THE AQUEDUCTS OF NAHAL BET HA-'EMEQ*

RAFAEL FRANKEL

Sections of the aqueducts of Nahal Bet Ha-'Emeq were discovered in the 1970s by the Western Galilee team of the Archaeological Survey of Israel, under the direction of the author (Fig. 1; Frankel 1979; Frankel, Getzov and Syon 2002) and will be described in detail in the final report of the survey (Frankel and Getzov, forthcoming). Between June 2000 and October 2006, excavations were carried out in one section of the aqueducts on behalf of Haifa University, also under the direction of the author.¹ A short preliminary report of these excavations was presented at a conference on aqueducts and related subjects in May 2001 (Frankel 2002a).

Remains of three parallel aqueducts were found over a distance of about 6 km. Aqueduct A is partly a tunnel with vertical shafts and partly a channel; Aqueduct B is a wide channel; and Aqueduct C is a narrow channel (Plan 1; Fig. 2). The westernmost remnant known to us is a section of the tunnel of Aqueduct A, found by chance while digging a cesspit in 'Amqa (Frankel, Getzov and Syon 2002:455, Fig. 7). This section of the tunnel was unfortunately covered a short time after its discovery. For most of their length, the aqueducts run along



Fig. 1. Location of the Nahal Bet Ha-'Emeq aqueducts and other aqueducts to 'Akko.

^{*} The excavations are dedicated to Uri Kahana who, but for his untimely demise, would certainly have led a central role in the excavations.



Plan 1. Nahal Bet Ha-'Emeq aqueducts.



Fig. 2. Shaft 3 of Aqueduct A (right), Aqueduct B (center) and Aqueduct C (left), looking east.

the lower slopes of the hills to the south of Nahal Bet Ha-'Emeq. The excavated section, one of the easternmost known to us, is situated between Abu Sinan and Kalil. 300 m to the south of Nahal Bet Ha-'Emeq (map ref. NIG OIG 1672-5/2641). 2172-5/7641. The excavation began at a point in the survey where sections of all three aqueducts were exposed (Frankel, Getzov and Syon 2002:457, No. 6, Figs. 6, 13, 14) and includes one of the shafts of Aqueduct A, Shaft 3 in the present report. In addition to the three aqueducts, a shaft tomb from the Intermediate Bronze Age and two winepresses were uncovered during the excavation. These are discussed separately below (Appendix 1 and Appendix 2, respectively).

AQUEDUCT A: TUNNEL AND CHANNEL

Six shafts (Nos. 1–6, east to west; Plans 1, 2) and the sections of tunnels and channels between them were excavated. Shaft 3 was discerned during the survey, and the excavation began from there to clear the tunnels to the east and west. Shafts 2 and 6 were discovered while excavating the aqueduct, and Shafts 1, 4 and 5 were located by Uri Bason using geophysical techniques. The tunnels were cleared via the shafts using small carts that were pulled in and out by ropes.

The Shafts

The shafts (Figs. 3–13) are all rectangular, except for Shaft 6, which is a corner shaft whose long sides bend slightly. The dimensions of the shafts are very similar (Table 1). The lengths of the short sides (east, west) vary from 0.97 to 1.24 m, with three sides measuring 1.1 m and another 1.11 m, suggesting an intended width of two cubits of c. 0.55 m.

Table 1. Dimensions of Shafts (m)

	North	South	East	West
Shaft 1	1.71	1.65	1.24	1.13
Shaft 2	1.72	1.65	1.10	1.10
Shaft 3	1.52	1.59	0.97	1.03
Shaft 4	1.71	1.68	1.10	1.10
Shaft 5	1.52	1.72	1.11	1.03
Shaft 6	1.74	1.64	1.04	1.05



Fig. 3. Shaft 1, looking north; Aqueduct B in background.



Fig. 6. Shaft 3 from above: channel in center and steps/shelves on either side.



Fig. 4. Shaft 2, looking north; note approach passage and footholds in northwestern corner.



Fig. 7. Shaft 3, looking into tunnel.



Fig. 5. Shaft 3, looking north; Aqueducts B and C in background.



Fig. 8. Shaft 4, looking east; note step.



Fig. 9. Shaft 4, looking south.



Fig. 10. Shaft 5, looking northwest; note protruding step.



Fig. 12. Shaft 6, looking east; note step in corner and channel section of Aqueduct A in background.



Fig. 11. Shaft 5; note step.



Fig. 13. Shaft 6, looking west; channel of Aqueduct A in foreground, two branches of Channel B, one below and to right of measuring rod and one behind it.



Fig. 14. Aqueduct A: built wall in open section west of Shaft 5.

Similarly, the long sides (north, south) vary from 1.52 m to 1.74 m, with two sides 1.65 m, one 1.68 m and another 1.64 m, suggesting three cubits of 0.55 m. The shafts are wider than the tunnel, creating a step or shelf on either of its sides (Fig. 6). The steps descending into the shafts vary. In Shaft 3, natural cracks in the walls made special arrangements unnecessary. In Shafts 4 (Fig. 8) and 6 (Fig. 12), there are small steps in the northeastern corner. In Shaft 5, a semicircular step protrudes from the northern wall of the shaft (Figs. 10, 11). In Shaft 2, an approach corridor was hewn opposite the northwestern corner with rock-cut footholds below it (Fig. 4) and in Shaft 1, there were also rock-cut footholds.

The Tunnel and Channel

The tunnel is c. 1 m high and 0.5–0.8 m wide. Between Shafts 2 and 5, the tunnel is complete and continuous. Fifteen meters to the west of Shaft 5, the tunnel passes through a large natural depression in the rock, 3 m in length, where it becomes a channel with a partially built wall (Plan 1; Fig. 14). To the west of the depression the tunnel passes below two winepresses (see Appendix 2) and at a distance of 27.5 m west of Shaft 5, the aqueduct becomes a channel (Fig. 15). At this point, it turns slightly northward and then continues due west for 73.4 m as the



Fig. 15. Channel section of Aqueduct A, looking west.

crow flies, reaching Shaft 6. From Shaft 6, the aqueduct again continues as a tunnel which, following the natural contour of the landscape, turns slightly southward (Plan 2). At the eastern end of the channel section is a point where the cutting of the channel had been started, but not completed, and it reaches a depth of only 20 cm (Fig. 16). The significance of this will be discussed below (Planning and Execution).

At points 12 and 24 m east of Shaft 6, immediately to the north of the channel (Plan 2), there are two sloping grooves in the rock. The grooves are of the same width as the channel, the western groove facing west (Fig. 17) and the eastern one facing east (Fig. 18). These grooves indicate that the channel was initially planned on a slightly different course, but then hewn on its present course farther south. They also provide evidence that the channel was hewn here in both directions at the same time.

The sections of the tunnel leading westward from Shaft 1, eastward from Shaft 2 (Plan 2)



Fig. 16. The meeting point between the tunnel and channel sections of Aqueduct A, looking east; entrance to tunnel on right at back. In the triangle in front of the measuring rod, the cutting of a channel that was started, but not completed, which changed the direction of the aqueduct.



Fig. 18. Measuring rod on eastern section of incomplete channel, looking east (see also Fig. 17).



Fig. 17. Measuring rod at western end of channel section that was not completed; to left, the completed channel and in background, the western end of channel section of Aqueduct A and Shaft 6, looking west (see also Fig. 18).

and westward from Shaft 6 (Plan 2) were never completed; the section from Shaft 1 ceasing after 17.4 m and that from Shaft 6, after 21.3 m. The easterly section from Shaft 2 is discussed below (Meeting Points).

One additional element in the tunnel that must be mentioned here, but is also discussed below, is a wall, 1.2 m wide, that was built in the tunnel 1 m to the east of Shaft 4 and blocked the tunnel completely (Fig. 19; Plan 2: Section 6-6).

The Distances between the Shafts

From Table 2, it would seem that the intended distance between the shafts of Aqueduct A at Nahal Bet Ha-'Emeq was fifty cubits, or



Fig. 19. Wall in tunnel east of Shaft 4.

Table 2. Distance between Shafts (m	(m)	Shafts	between	Distance	2.	Table
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Shafts	Distance between Shafts	Distance Including Length of Shaft
1–2	39	41
2–3	30	31.5
3-4	25.5	27.5
4–5	25.5	27.5
5–point where Aqueduct A becomes a channel	27.5	28.5

27.5 m. Standard lengths between shafts are mentioned in ancient written sources. For example, Pliny (*NH* 31:31 [57]) stipulates that the distance between the shafts of a tunnel should be two *actus*. Vitruvius (*De Architectura* 8.6.3) also refers to the distance between the shafts, although some understand the text as reading one *actus* (Robinson 1946:106; Granger 1962), others as two (Morgan 1960; Burdy 2002:239). The *actus* is the standard

Roman field length that measured 120 feet (c. 35.5 m). It is certainly possible that Pliny and Vitruvius stipulated different distances, as the wording of the two texts is completely different and they even use different terms for shaft (Pliny: *lumina*; Vitruvius: *puteus*). According to Burdy (2002:239), the Gier Aqueduct (Lyons) is the only one in which the distances between the shafts accord approximately to the specifications of two *actus*. In the past, we suggested that the distance between the shafts in the Nes 'Ammim Aqueduct was one hundred cubits (Frankel 1985:135).

Meeting Points

As has been pointed out many times, in such tunnels the shafts were sunk first and the workers then hewed the tunnels from adjacent shafts, working toward each other with the intention of meeting midway. The drama of the actual meeting of the masons is demonstrated in an inscription from a much earlier period, the famous Siloam Inscription from King Hezekiah's tunnel in Jerusalem: "and while there were still three cubits to be cut through [there was heard] the voice of a man calling to his fellow-and when the tunnel was driven through the quarrymen hewed [the rock] each man toward his fellow axe against axe and the water flowed" (c. 700 BCE; Pritchard 1969:321; see also 2 Kings 20:20; Isaiah 22:9-10; 2 Chronicles 32:3-5, 30).

A Latin inscription found at Lambaesis (modern Lambèse), Algeria, in the Roman camp of the Third Augusta Legion (the finest example of a Roman fortified camp extant [Weech 1949]), dating to 152 CE, also illustrates the problems involved in meeting from two directions below ground. This inscription includes several documents concerning a subterranean aqueduct situated at Saldae (modern Bejaia [Arabic]/Bougie [French]), c. 200 km to the northwest of Lambaesis. It also provides much information on the administrative and technical aspects of building ancient aqueducts (Wilmanns 1881, VIII:323, No. 2728; Dessau 1955, II.1:427–428, No. 5795; for English translation of part of

the inscription, see White 1984:215; for French translation of slightly more of the inscription, Fevrier 1955:88-89; for see additional bibliography, see Hodges 1992:423, n. 6). Two letters from two governors (procurators) of the province of Mauretania are addressed to commanders of the Third Augusta Legion, asking them to send (or thanking them for sending) a military water engineer (or 'leveler', librator in Latin) by the name of Nonius Datus, to supervise the work on the tunnel. It is also stated specifically that Nonius Datus personally gave the plans (forma) for the aqueduct to one of the governors, that another governor met Nonius Datus at the site and that a third also visited the site. These letters also reveal a number of administrative aspects of the aqueduct's construction, for example the water engineer who planned and supervised the project was stationed c. 200 km away and only visited the site periodically. Secondly, we learn of the involvement of high-level administrators with the digging of the tunnel, in this case the governors of a province and the commanders of a legion. This is especially remarkable considering that Lambaesis is c. 200 km to the southeast of Saldae and Caesarea (modern Cherchel), the capital of Mauretania, and the seat of the governor is c. 290 km to the west of Saldae. Thirdly, Fevrier, based on what is known regarding the careers of the various officials mentioned in the inscription, has calculated that the tunnel. 428 m in length, took fifteen years to quarry. However, by another calculation, it took only eight years (Fevrier 1955:88). If the cutting of the Saldae aqueduct, which had no shafts, took eight years, the tunnelers dug only 53 m a year, suggesting that the work was not carried out continuously. This is noteworthy when considering the Nahal Bet Ha-'Emeq aqueduct, which is at least 6 km in length and includes shafts.

The inscription also refers to an incident in which teams cutting the tunnel from opposite directions actually missed each other and carried on cutting two tunnels. A description of the events in Nonius Datus' own words is included in the inscription: "I arrived at Saldae where I met the Procurator Clemens. He escorted me to the mountain where they were complaining about the badly constructed tunnel. It appeared that the project would have to be abandoned, since the length of the tunnel exceeded the breadth of the mountain. What had evidently happened is that both tunnels had deviated from the straight line to such an extent that the upper tunnel was veering to the right in a southerly direction while the lower one was also veering right in a northerly direction. Both sections were thus out of the true alignment and the line had wandered off across the mountain from east to west. In case any reader may be in doubt about the tunnels, the use of the terms 'upper' and 'lower' should be understood as follows: the upper part is where the tunnel receives the water the lower where it discharges it. When I assigned the work to give each gang its own tunneling area, I set up a competition between the marines and the local mercenaries and they assembled to complete the tunneling through the mountain. So first I determined the level and alignment of the aqueduct and undertook the measures needed so that the work be carried out according to the plans that I had presented to the Procurator Petronius Celer. I brought the work to its conclusion. Procurator Varius Clemens dedicated the completed work when the water flowed through" (White 1984:215). Apparently, Nonius Datus had planned the aqueduct according to a line that he marked on the mountain. When he came to examine the error, he measured the courses of the two tunnels below the ground and then traced them above ground to determine the mistake. In clearing the Nahal Bet Ha-'Emeg tunnel, when we found a shaft below ground, we used the same method to find the opening of the shaft above ground.

When examining other aqueduct tunnels with shafts, it would appear that cutting from opposite directions to meet in the middle was not often a problem. In the tunnel of Caesarea Maritima's High-Level Aqueduct, for example, the meeting points are almost indiscernible (Porath 1996:30*–31*; for a list of other tunnels with shafts in Israel, see p. 39* therein).

In the case of Aqueduct A at Nahal Bet Ha-'Emeq, the problem of the meeting point was particularly acute and deserves special attention. The meeting points are easily recognizable. In some cases, the position of lamp niches cut into the walls also indicate the direction in which the workers were cutting, as the niches were usually above the workers' left shoulder. The meeting place between Shafts 4 and 5 is in the middle and only marked by a slight angle in the tunnel (see Plan 1). In this case, from the outset the two tunnels were not aligned toward each other, both veering slightly to the south, and thus assuring that they would cross. Both tunnels that started from Shaft 2 also veered southward, while the tunnel from Shaft 3 eastward did not, causing an error of 3.5 m in direction and 0.65 m in height between Shafts 2 and 3, and resulting in two sharp turns in the tunnel with a steep slope between them (see Plan 2: Section 4-4). At the meeting place between Shaft 5 and the point where the tunnel section of the aqueduct meets the channel section, the mistake is primarily in height, resulting in the tunnel ascending westward 1 m in two steps instead of descending (see Plan 2: Section 9-9; Fig. 20). The two remaining meeting points, between Shafts 3 and 4 and Shafts 1 and 2, are quite different from the others. In the meeting point of Shafts 3 and 4, both tunnels make two turns: that from the west turns to the north and then to the east, and that from the east turns to the north and then to the west (see Plan 2). As the hill slopes northward, both tunnels thus become open channels that meet in the middle (Figs. 21, 22). In this way, the tunnel diggers from both sides ensured that they would meet exactly. In the case of the tunnel leading eastward from Shaft 2, after 20 m it branches off into two tunnels (see Plan 2): one continues eastward and ends after 5 m; the other turns northward and becomes an open channel that turns eastward. It was clearly intended that this should be the meeting point with the tunnel



Fig. 20. Stepped meeting point east of Shaft 5.



Fig. 21. Open meeting point of the tunnel between Shafts 3 and 4; measuring rods on two courses of Aqueduct C that were probably cut by Aqueduct A.

from Shaft 1 according to a similar principle as that of Shafts 3 and 4, but, as already noted, the tunnel from Shaft 1 was never completed. To the east of Shaft 2 are two attempts to meet the tunnel from Shaft 1, one underground and the other open. The form suggests that the latter was the later of the two.



Fig. 22. Tunnel eastward from open meeting point, between Shafts 3 and 4.

Planning and Execution

A sufficient length of Aqueduct A has been excavated to allow us to attempt to examine the way in which it was planned and how the work was executed. Surprisingly, it appears that the positions of the shafts were not all planned ahead of time. This can be deduced from the point where the tunnel and channel sections meet. As discussed above, the cutting of the channel was started at this point, but not completed, and instead, the aqueduct turns slightly to the south and continues as a tunnel (Plan 2; Fig. 16). This suggests that the original intention had been to continue the channel eastward. Immediately to the east of this point, the tunnel passes below the winepresses, suggesting that the reason for the change was to avoid damaging them. The fact that the distance from this point to Shaft 5 is exactly 27.5 m, as are the distances between Shafts 5–4 and 4–3, would seem to indicate that the positions of Shafts 5-3 were only decided on after the eastern section of the channel

was completed. On the other hand, the fact that west of Shaft 6 the aqueduct is a tunnel, implies that the original intention was that the section running east from Shaft 6 would also be a tunnel. Only after Shaft 6 had been sunk was it decided to cut it as a channel, otherwise there would have been no use for a shaft here, as there is none at the other end of the channel section (Figs. 12, 13; Plan 2: Section 16–16). If our conclusions are correct, the final form of the various sections of the aqueduct was decided while work was in progress, which could explain the lack of uniformity in the distances between the shafts.

In two sections, the tunnel of Aqueduct A was never completed: between Shafts 1 and 2 and to the west of Shaft 6. The distance between Shafts 1 and 2 is greater than the distances between the other shafts, which explains why that section was not finished. Apparently, work was carried out on the various sections of the aqueduct at the same time, so work was completed in those sections where the shafts were closer to each other. The shafts to the west of Shaft 6 were probably also farther apart, although the seventh shaft has not been located. The channel section was completed, although it is much longer than the distances between the shafts, as many people can work at the same time on a channel, as opposed to a tunnel, where only one man can hew at a time. The two wide grooves facing opposite directions to the north of the channel (see Plan 2; Figs. 17, 18) clearly show how they operated.

AQUEDUCT B: THE WIDE CHANNEL

Aqueduct B (Figs. 2, 23) is mostly a rockcut channel, similar in width to the tunnel of Aqueduct A (0.5–0.8 m), but in some places where the rock surface slopes, it is in the form of a step with one wall probably originally built of stone masonry. Indeed, built sections were discerned at several points. Aqueduct B runs very close to Aqueduct A; for example, it is 1 m from Shaft 1, 0.5 m from Shaft 3 and 1.5 m from Shaft 4. From the easternmost



Fig. 23. Aqueduct B in center, looking east; to left, the two branches of Aqueduct C; at bottom right, Aqueduct C below Aqueduct B, leading toward open meeting point between Shafts 3 and 4 (see also Fig. 21).

point of the excavation till the point where the tunnel and the channel sections of Aqueduct A meet, Aqueduct B runs to the north of A. However, from that point westward till Shaft 6, B is located to the south of A. At Shaft 6, Aqueduct A turns southward and Aqueduct B crosses the top of the shaft and continues westward. Aqueduct B runs directly over open sections of Aqueduct A at four points: (1) where the tunnel that runs eastward from Shaft 2 comes out into the open (Plan 2); (2) over the open meeting point between Shafts 3 and 4, at which point a built section of B was discerned (Plan 2); (3) where the tunnel and channel sections of A meet (Plan 2) and B cuts into a large stone that was placed in the channel after it was filled with rubble (Fig. 24); (4) at Shaft 6, where traces of two different courses of Aqueduct B are visible (Plan 2; Fig. 13). The northern course is very short while the southern course continues westward. At these four points, large quantities of breccia were found. The fact that Aqueduct B was built over A is evidence that it was built after A was abandoned, while the large



Fig. 24. Stone on which Aqueduct B crossed the eastern end of the channel of Aqueduct A from north to south.

quantities of breccia suggest that Aqueduct B functioned for a considerable period of time. The fact that Aqueduct B is so close to A, and integrated with it, clearly indicates that the builders of B not only knew of the existence of Aqueduct A, but related to it.

AQUEDUCT C: THE NARROW CHANNEL

This channel is only 0.2-0.4 m wide and is more winding than Aqueduct B. It runs parallel to Aqueducts A and B except for one small section that runs to their north and below them (see Fig. 2). The exception is in the area of the open meeting point between Shafts 3 and 4. Here Aqueduct C divides into two branches, one continuing westward, to the north of the two aqueducts, the other turning in a southwesterly direction, passing below Aqueduct B and appearing again to the south of the open meeting point between Shafts 3 and 4 (Plan 2; Figs. 21, 23). It would appear that this southern branch was never completed. Nevertheless, its presence indicates that Aqueduct C is earlier than B. Theoretically, it is possible that Aqueduct C is later than Aqueduct A and built above the fill in the open meeting point of Aqueduct A, as was Aqueduct B. However, no traces of Aqueduct C were found above the fill and it is much more likely that its southern branch was cut by

Aqueduct A; therefore, Aqueduct C is almost certainly earlier than Aqueduct A.

In the area of Shaft 1, Aqueduct C was not found and B apparently replaced it. No trace of Aqueduct C was found west of the point where the tunnel and channel of Aqueduct A meet and where B crosses A southward. Although it is possible that Aqueduct C served a different purpose from the other two, perhaps supplying the tunnelers of Aqueduct A with water, it was probably the first of three consecutive attempts to build an aqueduct, the purpose of which will be discussed below.

AFTER THE AQUEDUCTS WERE ABANDONED

Parts of the tunnels were found completely filled with soil, while other parts were empty, which can be explained by the varying speed in which the shafts filled up. Shaft 2, for example, was apparently filled intentionally. There were many air spaces in the fill, as well as a comparatively large quantity of sherds. As a result, the tunnel on either side of this shaft remained empty. However, the other shafts apparently filled up more slowly, allowing the tunnels to fill with silt washed in during the winter rains. After the aqueducts were abandoned, the region was terraced for agricultural use, one terrace being built in the eastern section of the excavation, upon the northern wall of Aqueduct B and another in the west on the channel of Aqueduct A. It is unclear why Shaft 2 was filled, while the others were not.

THE FINDS AND THEIR SIGNIFICANCE

Only one almost complete, spherical jug was found in a section of the tunnel that was almost empty, to the west of Shaft 2 (Fig. 25). Although both rim and handle were broken in antiquity, which makes exact dating difficult, the material is typical of the Roman period and jugs of similar shape and size (diam. 10 cm) have been found at sites from that period (e.g., Tel Anafa—Herbert 1997: Pl. 49: PW440; Gamla—Berlin 2006:59, Fig. 2.30:1). The other finds recovered in the excavation of the aqueducts were sherds, which can be divided into three groups:

1) Sherds found in the fill in the open meeting point between Shafts 3 and 4 of Aqueduct A and below the channel of B, which provide a *terminus post quem* for the building of B. These were nearly all body sherds of amphorae that



Fig. 25. Jug found in tunnel.

can almost certainly be dated to the Hellenistic period.

2) Sherds found in the fill in Shaft 2, which provide a *terminus post quem* for the filling of the shaft. Nearly all the sherds from the shaft date to the Roman period.

3) Other sherds that are only evidence of general human activity in the region, mainly agricultural cultivation, many of which probably reached the area with dung spread in the fields. These are almost all from the Roman period, although it is, perhaps, significant that they include one stamped Rhodian jar handle.

From the ceramic evidence, Aqueducts A and C were apparently hewn in the Hellenistic period, while Aqueduct B could be somewhat later in date.

CONCLUSIONS

It is clear that the three aqueducts are closely related, and the later builders were aware of the existence of the earlier aqueducts. Aqueduct B is the latest of the three and it replaced the earlier two. While Aqueduct C is earlier than both A and B, it could have functioned together with A. The excavations have also revealed that Aqueduct A was never completed, and it would appear that B was built to replace A and to serve the purpose for which A was intended, although it was never fulfilled. The wall found in the tunnel to the west of Shaft 4 was probably built after the cutting of Aqueduct A was abandoned, and prior to the hewing of Aqueduct B. It probably served to convert the section of the tunnel to the east of the wall into a water cistern. The water could have been drawn through the open meeting point between Shafts 3 and 4, which was a few meters to the east of the wall.

The aqueducts almost certainly obtained their water from Nahal Bet Ha-'Emeq, a stream that today is dry in summer but in the past probably flowed all year round. Two possibilities have been raised for the destination of the aqueducts. They may have supplied villages in the region with drinking water and water to irrigate their fields, or they may have provided water to 'Akko-Ptolemais. The main argument for the aqueducts supplying 'Akko-Ptolemais is that it would have been difficult, both economically and organizationally, for any entity smaller than a city to carry out such a project. In the past, we excavated another aqueduct in the form of a tunnel near Nes 'Ammim, about 4.5 km west of the westernmost section of the Nahal Bet Ha-'Emeg aqueducts known today (Frankel 1985; 2002b; Frankel, Getzov and Syon 2002). Ceramic oil lamps found on the floor of the Nes 'Ammim aqueduct dated it to the Hellenistic period and we suggested that it supplied water to 'Akko-Ptolemais from the springs at Kabri. Nimrod Getzov has suggested that Aqueduct A along Nahal Bet Ha-'Emeq was part of the same aqueduct as that near Nes 'Ammim. The two tunnels, however, are far from similar and at least four differences can be noted: (1) the height of the tunnels: that at Nes 'Ammim is 1.75–1.85 m high, while that of Nahal Bet Ha-'Emeq is 0.8-1.0 m high; (2) the character of the shafts: in the Nes 'Ammim tunnel the shafts are sloping with steps, while those at Nahal Bet Ha-'Emeq are vertical, immediately above the tunnel; (3) the distances between the shafts: in the Nes 'Ammim tunnel the distance is probably 100 cubits, while in the Nahal Bet Ha-'Emeg tunnel, 50 cubits; (4) the standard of workmanship: this is far higher in the Nes 'Ammim tunnel than in the Nahal Bet Ha-'Emeq tunnel. These differences are clear indications that the Nes 'Ammim and Nahal Bet Ha-'Emeq aqueducts were not part of the same installation. Although it is, perhaps, possible that there were two tunnels to 'Akko-Ptolemais, the unusually poor workmanship of the Nahal Bet Ha-'Emeq aqueduct suggests that it was a local project. Aqueduct C was certainly not of a size to reach 'Akko-Ptolemais and if, as is probable, all three aqueducts served the same purpose, this also points to all three being intended for local use.

The picture that emerges is of three aqueducts built consecutively, first C, a narrow winding channel, then A, an unfinished aqueduct that is partly a tunnel, and finally B, a wide channel: three attempts to supply water to the villages and fields in the vicinity. Why were there three and why was the tunnel never completed? It should be pointed out that technically, the hewing of the tunnel of Aqueduct A was superfluous, as there is no natural obstacle to be overcome. There are places where tunnels are necessary, for example where water must be brought from one side of a mountain to the other, as in the case of the High-Level Aqueduct at Caesarea. However, as has been pointed out in the past (Frankel 1985:136; 2002b:86; see also Robinson 1946:103–104; Hodges 1992:32–33), early aqueducts of the Persian and Hellenistic periods throughout the Mediterranean region were usually subterranean, even where this was not technically necessary, and only later were aqueducts mainly above-ground channels. While the cutting of Aqueduct A may not have been completed for political or economic reasons, it is clear that Aqueduct B was cut only a short time after the work on Aqueduct A was abandoned. This would suggest that the reason was technological and ideological, and that the change was connected to the transition from underground to above-ground aqueducts. In Rome, the Aqua Appia dating to 312 BCE and the Anio Vetus dating to 272 BCE were both underground, whereas the Aqua Marcia from 144 BCE was already an above-ground channel. Similar developments almost certainly took place in other parts of the Mediterranean, although probably somewhat later.

It would appear, therefore, that initially a simple, modest, narrow channel was planned. Then an ambitious tunnel similar to those found in large cities was begun, but not completed. These were replaced by a wide channel. The reason for the change was perhaps partly due to the difficulties involved, but mainly because a tunnel was both unnecessary and no longer the accepted form for aqueducts.

APPENDIX 1: THE SHAFT TOMB

To the south of the channel of Aqueduct A, a shaft tomb was uncovered (Plan 2: Section 13-13; Figs. 26-28). On the eastern side, the northern edge of its shaft was cut by the aqueduct. The floor of the channel was at exactly the same level as the floor of the shaft of the tomb. The shaft measured 1.87×1.33 m and was 1.8 m deep. The entrance to the tomb was on the southern side of the shaft, which was located at the northern end of the tomb chamber. The blocking stone, 0.5 m high and 0.63 m wide, was still in position in the entrance. The rock-cut tomb was pear shaped, 2.92 m long and 2.65 m wide at its widest point, and the floor sloped down to a point 0.6 m from the entrance, where there was a raised step. The burial was to the south of the step (see Plan 2: Section 13-13).

The human remains were in a very poor state of preservation, but it was possible to discern a single skeleton of a young adult of undetermined sex.² The body was lying east– west with the head to the east. The only burial goods were three daggers (Fig. 29). The type of tomb and the daggers suggest that the burial dates to the Intermediate Bronze Age (also known as Middle Bronze Age I). The dagger



Fig. 26. Shaft tomb with stone blocking entrance, looking south.



Fig. 27. Shaft tomb without stone blocking entrance, looking south.



Fig. 28. Shaft tomb showing relationship to channel of Aqueduct A, looking southeast.

in Fig. 29:1 measures 28 cm in length, with a maximum breadth of 2.6 cm, thickness 0.4 cm, length and breadth ratio [LB] 11 and it had five rivets; that in Fig. 29:2 is 24.5 cm in length, with a maximum breadth of 2.6 cm, thickness 0.5 cm, LB 9.5, with holes for five rivets, one of which has survived; Fig. 29:3 is 20 cm in length, maximum breadth 2.6 cm, thickness 0.6 cm, LB 7.7, with three holes for rivets, one of which has survived. The daggers have rounded ends and no true midrib and in form are very similar to Kenyon's Types A [No. 1]



Fig. 29. Daggers from the shaft tomb.

and B [No. 3] (Kenyon 1965: Fig. 22, Nos. 1, 5; see also comparison to daggers from Tell el-'Ajjul in Kenyon 1960:138), Philip's Type 2 (Philip 1989:389, Fig. 27, the simple type) and somewhere between Maxwell-Hyslop's (1946: Pl. 2) Types 16 and 18. According to Philip, Dagger Type 2 averages 23.5 cm in length and 2.8 cm in breadth (Philip 1989:389) and the LB ratio of daggers of all types ranges between 7 and 9 (Philip 1989:102). The dagger in Fig. 29:1 is therefore unusually long and relatively narrow, and the daggers in Fig. 29:1 and 2 are exceptional in that they have five rivets. Three, four and six rivets are common, while neither Kenyon, Philip nor Maxwell-Hyslop mention daggers with five rivets. The only other example of a dagger with five rivets we know of is that from 'Ein Simia (Gophna 1989:116), although the form of the daggers and the arrangement of the rivets at 'Ein Simia are quite different from those of Nahal Bet Ha-'Emeq. In the Intermediate Bronze Age tombs at Jericho, there was usually one dagger per tomb, in three tombs there were two (Tombs A-26'L-1, L-2), but there were no cases of three. In some tombs there were weapons, but no pottery, called by Kenyon the Dagger-type tombs; in others there was pottery but no weapons. Kenyon (1960:141-142, 158) explains these differences as due to tribal organization. In Western Galilee, tombs contain weapons and pottery (e.g., one at Kabri, see Getzov 1995: Figs. 3, 4), or pottery, but no weapons (e.g., Hanita, see Singer and Dar 1986). The Nahal Bet Ha-'Emeg tomb is apparently the first to be discovered with only weapons. These differences can probably be explained as reflecting the character of those buried, in the case of Nahal Bet Ha-'Emeq a warrior with an exceptional number of daggers. Other Intermediate Bronze Age tombs have been excavated in the area of Nahal Bet Ha-'Emeq, four higher up the same hill, less than 1 km to the southwest (Getzov 2002), and another about 2 km to the southwest (Getzov 1995:15*-16*). Although no settlement site of the period has yet been identified in the vicinity, there is little doubt that such settlements did exist.

APPENDIX 2: THE WINEPRESSES

Two rock-cut winepresses were uncovered during the excavation of the aqueducts (Plan 2: Sections 10–10, 11–11; Figs. 30–33). They are located one next to the other, above the tunnel of Aqueduct A, immediately to the east of the point where the tunnel and channel sections meet and to the south of Aqueduct B. The treading floors of both winepresses were damaged by karstic erosion, creating holes in the floors that today penetrate into the tunnel. They are very similar in shape, and both the treading floors (TF) and the collecting vats (CV) can be described as square with rounded



Fig. 30. Eastern winepress, looking north.



Fig. 31. Eastern winepress, collecting vat and sump.



Fig. 32. Western winepress, looking north.



Fig. 33. Western winepress, collecting vat; note the two bores connecting the treading floor to the collecting vat and the cupmarks on the far rim.

corners. The dimensions of the western winepress are TF: 2.3×2.6 m, area 5.5 sq m; CV: 1.3×1.6 m, depth 0.5 m, volume 0.9 cu m; those of the eastern winepress: TF: 2.2×1.8 m, area 3.6 sq m; CV: 1.45×1.10 m, depth 0.6, sump in the northeastern corner: 0.58×0.77 m, depth 0.3 m, volume (including sump) 0.9 cu m. Despite the great similarity in shape, the two winepresses show several differences: (1) the eastern one has a large sump; (2) the western TF is connected to the CV by two bores, while the eastern one is connected by only one; (3) the western winepress has a small cupmark on either side of the TF. Winepresses with cupmarks on either side of the TF are common in the region (Frankel 1999:55), although no examples have been recorded in Western

Galilee in which the TF is connected to the CV by two bores. A winepress at Tell Ta'annek, in which the TF is connected to the CV by two bores and that also has cupmarks on either side of the TF (Lapp 1969:13-14), was revealed below a Middle Bronze Age wall, indicating a date in either the Early Bronze or Middle Bronze Age. However, both the TF and CV at Tell Ta'annek were perfect rectangles and the TF was extremely sloped. A group of winepresses very similar to that from Tell Ta'annek were found at Migdal Ha-'Emeq (Getzov, Avshalom-Gorni and Mugari 1998; Getzov, Covello-Paran and Tepper 2011), in the vicinity of a Middle Bronze Age site, and it was suggested that they also date to that period.

Wall paintings from Egyptian tombs provide three possible analogies to explain the purpose of such cupmarks: they may have held a framework to which a bag press was attached, or a frame for the men treading the grapes to grasp to keep their balance, or a similar frame with ropes that the men could hold on to. The steeply sloping treading floor of the winepress at Tell Ta'annek and similar examples clearly required support for the grape treaders, and the fact that cupmarks on either side of the treading floor are found in all the winepresses of this group strongly suggests that the third explanation is correct. However, as cupmarks appear in only one winepress at Nahal Bet Ha-'Emeq, perhaps in this case they served to hold a bag press.

The two winepresses from Nahal Bet Ha-'Emeq appear to have been hewn at the same time and been in use simultaneously. They are certainly earlier than the aqueducts, although they apparently continued in use after the aqueducts were cut. The characteristics of the western winepress, in common with those from Tell Ta'annek and Migdal Ha-'Emeq, no doubt evince a connection; however, rockcut winepresses remained in use for hundreds of years, so even if this type originated in the Middle Bronze Age, it could well have been copied in later periods. Therefore, in spite of the fact that there are Intermediate Bronze Age tombs nearby, it is very unlikely that the winepresses also date from this period.

NOTES

¹ License numbers G-31/2000, G-8/2001, G-2/2002, G-2/2003, G-2/2004, G-2/2005, G-4/2006. We were aided by many people and organizations, including school children and other youth groups, all voluntarily, but space allows us to thank only a few who made special efforts to help us: Dror Barshad, Eliezer Stern; Yoav Lerer and Nimrod Getzov, who drew the plans, and Hagit Tahan, who drew the jug, all of the Israel Antiquities Authority; Michael Eisenberg of the Zinman Institute for Archaeology of Haifa University, who surveyed the site; the geo-physicist Uri Bason; Ali Zgeier from the village of Yirke; the youth leaders and members

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² The remains were examined by Yossi Nagar of the Israel Antiquities Authority.

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