The Analysis of Historical Maps as an Avenue to the Interpretation of Pre-Industrial Irrigation Practices in Egypt

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> As the river retires, the fields are sown, which is sooner or later, according to their respective elevations; for some fields are not free of water till the month of December, and, in some temporary canals, it remains still longer. The canal Joseph is never dry, though at its beginning it is very shallow, and therefore soon loses the supply from the river.
> ANTES, 1800, p. 69

1. The Egyptological Debate on Early Irrigation Practices in Ancient Egypt.

The topic of how the Egyptian irrigation system worked has been amply studied. The Classical historians already referred to the remarkable fact that Egypt's prosperity depended on the silt annually deposited by the Nile flood ("Egypt is a gift of the Nile"). Classical and medieval Arabic authors also remark that different flood heights had a strong impact on harvests.[1] However, only few of these accounts provide detailed information on how the flood 'worked', and on

1 An overview of Classical and medieval Arabic sources on flood heights is given by Seidlmayer, 2001, p. 29-52. Several of the Classical sources are also dealt with by Garbrecht/Jaritz, 1990, p. 195-206.

how humans intervened in the natural landscape to maximize the agricultural yield. Published Egyptological studies clarify these issues only in part.[2]

The first authors to express an informed opinion on flood irrigation in Egypt were not Egyptologists, but civil engineers working in Egypt in the latter part of the nineteenth and in the early twentieth century. At the time, Egypt was in reality, if not nominally, under British rule.[3] The colonial overlords had a keen interest in the territories under their governance. Partly, this was due to the curiosity for things exotic that so much characterized Victorian England, but partly it also reflected plainly economic concerns: the British were interested in maximizing agricultural yield. This led to the publication of a whole range of studies on the hydrology and agricultural use of the flood in Egypt and the Sudan at that time.[4] These highly detailed works provide accurate information on matters like the cyclic evolution of the Nile volume in the course of the year, the river slope, and the system of water distribution before, during and after the annual flood. They also provide insight in the operation of the artificial irrigation basins during the inundation as they observed it with their own eyes. Fig. 1 reproduces the simplified, and, in Egyptology, highly influential plan Willcocks produced of this irrigation system, which operated on the basis of the simple fact that water flows from higher to lower levels, no use being made of water-lifting devices. In the landscape of the Nile Valley, two complementary principles of water movement were in force, and determined the way irrigation worked. The first is a south-north water displacement from the higher river beds in Ethiopia and the Sudan to the mouths of the Nile branches in the Delta, which lie at sea level.The second is a lateral movement of water away from the river. Here it is important to realize that, during the annual floods, the largest and heaviest sand particles fall out first, generating high embankments, called levees, immediately beside the river. Farther away from the river, only smaller particles settle. This process generates a convex East-West cross-section of the floodplain. Floodwater would under natural conditions particularly flood the deepest area, which, on the

2 Some of the most important references are: Butzer, 1976; Schenkel, 1978; Garbrecht/Jaritz, 1990; Eyre, 1994, p. 57-80; Menu (ed.), 1994; Hassan, 1997, p. 51-74; Bowman/Rogan (eds.), 1999; Lehner, 2000.

3 For the complex political structure of the Egyptian administration in the latter part of the nineteenth century, see Daly, 1998, p. 239-251; Ferguson, 2003, p. 230-234.

4 E.g. Ball, 1938; Hurst, 1957; Lyons, 1906; Willcocks, 1889; Willcocks, 1899, etc. For an overview of British interventions in Egyptian irrigation, see Cookson-Hills, 2013.

western bank of the Nile in Upper Egypt, lies closest to the edge of the Western Desert. These deeper areas lead to the emergence of natural drainage channels, and even though these can be quite significant waterways, they are never the main branch of the Nile.

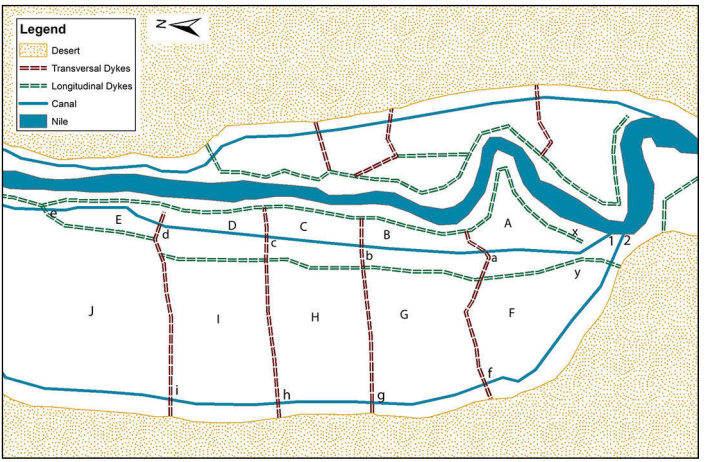

Figure 1. System of basin chains, after WILLCOCKS, *1899, pl. 14. N is to the left. Map Hanne Creylman.*

Willcocks observed an irrigation system that cleverly exploited these two principles. We see that the floodplain west of the Nile is intersected by two systems of dykes.[5] The dykes running parallel to the Nile (here indicated by a double green dotted line) ensure that the water does not run off directly to the deeper areas surrounding the drainage channel dependent of canal head 2, but is partly kept in the higher basins A-E dependent on canal head 1 (see fig. 1). The transverse dykes a-i, which run perpendicular to the river, have more or less the same purpose. If these dykes would not be there, all water would continue its northward movement, with a smaller amount of silts settling. The transverse dykes ensured that the floodplain was parceled up stepwise in chains of basins, in which each basin would be allowed to be covered with c. 1-1.5 m of water. Fig. 1 visualizes a situation with two parallel chains of basins, one being located in the deeper parts of the floodplain near the western desert edge (basins F-J in

5 We will concentrate here on this western part of the floodplain, as, in general, the floodplain east of the Nile is very narrow. For the sake of brevity, we here leave out of consideration the so-called syphon canals discussed by WILLCOCKS, 1899, p. 58-60.

fig. 1), and one being located on the higher land closer to the levees fringing the Nile (basins A-E in fig. 1).

In this landscape, the flood was managed as follows. The higher and lower basin systems were fed with water from the canal heads at 1 and 2. When the floodwater in the main river channel had risen sufficiently, the dykes would be broken at these points, and the dependent systems flooded. However, before this moment, openings had to have been made already in the dykes further downstream. In the higher basin chain, for instance, dykes a, b, c and d were broken. Then, when the river dyke was broken at the canal head 1, the water ran through the feeder canal linking basins A, B, C, D, and E of course continuing to the deepest point, *i.a.* basin E downstream from the break in dyke d. Once enough water had collected in this basin, the hole in dyke was closed, and basin D began to fill. Next came basins C, B and A. The lower series of basins F-J would be filled following the same pattern. At the end of the flood season, the water would drain back into the Nile through an outlet at the end of the basin chain (not depicted in fig. 1).

Willcocks described this model in detail and with great clarity, occasionally suggesting in passing that his account concerned a very ancient system.[6] It is perhaps for this reason that several Egyptologists apparently assume that the same basin chain system was already operational in pharaonic days (cf. n. 13). If true, this idea has important consequences for ancient Egyptian society. The figure is of course only schematic, and it shows merely a small chain of basins. In reality, however, Willcocks observed far more extensive basin chains, which could extend over hundreds of kilometres. To operate such a chain, the persons monitoring dykes at the canal heads and other people at the end of the chain and everywhere in between would have to know exactly what the other was doing. This implies a well-structured and tight water administration with a firm grip over vast areas. The supposition that the same system was in use in pharaonic Egypt bears the implication that a similarly tight control over large areas was in place in that period, too. In fact, the hydraulic hypothesis of Karl Wittfogel, who formulated the idea that the emergence of early states generally depended on the capacity of the leadership to exert a tight control over the irrigation systems, and that the administration would have emerged from centrally controlled systems of irrigation management, is based to no mean extent on Willcocks' account.[7] For a long time, Egyptologists agreed that the success of the Egyptian state

6 Willcocks/Craig, 1913, p. 299-300 attribute it to the time of king Menes at the beginning of the First Dynasty.

7 Wittfogel, 1957. This opinion is still found, for instance, in Brown, 1997, p. 9.

depended largely on the same principle.[8] However, they initially hardly bothered about the extent to which their perceptions fitted information about the ancient environment in the first place.

This only changed in the 1970s, when the geomorphologist Karl Butzer published his seminal *Early Hydraulic Civilization in Egypt*. He argued that, before an artificial irrigation system making use of dykes and canals emerged, there must have been a simpler one that made use of natural irrigation basins. The meandering Nile had, over the millennia, generated many different levee systems, and these natural elevations would trap floodwater as the inundation receded. In the Neolithic the utility of such natural reservoirs for small-scale irrigation would have been first realized, leading to natural basin irrigation. After this, attempts to improve the natural basins by the construction of dykes and the digging of canals would gradually have improved the irrigation system, leading to more adequate forms and sizes of basins, with a stronger control over the flooding regime (artificial basin irrigation). Butzer placed the transition from natural to artificial basin irrigation in the Early Dynastic period, because the king Scorpion macehead depicts the king while digging a canal. According to Butzer, "This significant document leaves little doubt that the transition from natural to modified and, ultimately, artificially regulated irrigation had been *completed* by the end of the Predynastic."[9] This would show that, from this point in time, a new, more thoroughly regimented irrigation regime was in place.

Since the publication of Butzer's book there has been considerable debate over these issues. This, however, did not concern the principle of the development envisioned by Butzer, but only the detailed chronology of the evolution. Thus, W. Schenkel argued that the Scorpion macehead does not depict an irrigation canal, and that evidence for artificial irrigation only appears in the record in the First Intermediate Period. The famines referred to in texts from this period would in fact have triggered the introduction of artificial basin irrigation.[10] This can now no longer be considered an adequate interpretation, as there is reason to doubt that the floods in the early First Intermediate Period were substantially worse than in the preceding period.[11] Moreover, an early Fifth Dynasty scene in the so-called *Weltkammer* in the solar temple of Niuserre depicts a dyke enclosing

8 E.g. Wilson, 1951; Kees, 1955, p. 19-20 and *passim*; Grimal, 1988, p. 51; Bonneau, 1993, p. XXI; Lehner, 2000, p. 298-314 (we express our gratitude to Barry Kemp for this reference).

9 Butzer, 1976, p. 20-21. (Italics: authors).

10 Schenkel, 1978, p. 37-49.

11 For an overview of the problems involved, see Moeller, 2005, p. 153-167.

a flooded basin, showing in unmistakable fashion that artificial basins at least existed in the early Fifth Dynasty, and there is no reason to doubt that artificial irrigation emerged well before this point in time.[12] Even though this does not prove that artificial basin irrigation emerged in the time of king Scorpion, as Butzer had argued, this evidence does show it existed long before the First Intermediate Period.

A far more fundamental problem, however, is what scholars like Butzer, Schenkel, and others mean when they say Egypt deployed a system of artificial basin irrigation. None of them is very explicit about what they think the actual landscape looked like. Some scholars seem to believe that, as soon as artificial basin irrigation existed, it was immediately introduced across Egypt. When Butzer, for instance, states that the transformation had been "completed" in the Early Dynastic Period, he suggests it had been generally implemented, and many others plainly follow Willcocks by drawing an image of extensive chains of irrigation basins covering the whole of Upper Egypt.[13] However, the available early evidence for the existence of artificial basin irrigation neither proves that it was immediately adopted everywhere, nor that the same extensive chain systems existed that were observed in the nineteenth century. In fairness it must be admitted that Butzer does not explicitly state as much. He for instance assumes that in pharaonic times, irrigation was organized on a local basis. Still, the reader remains puzzled about what this exactly looks like to Butzer.

In 1992, Ghislaine Alleaume published cogent evidence against the hypothesis of large basin chain systems in premodern times, arguing that these were only created under Muḥammad ʿAlī Pasha.[14] She based her argument both on maps of the *Description de l'Egypte*,[15] which were drawn in 1798-1800 during Napoleon's

12 Willems, 2012, p. 1101-1107.

13 Ruf, 1994, p. 281-293; Bonneau, 1993, p. XXI; Lehner, 2000, p. 298-314 Grieshaber, 2004, p. 7-8; 11; fig. 8. This author remarks (without offering any real arguments) that "hinsichtlich der Dämme die Verhältnisse des 19. Jh., die sich besonders im Kartenwerk der Description und des Linant de Bellefonds widerspiegeln, cum grano salis die Verhältnisse der Antike zeigen."

14 For the agricultural policy of his time, see Lutfi al-Sayyid Marsot, 1984, p. 149-161.

15 *Description de l'Egypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'Expedition de l'Armee française. Atlas Géographique* (Paris, 1826). All maps of this publication are easily accessible online (http://www.davidrumsey.com or www.descegy.bibalex.org), and the reader intent on following the details of the discussions of maps in this article is advised to consult

campaign in Egypt, and on written sources.[16] Focusing on the region between Luxor and Coptos, where the Nile Valley is narrow, she showed that basins were very small, and not connected by south-north feeder canals like those depicted in fig. 1. Rather, basins here had an east-west orientation perpendicular to the Nile, and each basin was fed by one or more east-west feeder canals that did not connect to adjacent basins. Clearly, irrigation was here a very local affair. The south-north feeder canal systems only emerged in the early nineteenth century. The system observed by Willcocks was hence not a survival from ancient Egypt, but a quite recent innovation, having been created earlier in the nineteenth century during a hydrological project that encompassed all of Egypt.

2. Aims of the Present Study

It is hard to overrate the importance of Alleaume's remarks for the issues we are interested in, as it shows that the nineteenth century agricultural landscape that has been so crucial in shaping our ideas on the situation in Antiquity distorts the picture rather than clarifying it. In this article we wish to show that historical maps produced before the interventions of the nineteenth century are essential to understand what the premodern landscape looked like. This does not mean that maps of more recent date are useless. Quite the contrary is in effect true. However, the earlier maps contain essential information that should not be discarded too lightly.

In what follows, we shall first go into the methodological issue of the extent to which the maps of the *Description de l'Egypte*can be relied upon. To this end, we will compare the record provided by these Napoleonic maps for different parts of Egypt. We will then focus on the area of Middle Egypt, where the authors have extensively worked in connection with the Dayr al-Barshā project of KU Leuven. To study this area, we will compare the Napoleonic maps with others, produced in the twentieth century, which provide details on surface relief which must have been of importance for the flooding regime both then and before.[17] Our analysis will not only show that in this part of Egypt, the irrigation regime of the

these sites (or the original publication). We have consulted the versions of the former website available on 01.12.2014.

16 Alleaume, 1992, p. 301-322; see also Michel, 2005.

17 Kemp, 2005 deployed very much the same method as we propose here, but we only became aware of the existence of his work after the present article had been finished. We express our gratitude to him for bringing his paper to our attention.

late eighteenth century displayed a much less thoroughly organized system of basin chains than the one that existed since the 1830s, but also that it was much more complex than the one in the Luxor-Coptos region that Alleaume analyzed. Also, some hitherto unobserved hydrological phenomena will be considered, which characterize not only the part of Middle Egypt we are most specifically interested in, but Upper Egypt north of Asyūṭ generally. Our new information is particularly intriguing when considered in connection with the landscape in the Banī Suwayf-al-Fayyūm area, which may have played a crucial role, not only as an important agricultural region in its own right, but also as an essential element in the water regime in Upper Egypt and the Delta generally. Finally, we will argue that our observations are not only relevant for eighteenth century Egypt, but also for ancient Egypt at least as early as the Middle Kingdom.

3. Methodology

3.1 The Accuracy of the Maps Published by the Description de l'Égypte

Alleaume's article clearly takes as its point of departure the assumption that the maps of the *Description de l'Égypte* provide information of sufficient accuracy to warrant their use in a study of the ancient landscape. However, a necessary preliminary question is whether these maps can really be relied upon. After all, they were produced in less than two years. In view of the vast surface covered, the short time span available, and the conditions under which the work had to be done (many of the maps indicate places where fights took place while the French troops were there), it would be naïve to suppose that the plans are error-free. In recent years, several scholars have in fact stressed their unreliability.

Thus, David Lorand has compared the French map for the area around al-Lisht with a Google Earth satellite image of the same area. He observed that the spatial relationships between sites show enormous differences between the two sources, which he attributes to the poor quality of the earlier map.[18] Similarly, a recent article by E. Subias, I. Fiz and R. Cuesta, aiming to reconstruct the middle Nile valley based on historical maps and satellite images, observed inaccuracies of such magnitude in the French maps that georeferencing them was considered quite impossible.[19] To Grieshaber, the unreliability of the *Description de l'Egypte*

18 Lorand, 2013, p. 139-143.

19 Subias/Fiz/Cuesta, 2013, p. 29.

maps is such an entrenched conviction that he hardly takes seriously the dykes that are clearly drawn there.[20]

These authors are certainly right that the Napoleonic maps include numerous errors. A first problem (not highlighted in earlier studies) is that maps pertaining to certain parts of the country provide more or different kinds of details than others concerning other parts of the country. Thus, whereas the maps used by Alleaume depict numerous dykes in the area immediately north of Luxor, those concerning the area between Aswān and Luxor show no dykes at all, with two exceptions.[21] Similarly, the map of the *Description de l'Egypte*, illustrating the region of al-Lahūn at the mouth of the Fayyūm, duly indicates the presence of the Jisr al-Shaykh Jād-Allāh (in the *Description de l'Égypte* called "Gisr el-Sheikh Gadallah"), a large dyke linking the village to the desert edge near the pyramid of Senwosret II, but omits the second dyke (the Jisr al-Bahlawān") which runs southwest from al-Lahūn.[22] Since both dykes are of the same type and probably of the same age, and since they only make sense if both existed side by side, the cartographers clearly omitted to enter information on one of the two.

This confirms the impression that the maps produced by the *Description de l'Égypte* are not flawless. However, this does not mean they are useless, and perhaps they are not even as generally unreliable as the authors cited believe. One should reckon with the possibility that the teams that produced maps in different parts of Egypt may not always have consisted of the same people, that the time available may not always have been sufficient, or that other practical circumstances imposed a less strict work routine than was adopted elsewhere. Such circumstances could well account for the striking difference between the landscape as mapped by the French to the north and to the south of Luxor.[23]

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20 Grieshaber, 2004, p. 32-33.

21 *Description de l'Egypte. Atlas Géographique*, pl. 2-5. The exceptions are two adjoining dykes linking the town of Idfū to the Nile and one short dyke near Isnā. This issue has been addressed briefly by Grieshaber, 2004, p. 9. It should be noted, however, that the apparent difference between the areas north and south of Luxor may not be due simply to errors in the maps. Alleaume, 1992 has argued, based on contemporary texts, that the elevation of land in the floodplain in the more southerly parts of Upper Egypt was so high that it was only to a very restricted degree reached by the flood in the eighteenth century.

22 *Description de l'Egypte. Atlas géographique*, pl. 19. We will discuss these dykes in more detail on p. 302-304.

23 The greater amount of details for the area north of Luxor may be related also to the fact that the advance of Napoleon's troops through Middle Egypt towards Luxor

Stated differently, before historical maps are used, their reliability should first be verified for each area investigated.

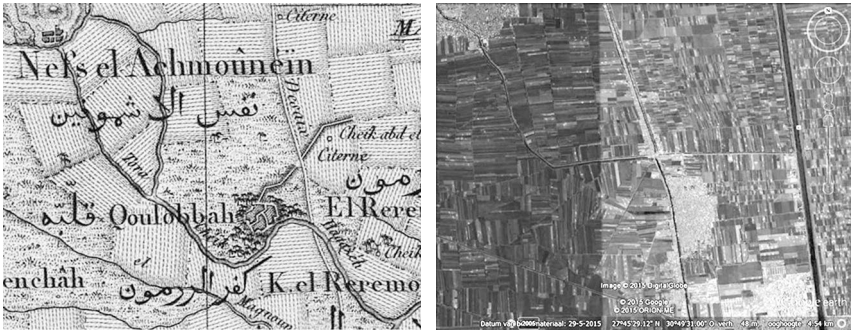

Figure 2. a. the Tirʿa al-Shaykh Hijāza ("Tora Cheik Hagazéh) near the village of Qulubba as drawn in the Description de l'Egypte*, map 14. b. the same channel today and crop marks betraying its former course (Google Earth).*

Figure 3. (Next page) Toponyms in the region of al-Ashmūnayn. All are given in Arabic phonetic transcription, except in a few cases (indicated by quotation marks) where the rendering in the Description de l'Égypte *is not entirely clear. "Tora" is undoubtedly the* Description*'s rendering of tirʿa. Map Hanne Creylman.*
Towns and villages: 1. Sabīl al-Khazindar; 2. Dairūṭ (al-Sharīf); 3. Banī Ḥarām; 4. Ismū; 5. Daljā; 6. Dayr Mawās; 7. Tānūf; 8. Kawm al-Sihāl; 9. Tandā; 10. Tūkh; 11. Nazlat al-Shaykh Ḥussayn; 12. Sinjirj; 13. Umm Qummuṣ; 14. Mallawī; 15. Al-Birka; 16. Rairamūn; 17. Qulubba; 18. Dayr al-Nuṣāra/Dayr al-Mallāk; 19. Al-Bayādīya; 20. Al-Ashmūnayn; 21. Ṭūna al-Jabal; 22. Al-ʿArin al-Baḥrī; 23. Nawāi; 24. Maḥraṣ; 25. Nazlat Abū Jāmī; 26. Kawm al-Riḥāla; 27. Iṭlīdim.
Waterways: a. Baḥr Yūsif; b. Tirʿa Tanūf; c. "Tora el Kiket"; d. Tirʿa al-Sanjāj; e. "Tora el Asarah"; f. "Tora Hoçein Cherkes"; g. Tirʿa Ḥasan Kāshif; h. Tirʿa al-Majnūn; i. Tirʿa al-Shaykh Hijāza; j. al-Sabakh.

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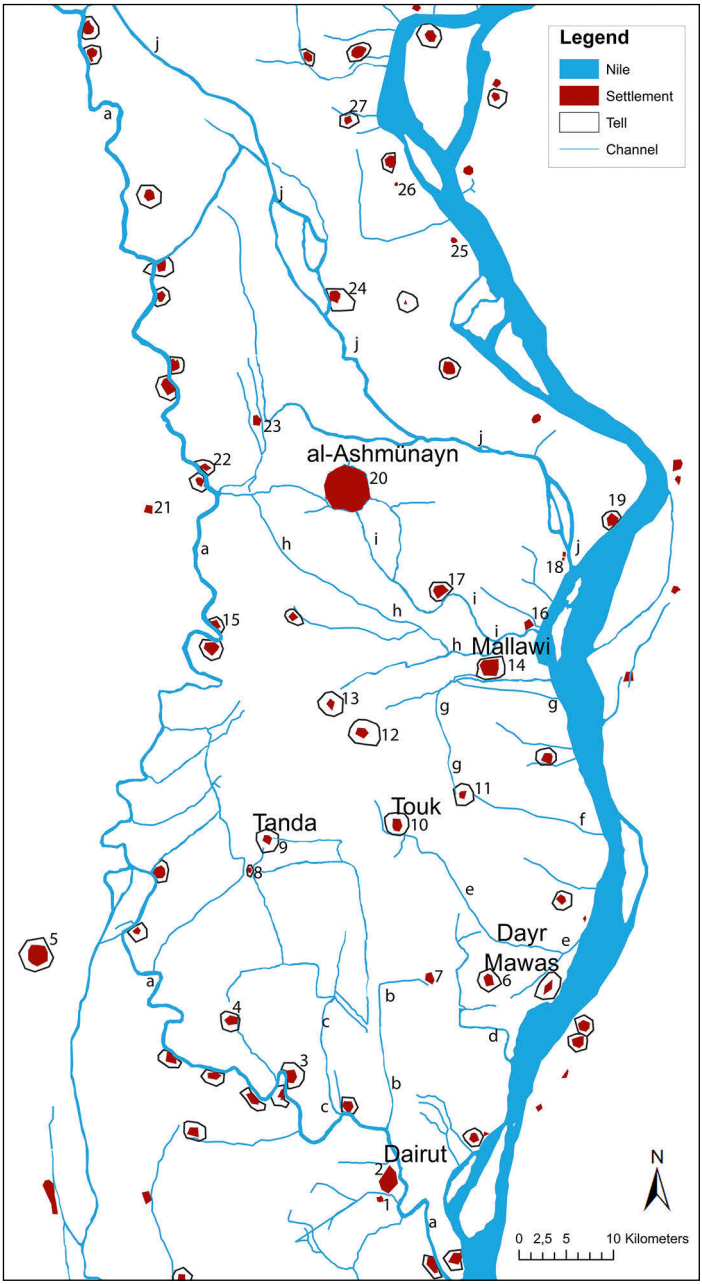
was slower and more peaceful than their stay south of Luxor (Strathern, 2007, p. 275-306). For the impact of conflicts or the lack of appropriate geodetic equipment during some periods of the campaign, cf. Gomaà/Müller-Wollermann/Schenkel, 1991, p. 30-43.



Our study will be mostly concerned with the area around the town mounds of al-Ashmūnayn in Middle Egypt. Here, the maps of the *Description de l'Égypte*[24] were partially compared with information provided by more recent maps and satellite images, or observed by ourselves on the ground. Thus, the dyke linking al-Ashmūnayn to Ṭūna al-Jabal ("digue d'Achmouneïn"; our dyke 21[25]) still exists, being currently the provincial road linking the two places; the E-W dyke to the north of al-Bayadīya (our dyke 24) also still exists, as do parts of the waterway called al-Sabakh ("el Sabbak") on the Napoleonic map (west of al-Bayadīya) (channel j in fig. 3).[26] The wide channel linking al-Ashmūnayn to the Nile at the village of al-Rairamūn ("Tora Cheik Hagazéh"; i in fig. 3) still exists in part, and can be seen on the road from Mallawī to al-Ashmūnayn. In its more southerly parts, near the village of Qulubba, the channel disappears, but its contour is clearly visible in the cropmarks on satellite images (see fig. 2).

The isohypses in the fields to the west of the modern village of Dairūṭ as shown on fig. 5 follow the same contour as a dyke drawn there in the Napoleonic map ("Gisr Dairoût Chérif"; dyke south of our dyke 1, but not numbered in this article). Probably, this dyke itself no longer exists, but depositions of silt that had accumulated behind it led to the difference in height indicated in the isohypses. Finally, the course of a channel between "N. Bercheh" (*i.e.* Nazlat al-Barshā) and "Dêr en-Nakleh" (*i.e.* Dayr al-Barshā) on the French map corresponds well-nigh exactly to that of a canal (since 2006 filled in) shown in later maps and satellite imagery. These features are so clear and significant that the map of the *Description de l'Egypte* must be deemed very accurate at least for this part of Middle Egypt.

It should be pointed out that we have only infrequently made use of earlier maps than the *Description de l'Égypte*, because they are drawn at such a small scale as to be nearly useless. Exception must here be made for the maps published in 1753 by Robert de Vaugondy (fig. 7) and in 1765 by J.B.B. d'Anville.[27]

24 *Description de l'Egypte. Atlas géographique*, pl. 13-14. Michel, 2005, p. 256 has stressed the reliability of these maps.

25 For the numbering of the dykes, see figs. 5-6 and section 4.1.2 in this article.

26 The key to the location of settlements and waterways in this article can be found in fig. 3.

27 de Vaugondy, Carte de l'Egypte Ancienne et Moderne, dressée sur celle du R.P. Sicard et autres, assujetties aux observations astronomiques, par le Sr. Robert de Vaugondy Geographe ordinaire du Roy. Avec Privilege, 1753,' in : *Atlas Universel, Par M. Robert Geographe ordinaire du Roy, et Par M. Robert De Vaugondy son fils*

3.2 Georeferencing historical maps

Every map is a two-dimensional projection of a three-dimensional reality. The maps to be compared in this study were not made on the basis of the same projections, and therefore, they needed to be georeferenced. This means that the technical coordinates on the two-dimensional maps are transferred into geographical coordinates. For this study, the maps were superimposed in ArcMap, using the normal cylindrical Web-Mercator-Auxiliary-Sphere (WMAS) projection, making use of the geodetic datum WGS1984, as this is the projection system of Bing maps, which is the reference map used for this study. We used the georeferencing tool in ArcGIS 10.1 software using the AFFINE polynominal transformation function. This tool allowed us to link ground control points (GCPs) in each of the maps to the same points in an independently generated Bing Maps Aerial base map.[28] This approach avoids accumulations of errors in the transformation process.

As noticed before, Subias, Fiz, and Cuesta were of the opinion that georeferencing the maps of the *Description de l'Égypte* is not feasible for the area they investigated, and for this reason they did not incorporate it into their GIS.[29] The reasonable accuracy of the map for the region between Dairūṭ and al-Ashmūnayn suggests, however, that the situation may not be as hopeless here. Yet it should be pointed out that georeferencing always generates transformation errors (the root mean square error, RMSE). Bearing in mind the intrinsic inaccuracy, particularly of the maps of the *Description de l'Egypte*, a reasonably high inaccuracy

Geographe ord. du Roy, et de S. M. Polonoise, Duc de Lorraine et de Bar, et Associé de L'Academie Royale des Sciences et belles Lettres de Nancy, Avec Privilege Du Roy, 1757. A Paris, Chez Les Auteurs, Quay de l'Horloge du Palais, Boudet Libraire Imprimeur du Roi, rue St. Jacques; J.B.B. d'Anville (1765 : Egypte, nomme dans le pays Missir. Par le Sr. d'Anville de l'Academie royale des Belles-Lettres, et de celle des Sciences de Petersbourg, Secretaire de S.A.S. Mgr. le Duc d'Orleans. MDCCLX). These maps can be conveniently consulted at the site http://www.davidrumsey.com. The d'Anville map was frequently reproduced, e.g. in Antes, 1800, Ripaud, 1800; Arrowsmith, 1812. It forms the basis of the Turkish *Cedid Atlas Tercümesi* map published in 1803. For this rare map, see the website of the Library of Congress: http://www.loc.gov/resource/g3200m.gct00235/?sp=63 (consulted 10 May 2015). For the Fayyūm region, an overview of the available historical maps has been published by Garbrecht, Jaritz, 1990, p. 11-24.

28 See http://be.bing.com/maps/.

29 Subias/Fiz/Cuesta, 2013, p. 29.

should be accepted. Considering the size of the area under investigation and the difficulty to identify identical points in both the *Description de l'Egypte* and the reference map, a RMSE of at most 200 m is considered to be acceptable.

Whenever georeferencing produced a larger margin of error, GCPs were added, or a different set of GCPs was chosen.

3.3 Analysing the maps

In this way an overlay was produced that combines different types of landscape features. The map of the *Description de l'Égypte* contains the following elements that are important for understanding the hydrology of the regions investigated: watercourses, settlements (including abandoned ones), roads, and dykes. The maps also include other elements, like field boundaries, wasteland, sand dunes, etc. However, it is not clear whether these were recorded accurately, and in mapping we have not systematically incorporated these elements, although we occasionally made use of them where other evidence was lacking.The maps also indicate marked differences in height, for instance in the case of town mounds. However, while the general aspect of surface relief is thus partly recognizable, it is impossible to quantify the difference in height, and less prominent elevations like levees are usually not indicated at all. Therefore, one can basically recognize the locations of some landscape features, but the result is still inadequate (see fig. 4). This is most clearly the case with the dykes, which are often interrupted. Clearly, such a dyke system can never have functioned properly.

It is likely that errors in the French map explain some of these anomalies: certainly the cartographers must have missed a number of dykes. It is impossible to assess the magnitude of such errors. Another problem is that dykes would of course not be built where there were natural elevations in the landscape, but since the *Description de l'Égypte* renders such elevations only in part, it is clear that the logic of the system will escape us unless we incorporate surface relief in our analysis. For this we have made use of the 1926 topographic maps (1: 100,000) of the topographic Survey of Egypt. These maps are superior to many others that have been published in that they indicate 1 m differences in elevation.[30] The integration of these maps with the Napoleonic ones is justifiable regardless of the time difference of about 125 years, because the accumulation

30 For Middle Egypt: the 1:100,000 topographic maps entitled *Minya* (Survey of Egypt map 26/402, sheets 56/54 and 56/60) and *Dairût* (Survey of Egypt 26/403, sheets 52/54 and 52/60). The 1957 map entitled *Mallawi* (52/263), sheet 140 offers closely similar information. Maps at a 1:25,000 scale, dated to 1940-1943, also

of alluvium on the surface would in this period have amounted to only about 10-20 cm.[31] This is much less than the 1 m intervals between the isohypses.

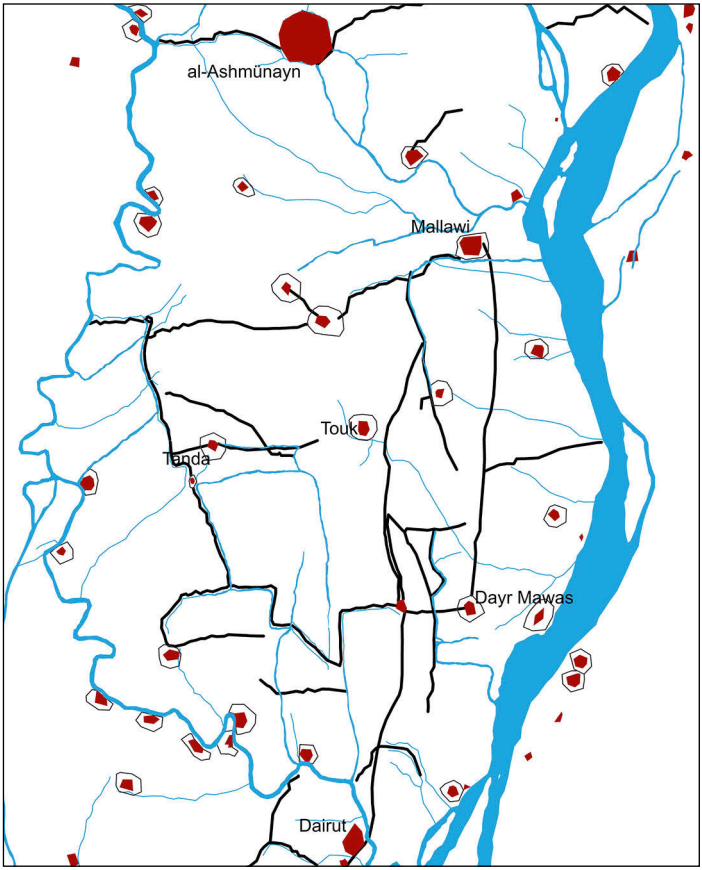


Figure 4. georeferenced map of a part of the area investigated in which the following information from the Description de l'Egypte *maps 13 and 14 has been included: settlements (red), tells (black contours around settlements), waterways (blue), and dykes (black). Map Hanne Creylman.*

exist, but their existence came to our notice too late for them being included in our analysis (see KEMP, 2005, p. 20, fig. 1.3).

31 As a rule of thumb, earth scientists often assume an average accumulation rate of 1 mm/y. The reality is of course more variable, and for this reason we here use a considerable margin of error.

In superimposing the two georeferenced maps, it becomes immediately clear that the interruptions in the dykes recorded by the *Description de l'Égypte* usually stop where the 1926 topographic map indicates a rise in surface level; we will offer ample illustration of this fact below (see fig. 5-6). A combined reading of surface relief and dyke contours leads to a meaningful subdivision of the floodplain in basins. Interestingly, many of these basins are defined by the combination of natural and man-made features that according to Butzer characterize early forms of artificial basin irrigation.

Another feature to be considered is that the Napoleonic maps often interrupt dykes shortly before they reach a settlement (for example near the village of "Touk" in fig. 4). A likely explanation is that these settlements stood on town mounds, and that the dykes stopped where the ground had risen to a sufficient height. Wherever town mounds were larger than the villages actually existing in the eighteenth century, the cartographic method deployed may suggest gaps in the hydrological system that did not actually exist.[32]

A further problem is that the maps of the *Description de l'Égypte* use topographic symbols that are not always easy to understand. In some cases, dykes are clearly recognizable, being drawn as a double line with an indication of the surface sloping down on both sides. In many cases, the map moreover includes the label "digue", or the Arabic "gesr" (i.e. jisr), which has the same meaning. Two problems have to be addressed here. In the first place, in some cases a dyke is characterized as an "ancienne digue." It is not clear to what extent this means the dyke was no longer in actual use. We have simply opted for accepting them as functional dykes. Secondly, some linear features in the landscape are also drawn by a double line, but without clear indications of surface relief. Are we not facing dykes here, but just roads at the level of the surrounding fields? This has a major impact on how the maps are interpreted. If road = dyke, then the number of basin demarcations will behigher than if we suppose that some roads crossed the basins without always following a dyke.[33]

32 That tells may have been larger than the settlements on top of them in the late eighteenth century is credible, due to a significant decrease in population in the preceding centuries (Garbrecht/Jaritz, 1990, p. 188-189).

33 Schenkel has stated that many settlements in the floodplain lay simply within the basins, without any connection by dyke to neighbouring settlements (in: Gomaà/Müller-Wollermann/Schenkel, 1991, p. 25; 27). He does not clarify what this point of view is based upon. Although in the more southerly area we have been concentrating upon, settlements occasionally do lie in isolation in an area without dykes (thus Nawāy and Ḥūr northwest of al-Ashmūnayn), in most cases the

Since the map was apparently drawn in late autumn, when the flood had already mostly receded, the French troops might have marched through dry areas where such low-lying roads existed. It is, however, often assumed that most major roads in the floodplain followed dykes. The absence of graphic indications may indicate that some of the roads lay on top of dykes of only a small magnitude. The impossibility to determine with certainty whether all linear features were really dykes unfortunately introduces an element of randomness in our interpretation of the maps.[34] In our commentary, we will explain which considerations have induced us to accept or reject a linear feature as being a dyke.

Finally, even after the integration of the two maps, some dykes remain that seem to be utterly useless. Since it is as unlikely that the French geographers drew non-existing dykes as that the Egyptians took the effort of building dykes for no useful purpose, one has to assume in such cases that additional dykes existed that went unrecorded. Here, we have in a few cases (to be remarked upon later) inserted dykes not entered in the plans.

4. Analysis

4.1 The Hydrology of the area between Dairūṭ and al-Ashmūnayn

As noted before, a major feature of the hydrology of the Nile floodplain is the phenomenon of levees being deposited on the banks of the Nile, and the gradually decreasing elevation of the field surface as the distance to the river increases. The isohypses (height lines) in the maps reproduced in figs. 5-6 clearly indicate this phenomenon. Everywhere, the surface level immediately beside the Nile is on the west bank considerably higher than further west. Here, the surface level gradually decreases until the western desert edge is reached.

Although this longitudinal S-N depression can be observed in most places, the picture is blurred by secondary levee systems, of which the most important one follows the course of the Baḥr Yūsif, which branches off the Nile near the town of Dairūṭ, and follows a meandering course through the deepest part of

settlements lie on high levees or dykes according to the map of the *Description de l'Égypte*. Contrary to Schenkel, Grieshaber, 2004, p. 29 seems to assume forthwith that the roads followed by the French army were dykes.

34 Some very significant dykes, such as parts of those near al-Lahūn, are in fact rendered as a mere double line in the *Description de l'Égypte*, map 19.

the S-N depression to the Fayyūm depression.[35] As explained elsewhere in this book,[36] the volume of water transported by this watercourse is much smaller than that of the Nile itself, and as a result, the levees in this area are generally much lower than those fringing the main river bed. But the Baḥr Yūsif levee system does lead to an interruption of the gradual decrease in elevation between the Nile and the western desert fringe. Here one can observe that, wherever the Baḥr Yūsif meanders away from the desert edge, depressions can be observed both east and west of it (see fig. 6). In some places, this even leads to the emergence of small lakes immediately east of the desert edge, but west of the Baḥr Yūsif. In the area investigated here, such a lake must have existed for instance near the town of al-Birka ("the Lake") near Ṭūna al-Jabal (no. 15 in fig. 3).[37] This situation suggests that the levees adjoining the Baḥr Yūsif are secondary, being deposited over the generally descending surface that existed in the western part of the Nile Valley.

The system observed here in some essential regards resembles the one in the area to the east of the Pelusiac branch of the Nile, in the eastern Nile Delta.[38] Here, too, the Nile is fringed by a gradually deepening depression, which functions as a natural drainage system. At its deepest point this has given rise to the emergence of a wide waterway locally known as the Baḥr al-Baqar, the "river of the cow". In width this waterway can reach some 50 m, not much less than that of the Baḥr Yūsif, although its depth probably is, and no accompanying levee system apparently exists here. Therefore the activity of the Baḥr al-Baqar is clearly substantially inferior to that of the Baḥr Yūsif, but to a large extent the two systems are nevertheless comparable. Both emerged in naturally grown depressions dependent on the Nile. However, the Baḥr al-Baqar is part of the Nile Delta, a vast expanse of low-lying land crosscut by two (and anciently as many as seven) Nile branches. As a result, the water volume spilling over the levees of the Pelusiac Nile branch must have been very much lower than in the Nile valley, and there were numerous drainage systems all of which transported only a relatively small part of the total flood volume.[39] By contrast, in Upper

35 This is what geomorphologists call a Yazoo river (Ward, S., 2004; Whittow, 2000).

36 Verstraeten et al., 2016, p. 248.

37 See p. 316 below. A better known example is the lake located due east of the pyramid of Amenemhat III at Dahshūr.

38 Bietak, 1975, p. 55-56.

39 Here one recalls that Classical authors recorded that in Elephantine the peak of the flood reached 28 cubits, but at the Mediterranean coast only 2 to 6 cubits. Compare also the remarks by Antes, 1800, p. 66.

Egypt, all water had to pass through the relatively narrow Nile valley, where the river slope is moreover steeper. Undoubtedly the much larger resultant local water volumes encountered here must have led to occasional breaks in the Nile levees, and ultimately to the (probably natural) creation of an open connection between the Nile and the Baḥr Yūsif drainage system. As a result, it would be correct to an extent to call the Baḥr Yūsif a 'branch' of the Nile, but yet this does not diminish the fact that it is not more than a secondary branch draining off Nile water to lower areas. In this regard, it differs completely from situations where the main bed of the Nile is split in two by islands, or where it bifurcates, as happens with the major Nile beds in the Delta.[40]

Today, the Baḥr Yūsif is the only remaining secondary system branching off the Nile, but the map of the Description de l'Egypte indicates several additional branches in existence in the late eighteenth century. One is the Tirʿa al-Shaykh Ḥijāza ("Tora Cheik Hagazéh") connecting the village of Rairamūn and the town of al-Ashmūnayn, another is al-Sabakh ("el Sabbak"), which crosses the Nile banks just south of the village of al-Bayaḍīya ("el Béïâdîéh") and following a winding course until it ends in the S-N depression just north of al-Ashmūnayn (see fig. 6).[41] For the location of these toponyms and names of waterways, see fig. 3. As figs. 5-6 show, these watercourses are also accompanied by their own, although less clearly expressed, levee systems.

Just as, to a lesser extent, the Baḥr Yūsif, these latter two waterways are secondary to the Nile itself. They are much narrower, and therefore undoubtedly also much shallower than the Nile. The obvious implication is that, when the Nile was low, an only small amount of water (or none at all) may have entered

40 The situation in the Baḥr Yūsif area reminds one of that around Memphis, where the current main branch of the Nile is accompanied on the west by the smaller, and less highly elevated Baḥr al-Libaynī. This waterway has been interpreted as the rudiment of an early dynastic Nile branch, the assumption being that the town then lay on the eastern Nile bank. This would only have changed as a result of a gradual shift of the Nile bed to the east (Jeffreys, Tavares,1994, p. 143-173). To us, it seems at least worth considering that the Baḥr al-Libaynī is a Yazoo-type river system (see n. 35) just like the Baḥr Yūsif. As a result, the perspective on the hydrology of ancient Memphis may have to be thoroughly reconsidered in the light of the present study.

41 *Description de l'Egypte. Atlas géographique*, pl. 14. At the mouths of these branches we have discovered remains of dams accompanied by brickwork water distributors built in the time of Muḥammad ʿĀlī. This suggests that the branches were blocked around 1830.

these waterways. They therefore mainly played their role in the hydrology of the floodplain during and after the Nile flood.

So far, all elevations along waterways have been termed levees, and we will continue to use this term below in this general sense. However, the landscape formation processes in the region studied here may bear witness not only to the result of sedimentation on embankments parallel to rivers. There is a second system, which evolves particularly inside river bends when large discharges of water erode small channels through an already existing levee. This results in large amounts of sediment being washed through the new gulley, and fanning out from there inside the basin ('crevasse splays'). Once formed, crevasse splay channels may be reactivated during subsequent floods, leading to the emergence of additional channels, and to sediment depositions on top of their embankments. Crevasse splays accordingly lead to the emergence of secondary levees bulging into the flood basins behind the main levees.[42] It will appear that this phenomenon also had an impact in the region here investigated.

4.1.1 Detailed Description of the Elements of the Hydrology of the Region

We will now discuss the hydrological elements (dykes, canals, channels, elevations in the landscape, etc.) in the region. This section is essential for this article, but for understanding its reasoning it is only of importance to those who might like to verify the detailed argumentation on which our assumptions are based. Readers not interested in these details are recommended not to read pp. 275-295.

The analysis to be presented here builds upon an account of the same issues published earlier in summary fashion by H. Willems.[43] This article was based on work carried out to prepare the construction of a functioning Nile model, which stood in the exhibition 'Keizers aan de Nijl' in the Gallo-Roman Museum in Tongres (1999-2000). For obvious reasons, this model had to be based on a highly simplified translation of reality. The base maps Willems used then were the same as are used in this article, but they were not properly georeferenced. Rather, the map of the *Description de l'Égypte* was somewhat impressionistically adapted to the topographical map of the survey of Egypt. Several errors were,

42 Bridge, 2003, p. 273; van Dinter/van Zijverden, 2010, p. 20-21 offer a good visualisation of the evolution of a crevasse splay. Note that the effects of crevasse splays in part of the area discussed here is already mentioned in Kemp, 2005, p. 23-24.

43 Willems, 2013, p. 346-352 and fig. 1.

however corrected in the georeferenced maps used in the present article, which were produced by Hanne Creylman and Véronique De Laet. We will present the relevant data from south to north, starting just south of the town of Dairūṭ, where Baḥr Yūsif branches off from the Nile.

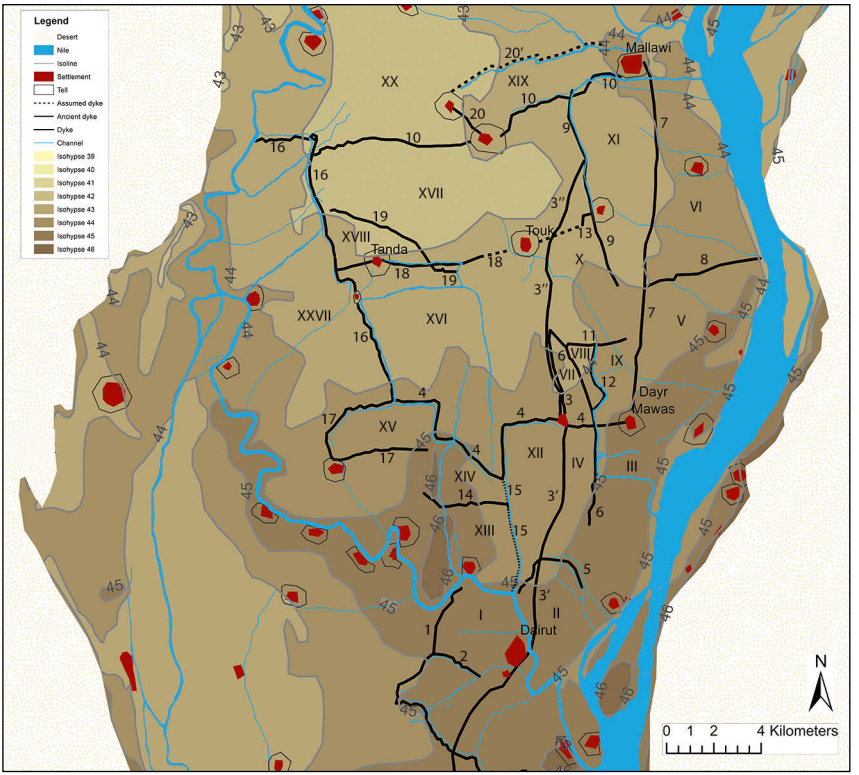


Figure 5. Georeferenced map of the northern part of Description de l'Égypte *plate 13, projected over a topographical map of the same area. Map Hanne Creylman.*

1. The Nile Levee near Dairūṭ (see fig. 5)

Dairūṭ lies immediately to the south of the Baḥr Yūsif, and accordingly on the levee of this Nile branch. The elevation of this levee (+ 45 m) is lower than that of the Nile levee southeast of Dairūṭ, the top of which lies above the 46 m contour line. Further north, the top of an island in the Nile reaches the same high level. The area near the beginning of Baḥr Yūsif, in between the two +46 m areas, is considerably lower (in the +44-45 m realm). This suggests that, at

a certain point in time, Baḥr Yūsif cut through an existing +46 m Nile levee, perhaps caused by a bend in the course of the river Nile.

Events of this kind are only likely when a high flood generates such a water pressure that the levees break. The same exceptional circumstances may explain why the northernmost +46 m area developed into an island with, judging by the closeness of the isohypses, steep slopes, and why two small channels divert from the Nile NE of Dairūṭ.[44] This renders likely that a break in the Nile levee east of Dairūṭ evolved into the major Nile branch now known as Baḥr Yūsif. Possibly this waterway was at its origin a crevasse splay channel, but it has long since developed into a perennial river branch.

2. The dykes west of Dairūṭ (fig. 5)

The *Description de l'Égypte*, pl. 13, indicates two dykes west of Dairūṭ. *Dyke 1* branches off from the Baḥr Yūsif to the southwest. It is called Jisr Dairūṭ al-Sharīf (in the *Description de l'Égypte*: "gesr Dairoût el Cherîf", the "dyke of Dairūṭ al-Sharīf"). Due west of Dairūṭ, the unnamed *dyke 2* branches off eastwards from dyke 1 towards the town. Dykes 1 and 2 roughly demarcate the west and south of a basin, but the *Description de l'Égypte* does not indicate how this was closed off on the east and north. However, the northern part corresponds to the levee constituting the southern bank of the Baḥr Yūsif, even though the isohypses on the map do not show a rise in elevation in this area. On the east, there lay the town of Dairūṭ itself and, just south of that, a smaller settlement called Sabīl al-Khazindār ("Sibil el Kâzendâr"). It is likely that the elevations on which these settlements lay (and which are clearly indicated on the map of the *Description de l'Égypte*) constituted the eastern perimeter of the basin. This basin was fed by a channel perpendicular to the Baḥr Yūsif, which entered it just north of the town. We will call this *basin I*.[45] After the flood, the residual water from basin I must have flowed back into the Baḥr Yūsif.

44 Since on pl. 13 of the *Description de l'Égypte*, these channels have no name, they have received no number in fig. 3.

45 In this article we will not discuss a basin surrounded by dykes to the southwest of basin 1. However, it should be noted that its dykes as indicated by the *Description de l'Égypte* follow the same contour as the 45m isohypse in the topographical map, even though this does not indicate any roads or dykes here. Probably the eighteenth century dyke had been removed by the time the twentieth century map was drawn, although the silt deposition that had accrued behind it was still there. For such depositions to reach a height of this kind (the topographical map used iso-

3. The Depression in the Floodplain West of Dairūṭ

From dyke 1 as far as the edge of the Western Desert, not a single dyke is noted by the *Description de l'Égypte*. This implies that at the latitude of Dairūṭ the area within dykes is restricted to a narrow band west of the Nile. Further west, the topographical map indicates an extensive depression (elevation: + 43m), crosscut by three natural S-N drains, the central one of which further north breaks into the Baḥr Yūsif. This undoubtedly humid depression may have been less suitable for agriculture in antiquity[46]. West of this depression, a S-N elevation in the + 44 m range may be the levee of a former branch of Baḥr Yūsif. The town of Daljā lies on top of this elevation.

4. The Hydrology of the Region between Dairūṭ and Dayr Mawās

Between Dairūṭ and Dayr Mawās, north-east of the Baḥr Yūsif, a wide + 45 m levee fringes the Nile on the west, which must have bounded a somewhat lower and descending area further west. This area continued even N. of Dayr Mawās. Just north of the mouth of the Baḥr Yūsif, and northeast of Dairūṭ, the levee is intersected by two small channels which do not bear a name in the *Description de l'Egypte*. SE of Dayr Mawās, the levee was intersected by a small Nile branch called the the Tirʿa al-Sanjāj ("Tora el Sangág"; see fig. 3).

The village of Tānūf ("Tanoûf") lies due west of Dayr Mawās. The two settlements are connected by *dyke 4*, which also continues west of Tānūf (see 7. below). In Tānūf, dyke 4 seems to be crossed by a N-S *dyke 3* called the jisr Tānūf ("gésr Tanoûf"). In fact, the *Description de l'Egypte* writes the name Jisr Tānūf only on the stretch north of the village. In the area further south a double line continues, which could indicate a dyke, but also a road. However, in this area a dotted line indicates the marching route of the French army *beside* this double line, and in other places, such a dotted line alone often indicates a road. The fact that it here appears beside a double line suggests that the latter may be more than just a road. Moreover, further south, west of Jarf Sarḥān, the double line goes over another double line which is itself undoubtedly a dyke. Although the matter is not quite clear, we have assumed that the stretch south of Tanūf is a dyke, but because it is not entirely certain to be really the continuation of dyke 3, we will designate is as dyke 3'. This dyke continues south as far as the north bank of the Baḥr Yūsif opposite Dairūṭ. Thus, the Nile levees, the E-W dyke 4,

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hypses at 1m intervals) the dyke must have been functional for a very considerable period of time.

46 Cf. the similarly low areas further north, to be discussed under 14, which, still in 1798, were only partly under cultivation.

the N-S dyke 3', and the levee on the north bank of Baḥr Yūsif circumscribe a roughly rectangular area which gently dips towards the west. This large area is intersected by two further dykes.

Dyke 5 branches off eastwards from dyke 3'in the direction of the Nile, but it does not reach it, undoubtedly because it runs up against the slope of the Nile levee. Dyke 5 separates two basins II and III. The area between the Nile levee and the Baḥr Yūsif, dykes 3' and 5 constitutes *basin II*, which is fed by a small channel. *Dyke 6* crosses dyke 4, continuing southwards through an area at an elevation of +44 m, but stopping where it meets the +45 m contour line. It seems likely that dykes 4 and 6 and the Nile levee surround a higher *basin III*, which mostly lies above the 45 m contour line. It is fed by the Tirʿa al-Sanjāj, and, in its southerly part, by a small channel already mentioned. This latter continues down into the +44 m depression east of dyke 3', which is here called *basin IV*.

Basins II and III mostly lie above the 45 m contour line, and will only have been flooded by a high inundation. The small, deeper areas of these basins, as well as basin IV, in the +44 m realm, were probably flooded almost every year. The *Description de l'Egypte* does not indicate in which direction floodwater drained off at the end of the inundation period, but small channels linking their deeper parts to the Nile exist on either side of dyke 5. It is likely that, at the end of the flood season, remaining floodwater was allowed to drain back into the Nile through these channels and the Tirʿa al-Sanjāj.

5. The Hydrology of the Region between Dayr Mawās and Mallawī, Eastern Part

This area is in many regards similar to the more southerly one we have just discussed. Immediately adjoining the Nile there is a levee, which gradually decreases northwards in elevation corresponding to the slope of the Nile itself.[47] In the south, the levee reaches a level of + 45 m, in the north of + 44 m. West of the levee, the fields slope down gently to the west.

Excursus: Concerning this Nile levee, a confusing element in the *Description de l'Egypte* must be discussed. Its map 13 indicates that, south of Rairamūn, the western bank of the Nile lay considerably farther west around 1720 than was the case in 1798 (and today). At that time, Mallawī would have lain immediately on the western Nile bank.[48] However, the extensive levee east of Mallawī, which we

47 According to Willcocks, 1889, p. 8, the Nile slopes down 1 m per 12.9 km.

48 This is also reported in Jomard, 1821, p. 316, and is occasionally accepted in the literature: Kessler,1981, p. 85

have just discussed, renders this unlikely. Under normal processes of alluviation it can impossibly have accumulated between 1720 and 1798, or even 1926. The *Description de l'Égypte* does not clarify what its interpretation was based upon, but the indicated date ("vers 1720") renders likely that the source of information was a description by Claude Sicard dated to 1722, which Robert de Vaugondy used for the map he published in 1753.[49] However, on this map one can see that Mallawī did not lie on the river, but instead that the situation recorded by the French cartographers in 1798 already obtained then. We therefore assume that the course of the Nile did not change significantly between 1722 and today. Based on the remarks in 12.b and 12.f, it may even have lain further east at some point prior to Napoleon's campaign (End of Excursus).

West of the Nile levee, the N-S *dyke 7* leads south from Mallawī to Dayr Mawās. This long dyke is described in the *Description de l'Égypte* as an "Ancienne Digue".[50] About halfway between the two towns, *dyke 8*, called Jisr Khuzām ("gesr Kozâm"), runs perpendicular from this old dyke to the Nile. In this way, two basins are created. *Basin V* extends along the Nile from Dayr Mawās to the Jisr Khuzām, and this basin is provided with water from a small channel called "Tora el Asarah".[51] The adjoining *basin VI* fringes the Nile from the Jisr Khuzām to Mallawī, its northern limit probably being formed by the tell of Mallawī and the Nile levee. This basin is fed by three different channels. The contour lines show that, during low floods, only a narrow + 43 m area adjoining the ancient dyke 7 could be flooded in basin VI, but during higher floods, the covered area, in both basins V and VI, would increase significantly. In both basins, one channel continues into the adjoining basins on the west (basins IX and XI; see below).

6. The Hydrology of the Region between Dayr Mawās and Mallawī, Western Part

Under 4., we have already discussed the southern stretch 3' of dyke 3, extending from Dairūṭ to Tānūf, but this dyke also continues north of Tānūf. There is some uncertainty, however, as to where exactly it stops. Leaving from dyke 4 to the north, dyke 3, explicitly designated as Jisr Tānūf, certainly continues northwards until the point where it meets the northward extension of the more

49 See n. 27.

50 It is uncertain whether it was still functional in 1798. If not, dyke 9, to be discussed below, may have taken over its function. In his discussion of this dyke, Grieshaber, 2004, p. 33 apparently confuses dykes 7 and 3''.

51 Arabic transcription unclear.

easterly dyke 6. The triangular area surrounded by dykes 3, 4 and 6 is here called *basin VII*. The map does not indicate any waterway connected to this basin, so that it cannot be ascertained how it was flooded, and in which direction the remaining water drained off after the flood. This basin cannot, therefore, be used in reconstructing the hydrology of the region.

The problem is whether dyke 3 continues northwards from the point discussed here. The map in the *Description de l'Égypte* suggests it does not. It also shows, however, that a road (indicated by two parallel lines) runs immediately beside dyke 3, to its west. Now dykes often serve as roads, and the dotted line indicating general Desaix' march route ascertains that dyke 3 was no exception (for it makes clear the French troups followed the top of dyke 3 near the northern end of basin VII, and not the road running immediately beside it). If we read the *Description de l'Égypte* map at face value, two roads seem to have run completely parallel from the village of Tānūf northwards. The lower of the two roads would be perfectly superfluous, and it would render a considerable surface of agricultural land useless.

Therefore it is assumed here that dyke 3 and the road immediately adjoining it on the west in fact were one and the same. This assumption, for which there unfortunately is no final proof, implies that dyke 3 continued further north to the village of Tūkh, where it turned northnortheast in the direction of the town of Mallawī, and reaching *dyke 9* near the cistern indicated on the French map. The somewhat hypothetical stretch of dyke 3 extending northwards beyond the northern end of basin VII until the cistern will here be called *dyke 3"*.[52] This dyke runs over (and probably dammed off) the "Tora el Asarah" just SE of the village of Tūkh.

Before discussing dyke 9, the hydrology on the southern fringe of the town of Mallawī must be discussed. Just southeast of the town, a Nile branch designated as Tirʿa Ḥasan Kāshif ("Tora Haçan Kâchef") crosses the Nile levee, passing the town on the south, and turning south a short distance after in the direction of Nazlat al-Shaykh Ḥussayn ("N. Chéïk Hoçein").

West of Mallawī, the map indicates a settlement called Sinjirj ("Singerg"), and a complex dyke system (*dyke 10*) connects the two. At halfway between the two settlements, *dyke 9* branches off south, enclosing the Tirʿa Ḥasan Kāshif on the west,[53] passing Nazlat al-Shaykh Ḥussayn on the west, and stopping not far

52 Linant de Bellefonds' map indicates a dyke following exactly this course (Grieshaber, 2004, p. 33).

53 On the north, the map suggests this waterway was not completely surrounded by dykes. Not far from Mallawī, the waterway is shown to break through dyke 10,

west from the juncture of dykes 7 and 8. The isohypses show that dyke 9 stops on the ascent of the Nile levee, somewhere above 44 m above mean sea level.

The above, rather complex, description shows that a large, rectangular basin system is contained within dyke 7 (east), 10 (north), 4 (south), and 6, 3'' and 9 on the west. This large area can be subdivided into further basins.

Basin VIII: This basin lies east of dyke 6. It is bounded on the north by the E-W *dyke 11*, which runs eastwards from dyke 6, crossing a +43 m depression and ending in the + 44 m realm on the Nile levee. Further south, a second *dyke 12* also branches off from dyke 6, meeting dyke 11 further north. Dykes 6, 11 and 12 surround basin VIII, which lies in the +44 m and the +43 m area. Like in the case of basin VII, no waterways are indicated that could explain how basin VIII was filled and emptied. This basin cannot, therefore, be used in reconstructing the hydrology of the region. The fact that the adjoining basins VII and VIII have to be disregarded does not pose a grave problem, as both are rather small.

Basin IX: East of basin VIII lies basin IX. It is bounded by dykes 4, 7, 11 and 12. In its deepest part, it lies in the lowest +44 m altitude range. The *Description de l'Égypte* indicates that this dyke system is open in the northeast, but this area lies well in the +44 m range, so that the raise in natural relief may have served to close this area off. Arguably, dyke 11 may also have continued as far as dyke 7. Basin IX receives its floodwater through the "Tora el Asarah", which enters it from basin V.

Basin X lies north of basins VII and VIII, and northwest of basin IX. It is bounded by dykes 3'', 9, 13 (to be discussed below), 11, and the +44 m area forming part of the Nile levee, which, because it bulges out far from the river bank to the west, may be a crevasse splay. It can only have been flooded through the narrow "Tora el Asarah," which has its head in basin V, passing through basin IX into basin X. Thus, we here have a basin chain V – IX – X.

Basin XI lies north of the previous ones, being surrounded by dyke 7 (east), 10 (north), 9 (west) and the +44 m contour forming part of the Nile levee in the south. No waterways connect Basin XI with the more southerly basins VII, VIII, IX and X. Instead, it receives its water from the east, from the Tirʿa Ḥasan Kāshif and, further south, the "Tora Hoceïn Cherkes".[54] This implies an E-W

and to return within it a short distance further downstream. The small part of the Tirʿa Ḥasan Kāshif lying outside the dyke connected to a small channel leading deeper into the adjoining basin. It seems hard to find a rational explanation for the course taken by the channel. Perhaps the published map is erroneous here, or it may reflect a situation that emerged after a partial destruction of the dyke.

54 Transcription unclear.

basin chain VI-XI. There seems to be no clear connection between this basin chain and more westerly basins, so that residual floodwater is likely to have moved back into the Nile from the channels through which it had arrived.

7. The Hydrology of the Area between Dairūṭ, Tānūf, and Ismū

Two main natural features dominate the landscape in this area: the +45 m levee of the Baḥr Yūsif and two +46 m elevations north of the Baḥr Yūsif, which begin under and extend to the north of the village of Banī Ḥarām ("Beni Harâm"). Immediately east of this elevation, a rather large waterway branches off from the Baḥr Yūsif, running straight north: the "Tora el Kiket".[55] The outline of the + 46 m, +45 m, and +44 m contour lines just discussed strongly suggests that these are levees and thus that the "Tora el Kiket" was once a very active waterway, or that there is a crevasse splay here. Perhaps it is what remains of a precursor of the Baḥr Yūsif.

East of the "Tora el Kiket", a second waterway branches off to the north from the Baḥr Yūsif, leading to the village of Tānūf. This is the Tirʿa Tānūf.

These two waterways feed a series of basins further north, that are bounded on the south by the levee of the Baḥr Yūsif, on the east by dyke 3', and on the west by the + 46 m levee system just discussed. A major problem in interpreting the landscape in this area is a further landscape feature: *dyke 14*. This dyke, called Jisr al-Nāṣirīya in Arabic ("gesr el Nasriéh"), starts in the west at the northern tip of the southernmost +46 m elevation and runs straight eastwards to the Tirʿa Tānūf, where it stops. Since it is quite unlikely that a dyke would stop in mid-air, it must have continued somewhere, or it must have hit a higher surface not indicated on the map.

One possibility is that the Tirʿa Tānūf was fringed by a levee just like the "Tora el Kiket". Since the *Description de l'Égypte* generally disregards levees, the absence of the feature would be understandable. However, the Tirʿa Tānūf seems to have been quite small, and it is therefore unlikely to have created a levee of significant height. Another possibility is that such a levee may have been artificially heightened by earth dredged out of the channel. Such a dyke fringing the Tirʿa Tānūf is, in fact, visible further north. This is the westward extension of dyke 4 discussed already under 4. From Tānūf, the dyke first follows a westerly course for c. 2 km, then it sharply turns south for c. 2 km, where it fringes the Tirʿa Tānūf. We will assume here that this dyke continued all along the western

55 Transcription unclear.

side of the Tirʿa Tānūf to the Baḥr Yūsif.[56] This hypothetical dyke (indicated by a dotted line) is here called *dyke 15*.

Basin XII: This is the basin just discussed. It is surrounded by the levee of the Baḥr Yūsif (south), dyke 3' (east), dyke 15 (west), and dyke 4 (north and west). This basin does not connect to any other, so that any remaining floodwater from it would have to flow back directly into the Baḥr Yūsif after the flood season. From there, it would be transported, not back to the Nile, but northwest into the Baḥr Yūsif depression.

Basin XIII: This is the basin enclosed on the west by the southernmost +46 m elevation, on the north by dyke 14, on the east by dyke 15, and on the south by the Baḥr Yūsif levee. It is fed exclusively by the "Tora el Kiket", which continued north of dyke 14, leading into

Basin XIV: This is enclosed on the south by dyke 14, which, on its western end, links the southernmost +46 m elevation to the northernmost one, which bounds basin XIV on the west. On its north, basin XIV is enclosed by the westward continuation of dyke 4, and on its east perhaps by the hypothetical dyke 15. At the northwest of the basin, there is a small gap between dyke 4 and the +46 m elevation, but this is closed off by a small mound indicated in the *Description de l'Egypte*.[57] The "Tora el Kiket" crosses basin XIV from S to N, continuing further into basin XVI. However, just south of dyke 4, two branches of the "Tora el Kiket" lead east[58] and west, the western one providing water to basin XV, and the eastern one hugging dyke 4 on the south and stopping short of the hypothetical dyke 15.

Basin XV: This basin is enclosed on the north by the westward continuation of dyke 4, which continues until where it touches *dyke 16*: the Jisr Badramān ("gesr

56 In the study cited in n. 43, H. Willems assumed that such a dyke only ran from dyke 14 southwards, which is inconsistent. If it at all existed, it most likely continued all the way from dyke 4 to the Baḥr Yūsif, and hence north of the Jisr al-Nāṣirīya.

57 In the above, the hypothetical but likely dyke 15 has been added. If it did not exist (and dyke 14 was accordingly utterly useless), basins XII and XIII would in fact constitute one basin fed by two channels. For the rest, nothing in our interpretation would change.

58 The one turning to the east runs in the direction of the Tirʿa Tānūf, but before reaching it, it makes a turn to the south. This could be explained by assuming that the waterway could not prolong further in a straight course because of a rise in surface elevation, as we have assumed when arguing there was a dyke (15) here.

Badraman").[59] Beyond this, dyke 4 continues further to the west, but since, as of this point, the *Description de l'Égypte* gives it the new name of Jisr al-Qashāsh ("gésr el Qachâch"), we have called it *dyke 17*. After continuing for a while to the west, it bends to the south, and then eastwards past the village of Ismū ("Esmoû") until touching the northernmost +46 m elevation. Where dyke 4 meets dyke 16, a channel leads into basin XVI, which lies mostly in the + 43 m realm, and thus lower than basin XV. Therefore it is likely that any floodwater remaining in basin XV at the end of the flood season would flow out of it this way.

8. The Hydrology of Basin XVI

This basin is enclosed on the south by dyke 4, on the east by dyke 3-3'', and on the west by dyke 16. In its southern part, its floor lies in the +44 m range, further north in the +43 m range. Just after entering this basin, the "Tora el Kiket" gables, one branch continuing to the north, and a narrower one turning sharply to the east, hugging dyke 4. Then it, too, turns to the north. In the northern part of the basin, this waterway splits into a westward branch reaching dyke 16, and a northern one continuing into basin XVII.[60]

The most problematic issue is determining the northern demarcation of basin XVI, here indicated as *dyke 18*. This is the Nazlat al-Shaykh Ḥussayn –Tūkh – Tanda – Kawm al-Sihāl dyke system. Under 6. we have discussed dyke 9, running south from Mallawī to Nazlat al-Shaykh Hussayn. *a.* At the latter village, a short length of dyke has been drawn by the French cartographers, which roughly goes westwards in the direction of the village of Tūkh ("Touk"). The dyke as drawn is so short that it makes no sense, and the isohypses do not make things easier to understand. Probably the rest of the dyke has not been drawn. The crop

59 Grieshaber, 2004, p. 32-33 considers dyke 16 (with an overall N-S orientation) a "Querdeich", i.e. an E-W dyke. This clearly does not do justice to the situation.

60 What we here call "basin XVI" might actually cover two distinct basins. Map 13 in the *Description de l'Egypte* indicates a road or dyke departing northeast from the northeastern corner of basin XV, and continuing in a northeasterly direction towards the village of Tūkh and dyke 3''. It is indicated in the map in exactly the same way as dyke 3'' and therefore it would be consistent to interpret this as a dyke as well. On the other hand, while in the case of dyke 3'' other indications discussed above suggested that the feature represents a dyke, such supplementary indications are lacking in this case. Based on this uncertainty, we have not considered this a dyke; if it would be one after all, the only difference for the hydrology would the existence of an additional basin in the chain. For our interpretation of the irrigation the question of whether this dyke exists or not is immaterial.

boundaries indicated in the *Description de l'Egypte* seem to indicate an E-W line connecting the end of the dyke near Nazlat al-Shaykh Hussayn to Tūkh (dyke 13, see 6), and this has here been taken as being the easternmost part of dyke 18. It must be admitted that this interpretation is conjectural.[61] *b.* Between Tūkh and Tanda ("Tendéh"), no dyke is indicated immediately west of Tūkh, but the field boundaries between differently oriented crops exactly follows the expected trajectory of dyke18. For this reason, and because, otherwise, dyke 18 would be useless, we assume that there existed a continuous dyke here. *c.* At a short distance southwest of Tanda lies the town mound indicated as Kawm al-Sihāl (8 in fig. 3). The *Description de l'Égypte* shows no dyke between the two places, but since both are mounds one may perhaps assume that the intervening land was slightly more elevated, rendering dam construction superfluous.[62] *Dyke 18* constitutes the northern perimeter of basin XVI, which lies almost entirely in the +43 m range.

9. The Hydrology of the Area Southwest of Mallawī: Basins XVII and XVIII

a. About halfway between Tūkh and Tanda, the E-W dyke 18 is crossed by another roughly following a WNW-ESE course. This *dyke 19* is called Jisr Tanda ("gesr Tendéh"). It almost continues as far as the Jisr Badramān (dyke 16). In the remaining gap the drawing published in the *Description de l'Égypte* does show a field boundary in the extension of dyke 19. The contour lines indicate that the dyke may also stop before reaching dyke 16 because of a rise in surface level in this area. *b***.** Dykes 16, 18 and 19 circumscribe a small triangular basin here designated as "basin XVIII". This basin lies in the + 42 m and the +43 m realm. South of the Tūkh – Tanda dyke, dyke 19 continues its course for a short distance, creating another triangular, but extremely small basin. This does not have a dyke at its eastern end, but the *Description de l'Egypte* here indicates the presence of

61 If this length of dyke did not exist, then basin X would simply be a bit larger. The option has no consequences for the interpretation of the hydrology of either this basin, or of basin XVI.

62 From Tanda, a double line continues further westwards to the village of Badramān. It crosses the Jisr Badramān dyke previously discussed (dyke 16). This double line seems to be deliberately less marked than the lines used for dykes, and we have therefore assumed this is not a dyke but a road. However, the possibility remains that this is a dyke after all, in which case the E-W dyke system here being discussed continued all the way to about the 44 m contour line of the Baḥr Yūsif levee.

a small kôm, which could have closed the basin from this side. In view of its miniature size, this basin will not be incorporated in the overall interpretation in this chapter. *c.* The vast "basin *XVII*" extends north of dykes 18 and 19, east of the northern end of dyke 16, and west of dykes 3'' and 9. The northern perimeter is more difficult to reconstruct. Under 6. we have discussed dyke 10 leaving the town of Mallawī to the west. Beyond where dyke 9 branches off, dyke 10 continues its westerly course to the village of Sinjirj ("Singerg"). From this point the drawing becomes more problematic. From Sinjirj, a double dotted line indicates the location of an "Ancienne Digue",which continues westwards as far as the Baḥr Yūsif levee, and which we interpret as the continuation of dyke 10. Some confusion on the part of the printer is apparent, as at a certain point, the map indicates a bridge passing over the dyke. This of course cannot be correct. Moreover, the westernmost part of this ancient dyke is graphically rendered, not as a dyke, but as a channel[63] running in the direction of the Baḥr Yūsif. Probably, there was a canal on the inside (i.e., south) of dyke 10 surrounding basin XVII. Because the dyke was "ancient", and therefore perhaps not easily recognizable everywhere, the tract of the dyke may have been unclearly drawn by the cartographers, being misinterpreted by the printers as a canal.[64] These considerations do not alter the likelihood that Sinjirj was linked to the levee of the Baḥr Yūsif by dyke 10, which linked up to dyke 16.[65]

Basin XVII mostly lies in the +42 m range, and thus deeper than basin XVIII and all other basins discussed previously. Inside this basin, the map of the *Description de l'Egypte* indicates only few waterways, but we have seen that there probably was one on the south of dyke 10, and flowing in the direction of the Baḥr Yūsif. However, this waterway must under most conditions have been unsuitable to transport off water into the Baḥr Yūsif, which in this area lies higher. Perhaps, a waterway crossed dyke 10 in the direction of basin XX. One

63 Because the empty space between the lines is filled in in grey.

64 It is also conceivable that the "ancient" dyke 10 was no longer functional and did not exist everywhere anymore. In this case, basin XVII would be continuous with basin XX. The resulting basin would however be so much larger than any of the other ones on the map that this seems less likely.

65 Where dyke 16, i.e. the Jisr Badramān, turns west, the map of the *Description de l'Egypte* suggests the presence of some rather complex water works: the dyke does not just make a turn to the west, but there seems to be another dam making a turn around the corner of the dyke. Precisely at this point, numerous smaller and larger channels occur. We have not succeeded in finding an explanation for this system.

can see, however, that the continuation of the "Tora el Kiket" enters basin XVII from basin XVI, immediately turning west into the +43 m basin XVIII.

No waterway is visible through which the water may have drained off from basin XVIII after the inundation. However, it is impossible for this water to have drained off across the much higher Nile levee. The only realistic direction is through the low basins XVII and XX. It is therefore likely that a waterway was omitted in the *Description de l'Égypte*.

10. The Hydrology between Mallawī and al-Ashmūnayn (fig. 6)

Just northeast of Mallawī lies the village of Rairamūn. Still today, this is recognizable as a large tell, although it is now completely overbuilt. In the late eigthteenth century, it lay at the beginning of a Nile branch designated as the Tirʿa al-Shaykh Ḥajāza ("Tora Cheik Hagazéh"), which continues past Qulubba to al-Ashmūnayn. This situation is already seen in the map by de Vaugondy, which reflects the situation in 1720. Both north and south of the mouth of the Tirʿa al-Shaykh Ḥajāza, which itself lies in the + 43 m realm, the Nile levees lie in the + 44 m range. This suggests that, at an earlier point in time, a continuous + 44 m Nile levee was broken, leading to the emergence of the Tirʿa al-Shaykh Ḥajāza. The situation reminds one of the inlet of the Baḥr Yūsif to the east of Dairūṭ al-Sharīf.

The isohypses indicate a clearly expressed levee system here, which must have been deposited by an active Nile branch starting southeast of Mallawī. It is indicated by the + 44 m contour line on which the town of Mallawī lies, by the + 43 m contour line on which lies al-Ashmūnayn, and by the + 42 m contour northwest of that town. One also notes that, from a point close to the mouth of the Tirʿa al-Shaykh Ḥajāza, many channels fan out in different directions. This pattern is reminiscent of what would be found in a large crevasse splay, and this may explain the form of the landscape here.

Apart from dyke 22, to be discussed later, no dykes are indicated anywhere in this area, suggesting that the levees were sufficiently prominent to function as such.

West of Mallawī, in the village of Sinjirj, *dyke 20* branches off to the NW from dyke 10, forming a connection with the village of Umm Qummuṣ ("Moqommos"). Unexpectedly, no dyke continues from here according to the *Description de l'Egypte.* Nor do the isohypses offer an explanation as to why this dyke would stop in mid-air. One possibility is that a dyke simply was not observed by the French cartographers, or that the printers may have misinterpreted the information they were provided with, confusing a channel with a dyke. Since exactly the same kind of problem has been encountered elsewhere in the same

region (see under *9c*), this is perhaps the best explanation. Here one should consider two points. On several occasions, we have already seen that canals/channels lie immediately beside a dyke. For canals this is self-evident: earth had to be dug up to build a dyke, and the easiest way of working would be to use the soil dug up for digging a canal for constructing the adjoining dyke. Research carried out in other parts of Egypt suggest that such canals normally lay just south, i.e. upstream, of the dyke they accompanied.[66] Therefore, if the *Description de l'Egypte* indicates a canal but no dyke, a dyke may nevertheless have existed (just as in the clearer case of the western end of dyke 10). Now a channel runs from Mallawī to Umm Qummuṣ, and if we tentatively assume the existence of a *dyke 20'* beside this channel, the problem is solved. This dyke would run up against the tell of Mallawī, constituting a *basin XIX* to the west of that town. This basin would be enclosed by dykes 10, 20, 20' and the Mallawī town mound.[67]

11. The Hydrology Southwest of al-Ashmūnayn[68]

a. Dyke 21 west of al-Ashmūnayn: this "digue d'Achmouneïn" runs from the western part of al-Ashmūnayn to the levee of the Baḥr Yūsif, and it thus constitutes the northern perimeter of the large *basin XX*. This basin is bounded on the south by dykes 10, 20 and 20', on the east by the +43 m levee of the Tirʿa al-Shaykh Ḥajāza, and on the west by the +43 m levee of the Baḥr Yūsif. *b.* From the western end of dyke 21, the *Description de l'Égypte* shows a double line turning south on the east bank of the Baḥr Yūsif to the village of al-Birka ("El Birkeh"), continuing all the way south to dyke 16. Since this element runs over the highest point of the levee of the Baḥr Yūsif, it could be just a road; it could also be an artificial elevation serving as a dyke. However, in that case

66 This has been described in more detail for dykes in more northerly parts of Middle Egypt. It was observed that, to the south (i.e. upstream) of dykes, a thickness of between 0.5-1 m had been removed of a wide surface south of the dyke. Within this already slightly deeper area, drains were then dug (Gomaà/Müller-Wollermann/Schenkel, 1991, p. 66-67).

67 This is really not more than a guess. Note that Michel, 2005 found no evidence in papyrological sources or in Ottoman dyke lists suggesting that canals were ever dug during this long period of time. If he is right, the evidence studied by Gomaà/Müller-Wollermann/Schenkel must be rather recent, and our reasoning leading to the assumed presence of dyke 20' would be invalid.

68 From this point, all areas discussed can be found in map 14 of the *Description de l'Égypte*; see our fig. 6.

such a dyke would also be expected on the Tirʿa al-Shaykh Ḥajāza levee, which reaches the same elevation. Since this is not the case, the feature discussed may be a road rather than a dyke. The toponym al-Birka means "the lake". Although no lake is indicated in the Napoleonic map, the topographic map we used, which was made 125 years later, does show one west of the village in the +42 m realm. The name of the settlement leaves no room for doubt that the lake must have been a reality already in the 18th century. The fact that the 'lake' was not noted when the map was drawn in late December 1798, suggests this may have been an exceptionally dry year. This should be kept in mind in interpreting other elements of the hydrology as well. *c.* Basin XX was supplied with water through the Tirʿa al-Shaykh Ḥajāza branching off from the Nile at Rairamūn. This waterway runs all the way to al-Ashmūnayn, which it bypasses on the south, continuing its course as a narrow channel in the direction of the Baḥr Yūsif. North of Mallawī, a smaller waterway called the Tirʿa al-Majnūn ("Tora el Magnoun") branches off to the west from the Tirʿa al-Shaykh Ḥajāza. The Tirʿa al-Majnūn crosses the centre of basin XX from SE to NW. Near the centre of dyke 21, it crosses the Tirʿa al-Shaykh Ḥajāza again, and the fact that it seems to continue through dyke 21 suggests that this dyke could be opened to drain remaining floodwater off to the north, into the deepest part of basin XXVI (+ 41 m).[69] In the southwestern corner of basin XX, two further waterways enter it from the Baḥr Yūsif, so that this very large basin seems to have been inundated (or: inundatable) from two sides.[70]

69 Waterways called al-majnūna and draining off to the deepest part of the floodplain existed in different parts of Upper Egypt (Michel, 2005, p. 259).

70 In the southwestern corner of the area discussed, the *Description de l'Égypte* indicates a somewhat more complex dyke system than anywhere else in the area investigated. Although the functioning of this dyke system is not clear to the authors, it might have something to do with the fact that basin XX was fed by two different channel systems.

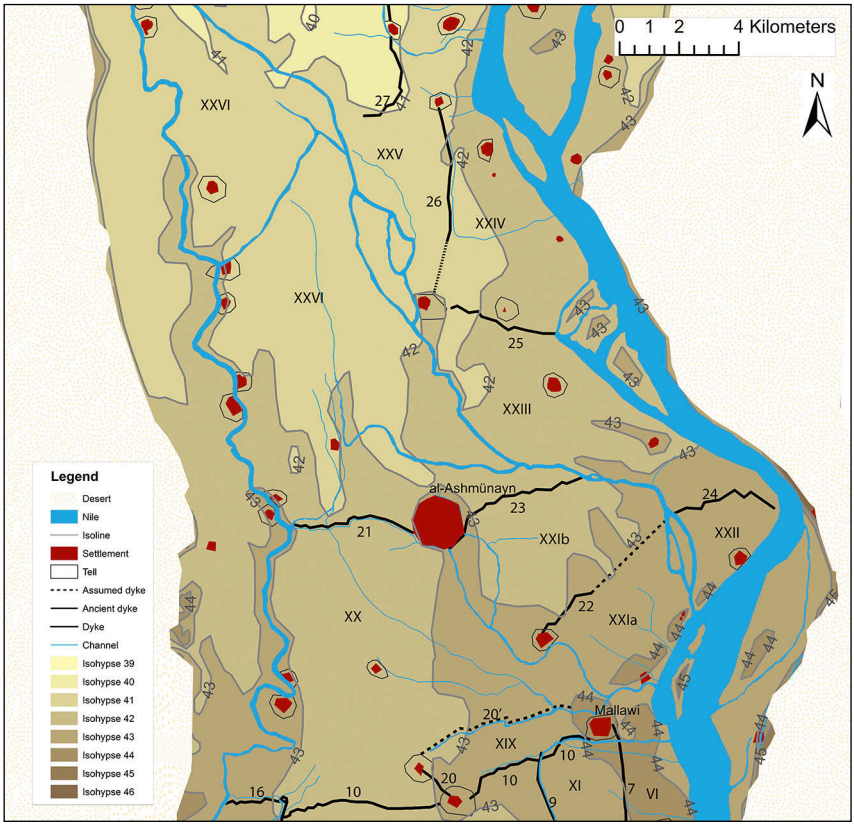

Figure 6. georeferenced map projecting information on dykes, waterways and settlements as provided by the Description de l'Égypte*, map 14 over a modern topographic map. Map Hanne Creylman.*

12. The Hydrology Northeast of al-Ashmūnayn

a. The main natural feature NE of al-Ashmūnayn is a watercourse branching off the western Nile bank at a place called "Deïr el Nosara" in the *Description de l'Égypte*, map 14. This village is today called Dayr al-Mallāk. This wide Nile branch, called al-Sabakh ("el Sabbak") may have been cut through the Nile levee by the force of the Nile waters in the bend in the Nile, in which case this levee system would, at least in origin, be a crevasse splay. From here, al-Sabakh followed a northerly course, turning west to the northwest of the village of al-Bayāḍīya ("El Béîâdîyeh"), bypassing al-Ashmūnayn on the north. As a result, this town lay in between two Nile branches: the Tirʿa al-Shaykh Ḥajāza and the

much larger Sabakh. The isohypses indicate that the Sabakh is fringed by a +43 m levee system. However, this levee is expressed less markedly than the one accompanying the smaller Tirʿa al-Shaykh Ḥajāza, suggesting that, in the past, the latter may have been more active than al-Sabakh. *b.* Between Rairamūn and Dayr al-Mallāk, the +44 m Nile levee is interrupted. In this area lie not only the mouth of al-Sabakh, but also, slightly to the south, a much smaller, anonymous water inlet, which may also be due to erosion by the outside of the bend of the Nile.[71] West of this point, the contour of the isohypses is suggestive of a crevasse splay. Therefore it is likely that the Nile levee was broken here at some point in time.

Between Rairamūn and Dayr al-Mallāk, we have observed that the currently almost vertical profile of the western Nile bank cuts through Late Roman floor levels.[72] Clearly, a settlement has since the mid-first millennium A.D. been eroded here by a westward movement of the Nile.[73] Moreover, a core drilling (2012) at

71 Our plan in fig. 6 differs in two respects from the maps we used. Firstly, the *Description de l'Égypte* indicates the presence of a village called "K"(afr) el Reremoun" just beside this waterway. However, today there is no village here, but only farmland, with no traces of even a ruined village. Al-Rairamūn has enormously expanded, but even today, its northern fringe lies c. 1 km south of the channel here discussed. Therefore, the French map must contain an error, and we have therefore suppressed the village of "K. El Reremoun". Secondly, the Survey of Egypt map is erroneous, indicating that "el Malak monastery" (= the current Dayr al-Mallāk) lies to the east of, and closer to the Nile than, the + 44 m levee in this area. Our research there has shown that it lies very close to the river and on the highest point of the levee. This suggests that the + 44 m levee in this area has been somewhat misplaced. We have therefore adapted the map based on our knowledge of local conditions.

72 Clearly characterized as such by the presence of red brick and late Roman amphora sherds.

73 Above these archaeological depositions, the Nile bank has been heightened at some point in time as far as the level where brick waterworks were built in the time of Muḥammad ʿAlī to control al-Sabakh and the smaller water inlet. This suggests that the Dayr al-Mallāk-Rairamūn dyke topping the earlier levee was built prior to 1830, but after 1798, when no dyke was yet recorded in the map of the *Description de l'Égypte*. The likelihood of a westward migration of the main bed of the Nile in this area has been discussed elsewhere in this volume (see p. 242-247). This contradicts the widespread assumption that the Nile displayed a general eastward drift (Butzer, 1976, p. 35-36; followed by Grieshaber, 2004, p. 29; 34;

the site produced Late Period or Ptolemaic period ceramics. This movement may have caused the break of the levee between Rairamūn and al-Bayadīya. Farmers have told us that the smaller inlet in this area was used to supply the village of Tabūt, near al-Ashmūnayn, with water.[74] *c.* From Qulubba *dyke 22* runs NE in the direction of al-Sabakh, but it stops after only a short distance. Field boundaries drawn in *Description de l'Égypte* map 14 follow the line one would expect the dyke to have followed in the direction to the Sabakh. This renders likely that the dyke at some point in time had continued. Quite possibly, the event which caused the Nile levee to break between Rairamūn and Dayr al-Mallāk also swept away this dyke. *d.* From al-Ashmūnayn, *dyke 23***,** called al-Jisr al-Ṣulṭānī ("gesr soultâni") runs eastward, also reaching the al-Sabakh levee, damming off *basin XXI* in between. This basin is bounded on the east by the Nile levee continuing northwards to the levee of al-Sabakh, on the west by the levee of the Tirʿa al-Shaykh Ḥajāza, and on the north by dyke 23. As noted under 11c, dyke 22 may once have continued and basin XXI may actually have consisted of two basins XXIa and XXIb. Basin XXIa may have taken its water directly from the Nile, forming a chain with XXIb, and draining off in the direction of al-Sabakh. It is here assumed, however, that the channel between Rairamūn and Dayr al-Mallāk was the result of the break of the levee discussed above. If this is correct, basin XXIa may have received its water from the westernmost branch of al-Sabakh, and basin XXIb from the easternmost branch of the Tirʿa al-Shaykh Ḥajāza, which in fact crosses the +43 m isohypse into the lower-lying basin. After XXIa and b had fused into a single basin, this was probably filled from al-Sabakh,[75] in which it may also have drained off again at the end of the flood season. *e.* North of al-Bayadīya ("el Béïâdîéh") a *dyke 24* runs E-W from the bank of the Nile to the al-Sabakh waterway. This dyke still exists today. Like the previous one, it probably formed the northern perimeter of a basin (*basin XXII*), of which the southeastern limit was formed by a levee (in fig. 6 partly indicated by the 44 m isohypse and the tell of al-Bayadīya) and the western one by the levee of al-Sabakh. As the latter is not indicated in the topographic map, it was probably not very high, and the same is likely for the dyke.This basin probably received its water from the easternmost branch of al-Sabakh at this point, with

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Antoine, 2011, p. 18; Bunbury/Malouta, 2012, p. 119-122; counterevidence is now also available for the situation at Karnak, see Boraik/Gabolde/Graham, this volume). Kemp, 2005, p. 26-29 also argued that the current zone in which the Nile bed lies, differs barely from the situation since the Late Roman period.

74 This village lies in basin XXIb, to be discussed below.

75 Because the surface is higher there.

residual water flowing off that way again as well. *f.* North of dyke 24 the Nile banks show evidence of erosion due to high Niles. There are several remains of a +43 m levee which are crosscut by lower areas, and which in some cases have become detached from the river bank, constituting a whole series of high islands. This again suggests that the Nile has been moving westwards. Although the levee was degraded, and presumably reduced in height, it remains likely that further west the surface was still lower, although the difference cannot have been great. Along the northern bank of al-Sabakh, the isohypses also indicate a levee outline. North of al-Ashmūnayn, the village of Maḥraṣ lies on this levee. East of Maḥraṣ lies a "petite Digue" (*dyke 25*), continuing all the way to the river bank. The *Description de l'Égypte*s uggests this dyke started east of Maḥraṣ. The village is, however, drawn as lying on an elevation, and this is also recognizable in the isohypses. This elevation must have rendered unnecessary the construction of a dyke all the way to Maḥraṣ. The Nile levee, dyke 25, and the levee on the north bank of al-Sabakh enclose *basin XXIII*, which mostly lies in the +42 m realm, but in its northernmost part in the +41 m realm. Since the *Description de l'Égypte* indicates only one very small waterway entering basin XXIII from al-Sabakh, this basin was probably both filled up and emptied again at the end of the flood season from al-Sabakh.

13. The Hydrology of the Area North of Maḥraṣ

The amount of dykes in this area is very small.[76] *a.* North of Maḥraṣ as far north as the village of Itlīdim, *dyke 26* running parallel to the Nile, is clearly indicated, although according to the *Description de l'Égypte* it starts at quite a distance north of Maḥraṣ. Neither the *Description de l'Égypte* nor later topographic maps offer clear indications as to why this is the case, but as dyke 26 would otherwise be useless, we have assumed it continued further south than the *Description de l'Égypte* suggests. We have indicated this by a dotted line. The Nile levee, dyke 26 and dyke 25 surround *basin XXIV*. Immediately adjoining the Nile the levee lies in the +42 m range, just east of dyke 26 it is in the +41 m range. It is fed directly from the Nile by an anonymous waterway between the

76 The map of the *Description de l'Égypte* indicates the route followed by general Desaix through Middle Egypt as a double line. A part of this route, which branches off from dyke 27 south of at Itlīdim ("Atlidem") and passing east of al-Ashmūnayn, was earlier interpreted by Willems as a dyke (see n. 43). We have here assumed that this may not be a dyke. If it was one after all (we have seen that roads often followed dykes) this would not fundamentally change our interpretation, but just lead to the subdivision of some basins into more smaller units.

villages of Nazlat Abū Jāmiʿ ("N. Aboû Gâma") and Kawm al-Riḥāla ("Koûm el Rahâléh"). Two very small waterways crosscutting the Nile levee are also indicated near the village of Itlīdim. According to the *Description de l'Égypte* basin XXIV is fed through the already mentioned waterway directly from the Nile. As no waterways continue from basin XXIV further west, it is likely that, at the end of the flood season, residual water was channeled from this basin back into the Nile. *b.* Here, we will not discuss the dyke system north and northwest of of Itlīdim. Suffice it to say that, at the height of this village, only a very narrow strip along the Nile is confined within the Nile levee and a dyke (26 and 27). North of al-Ashmūnayn, the vast and low-lying floodplain area between the levees of Baḥr Yūsif and al-Sabakh (*basin XXVI*) and between the levees of al-Sabakh and dykes 26 and 27 (*basin XXV*) are entirely devoid of dykes. In this depression, the *Description de l'Egypte* indicates several large marshland areas that had not yet been converted into farmland. Presumably, the whole area had before been an area badly suitable for agriculture.

14. The Hydrology West and Northwest of al-Ashmūnayn

a. At the western end of dyke 21, a small road leads northwest to a village designated by the *Description de l'Égypte* as "el ʿArîn el Bahrî". This village lies on the east bank of the Baḥr Yūsif. A highly interesting point is that, between the village and the end of the al-Ashmūnayn dyke, a small and unnamed channel branches off to the northeast in the direction of the village of Nawāi, leading water into the large *basin XXVI* to the north and northwest of al-Ashmūnayn. This channel follows a winding course, and is joined along the way by the Tirʿa al-Majnūn from basin XX (see 11c). A distinguishing feature of the channel is that the map explicitly notes that the road from the al-Ashmūnayn dyke to al-ʿArîn al-Baḥrī passes over it by means of a bridge. Therefore, different from many channels in Egypt, this one was not contained within dykes. The only reason for this can be that an open connection existed between the Baḥr Yūsif and basin XXVI north of al-Ashmūnayn. Apparently, no system to control water existed here, and this probably correlates with the fact that the *Description de l'Égypte* does not indicate any dykes west of the line al-Ashmūnayn-Maḥraṣ (see 13). Also, as noted under 13, in this area there were in 1798 several large marshland areas. This probably means that this whole basin was ill suited for agricultural purposes.

15. The Hydrology along the Baḥr Yūsif (fig. 5)

We have already discussed some basins along the Baḥr Yūsif: basins I, II, and XIII. None of the more northerly basins we have discussed, except the last, lie immediately along that waterway, however. Basins XIV, XV, XVI, XVII and XVIII are all fringed on their western sides by natural elevations or dykes (16, 17) which lie at a considerable distance east of the Baḥr Yūsif. Along Baḥr Yūsif itself, this area is fringed by the + 44 m levee generated by that waterway and areas of lower altitude in the +43 and partly the + 42 m realm. The existence of dykes 16 and 17 shows that a conscious attempt was made to prevent floodwater entering freely from the west into the basins just listed. No dykes occur anywhere else in this area, so that it must have constituted a continuous basin XXVII. This basin is closed off at its northern end by the northernmost part of dyke 16, which here makes a sharp turning to the west, constituting a bar between basin XXVII and basin XX. However, precisely here lies the not entirely comprehensible dyke system crosscut by two waterways into basin XX (see 11). In several places, basin XXVII is crosscut by side branches of the Baḥr Yūsif, suggesting that during the flood period it would be entirely flooded. The existence of the dyke system suggests that any residual water that remained here at the end of the flood period was not allowed into the more easterly basins, but that it had to flow back into the Baḥr Yūsif. In basin XXVII, not a single settlement is marked on the map of the *Description de l'Égypte*, except on the levees of the waterways. This suggests the area must have been rather humid.

Lower areas also exist west of Baḥr Yūsif. These areas received all their water from there, which could only flow back again in the direction whence it had come. This simple system will not be commented upon here.

4.1.2 Analysis of the results

The detailed discussions above all suggest that in the way the basins were operated, the following varieties occurred: 1) Basins or basin chains receiving their water directly from the Nile and channeling residual water back to the river through the same channel at the end of the flood season; 2) basins or chains of basins receiving their water directly from Nile branches (the Baḥr Yūsif, the Tirʿa al-Shaykh Ḥajāza, or al-Sabakh) and channeling residual water back there through the same channel at the end of the flood season; and 3) basins or chains of basins taking their water from the Baḥr Yūsif or the Nile and channeling residual flood water to low-lying areas in the western part of the floodplain. Besides this, the information provided by the *Description de l'Égypte* is in the

case of a few small basins insufficient to decide the kind of flooding regime that was deployed.[77]

1) Basins or basin chains receiving their water directly from the Nile and channeling residual water back to the river through the same channel at the end of the flood season. The following basins belong to this group: II, the basin chain III-IV, basin XXIV, and probably basins V and VI partly as well, since here the Nile is always close by and rather prominent waterways cross them in several places. In the case of basin V, one of these waterways continues into basins IX and X, and thence further into basins XVI and XVII, suggesting that some of the water in this chain of basins may have drained off to the northwest, and away from the Nile. Basin VI constitutes a chain with the lower basin XI. Both are crosscut by several waterways that probably served to channel water back into the Nile.

This means that most, but not all, of the basins immediately bordering on the Nile, returned their water back into the river at the end of the flood season, and that some small, dependent basins channeled some of their water back that way. In all other cases, however, the water did *not* move in that direction.

2) Basins or chains of basins receiving their water directly from Nile branches (the Baḥr Yūsif, the Tirʿa al-Shaykh Ḥajāza, or al-Sabakh) and channeling residual water back there through the same channel at the end of the flood season. This is the case in basins I, XII, and the very large basin XXVII linked to the Baḥr Yūsif. If our interpretation of basin XIX is correct, this received its water from a branch of the Tirʿa al-Shaykh Ḥajāza, through which the residual water was drained off again later. The situation in basin XXI is complex, but one reading of the facts could be that the same situation obtained here as in basin XIX. According to another interpretation basin XXI was fed with water from al-Sabakh, making a U-turn at the end of the flood season. Basin XXII was irrigated in the same way from al-Sabakh.

Even though in some of the cases here discussed, the Nile is close, the fact that the three Nile branches have a steeper slope than the river makes it likely that the water return did not move to the Nile, but away from it to the deeper parts of the floodplain further northwest.

*3) basins or chains of basins taking their water from the Baḥr Yūsif or the Nile and channeling residual flood water to low-lying areas in the western part of the floodplain.*The whole chain of basins XIII, XIV, XV, XVI, XVIII and XVII, the latter perhaps communicating with XX, is fed from the Baḥr Yūsif

77 This happens in the case of basins VII, VIII and some other, very small basins that were not attributed a number.

near Bānī Harām. At the entry point, the elevation is in the +45 m realm, at the end in the +42 m range. All residual water from the upper basins would, at the end of the flood season, naturally flow down to this latter level. Since, at this latitude, the basins along the Nile lie in the +44 m range, the only conceivable direction in which the water could flow was through the depression between the levees of the Nile and the Baḥr Yūsif, which must have developed into a very wet environment. North of basin XX, no dykes were even built; we have seen that, north of dyke 22 there was an open connection from the Baḥr Yūsif (with local levees at +43 m) to the +40 m[78] basin XXVI.

Based on the reconstruction of the irrigation regime by authors like Willcocks, Egyptologists often tacitly assume that at the end of the flood season, the residual floodwater receded into the Nile. In doing so, they project patterns observed in the late nineteenth century and later into the pharaonic past. However, the preceding pages have demonstrated that, even as late as the late eighteenth century, a completely different system was operative in the area between Dairūṭ and al-Ashmūnayn. Here, only a part of the floodwater drained back directly into the Nile. The rest flowed back into the Baḥr Yūsif, which transported the water northwards along the western fringe of the Nile Valley. Besides, a major amount of drainage water must have been transported via the deep depression between the Baḥr Yūsif and the Nile.[79]

It is still too early to estimate the ratio between the three groups. However, most of the basins from which water was channeled back into the Nile lie at a relatively high altitude, suggesting that during low Niles these received hardly any water at all, whereas the increased volume at periods of high Nile floods must still have been inferior to that collecting in the lower basins further west. Moreover, the lower areas which drained off either through Nile branches to the northwest, or through deeper-lying areas between the Nile and the Baḥr Yūsif, cover a substantially larger surface than the basins draining off directly to the Nile. This suggests not only that by far not all residual water flowed back into the Nile, but even that the latter water volume was substantially lower than the volume carried northward by Bahr Yūsif and the depression east of it. We will see below that this picture is confirmed by the situation further north in the Nile Valley.

78 West of Itlidim there is an area lower than the 40 m, isohypse.

79 The same point was already made by Nicholas, 2005, p. 259, without, however, going into the consequences of this observation, which will be studied in the present article.

4.2 The Hydrology of the area between al-Ashmūnayn and the Fayyūm

The first area to be crossed by these waters is the region between al-Ashmūnayn and the entrance to the Fayyūm depression. Most of this area was recently investigated by E. Subias, I. Fiz, and R. Cuesta.[80] The method they deployed much resembles ours, being based on a combined analysis of historical maps and remote sensing.

Their study leads to a reconstructed landscape that looks different in important regards to the results of the preceding pages. Based on the maps of the *Description de l'Égypte* combined with actually remaining traces of dykes, they showed that the basins in this area were, already in the late 18th century, separated by large transverse dykes linking the Nile to the Western Desert.[81] The roughly rectangular basins in this part of Middle Egypt were of a less varied size and shape than we have observed further south. However, Subias, Fiz, and Cuesta also found traces of earlier waterways, which they interpret as "crisscrossing" side branches of the Nile.[82] According to the authors, this irregular system predates a more recent stage when the dykes parceled up the landscape in rectangular basins. This earlier system is very similar to what we have observed near al-Ashmūnayn, where two large branches of this kind existed beside the Baḥr Yūsif.

They also suggest that a south-north watercourse ran through the depressions between the levee systems of the Nile and the Baḥr Yūsif.[83] Although they do

80 Subias/Fiz/Cuesta, 2013, p. 27-44. This article relies heavily on earlier research by Gomaà/Müller-Wollermann/Schenkel, 1991. Since Antoine's reconstruction of the ancient landscape in this region (2011, p. 9-27) does not take into consideration the reinterpretation of geography of the papyrus Wilbour proposed by Id., 1991, p. 105-168, we will not incorporate his views here. In his article in the present volume, he does consider the depression area between the Nile and the Baḥr Yūsif.

81 Subias/Fiz/Cuesta, 2013, p. 31-35. Unfortunately, their account is not as clear as it might have been. Partly this is due to a sometimes unclear and inaccurate use of terminology (thus it seems that they use the term 'levee' as a synonym for 'dyke'). Also, their reconstruction of the infrastructural improvements carried out in the course of the nineteenth century surprisingly suggests that the surface of the irrigated land was starkly reduced in the process (p. 32, fig. 4), which cannot be true.

82 Id., p. 38.

83 Id., p. 40. This situation was already pointed out by Kemp, 2005, p. 29.

not point this out, this waterway would be very similar to the natural drains existing between Nile branches in the Delta,[84] and to the area of basin XXVI studied above.

Figure 7. part of the map of Robert de Vaugondy, showing Middle Egypt between Mallawī and the Fayyūm.

84 Bietak, 1975, p. 54-55.

In this connection they refer to the Robert de Vaugondy map dating back to 1753, which, as we have seen, was based on information collected in 1722 by Claude Sicard (see n. 27; fig. 7). This map is highly intriguing. It indicates a vast expanse of water thrice the width of the Nile, which lies about halfway between the river and the Baḥr Yūsif, and runs all the way from between the villages of Rawda ("Rouda") and al-Ashmūnayn, to an area just before the entrance of the Fayyūm depression. The same waterway is indicated on the d'Anville map (1765), where it is however shown to start farther to the north (see n. 27). This slight difference may reflect inaccuracies in the maps, or changes in the landscape that had occurred between 1720 and 1765, or different conditions occasioned by a difference in flood height in the two years when the maps were drawn. However, the fact that both maps indicate a very significant water volume between the Nile and the Baḥr Yūsif leaves no room for doubt that this very humid and extensive depression really existed.

Clearly, the maps do not show what Egypt looked like during the inundation (when most of the Nile valley would have been flooded). They can only be meant to visualize the situation after the end of the flood season, when the basins had been opened again, allowing residual water to drain off to the Fayyūm. This information must go back to observations made at a time the Nile was receding.

These maps confirm the hypothesis developed on the basis of the detailed analysis of the area further south, and it proves that vast masses of water plied their way through a depression between the Nile and the Baḥr Yūsif in the direction of the Fayyūm.

A very interesting point in the analysis of Subias, Fiz, and Cuesta is that their remote sensing images show anomalies reflecting an irregular pattern of waterways, whereas a more regularized pattern of artificial basins can be observed from the maps of the *Description de l'Égypte*. This is interpreted as evidence for an older (i.e. pre-Napoleonic), irregular pattern of basins that, by the time Napoleon's army arrived in Middle Egypt, had already been supplanted by a more regular system.

Interestingly, the *Description de l'Égypte* does not display any of the straight east-west dykes characterizing more northerly regions in the al-Ashmūnayn region. This suggests that Napoleon's cartographers recorded a hydrological system there that in other parts of Upper Egypt was already obsolete in 1798. From an Egyptological perspective this is important, as it suggests that the archaic al-Ashmūnayn hydrological system may be more similar to the pharaonic irrigation system than the ones that can be observed elsewhere.

4.3 The Hydrology of the Fayyūm and Lower Egypt

At the mouth of the Fayyūm, the Baḥr Yūsif turns to the west, carving its way through the narrow depression between al-Lahūn in the east and Hawwārat al-Maqṭā in the west (see fig. 8). From here, myriads of smaller waterways fan off from the Baḥr Yūsif, most of which eventually end up in the Fayyūm Lake. Several other natural phenomena in the region must have exerted great influence on the hydrology. These include:

1) Roughly between Banī Suwayf and Maidūm, the floodplain narrows significantly. Moreover, between Banī Suwayf and al-Lahūn,the Jabal Abū Ṣīr rises up from the surrounding fields. These two features result in a significant reduction of the surface of the area that could be flooded. Because in this way the northward flow of the Nile flood was restricted, this must have led to a significant local rise in flood height.[85] Precisely at this point, however, the Baḥr Yūsif branched off into the Fayyūm depression, enabling floodwater to drain away from the Nile valley.

2) The bottom of the Fayyūm depression today lies at about 45 m below mean sea level, whereas near al-Lahūn, it is at about +23 m.[86] This enormous difference in height carries the implication that water flowing into the Fayyūm

85 The extent of this difference can be roughly calculated. At the entrance of the Fayyūm there exists a dyke system to be discussed below. The distance from the dams to the nilometer at Rawdā is about 100 km. Garbrecht/ Jaritz, 1990, p. 142 argue that the dams could have broken during major flood events such as took place in 1860. In that year, the peak flood level reached at Rawdā amounted to 19.5 m a..s.l. In view of the average river slope of 1 m per 12,9 km, one would expect that during the same flood event, the flood near al-Lahūn reached a height of about 7.75 m more, i.e. c. 27.25 m a.s.l. However, the crown of the dams was more than two 2 m higher (*op. cit.*, p. 144) than this. Since it is unlikely that the dam would really have been so much higher than the exceptionally high flood height of 27.25, there must be local factors complementing the average river slope to explain this. We assume that the reduced width of the floodplain must have played an important part in this. This also suggests that the general water (and groundwater) level south of the mouth of the Fayyūm depression must have been significantly higher (with reference to the surface level of the fields in the region) than elsewhere in Upper Egypt. This must have had its effect on agricultural yield in the region, and this may explain why the area south of the Fayyūm is generally poor in archaeological remains (cf. Willems, 2014, p. 29, n. 94).

86 Garbrecht/ Jaritz, 1990, p. 9; cf. also the article by Römer in this volume.

from the Nile Valley could do so with great force, transporting large quantities of alluvium into the depression. In fact, the town of Madīnat al-Fayyūm lies on a delta-shaped fan of alluvial mud, which must be the result of such processes. In Prehistory, when Man did not bar the Baḥr Yūsif from flowing into the depression, the water level was significantly higher than it is today.[87] This is often explained by referring to the greater flood height in that period. However, long after the flood levels had receded to the levels characteristic for the Pharaonic period, the Fayyūm remained poorly inhabited, which is easily explained by assuming that areas inhabited or cultivated later, were still covered by water.

It is generally accepted that irrigation measures taken in the Middle Kingdom and particularly in the Graeco-Roman period and later led to the area being made suitable for habitation and agriculture. However, the exact role of the dyke systems at the entrance of and inside the Fayyūm have never been fully explained, at least not with reference to the argument that has been developed on the preceding pages, to the effect that the flood regime in Middle Egypt had as its effect that residual flood water mostly did not flow back into the Nile, but that it drained off northwards along the edge of the Western Desert. During its course, huge water volumes inevitably ended up at the entrance to the Fayyūm depression. We will argue that this new idea is of immediate relevance to the interpretation of some major archaeological features in the region.

4.3.1 The al-Lahūn Dyke and Waterway System

The most remarkable feature of this system is formed by two vast dykes, which still exist today (fig. 8). One of the two, de Jisr al-Shaykh Jād-Allāh ("digue en pierres") starts in the northwestern outskirts of al-Lahūn, and follows a winding northwesterly course to the desert edge near the pyramid of Senwosret II (trajectory A-B in fig. 8). It is still largely intact.[88] It is a vast dam made of clay and provided with a stone casing on the northern side. On this side it is also buttressed. In some places it includes tunnels which must have served as sluices, allowing water to flow in or out. At its foot, this dyke measures c. 25 m in width, at its top 8 m. It still today stands about 3.25-4 m above the surrounding fields.[89]

87 As is shown by the fact that habitations of the Fayyūm culture lie at a level much above that of the current shore (Hassan/Tassie, 2006, p. 39).

88 Some of the authors inspected this dyke in March 2013 and March 2016.

89 See Garbrecht/Jaritz, 1990, p. 144 and Anlage 103. Gomaà/Müller-Wollermann/Schenkel, 1991, p. 62 give heights of between 3.4-4.2 m. The top width, these authors indicate as being between 12 and 15 m.

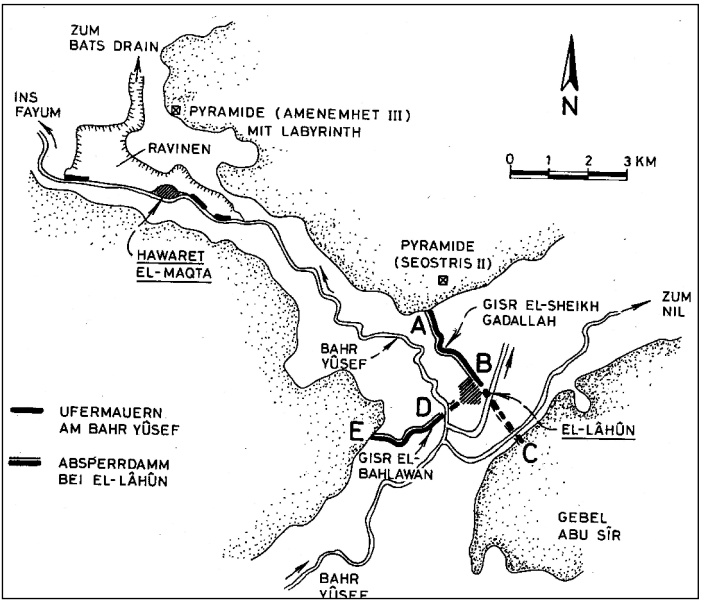

Figure 8. Waterworks at the entrance to the Fayyūm depression (after: Garbrecht/Jaritz, 1992, p. 248, fig. 14).

A short distance south of al-Lahūn lies the village of Hawwārat al-ʿAdlān (in the *Description de l'Egypte*: "Howârah el-Kebîr"). From here, dyke D-E, the Jisr al-Bahlawān, runs west to the western desert edge. This dyke has been omitted on the Napoleonic map, but it is of the same type as the Jisr al-Shaykh Jād-Allāh, although it does not have a stone casing. It does, however, have the same bottom width of 25 m, a top width of 8 m, and a height of c. 3.25 m.[90] The top of both dykes lies at c. + 29.25 m a.s.l. On the inside of the dykes (i.e. in the direction of the Fayyūm) the field surface is c. 1 m lower than outside the dykes (i.e. in the Nile floodplain).[91]

Anciently, a third dyke seems to have existed running eastwards from al-Lahūn to the Jabal Abū Ṣīr (tract B-C in fig. 8). This dam is referred to in Arabic documents dating back to the eleventh century AD.[92] If, accordingly,

90 See Garbrecht/Jaritz, 1990, p. 142 and Anlage 100. Gomaà/Müller-Wollermann/Schenkel, 1991, p. 63-64 indicate a bottom width of 19 m, its height is indicated as 4.2 m, and its top width as 12 m.

91 Gomaà/Müller-Wollermann/Schenkel, 1991, p. 64.

92 See Garbrecht/Jaritz, 1990, p. 141 and Anlage 98b, referring to Shafei, 1957.

a continuous dam A-C would have blocked flood water advancing northwards through the depression between the Jabal Abū Ṣīr and the Western Desert, a substantial part of it would perforce move in the direction of the Fayyūm. This structure would accordingly have had the effect of diverting the vast volumes of water descending northwards away from the Nile valley, into the channel of the Baḥr Yūsif.

The Baḥr Yūsif passes between al-Lahūn and Hawwārat al-ʿAdlān. Today, an extensive sluice system, reconstructed in the early nineteenth century, exists here. It includes a series of large sluices between the two villages, which serve to control the water volume flowing into the Fayyūm depression. A second series of sluices exists at the head of a channel branching off from the Baḥr Yūsif to the north, which pursues its course through the depression between the western desert and the Jabal Abū Ṣīr, passing by dam B-C in fig. 8. By finetuning the two sluice systems, the amount of water entering into the Fayyūm could be decreased or increased, with the water moving north being increased or decreased. At least part of this system is ancient, as the sluice system between al-Lahūn and Hawwārat al-ʿAdlān is already indicated in the *Description de l'Égypte*, map 19. We will see below that it was in fact very much older than that. The possibility to block water entering the Fayyūm accordingly existed already at the time the premodern systems in Middle Egypt, discussed above, were operational.

4.3.2 The area between al-Lahūn and the Hawwāra pyramid

Between al-Lahūn and Hawwārat al-Maqṭā, the north bank of the Baḥr Yūsif is still today partly fringed by high stone walls. In several places, these dams were broken by high floods and subsequently repaired in the nineteenth century. These more recent dams, which are made exclusively of earthwork, also still partly exist.[93] The presence of these dams, as well as the fact they broke, suggests that water pressure in this area was repeatedly very significant. In fact, both east and west of Hawwārat al-Maqṭā, the north bank of the Baḥr Yūsif was badly eroded away, leaving a deep ravine.[94] Apparently, one or more flood catastrophes led to the erosion of the surface in this area, allowing vast quantities of water to flow away in the direction of Lake Fayyūm. The stone walls in this area must partly have been repair works after these events.

However, this is not the full story. Map 19 of the *Description de l'Egypte* depicts several walls/dykes in this area, which largely correspond to those still observed in 1988 by Garbrecht and Jaritz. The easternmost of these walls, the

93 Garbrecht/Jaritz, 1990, p. 150-160.

94 Indicated by "Ravinen" in fig. 8.

Description de l'Égypte, however, does not merely designate as a dyke, but as a "déservoir", i.e. a facility serving to channel water away from the Baḥr Yūsif. This must correspond to structure 3 in the Hawwārat al-Maqṭā area, which Garbrecht and Jaritz date to a period between the thirteenth and the seventeenth/ eighteenth century A.D., and which, according to them, was clearly the main sluice serving to channel water from the Baḥr Yūsif to the northern Fayyūm depression and Lake Fayyūm, through the easternmost of the channels (Bats drain) in the north of the depression.[95] It is quite possible that this sluice system is not very ancient. However, since the map of the *Description de l'Égypte* shows several very wide channels branching off Baḥr Yūsif to the north, it is clear that vast amounts of water must have carved their way to the lake from here, and undoubtedly other sluice systems like structure 3 must have existed earlier in this area. The draining of the Fayyūm in the Ptolemaic and Roman period is inconceivable without such devices. Even if they may have been washed away long since, they must have existed somewhere in this area.

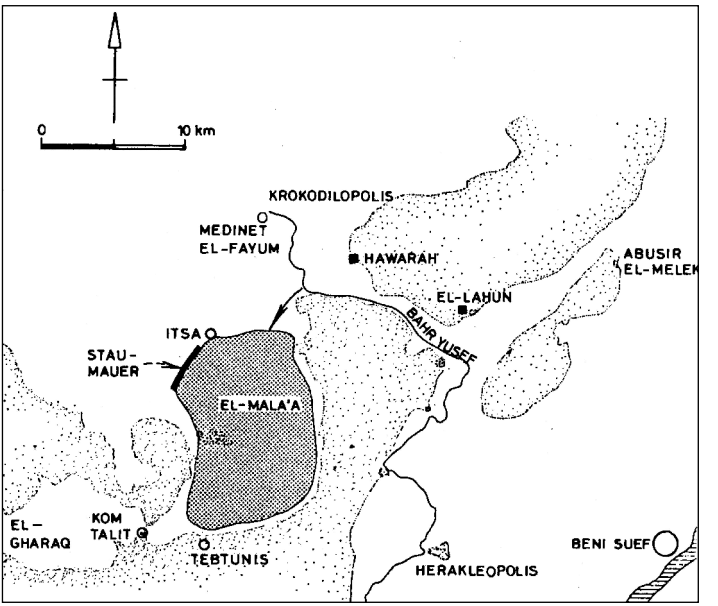

Figure 9. The setting of the al-Mala'a basin (after Garbrecht/ Jaritz, 1992, p. 248, fig. 13).

95 Id., 1990, p. 152.

Shortly after the pyramid of Amenemhat III at Hawwāra, the Baḥr Yūsif branched into a large number of smaller channels, which allowed water to fan out all over the Fayyūm depression. It seems likely that these channels were once headed by sluice systems, but of these only the one near ʿIzbat Muṣṭafā al-Jindī now remains.[96] These waterworks must have controlled water entering into the artificial lake to be discussed next.

4.3.3 The Artificial al-Mala'a Lake

ʿIzbat Muṣṭafā al-Jindī lies southwest of the Hawwāra pyramid, at the juncture of the Baḥr Yūsif and a channel leading south into a depression called al-Mala'a (fig. 9). On its east and south, this depression is fringed by the desert, and on the north by the high alluvial deposits on which Madīnat al-Fayyūm lies. Towards the west, the surface slopes down into the Fayyūm, but here, there are remains of a vast dam running from Itsā in the north to the village of Shidmū in the south. The remains of this dam were documented in detail by Garbrecht and Jaritz.[97]

According to these authors, the top of the Itsā-Shidmū dam reached a height of about 17.50 m a.s.l.; the maximum flood level of the reservoir lay at about 16.50 a.s.l., the surface of the lake was 114 km^2, and it could hold c. 275 million m^3 of water.[98] Under optimal conditions, this would have allowed a surface of c. 260 km^2 to be supplied with additional water in the spring months, according to Garbrecht and Jaritz making a second harvest possible.[99]

4.3.4 Overall Interpretation of the Waterworks in the Fayyūm Region

The various dykes and drains discussed in the preceding paragraphs together constitute a well-conceived system serving to optimize the distribution of water in the whole area. Depending on how the sluices were used, the water volume flowing into the Fayyūm could be increased or decreased, leading to an inverse decrease or increase in water volume in the Nile valley proper.[100] Within the Fayyūm, the water could be distributed between Lake Fayyūm, the Mala'a reservoir, and the fields around Madīnat Fayyūm. We will show now in a probably simplified way how this functioned, discussing the consequences of

96 Id., 1990, p. 160-163; Id., 1992, p. 250-251.

97 Id., 1990, p. 38-134.

98 Id., 1990, p. 133.

99 Id., 1990, p. 170-173. That the lake was actually used to this effect is known from early eighteenth century sources (see Mikhail, 2010, p. 574-575).

100 What follows is in many regards similar to the shorter account presented by Römer elsewhere in this volume.

sluices in the dams being either closed or opened. Of course, in reality, there would be intermediate options as well, depending on the degree to which sluices were opened. However, by discussing the extreme options, it will be easier to conceive what the effects of the different options were:

Option 1: The dam system A-C (fig. 8) is closed. This will lead to large water volumes collecting in front of dykes D-E and the tell of the town of al-Lahūn, and this for prolonged periods after the end of the flood season. In this case, the sluice system between al-Lahūn and Hawwārat al-ʿAdlān will be opened. The Baḥr Yūsif will bring all its water volume into the Fayyūm depression.

Option 1a: The sluices east of Hawwārat al-Maqṭā are closed; no water flows through Bats drain into Lake Fayyūm. The ʿIzbat Muṣṭafā al-Jindī sluice is opened, and the al-Mala'a reservoir is filled with water.

Option 1b: The sluices east of Hawwārat al-Maqṭā are opened, so that water flows through Bats drain into Lake Fayyūm. The ʿIzbat Muṣṭafā al-Jindī sluice is closed, and the al-Mala'a basin receives no water.

In reality, options 1a and 1b were probably not mutually exclusive. The relatively small al-Mala'a reservoir would undoubtedly be filled every year, while the remainder of the water supply would be channeled into Bats drain and into the smaller channels around Madīnat al-Fayyūm. Moreover, in years when the water supply was particularly abundant, the sluices in the Itsā-Shidmū dam might remain open to permit water to flow out in that direction as well.

Option 2: Dam system A-C is opened, the sluices at al-Lahūn are closed. This will prevent water from the Nile valley spilling into the Fayyūm depression, allowing all water to continue its northward course through the depression between Jabal Abū Ṣīr in the direction of Memphis.

Again it is important to realize that we are here discussing an extreme option which was perhaps never put into practice. More realistically, options 1 and 2 were combined to different degrees. Let us envisage different possible situations:

Situation 1: the operation of the dyke and sluice system during a year with very low Nile floods. In this situation, only a small part of the fields could be reached by the flood, and opening the Baḥr Yūsif sluices at al-Lahūn would deprive the Nile valley of precious water. Closing dyke A-C, while having the effect of storing as much water as possible in Upper Egypt south of the Fayyūm, would also reduce water supply further downstream. To prevent this, the Baḥr Yūsif sluices near al-Lahūn could be closed and dyke A-C would be opened. Under these circumstances, only the Fayyūm would be deprived of water. To reduce this latter effect somewhat, the al-Lahūn sluices could be temporarily opened, but the sluices east of Hawwārat al-Maqṭā remained closed to prevent precious water spilling away into Lake Fayyūm. By opening the sluices at ʿIzbat

Muṣṭafā al-Jindī, however, the al-Mala'a reservoir could be filled, permitting a controlled flooding of certain areas further downstream. In this way, a substantial part of the Fayyūm would have access to water. After this, the al-Lahūn sluices could be closed to retain as much water as possible in the Nile valley.

Situation 2: A moderately high flood. In the Nile valley most, but not the highest basins would be flooded. Probably the sluices in dam system A-C and those at al-Lahūn would be open sufficiently long to flood both the fields in the Nile valley and in the Fayyūm. The al-Mala'a reservoir would be filled, but the amount of water draining off through Bats drain into Lake Fayyūm would be kept restricted at the Hawwārat al-Maqṭā sluice system.

Situation 3: A high Nile flood. In the Nile valley, even the highest basins on the levees would be flooded.[101] Probably the sluices in dam system A-C and those at al-Lahūn would be open sufficiently long to flood both the fields in the Nile valley and in the Fayyūm. The al-Mala'a reservoir would be filled, and the sluices at Hawwārat al-Maqṭā would be opened to drain off water into the Lake Fayyūm. This would have the effect of raising the water table in that lake. The sluices could be controlled to ensure that the volume of water flowing through the channels would not endanger the embankments and waterworks.

Situation 4: An exceptionally high flood. Under these conditions even the highest basins in the Nile floodplain would be inundated. The sluices in dam system A-C would be opened to allow as much water as possible to drain off to the north, while the sluices at al-Lahūn would be open, allowing a maximum volume of water to drain off into Lake Fayyūm. Quite conceivably, the sluices at ʿIzbat Muṣṭafā al-Jindī and in the Itsā-Shidmū dam would also be open so as to allow as much water as possible to drain off in a controlled way. Very high floods could, however, be of such magnitude that the waterworks were damaged, leading to a situation in which the amounts of water could no longer be kept in check. This explains the breaks in the Jisr al-Shaykh Jād-Allāh, in and behind the embankments of Baḥr Yūsif near Hawwārat al-Maqṭā, and in the Itsā-Shidmū dam.[102]

101 According to Willcocks, 1899, p. 59, this would happen eight or nine times per century.

102 This has been associated to a very small number of catastrophically high floods listed by Garbrecht/ Jaritz, 1990, p. 184-186. However, the cause of dams collapsing may have been the state of repair and bad maintenance as much as flood height, as the documentation from the early eighteenth century proves (Mikhail, 2010, p. 580-582). And the frequency of the collapses may accordingly have been significantly greater.

Under several of the scenarios described above, the water retained in the al-Mala'a lake could be stored for later use. It has been argued that this could lead to a second harvest in spring in part of the Fayyūm.[103] Taking into consideration a maximum volume of the lake of c. 275 million m^3 and an evaporation of 75 million m^3, the amount of available water would be in the range of 200 million m^3, sufficient for irrigating c. 150 km^2 for a second harvest, i.e. c. 12.5 % of the Fayyūm.[104]

Our study adds one, probably significant, element to this discussion. In the present section we have argued how the dykes and sluices at the entrance of and within the Fayyūm may have been used in the course of the Nile flood. However, we have also argued that, *after* the flood, the opening of the basin dykes in Upper Egypt must have led to the release of a very significant amount of water that flowed through the Baḥr Yūsif and through the depression between it and the Nile. Since this happened at a moment the flood waters had already been receding for some time, it must have had the effect of producing a second 'wave.' We put the word 'wave' between inverted commas, because this water transport through shallow basins must have been much slower than that of the inundation proper. Although we are unable to quantify the volume and speed of this water displacement, it is likely to have plied its way to the Fayyūm over a somewhat prolonged period of time, and the sluices at al-Lahūn and further west are likely to have been used in this period as well. This raises the possibility that the water in the al-Mala'a reservoir was fed by additional water, replacing water that had evaporated or that had already been channeled to the fields downstream. This suggests that the evaporation factor referred to in the above calculation may have been neutralized, and also that the reservoir may not have been filled just once, but may have been replenished continually over a prolonged period of time. This possibility, which has never before been mooted, has the consequence that a far greater part of the Fayyūm depression than the 12.5 % mentioned above may have been irrigated.

5. Chronological Aspects of the Waterworks Discussed

This article has thus far attempted to reconstruct the functioning of the hydrological systems in Middle Egypt and the Fayyūm in the late eighteenth

103 Id., 1990, p. 168.

104 Id., 1990, p. 170-173.

century, the aim being to understand their operation in the period before the major infrastructural works undertaken in the early nineteenth century by Muḥammad ʿAlī. In this way it has been possible to filter out a number of modern innovations that had hitherto often been assumed to be characteristic for far more ancient irrigation practices, and even for pharaonic Egypt. The result of our enquiry has been that this latter approach is unwarranted, since only thirty years before Muḥammad ʿAlī, the situation was already utterly different.[105] It is quite likely that the less advanced infrastructure of the *eighteenth* century brings us closer to the situation in the preceding millennia. However, it would be naïve to suppose without further ado that the Napoleonic maps record a system that would be directly transferable to the Roman or an even more distant past.[106] The present section has as its aim to study ways that might enable us to disclose with greater reliability which elements of the landscape as observed in Napoleon's day have ancient roots.

In doing so, attention will be paid to information from historical toponymy and ancient written sources, archaeological evidence, and information on sedimentation in the landscape recorded in the *Description de l'Egypte*. These aspects will first be discussed for Middle Egypt and then for the Fayyūm.

5.1 Middle Egypt

5.1.1 Historical Toponymy

In this section we will first compile the available evidence on place names in the region studied. We will proceed from south to north.

1. Dairūṭ (al-Sharīf). The etymology of this name is currently understood as *Ỉw-rd* "plant island". It is assumed that the D in Dairūṭ goes back to the article

105 For the area between Ṣamalūṭ and the Fayyūm, however, Gomaà/Müller-Wollermann/Schenkel, 1991, p. 44, have argued that the dykes constructed in the nineteenth century lay more or less at the same locations as those rendered in the *Description de l'Egypte.*

106 Id., 1991, p. 52-53 have argued that the distances between the dykes observed by the Napoleonic mission between Ṣamalūṭ and the Fayyūm may reflect the pharaonic *itrw* measure, and thus that the basin system observed there dates back to at least the Ramesside period. Of course this single argument can hardly be accepted as proof. Moreover, in other supposedly ancient dykes, this distance was not observed (Grieshaber, 2004, p. 20).

t3, Coptic ⲧ. For Dairūṭ, the Coptic variant ⲧⲉⲣⲱⲧ is in fact known.[107] Gardiner still linked *Ỉw-rd* to a place north of al-Ashmūnayn, because P. Harris I, 61b,3-7 features a town list arranged *Ḥmnw – Ḥw.t-wr.t – Ỉw-rd*.[108] The al-ʿArīsh list also features the town after *Ḥw.t-wr.t*. This might be taken as an argument against identifying *Ỉw-rd* with Dairūṭ. However, there are many places in Egypt with the name Dairūṭ, and therefore there were arguably as many different ancient places named *Ỉw-rd*.[109] Even though it is hard to attribute any one textual reference to *Ỉw-rd* to any one of the many sites with the name Dairūṭ, the name as such is well attested since the Old Kingdom. This is an argument for assuming that the Dairūṭ in the area we are concerned with, is of (probably early) pharaonic date. In the area we are here interested in, two villages of this name are mentioned in the *Description de l'Égypte*: the larger settlement at the beginning of the Baḥr Yūsif, (Dairūṭ al-Sharīf), and a smaller village on the eastern bank of Baḥr Yūsif due west of al-Ashmūnayn.

2. Ismū. In P. Duk. Inv. Miss 88, listing a number of settlements between al-Ashmūnayn and Ṣanabū, there is a mention of a village called Σόμου, which van Minnen identifies with Ismū. This village is also attested in other documents, some of them dating back to between the first and third centuries A.D.[110]

Maspero has suggested that the modern name Ismū goes back to Coptic ⲥⲙⲟⲩ or ⲥⲓⲙⲟⲩ, which is attested since the fourth or fifth century A.D.[111] Drew-Bear expressed doubts against this, since according to a papyrus in Munich, ⲥⲓⲙⲟⲩ would have been the place of birth of Apa Phib, whereas the Life of Apa Phib attributes his birth to a village named Ψινομουνις in the Antinoite nome. Since the Antinoite nome centres around Antinoopolis on the east bank of the Nile, she believes that ⲥⲓⲙⲟⲩ must have lain on the east bank of the Nile as well, and therefore could not have been identical with Ismū.[112] However, the etymology is very unconvincing. Ψινομουνις must go back to Egyptian *Pȝ š n Ỉmn* "The basin of Amūn". Drew-Bear's interpretation involves that both the genitive-*n* and the *n* in the name of Amūn would have been dropped, for which

107 Zibelius, 1978, p. 26-28; Drew-Bear, 1979, p. 289; Timm,1984, p. 562-565; Peust, 2010, p. 34-35.

108 Gardiner, 1947,II, p. 87*-88* (379A).

109 For this reason, Jacquet-Gordon's suggestion (1962, p. 115 and *passim*), that all Old Kingdom references to domains named *Ỉw rd* must refer to the place identified by Gardiner, is far from compelling.

110 Van Minnen, 1994, p. 85.

111 Maspero, 1931, p. 96, n. 1.

112 Drew-Bear, 1979, p. 328-329.

she fails to adduce any parallel, and which is singularly unlikely. Moreover, the Antinoite nome during certain periods may well have extended to the west bank of the Nile, and the Munich papyrus locates ⲥⲓⲙⲟⲩ in the nome of Hermopolis. The only argument is the purported place of birth of saint Phib. But as a glance at for instance Timm's toponymical list shows, literary accounts bristle with errors in accounts of this type. In my view, there can be no doubt that Ismū = ⲥⲙⲟⲩ, ⲥⲓⲙⲟⲩ = Σόμου, an etymology which would bring us back uninterruptedly from the present to the first century A.D.[113]

As we will see in the discussion of the toponym Sinjirj, the element Si- in place names is often interpreted as "place", but it might as well be connected to *š* 'basin". The element -ⲙⲟⲩ following this could go back to Egyptian *mw* "water", in which case the toponym would mean something like "basin of water". However, this sounds tautological. -ⲙⲟⲩ might also go back to *mꜣ.wt* (ⲙⲟⲟⲩⲉ) "island", in which "island" might refer to a high place not normally flooded by the inundation. In this case the name would mean "basin of the island". It must have been commonplace for basins to be located in the vicinity of such "islands" (i.e. high places on levees), but since basins are not dependent on isolated islands, but rather on circuits of higher land (including dykes and 'islands') the name sounds somewhat odd as well. However, the word ⲙⲟⲟⲩⲉ "island", originally "new land" goes back etymologically to the Egyptian root *mꜣwi* "to be new". In Coptic, this root has barely survived, although there is a rare word ⲙⲟⲩⲓ of this meaning.[114] Arguably, ⲥⲓⲙⲟⲩ could go back to *š mꜣwi* "the new basin". This would, at the time of the creation of an artificial basin, have been an appropriate name for a locality.

This interpretation seems the most attractive to us, and it has the important consequence that the toponym consists of a noun followed by an adjective. In Demotic and Coptic, this adjective would be connected to the preceding noun by an indirect genitive (*š n mꜣw.t*; ⲥⲙ̄ⲙⲟⲩⲓ), which is not in keeping with what the writings of the toponym suggest. Therefore, the place name is arguably of pre-Demotic date. If the etymology holds, it presupposes that the toponym dates back to at least as early as the Third Intermediate Period.

113 I express my gratitude to Willy Clarysse, with whom I discussed this problem, and who was entirely of the same opinion. The same opinion is found in Peust, 2010, p. 54.

114 The only dictionary mentioning it is Westendorf 1965-1977, p. 88.

3. Tānūf. This is certainly not an Arabic place name. Drew-Bear relates it to the Greek settlement of Ιβιών Τανουπεως, which goes back to as early as A.D. 128.[115] Peust relates it to the Demotic female name *T3-Ỉnpw*.[116]

4. Daljā. The etymology is again unclear, but it does not sound like an Arabic name, and it is in fact attested in medieval Arabic, Coptic, and Greek sources going back to at least as early as A.D. 709 (Τέλκε; ⲧⲏⲗⲕⲉ).[117] Perhaps this name includes the feminine article ⲧ,[118] in which case an etymology with an earlier Egyptian ancestor of ⲏⲗⲕⲉ hould be sought for. The town is built on a large tell, so that it must be of very considerable age. This tell lies on what may be an earlier levee of the 'palaeo-Baḥr Yūsif' (see 4.1.2 (3)). Research carried out there by Verstraeten's team in collaboration with the Dayr al-Barshā project has revealed that agricultural fields in this area go back to the early third millennium B.C.[119]

5. Badramān. Despite its Arabic appearance, this toponym, referring to a settlement located on the Baḥr Yūsif close to al-Shaykh Shibaykā, has been argued to go back to Greek Πατριμο[…], Coptic ⲡⲁⲧⲣⲉⲙⲱⲛ (and variants), references to which go back to the sixth century A.D. It may be referred to even earlier, in the fourth century A.D., in a Greek text referring to an "Island of P[a] trim[…]".[120]

6. Tūkh. This name apparently goes back to ⲧⲱϧⲉ. This place name is widely attested throughout Egypt, and therefore no source can with certainty be related to the village of this name in the region here investigated. However, it is clear that we are facing an ancient indigenous name.[121]

7. *Nazlat al-Shaykh Ḥussayn.* Although this place name is not ancient, the settlement probably is. Jomard reports having seen there some limestone blocks that were between three and four metres long, and that the locals speak of the presence of a "Birbé" there.[122] As is well known, this word birba derives from the Egyptian word *r-pr* 'temple', and the Copts used this term for referring to pagan

115 Drew-Bear, 1979, p. 129.

116 Peust, 2010, p. 94.

117 Drew-Bear, 1979, p. 274; Timm, 1984, p. 502-504. Timm assumes the town existed already much earlier than this.

118 Thus also Peust, 2010, p. 32.

119 Mohamed, 2012, p. 107-110; 122-123; Verstraeten et al., 2016.

120 Drew-Bear, 1979, p. 242; Timm, 1984, p. 277-278; Peust, 2010, p. 17.

121 Drew-Bear, 1979, p. 312-313; Timm, 1992, p. 2865 ff.

122 Jomard, 1821, p. 320.

temples. It is therefore likely that this settlement goes back to the pharaonic period.

8. Tandā. This village is first referred to in an Arabic document mentioning Arianus, the governor of Anṣinā, who lived in the fourth century A.D.[123]

9. Sinjirj. This toponym goes back to Σενκύρκις, a name attested at least since A.D. 136, and perhaps since 128.[124] Yoyotte has argued that the element –jirj, -κύρκις goes back to Eyptian *grg* "poser un filet de chasse, un piège, une nasse", while –n- would be the Egyptian indirect genitive and the first part of the name Coptic ⲥⲉ or ⲥⲓ, "seat, place".[125] The name would accordingly mean "la place où l'on chasse". This is now widely accepted,[126] but the reasoning that brings Yoyotte to his conclusion is not really convincing.

His argumentation is as follows. Egyptian possessed two roots *grg*, one with the meaning "to place a hunting net or trap" (ϭⲱⲣϭ), and a second one that can be translated as "to estabish, to found, to organize, to equip, to populate" (ϭⲱⲣ̄ϭ). The existence of marshlands throughout Egypt render likely that hunting and catching birds by traps would have been a widespread custom, and for this reason, according to Yoyotte, "il serait … étonnant que *grg* "chasser" n'ait laissé aucun vestige dans la toponymie d'époque pharaonique". However, "malheureusement, seules les transcriptions greques (et encore!) permettraient de reconnaître si une forme  signifie "La Chasse" (*grg* = κυρκ-) plutôt que "La Fondation" (*grg/grgt* = κερκ-)".

This reasoning is hardly compelling. Yoyotte's use of the subjonctifs "serait" and "permettraient" and the exclamation "et encore!" suggest that he himself was only partly convinced by his hypothesis. While Yoyotte seems to take for granted that κυρκ- = Coptic ϭⲱⲣϭ and κερκ- = ϭⲱⲣ̄ϭ, he fails to pay attention to the facts that 1) the Coptic spellings are near identical (and entirely so if the line over *r* would be omitted, as would frequently happen); 2) in the examples he quotes the Greek forms κυρκ and κερκ are to an extent interchangeable (he explicitly quotes variants Σιν**κερκ**ις, Σιν**κυρκ**ις, etc. for the toponym we are here discussing, and 3) the form κερκ seems to be predominantly attested in the first position of a direct genitive, whereas κυρκ occurs mostly in cases like Σενκύρκις as the second element in an indirect genitive. It is quite possible that

123 Timm, 1992, p. 2498-2499

124 Drew-Bear, 1979, p. 242.

125 Černý, 1976, p. 145 relates this word to Egyptian *s*.*t* "place." The interpretation as "place" for the toponym Sinjirj can also be found in Crum, 1939, p. 316b; Peust, 2010, p. 87.

126 Yoyotte, 1962, p. 84; accepted by Drew-Bear, 1979, p. 242.

we are facing one and the same word in which the difference in pronunciation may be due to a difference in grammatical construction, to dialectical differences, or both. Since Yoyotte is unable to prove in a single case that the element *grg* refers to the verb "to hunt," it is for the time being better to assume that all toponyms with the element *grg/grg.t* refer to the ubiquitous word 'agricultural domain' or similar.[127]

This is all the more likely since several ancient toponyms designating settlements in the immediate vicinity of Sinjirj are of the type Κερκε + divine name, "settlement of god X". This is the case for Κερκεθοηρις "the agricultural domain of Thoeris" in Greek texts dating back to the mid-third century A.D,[128] as well as for Τκερκεθωθις, "the domain of Thoth".[129] If *grg.t* in this name means 'agricultural domain,' a further consequence is that the traditional interpretation of the element Sin- in Sinjirj must be reconsidered. As noted above this is usually understood as an indirect genitive preceded the Coptic word ⲥⲓ- "place, seat". However, the resulting meaning of the toponym as "place of the agricultural domain" sounds odd, since a domain is by definition a "place". ⲥⲓ- might therefore rather derive from *š* "basin". In toponyms of the type *Š-n-Ḥr* "basin of Horus", this name survives to the present day in forms like Shanhūr (referring to the village of that name just north of Luxor), but the Greek form Ψενυρις shows that *š n* could evolve into Sen-. The Arabic descendant of a village of this name in the Fayyūm is Sinnūris.[130] Accordingly, the place name Σινκερκις might well go back to "the basin of the agricultural establishment". The names Κερκεθοηρις and Τκερκεθωθις might refer to specific establishments within the basin. If there is such a causal relationship between the origin of the three toponyms, this could be chronologically relevant, since names of the type *Grg*(*.t*) + divine name are not attested before the first millennium B.C.[131] This reasoning would permit us to date the origin of the name Sinjirj to a date as early as this. It is however also conceivable that there is no causal connection, and that the name Sinjirj is in fact much older. Since domains called *grg.t* are frequently attested since the Old Kingdom, it might in fact be very old.

127 Erman, Grapow, 1931, p. 188,14-15; same etymology proposed by Peust, 2010, p. 87. For the nature of a *grg.t*, see Moreno Garcia, 2013, p. 96, with references to further literature.

128 Drew-Bear, 1979, p. 139. She translates this toponym as "le domaine aménagé pour Thoueris". This toponym must also contain the element *grg.t*.

129 Id., p. 271; Timm, 1992, p. 2567.

130 Peust, 2010, p. 87-88.

131 Yoyotte, 1962, p. 85.

10. al-Birka. This place name in Arabic means "the Lake" (see p. 288-289), a name probably derived from the location of the settlement close to the western desert edge, where a lake is effectively indicated on the Survey of Egypt maps. Although al-Birka is certainly an Arabic name, settlements lying in similar positions were already called *Brk.t* in the tenth century B.C., using a term of Semitic origin that is etymologically related to the modern Arabic word.[132] It is therefore theoretically possible that the name is not originally Arabic, but goes back to a far more ancient precursor. However, against this hypothesis, it should be pointed out that no toponym similar to al-Birka is known from the papyrological record.

11. Mallawī. This place name is generally believed to go back to Coptic ⲙⲁⲗⲗⲁⲩ, which is attested since AD 1296.[133] There are reports of finds of columns and other architectural elements even including a naos in the town, but nothing of it was found *in situ* or in controlled excavations. Yet it has been argued that these finds suggest the floruit of the town was in the Late Roman and early Islamic era.[134] Tombs dated to the Graeco-Roman period have also been reported, but this dating is of uncertain value.[135]

12. Al-Rairamūn. In this town, there is a very large tell, indicating a significant age for this settlement. Remains of Coptic buildings visible today in the streets of Rairamūn suggest the village goes back at least to the early Christian period. Because of the element –amūn, it has been argued that this toponym contains a reference to the god Amun, although this is not quite certain. D. Kessler has intensively discussed the indications for the identification of the ancient name of Rairamūn. It could be the *Nʿy-Wsr-mȝʿ.t-Rʿ Mr.y-Ỉmn* mentioned in P. Wilbour II, § 89.[136] Although this cannot be considered certain, Kessler plausibly argues that the cemeteries of al-Ashmūnayn at al-Shaykh Saʿīd and Dayr al-Barshā should be linked to the town by an easily negotiable road or waterway, and he

132 See Antoine, 2016, p. 25.

133 Drew-Bear, 1979, p. 165. The Coptic etymology proposed by Crum 1939 ("place of things"), to which she refers, is hardly credible. Černý's alternative idea that it might refer to a "place of textile" (ⲗⲁⲩ) is more acceptable (1976, p. 346). See also Timm, 1988, p. 1542-1543.

134 See the overviews in Drew-Bear, 1979, p. 35-36; Kessler, 1981, p. 93.

135 Found by Usīrīs Ghubriāl, see Leclant, 1971, p. 234; Id., 1973, p. 405. However, the same author has attributed tombs in Dayr al-Barshā to the Graeco-Roman period that are more likely to date to the Late Period. This suggests his dating may not be accurate.

136 Kessler, 1981, p. 92-103.

deems likely that Rairamūn "like today" would constitute the ideal place for a ferry to cross the Nile. This he takes as an argument to assume that the waterway between al-Ashmūnayn and Rairamūn is as ancient as the cemeteries are. This is a convincing line of argument. However, the shortest connection to Dayr al-Barshā would not be through Rairamūn, as Kessler suggests, but through Dayr al-Mallāk, two kilometers further north. This implies that the ferry harbor used for the trip to Dayr al-Barshā lay at the mouth of al-Sabakh. The Tirʿa al-Shaykh Hajāza, leading from al-Ashmūnayn to Rairamūn, would, however, be very suitable to travel to the Old Kingdom cemetery at al-Shaykh Saʿīd. In this case, the harbour at Rairamūn might go back in time as far as this, and Rairamūn might be equally ancient.

13. al-Ashmūnayn. Textual attestations of the town of al-Ashmūnayn go back in time to the early third millennium B.C., even though archaeological remains of that early date have not surfaced thus far.[137] Since late Old Kingdom settlement remains have, however, been found here, there is no reason to doubt that the town is very ancient.[138] According to Butzer and other authors, it then lay on a Nile levee. The Nile would only later have shifted its bed to the more easterly location where it is now. However, no evidence has been marshaled to prove this eastward migration of the Nile bed. We have argued above that no such shift took place, that the Tirʿa al-Shaykh Ḥajāza is an ancient Nile branch, and that its levee led to the emergence of the tells of the settlements at Rairamūn, perhaps Qulubba, and al-Ashmūnayn. In the near future, we hope to be able to carry out augerings in this area to put this hypothesis to the test.

14. Nawāi.The earliest papyrological sources mentioning Nawāi date to the sixth-seventh centuries A.D,[139] but already in the fourth century A.D. there was a monastery in this village.[140] Kessler suggests that a precursor of the name can be found in the toponym *Nꜣ-ḥr-ḥw*, mentioned in a papyrus from the time of Ramses II.[141] Jomard has seen limestone blocks there.[142]

15. Itlīdim. It is assumed that this modern place name goes back to Greek Τληθμις, which is attested in papyrological sources at least as early as the first century A.D.[143] It has been argued that this village is identical to the pharaonic

137 Gomaà, 1978, p. 189-190.

138 Roeder, 1959, p. 48 and the literature there cited.

139 Drew-Bear, 1979, p. 178-179.

140 Timm, 1988, p. 1755.

141 Kessler, 1981, p. 69-70; P. BM 10447,1 and 5 (see Gardiner, 1948, p. 59).

142 Peust, 2010, p. 68.

143 Drew-Bear, 1979, p. 302-303; Timm, 1985, p. 1204-1205.

town of Nefrusy. However, Kessler stresses that this identification is uncertain.[144] He localizes Nefrusy in the centre of the floodplain due west of Banī Ḥasan,[145] far outside the area we are here investigating. Etymologically, the word may be related to Demotic *ltm*, referring to a tree.[146]

16. Maḥras. Evidence that this place might date back to the pharaonic era is rather unsecure.[147]

5.1.2 Interpretation of the Toponymy within the Context of Information on Sedimentation, Soil Composition, and Archaeological Indications

We have seen in 4.2 that E. Subias, I. Fiz, and R. Cuesta observed a dyke system between Ṣamalūṭ and the Fayyūm entrance that was much more regular than the one in the al-Ashmūnayn-Dairūṭ region. Based on remote sensing analysis, they also showed that, before the introduction of this system, a similarly irregular pattern of waterways had existed there as we have observed between al-Ashmūnayn and Dairūṭ based on the *Description de l'Egypte* maps. We accordingly drew the conclusion that the hydrology of the latter region that still existed in 1798 is more ancient than the one observed further north.[148]

To this can be added the observation that, between the Middle Ages and the early nineteenth century, only few innovations in the waterworks seem to have been carried out in Egypt.[149] It is not easy to assess the importance

144 Kessler, 1981, p. 159-161.

145 Kessler, 1981, p. 120-185.

146 Vycichl, 1983, p. 214; Peust, 2010, p. 55.

147 Kessler, 1981, p. 72-73.

148 As noted in n. 105-106, Gomaà/Müller-Wollermann/Schenkel put forward the idea that the dykes in the region between Ṣamalūṭ and the Fayyūm entrance are spaced at distances that would reflect the ancient Egyptian *itrw* measure. By consequence, the dyke system in this region would date back to the New Kingdom. The idea that the system in the al-Ashmūnayn region is less regular, and therefore arguably less recent, would date the Ashmūnayn dyke pattern even further back in time. It goes without saying that this argument, which rests on the similarity between the distance of extant dykes and the ancient *itrw* measure, is not compelling, and we will not use it here.

149 Garbrecht/Jaritz, 1990, p. 188-189. For the collapse of the irrigation system after medieval plagues, see Borsch, 2004, p. 458-463. The effects of the Black Death on population size must have had a long-term impact. Mikhail, 2010, p. 580-582 gives an enlightening account of the chaotic way in which the central

of this consideration for the relative dating of the different systems of water management, but if it is true that the dyke systems remained generally unchanged since medieval times, the consequence is that the more modern system in the Minia region was itself realized probably no later than that.

Carrying this reasoning further, the implication would be that the phenomena observed in the al-Ashmūnayn-Dairūṭ region were earlier still, at least in conception. We do not have to stress that this reasoning is tentative, but in support of it one might refer to the basin system in the Delta, which, already in the thirteenth century A.D., operated on the basis of large, rectangular basins.[150] This could be taken as an argument to push the al-Ashmūnayn system back in time to a date well before the end of the Middle Ages.

It is likely that the two systems may reflect different degrees of state penetration in the organization of irrigation. In the Ottoman period, large irrigation works servicing extensive areas were called al-jusūr al-ṣulṭānīya "state dams", a term that applied for instance to the large dams at al-Lahūn and between Itsā and Shidmū. By contrast, al-jusūr al-baladīya "peasant dams", were built and maintained by local initiative and served local concerns only. The terminological difference between the two kinds of waterworks goes back to the Middle Ages.[151] It is likely that the former of the two systems operated in the al-Ashmūnayn region as well, although evidence for state dams is restricted to dyke 23, which is designated as "gesr Soultâni" in the map of the *Description de l'Egypte.* Arguably, this is part of a destroyed dyke system linking dyke 21 to dyke 23. If this hypothesis is correct, a large E-W state dam linking the Nile past al-Ashmūnayn to Ṭūna al-Jabal may have existed in the Middle Ages and the Ottoman period.[152]

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state intervened in the maintenance of the dams in the Fayyūm still in the early eighteenth century.

150 Lecture by Borsch, held at the Mainz conference on the Nile. Unfortunately his paper could not be included in this volume.

151 Borsch, 2004, p. 458-460; Michel, 2005, p. 260; Mikhail, 2010, p. 588, n. 50. It seems not unlikely that the larger-scale system in the Minia region and the small-scale system still prevailing in the al-Ashmūnayn area reflect these two different systems, and accordingly a less deep penetration of state involvement in irrigation affairs in the latter area.

152 Kessler, 1981, Karte 1, indicates that al-jisr al-ṣulṭānī continues all the way from al-Ashmūnayn to the Nile. In his map, this is an entirely straight dyke, an interpretation that is not borne out by the evidence provided by the *Description de l'Egypte*. This observation also warns us that simplified reconstructions of dyke

Other aspects are the date of origin of some of the landscape features that shaped the hydrology of the region. The levees of the Baḥr Yūsif are a case in point. It has been claimed that in Antiquity this waterway did not branch off from the Nile at Dairūṭ, the argument being that medieval records suggest it began further south, near Manhā. This may well be correct, as we have referred on p. 277 above to waterways in the depression southwest of Dairūṭ leading to the Baḥr Yūsif, which may be the remains of this system.[153] However, the existence of a more southerly Nile branch connecting to the Baḥr Yūsif in no way implies that there was not also a branch starting near Dairūṭ. The very prominent levees between Dairūṭ and Daljā leave no doubt that this waterway must have a very considerable age. As we have seen in the preceding analysis, many waterways branched off from the Nile in the direction of the Baḥr Yūsif. We would therefore posit that the Dairūṭ branch may well be ancient.

We have seen in 4.1.1 that the Baḥr Yūsif is a Nile branch that emerged when the gradually descending landscape west of the Nile had already been formed. Initially there was a depression in the western part of the floodplain, of which the topographic maps made in the mid-twentieth century indicate an elevation in the +43 m realm (unnumbered basin southeast of Daljā; basins XVII, XX, XXVI). In this area, the elevation reached by the levee of the Baḥr Yūsif is higher than 45 m a.s.l. This means that Baḥr Yūsif has risen at least over 2 m since it emerged. Following the rule of thumb of an average of 1 mm of sedimentation per year, the levees around the Baḥr Yūsif would go back at least two millennia. However, since the basins beside the levees have in the meantime also been silting up, thereby covering the lower parts of the levees, the Baḥr Yūsif levees must be much older than two millennia.

In fact, geomorphological research carried out north of Daljā suggests that a precursor of Baḥr Yūsif or a similar channel originating from further south already existed around 1400 A.D. in the region that is nowadays covered with dunes (i.e. 2 km further to the west of the current-day channel of Baḥr Yūsif). Although no other palaeochannels could be clearly identified, the presence of floodbasin sediments in between dune ridges, dated at 4520-4440 cal BC, demonstrates that tributary channels of the Nile, such as Baḥr Yūsif, were able to transport sufficient amounts of water and sediment to the western desert edge at the time. Moreover, an area to the west of the Baḥr Yūsif seems already to

systems such as are often based on papyrological documents, can only convey a very schematic view of what the dyke pattern may have looked like in reality.

153 Kessler, 1981, p. 26-27, referring also to the earlier literature; Drew-Bear, 1979, p. 289-290.

have been under cultivation by the early Old Kingdom.[154] All of this suggests that the major hydrological elements of the landscape, the Nile and the Baḥr Yūsif, go back to a period at least early in the pharaonic era.

This is confirmed by some of the toponyms analysed above. With the exception of Mallawī, which is first attested in 1296 A.D., all investigated place names go back to at least the (late-) Roman period, suggesting at least this time depth for many of the settlements recorded by the *Description de l'Egypte*. Some settlements, however, are likely to be much older. Two villages both called Dairūṭ lie on the levees of the Baḥr Yūsif: one at its entrance and a second one (called "Daroût Achmoun" in map 14 of the *Description de l'Égypte*) west of al-Ashmūnayn. This toponym is etymologically connected to Egyptian *ỉw rd* "plant island", a name known since the Old Kingdom for agricultural domains (see p. 310-311). The term *ỉw* 'island' designated not only permanent islands, but also higher parts of the floodplain that were islands only during the inundation.[155] The two villages called Dairūṭ are located on the levees of the Baḥr Yūsif, and they may well have lain on parts of these levees that were such temporary islands.[156]

As designations of such places, Egyptian knew two names: *ỉw* "island" and *mȝ.wt* (Coptic ⲙⲟⲩϵ), literal translation "new land". While it is true that the two terms were in simultaneous use in the Twentieth Dynasty expression *ỉw n mȝ.wt* "island of new land", *ỉw* was generally a more ancient name, which is attested since the Old Kingdom, and was gradually being supplanted by *mȝ.wt* from the Amarna period onwards.[157] This suggests that the various Dairūṭs are very old, and may go back to one of the Old Kingdom royal domains named *ỉw rd*.

All of this suggests that the Baḥr Yūsif has followed a course very similar to the current one since very early in pharaonic history. This is confirmed by the probably great age of the tell of Daljā, and the nearby agricultural fields dating back to the early third millennium B.C. between the same site and al-Shaykh Shibaykā, and which relate to the Baḥr Yūsif.

The Tirʿa al-Shaykh Ḥajāza and al-Sabakh have levees that today rise at least 1 m above the surrounding landscape, and that may be of comparable age. A chronological indication is that two major Old and Middle Kingdom cemeteries dependent on al-Ashmūnayn are located near al-Shaykh Saʿīd just north of al-Amarna, and near Dayr al-Barshā. In the decision to locate these burial grounds

154 Mohamed, 2012, p. 107-110; 122-123. See also p. 249-250 in this volume.

155 A similar ambiguity in meaning exists with the Arabic word *jazīra*.

156 Schenkel, 1978, p. 62-65.

157 Id., p. 64; Antoine, 2016, p. 25-27.

where they were, considerations of accessibility must have played an important role. Now the Tirʿa al-Shaykh Ḥajāza, connecting the very old town of al-Ashmūnayn with al-Rairamūn (with a likely time depth going back at least to the New Kingdom) goes in the direction of the Old Kingdom cemeteries at al-Shaykh Saʿīd, suggesting it must be ancient. For similar reasons, the al-Sabakh is ideally located as a transport way linking al-Ashmūnayn to Dayr al-Barshā, where vast cemeteries existed in the Old and Middle Kingdoms (see p. 316-317).[158]

The early date of at least the Tirʿa al-Shaykh Hajāza receives support from the interpretation of the landscape in fig. 10, which combines the plans already rendered in figs. 5 and 6, but adds information on the form of the levees. Here the grey areas surrounded by a green line indicate the levee belts built up alongside the major river systems (Nile and Baḥr Yūsif). The rose-coloured areas surrounded by a red line indicate areas where levees of a different kind built up. These are probably crevasse splays: they take their point of issue at the outside of a bend of the river and deposit alluvium in a wide area fanning out from where the main levee broke. The fan-shaped form of the channels in the Mallawī area are very typical for crevasse splay channels. It is quite apparent that the settlements of Qulubba and al-Ashmūnayn lie on a single levee system that is likely to have been in origin a crevasse splay. In fact, from this perspective the location of al-Ashmūnayn is easy to understand: it is surrounded by irrigable land, but lies itself on higher ground. The situation of the town, which is known to go back to the third millennium B.C., suggests that the levees of this crevasse splay go back to at least as early as that.[159]

Other settlements also merit being mentioned here. The name of Sinjirj has been argued above to go back to Egyptian *š n grg.t* "the basin of the agricultural domain" (or similar). This name must be pharaonic, and its agricultural meaning is interesting, because the eighteenth century village lay on a dyke, and therefore on the edge of a flood basin. This is an argument for assuming that the dyke on which Sinjirj lies is ancient, and the same may be the case for other dykes in the same area.

158 Currently, a project directed by the first author in collaboration with G. Verstraeten and W. Toonen is investigating the geomorphology of this region.

159 One reason why Butzer assumed the Nile must originally have followed a course immediately past al-Ashmūnayn was his idea that early settlement emerged on levees. This has also been assumed by archaeologists working in other areas, like the Rhine Delta. However, as van Dinter/van Zijverden, 2010, have shown, crevasse splays are admirably suited for incipient settlement.

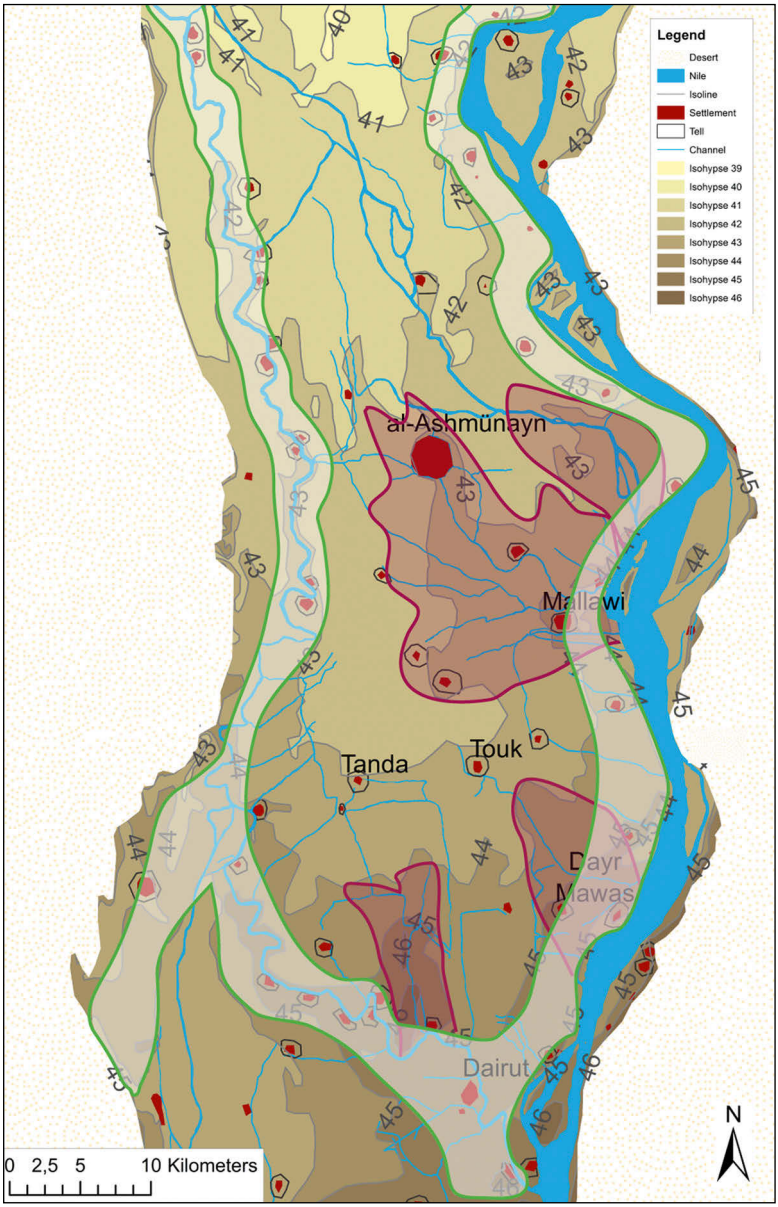

Figure 10. Levees and crevasse splays in the region investigated. Grey with green line: levee. Rose with red line: crevasse splay. Map Hanne Creylman, Gert Verstraeten and Georgia Long.

The village of Ismū may have similar roots. As the (possible) precursor of the name ⲥⲓⲙⲟⲩ suggests, this name may originally have meant "new basin", and may date back to at least as early as the Third Intermediate Period. It is highly interesting that this village still in the eighteenth century lay on the dyke enclosing basin XV. This strongly suggests that dykes 4 and 17 enclose a basin that may have been created during or before the Third Intermediate Period, a basin which, at the time of its creation, may have been baptized "new basin".The location of this basin, at great distance from the Baḥr Yūsif, would moreover suggest that it must always have been part of a basin chain. This offers support for the assumption that the dyke system encountered by the French army may be of very ancient date.

Finally, the obviously ancient architectural remains (vast blocks of ashlar masonry) at the village of Nazlat al-Shaykh Ḥussayn and the lore about the presence of a 'birbā' ('temple') there suggests the presence of a settlement at least going back to the Pharaonic period (see p. 313-314). This settlement in the eighteenth century lay directly beside a dyke.

A series of texts in the quarries of Hatnub, and dating back to the early Middle Kingdom, offers supplementary information. These texts describe a warlike situation in the reign of pharaoh Amenemhat I, in the course of which the town of al-Ashmūnayn was under siege. Several of the texts suggest that the population fled the city. In this connection one of the leaders of the town describes himself as "someone who acted as its rearguard in *Šdy.t-š3* when all people had fled".[160] The place name *Šdy.t-š3* has always been interpreted as a marsh-like wilderness that was hard to find access to by enemies unfamiliar with local conditions.[161] Egyptologists have never attempted to localize *Šdy.t-š3*, but it stands to reason that it must have designated the humid depression between the levees of the Nile and the Baḥr Yūsif. In the eighteenth century, the area south

160 Anthes, 1928, Gr. 17,12-13. Similar expressions occur in Gr. 16,5; 23,5; 24,8; 25,7; 26,6. For the date of the texts, see Willems, 2014, p. 79-87.

161 In Middle Kingdom texts the term *šdy.t* refers to a region rich in water and where fish live, although it is also said to refer to a type of land (Erman/Grapow, 1930, 567,11-14). *Š3* has a similar range of meaning: it refers to flooded land, or land where flowers grow. It is used in opposition to *sḫ.t*, the normal expression for agricultural fields (Id., 399,7-400,1). It is only in texts of the Graeco-Roman period that both terms are apparently used with reference to farmland. *Šdy.t-š3* was probably a direct genitive, but in view of the range of meaning of both components of the expression it is hard to translate. In any case it seems clear that a kind of marsh-like environment is being referred to.

of dyke 21 seems to have been under cultivation, but north of it, i.e. northwest of al-Ashmūnayn, there was an area without dykes, and which the waters of the Sabakh and the Baḥr Yūsif had free access to (basin XXVI and perhaps XXV). It stands to reason that the Hatnub texts are referring to a precursor of this area in the neighbourhood of al-Ashmūnayn.

The above indications suggest that the main hydrological arteries that were observed in the late eighteenth century by the French lay at more or less the same places as their precursors had since early in pharaonic history: the Nile, the Baḥr Yūsif, the Tirʿa al-Shaykh Ḥajāza, and the Sabakh, and a precursor of basin XXVI. Moreover, the settlements of Sinjirj and Ismū have names that may point to an originally agricultural background, which would fit in well with their location on dykes still extant in the eighteenth century. Since, as has been remarked by Gomaà, Müller-Wollermann, and Schenkel, maintenance of dykes is more likely to entail repairs of already existing earth works than the wholesale construction of new ones, it should come as no surprise that dykes might reach back far in time. The long history of agriculturally-based toponyms, and the persistence of the general layout of the landscape suggest that the pattern we have been discussing may be very old.[162]

This brings us to a last point. The area we have been discussing encompasses an extensive system of basins that starts where the Baḥr Yūsif branches off the Nile near Dairūṭ, and ends between Iṭlīdim and al-Ashmūnayn, in the humid basin XXVI, with its open connections both with the Nile and the Baḥr Yūsif. Both near Dairūṭ and south of Iṭlīdim, the flood basins within dykes and levees cover only a narrow strip along the Nile, whereas in the area in between, artificial irrigation basins extend westward almost as far as the western desert. Stated differently, the artificial irrigation basins rendered in the *Description de l'Egypte* do not constitute a continuous system, but only a local network of basins centred around al-Ashmūnayn.

There are again indications that this situation may have originated long before it was recorded by the French army. In fact, the areas where the irrigation basins are reduced to mere strips of land bordering on the Nile, seem to be

162 Accordingly, the assumption of a general eastward migration of the Nile (suggested, for instance, by Bunbury/Malouta, 2012, p. 119-122) is for this region rather unlikely. Note that Michel, 2005 has convincingly argued that, technically, the irrigation system has not changed much between the Graeco-Roman and Ottoman period. Over this long period of time, according to him, there is little or no evidence for the construction of artificial canals, the only major intervention in the landscape consisting in the construction of dams and the cleaning of channels.

located precisely where the northern and southern borders of the fifteenth Upper Egyptian nome were located already in the Middle Kingdom, and perhaps before.[163] It is unlikely that this correspondence is due to mere coincidence. We would suggest that the network of basins surrounding al-Ashmūnayn may have played a crucial role in defining the surface of the nome. Here it is worth recalling that the hieroglyph for *sp3.t* "nome" depicts a network of fields surrounded by small dykes (). We would suggest that the ancient fifteenth Upper Egyptian nome, and perhaps other nomes as well, may have crystallized around agriculturally coherent zones, which in Egypt implies the presence of irrigation basins.

The suggested relationship between the successful maintenance of agricultural basins and provincial administration does not necessarily imply a return to Wittfogel's model of oriental despotism, however (see n. 7). To him, a centralised irrigation authority lay at the roots of state administration. To us, it seems entirely acceptable that the origin of basin systems may have been based on local and informal systems of collaboration, which only in the course of the state formation process were partly integrated in more encompassing systems of administration. The form and nature of the basins in the al-Ashmūnayn area in fact suggest that human interference in the landscape was very restricted.

This is is confirmed by fig. 10. As explained above many channels in the region can be explained as naturally formed waterways, whereas it is in

163 This requires some explanation, as Helck 1974, p. 109; 205 placed the southern border between Dairūṭ and Dayr Mawās, and the northern one on the west bank even to the north of the latitude of Banī Ḥasan. His reasoning for this is 1) that the nome list in the *chapelle blanche* attributes a length of 3 *itrw* and 3 *ḫ3,* i.e. 33.069 km, to the Hare nome; 2) that the northern border of the nome must have passed north of Iṭlīdim and Balanṣūra, and 3) that because the southern border must have lain c. 33 km further south, Dairūṭ must have lain in the 14th Upper Egyptian nome, and not in the 15th. This whole reasoning rested on Helck's identification of Iṭlīdim and Balanṣūra with ancient Egyptian place names. In a thorough reevaluation of this toponymical evidence, however, Kessler, 1981, p. 120-185 showed convincingly that the northern border of the 15th nome cannot have passed north of Balanṣūra. He instead places it at the height of al-Shaykh Tīmai on the east bank, which corresponds roughly to the latitude of Iṭlīdim on the west bank. Because the northern border must accordingly be moved southwards for a considerable distance, and the location of the southern border can only be determined based on its 33-km distance to the northern border, Dairūṭ clearly must have been part of the 15th nome.

no case evident that a waterway is of man-made origin. This means that very little hydrological engineering was required to create the landscape we have discussed.[164]

5.2 Northern Middle Egypt and the Fayyūm

In previous sections we have shown that the natural process of sedimentation from both the main bed of the Nile and the Baḥr Yūsif led to the emergence of a shallow depression between the two waterways. At the end of the flood period, the dykes were opened, an occasion referred to in ancient texts as *wbȝ š* "the opening of the basin'.[165] Only after the residual water had drained off from the basins in this way, it was possible to start plowing and sowing the fields.

The "opening of the field" took place throughout Egypt after the flood period, and it must have generated a major water displacement in the direction of the Fayyūm though the depression between the levees of the Nile and the Baḥr Yūsif, as well as through these waterways themselves. Although the depression has occasionally been referred to in the literature, the vast impact it must have had on the hydrology of all of northern Upper Egypt, on the spread of agriculturally useful fields, and on the demography of the region, has not been addressed before.[166] It seems likely that the magnitude of this factor explains the scale of the dyke system in the Fayyūm, of which the functioning in the eighteenth century has been discussed above (4.3.1-4). In this section we will attempt to show that it goes back much farther in time.

The sluice system at the entrance to the Fayyūm, between the modern villages of al-Lahūn and Hawwārat al-ʿAdlān, is repeatedly mentioned in medieval accounts dating back to the eleventh to thirteenth centuries A.D. The sluice currently in use was adapted in the nineteenth century, but in essence the

164 Of course this does not rule out that existing natural channels may have been maintained. This confirms the results of Michel, 2015, which was based on papyrological and Ottoman administrative documents.

165 For an overview of the pertinent literature, see Egberts, 1995, p. 321-322, n. 10.

166 This is not the place for a calculation of the water volume concerned. Although losses in water volume during the flood period have to be reckoned with due to infiltration and evaporation, the impact of the former factor must in the deeper areas have been significantly below average due to the relative closeness of the groundwater table. Moreover, as these deep areas were flooded far longer than the higher ones, the groundwater level itself must have been higher than average.

present structure dates back to 1245 A.D.[167] The archaeological study of the dams at the Fayyūm entrance and near the al-Mala'a reservoir, and the stone-lined walls north of the Baḥr Yūsif near Hawwārat al-Maqṭā, has shown that these structures are at least partly of Roman date.[168] An interesting point is that the Jisr al-Shaykh Jād-Allāh (i.e. the al-Lahūn dyke) has a Roman period stone casing. Since this casing is likely to have been applied in response to flood damage, the presently visible dyke must have been preceded by an older clay dam. The Jisr al-Bahlawān, the partner dyke of the Jisr al-Shaykh Jād Allāh, never received such a coating. The clay dams therefore seem to be earlier structures, perhaps of pre-Roman date.[169] The enormous expansion of agricultural activity in the Fayyūm can only be explained by the implementation of large-scale systems of water management from the Ptolemaic period onwards. Moreover, Herodot offers an account of the irrigation system in the Fayyūm that is in many regards unreliable, but that at least presupposes the presence of mechanisms to control the amount of water flowing into the depression. Since this would have been impossible without major waterworks being in place, some dykes and sluices must have existed at the entrance to the Fayyūm at least by Herodot's day, i.e. around 445 B.C.[170]

According to Classical lore, irrigation processes were, however, already undertaken in the Fayyūm in the Middle Kingdom. These works are attributed to a king Lamares, who is generally believed to be Amenemhat III.[171] In fact very little evidence remains of the long intervening period, except an Eighteenth Dynasty statue of a Sobkhotep, who claims the title of *ḥ3.ty-ʿ n š-rs.y š-mḥ.ty* "Lord of the southern lake and of the northern lake".[172] It has been argued that in this text, "the northern lake" refers to Lake Fayyūm, while "southern lake" designates the area of the al-Mala'a reservoir, which would accordingly reach back in time at least as far as this.[173] In fact, the term "southern lake"

167 Garbrecht/Jaritz, 1990, p. 141; 147.

168 The oldest dam in the Mala'a area is Roman: Id., 1990, p. 133.

169 Id., p. 109.

170 Id., p. 140-141. Römer, 2016, p. 136 takes seriously Herodot's statement that surplus water could flow back from the Fayyūm depression into the Nile valley floodplain. We agree to the work of the authors cited in the preceding notes that this is rather unlikely.

171 Riad, 1958, p. 203-206, with references to the pertinent Classical literature. See also Römer, 2016, p. 173-177.

172 Helck, 1956, p. 1588,14-15.

173 Garbrecht/Jaritz, 1990, p. 31.

already occurs much earlier, being attested several times during the early Old Kingdom.[174] The earliest references occur in the inscriptions of Metjen of the early Fourth Dynasty and in a text from the reign of king Khufu recently found in the Wādī al-Jarf.[175] Recent geomorphological reconstructions suggest this 'lake' already existed since the late eighth millennium B.C.[176]

There are in fact good reasons to assume that Amenemhat III (and his predecessors) pursued a policy of developing the Fayyūm. In this connection, the remarkable location of the pyramids of Senwosret II (near al-Lahūn) and Amenemhat III himself (near Hawwārat al-Maqṭā) in the Fayyūm has been duly noted, as has the presence of two colossal statues of Amenemhat III on the Middle Kingdom shore of Lake Fayyūm near Biahmū.[177] While all of this clearly bears witness to an unusual interest for the Fayyūm, it is possible to be far more specific about what was happening there than has been realized.

A first point of note is that the pyramids of Senwosret II and Amenemhat III are not just located in de Fayyūm region, but at very conspicuous places there. The pyramid of Senwosret II lies at the end of the al-Lahūn dam, and the pyramid of Amenemhat III lies close to Hawwārat al-Maqṭā. Like the location of the al-Lahūn pyramid, this is an important place in the irrigation landscape of the Fayyūm. On the one hand, the Bats drain, the most significant drainage system leading to the Fayyūm lake, begins here. In the Roman period, an important sluice system was built here serving to control the amount of water flowing off in this direction. But owing to the natural landscape, there must have been a dam system here earlier as well, because otherwise it would have been difficult to control the hydrology of the Fayyūm at all. The extensive erosion areas visible here must date back to periods before the construction of the dams, or to periods when they were broken, and this dramatically illustrates the impact of uncontrolled flooding in this area.

174 Ćwiek, 1997, p. 17-22.

175 Sethe, 1933, p. 3,12; Tallet/Marouard/Laisney, 2012, p. 413 and p. 441, fig. 22. Here, *š rs . y* is erroneously translated as "Fayyūm".

176 Hassan/Tassie, 2006, p. 39.

177 Other remains have also been found in Madīnat Fayyūm and at Abjīj (the structure at the latter site even going back to as early as Senwosret I). For an overview of the Middle Kingdom evidence, see Tallet, 2005, p. 101-109. Other publications pointing out the significant location of the pyramids of Senwosret II and Amenemhat III are Gomaà/Müller-Wollermann/Schenkel, 1991, p. 27-28 and Schenkel, 1978, p. 65-67.

Further south, but still close to Hawwārat al-Maqṭā, lies the medieval sluice system of ʿIzbat Muṣṭafā al-Jindī, which served to control water flowing into the al-Mala'a reservoir. The question is, of course, whether this reservoir was already operational in the Middle Kingdom, but if it was, the location of the Hawwāra pyramid in front of two important water works is most conspicuous.

We have already noted evidence for an Eighteenth Dynasty official and others dated to the Old Kingdom who may have been in charge of the al-Mala'a reservoir, but there is more compelling evidence that the reservoir may have been used in the Middle Kingdom. Here one preliminary remark must be made. Throughout this article, repeated mention has been made of the al-Mala'a reservoir, but it has not yet been pointed out that at its southwestern end, the al-Gharaq channel constitutes the connection to the more westerly al-Gharaq depression, which, if sufficient water was available, could also be flooded. It is around the southern banks of the al-Mala'a reservoir and the Gharaq depression that two major settlements evolved in the Ptolemaic period: Tebtynis and Madīnat Mādī (see fig. 9). However, the latter settlement certainly goes back to the Middle Kingdom, witness a temple built there under Amenemhat III and Amenemhat IV. Interestingly this temple is dedicated to Renenutet, an agricultural goddess, and Sobek, a deity linked to the Nile flood.[178] Somewhat further east, between Tebtunis and Madīnat Mādī, lies the extensive Middle Kingdom cemetery of Kawm al-Khalwā, interestingly on a promontory overlooking both the Mala'a reservoir and the Gharaq depression. The imposing tombs here resemble those of nomarchs further south in Upper Egypt.[179] The location of all the monuments discussed thus far lies so conspicuously close to places that played a crucial role in the Ptolemaic and Roman irrigation regime of the Fayyūm that it is hard to escape the impression that this infrastructure had Middle Kingdom precursors at exactly the same spots. That this should be so is not surprising, considering the constraints imposed by the natural landscape.

The most important indication as regards the functioning of the hydrological system is, however, provided by the toponymy of settlements in the region.

Here, pride of place goes to the village of al-Lahūn. It is well known that this name goes back to *R-ḥn.t*, a toponym that is attested from the Middle Kingdom onwards.[180] Its meaning has been intensively studied. Since *ḥn.t* indicates

178 This point is duly remarked by Tallet, 2005, p. 105, who does not, however, comment on the geographical proximity of the reservoirs.

179 Bresciani, 1997–1998, p. 9–48. The tombs are briefly discussed also by Tallet, 2005, p. 105-107.

180 Erman/Grapow, 1929, p. 398,3.

a waterway, lake, or similar, there is general agreement that it conveys some such meaning as "the opening/beginning of the *ḥn.t*-water". Early researchers like Brugsch assumed that *ḥn.t* means "canal", a reading accepted by Erman and Grapow.[181] In a detailed reassessment of all the then available evidence, Gardiner and Bell dismissed this interpretation, arguing instead that a *ḥn.t* is a lake, and that, in the Fayyūm, it could only designate the "Lake of Moeris", a designation they assumed refers to Lake Fayyūm.[182] However, this reading of the evidence seems to be far too restricted. In the Book of the Fayyūm, the entrance area near al-Lahūn is explicitly called *ḥn.t*. The same word is also used for watery areas further west. Beinlich has argued that the word designates the entire humid area ("Feuchtgebiet") in the Fayyūm, but not the lake itself (which would be named *š*). He seems to restrict this interpretation somewhat to the more moor-like parts of the hydrology, excluding the main waterway, the Baḥr Yūsif, which according to him is designated in the text as *Mr-wr* "Great Waterway".[183] However, none of the passages cited by Beinlich rule out that the Baḥr Yūsif forms part of the *ḥn.t.* In fact, the eastern part of the *ḥn.t* as depicted in the Book of the Fayyūm includes a large channel which flows past an area called "Pyramid land", *i.e.* Hawwāra.[184] This general area is called *ḥn.t n.t Mr wr* "the flood area of the Great Waterway".[185] In a detailed analysis of the available Demotic and Greek papyrological (and earlier) evidence, Vandorpe has moreover argued that, in the Fayyūm, this element of the topography is only referred to in the singular, and that these texts locate settlements either to the north or to the south of it. Since these settlements lie on opposite sides of the Baḥr Yūsif within the Fayyūm, she argues that the *ḥn.t* must correspond to the Baḥr Yūsif, and that it therefore means "canal".[186] This argumentation seems entirely convincing to me, except in one regard: a "canal" is, as Gardiner already pointed out in the article cited above, a man-made waterway, which the Baḥr Yūsif certainly is not. The translation "channel" seems better.

181 Id., p. 105, 1-5

182 Gardiner/Bell, 1943, p. 37-50; followed by Černý, 1976, p. 346. According to Garbrecht and Jaritz, Lake Moeris does not designate Lake Fayyūm, but the al-Mala'a reservoir. Gardiner and Bell were clearly not aware of the existence this reservoir, and did not consider it in their interpretation.

183 Beinlich, 1991, p. 289-293.

184 For the interpretation of this area, see Beinlich, 1991, p. 79.

185 Id., p. 138 (line 1). For this interpretation of the term *ḥn.t*, cf. Yoyotte, 1987-1988, p. 146-147.

186 Vandorpe, 2004, p. 61-78.

In view of all of this, the toponym *R-ḥn.t* "al-Lahūn", i.e. "mouth of the channel", must refer to a settlement at the head of the part of the Baḥr Yūsif leading into the Fayyūm. Its location is on the Jisr al-Shaykh Jād-Allah, and opposite Hawwārat al-ʿAdlān on the Jisr al-Bahlawān. The Baḥr Yūsif and the sluice systems controlling its access into the Fayyūm lie right between the two settlements. The "mouth" referred to in the toponym is undoubtedly the opening between the two dams (or precursors of those). There is accordingly no room for doubt that the name al-Lahūn refers to this constellation of waterworks. And since *R-ḥn.t* is attested since the Middle Kingdom, the waterworks must go back at least as far as that.[187]

This impression is strengthened by the location, date, and toponymy of other pharaonic settlements in the region. Several rather important ones cluster in the area of the Fayyūm entrance. We have already mentioned Hawwārat al-ʿAdlān, at the northeastern end of the Jisr al-Bahlawān. Another important settlement is the site of Ghurāb at the southern end of the same dyke, where a royal palace was located in the New Kingdom. According to early results of recent corings undertaken here, a subsidiary branch of the Baḥr Yūsif may have passed Ghurāb in the New Kingdom.[188] And since the name of al-Lahūn only makes sense under the assumption that a precursor of the Jisr al-Bahlawān existed already before the New Kingdom, it stands to reason to assume there was a second sluice system in this dam near Ghurāb.

The etymology of the name Hawwāra, a toponym attested twice in the region here being discussed, is likewise of importance. It has been shown that this name goes back to Egyptian *Ḥw.t-wr.t*, a designation of ancient date that was since the Old Kingdom used to describe a legal institution.[189] It seems striking that one settlement with this name lies immediately opposite al-Lahūn, beside the sluice system through which the Baḥr Yūsif entered the Fayyūm, while the second, Hawwārat al-Maqṭā, lies beside the Roman sluices controlling the influx of water into the Bats drain.

187 Hassan/Tassie, 2006, p. 40 state that the jisr al-Shaykh Jād-Allāh "dates to the Middle Kingdom" (an interpretation accepted elsewhere by Römer, 2016, p. 177. However, no evidence to this effect is indicated in the publication.

188 Bunbury, 2012, p. 52-54.

189 For the identification, see Gauthier, 1927, p. 59; Gardiner/Bell, 1943, p. 43. Habachi, 1977, has claimed that the name of Hawwāra rather has an Arabic origin, as "a designation of isolated places". However, the sources discussed by Gardiner, which were apparently unknown to Habachi, leave no room for doubt that the proposed etymology is correct.

Taking a look at the plan of fig. 8, it is clear that all the settlements discussed are strategically located on the dyke systems A-B and D-E. This figure also indicates the former presence of a dyke B-C, which ran from the village of al-Lahūn to the Jabal Abū Ṣīr. Of this dyke, nothing now remains, but as explained above it must have played an important role in managing the distribution of water in the Nile Valley. It has not been remarked before that, precisely where dyke B-C reached the Jabal Abū Ṣīr, there is another prominent site: the vast Middle Kingdom cemetery of al-Ḥarāja.[190] It is usually assumed that this cemetery belongs to the Middle Kingdom site of Kahun. This interpretation is, however, not convincing, as Kahun lies on the desert edge, and it cannot have been difficult to find suitable cemetery ground here. The possibility that there may have been an important settlement close to al-Ḥarāja should not be discarded too lightly, therefore. However, even if the cemetery of Kahun town really lay at al-Ḥarāja, the fact that the town was separated from it by a depression where the water speed must have been rather high during the flood, suggests that there must have been a land route between the two. Perhaps, dyke B-C dates back to as early in time as this.

Taken together, indications that the dyke system in the Fayyūm may go back to as early as the Middle Kingdom are certainly not restricted to the remarkable location of two pyramids, but to a whole array of indications for human activity at rather conspicuous places. The name of al-Lahūn, attested since the Middle Kingdom, in our view leaves no room for doubt that precursors of the Roman dyke system here must date back to at least the Twelfth Dynasty. Also, the constellation of important settlements and cemeteries only makes sense if dykes A-E in the entrance area of the Fayyūm already existed then.

If dykes of sufficient magnitude to control the flood could be built with the means available in the Twelfth Dynasty, then it should be no cause for surprise that a second dyke system was built between Itsā and Shidmū, and this in fact explains the location of a settlement at Madīnat Mādī and of a major cemetery at Kawm al-Khalwā.

In view of the major efforts that must have been made in this region, it cannot fail to surprise that the archaeological record for irrigation works in the Fayyūm immediately stops again after the Twelfth Dynasty. In fact, archaeological evidence is in general extremely poor then. It is impossible at the present juncture to explain this satisfactorily. However, there is an ongoing debate over how the extremely high flood records at Semna should be interpreted. These

190 Engelbach, 1923.

records only start under Amenemhat III, continuing through the first decades of the Thirteenth Dynasty.[191] If these records really reflect catastrophic floods, this must have had a great impact on the freshly built dams at the Fayyūm entrance. One might speculate that the damage caused was of such magnitude that further attempts to bring the Fayyūm under cultivation were forestalled for many hundreds of years.

6. Summary and Conclusions

The aim of this article was to show how historical maps can be used to reconstruct the preindustrial Egyptian irrigation landscape in the area between Dairūṭ al-Sharīf and the Fayyūm depression. It made use primarily of the maps of the *Description de l'Egypte*, produced in 1798-1799, which provide detailed insight in the hydrology of this region before the landscape was fundamentally changed by the large scale modernisations of the irrigation system implemented in the nineteenth century. These maps were georeferenced with maps of the early twentieth century which provide information on natural relief. In this way, a very detailed reconstruction was proposed of the eighteenth century hydrology in the region between Dayrūṭ al-Sharīf and an area to the north of al-Ashmūnayn. After a detailed critique of the (sometimes erroneous or unclear information provided by the) ancient maps, an analysis of the irrigation basins was presented. The reconstruction revealed a highly complex system, with basins of rather irregular shapes. Some of these functioned as units in their own right, while others constituted chains of basins, some of which were fed directly from the Nile, and yet others received their water from the Baḥr Yūsif or other Nile branches. An aspect not hitherto paid attention to in Egyptological studies of the irrigation landscape is that, owing to the form of the floodplain, only a relatively small part of the floodwater could drain back into the Nile after the flood season, because it remained trapped between the levees of the Nile and the Baḥr Yūsif.

North of al-Ashmūnayn, and south of the entrance to the Fayyūm, the *Description de l'Egypte* shows a far more regular system of dykes. However, recent remote sensing investigations have shown that prior to this, an equally irregular system of waterways existed there as the one still encountered around al-Ashmūnayn in the Napoleonic age. This suggests that the system in the latter area represents a less developed irrigation system than the one recorded further

191 Seidlmayer, 2001, p. 73-80.

north. The de Vaugondy map, published in 1753, but based on information collected around 1720, and the d'Anville map published in 1765, show that, at that time, the low area between the Nile and the Baḥr Yūsif was in fact a wide, humid area, through which residual flood water flowed north to the mouth of the Fayyūm depression.

The existence of this important hydrological system, combined with natural factors, must have led to large accumulations of water in front of the Fayyūm entrance long after the end of the flood season. Under natural conditions, part of this water could drain off further north to the Nile Delta, while another part of it would be transported by the Baḥr Yūsif into the Fayyūm depression. The vast dyke systems at the entrance of this depression, near the town of al-Lahūn, must have served to monitor the amount of water being allowed into the Fayyūm. Internal dyke and sluice systems within the Fayyūm moreover served to store water for later distribution after the flood. For this, the al-Mala'a reservoir existed, southeast of Madīnat al-Fayyūm. We assume that it could be replenished with water until long after the flood season, and that, accordingly, the al-Mala'a basin may have provided a far larger area within the Fayyūm with water than was hitherto thought.

Particularly for the al-Fayyūm area, there is well-documented evidence showing that the dyke systems discussed must have been functional already in Medieval, Byzantine, and Roman times. The hydrology of Middle Egypt as elaborated in this article shows, however, that the water trapped in the depression between the Nile and the Baḥr Yūsif must already at that early date have led to a substantially higher water supply to the al-Fayyūm region than was hitherto suspected, and this very fact may explain the scale of the waterworks in the Fayyūm region. The amount of the water reaching this area was, however, dependent on the hydrology of Middle Egypt.

Since these conditions are mainly contingent on natural conditions, it stands to reason that in Antiquity, the hydrological system must have been similar in some essential regards to that of the late eighteenth century. For this reason, an investigation was undertaken to determine how old this system was. Historical toponymy suggests that many of the settlements recorded by the *Description de l'Egypte* have names that can be traced to villages and towns known from the Graeco-Roman period. In several cases, place names are demonstrably much earlier, and their etymology occasionally relates them to hydrological conditions that resemble those highlighted by the maps of the *Description de l'Egypte* quite closely. Moreover, the scant geomorphological evidence available, as well as the spread of archaeological sites (mostly in the Fayyūm) and textual data, provide

strong evidence that some of the essential elements of this system may have roots as early as the Old or Middle Kingdoms.

New hypotheses developed in this study concern 1) the longevity of pharaonic hydrological patterns, many of which may have survived into the Middle Ages and the Napoleonic era; 2) the existence of a vast wet zone between the Nile and the Baḥr Yūsif south of the Fayyūm, which must have had an enormous impact on the functioning of the Fayyūm and on the necessity to build large scale water works here from an early date. 3) This moreover has implications for calculations of the carrying capacity of land for sustaining a population. In current estimates, the wet zone, which must have covered a vast area of land, is never taken into consideration. Since it is unlikely to have been suitable for the cultivation of cereals as much as for habitation, estimates of population size may have to be lowered significantly. In fact, even in the eighteenth century, the wet zone seems to have been only thinly inhabited.

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