

# EXCAVATIONS AT WADI NADIYA 2 AND SUPPLEMENTARY INVESTIGATIONS OF THE JAFR NEOLITHIC BARRAGE SYSTEM

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## Introduction

The third phase of the Jafr Basin Prehistoric Project (JBPP), directed by the primary author, has addressed the issue of correlating the history of water-use in the arid margins with the process of pastoral nomadization. The first field season, carried out over roughly two weeks from 13 to 24 September 2009, was devoted to a reconnaissance survey of archaeological sites associated with this issue (Fujii 2010a, 2010b). The second season, which took place over about three weeks from 14 September to 2 October 2010, carried out rescue excavations at the Neolithic barrage site of Wadi Ghuwayr 106 (Fujii 2010c, 2012; Fujii, Adachi *et al.* 2011) and its neighboring outpost of Wadi Ghuwayr 17 (Fujii 2012b, Fujii, Quintero *et al.* 2011). These investigations confirmed once again that the combination of a barrage and an outpost was the norm for the Jafr Pastoral PPNB and that this type of complex extended far across the basin, beyond the type-site of Wadi Abu Tulayha (excavated during the second phase of our research project [Fujii 2006a, 2006b, 2007a, 2007b, 2007c, 2008, 2009a]). The third and fourth seasons were carried out for a total of six weeks from 4 to 29 September 2011 and from 18 March to 5 April 2012, focusing on the comprehensive investigation of another barrage site: Wadi Nadiya 1. The investigations provided valuable insights into the location, chronology, function and formation processes of the Jafr PPNB barrage system as a piece of essential infrastructure supporting early pastoral transhumance (Fujii, Adachi *et al.* 2012). The fifth field season, our main effort, took place over about five weeks from 26 August to 2 October 2012. For this, we shifted to the adjacent barrage site of Wadi Nadiya 2 and

investigated the techno-typological sequence of the Jafr Neolithic barrage system. This report briefly summarizes the results.

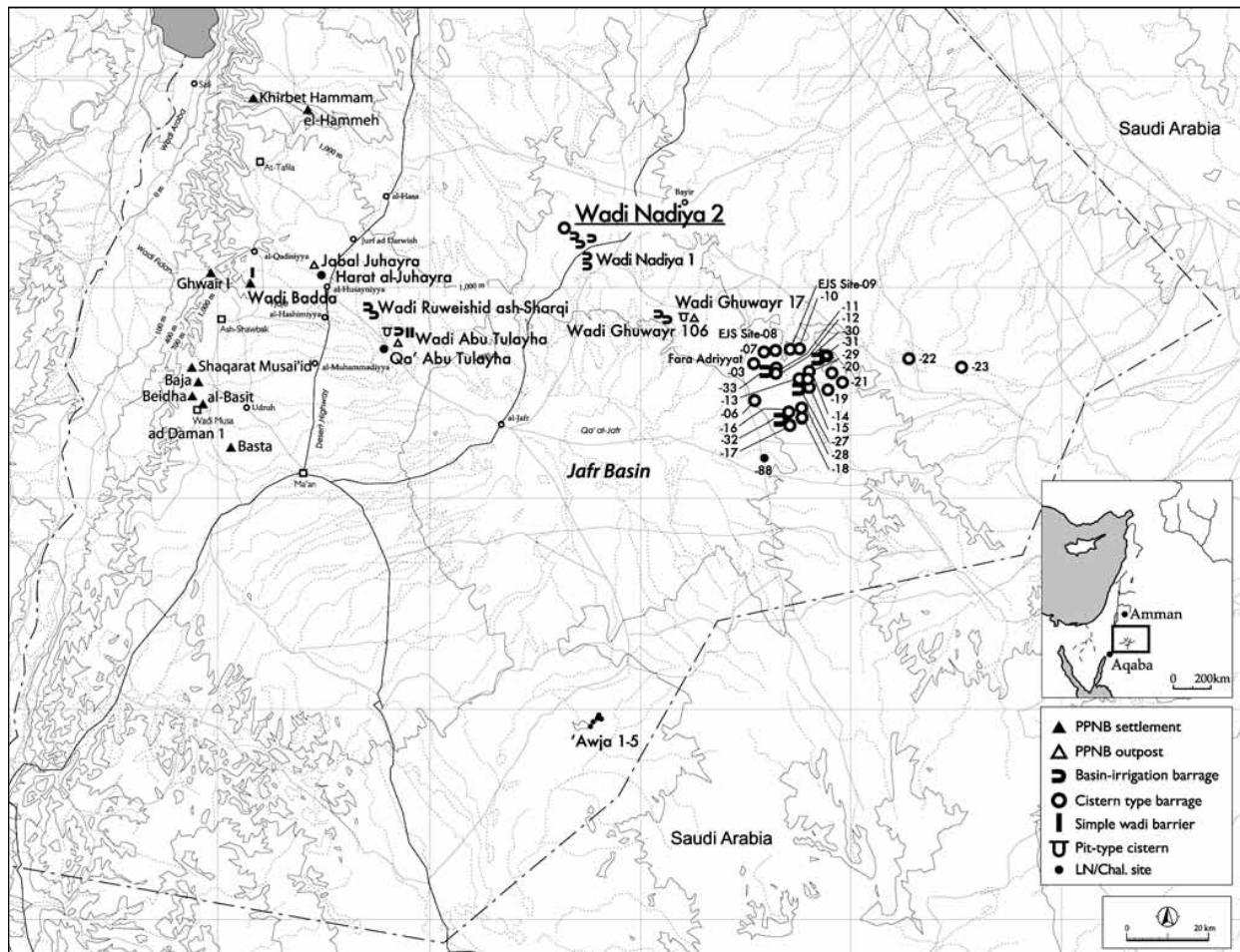
## The Site and Site-Setting

The site of Wadi Nadiya 2 is located in a flint pavement desert (*hamada* in Arabic) that extends behind the escarpment fringing the northern edge of the Jafr basin (Figs. 1 and 2). It was discovered last season, during the course of excavations at the adjacent barrage system of Wadi Nadiya 1. The surrounding environment is the same as at the adjacent site, so no repetition is needed here. We would like to only note that the site setting is (and probably was) very harsh and that local land use has long been limited to sporadic seasonal pasturing.

Wadi Nadiya 2 is an extramural barrage site, consisting of four stone-built barrages of various sizes (Fig. 3). It is isolated in the middle of the flint-strewn desert at an elevation of *ca* 1,030 - 1,050 m asl and appears not to have been associated with a neighboring settlement as its 'operating body' (Fig. 4). Three of the four barrages are aligned at roughly equal intervals along a small *wadi* that drains from the playa system where Wadi Nadiya 1 is located. The other barrage is located *ca* 550 m east of the complex, being constructed across another small *wadi* flowing out of the same playa system. These four barrages combine with the two upstream barrages (i.e. Barrages 1 and 2 of Wadi Nadiya 1) to form a large-scale water-use system consisting of a total of six barrages.

## The Investigation

We designated the three westerly features as Barrages 1 - 3 in descending order of elevation,



1. Wadi Nadiya 2 and other Neolithic sites in the Jafr Basin.

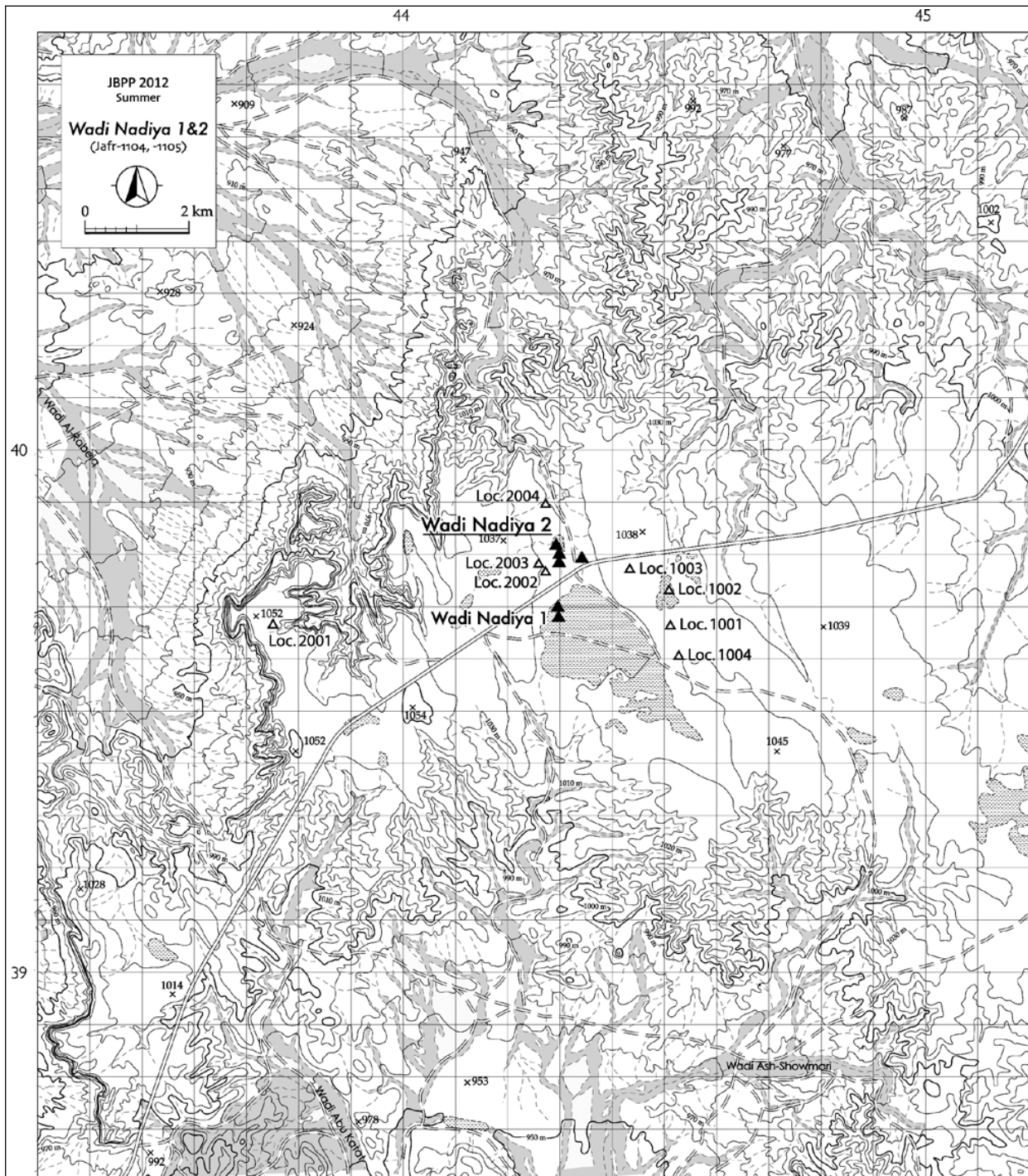
i.e. from south to north. The other example was designated Barrage 11. For the convenience of operating in separate locations, we set up four arbitrary fixed points: BM-1 for Barrage 1 (ca 1,026 m asl; N 30°42.253, E 036°24.267), BM-2 for Barrage 2 (ca 1,025 m asl; N 30°42.358, E 036°24.278), BM-3 for Barrage 3 (ca 1,025 m asl; N 30°42.472, E 036°24.233) and BM-11 for Barrage 11 (ca 1,030 m asl; N 30°42.252, E 036°24.568).

Barrage 1 was poorly preserved and was, therefore, only briefly examined by means of a small-scale excavation near the middle of the barrage wall. In addition, we cleaned a nearby bulldozer trench and examined the natural stratigraphy around the site. (For details of the natural stratigraphy at the site, see also the last report concerning the excavations at Wadi Nadiya 1.) Barrage 2 was more intensively examined by means of four excavation areas, three

of which aimed to define the range of an open-cut limestone quarry dug in front of the barrage wall. Though much smaller in scale, the same operation was carried out at Barrage 3 as well. Barrage 11, on the other hand, was only briefly examined by means of surface cleaning. Excavated soil from the first three barrages was not sieved owing to the extreme scarcity of small finds.

### Excavation of Barrage 1

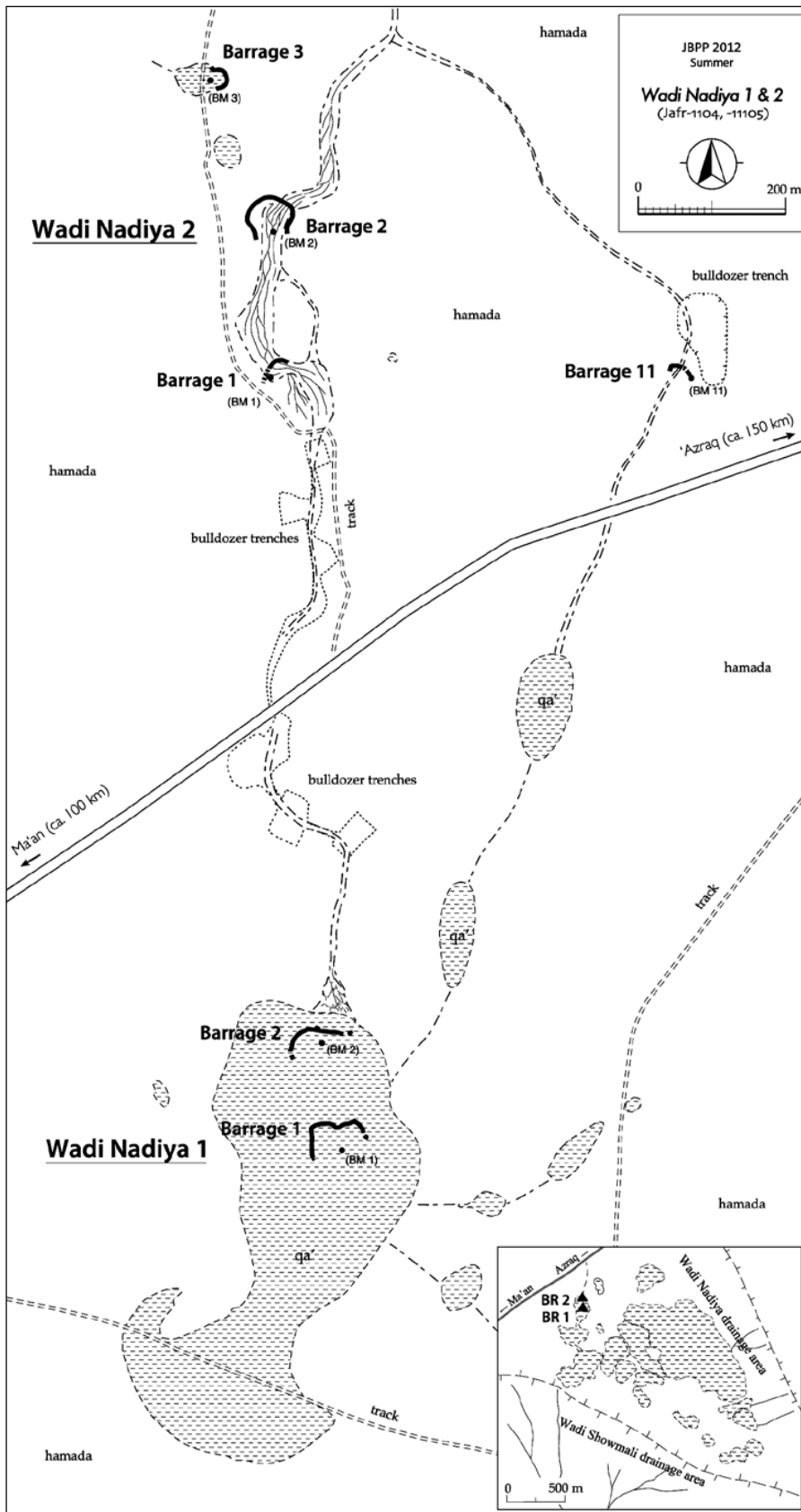
Barrage 1 is located ca 1 km downstream or north of Barrage 2 of Wadi Nadiya 1, with the Azraq - Ma'an highway (i.e. Route 5) running between them. It is constructed across a bend in the small *wadi* that drains from the upper barrage system (Fig. 3). This was probably done to protect the barrage from seasonal floods. As a matter of fact, a well-developed braided channel covers the surrounding *wadi* beds, indicating



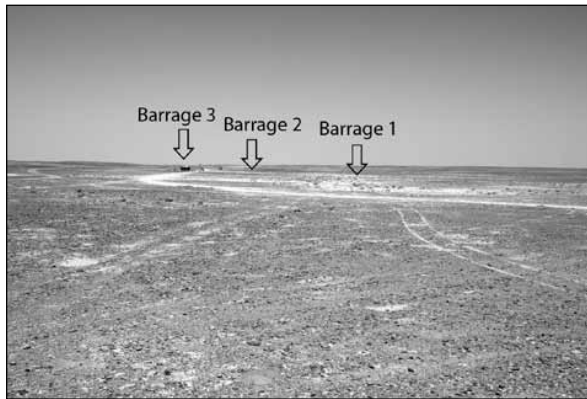
2. Wadi Nadiya 2: site location and its surrounding topography.

that the flow velocity of the *wadi* is (and probably was) reduced at the turning point. As noted below, Barrage 2 was constructed in a similar location downstream, suggesting that placement on a *wadi* bend was the norm for the barrage system of Wadi Nadiya 2.

The barrage wall is designed so as to bridge both banks, tracing a gentle curve ‘opening’ in an upstream direction. However, it is poorly preserved and survives only in sections owing to repeated floods. The washouts focus on the western half of the barrage wall, corroborating



3. Wadi Nadiya 1 and 2: site plan.



4. Wadi Nadiya 2: distant view of the site (looking NE).

the hydrodynamic principle that the current in a river / wadi is strongest on the outside of a bend. The barrage wall is *ca* 55 m in minimum length (including the intermittent gaps) and up to *ca* 0.4 - 0.5 m in height from the prehistoric ground surface.

#### Area 1

Area 1 was opened to examine the structure of a well-preserved wall segment (WS-5/6) near the middle of the barrage wall. The excavation showed that the wall segment was constructed of a single row and single course of undressed or partly dressed limestone cobbles and boulders placed in an upright position, and that it was based on a foundational bank *ca* 3 m in width and *ca* 0.1 - 0.2 m in preserved height (Figs. 5 and 6). As with the two upper barrages, a large pit *ca* 0.5 - 0.6 m in depth was identified in front of the wall. This pit reaches the upper surface of Layer 5 and probably represents part of an open-cut quarry excavated for the procurement of construction material. However, unlike Barrage 1 (but like Barrage 2) of Wadi Nadiya 1, the northern edge of the open-cut limestone quarry was not equipped with a subterranean masonry retaining wall that would have protected the main body of the barrage wall from erosion. The far end of the pit extended beyond the excavation area, but it seems likely that the quarry was several meters wide and extended in a gentle arc along the barrage wall. No *in situ* finds were recovered, but a tabular scraper core (Fig. 17: 1), a robust tabular scraper (Fig. 17: 2) and a spherical hammerstone made of a cortical flint pebble (Fig. 17: 3) were found close together in the upper fill layers. The occurrence of these

Chalcolithic - EB flint artifacts allows us to define a *terminus ante quem* for the construction of the barrage.

#### Bulldozer cut

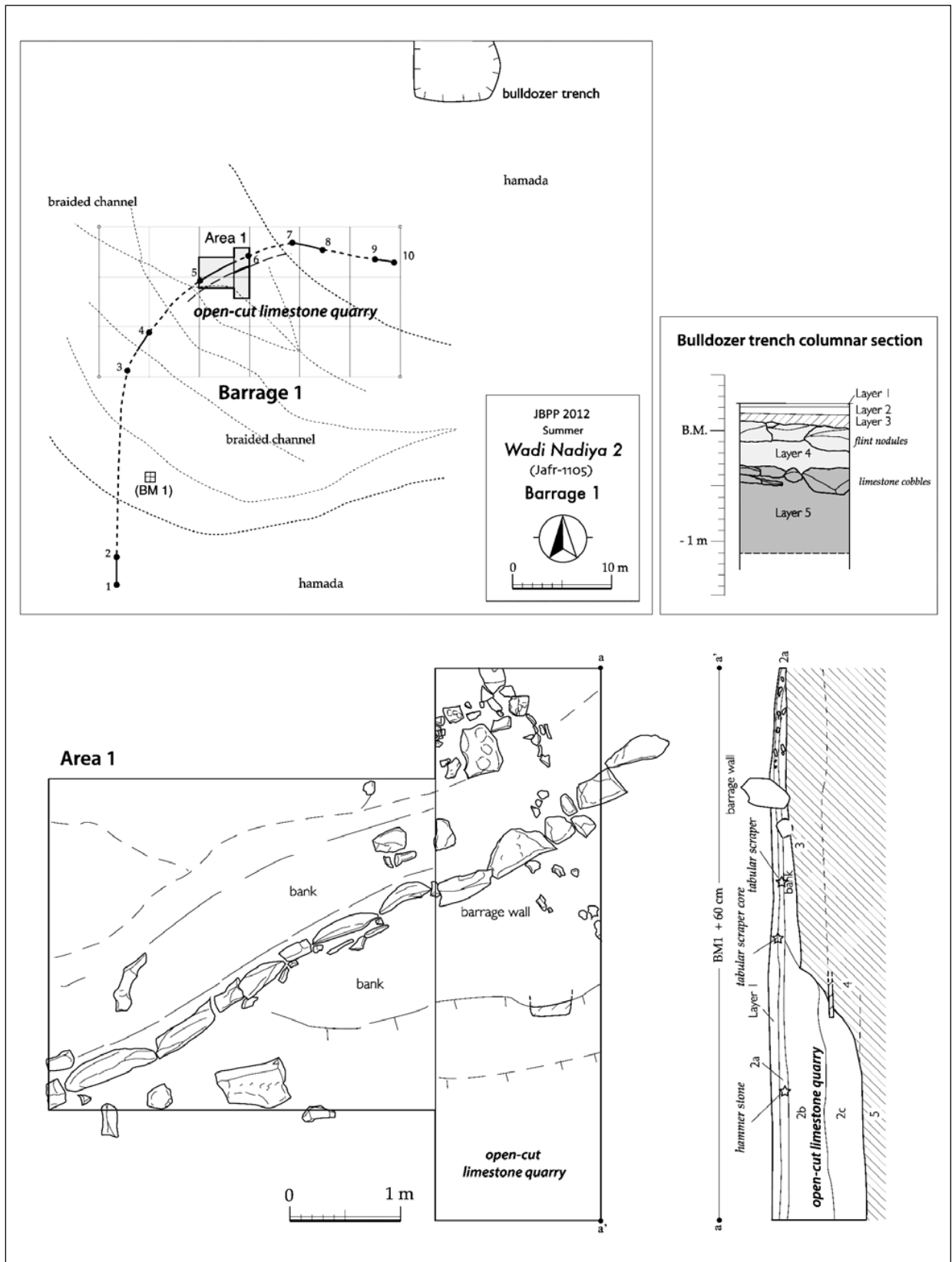
The cross-section of a nearby bulldozer cut confirmed that the natural stratigraphy of the site was almost identical to that of the upper barrage system (Fujii, Adachi *et al.* 2012: Fig. 24). Of significance is the fact that limestone cobbles and boulders adhere to the upper surface of the chalky limestone layer (i.e. Layer 5). It follows that the large pit in front of the neighboring barrage wall was dug to obtain these high-quality construction materials. The existence of a similar pit at Barrage 2 (described below) can be understood in the same context. (It should however be noted that, as evidenced by the site stratigraphy of Wadi Nadiya 1, a flint sub-layer occasionally takes the place of the limestone sub-layer. In this case, the barrage wall would have been constructed of flint nodules. This is the case with Barrage 3 [described below].)

#### Excavation of Barrage 2

Barrage 2 is located at the top of another bend *ca* 200 m downstream from Barrage 1 (Fig. 3). It was constructed so as to enclose the small wadi, tracing a large semi-circle *ca* 60 m across. The barrage wall, which was *ca* 135 m in total length and up to *ca* 0.6 - 0.7 m in preserved height, was equipped with a bottleneck-like inlet *ca* 40 m wide (Figs. 7 and 8). This was the largest of the three barrages and its semi-enclosed flood zone was estimated at *ca* 0.2 ha. Here again, a well-developed braided channel extended over the surrounding wadi beds, confirming that the stream velocity of the wadi is (and probably was) reduced to a significant extent by the presence of the bend on the one hand and the barrage on the other.

#### Area 1

This elongated, trench-like excavation area was set up across the central part of the barrage wall. The excavation revealed a poorly constructed masonry wall up to *ca* 0.4 - 0.5 m high, which was supported by a *ca* 4 m-wide rear bank covered with limestone and flint rubble (Fig. 9). The rubble layer probably aimed to protect the bank from erosion. Here again, an open-cut



5. Barrage 1: plan and cross-section.



6. Barrage 1: general view of Area 1 (looking N).

limestone quarry *ca* 0.5 - 0.6 m in depth was identified in front of the barrage wall. It reached the upper surface of Layer 5, corroborating that the large pit was dug to procure construction materials. As with Barrage 1, it was not associated with a subterranean masonry retaining wall that would have protected the main body of the barrage from seasonal floods. No datable *in situ* finds were recovered.

#### Areas 2, 2/3 and 3

These three excavation areas were set up intermittently along the major axis of the barrage with a view to locating the far end of the open-cut limestone quarry identified in Area 1. It turned out that the quarry gradually terminated near the northern edge of Area 2/3 (Fig. 7). It follows that the quarry had a width of *ca* 20 m, although it probably represents a cluster of smaller quarrying pits. In view of the fact that its eastern extent was confirmed in Area 4, it is conceivable the open-cut quarry traced a semi-circle in front of the barrage wall.

A limestone cobble was found *in situ* near the middle of Area 2, in a state of being removed from the upper surface of Layer 5 (Fig. 10). Also of interest is the existence of a large pit (within the pit) beside the cobble, which demonstrates that, when necessary, the barrage constructors dug below Layer 5 in search of more substantial construction material. Area 2 yielded a diagonally truncated stone bar (Fig. 17: 8) and a flint bowlet (Fig. 17: 9), both of which are described in more detail below.

#### Area 4

This excavation area was opened along the

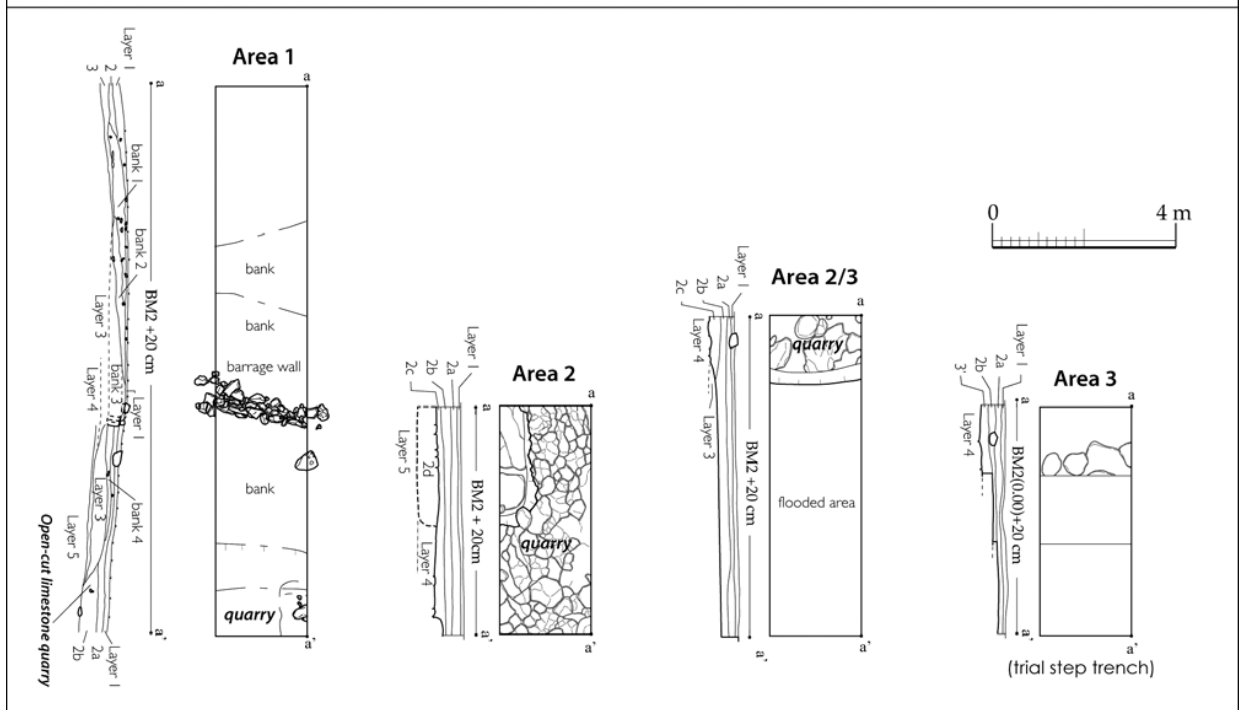
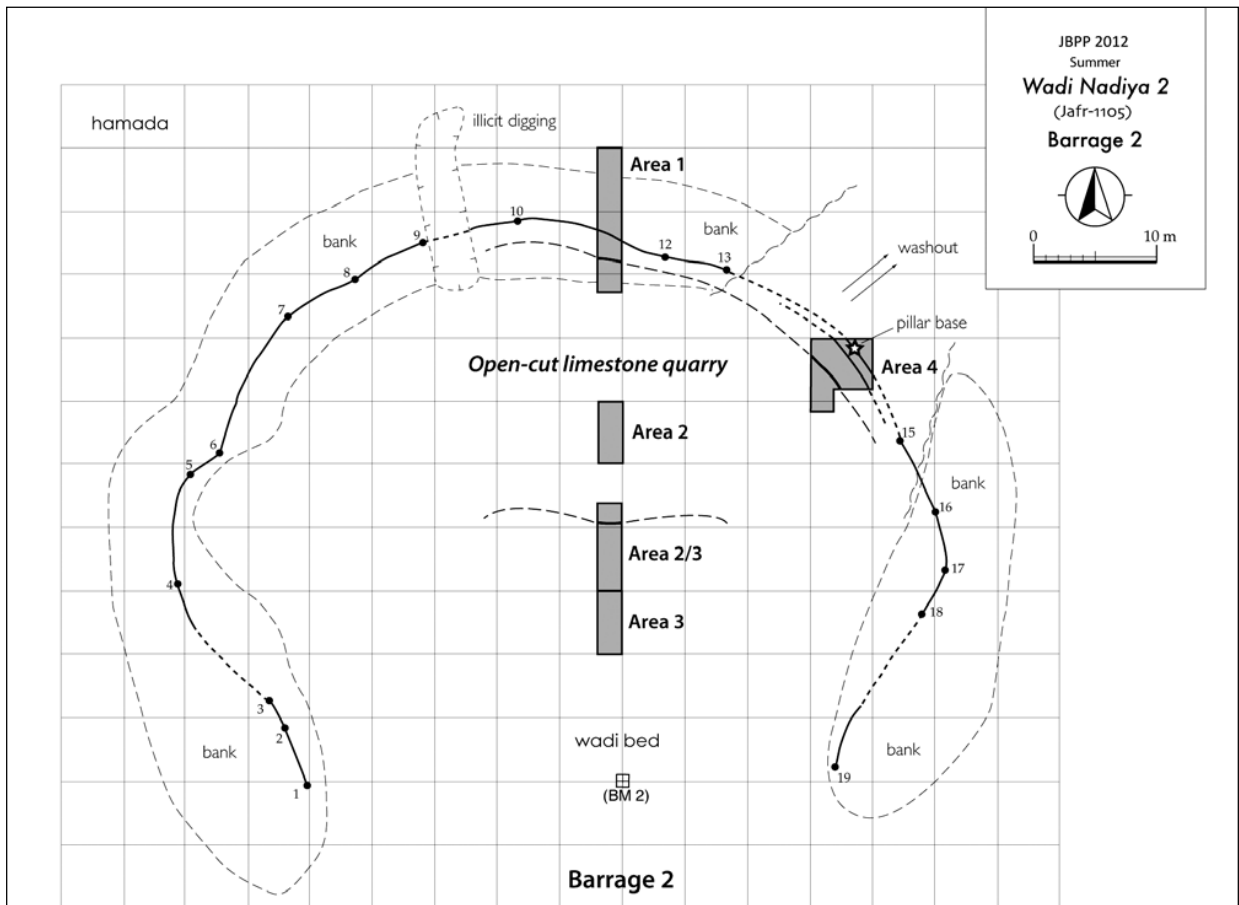
north-eastern part of the barrage wall, roughly in the center of the washout, to explore the structure of the wall segment subject to the strongest sideways water pressure. The excavation revealed that the wall segment directly overlays thermal-flaked flint nodules forming the upper surface of Layer 4 (Figs. 11 and 12). This means that the Layer 3 silty sand deposits (upon which the Jafr PPNB barrages were normally constructed) had already been washed away when the barrage was built, leaving the jagged flint sub-layer exposed in the *wadi* bed. Unlike the other wall segments, large limestone cobbles and boulders were used for the construction of this key part of the barrage wall. In addition, they were arranged in two rows with rubble core in between. Of interest is the fact that, while the rear wall used smaller but more standardized stones and arranged them in stretcher bonds, the front wall used larger but less standardized stones and placed them in header bonds. This contrast allows us to view the former as the main body of the barrage and the latter as a sort of protection wall. A large pillar base, a chronological marker of the Jafr PPNB, was found in incorporated into the rear wall (Fig. 13).

The open-cut limestone quarry in this excavation area was much deeper (*ca* 0.7 - 0.8 m) than in the other excavation areas and reached the middle part of Layer 5, where large limestone boulders were often concentrated. This is probably because the construction of this key wall segment required construction materials large enough to withstand the full force of seasonal flooding. It is also conceivable that the deep depression in front of the barrage wall helped to slow surging floodwaters. Regardless, the remarkable differences in both structure and construction materials between Areas 1 and 4 confirms that careful thought went into the design and construction of the barrage.

In addition to the pillar base, the area yielded a dozen early Islamic grayish ware sherds from the lower fill layer (Fig. 17: 10). These are described below in some detail.

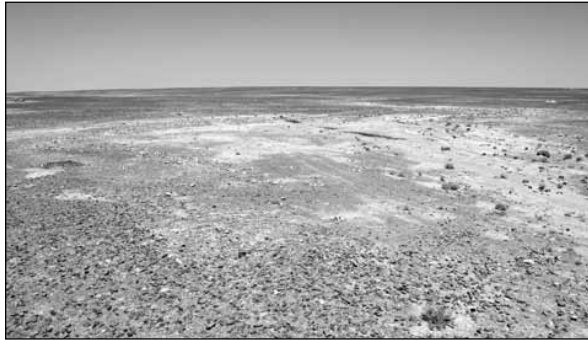
#### Excavation of Barrage 3

Barrage 3 is located *ca* 200 m NNW of Barrage 2. However, it is *ca* 150 m distant from the small *wadi* and instead occupies flat terrain at the lower edge of a small-scale closed drainage



7. Barrage 2: plan and cross-sections.





8. Barrage 2: general view (looking NE).



9. Barrage 2: general view of Area 1 (looking NW).



10. Barrage 2: general view of Area 2 (looking N).

system. For this reason, a small playa (instead of a braided channel) has formed in its flood zone. The barrage has a semi-circular plan opening westward and is equipped with a short, slightly out-curved guiding wall at both ends (Fig. 14). This barrage is relatively well-preserved and is characterized by its small size, semi-enclosed plan and a well-developed rear bank covered with flint rubble. The total length of the barrage wall is *ca* 55 m and its preserved height *ca* 0.2 - 0.3 m. Instead of limestone cobbles, angular flint nodules *ca* 20 - 40 cm long are used as the main construction material. As noted above, this is

probably due to minor differences in the nature of the underlying strata as a source of construction material. No *in situ* finds were recovered.

#### Area 1

Bearing the results from the upper two barrages in mind, we set up an elongated excavation area along the main axis of the barrage and examined the structure of the open-cut quarry and central wall segment behind it. It turned out that the quarry was *ca* 5 m wide and *ca* 0.8 m deep, extending along the barrage wall. Although we could not identify both ends of the quarry owing to time constraints, it probably traces an arc along the barrage wall. A pile of angular flint nodules (similar to those used in the construction of the barrage wall) was found at the eastern edge of the quarry, immediately below the barrage wall. These were probably prised out of the bottom of the quarry (i.e. the upper surface of Layer 5), but were left unused for some reason. This discovery once again attests to the function of the large pit in front of the barrage wall as an open-cut quarry.

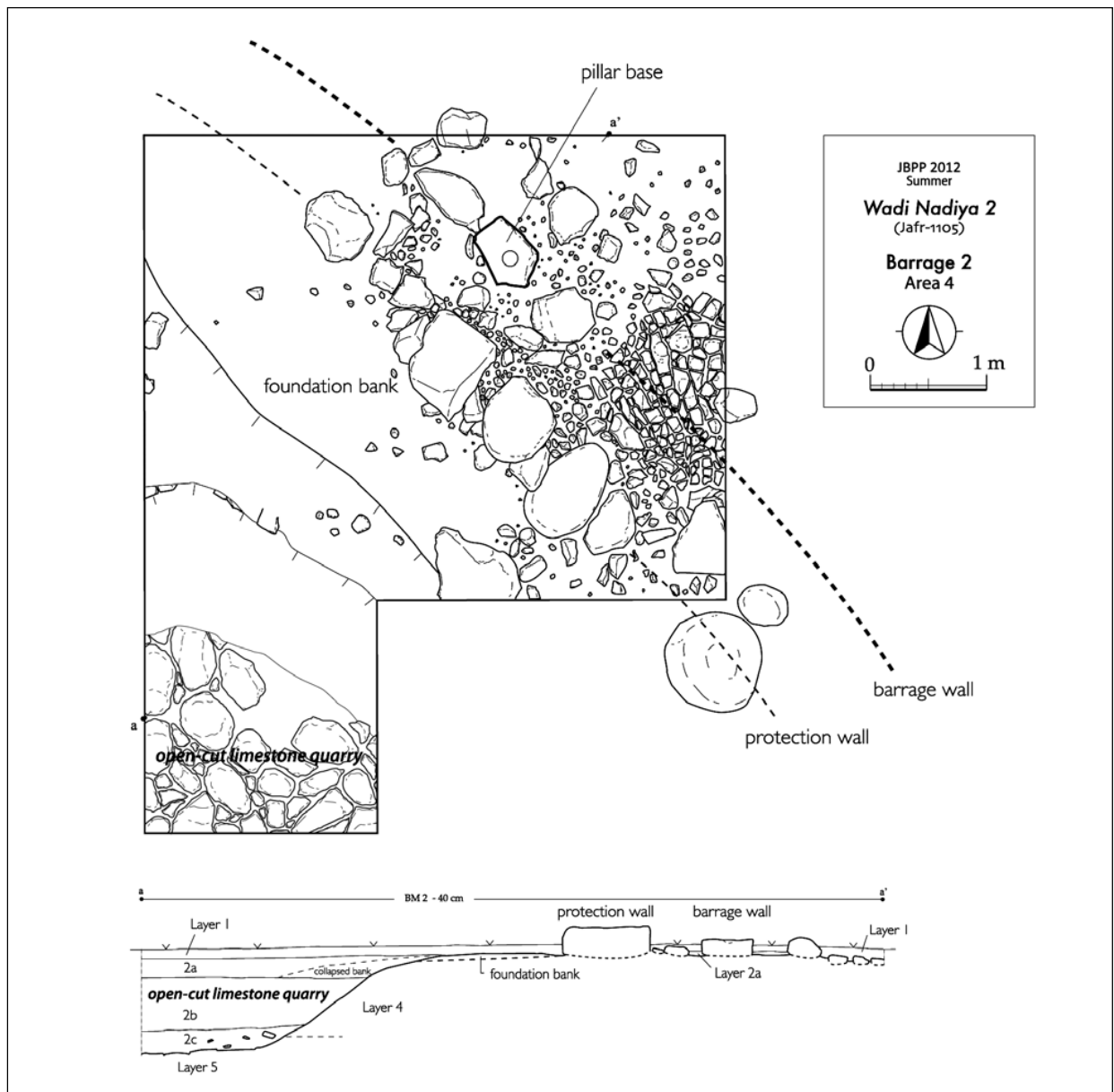
The barrage wall was simple in structure, being constructed of a single row and single course of angular flint nodules arranged in stretcher bonds. What interested us more was the rear bank, which was *ca* 5 m wide, *ca* 0.3 - 0.4 m high and was covered with flint and limestone rubble. There is no doubt that both of these construction materials were sourced from the adjacent open-cut quarry. It follows that the quarry supplied construction material for both the rear bank and the barrage wall. The open-cut quarry probably also served as an *ad hoc* cistern for storing seasonal run-off surface water - a rational device well-suited to highly mobile groups such as early pastoral nomads.

#### Area 2

This small excavation area was established 1 m west of Area 1 with a view to checking the extent of the open-cut quarry. The excavation confirmed that the quarry ended in the western part of Area 1 and did not reach the central part of the flooded area.

#### Investigation of Barrage 11

Though not excavated, a brief examination confirmed that this isolated barrage measured *ca* 35 m in total length and was constructed of



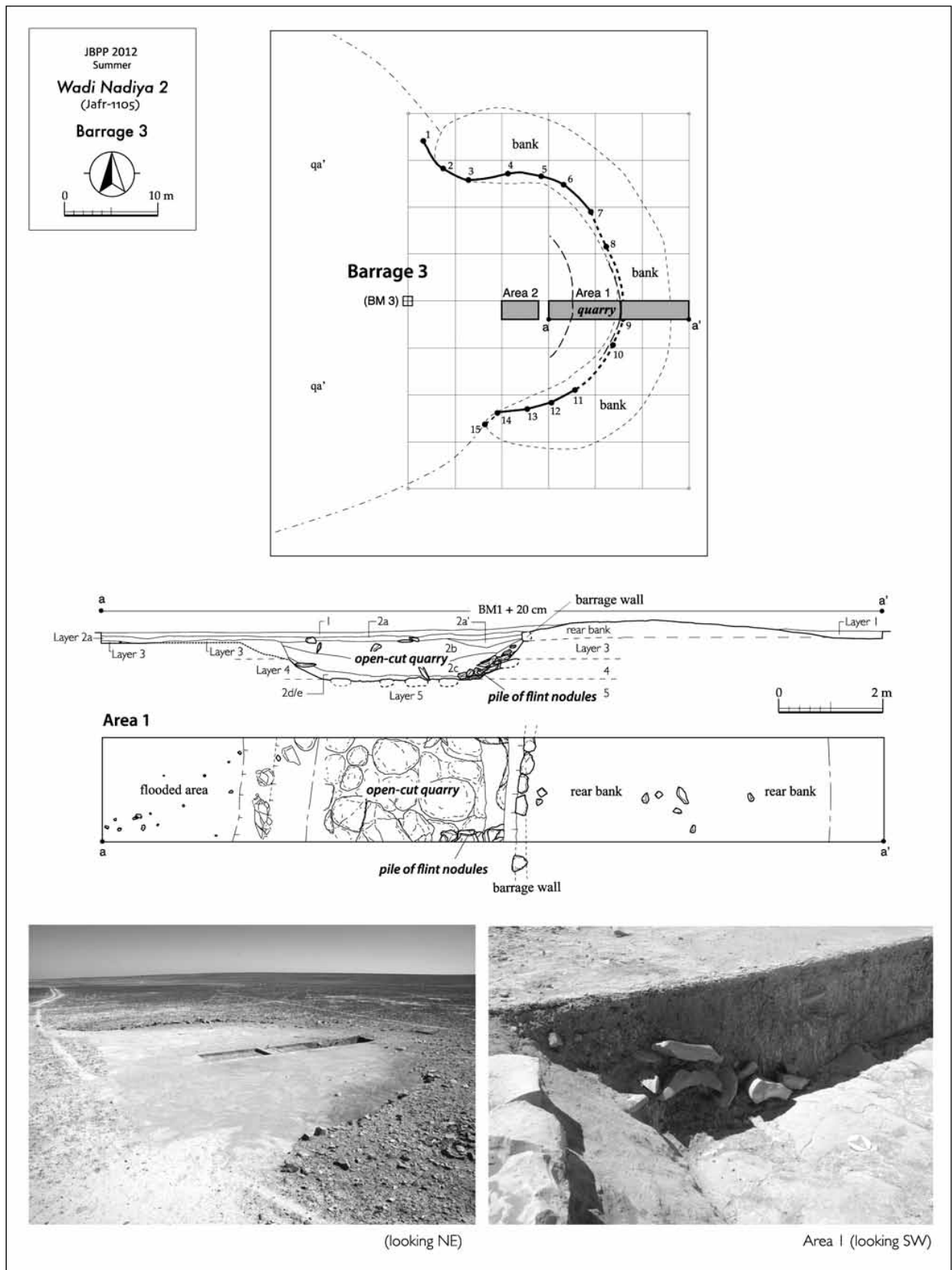
11. Barrage 2: plan and cross-section of Area 4.



12. Barrage 2: general view of Area 4 (looking NE).



13. Barrage 2: close-up view of the barrage wall at Area 4 (looking N).

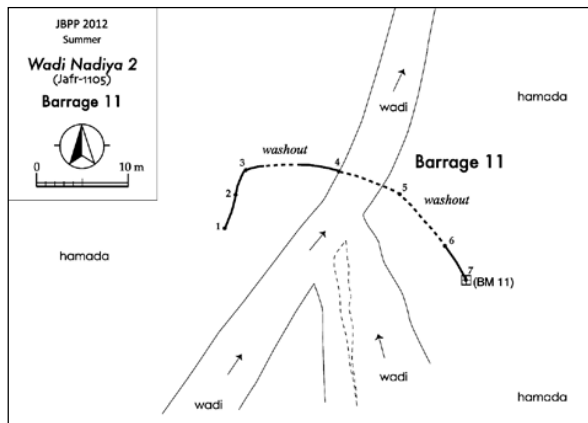


14. Barrage 3: plans and cross-section.

a single row and single course of undressed or partly dressed limestone cobbles that were usually placed in an upright position (Figs. 15 and 16). It had much in common with Barrage 1, including its location near a bend in a small wadi, an arc-shaped general plan, its overall dimensions and the frequent use of upright stones. There is a possibility that, as with Barrage 1, this barrage likewise represents the uppermost feature of a barrage system, but no clear evidence for lower features was confirmed (Fig. 3). No artifacts were found.

### Small Finds from Wadi Nadiya 2

As is usual with extramural barrage sites, Wadi Nadiya 2 was very poor in small finds. Those recovered in and around the excavation areas were limited to a pillar base, a diagonally truncated stone bar, a small number of chipped flint artifacts and a dozen early Islamic pottery sherds. Although none except the pillar base were found *in situ*, they do provide some insight into the date of the barrage system.



15. Barrage 11: schematic plan.



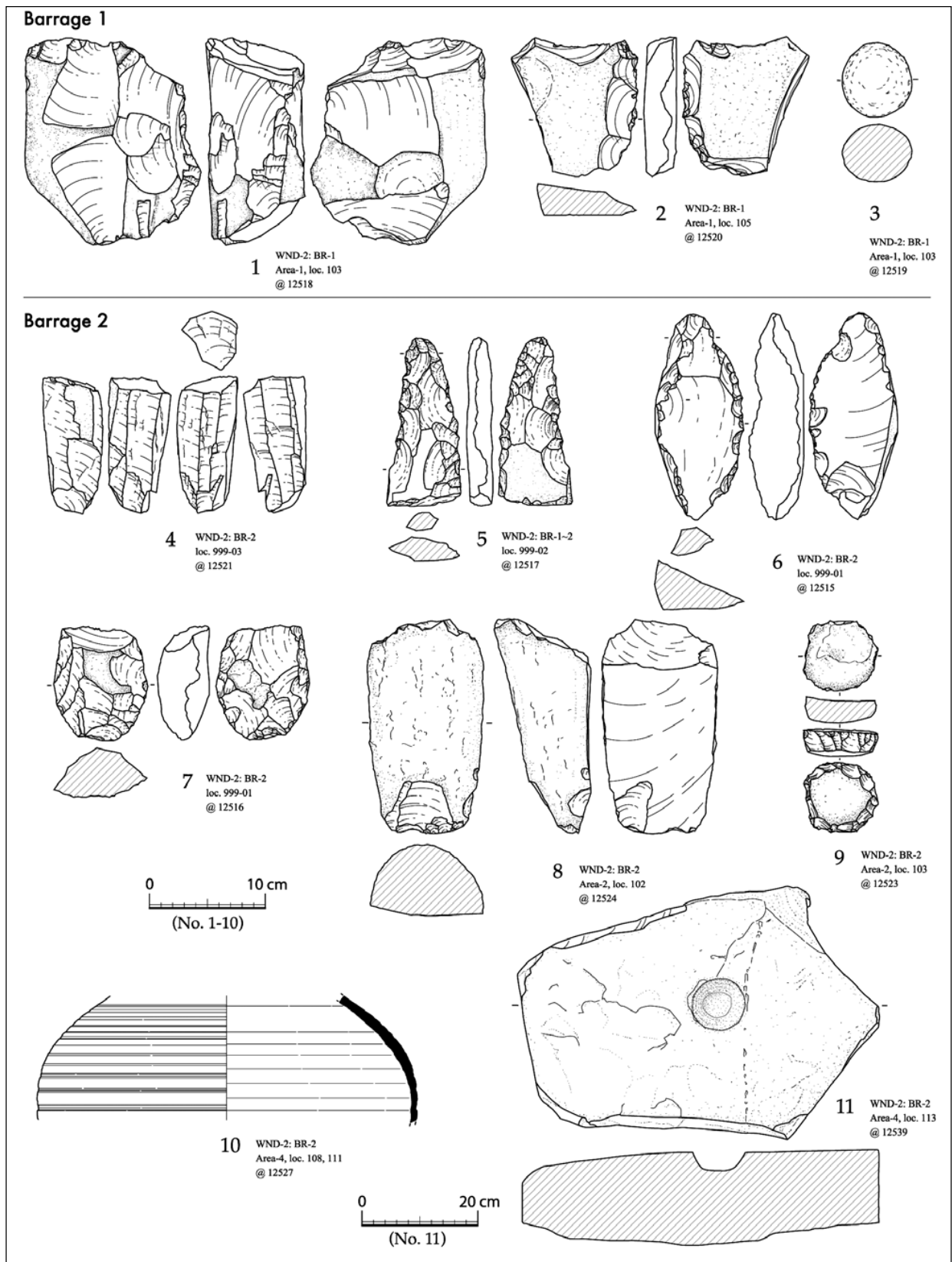
16. Barrage 11: general view (looking NW).

### Pillar base

As noted above, Barrage 2 incorporated a large pillar base within the central wall segment that faced the seasonal floods of the small wadi (Fig. 13). This limestone object was 63 cm long, 14 cm thick and weighed *ca* 59 kg, being equipped with a small concavity (9 cm in diameter and 3 cm deep) roughly in the center of its flat upper surface (Fig. 17: 11). No notable macroscopic use-wear was recognized in the concavity. Similar artifacts have been found at two PPNB outposts and several contemporary barrages in the Jafr Basin (e.g. Fujii 2007b: Fig. 16, 2007c: Fig. 9; Fujii, Adachi *et al.* 2011: Figs. 32, 33; Fujii n.d.: Fig. 13). It appears that they were incorporated in a key wall segment as good luck talismans intended to secure the safety and longevity of the barrage (Fujii, Adachi *et al.* 2011: 206). There is little doubt that the pillar base from Barrage 2 shares a similar date and function with previously identified examples. This *in situ* find from the barrage wall provides a reliable clue to the date of the Wadi Nadiya 2 barrage system.

### Diagonally truncated stone bar

A diagonally truncated stone bar, another chronological marker of the Jafr Pastoral PPNB, was found as a stray find within an upper fill layer in the open-cut limestone quarry of Barrage 2 (Fig. 17: 8). This heavy-duty tool, 25 cm long and *ca* 3.4 kg in weight, is made of a cortical flint nodule. As with the flint bowlet described below, it was crafted to take full advantage of the original shape of the raw material, with secondary retouch being limited to diagonal truncations at either end. In view of its weight and the remarkable edge damage it had sustained, this *ad hoc* tool was probably used for digging the open-cut limestone quarry. A large number of similar examples, admittedly made mostly of limestone, have been reported from the PPNB agro-pastoral outposts of Wadi Abu Tulayha (e.g. Fujii 2008: Fig. 31, 2009a: Fig. 19) and Wadi Ghuwayr 17 (Fujii, Quintero *et al.* 2011: Fig. 27). The neighboring barrage system of Wadi Nadiya 1 also yielded a similar object (Fujii, Adachi *et al.* 2012: Fig. 34, no. 1). Though from a fill layer, the occurrence of this diagnostic artifact provides further support for dating the barrage system to the PPNB.



17. Barrages 1 and 2: small finds.

### Flint bowllet

The ‘flint bowllet’ is a palm-sized, pallet-like stone vessel peculiar to M - LPPNB settlements in southern Jordan. It is characterized by its unique production technique that takes full advantage of a thermally pitted, shallow concavity on the upper surface of a tabular flint nodule (Gebel 1999). While MPPNB bowllets is typically larger in size and roughly trimmed, LPPNB examples are usually much smaller with fine retouch along their periphery (Fujii 2009b, 2012a). A typical example of a LPPNB bowllet was found near the diagonally truncated stone bar, that is to say in the surface layer of Area 2 of Barrage 2 (**Fig. 17: 9**). This bowllet (125 gm in weight, 6.5 cm in diameter, 2.1 cm high and *ca* 2 - 3 cc in maximum capacity) is notable for its small size, elaborate lateral retouch and sophisticated profile. The occurrence of such a precious object, which seems somewhat out of place at an extramural water-use facility, hints at the presence of a nearby LPPNB outpost that would have functioned as the ‘operating body’ for the barrage system. Taking this into consideration, we feel able to narrow down the likely date of the barrage system to the LPPNB.

### Chipped flint artifacts

A small number of chipped flint artifacts were collected in and around the excavation areas of the three barrages. As described above, the finds from the upper fill layer of Barrage 1 included a tabular scraper core (**Fig. 17: 1**), a heavy-duty tabular scraper (**Fig. 17: 2**) and a spherical hammer stone (**Fig. 17: 3**). It is important to note that they were found close together as a rough ‘set’. As suggested above, their occurrence provides a *terminus ante quem* for the construction of the barrage. The upper fill layer of Barrage 2, on the other hand, yielded two blade cores (**Fig. 17: 4**), three digging tools (**Fig. 17: 5-7**) and several blades and flakes. The frequency of heavy-duty digging tools is characteristic of the Jafr Pastoral PPNB, and parallel examples have been found at Wadi Abu Tulayha (e.g. Fujii 2007a: Fig. 28, 2009a: Fig. 15) and Wadi Ghwayr 17 (Fujii, Quintero *et al.* 2011: Fig. 25), as well as at the neighboring barrage complex of Wadi Nadiya 1 (Fujii, Adachi *et al.* 2012: Fig. 34, no. 5-8). As with the diagonally truncated stone bar, they were probably used for digging

the open-cut limestone quarry (in the case of a barrage site) or foundation pit for semi-subterranean structures (in the case of an outpost). There is little doubt that these finds from Wadi Nadiya 2 were used for the former purpose. In addition, the barrage system yielded a few dozen miscellaneous flint artifacts (including Mousterian points, tabular scrapers and Jafr blades) as stray finds.

### Pottery

A dozen early Islamic grayish ware sherds were found in Area 4 of Barrage 2, in a lower fill layer within the open-cut limestone quarry (**Fig. 17: 10**). They were wheel-made, well-fired, tempered with dark gray sand particles (*ca* 1 - 5 mm across) and decorated with fine horizontal ribs. Refitting showed that they formed a single pot with an external diameter of *ca* 33 cm. It appears that they were probably swept away from some feature, probably a tomb, in the upper course of the *wadi*. Incidentally, similar sherds were found at Barrage 1 of Wadi Nadiya 1 (Fujii, Adachi *et al.* 2012: Fig. 34, no. 10-11), along with a gravestone inscribed with early Islamic letters (*ibid.*: Fig. 34, no. 9). The same is true of Barrage 1 at Wadi Abu Tulayha (Fujii 2007a: 409-411). These finds highlight the fact that there was unexpectedly frequent traffic in the Jafr basin during the early Islamic period. Also of significance is the fact that, as evidenced by traces of washout, most of the residual spoil of the open-cut quarries was carried away by repeated floods and replaced by later deposits. This makes it difficult to date the barrage systems and reconstruct the ancient environments around them on the basis of the barrage deposits.

### Surrounding Features

In addition to Loc. 2001, found last season, three surrounding features were newly discovered during the course of the excavations at Wadi Nadiya 2 (**Fig. 2**). Loc. 2002 is situated *ca* 0.4 km south-west of Barrage 1. It is a small concentration of petroglyphs, which depict herbivorous animals and other miscellaneous figures on cortical limestone cobbles. Both pecking and line-drawing technique were used separately but, in view of the marked difference in the degree of weathering, the former technique appears to be much earlier in date than the latter. In addition,

*wasm*-like signs as well as Thamudic and Islamic letters were inscribed either separately from or overlapping the petroglyphs.

Loc. 2003, situated *ca* 0.5 km west of Barrage 1, is a small flint workshop. Tabular scraper cores and their related debitage class samples were found sporadically, but tool blanks - to say nothing of finished products - were very scarce. Most of the cores used locally available small cortical tabular flints, found scattered on the ground surface, as raw material, suggesting that the workshop was *ad hoc* in nature and not associated with flint mines.

Loc. 2004 occupies a gentle slope *ca* 0.8 km north of Barrage 3. The site included a semi-circular feature *ca* 8 - 10 m long, *ca* 4 - 5 m wide and *ca* 0.3 m in preserved height. It was poorly preserved, and its function and date remain unknown.

### Supplementary Investigations of the Jafr Neolithic Barrage Systems

On the basis of the results of our research at Wadi Nadiya 2, we conducted a brief re-examination of Wadi Nadiya 1 and Wadi Ghuwayr 106. These supplementary investigations reconfirmed that each of these barrage systems was associated with a large-scale open-cut limestone quarry that supplied construction material and, at the same time, functioned as an *ad hoc* cistern storing seasonal runoff surface water. (The contemporary barrage systems of Wadi Abu Tulayha and Wadi Ruweishid ash-Sharqi were not revisited due to time constraints, but both will be re-examined next season.) It also turned out that the PPNB outpost of Wadi Ghuwayr 17 was equipped with a small cistern. In addition, a brief survey in the eastern part of the Jafr basin provided valuable insights into the functional evolution of the Neolithic barrage system.

#### Wadi Nadiya 1

The barrage system of Wadi Nadiya 1 was excavated last season, when a large-scale open-cut limestone quarry was found for the first time at Areas 1, 2 and 5 of Barrage 1 (Fujii, Adachi *et al.* 2012). With a view to ascertaining the western extent of the quarry, we enlarged Area 6 and pursued further details of its stratigraphy. The re-examination demonstrated that the quarry extended as far as the western half of the system,

but that the subterranean retaining wall protecting the barrage wall from erosion did not and that it terminated somewhere between Area 2 and Area 6 (**Fig. 18**).

In addition, the re-examination of Area 1 at Barrage 2 confirmed that the lower barrage was also associated with an open-cut limestone quarry *ca* 1 m deep and that the quarry was equipped with protective banks instead of a subterranean masonry retaining wall (**Fig. 19**). It also suggested that, as at the lower three barrages, the poor quality of the construction material procured in the quarry necessitated the construction of foundation banks underlying the barrage wall.

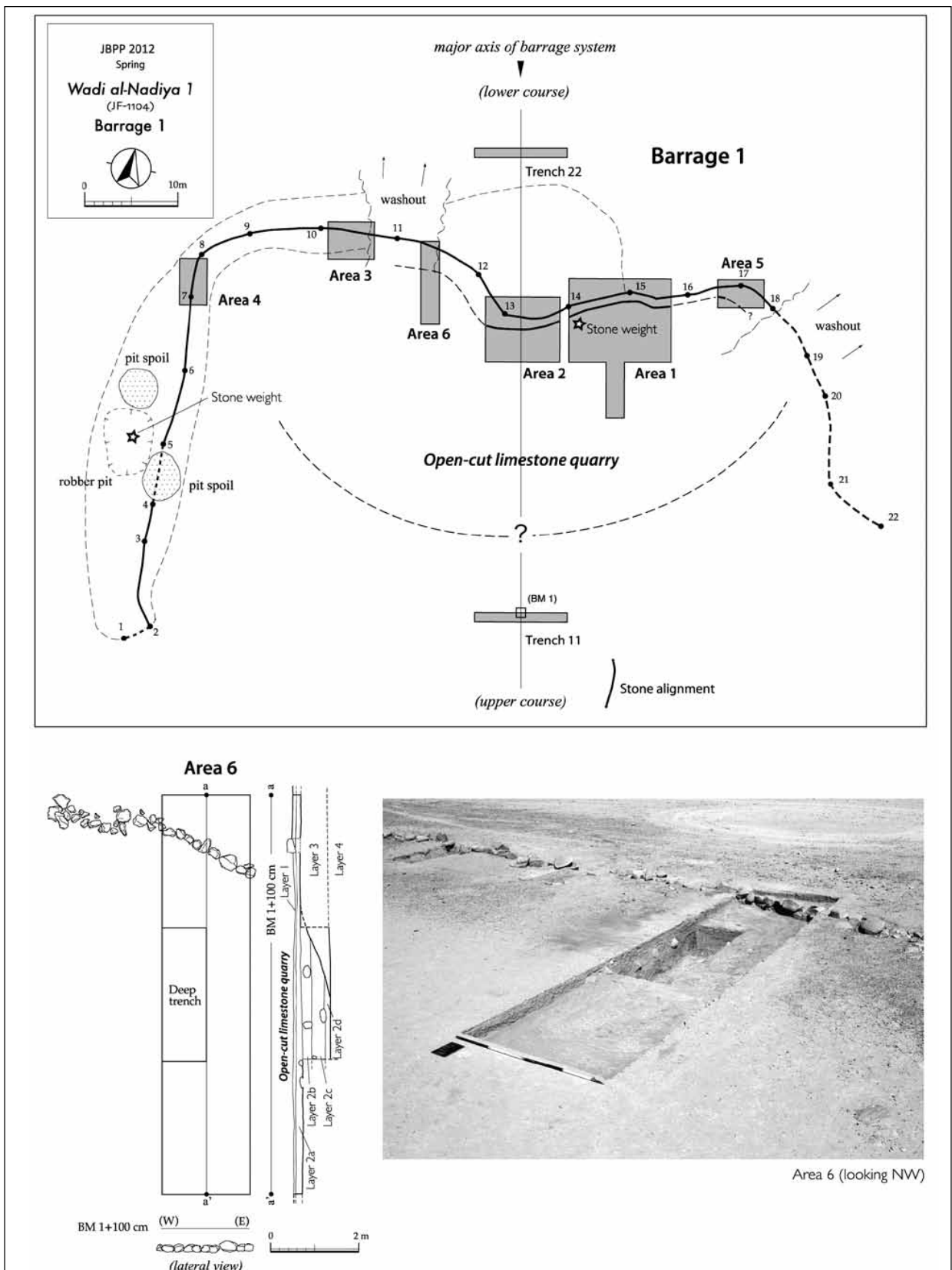
#### Wadi Ghuwayr 106

The barrage system of Wadi Ghuwayr 106 is located *ca* 20 km south-east of Wadi Nadiya 1 and 2. It was excavated in 2010, but no clear evidence for a quarry was found at that time (Fujii, Adachi *et al.* 2011). The re-excavation of the central parts of Barrages 1 and 2 revealed the existence of an open-cut limestone quarry *ca* 1 - 1.2 m deep in front of both (**Figs. 20 and 21**). Once again, no subterranean retaining wall was associated with the lower edge of the quarries. A stone concentration in front of the main wall of Barrage 1 is worthy of note. Our previous report interpreted it as a remnant of a protruding reinforcement wall aimed at protecting the barrage wall, but further scrutiny this season confirmed that it represents part of the erosion-control material that covered the edge of a subterranean bank in front of the barrage wall.

#### Wadi Ghuwayr 17

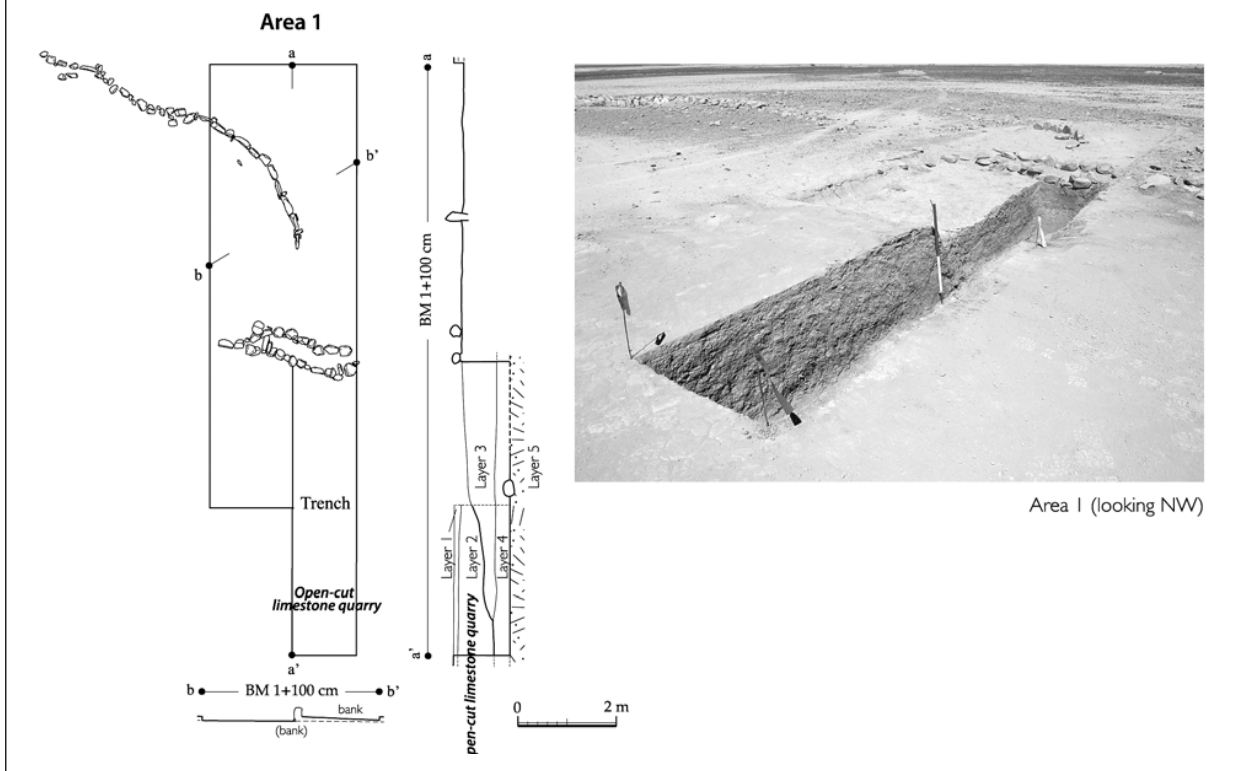
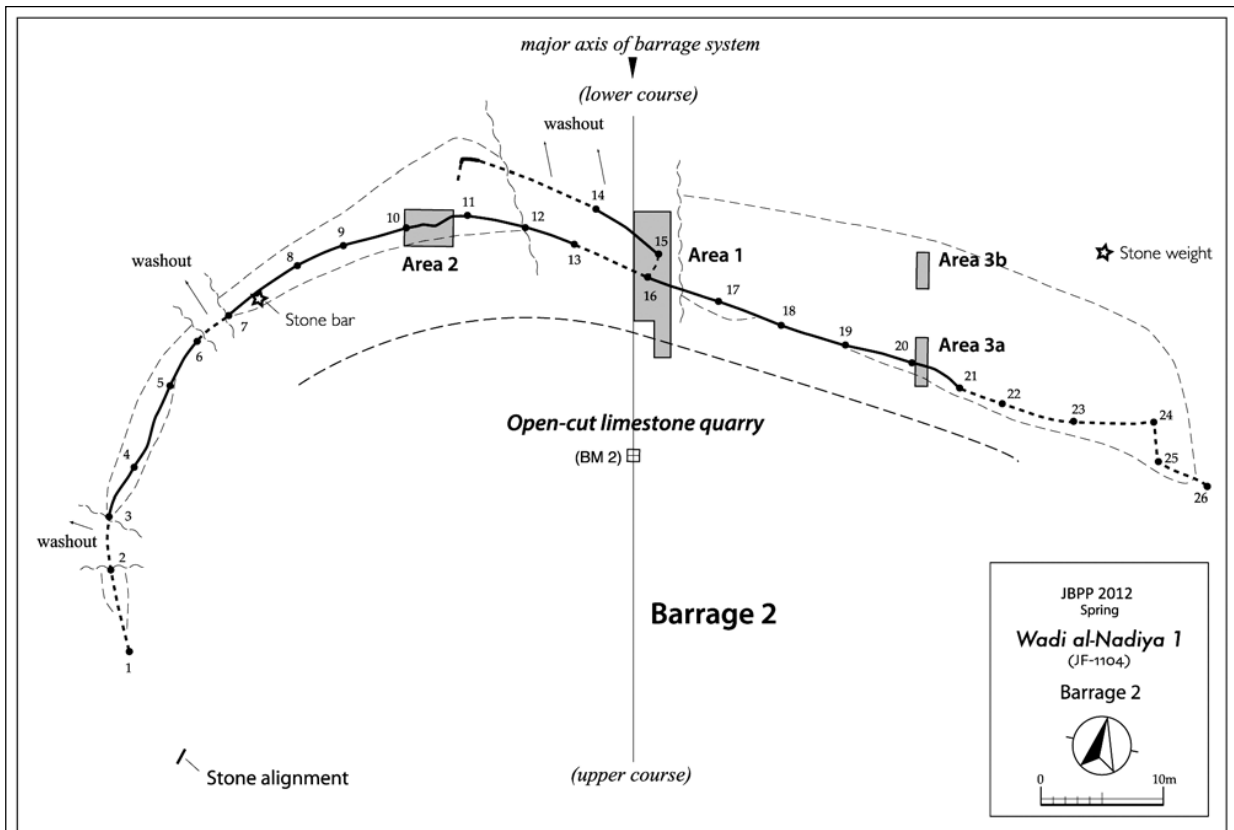
Taking advantage of our re-examination of the barrage system of Wadi Ghuwayr 106, we also conducted a brief re-investigation of the neighboring PPNB agro-pastoral outpost of Wadi Ghuwayr 17 (previously excavated in 2010 [Fujii, Quintero *et al.* 2011]). Our operation focused on a short stone alignment *ca* 130 m north of the main body of the outpost, which was found by chance when we revisited the site last season (**Fig. 22**).

The excavation demonstrated that the stone alignment represented part of a small structure (Structure 101) *ca* 3 m long, *ca* 0.5 - 1.2 m wide and *ca* 0.5 - 0.7 m deep (**Fig. 23**). What is important is that: (1) it is separated from the main

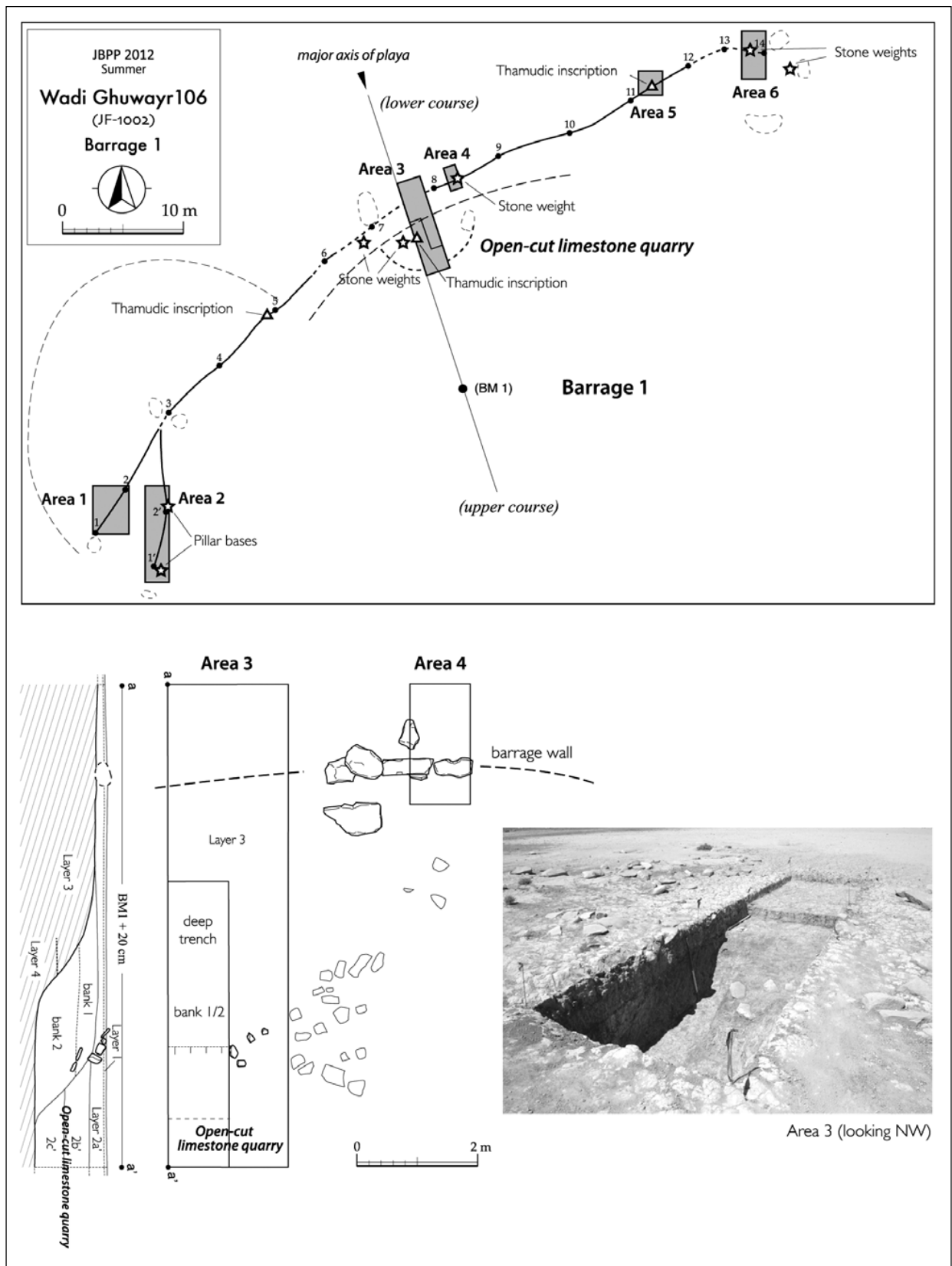


18. Wadi Nadiya 1: plan and section of Barrage 1.

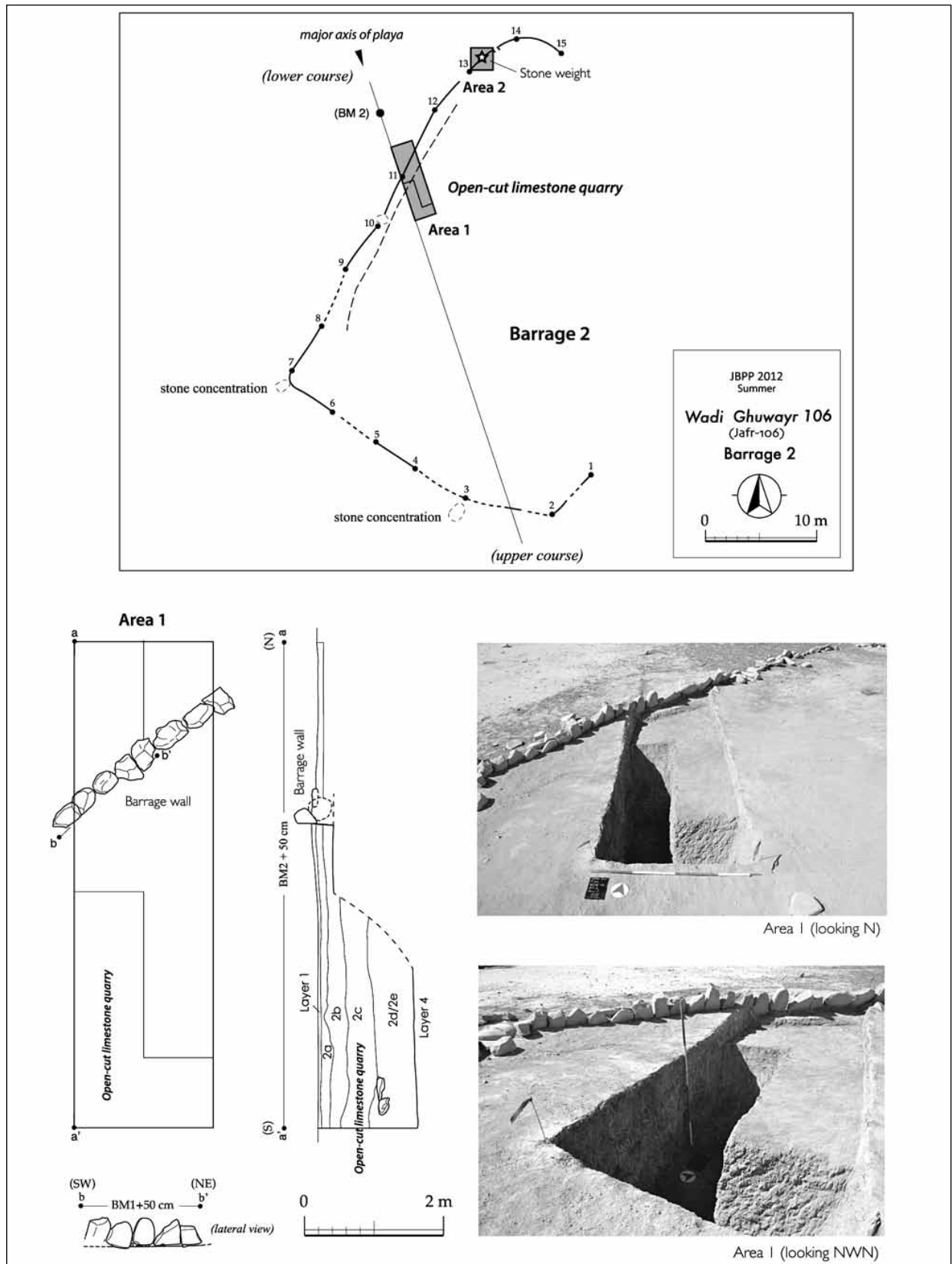




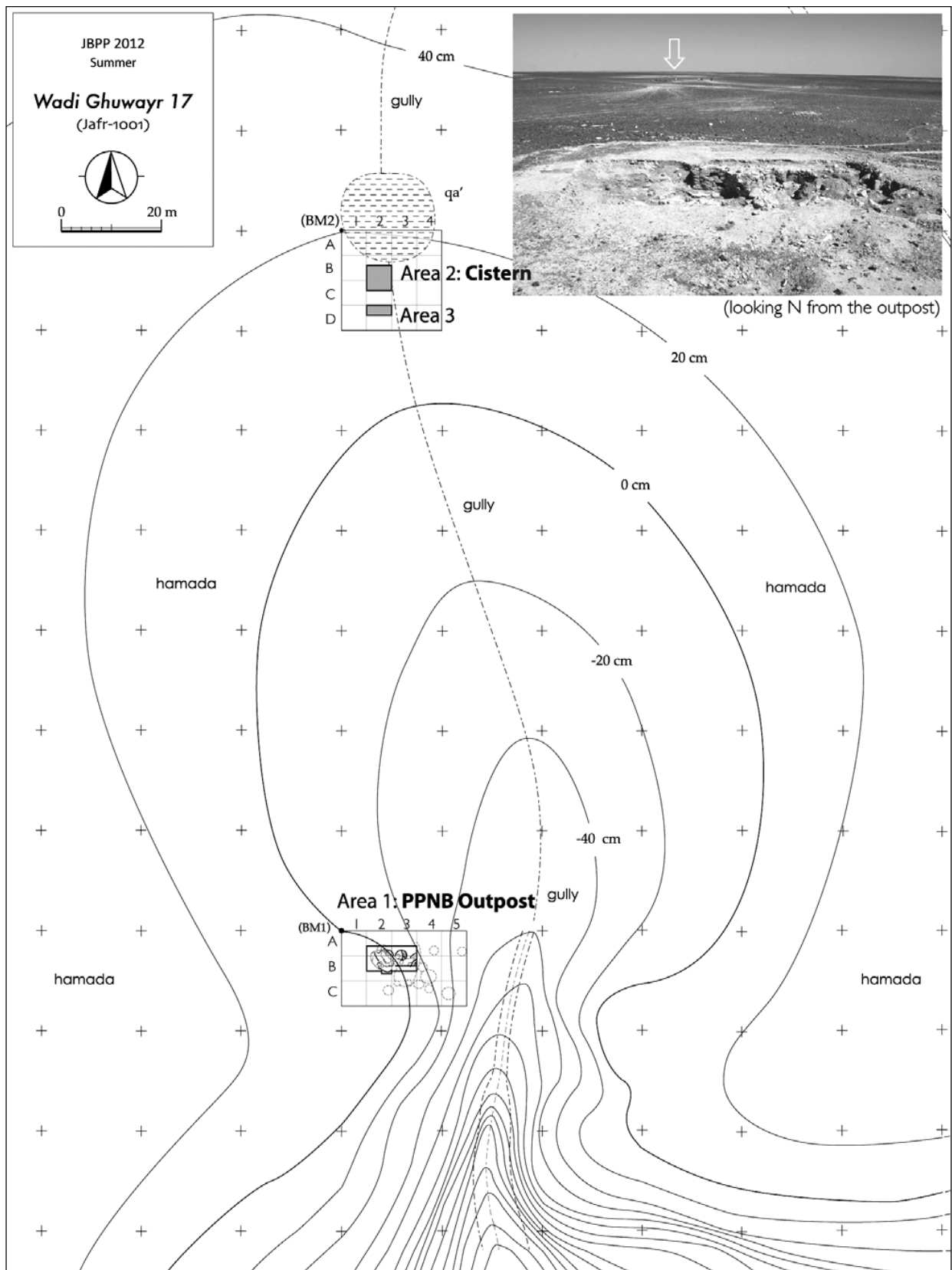
19. Wadi Nadiya 1: plan and section of Barrage 2.



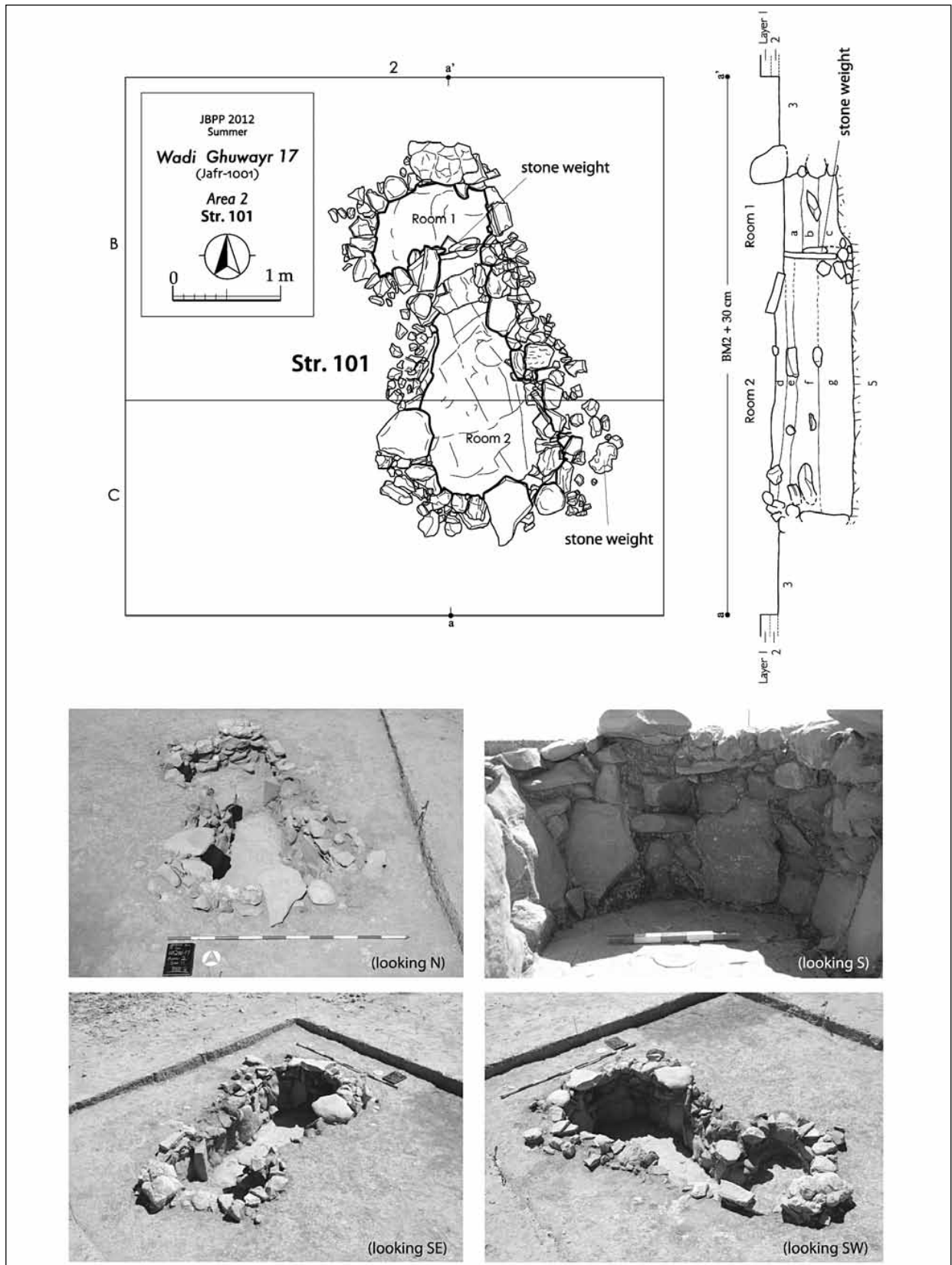
20. Wadi Ghuwayr 106: plan and cross-section of Barrage 1.



21. Wadi Ghuwayr 106: plan and cross-section of Barrage 2.



22. Wadi Ghuwayr 17: site plan.

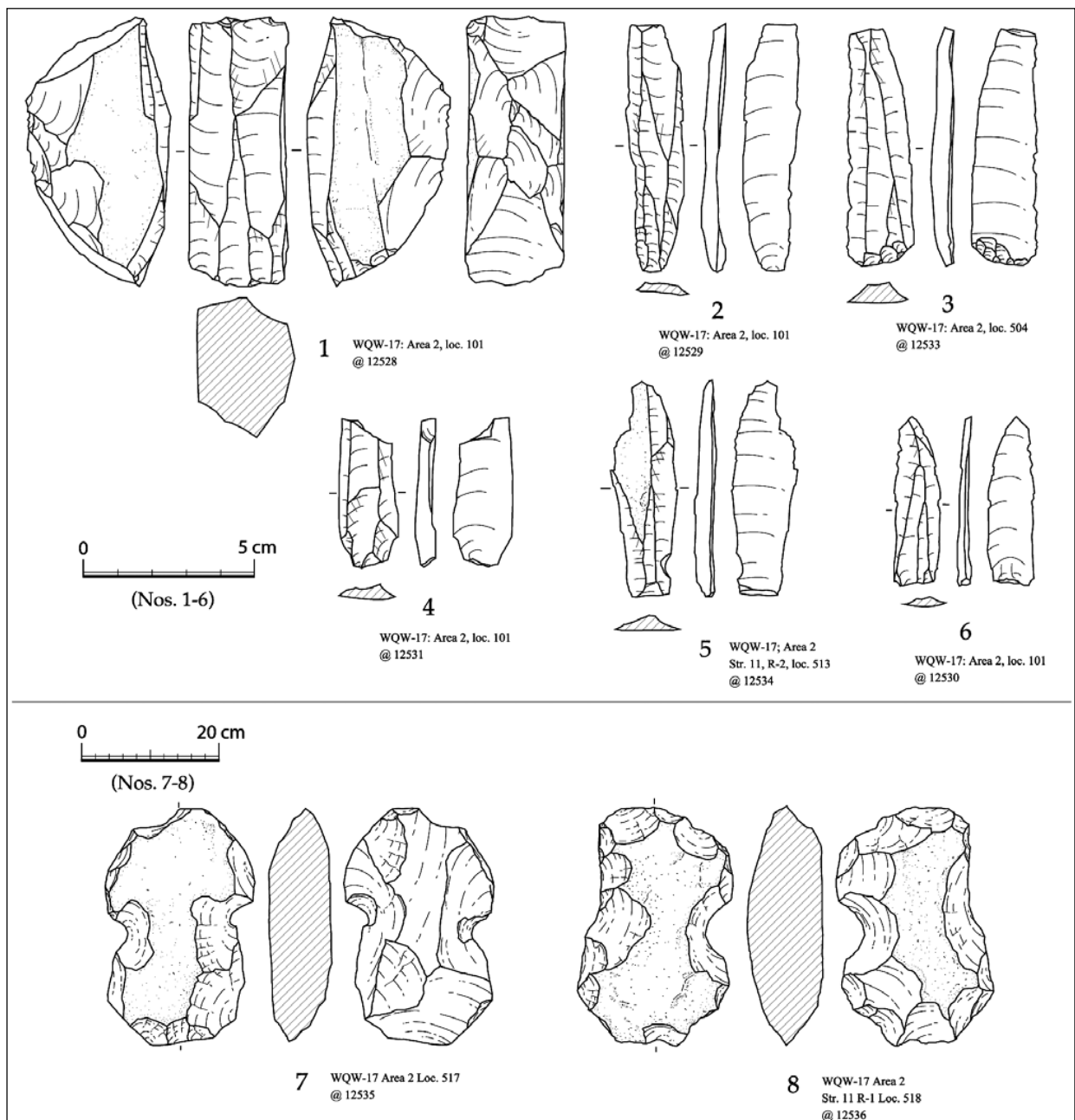


23. Wadi Ghuwayr 17: plan and cross-section of Structure 101.

body of the outpost and, unlike the outpost, occupies a *wadi* bed; (2) as evidenced by excavations at the neighboring Area 3, it is isolated and does not form a structural complex of multiple features; (3) its masonry wall is partially coated with a layer of clay mortar *ca* 5 cm thick. These traits allow us to interpret the feature as a small cistern. In contrast to the neighboring outpost, neither hearths nor *in situ* artifacts were found on the floor of the structure. Even stray finds

from fill layers were very scarce, being limited to a dozen flint artifacts including naviform core and blade components (Fig. 24: 1-6).

Given this functional identification, it would follow that the site is a second example of the 'triple set' of the Jafr Pastoral PPNB (i.e. outpost, barrage system and cistern), after the type-site of Wadi Abu Tulayha (Fujii 2014, n.d.). As a matter of fact, the structure incorporated two diagnostic stone weights into its masonry walls,



24. Wadi Ghuwayr 17: small finds from Structure 101.

suggesting contemporaneity with the neighboring outpost (**Fig. 24: 7-8**). It would appear that the small size of the cistern (*ca* 2 m<sup>3</sup> maximum capacity) accords well with the small scale of the nearby outpost (*ca* 0.015 - 0.02 ha; Fujii, Adachi *et al.* 2011: 180).

#### Eastern Jafr Barrage Survey

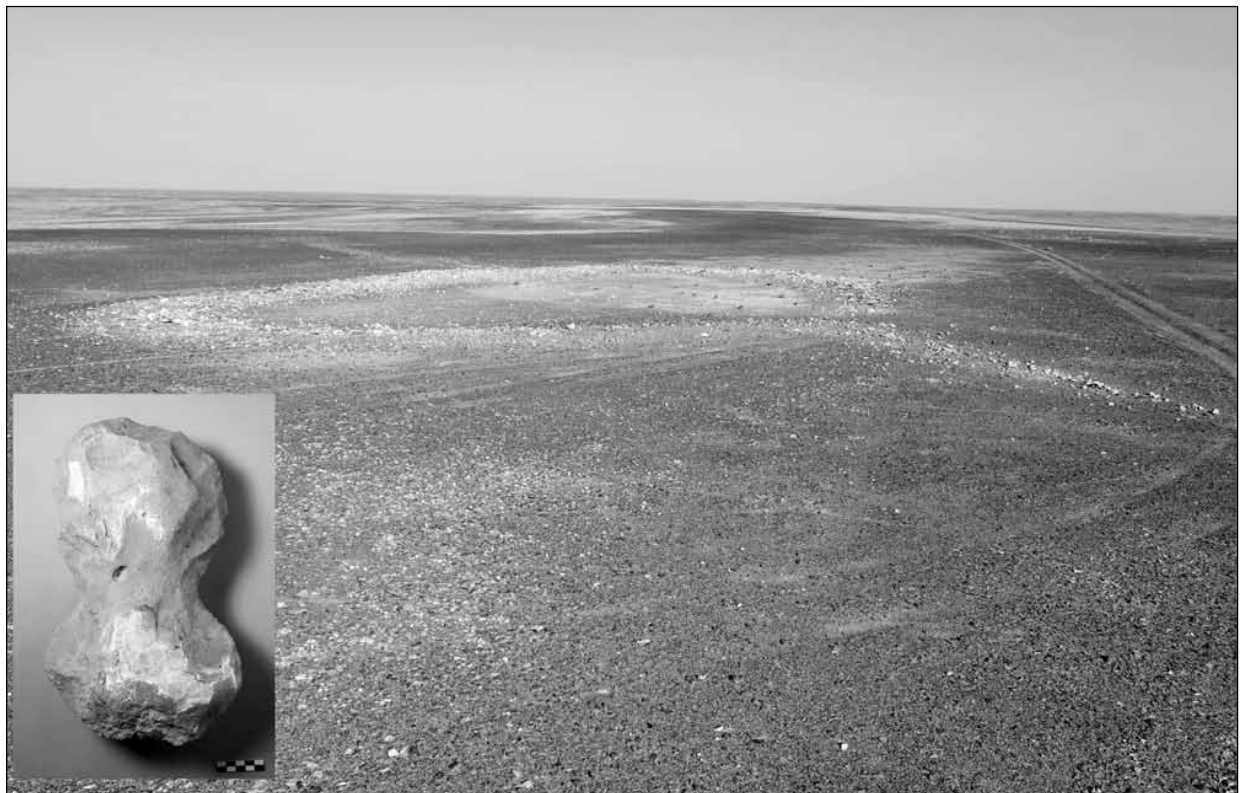
We conducted a brief general survey in the eastern Jafr basin aimed at gathering additional information on the Jafr Neolithic barrages. It was triggered by our tentative hypothesis that the composite barrage systems of Wadi Nadiya 1 and 2 began with the large-scale basin-irrigation barrage and gradually shifted to the small-scale cistern-type barrage. The survey aimed to test this hypothesis in a broader context.

The survey located a few dozen barrages within a relatively limited area (**Fig. 1**). Interestingly enough, most of them were typical cistern-type barrages equipped with a completely closed wall, a few narrow inlets and a few guiding walls (**Fig. 25**). It should also be added that they incorporated a diagnostic stone weight(s) into their wall. Given the suggested techno-

logical sequence of the Wadi Nadiya barrage systems, it would follow that they represent a later form of the Jafr Neolithic barrage. The survey also suggested that while basin-irrigation barrages were more common in the hilly terrain to the west, nearer to contemporary farming communities, the cistern-type barrages penetrated deep into the desert. Furthermore, while the former was often associated with a nearby agropastoral outpost, the latter was usually isolated in the middle of *hamada* and was not associated with any fixed ‘operating body’. These observations seem to indicate that the early Holocene Jafr basin witnessed a dramatic shift in water-use strategy. It is our present interpretation that the shift was linked with a change in lifestyle from PPNB pastoral transhumance to subsequent pastoral nomadism, but further scrutiny is required to validate this tentative perspective.

#### Discussion

The excavations at Wadi Nadiya 2 have demonstrated that the site represents a fifth example of the Jafr Neolithic barrage system, after Wadi Abu Tulayha, Wadi Ruweishid ash-Sharqi (Fu-



25. EJS/Site-11: general view of the site (looking N) and a stone weight found along the barrage wall (below left).

jii 2007b; 2007c; 2010a), Wadi Ghuwayr 106 (Fujii, Adachi *et al.* 2012) and Wadi Nadiya 1 (Fujii, Adachi *et al.* n.d.). However, it differs somewhat from the others, suggesting some difference in date and / or function. The following discussion briefly reviews the results of our research and pursues further details of interpretation.

#### *Date and Function*

There is little doubt that the Wadi Nadiya 2 barrage system dates to the PPNB, not least because the site yielded an assemblage of diagnostic limestone and flint artifacts comparable with those from the two PPNB agro-pastoral outposts (i.e. Wadi Abu Tulayha and Wadi Ghuwayr 17) and other barrage systems known in the Jafr basin. The presence of an open-cut limestone quarry in front of the barrage wall is also shared by the other barrage systems, confirming the technological affinities and contemporaneity between them. No less important is the occurrence of the remarkable flint bowlet, which suggests that we could narrow down the date of the barrage system to the LPPNB.

It is also indisputable that the four barrages at Wadi Nadiya 2 were used as water catchment facilities. A series of recurring characteristics - *viz.* the location across a *wadi* or at the lower end of a closed drainage system, the incurved stone wall 'opening' towards the upstream end of the system, the attachment of a pair of guiding walls and the extreme scarcity of small finds - all highlight the function of these structures as extramural facilities for collecting seasonal surface runoff water. However, the four barrages at Wadi Nadiya 2 differ in location, scale and typology from those of the other barrage systems, including Wadi Nadiya 1, which suggests that they may have differed in function from the others. This leads us to the following discussion.

#### *Chronological Sequence of the Jafr Neolithic Barrage System*

A key to shedding light on this issue is our assessment that the Wadi Nadiya 1 barrage system was gradually renewed downstream because of topsoil salinization (Fujii, Adachi *et al.* 2012: Fig. 40). Assuming that this principle is applicable over the lower barrage system as well, it

could be proposed that the Wadi Nadiya 1 and 2 composite barrage system evolved in specific use as follows:

The composite system began with Barrage 1 of Wadi Nadiya 1, the uppermost component. This barrage was large in scale and open in general plan. In view of its location at the lower end of a semi-open (and thus less salt-damaged) playa system and the formation of an extensive, shallow flooded area on permeable silty sand deposits, it is conceivable that this barrage was used for opportunistic basin-irrigation agriculture by PPNB transhumant pastoralists. Of significance is the existence of a large-scale open-cut limestone quarry in front of the barrage wall. Unless it was quickly backfilled, it must have served as an *ad hoc* open-air cistern. In this sense, we could argue that the barrage combined two distinct functions (i.e. basin-irrigation in the flood zone and storage of drinking water in the simple cistern) from the outset. This perspective provides a key to understanding the typological sequence of the six barrages that constitute the composite barrage system.

When Barrage 1 fell out of use because of topsoil salinization, a new barrage (i.e. Barrage 2 of Wadi Nadiya 1) was constructed *ca* 180 m downstream. Although much inferior in construction quality, it shares similar traits with the upper barrage and is thought to have combined the two functions suggested above.

(3) The results of our investigation at Wadi Nadiya 2 suggest that a drastic change in water-use strategy took place at the next stage of downstream renewal. Barrage 1 of Wadi Nadiya 2 was much smaller in scale and more incurved in general plan. These changes meant that the barrage no longer aimed to produce an extensive shallow flood zone. Another notable change was in its location. In contrast to the two upper barrages, which both occupied the lower edge of a semi-open playa system, Barrage 1 was constructed on a bend in a small *wadi*. This suggests that the barrage emphasized storage of drinking water (in the open-cut limestone quarry) over production of a basin-irrigated cereal field. In other words, the third barrage specialized in just one of the two distinct functions that the Jafr Neolithic barrage originally had. The same is probably true of Barrage 11 as well.

Barrage 2 of Wadi Nadiya 2 is also located on



a bend in the small *wadi*. Though much larger in scale than Barrage 1, it is more closed in general plan and traces a semi-circle equipped with a short pair of guiding walls at its inlet. Consequently, its flood zone, albeit slightly larger than that of Barrage 1, was reduced to approximately one-tenth of those of the upper two barrages. This clearly indicates that, as in the case of the third barrage, the fourth example was also used as a cistern-type barrage.

(5) This general trend took an even clearer form at Barrage 3, the final component of the Wadi Nadiya composite barrage system. Though similarly semi-closed in general plan and equipped with a short pair of guiding walls, it was much more compact than Barrage 2. More importantly, its location shifted from a bend in the small *wadi* to the lower end of a small-scale closed drainage system. Both changes can be understood as a device to avoid the washouts that plagued the upper two barrages. In this sense, we can argue that the final barrage represents a further refinement of its specialized function, namely, the storage of drinking water in the open-cut quarry. What is important here is that the builders of the barrage did not return to a semi-open playa system, but instead opted for a closed drainage system. This is probably because topsoil salinization was no longer such a problem for a cistern-type barrage.

Such is our present perspective concerning the chronological sequence and functional evolution of the Wadi Nadiya composite barrage system. Of interest is the fact that the more typical, even more closed cistern-type barrage equipped with long guiding walls appears to have been the norm in the eastern Jafr basin. Taking this into consideration, we may argue that Barrage 3 represents a divergence from the large-scale basin-irrigation barrage of PPNB transhumant pastoralists to the small-scale cistern-type barrage of post-PPNB pastoral nomads. In this sense, barrage chronology may provide valuable insights into the process of pastoral nomadization in southern Jordan, which is the main focus of our research project.

### Concluding Remarks

The investigations at Wadi Nadiya 2 have contributed to the establishment of a tentative chronology for the Jafr Neolithic barrage. Avail-

able evidence suggests that it started with the large-scale basin-irrigation barrage and gradually evolved into a smaller-scale cistern-type barrage. While the former appears to have been part of the well-organized social infrastructure of PPNB transhumant pastoralists, the latter most likely represents a ubiquitous, *ad hoc* installation of post-PPNB pastoral nomads. It would follow that, in addition to cairn chronology (Fujii n.d.), we have found another key with which elucidate the process of pastoral nomadization. However, this barrage chronology is still tentative and needs further verification. The next field season aims to continue supplementary investigations of the Jafr Neolithic barrage system and to conclude a series of operations exploring the correlation between the history of water-use in the arid margins and the process of pastoral nomadization.

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