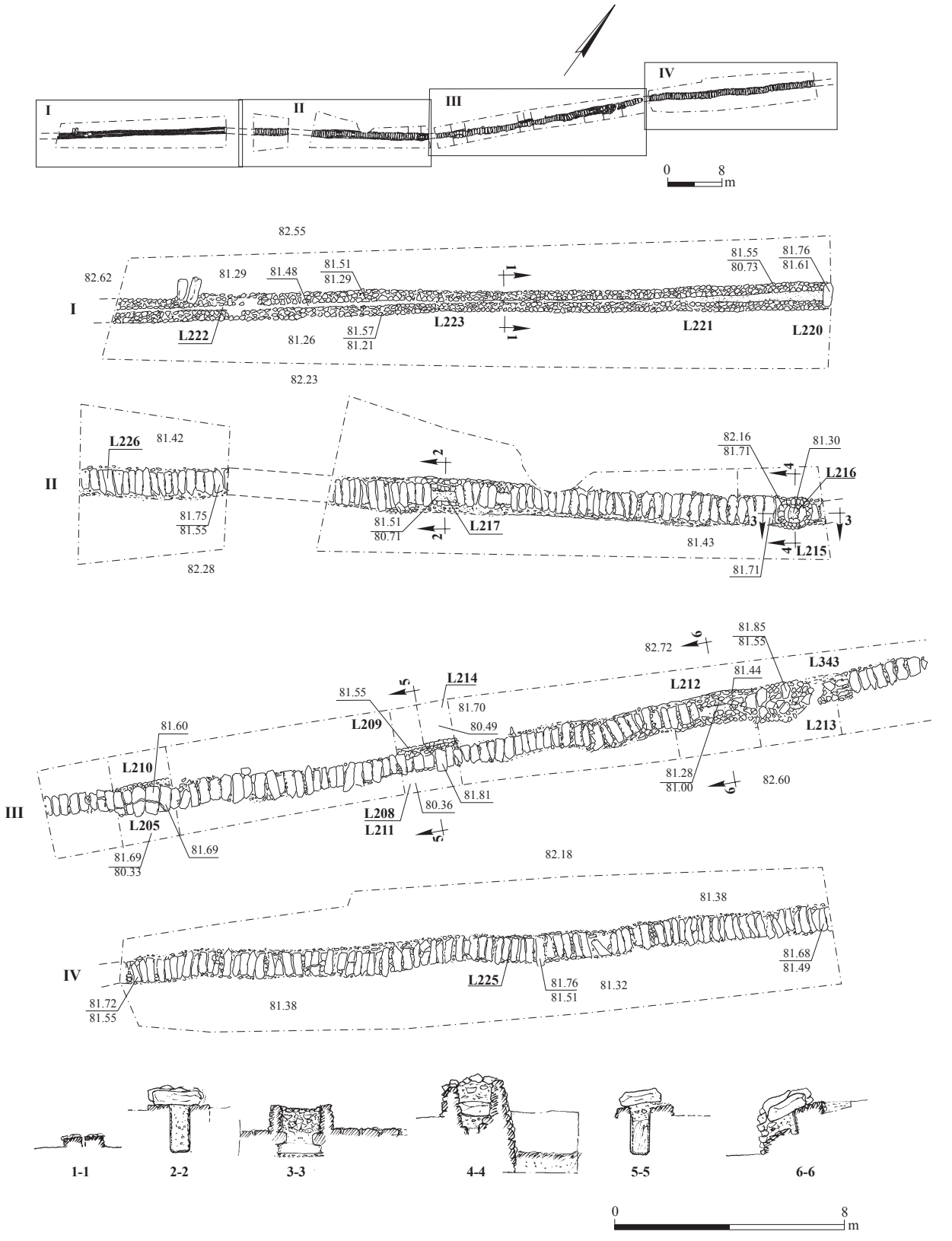
Excavations over the years in the area revealed several sections of the aqueduct along a reconstructed course of 10 km (Gorzalczany 2008c; 2011: Fig. 1, and pp. 196–197 for a summary of this work) and remains of a cemetery, dated to the Mamluk or Early Ottoman period (Onn 2008).[2]

The present excavation (Plan 1; Gorzalczany 2008b) exposed the excellently preserved remains of the aqueduct in Area B. Nine pit graves that can be attributed to the cemetery excavated by Onn (2008) were unearthed—seven in Area A and two in Area B (Plans 1–3).

THE AQUEDUCT

The Excavation

The main feature revealed in Area B are the remains of the aqueduct, which was well preserved (Plans 1, 2; Figs. 2–5), except in



Plan 2. The aqueduct, plan and sections.

Fig. 2. Aerial view of the central segments (II and III) of the aqueduct and Shaft 216; note the olive grove, which badly damaged the channel.

Fig. 3. The southern segment (I) of the aqueduct, looking southwest; the cover stones were looted in antiquity.

Fig. 4. Aerial view of the northern segment (III–IV) of the aqueduct; note the modern cement wall, which delimited the olive grove.

three places where it was damaged by olive-tree roots and a section that was severed by a modern cement wall, which delimited the olive grove (Figs. 2, 4, 5).

The technical aspects of the aqueduct were established in Gorzalczany 2011. The excavation of its section in Area B, recorded as Segments I–IV, is therefore presented here as a narrative, with specific details yielded by its full excavation in three squares (see Figs. 6, 7, 16), and pertinent special features.

This section of the aqueduct, generally oriented southwest–northeast, was exposed along c. 150 m (the width of Road 431, including the planned infrastructure flanking it) and to a depth of 1 m below surface. The stone foundations of the aqueduct were excavated into layers of *ḥamra* that overlaid a tamped dark clay layer of varying thickness (Figs. 6, 7). It was built of two parallel walls constructed of fieldstones and bonding material (width 0.35–0.40 m) and a plastered channel between them (Plan 2: Section 7–7). In Segment II, a layer of ribbed Byzantine or Early Islamic potsherds (Fig. 8) was located between the stone walls of the aqueduct, overlaid by two layers of hydraulic plaster (L226, L217; Plan 2: Section 5–5); the first layer pink, and the second, gray, probably a later repair (Fig. 9; identical to the scenario described in Gorzalczany 2005; 2008b; 2008e:13; 2011:199–200). The channel was covered with limestone slabs (average dimensions 0.6 × 0.7 m; Plan 2: Sections 5–5, 6–6; Fig. 10),

Fig. 5. The northern segment (IV) of the aqueduct, severed by the modern cement wall, looking southwest; note the alluvial clay, which pressed and moved the stones.

Fig. 6. The northeastern side of the aqueduct, looking north; note the soil layers on which the aqueduct is based.

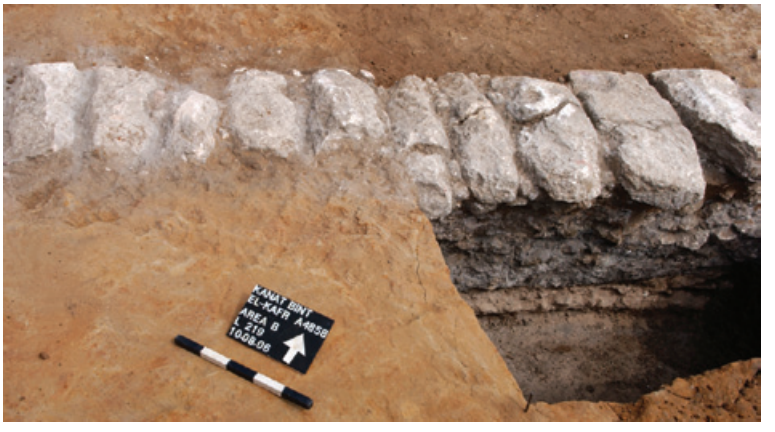


Fig. 7. The southwestern side of the aqueduct, looking northwest; note the aqueduct's foundation and the layers on which it is based.

Fig. 8. Detail of the plastered channel; note the thick layer of pottery sherds located between the plaster layers and the walls.

Fig. 9. Two layers of hydraulic plaster: original and repair, looking southeast.

Fig. 10. Well-preserved limestone cover slabs in Segment II, looking southeast.

Fig. 11. Cover slabs missing (detail).

Fig. 12. Ground shift due to the clayey soil; note the pressure on the walls of the channel (L218).

except for the last 20 m in the southwest, where the cover stones had probably been looted in antiquity (Figs. 3; 11). The aqueduct was damaged on its southwestern side (especially in Segments I [L220–L222] and III [L218, L219, L224]; Plan 2: Section 1–1), due to ground shifting, especially where it was clayey (Figs. 12, 13). The lack of cover stones probably also contributed to the instability of this section of the aqueduct; a similar phenomenon was discerned in the segment revealed near Kibbutz Na'an (Gorzalczany 2005; 2011:204). A pair of *ex situ* cover stones was found close to the southern end of the excavated area (Segment I, L222; Plan 2; Fig. 14). In Segment III, the aqueduct was excavated for a distance of 1.8 m (L212, L213 and L219). It was determined that the aqueduct and channel were narrower in the northernmost square than in the other excavated squares (width of aqueduct 0.9 m; width of channel 0.3 m; depth of channel 0.23–0.30 m vs. overall width 1 m; width of channel 0.35 m; depth of channel 0.8 m; Plan 2: Sections 5–5, 6–6). As in previous excavations, this contraction could be attributed to the pressure caused by the clayey soil (Gorzalczany 2011).

Two maintenance shafts (L216, L224) were located along the aqueduct. Shaft 216 was in a very good state of preservation (Plan 2: Sections 4–4, 8–8; Figs. 15, 16), while Shaft 224 had collapsed (Plan 2: Segment III). The building stones were scattered around their original location (see Fig. 13). The dimensions of the channel and the shafts precluded an adult's entry through them for cleaning and repair,

Fig. 13. Collapsed section of the aqueduct, looking southwest;
note the layers of plaster on the wall (L219).

Fig. 14. A pair of *ex situ* cover slabs,
looking northheast.

Fig. 15. Aerial view of Shaft 216,
looking northeast.

Fig. 16. Excavation along the well-preserved Shaft 216, looking southeast.

but may have allowed that of a child. This is opposed to the situation observed in manhole shafts in the aqueduct section near Kibbutz Na'an, where the size and diameter of the shafts indeed allowed a person's entrance so as to keep the channel clean if needed (Gorzalczany 2011:202). As only two maintenance shafts were discovered, it is not possible to establish whether these installations were positioned at fixed or random distances, or pre-situated at weak points of the conduit in order to facilitate maintenance or to detect flooding where obstructions to the channel could be expected. This arrangement could have helpped to locate blockages and thus facilitate maintenance. It is noteworthy that in the segment of the aqueduct excavated close to Na'an, one of the shafts is located precisely at the point where the channel deviates slightly (8°; Gorzalczany 2011:203). It is indeed probable that at this point of the course, soil would eventually accumulate, forcing the performance of maintenance tasks.

Checking the elevations at the two ends of the aqueduct, it was ascertained that it was built with a 0.05% gradient, as Vitruvius (see Di Segni 1989) suggested regarding the construction of aqueducts.

The Rate of Flow (Table 1)[3]

The discharge and flow rate of the aqueduct were calculated by means of Manning's formula, which also takes into account the effect of the friction of the water on the rough margins of the conduit (Hodge 1992:354–355). The present calculation of the maximum rate of flow in the aqueduct is only theoretical and is based on the data acquired from the excavated squares. The chosen roughness coefficient was the equivalent to smooth plaster (K = 70). Since the height of flow is unknown, calculations were performed taking into consideration two different possible heights: 0.7 m (the maximum possible level of the flowing water) and 0.46 m (two-thirds of this level).

Discussion

The section of the aqueduct described here is the northernmost part of the Umayyad-period aqueduct to Ramla found to date.[4] It has been assumed that the aqueduct entered the city of Ramla at this point. However, due to various considerations cited below, this particular section of the aqueduct may well be a secondary branch of the aqueduct that split from the main channel at some unknown location situated

Table 1. Calculation of Discharge and Flow Rate of the Aqueduct

$V = K \times R^{2/3} \times I^{1/2}$ $Q = V \times A$		
Q	Discharge	m^3/s
V	Velocity	m/s
A	Cross sectional area	m^2
R	Hydraulic radius	A/P
P	Wetted perimeter	2h + w (m)
h	Height of flow	0.7 m
W	Width of flow	0.35 m
K	Roughness coefficient	70 (smooth plaster)
I	Slope	h_1/L
L	Length	100 m
h1	Level difference	0.05 m
Discharge (Q) according to maximal possible flow h = 0.7 m		Discharge (Q) according to two-thirds height flow h = 0.46 m
A	$0.35 \times 0.70 = 0.245$	$0.35 \times 0.46 = 0.161$
P	0.7 + 0.7 + 0.35 = 1.75	0.46 + 0.35 + 0.46 = 1.27
R	0.245/1.7 = 0.1765	0.161/1.27 = 0.1267
I	0.05/100 = 0.0005	0.05/100 = 0.0005
V	$70 \times 0.14^{2/3} \times 0.0005^{1/2}$	$70 \times 0.14^{2/3} \times 0.0005^{1/2}$
V	$70 \times 0.2696 \times 0.0223 = 0.4208$	$70 \times 0.2529 \times 0.223 = 0.3947$
Q	$0.245 \times 0.4208 = 0.1030$ m^3 m/s	$0.161 \times 0.3947 = 0.0635$ m^3/s
Q	0.1030 m^3 m/s × 3600 = 370 m^3/h	0.0635 $m^3/s \times 3600 = 229$ m^3/h

between Road 431 and the entrance to Moshav Yashresh on Road 40, the closest known point of the aqueduct to the southwest. To the northeast, beyond the limits of Road 431 and therefore, not excavated, the continuation of the aqueduct can be discerned under the topsoil, especially in aerial photography (Fig. 17), breaking through under the houses of modern Ramla, in the Joarish Quarter.

It is obvious that the presently excavated channel bears the same characteristics exhibited by the previously uncovered parts of the conduit (plaster, building techniques and general layout; Gorzalczany 2011), reinforcing the conclusion (Gorzalczany 2011:215) that the entire water-way was conceived and built as one project. However, the reduced dimensions of this branch (width 0.35 m vs. the 0.5 m width near Moshav Yashresh, only a few hundred meters distant) clearly show that it constitutes a subdivision of the main one. This becomes evident when we compare the discharge rate of this branch (229–370 m^3/h) with that calculated for the main channel (705–822 m^3/h; and see Gorzalczany 2011). We are left with the question regarding the identification of this branch's final destination.

Examination of the map of Ramla indicates that it is indeed possible that the final destination of the aqueduct was located in the water cisterns in the White Mosque area (Gorzalczany 2011). However, another possibility exists. Due to the construction of Road 431, a neighborhood south of Ramla and close to Moshav Maẓliaḥ underwent substantial

Fig. 17. Aerial view of the northern segments (III–IV) of the aqueduct, looking northeast; in the background, the Joarish Quarter in Ramla. The continuation of the aqueduct's path (unexcavated) can be discerned breaking through the houses.

excavations (see Fig. 1:11; Gorzalczany 2006; 2008a; 2008d; Gorzalczany and Spivak 2008; Tal and Taxel 2008). During these excavations, a vast industrial area was excavated, yielding an unequaled number of industrial plastered installations, water cisterns and wells, along with an intricate network of local water pipes, channels and conduits. Similarly, installations that are highly water demanding, including two bathhouses, were uncovered (Gorzalczany 2008a:33). Moreover, traces of a flax industry, which needs substantial quantities of water, were discerned (Tal and Taxel 2008:123–124). It is evident that an enormous quantity of water was needed at this site. Keeping this in mind, it seems probable that the water supply indicated by the numerous water-wheel (*antiliya/sāqiya*) vessels (Tal and Taxel 2008:151, Fig. 6.96) and at least one well would have had to be augmented by means of a branch of the aqueduct. This posited branch could be the one presented here or even a minor subdivision of it, built as part of the effort to ensure the basic necessities to, as well as the economical infrastructure for, Sulaymān's new capital city. It is also conceivable that the narrow irrigation channel uncovered by Shmueli in 2004 (Shmueli 2011), located near the presently excavated branch and parallel to it, is somehow related to the general layout of the conveying water system. A picture of intricate networks of water conduits to and within the city begins to materialize, as shown also by other recent excavations (e.g., Sion and Toueg 2008:26–28; Tal and Taxel 2008:84–114).

THE CEMETERY

After the aqueduct was no longer in use, the area north of it was converted into a Muslim cemetery (Plans 1, 2), first uncovered by Onn (2008). We excavated seven pit graves (L105, L107, L108, L109, L110, L111, L112) in Area A (Figs. 18, 19; Plan 3) and two in Area B (L209, L210; Figs. 20, 21; Plans 4, 5) out of dozens that were discovered during Onn's explorations. The graves were simple, elliptical irregular pits dug into the ground, a compact *ḥamra* soil (depth 1.4–1.6 m), and were unlined; the burials lacked funerary offerings. The deceased were placed on their right side in an anatomically articulated position, indicative of primary burial (see Nagar, this volume); only Burial 209 was incomplete, with only the upper half of the skeleton and fragments of the cranium preserved (Fig. 20; Plan 5). They were positioned in an east–west direction, the head in the west and the face looking south. This method of interment, with the gaze of the deceased toward Mecca, is characteristic of Muslim burial and well-attested in many cemeteries in Israel (see below; and possibly *de riguer* since the earliest days of Islam, as reflected, e.g., in the poetry of the Umayyad period [al-Farazdaq, *Dīwān*:283, §10; 338, §10]).

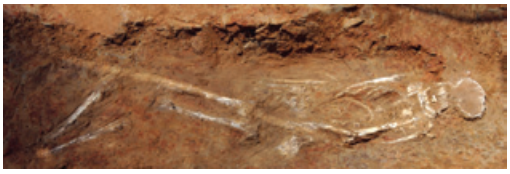
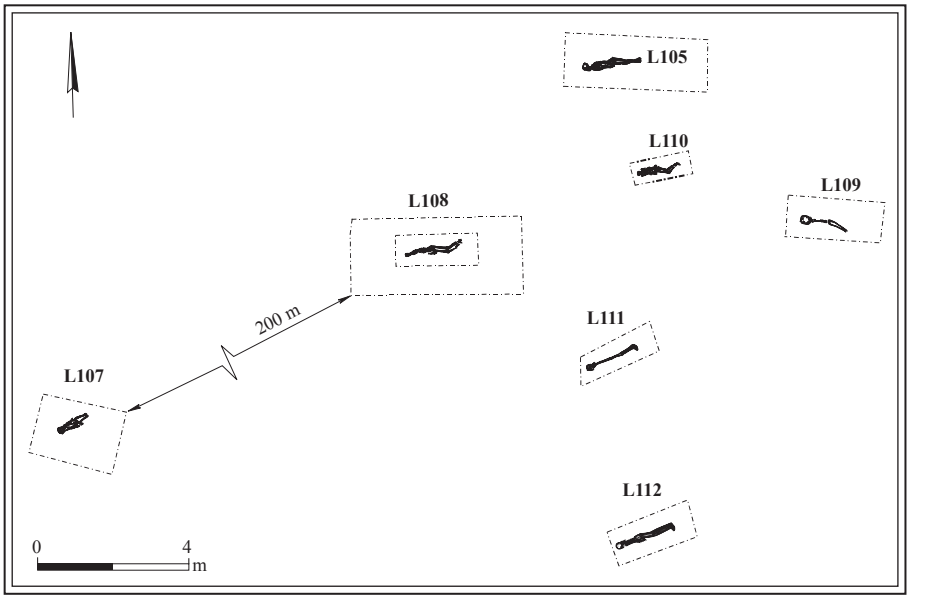


Fig. 18. Burial 110 in Area A, looking southwest; note gaze to south.

In the present excavation, the azimuth of the grave's longitudinal axis ranged from 60° to 105° in relation to the north (azimuth 0°). Recently, I have suggested that the minor divergences in the orientation of grave axes are related to the customary Muslim interment custom of turning the deceased's face toward Mecca, as well as to the annual variation in the direction of sunrise (Gorzalczany 2007; 2009).

The two burials (L209, L210) in Area B in the central part of the excavated area (see Segment III: Plans 4, 5; Figs. 20, 21) clearly postdated the channel, having been cut through the foundation channel of the aqueduct. The

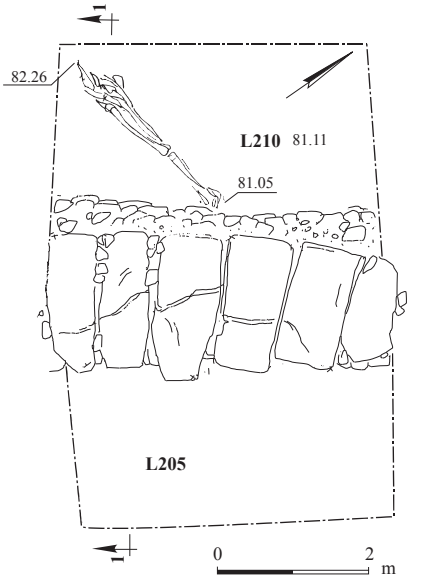
Fig. 19. Burials 111 and 112 in Area A, looking northwest; note anatomic articulation, placement on right side, head to west and gaze to south.

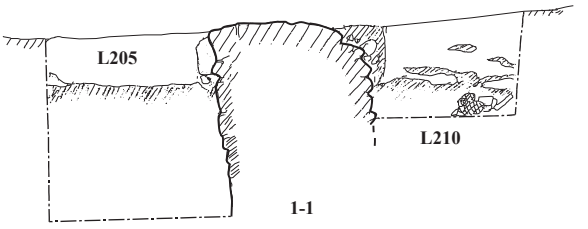


Plan 3. Plan of the cemetery in Area A.

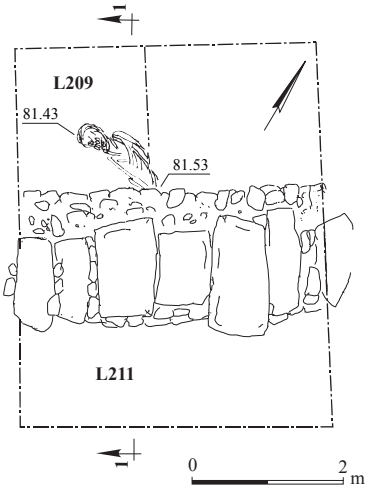
Fig. 20. Burial 209 in Area B, looking west.

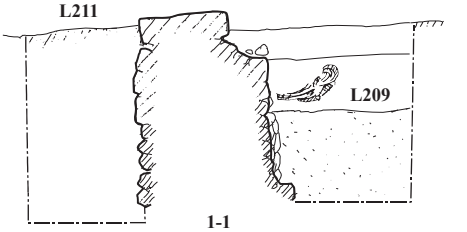
Fig. 21. Burial 210 in Area B, looking southwest.





Plan 4. Area B, Burial 209, plan and section.





Plan 5. Area B, Burial 210, plan and section.

cemetery can possibly be dated to the Ayyubid–Mamluk periods, based on a copper coin (*fals*) that was found next to Burial 210. The coin (IAA Reg. No. 112746) was minted during the latter days of the Mamluk ruler Barqūq (1389–1398 CE).[5]

Discussion

Only a minimal part of the cemetery was excavated and documented, before it was covered and the topsoil elevated in order to allow Highway 431 to be built without damage to the graves.

The burials excavated during the present season are similar to the four graves exposed during the trial excavation carried out by Onn (2008). No offerings were found in the rather simple pit graves, which lack tombstones or even cover stones. It seems that it was the commoners' graveyard. The burial style, outline and orientation correspond well with the usual layout of Muslim cemeteries investigated in Israel. On the grounds of the numismatic find, the necropolis can be dated to the Mamluk period. It can be ascribed to the group of burial grounds that surrounded the city of Ramla (Avni 2008:4, unnumbered figure; Parnos 2008) and is one more among the increasing number of Mamluk-period graveyards discovered in this area (Gorzalczany, forthcoming).

Similar cemeteries have been excavated further afield, for example at Tel Te'o (Eisenberg, Gopher and Greenberg 2001:46), Tel Mevorakh (Stern 1978:4–9), Kefar Sava (Gorzalczany 2007; 2009), Ḥorbat Gelilot (Kletter 1999), Bet Dagan (Yannai 2008), Tel Gat (Yeivin 1961:3–11, Pl. I:1), Tel Nagila (Guérin 1868:295; Amiran and Eitan 1965:117), Tel Ḥesi (Toombs 1985: pocket insert 1; Eakins 1993:22–26) and Tel Zeror (Ohata 1967:6). Some of the Muslim cemeteries excavated are located in the vicinity of a contemporary site, such as Nes Ẓiyyona (Levy 1992; Glick 1998; Gorzalczany 1998; 2004) and Ge'alya (Gorzalczany 1997; forthcoming). Other cemeteries that were surveyed or excavated but have not yet been published include Khirbat Sibb, Yafo (Jaffa), Naḥal Tut, Kerem Maharal, Ṭirat Ha-Carmel, Nebi Yamin, Tel Haror, Tel Shari'ah and Tel Tanim.[6]

NOTES

[1] The excavation (Permit No. A-4858) was conducted by the author on behalf of the Israel Antiquities Autnority and funded by the Department of Public Works, with the assistance of Yehiel Zelinger (probes), Orit Segal (area supervisor), Shlomo Ya'akov-Jam and Elie Bachar (administration), Yossi Nagar (physical anthropology), Avraham Hajian (surveying and field plans), Tzila Sagiv (field photography), Sky Ballon (air photography), Rami Chen (metal detection), Aviva Buchennino and Yigal Moyal (archaeological inspection), Yehuda Peleg (hydrological calculations), Natalia Zak and Boris Entin (drafting and final plans), Lena Kupershmidt (metallurgical conservation laboratory) and Robert Kool (numismatics). Shimon Gat provided valuable advice regarding Early Islamic literary sources. Yoav Arbel commented upon an earlier version of this report. Additional assistance was granted by Amit Re'em, Ronit Lupu, the late Alexander Onn, Tzach Kanias and Anan Azav. The works were carried out with the help of workers from Ashqelon. The author is indebted to all.

Part of the aqueduct was restored by the Conservation Department of the IAA under the auspices and with the funding of the Cross-Israel Highway Company. The restored segment can be seen close to its original location, on the western edge of Road No. 6, near the gas station.

[2] Yiftach Gutman also discovered the segment of the aqueduct excavated by the author in 2001 and reported it to the IAA. In addition, another section of the aqueduct can be added to the list in Gorzalczany 2011:196–197. Its continuation to the west was recently unearthed by Ron Toueg in 2008 (Permit No. A-5457), and it is located to the west of the section excavated in 2001 (Toueg 2010).

[3] The hydraulic calculations were kindly performed by Yehuda Peleg, to whom the author is deeply grateful. There are a number of other formulae used by hydrologists and engineers for determining the flow rate of channels and rivers. Further information on Manning's, Bazin's and Chezy's formulae can be found in Gorzalczany 2011: nn. 11, 12.

[4] For a thorough discussion regarding possible water sources for the aqueduct, see Gorzalczany 2011:194–196.

[5] The coin was identified by Robert Kool.

[6] The author is grateful to his colleagues who kindly permitted him to study the relevant plans. For burial and mourning customs during the Ottoman period in Israel, see also Bar-Tzvi, Abu-Rabia and Kressel 1998. For Muslim burial rites, see Halevi 2007. For a comprehensive summary, discussion and list of Muslim cemeteries excavated in Israel and Transjordan, see Gorzalczany 2007:75, Table 1; Gophna, Taxel and Feldstein 2007:25, Table 2.1).

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