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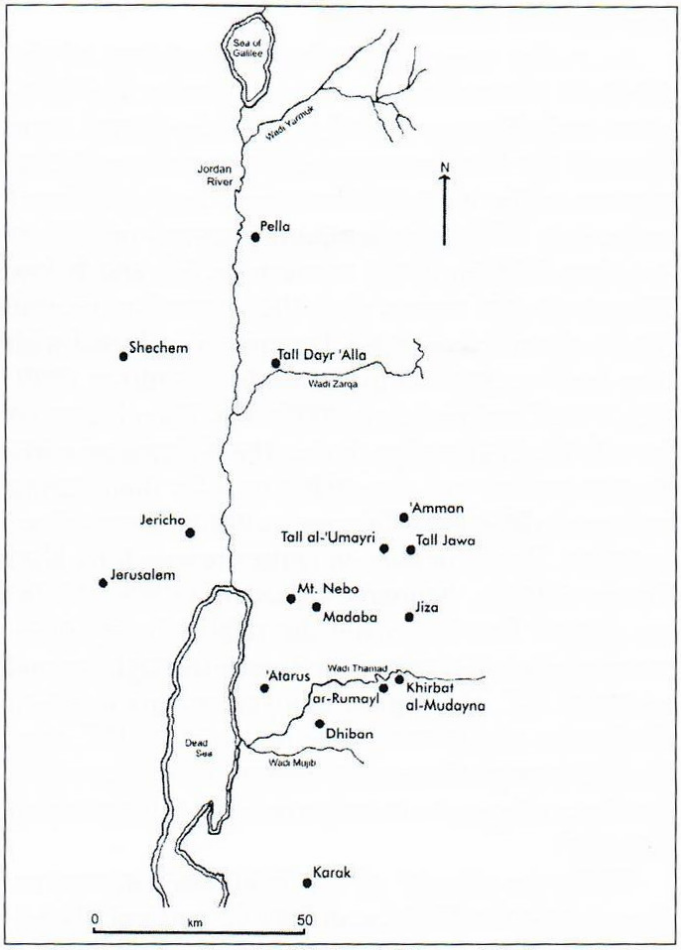
Nabataean Water Management Systems in the Wādī ath-Thamad

Introduction

The Wādī ath-Thamad is a major river system that begins east of the Desert Highway, southeast of Zīzyā[1] and south of Tall Burayk, and extends southwest for more than 50km before it flows into the mouth of the Wādī al-Mūjib. Along its trajectory between its source and Khirbat Iskandar, where it is known as the Wādī al-Wāla/Wādī al-Hīdān, the Thamad is fed by a series of secondary wadis, which flow into it from both the north and south. This river system provides water for modern agriculture and pastoralism over an extensive area, while the Wādī ath-Thamad itself forms the northern perimeter of the Dhībān plateau (FIG. 1).

The Wādī ath-Thamad Regional Survey[2] area covers approximately 110km2 centered on a Northeast-Southwest oriented graben and its surrounding drainage area. The catchment is bounded by the land to the east of the late Roman fortress of az-Zūna, the upland area south of the Wādī Shābik, the area to the west of the Iron Age site of ar-Rumayl and the Nabataean fortress known as Qaṣr az-Za'farān, and by Rujm al-Ḥīrī and West 'Urayniba on the north. The region naturally falls into three general topographic zones. To the north of the Thamad Graben is a narrow upland plain running east-west between the towns of West 'Urayniba and Za-



1. Area map showing the Wādī ath-Thamad drainage basin.

[1] Zīzyā is the name given to the modern town by local folk, although the site of the large reservoir was known to Tristram (1874:182-185) from the *Notitia Dignitatem* as "Ziza", one of the stations of the Equites Dalmatici Illyriciani Ziza. In JADIS (1994:2.158), the reservoir is included in the listing for Jizeh/Jīza (2412.003), with a reference to Tristram, while the listing for Zīzya (2413.005) refers only to a Middle Paleolithic wadi terrace.

[2] The Regional Survey is a component of the larger Wādī ath-Thamad Project, directed by Dr. P. M. Michèle Daviau of Wilfrid Laurier University, Canada. Complementing the excavations at Khirbat al-Mudayna, the survey of the Wādī ath-Thamad drainage basin aims to situate al-Mudayna in its landscape, sto clarify the relationship between the settlements (Iron Age, Nabataean) at al-Mudayna with outlying sites and features, to elucidate regional socio-economic systems, and to isolate paleo-environmental factors affecting settlement and land use. Conversely, it seeks to understand the impact of settlement and agricultural activity on the ancient environment.
The first two seasons of the regional survey were directed by J. Andrew Dearman (1996; 1997),
Austin Presbyterian Seminary, Austin, Texas, USA. Christopher M. Foley (1998, 1999, 2001), University of Saskatchewan, Canada, has directed the survey in subsequent seasons. The 2003 season was devoted to a study of the Iron Age cisterns and caves at at-Rumayl (Site WT-18).

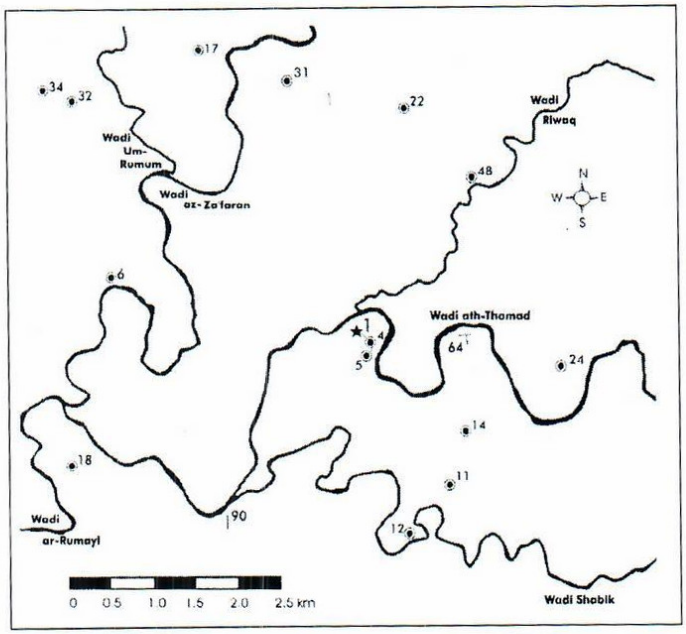
ynab. This relatively flat region gives way to the undulating terrain along the northern edge of the graben, which descends sharply as one proceeds southward into the bottom lands of the Wadis ath-Thamad, Za'farān and Shābik. These wadis, which run through the floor of the graben, are separated by limestone outcrops of the Eocene Umm Rijam Chert Limestone (Al-Hunjul 1995), resulting in areas of steep slopes and alluvial flood plains. The wadis are fed by smaller wadis, such as the ar-Ruwāq, and by numerous gullies descending from higher terrain to the north, the south, and to a lesser extent, the east. The third zone is another upland area south of Wādī Shābik.

As is the case today, the environment of the Wādī ath-Thamad catchment area during the Nabataean-early Roman Period was a transitional zone between the Mediterranean climate and vegetation regimes to the west and the steppe land and desert to the east. With a contemporary annual rainfall of less than 300mm in the western sector, and below 200mm as one moves east, the vegetation regime can be classified as Irano-Turanian, combined with "dry-bed" vegetation in the wadis (Cordova 1999: 183, 191; Cordova *et al.* 2005: 30). The climate of the ath-Thamad region during the Nabataean-early Roman period was somewhat moister than during both preceding and following cultural phases of occupation. Based in part on earlier research by Karl Butzer (1955), Numan Shehadeh (1985: 27-28) has argued that following the relatively dry environmental conditions of the fourth through second centuries BC, the region enjoyed an amelioration of climatic conditions in the first century BC, continuing through the second century AD, after which the climate began to revert to drier conditions about 180 AD[3].

While the climate of the Wādī ath-Thamad region during the Nabataean Period, particularly between the first century BC and the second century AD, was comparatively moist, with greater rainfall than today, it is unlikely that the flora regime was substantially different than that of today. Nevertheless, the increased moisture between 63 BC and AD 324 allowed a degree of agricultural expansion (Cordova 1999; Glueck 1970; LaBianca 1990) previously unknown. The fact that there is evidence for increased erosion during this same period may reflect periods of heavy rain, and/or the impact of increased agricultural activity due to a rise in population and extension of settlement into marginal areas[4]. Recent investigations of the archaeological and geomorphic records confirm that populations with appropriate technology were exploiting the more unstable, marginal agricultural lands to the east of the Mādabā Plateau.

Agricultural Settlements

A number of major agricultural sites, dating to the late Hellenistic-early Roman period, are located within the ath-Thamad Graben (Sites WT-1, WT-6, WT-12, WT-14; FIG. 2). The distribution of these settlements within the ath-Thamad survey area forms a consistent pattern; each site was located on the perimeter of a broad valley bottom, which was surrounded by a gentle meander of the wadi often associated with a ford. In some instances, these small communities were built up against the base of the escarpments, which edge the wadis running through the depression, or on outcrops of harder limestone formations within the graben itself. Their



2. The Wādī ath-Thamad Drainage Basin.

[3] According to Shehadeh (1985:27-28), the moist period ended by the 3rd century, with a climate regime of low rainfall continuing until the end of the 6th century. This climate pattern of a rainy period followed by a dry period corresponds to a comparatively warm, wet climate phase posited for the Mediterranean region between 200 BC and AD 400, with between 200 and 300mm rain per year (Green 1986: 81ff.).

[4] Although he did not have the Wādī ath-Thamad region in mind, Glueck (1965: 361) was convinced that the Nabataeans engaged in intensive dry farming to support settlements along their trade routes.

geographical location facilitated the exploitation of the water's flow for irrigation, a technology which can still be seen today where the local people pump water from the wadis into subsidiary pools located at the level of their fields. Bowersock (1983: 64) dates an increased investment in agriculture on the part of the Nabataeans to the reign of Aretas IV (8 BCBAD 40). This shift in economic priorities was associated with expanded sedentarization and the refinement of irrigation techniques, especially for Nabataean settlements around Petra itself and in the Negev. Our discovery of a series of sites along Wādī ath-Thamad, Wādī az-Za'farān and Wādī Shābik now argues for comparable expansion both in the implantation of Nabataean settlements and in water management facilities in the area southeast of Mādabā. From west to east, these sites include Toga (WT-6), north of ar-Rumayl; Nabataean al-Mudayna (WT-1; JADIS 2311.014)[5]; al-Wathir (WT-14); and no-name site WT-12. Both Toga and Site WT-12 consist of a line of buildings located on a terrace flanking the wadi and overlooking the valley bottom. By contrast, al-Wathir flanks a small stream, not immediately related to agricultural land, and al-Mudayna is located on the valley bottom itself and extends perpendicular to the wadi bed.

Water Management Systems

Each of the Nabataean settlements in the Wādī ath-Thamad drainage basin was associated with a variety of installations to control and conserve water. One such water management system was located between the Wādī ath-Thamad and Wādī Shābik at al-Wathir (WT-14). Across the bed of a subsidiary stream or gully, flanked by two elongated hills, are three dams constructed of stones and packed earth; the largest dam (WT-14/D-1) at the south end measures 37.80m in width, 3.70m thick, and 1.30m in height (FIG. 3). No date can be assigned to the initial construction of this dam, since it appears to have been repaired in recent times. However, potsherds of *terra sigillata* and Nabataean painted vessels were scattered in front of a group of caves and cisterns that line the terrace flanking the gully. Above this dam to the west is a round hill with a carved bedrock channel running completely around it (FIG. 4). This channel carries runoff water into a large cistern (WT-14/C-1). Several other cisterns are visible further up hill, overlooking the ravine with its three dams.

3. The southernmost dam at al-Wathir (WT-14).

4. Rock-cut channel and cistern at al-Wathir (WT-14).

A similar pattern, consisting of three dams across a secondary rivulet, is seen at Site WT-48. Here the stream bed runs down to the cliff above Wādī ar-Riwāq, which flows southwest to join the Wādī ath-Thamad at Khirbat al-Mudayna. Pottery from the middle dam can be dated to the Roman and Byzantine periods[6]. However, the presence of a Thamudic inscription (WT-48/TT-5) pounded into the bedrock at the lip of the wadi suggests that these

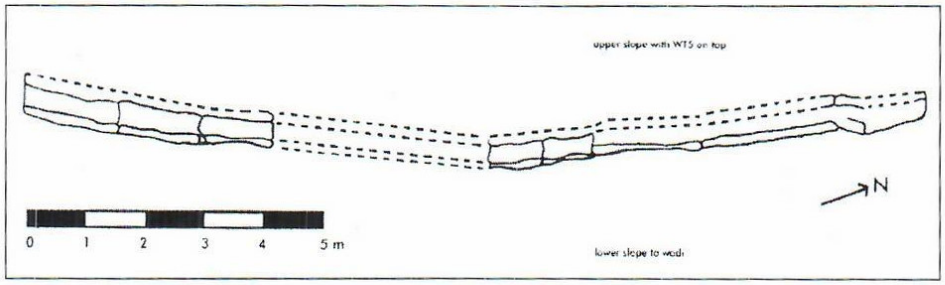
[5] Among six sites with the same name, al-Mudayna on the Thamad is the northernmost of these sites (Miller 1989). JADIS is the Jordan Archaeological Database and Information System.

[6] Oleson (1992: 270) mentions "sets of wadi barriers" and "stone piles", which are in themselves undatable, but can be assigned a date on the basis of their relationship to the Nabataean settlement and to the aqueduct.

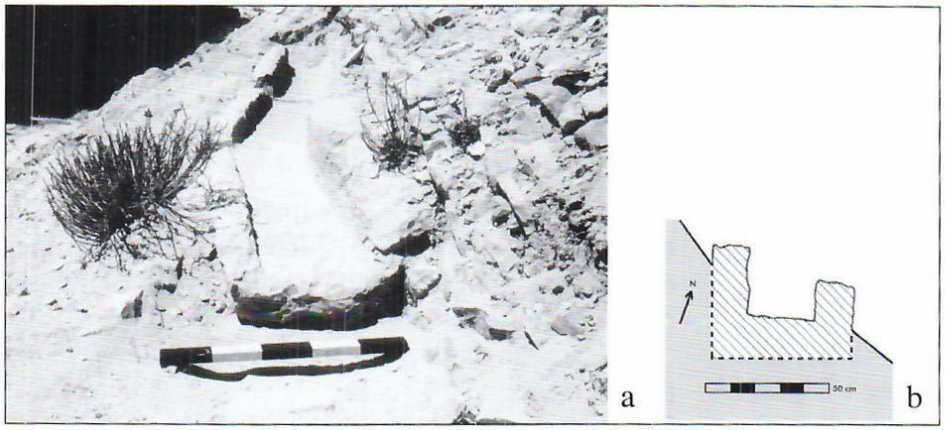
dams were already in use in the Nabataean period[7]. A similar pattern appears at Toga, where a series of small dams were built across an erosion channel, which cut through the escarpment to the northwest of the settlement. Comparable step dams to reduce erosion or to control and collect rain water can be seen in Wādī Abū Saq'a near Petra (Dentzer and Zayadine 1992: 236, Fig. 2) and in Petra itself in the Wādī al-Mudhlim (Akasheh 2002: 221).

The most complex assemblage of water installations is located at the Nabataean town site located at the foot of Iron Age Khirbat al-Mudayna (WT-1). Beginning to the southeast of the Nabataean town is an elaborate water collection system on the side of a hill (WT-5)[8], which forms the southern perimeter of the valley bottom. This system consists of a stone-carved channel (WT-47; FIG. 5) located on the eastern slope of the hill that was designed to collect runoff water, and divert the water before it ran into the Wādī ath-Thamad. The channel (FIG. 6a, b) was elaborately constructed; first a horizontal bed with vertical sides was cut into bedrock[9], and stone-cut blocks were installed. Chisel marks and diagonal Nabataean stone-dressing marks are visible on these blocks, which measure 0.60m in width with a central channel ca. 0.27-0.30m wide (FIG. 7). Each block was 1.25-2.25m in length, and the seams between the blocks were plastered (FIG. 5). The total preserved length of this water channel is ca. 18.40m. This would have been a very efficient system, since the east face of the hill is primarily exposed bedrock with little soil to absorb the runoff.

The blocks which form the al-Mudayna channel are somewhat larger than those documented at Nabataean sites in the south, where they measure approximately 0.90m long, with a channel 0.12m wide and 0.15m deep (Oleson 1995: 714). Such



5. Stone-lined water channel at Site WT-47.

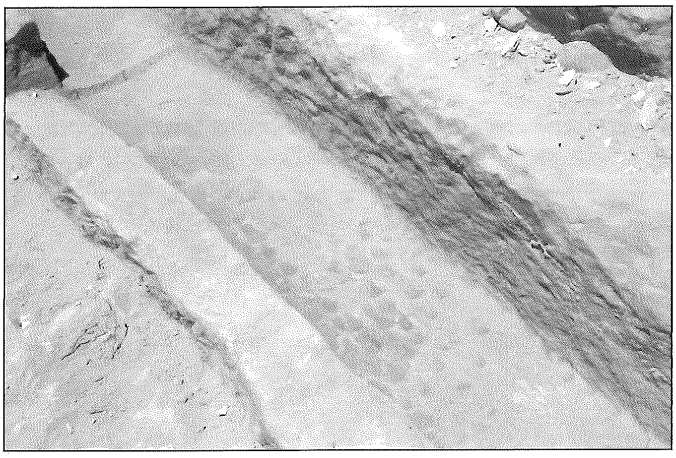


6a, b. Section of stone-lined Channel WT-47.

[7] To date, 13 Thamudic inscriptions have been located; 5 on building stones in Building 800 at al-Mudayna, 3 at West 'Urayniba, 2 at Tomb Site WT-61, and others on bedrock or on stones located at various sites in the survey area (Graf and Zettler 2004; M. C. A. MacDonald, in preparation). Additional epigraphic evidence can be seen in the area of the Queen Alia Airport where a Thamudic text was discovered in a cemetery (Röllig 1987). At southern sites such as al-Ḥumayma, water works are also dated on the basis of inscriptions carved on the rock in their immediate area (Oleson 1992: 270).

[8] Site WT-5 (PGE: 236550, PGN 110725) is a structure located on the rounded hill, which lies at the south end of the valley bottom, east of Khirbat al-Mudayna and inside the loop of the wadi. The wall lines consist of a single course, 1-2 rows thick, formed of medium size boulders, and enclose a rectilinear structure, 16.70 x 12.90m in size. Little debris or stone tumble survives from the superstructure of this building, if that is what the wall lines represent. Although architectural features are meagre, 208 sherds were collected, dating to the Iron Age and the early Roman-Nabataean period. The ceramic sherds include first century AD painted Nabataean fine ware.

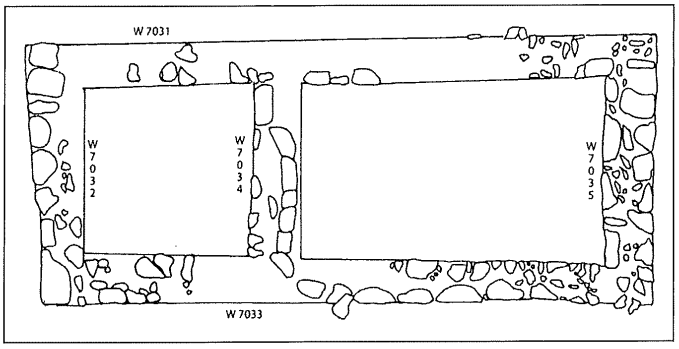
[9] Browning's photograph (1989: Fig. 55) of a section of the water channel along the wall of the Siq at Petra is a good example of this type of stone-carved channel. However, in this channel, there was a pressurized ceramic pipe, sections of which are still preserved (personal observation, 2004; see also Bellwald 2004).



7. Tool marks on the interior of the water channel (WT-47).

conduits have been found in Petra (Bedal 2002: 228)[10], in 'Ayn ash-Shallāla in Wādī Ramm, and at al-Ḥumayma (Oleson 1995: Figs. 9, 10), where the conduit was capped because it functioned as a ground level aqueduct.

At al-Mudayna, the channel served as both a catchment devise and as an aqueduct, carrying water around the side of the hill (WT-5). This channel was part of a complex system of water management installations and cisterns located along the south-eastern perimeter of the valley bottom. A second series of installations is located at the base of the north side of the same hill, where rain water flowed into a series of small settling tanks (WT-4. Feature A=B730; FIG. 8), which are associated with a water control wall (W7025=WT-4)[11]. Examples of water redistribution tanks are preserved in the garden terrace at Petra (Bedal 2002: 228) as well as at al-Ḥumayma (Oleson 1995), where a ground-level conduit carried water to a settling tank before continuing on to the major reservoir (Building 700).



8. Water collection tanks (B730) at the foot of the hill (WT-5) east of Khirbat al-Mudayna.

Although Wall 7025 appears to be a single wall, it may have functioned to control water in much the same way as ground-level aqueducts known at other contemporary sites in the southern Levant. Ground level aqueducts at Mampsis[12] and at Jericho were constructed with two parallel walls of boulder-and-chink construction, each 2-3 rows thick, comparable to the single wall (W7025) at al-Mudayna. Located north of the Wādī Qilt, the Jericho aqueduct irrigated a farming area of 4.0 ha located north of the Hasmonean palaces at Tulūl Abū al-'Alayiq (Netzer 1993: 690). A covered aqueduct in the Petra region at Qaṣr Umm Rattām was also built of boulder-and-chink construction (Dentzer and Zayadine 1992: Fig. 6), indicating a common tradition in the late Hellenistic-early Roman period. In contrast, dressed stones were used to form the flanking walls of the water channel at al-Amti in the Bayḍā region of Petra, where large gardens were irrigated in a broad valley bottom (Bikai 2004).

At al-Mudayna, the water control wall (W7025) forms the perimeter of the agricultural field in the valley bottom and directs water toward Building 700 (FIG. 9; Daviau 2000: 286)[13], an unroofed reservoir[14] measuring ca. 11.00 x

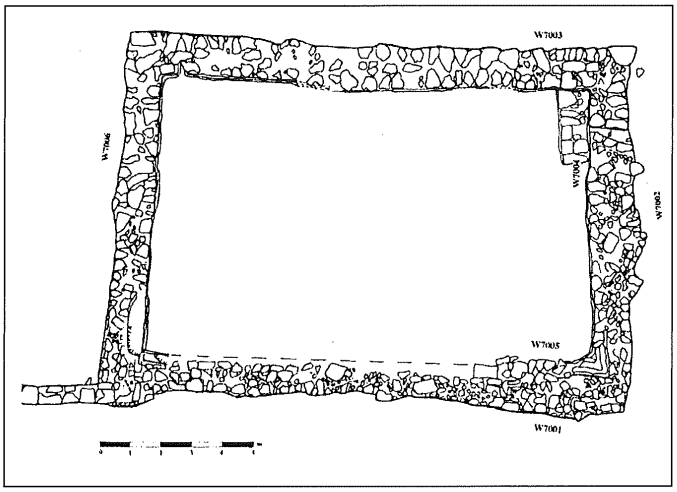
[10] Upper, right-hand photograph.

[11] Excavation in Building 720 during the 2004 field season uncovered a structure measuring *ca.* 4.50 x 10.50m and consisting of two units. The final interpretation of function must await completion of excavation in 2005.

[12] The width of the aqueduct channel at Mampsis measures 0.25cm wide (Negev 1988: 186; Photo 199-201), comparable to the width of the stone-carved conduit at al-Mudayna. However, the Mampsis channel was similar to other ground level aqueducts in that it was formed of two rows of stones, not of large stone blocks.

[13] Excavation during the 1997-1999 seasons revealed that the reservoir had two periods of use; at some point in its history, B700 was spanned by 10 opposing arches and had a stone roof. Interpreting the precise construction history of Building 700 is still problematic, in part because so few reservoirs are described in detail. It is possible that the reservoir continued to be used for water conservation after it was roofed (Daviau *et al.* 2000: Fig. 4), and only at a later time, when the spaces between the arch piers were filled with low connecting walls, was the building converted to a domestic or storage facility. However, the fact that the arch piers and their connecting walls were not plastered may indicate that the reservoir was converted in the second use phase into a storehouse or domestic structure, because the piers could not survive if surrounded by water. Further evidence for this second use phase was uncovered in 1996 and 2001, when repairs to the plaster floor and the presence of two ovens, one directly on the floor (L22:16) and a second oven (L33:27) inside a protected cooking area, were exposed. In addition, the presence of ceramic vessels, cooking pots, and a mould-made lamp (Daviau *et al.* 2000: Fig. 7:1-5, 8) clearly indicate a change of function in Building 700.

[14] A large open reservoir, as well as a smaller stone-roofed reservoir, is preserved at Umm al-Jimāl (de Vries 1998: Figs. 46, 67). Several examples of roofed reservoirs were also documented at Mampsis (Negev 1988: Photos 192-198) and at Petra (Bellwald 2004).



9. Reservoir 700 at Khirbat al-Mudayna.

10. Floor make-up of Reservoir 700.

16.50m in size[15]. Cut into the virgin soil on the northeast slope of the mound, the reservoir walls were deeply footed below the level of the floor. Superimposed layers of flat-topped boulders and cobblestones packed with impermeable mortar/cement (L13:24)[16] were laid as the foundation for the floor (FIG. 10). The floor itself and the walls were coated with 4-5 layers of fine plaster and a cement curb of plaster and small pebbles filled the angle between the walls and the floor, as well as the vertical corners[17].

The south wall was cut into the slope of a large Iron Age dump composed of ashy soil filled with pottery sherds, animal bones and *ṭābūn* fragments. The porosity of this dump would have facilitated the gentle runoff of water into the reservoir. Built into the south wall is a stone-cut channel that directed water around the south and east sides[18]. A plastered drain through the east wall may be related to the ground level wall, W7025, coming from the southeast[19]. While these features are related to filling the reservoir, a plastered drain in the north wall may have served as an overflow drain to irrigate the agricultural valley bottom to the northeast.

Although the water management systems described above are modest in scale, when compared to the dam north of West 'Urayniba (Bisheh 1986: 9), the reservoir at Zīzyā (Jīza), and the large birkah (95.00 x 104.00m) at Mādabā (Piccirillo and Denton 1996: 25). Nevertheless, they served to enhance the available ground water necessary for successful agriculture at the rural Nabataean villages in ath-Thamad graben.

Roads

Connections between these sites are also a factor in their location. In each case, there is a place where the wadi can easily be forded, usually at the opening to the valley bottom. In the case of Toga (WT-6), one opening is at the opposite end of the valley from the settlement, while a second access point is located to the west, on a saddle that connects Toga to agricultural land north of ar-Rumayl (Glueck 1970: Fig. 84). At al-Mudayna, there is a gentle ford immediately north of the settlement and a second ford less than 1.0km to the west.

Another feature which served to link the sites in the Wādī ath-Thamad region is a network of local roads running predominantly east-west and still recognizable in a number of road fragments. At this stage in our investigation, these local roads have

[15] This reservoir is small in comparison to the one at Musayṭiba (Museitbeh, JADIS 2409.001), southeast of Umm ar-Raṣāṣ; this well-preserved reservoir measures 12.00 x 27.00 x 9.00m deep (Glueck 1934: Fig. 17). It is interesting that Glueck thought the reservoir dated to the Byzantine period, based on a comparable reservoir at Umm ar-Raṣāṣ, even though the adjoining fortress (or platform) was littered with Nabataean pottery and *terra sigillata*. When Tristram (1874: 149) saw this site in January 1873, it was located in a rich agricultural and pastoral zone, which is still the case today (personal observation, August 2003).

[16] The development of Nabataean cement is discussed by Gibson, http://nabataea.net/cement.html.

[17] The same feature (a plaster curb) is preserved in the reservoir (Building VII) at Mampsis (Negev 1988: Photo 195). However, in the vertical corners, a triangular cobblestone and mortar packing, coated with plaster, was installed (Negev 1988:184-185).

[18] Additional conduit blocks were recovered in Building 800, a large house located to the north of the reservoir (Daviau *et al.* 2000: 279). Both blocks were carved in a U-shape, comparable in size to the drain blocks built into the walls of Reservoir 700; when found, they were in secondary deposition and are evidence for the abandonment of the settlement at al-Mudayna.

[19] Comparable channels are seen entering a settling tank and in the east wall of a roofed reservoir (10.00 x 23.00m in size) in an agricultural area south of Bayḍā (al-Muheisen 1992: 216; Fig. 3).

not been linked to the major caravan routes that probably ran along the western and eastern reaches of our survey area[20]. One fragment of road (WT-75) is located on the east side of the flood plain at Khirbat al-Mudayna. In comparison with modern tracks, this road is lined with a stone curb.

A more substantial road fragment (Site WT-64), identified in the bottom land to the east of Wādī ath-Thamad and east of Khirbat al-Mudayna, is composed of two roads intersecting at approximately a 120-degree angle. The first road (Feature A) runs east-west for 126.07m, parallel to the wadi, and has a width of 3.25-3.65m. The most probable course for the westwards extension of this fragment would be to cross the wadi at the point where the wadi embankments become narrow. The road would then run along the alluvial bottomland on the north side of the wadi in the direction of al-Mudayna, and would cross the ford to the south side at al-Mudayna itself.

Intersecting with the east-west road to form a wide cobbled area, a branch of the road (Feature B; FIG. 11) runs southeast and crosses the alluvial terrace heading in the direction of an upland region separating Wādī Shābik from Wādī ath-Thamad. At it north end, the roadbed was built into reddish alluvial sediment, but disappears to the south under grayish colluvium. The exposed roadway is punctuated with Bedouin burials, which opportunistically utilize the stones forming the road to provide security for the deceased. These burials occur only in the road itself. After the point at which the roadway is subsumed by the colluvial deposit, the burials continue in a straight line, along the course of the road and thereby indicate its continuing trajectory.

11. Road (WT-64; Feature B) running southeast.

Conclusion

The discovery of a number of strategically placed farming settlements, each supplied with elaborate and extensive water management facilities, fills a gap in our knowledge concerning the organization and exploitation of farmland north of the Wādī al-Mūjib by the Nabataeans. The rich agricultural resources of this region, still evident today, were utilized by a settled and literate community, which extended from Mādabā in the west to Zīzya/Jīza in the east, linking the two principal trade routes north to Philadelphia. Excavation and survey in the Wādī ath-Thamad region shows clearly that Nabataean construction methods were in use, including diagonal stone dressing, plastered reservoirs with cement curbs, carved stone conduits, and stepped dams. The ceramic material indicates that the local inhabitants made use of Nabataean painted pottery and lamps, probably imported from Petra itself[21]. These obvious links to the centre of Nabataean culture leave no doubt that the Wādī ath-Thamad basin was an integral part of the Nabataean kingdom.

In this paper, we have reviewed the archaeological evidence for full-scale development of northern Moab by the Nabataeans, who established towns and farming settlements, built dams, aqueducts, reservoirs, cisterns, and local roads in the Wādī ath-

[20] Negev was able to date the extensive road system between Petra and sites in the Negev on the basis of his excavation at Oboda, showing its importance prior to Roman control. In his judgment, after Roman and Palmyrene reorganization of the trading patterns, Nabataean settlements in the Negev were dependent primarily on agriculture (Negev 1966: 97).

[21] Personal communication, Y. Gerber.

Thamad graben. Like the towns in the Negev (Negev 1976: 131), this implantation of settlements in northern Moab was the work of Nabataeans knowledgeable in stone architecture, engineering, climate and water conservation. Based on the ceramic repertoire from Khirbat al-Mudayna and from the survey sites, the Nabataeans appear to have exploited this area of northern Moab during the first and early second century. Further excavation and survey may help to clarify the character of the relationship of these agricultural villages to each another and to the urban centres at Mādabā and Dhībān[22].

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Bibliography

Akasheh, T. S. 2002. Ancient and Modern Watershed Management in Petra. *Near Eastern Archaeology* 65: 220-224.

Bedal, L.-A. 2002. Desert Oasis: Water Consumption and Display in the Nabataean Capital. *Near Eastern Archaeology* 65: 225-234.

Bellwald, U. In preperation. The Hydraulic Infrastructure of Petra. A Model for Water Strategies in Arid Lands. *SHAJ* 9.

Bikai, P. M. In preperation. Petra, Bayda: Al-Amti and the Nabataean Village. *SHAJ* 9.

Bisheh, G. 1986. Notes on Some Newly Discovered Umayyad Remains. *ADAJ* 30: 7-14 (Arabic).

Bowersock, G. W.1983. *Roman Arabia.* Cambridge, MA: Harvard University Press.

Browning, I. 1989. *Petra.* (3rd ed.). London: Chatto & Windus.

Butzer, K. 1955. Some Aspects of the Postglacial Climatic Variations in the Near East Considered in Relation to Movements of Population. Ph.D. dissertation, McGill University, Montréal.

Cordova, C. E. 1999. Landscape Transformation in the Mediterranean-Steppe Transition Zoneof Jordan: A Geoarchaeological Approach. *The Arab World Geographer* 2: 188-201.

Cordova, C. E., Foley, C., Nowell, A. and Bisson, M. 2005. Landforms, Sediments, Soil Development, and Prehistoric Site Settings on the Madaba-Dhiban Plateau, Jordan. *Geoarchaeology: An International Journal* 20: 29-56.

Daviau, P. M. M. 2000. Survey and Excavation in Northern Moab. Pp. 279-292 in P. Matthiae, A. Enea, L. Peyronel, F. Pinnock (eds.), the *Proceedings of the First International Congress on the Archaeology of the Ancient Near East* (Rome, May 18th-23rd 1998, Rome: Università di Roma "La Sapienza"/Herder.

Daviau, P. M. M., Mulder-Hymans, N. and Foley, L. with a contribution by C. J. Simpson 2000. Preliminary Report of Excavations at Khirbat al-Mudayna on the Wadi ath-Thamad (1996-1999): The Nabataean Buildings. *ADAJ* 44: 271-282.

Dearman, J. A. 1996. The 1996 Regional Survey of the Wadi ath-Thamad Project. Unpublished Report; submitted to the Department of Antiquities of Jordan.

—— 1997. The 1997 Regional Survey of the Wadi ath-Thamad Project. Unpublished Report; submitted to the Department of Antiquities of Jordan.

Dentzer, J.-M. and Zayadine, F. 1992. L´espace urbain de Pétra. *SHAJ 4:* 233-251.

De Vries, B. 1998. *Umm el-Jimal. A Frontier Town and its Landscape in Norther Jordan. Volume 1, Fieldwork 1972-1981.* in J. H. Humphrey (ed.), Journal of Roman Archaeology 26. Portsmouth, RI: Journal of Roman Archaeology.

Foley, C. M. 1998. The Wadi ath-Thamad Regional Survey, 1998. Unpublished Report; submitted to the Department of Antiquities of Jordan.

—— 1998. The Wadi ath-Thamad Regional Survey, 1999. Unpublished Report; submitted to the Department of Antiquities of Jordan.

—— 2001. The Wadi ath-Thamad Regional Survey, 2001. Unpublished Report; submitted to the Department of Antiquities of Jordan.

Glueck, N. 1934. *Explorations in Eastern Palestine, I.* AASOR XIV. Phila.: American Schools of Oriental Research.

—— 1965. *Deities and Dolphins. The Story of the Nabataeans.* New York: Farrar, Straus and Giroux.

—— 1970. *The Other Side of the Jordan.* Cambridge, MA: American Schools of Oriental Research.

[22] The position of al-Lāhūn on the north bank of the Wādī al-Mūjib (Homès-Fredericq 1997: 80-89), due south of Khirbat al-Mudayna, suggests another strategically located Nabataean site on the Dhībān plateau.

Graf, D. and Zettler, M. 2004. The North Arabian Thamudic E'Inscription from Uraynibah West. *BASOR* 335: 53-89.

Green, K. 1986. Agriculture in the Roman Empire. Pp. 67-97. in *The Archaeology of the Roman Economy*. Berkeley: University of California Press.

Homès-Fredericq, D. 1997. *Lehun et al Voie royale. Les fouilles belges en Jordanie/Lehun en de Koningsweg. De Begische opgravingen in Jordanië*. Bruxelles: Musées Royaux d=Art et d=Histoire.

Al-Hunjul, N. G. 1995. *The Geology of Madaba Area: Map Sheet (3153-II)*. Geographical Bulletin 31. Amman: Geology Directorate, Geological Map Division, Natural Resources Authority.

LaBianca, O.S. 1990. *Hesban 1: Sedentarization and Nomadization: Food system cycles at Hesban and Vicinity in Transjordan*. Berrien Springs, MI: Institute of Archaeology and Andrews University Press.

Macdonald, M. C. A. In preparation. The Inscriptions from the Wadi ath-Thamad.

Miller, J. M. 1989. Six Khirbet el-Medeinehs in the Region East of the Dead Sea. *BASOR* 276: 25-28.

Al-Muheisen, Z. 1992. Modes d´installations agricoles nabatéennes dans la région de Pétra et dans le Wadi 'Arabah. *SHAJ IV*: 215-219.

Negev, A. 1966. The Date of the Petra-Gaza Road. *PEQ* 98: 89-98.

—— 1976. The Early Beginnings of the Nabataean Realm. *PEQ* 108: 125-133.

—— 1988. *The Architecture of Mampsis. Final Report. Volume I: The Middle and Late Nabatean Periods*. Qedem 26. Jerusalem: The Hebrew University of Jerusalem.

Netzer, E. 1993. Tulul Abu el-'Alayiq. Pp. 682-691 in E. Stern, A. Lewinson-Gilboa, and J. Aviram (eds.), *New Encyclopedia of Archaeological Excavations in the Holy Land*. New York: Simon & Schuster.

Oleson, J. P. 1992. The Water-Supply system of ancient Auara: Preliminary Results of the Bumeima Hydraulic Survey. *SHAJ* 4: 269-275. Amman: Department of Antiquities of Jordan.

—— 1995. The Origins and Design of Nabataean Water-Supply systems. *SHAJ* 5: 707-719. Amman: Department of Antiquities of Jordan.

Piccirillo, M. and Denton, B. 1996. Archaeological Remains. Pp. 25-45 in P. M. Bikai and T. A. Dailey (eds.), *Madaba: Cultural Heritage*. Amman: American Center of Oriental Research.

Röllig, W. 1987. The Thamudic Inscriptions. Pp. 43-45 in M. M. Ibrahim and R. L. Gordon (eds.), *A Cemetery at Queen Alia International Airport*. Yarmouk University Publications. Institute of Archaeology and Anthropology Series, Vol. 1. Wiesbaden: Otto Harrassowitz.

Shehadeh, N. 1985. The Climate of Jordan in the Past and Present. *SHAJ* 2: 25-37. Amman: Department of Antiquities.

Tristram, H. B. 1874. *The Land of Moab: Travels and Discoveries on the East Side of the Dead Sea and the Jordan*. New York: Harper.