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Navigating the ancient Tigris – insights into water management in an early state

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ABSTRACT

This paper offers the first detailed investigation of water management in pre-classical antiquity based on primary sources. The importance of water management for ancient societies can hardly be overstated, as many of the earliest civilizations emerged in large river valleys (Nile, Euphrates and Tigris, Indus, Yellow and Yangtze river). More importantly many of those early civilizations occupied the reach of the river, which was located in the arid/semi-arid zone, by which rivers vital sources of water, in particular for irrigation. Many studies on ancient water management have focused on irrigation, often failing to recognize the full extent to which rivers were managed and utilized. The water management scheme of late 3rd millennium Southern Mesopotamia, described in this paper, was designed to not only serve irrigation, but equally navigation and flood control. It combined the manipulation of water levels with the diligent observation and maneuvering of water masses of the ancient Tigris, by which the otherwise conflicting demands of irrigation, navigation and flood control could be reconciled. The written sources used in this study allowed to describe this water control system in great detail and is a testimony to remarkable ancient hydraulic engineering as early as the 3rd Millennium BC.

1. Introduction

The history of ancient water management has not yet been written on the basis of empirical evidence. Researchers have largely been dependent on very scant archaeological evidence, which is limited in the detail it can provide with regards to how water management was realized on a technical but more importantly on a social level. This is all the more important, since many of the societies concerned – Egypt, Mesopotamia, the Indus Valley, and China – were hugely dependent on the management of water. A blurry picture of their practices in this respect, therefore, obscures the very basis on which they subsisted.

This paper will show that water management can be studied for Ancient Mesopotamia on the basis of primary written sources inscribed by the very administrators who ran the water management system. This transforms our understanding of how the system worked, making it possible to provide detailed insights into hydrological engineering of 5000 years ago. In addition, the written sources also allow us to assess the degree of state involvement in the management of the water control system, a question that has been of great interest in particular with regards to early state formation. Hence, the paper's results also provide a large-scale case study relevant to scholars specializing in other riverine societies. We will concentrate on the 'Ur-III' period (2012–2004 BC) in Sumer (southern Iraq). One of paper's main results is the demonstration that river navigation was of prime importance in the system of water management. We will show how navigability was ensured through the use of barrages. Our discovery of the administration of navigability supports an important theory put forward by Guillermo Algaze (2001), according to which navigation was not only important in ancient Sumer, but gave the region an advantage over its neighbors and supported the growth of social and political complexity at a much earlier point than in other parts of Southwest Asia.

With the exception of Algaze's theoretical model, scholars have so far taken little notice of the rivers in ancient Sumer being actively managed for navigation. One reason for this is that many scholars are not fully aware that navigation in that region confronts severe challenges (with the exception of Adams, 2006: 139). We will therefore review these challenges, before outlining the means by which they were overcome. The challenges to river navigation in ancient Sumer spring in the first instance from the water regime of the Euphrates and Tigris river. These were and still are characterized by strong, often very unpredictable, seasonal fluctuations, that affect the river's water volume, flow velocity as well as water levels. Unlike the Nile, annual flooding of Euphrates and Tigris does not coincide with the crop cycle of winter grain (barley and wheat). The water level is low during the sowing of winter grain in October/November and peaks just prior to the harvest in April/May (Postgate, 1992: 181–183; Verhoeven, 1998: 199, 201–203, see Fig. 1).

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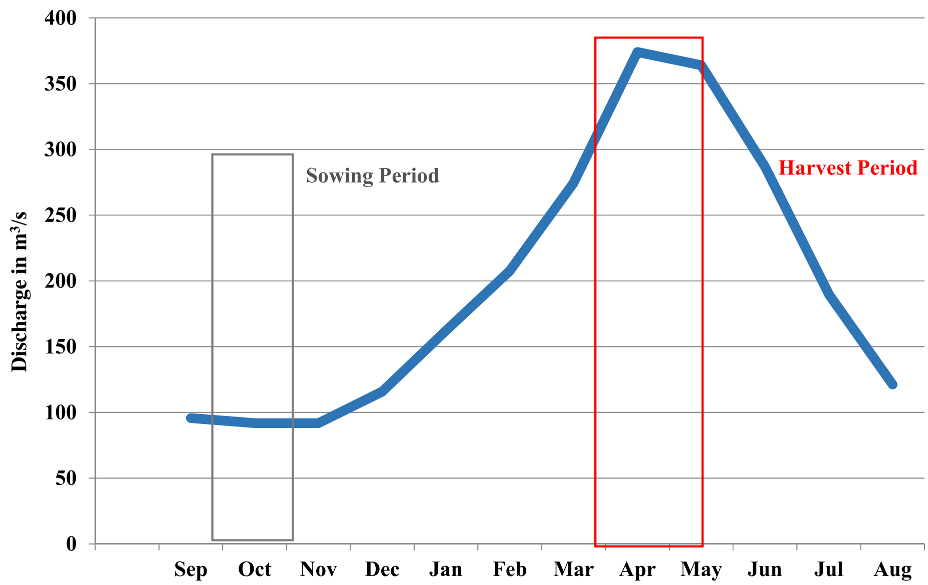


Fig. 1. Monthly means in m^3/s at the Tigris below Amara 1919–1923. Green box: sowing period, red box: harvesting period. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Source: Ionides (1937: 45).

Within this large-scale picture, much attention has been paid to the problems of high water levels coinciding with the harvest in April/May, however much less thought has been given to the problem of low water levels (Adams, 1981: 6; Civil, 1994: 109–110, 134–135; Postgate, 1992: 181–182). While high water levels pose a considerable risk of losing a year's worth of food supply, low water levels are equally problematic for irrigation, but more so for waterborne transportation. The water levels in Euphrates and Tigris start to drop at the end of May to the beginning of June, reaching their lowest point in September/October, which greatly impact the river's navigability.

Travel accounts from late 19th century AD report that a voyage on the Tigris downstream from Diyarbakir in southeastern Turkey to Mosul in northern Iraq (476 km) on large rafts made of 200–300 inflated skins took only 3–4 days during the flood season but nearly 15 days during the time of low water. In addition, boats could not draw more than 1 m of water between August and November, considerable limiting the cargo that could be transported during the summer months (Chesney, 1850: 32, 38–39).

The impact of low waters levels on the river's navigability would have been more severe further downstream where the river's gradient is even lower. Hence, for at least a quarter of the solar year the river's navigability would have been greatly diminished, – if left unmanaged.

In addition to the rivers' natural fluctuations, another factor, which posed a challenge to navigation, was the demand for irrigation water. One reason for this is that diverting water for irrigation can considerably reduce the amount of water in the river downstream, lowering the water table to a point at which river navigation becomes impossible.

In the recent past, a further obstacle to navigation has been the use of barrages, which are employed to raise the water level for purposes of irrigation. Since water levels are low at the onset of the agricultural season in August/September, and the inlets of primary canals tend to be located above the water level, in order to force irrigation water into primary canals, the river's level needs to be raised artificially. Prior to the widespread use of water pumps, barrages were used for this. Iraqi farmers constructed them of reeds, brushwood, and earth (for details see below), placed perpendicular to the river's current.

In the same period of the recent past (we will see that the situation in ancient times was different), barrages both posed a physical obstacle to navigation and considerably reduced the river's flow velocity. Moreover, they caused the river to prematurely deposit larger amounts of sediments within its bed. Over time the river channels thus silted up, greatly diminishing navigability. In a worst case scenario, the silt deposits induced by the barrages could even cause the river to abandon its course, depriving an entire region of water (Fernea, 1970: 28).

Finally, irrigation and navigation could be in competition for physical space. As emerges both from ancient records and from ethnographic accounts, much of the water born transportation on the Tigris entailed towing boats upstream (Steinkeller, 2001, see Fig. 2). The towpaths were usually located along the river's bank, intermitted with inlets to primary canals, which, if left open, would have considerably interfered with the towing operation (Steinkeller, 2001, also Adams, 2006).

2. The present case study

Given all these obstacles, navigation of the Euphrates and Tigris could have only reach its full potential with a comprehensive system of water control that allowed for reconciling the demands of irrigation with the requirements of flood control and water born transportation.

The case study I am going to present is just such a system that was designed to comprehensively manage the water levels of the ancient

Fig. 2. "Near Majar al Kabir: a boat being towed against the current up one of the branch streams that flow down from the main channel of the Tigris into the Marshes." (Thesiger, 1979: 193), Pitt Rivers Museum, University of Oxford.

Tigris (or a major channel thereof). As I hope to show, it is an example of remarkable ancient hydraulic engineering and the careful coordination of water masses as early as the 3rd Millennium BC. While for most ancient societies, a detailed description of the water management system remains very difficult due to the lack of empirical data, in the case of Mesopotamia, we are in the fortunate position of having an extraordinary abundance of written sources on ancient water control. This study conducts the first comprehensive analysis of these records. In particular, I undertake a systematic study of the archive of the "Umma province", which constitutes the oldest and so far also the most comprehensive record on ancient water control of the river Tigris.

The Umma province belonged to the kingdom of the Third Dynasty of Ur (2012–2004 BC) (Jacobsen, 1939). This dynasty ruled over Southern Mesopotamia for a period of a little over a century at the end of the late 3rd millennium BC. The core of this kingdom embraced an area roughly equivalent to modern-day southern Iraq and unified a former patchwork of cities-states that became name giving for the individual provinces (Sharlach, 2004: 80, see Map 1). The periphery of the Ur III state extended all the way to Iran in the east and to modern-day Syria in the north (Dahl, 2007: 1). This paper will concentrate on the region of Umma (see Map 2), in ancient Sumer (Southern Iraq).

The Ur III period is one of the best-documented eras in antiquity since the state was governed by means of a highly complex administrative system that was based on extensive record keeping in Sumerian language (Garfinkle, 2008: 55; Steinkeller, 1987: 20–21). To date, the corpus of Ur III texts housed in museums and private collections all over the world amounts to about 120,000 cuneiform tablets in Sumerian, of which around 75,000 are published (Molina, 2008: 20). My analysis is based primarily on documents that derived from the archive of the governor of the province of Umma, who managed an estate of about 14,000 ha of land with a staff of employed laborers and administrators. The total Umma corpus consists of approximately 30,000 cuneiform tablets, mostly dating to a period of thirty-eight years (2062–2025 BC) which kept record of many aspects of economic life, including that of water management (Molina, 2008; Steinkeller, 2003: 40, see Map 2). The number of tablets dealing with water management is c. 3000. All of them were studied for the present investigation.

The following is a representative example of one of our sources:

AOS 32 I 49[1]
7 workmen for one day cleaned the Kun-Nagar-canal.
Supervisor (was) Insasa,
(tablet was) sealed by Akala, the inspector of the plow oxen.
In the month of gleaning (= August).
In the year: "Enunugal was installed as en-priest of Inanna".[2]

The tablet also bears a seal impression, which has a cuneiform inscription of its own, in this case identifying the official who authorized the project:

Akala, scribe, son of Ur-nigar, the chief livestock manager

As can be seen from this example, our sources provide detailed information on work projects, such as (a) the number of workmen involved, (b) the duration of the project, (c) the types of activities involved (e.g., cleaning a canal or irrigating a field) and/or the amounts of construction materials deployed (e.g. number of reed bundles, volume or earth or adobe) (d) the project's location, (e) the supervisor's name and the name of the official who authorized the execution of the project, and (f) the date (year and/or month).

[1] Abbreviations for labelling the individual cuneiform texts follows the list published on the Cuneiform Digital Library Initiative (CDLI http://cdli.ox.ac.uk/wiki/abbreviations_for_assyriology).

[2] On the Ur-III dating system (which uses 'year names') see Table 2.

It is thus not only the *quantity* of Ur-III sources about water management which is exceptional, but the detail they provide on labor and construction materials for waterworks is unmatched in history. It even surpasses more recent ethnographic accounts of the organization of irrigation.

Despite the abundance of detailed information these records provide, their interpretation is not without problems. The main problem is that much of the Sumerian vocabulary pertaining to water management is poorly understood. For example, the term kun-zi-da (super-literally 'true tail') has been translated as 'reservoir', 'basin' (Falkenstein, 1956: 301, fn 2; Nissen, 1975: 26, fn 91; Oppenheim, 1948: 39, fn 59), 'catchment basin at the inlet of a canal' (Kraus, 1955: 53; Salonen, 1970: 30, 198; Sauren, 1966: 50-51, fn 122) next to the more accurate suggestion of it describing a barrage/weir (Carroué, 1993: 60, 62-64; Civil, 1994: 130; Kang, 1973: 437-438; Maeda, 1983: 75; Steinkeller, 2001: 35, 37). Obviously it is crucial to understand what the term means, if the system is to be properly reconstructed.

Another problem is that textual records very rarely specify the *dimensions* of water control devices, making it difficult to determine their size and construction design to understand their exact function within the larger hydraulic context.

In principle, these obstacles could be overcome by matching the written sources with archaeological remains. However, with the exception of the "water regulator" found near the ancient city of Girsu, there is hardly any archaeological evidence for water control that can be matched with written sources (Huh, 2008: 202–216; Jacobsen, 1969: 103–109; Parrot, 1948: 216; Pemberton et al., 1988: 220). Indeed, thus far, only the locations of the former courses of the Euphrates and Tigris and some primary canals have been detected archaeologically, and not always with total confidence (Adams, 1981; Adams and Nissen, 1972; Gasche and Tanret, 1998; Hritz, 2005; Jacobsen, 1969, 1960).

In the absence of usable archaeological evidence, the system and its nomenclature has to be reconstructed through large-scale analysis, where the study of the terms and the study of the phenomena they represent becomes inter-dependent, with one supporting the other. Such is the approach underlying this paper, which forms part of a holistic study of Ur-III water-management, and several of the findings reported here were discovered in relation to other findings which are not discussed here. Nonetheless, the present paper forms a self-contained and self-standing investigation.

For the larger, holistic, project I studied the twenty-two most common and most important Sumerian terms describing water management (Rost, 2015). All tablets containing one or more of the twenty-two terms were analyzed, amounting to a total of 3690 occurrences with an additional 1260 attestations of related geographic places. This large-scale, systematic analysis clarified the meaning of many Sumerian terms. The comprehensive nature of the enquiry, relying on detailed examination of thousands of sources, has made it possible to go beyond the many studies which examined Sumerian words in isolation (e.g. Civil, 1994; Kang, 1973; Liverani, 1996, 1990; Pemberton et al., 1988; Renger, 1990; Steinkeller, 1988; Waetzoldt, 1990). Overall, I am able to resolve most of the confusion surrounding Sumerian water-management terminology, and to provide more accurate translations of the relevant sources.

The improved understanding of the twenty-two terms made it possible to reconstruct a clear picture of the Ur III watercourse management systems. One of the main discoveries to emerge from the overall project was that the system actively managed the river not only for irrigation, but also for navigation. It is this aspect, which is reported in the present paper.

3. Questions of method

Crucial to my analysis of the Ur III records is the use of modern environmental and ethnographic/historical data on traditional methods of crop cultivation, irrigation and flood control, and in particular their place in the grain cultivation calendar.

While in principle one might hesitate to use ethnographic data to reconstruct practices five millennia ago, in the particular case of Ur-III water management this proves not to be problematic. The key point is that, as I was able to show, the Ur-III agricultural cycle was very similar to the modern one. In both cases, the climate leads to a focus on grains planted in winter (barley and wheat) rather than crops planted in the summer (e.g. vegetables): the Iraqi climate is characterized by moist and cool winter months, but extremely hot (as high as 50 °C) and virtually dry summer month (Adams, 1981: 11-12; Food and Agriculture Organization of the United Nations, 1997: 103; Nützel, 2004: 5). By sowing barley and wheat in late fall (mid-October/November) and harvesting it in early spring (March/April), the cultivator is able to take advantage of cooler and moister conditions of the winter months (Charles, 1988: 4-5). During the hot summer months (May–September), evaporation rates doubles with every 10 °C increase in temperature, and evapotranspiration rates reach 10 mm per day, whereby the crop's water demands quadruples. Given these climate conditions, the cultivation of crops planted in summer has always played a minor role in Iraq's agricultural production. In the year 1952/53, for example, 88% of the total agricultural area was cultivated with winter grains, while only 7% was cultivated with summer crops (Wirth, 1962: 47-48). There is very strong evidence that the same pattern holds for ancient times: the record of an ancient survey of agricultural land from the Ur-III province of Girsu/Lagaš shows that 99.65% of the 24,266 ha recorded area was cultivated with winter grains (barley, emmer and wheat). Only 0.35% of the area was reserved for summer crops (pulses, spices, onion, and garlic) (Maekawa, 1985: 97-101).

This has two implications for the present study: first, it is methodologically sound to suppose that the ancient cultivation calendar is more or less the same as the modern one; secondly, ancient administrative records about irrigation are overwhelmingly likely to be about grain irrigation, as this was by far the dominant sector. Both these points are very important, because many of the ancient sources dealing with water management are dated by month. Knowing which periods were associated with which agricultural activities means that, for any given dated source, one can infer whether it records irrigation work (which is overwhelmingly likely to be for grain cultivation), or work for other purposes (esp. flood control and navigation). Thus for example a record of construction work on a canal dated to August will almost certainly refer to maintenance work in preparation for the start of grain irrigation in October. By contrast, a record dated to March is much more likely to refer to flood control, because the rivers flood in March.

In addition to providing a proxy for the ancient agricultural calendar, ethnographic accounts of traditional irrigation and cultivation methods are also useful in that they describe the technology used to mitigate the environmental constraints to meet the crops demands. Knowledge of these traditional methods proved a valuable framework in making sense of the ancient evidence.

Further uses of the ethnographic data are that it highlights the environmental challenges that southern Mesopotamians faced in their efforts to control watercourses for irrigation, flood control but also, as it turned out, for navigation; and helps to anticipate what texts pertaining to watercourse management are most likely to record.

Despite the many continuities between the Ur III situation and ethnographic evidence, which make the analysis of the two together useful, we will also meet major differences between ancient and modern control of the river's water level. It is in this connection that the mind-boggling scale to which the ancient river was actively managed for waterborne transportation became apparent.

4. Barrages described in ethnographic accounts

My analysis of the ancient written sources shows that a key component of the water management system in the Ur III Umma province was manipulating the rivers' seasonally fluctuating water levels. We shall see that the water level was raised as needed with large barrages of reed and mud. We will therefore first introduce ethnographic data on barrages, before moving to the Ur III evidence.

Ethnographic accounts describe Iraqi farmers using barrages to force water into primary canals. The most detailed description of such barrages in the recent past comes from letters of the British colonial officer James Saumarez Mann (1921: 235, 279). Mann was in charge of the agricultural development of the district Eastern Shamiyah along the Euphrates near Kifl and Shinafiyah in the Diwaniyah District from August 1919 to July 1920, when he was killed during tribal upheaval against the British Occupation. Despite the fact that the major crop cultivated in the area was rice. (sown in March/May and harvested in November), his weekly, and at times daily, reports on his supervision of the construction of irrigation and flood control devices provides very detailed insight into watercourse management that is of great relevance to the interpretation of the Ur III records about water control.

In a letter from June 5, 1920, Mann states:

> "As the water falls in the river, which is from now onward till it reaches its lowest in October or thereabouts is a steady process, my tribes have to put dams to keep up the levels; and we are just going to start work on them. They are very wonderful things, made according to the wisdom of time immemorial, of reed and earth only; a gap of only a few yards [3–4 m] in the middle to let the water through, and when you reflect that the river is about the width of the Thames at Kingston [approx. 60 m][3] and has a depth of 10–12 feet [3–4 m] a stream of 5–6 miles an hour [2.2–2.7 m/s], you will see that to construct such a dam with absolutely no appliances whatever takes a bit of doing. In each of the larger tribes there are one or two families who have the knowledge of the art handed down from father to son, and they take charge of the operation (Mann, 1921: 279, fn 1)."

Calling the barrages "dams", Mann indicates they are used to keep up river levels, made of reed and earth, and a construction requiring specialized expertise. In a letter to his father on June 26th 1920, he provides further details:

> "The idea is really to plait a rope of reeds twenty to thirty feet broad [6.1–9.2 m] and as deep as the river may require, and then load it down with earth until it becomes stable. Anything up to 100,000 bundles of reeds may be needed, and every single bundle passes through the hands of the expert, who lays it in position. His skill is transmitted from father to son, and is, I suppose, as old as Babylon."

Here we get a sense of the scale involved, and also learn how the reed and earth are put together.

As slightly earlier images show (Figs. 3a–3c), these barrages were very effective and could even block the entire Euphrates river, as was done in the course of the construction of the Hindiyah barrage by the Ottoman empire in the early 1900s (images published by Great Britain and Naval Intelligence Division, 1944, see Figs. 3a–3c). As can be seen in Figs. 3a and 3b, this barrage consisted of gigantic reed mat rolls, close to 30 m long and 2.5 m high, which, were weighed down with mud (Great Britain and Naval Intelligence Division, 1944: 436). A more detailed description of these reed rolls is provided by Ionides (1937: 71), a hydrologist who studied the Euphrates and Tigris before World War II:

> "The breach was closed by an interesting method which has been used for centuries in the lower Euphrates area. Huge mats of brushwood and reeds are rolled round a central rope made of date palm fronds, to form a sausage-like mass called a *'badkha'*. The central rope may be as large as 40 centimeters in diameter and the finished *badkha* 3 or 4 meters in diameter and 40 meters long. A

[3] The width of the Thames by Kingston is based on Google Earth, Oct. 5, 2012.

Fig. 3a. Reed dam to block the Euphrates (Great Britain and Naval Intelligence Division, 1944: 436).

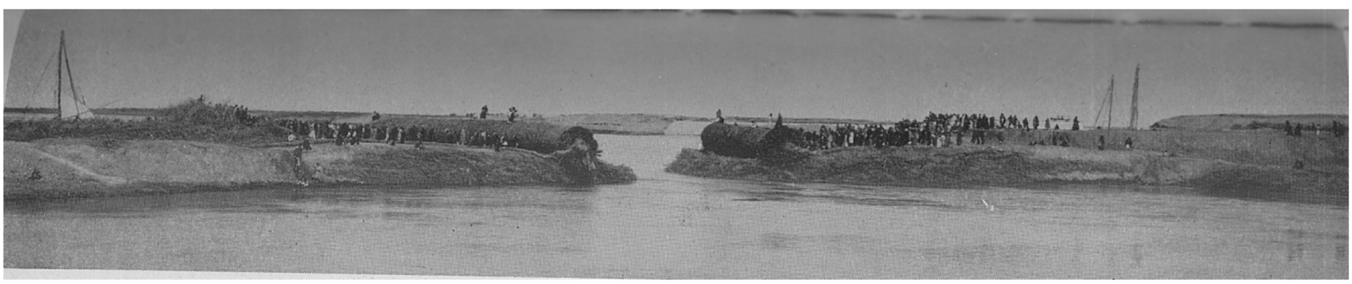


Fig. 3b. Reed dam from south-north perspective (Great Britain and Naval Intelligence Division, 1944: 436).

Fig. 3c. Materials used in the construction of the reed dam (© Royal Geographical Society [IMB]).

deep trench is now dug along the bank of the river near the breach and a heavy rope, sometimes as much as 60 centimeters in diameter, is buried in it as an anchor. To the free end of this is attached an end of the core rope of the *badkha* whose other extremity is held by a smaller rope. The *badkha*, now lying along the bank parallel to the line of flow of the water through the breach, is rolled into the water, partially closing off the opening and itself restrained from being swept downstream by the anchored rope, while the smaller rope at the other end keeps its tail in the shore. If the water is deep enough it floats, and is covered with tree branches resting on the shore and on the *badkha* itself. On top of these branches, camel thorn and earth are piled up until the *badkha* sinks to the bottom, when a second one is rolled in on top of it. This process is continued from both banks until the breach is entirely closed."

The barrage described by Ionides is very similar to the one described by Mann, even though they were used for different proposes: raising the water level for rice irrigation (Mann) versus repairing a breach (Ionides). It is also striking that both authors envisioned considerable longevity to the techniques they witnessed, and we will see below that they were even older than "Babylon". As for the difference in materials (Mann's reeds vs Ionides' palm fronds), these could presumably vary with local tradition and availability. The *badkha* described by Rost and Hamdani (2011: 214) could also contain palm tree trunks at its center. Figs. 3b and 3c also depict the huge amounts of construction materials piled up all along the bank of the Euphrates as well as the large amount of human labor that was required. Even though this barrage might have been larger than most, reed-earth-brushwood barrages were still widely in use during the 1940s before the British Mandate government gradually replaced them with more permanent structures made of metal and concrete. The Diyala weir, built in 1927–1928, for example, replaced a temporary barrage made of brushwood and earth that would force water into six main canals (Great Britain and Naval Intelligence Division, 1944: 439). The Euphrates was tapped in a similar fashion from Nasiriyah eastwards to the Hammar Lake, as was the lower Tigris below Kut al Amarra. These barrages would frequently be washed away during the flood season and had to be rebuilt every year (Britain and Naval Intelligence Division, 1944: 439; see also Mann, 1921: 235 above).

5. The Sumerian Barrage (kun-zi-da)

My systematic study of the Ur III texts provides convincing evidence that the water levels in the ancient Tigris were controlled by devices very similar to the barrages documented for the early twentieth century AD, discussed above. These devices were called kun-zi-da (super literally "right tail") and were located at key points of the river and its tributaries and major canals. These devices are attested 444 times in my corpus, for a total of 113 locations in the Umma province. The full catalogue of attestations is accessible through proQuest (Rost, 2015: 90–107, appendix A).

As we shall see, the term kun-zi-da refers to water blockages in rivers as well as in canals. Despite the ancient term's inclusive meaning, it is useful to distinguish these two cases, and I shall do so with the terms 'barrage' (blockages of a large watercourse) and 'weir' (blockage of a small water course). Barrages were constructed differently from weirs. Also, they served different functions: barrages served to raise the river's water head for irrigation and navigation; weirs served to raise the water head for diverting water into fields or smaller canals.[4] This paper is primarily concerned with the barrages located in the Tigris River.

The Ur III texts show that barrages, like their modern analogues, were placed in the river and posed an obstacle for river navigation. There are many references to the movement of boats and/or cargo over these barrages (Foxvog, 1986: 66; Steinkeller, 2001: 35, fn 46). An example is documented in text MVN 13 28.

MVN 13 282
Eight workers for 2 days (first) towed and (then) floated the boat from the harbor to Gudena
(then) for 3 days loaded barley into the boat
(and then) towed the boat from Gudena to the **barrage** of the town of Maškan
(and) for 2 days passed the boat over the **barrage**
(and) for 3 days towed the boat from the **barrage** to the harbor (of Umma)
(then) unloaded the boat in the harbor
(and) transferred the grain and cased the grain silo with clay.
Supervisor (was) Agu
(tablets was) sealed by Lu-TUG.AN
In the year: "Simanum was destroyed"
Seal: Lu-Šara-AN.DUL, scribe, son of Lu-Šara, the land surveyor

The similarities between the Sumerian barrage and those documented ethnographically become striking when looking at texts that document the kind of materials used in its construction.

Ancient barrages were made primarily of large quantities of reeds (gi) (or products of reed, such as reed mats [^{gi}kid] and reed ropes [gilim]), but also earth (sahar), and plant material (u_2). The use of timber is attested for three barrages,[5] all of which were most likely located on the Tigris.

Considering sources, which list the materials used to build it, it transpires that there is a very strong correlation between size and nomenclature. The correlations are clear and so well documented that ancient terminology ('kin u_2 sahar-ba' vs 'sahar' and 'u_2'; presence or absence of reeds) can be used to infer the size of an obstruction (i.e. barrage or weir) when a document does not specify it.

The term 'kin u_2 sahar-ba' ('work with plant and earth') primarily appears in the construction and repair of weirs within irrigation canals. Conversely, documents about barrages feature the two terms sahar (earth) and u_2 (plant matter), which rarely appear for weirs (see Table 1).

Though kin u_2 sahar-ba looks very similar to 'sahar' and 'u_2', inasmuch as it using the same Sumerian words, the above distribution shows that the two expressions refer to different things, which are used in different contexts of production. The co-occurrence of 'earth' and 'plant' in the expression 'kin u_2 sahar-ba' suggests that this refers to adobe.

As for reeds, significant amounts of them are only attested for large obstructions, most of which were located either at the Tigris or within major tributaries (Rost, 2015: 97). The amount of bundles for a single repair effort in the Umma province was almost always above 1000. For the major Tigris barrages it can even stretch into five digits. The individual instances can be seen from the following table:

Thus, for example, 21,000 bundles are attested of the Tigris barrage, indicating that we are dealing with quite massive structures. It is therefore not surprising that the reconstruction of the Tigris barrage in the 34th year of King Šulgi reign was commemorated in a year name – "Year: the barrage of the Tigris was restored".[6]

The materials we meet in Ur III sources are thus very similar to

[4] The function of a barrage is defined by the *Multilingual Technical Dictionary on Irrigation and Drainage* (*MTDID*) (International Commission on Irrigation and Drainage 1996: 2724, emphasis added), "*a barrier*, provided with a series of gates, *across the river to regulate water surface level and flow upstream and to divert water supplies into a canal*…" A"weir" on the other hand is defined as "a continuous solid, not necessarily fixed, barrier across a stream for diverting, for control or for measuring the flow" (*MTDID* 1996: 1465; 2719; 594, emphasis added).

[5] See text Hom. Lenoble no. 44, o.6 – r.1, r.6, which records 100 pieces of lumber for the barrage of the Sisa-canal and 60 for the barrage of the Ubada-canal, authorized by Ur-E'e.

[6] Text BPOA 2, 2477: r. 3 mu-ba i_7-da kun-zi-da i_3-gi_4-am_3.

Table 1
Difference in construction materials for different types of obstructions.

Type of obstruction	Number of attestations			
	'kin u_2 sahar-ba' (adobe)	'sahar' (earth)	'u_2' (plant matter)	'gi' (reed)
Large[1] (barrage)	2	11	16	17
Small (weir)	12	3	9	2

[1] The difference between 'large' and 'small' obstructions is very clear, with 'large' involving on average 1047 m^3 of earth (sahar) and on average 3314 bundles of reed, and 'small' only 470 m^3 of earth and plant matter (kin u_2 sahar-ba) and only two attestations of 30 and 60 reed bundles.

those documented ethnographically. Are they being used in the same way? An indication, which leads us towards a positive answer is that reeds are made into mats and ropes. The 13,223 reed bundles recorded for the repair of the barrage at the Tigris tributary Udaga[7] were plaited into reed mats of 3 m^2 each.[8] Further, text BPOA 1 0905 attests to the use of reed ropes of considerable length:

> **BPOA 1 0905**
> 30 bundles of reed for 5 reed ropes of 72 m length for the … barrage at the fields ^{d}Šara, Latur, and Engabara.
> (Tablet was sealed) by Namlu-idu
> In the year: "Second year after the year the Amurru wall was built"
> Seal: Ur-emah, priest of ^{d}Šara, the servant of Nam-lu-idu

This suggests that the major construction components of the barrage were large reed ropes, as described by Mann and Ionides.

6. Difference between ancient and modern barrages

Contrasting the information deriving from the ancient text records with the modern data highlights important differences between the ancient barrages and their modern analogues. These differences become very apparent when one considers the interrelation of two variables: *which* works were carried out, and *when* they were carried out.

The different types of work are listed in Table 3[9]:

Tasks ranged from covering the barrage with earth, coating it with 'kin u_2 sahar-ba' (adobe?), restoring it, or simply being stationed at the barrage to perform any of the above-mentioned tasks. In the account by Mann (1921), barrages were apparently only used to raise water for irrigation – June/July for Mann's rice, which would correspond to August/September for grain. However, the Ur III evidence reveals a very different picture for the past. Even though the percentage of texts dated by month is usually low (20% or less), clear and statistically robust patterns can be discerned when the data are examined in detail. An example is provided by Fig. 4[10], which shows that barrages were restored (gi_4-a) right after the flood season.

This distribution makes no sense in a model where barrages are only used for irrigation. What must be happening is that barrages were restored (gi_4-a) right after the flood season (March/April), when the devices would have suffered the most damage. This coheres with the timing of the delivery of construction materials (see Fig. 5[11]).

These data suggest that Ur III barrages served functions beyond irrigation: since barrages left in the river will tend to decay over time, had they only been used to raise water levels for grain irrigation, one would have expected them to be strengthened/restored at the onset of the agricultural cycle, in August/September.

Moreover, as is shown in Fig. 6[12], work was done on these barrages year round as the timing of when work duty was performed at the barrage.

These data suggest that Ur III barrages were kept permanently in the river, which provides a first indication that they were used not only to raise the rivers' water level for irrigation but also for navigation.

Given the significance of waterborne transportation during the Ur III period (see below), but also earlier and later periods, keeping water levels raised year round was important to maintain the navigability of the river. It is therefore not surprising that the barrages along the ancient Tigris were the largest.

7. Context and function of barrages

One of the biggest barrages we know of was located at Apisal[13] to control the bulk water of the Tigris upstream (see Map 2). Judging from the recorded amounts of reed bundles, the barrage at Apisal appears smaller than, for example, the Tigris barrage or the barrages of the Iš-taran-Sisa and Udaga watercourses (see Table 2). However, in terms of the amount of labor invested in the course of one year, the quantity recorded for the Apisal barrage was by far the greatest (see Rost, 2015, appendix A, table A. 18). In addition, the barrage of Apisal belonged to a subset of eight barrages that were large enough to pose an obstacle for boat traffic that needed to be surmounted (ma_2 bala-ak = transferring boat over an obstacle, e.g., barrage, see Table 4).

The placement of a large barrage at Apisal, that is at the lower end of the Tigris river, would have made a lot of sense, as it would have effectively raised the head of the water level further upstream. Rivers and canals within a terrain as flat as southern Mesopotamia have a very low bed gradient. A barrage would have had an effect on the river's water levels upstream for a much longer stretch than in a river with a steeper gradient. In turn, long stretches of the river could have been kept free of barrages that would have obstructed boat traffic (Ertsen p.c. 2012/2013). Moreover, managing the water levels in a river with great seasonal fluctuations will be beneficial for irrigation as well as for river transportation, as it alleviates diverting water into primary canals.

There is also evidence that the ancient barrages, just like their modern analogues, did not block an entire width of the river but had a gap allowing water to pass further downstream. The 60 m long brushwood barrages across the Euphrates River described by Mann (1921: 279) had openings 3–4 m wide.

There is evidence that this was also the case for the ancient barrages as this text shows:

> **BPOA 1 0763: o. 1–r. 2**
> Blocking (the opening) in the barrage of Apisal from July 18 until October 10 … tenth …

This text clearly shows that the opening of the Tigris barrage at Apisal was blocked for close to three months, which was an additional measure to raise the water level during the time when the river was naturally at its lowest.

The water levels in the ancient Tigris River would have had to be controlled again further upstream, where the damming effect of the barrages at Apisal would have ceased. Given our poor knowledge of the geography of the Umma province, it is not possible to determine the exact location of these barrages to determine the interval at which the

[7] There are indications that the watercourse named Udaga was in fact a major tributary of the ancient Tigris (see discussion Rost, 2015: 135, fn 111).

[8] Text MVN 16 1593: r. 1–7.

[9] For details see Rost, 2015: 99–108, Table 4.3, 4.4, Appendix A, Table A.17–20.

[10] For details see Rost, 2015: Appendix A, Table A.17.

[11] For details see Rost, 2015: Appendix A, A.20.

[12] For details see Rost, 2015: Appendix A, Table A.18.

[13] Apisal has not been archaeologically identified, but there is sufficient evidence to suggest that it was located in the northeastern corner of the Umma province, and it has been tentatively identified by Steinkeller (2001: 34–35) with the site of Tell Muhallaqiyah (see Map 2).

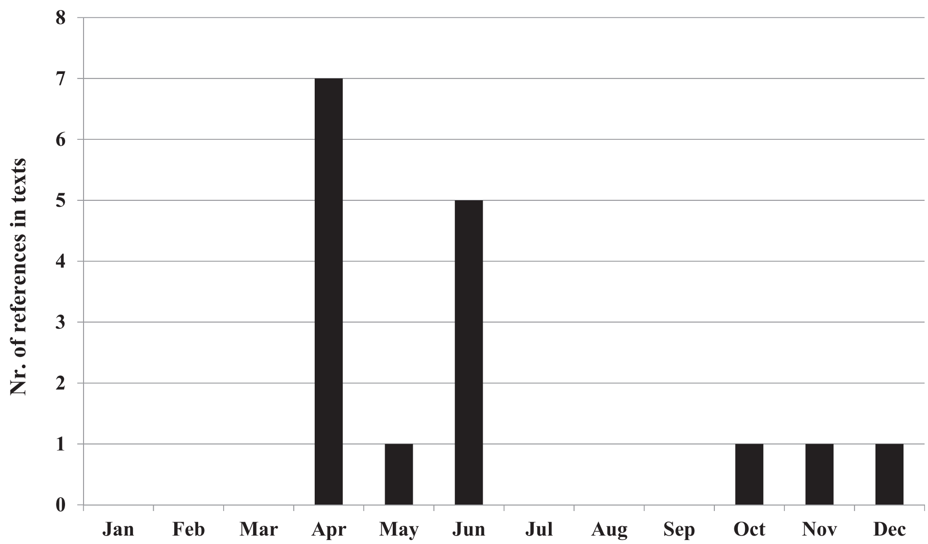


Fig. 4. Monthly distribution of the task 'restoring (gi$_4$-a) the barrage'. Sample size is 16 out of 55 text references (29%).

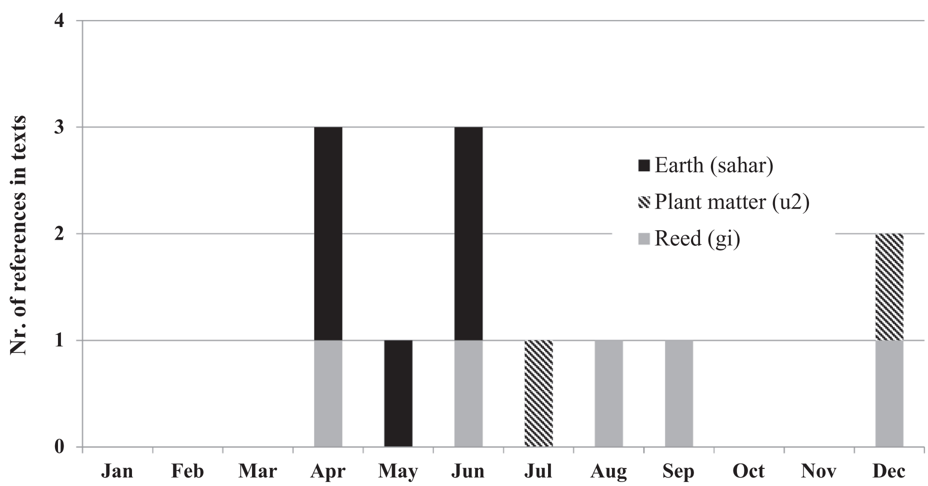


Fig. 5. Monthly distribution of construction materials. Sample size is 12 out of 40 text references (30%).

Tigris had to be dammed in order to keep the water level sufficiently raised to accommodate both: the demands for irrigation water and the requirements for navigation. My ongoing settlement survey project in the Umma region is designed to locate the hamlets, villages and towns mentioned in the texts and will provide the necessary data to answer this questions in the near future (Rost, 2018).

Controlling the rivers' water level with barrages was only effective if water was contained within the river system, which required preventing water to escape through tributaries and the inlets of primary canals. My analysis showed that the scheme of manipulating the rivers water level was combined with closing off the inlets of canals and tributaries with dams, a practice that is still found today in southern Iraq (Rost and Hamdani, 2011). In modern times, these dams inserted into mouth of the canal consists of either sand bags or are constructed from earth, plant materials, tree trunks, and reed bundles as well as reed mats. Water intake is regulated by built-in clay pipes at the bottom of the dam (for detailed description see Rost and Hamdani, 2011: 209–214, Fig. 4).

The ancient sources show that inlets of irrigation and major tributaries canals had been closed off in a very similar fashion as documented in modern times. There are 34 texts from the Umma archive, which document the different tasks associated with the construction or the repair of a dam, that was placed into the inlet of the Amar-Suen-kegara-canal, which was one of the major irrigation canals in the Umma province (see Rost, 2015, appendix B). There is even a text (MVN 16 1016) recording the delivery of vessels to be installed at the very bottom of the inlet dam to facilitate water intake. The full evidence of the construction of this ancient inlet dam would, cannot be presented in this paper and will be discussed separately in a different publication (Rost, in prep.)

It's important, however, to note, that by closing off inlets of canals another very important challenge concerning river navigation is met. Prior to the motorization of water born transportation, river navigation on the Tigris, as mentioned earlier, entailed towing boats upstream, with towpath usually running along the river bank. Open inlets would have considerable interfered with such towing operations (Steinkeller, 2001, see also Adams, 2006). Thus, the inlet dams fulfilled two function, preventing water escaping from the main river channel, while also functioning as 'bridges' across canals, which facilitated easy passage along the river.

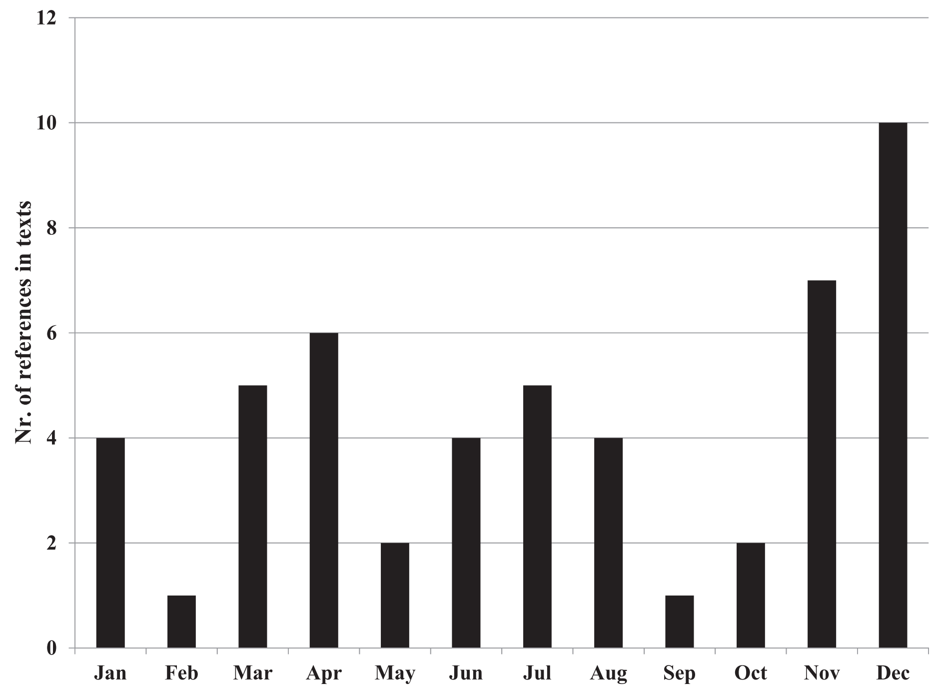


Fig. 6. Monthly distribution of the task ‘stationed (gub) at the barrage/weir (kun-zi-da)’. Sample size is 51 out of 204 text references (25%).

Table 2
Amount of reed bundles used in the construction/repair of barrages (kun-zi-da).

Location[1]	District	Date[2]	Publication	Reference	# Reed bundles
Gibil-canal	?	SS01-00-00	UTI 4 2443	o. 1–4	180
Gizi[a]	?	SS03-00-00	Princeton 2 184	r. 9–11	1230
Lamma Temple	Apisal	SS02-00-00	BPOA 6 0198	o.1–2	1400
Šara-pada-canal	Apisal	SH41-00-00	SAT 2 0292	o. ii 6′–8′	1500
[village] of the ^{giš}Manu-field	Da-Umma / Apisal	SH41-00-00	SAT 2 0292	o. ii 2′	1720
Magur-canal	Apisal/Gu’edena	AS08-01-00	BPOA 7 2277	o. 1–3	1720
Il6-[…]-?	?	SH41-XX-XX	SAT 2 0292	o. ii 9′–14′	1800
SUHgibildu’a-canal	Da-Umma	SH41-XX-XX	SAT 2 0292	o.i 22–o. ii 1′	2010
Ubada-canal	Apisal?	AS09-00-00	UTI 4 2789	o. 6 – r. 2	2460
A (?)-canal	?	IS01?]-00-00	Nisaba 24 10	r.vi 1–8	3075
Sisa-canal	Apisal	AS09-00-00	UTI 5, 3499	r. 16–17	3600
Apisal	Apisal	AS03-00-00	UTI 5, 3421	o. 1–4	7200
Ištaran-Sisa-canal opposite of the village Luduga	Apisal	IS01?]-00-00	Nisaba 24 10	r.v 22–30	13,825
Udaga-canal	Apisal	AS09-00-00	UTI 5, 3499	r. 7–8, r. 15	19,435
Idigna (Tigris)	Apisal?	AS04-06-00	SAT 2 0323	o. 1–2	21,633

[1] Barrages as well as weirs are named after rivers and canals, adjacent fields, or nearby places such as towns (e.g., Apisal), villages/hamlets, and temples (e.g. Lamma-temple) (Rost, 2015, appendix A, Table A.1–A.16). The naming of barrages/weirs after specific places only marks the specific location alongside a natural or man-made watercourse. The barrages of the town Apisal (see Map 2) and the village Eduru-Šulpa’e, for example, were both located on the Tigris.

[2] NOTE. – Dates are given in abbreviated form AS01-02-20. The first two letters stand for the abbreviation of the ruler’s name (Amar-Suen in this case), which is followed by the number of the regnal year. This is followed by the month name and the day. The reader should be aware that the Ur III calendar was very different from our Gregorian calendar. For one, April (month I) was considered the beginning of the year and the Sumerian month consisted of 30 days and therefor shifted annually somewhat within the solar year. Sumerian bureaucrats were aware of this discrepancy and inserted an intercalary month (*iti diri*, or “thirteenth month”) at a frequency which is so far not well understood, as it was done irregularly and varied from city to city (Cohen, 1993: 5; Lehoux, 2000: 172–174; Sallaberger, 1999: 233–236). Englund (1988: 123) suggests that an intercalary month was added every three years. In Umma the intercalary month was always inserted after the twelfth month.

8. Barrages and flood prevention

Having permanent barrages in the river obviously poses the question as to what happens during the flood. The barrages must have posed a considerable risk, as the river was more prone to overtop its levee at these locations. Geomorphological research suggests that the ancient Tigris had a more anastomosing configuration in the area of Umma in the late third millennium BC and was distributed among several tributaries (Gasche and Tanret, 1998: 32-35; Hritz, 2010; Verhoeven, 1998: 160). This would have made both the flood and the difference between high and low water levels less severe than on the main Tigris channel today. On the main Tigris channel at Baghdad, for example, the difference between high and low water amounted to 2–5 m. But even for the modern Tigris, at Amara, where it splits into two main branches

Table 3
Tasks performed at barrages.

English	Sumerian	# of Reference in texts
● restoring the barrage	gi_4	45
● provisioning of construction material (lit. "carrying reed, plant matter and baskets of earth" to the barrage)	gi /u_2/$^{giš}il_2$ ga_6-ga_2	57
● "to be assigned to do work" at the barrage	gub	210
● (coating) the barrage with adobe	kin u_2 sahar-ba	14
● dismantling the barrage (lit. "cutting/incising")	ku_5	15
● covering the barrage with earth	sahar si-ga	15
● blocking the barrage	$uš_2$	4
Total		360

Table 4
Location of barrages (kun-zi-da) that required the transfer boats (ma_2 balak ak).

Location Barrage of/at (the)	Publication	Line	Date
Amar-Suen-nitum canal	BPOA 1 1045	o. 1–r. 2	SS03-00-00
	TCL 5 5676	r. iv. 11–17	SS02-1-12-00
	UTI 4 2896	o. 11–r. 1	SS02-00-00
	UTI 5, 3455	o. 9–r. 3	SS02-12-00
Apisal (town)	BPOA 6 1402	o. 1–r. 4	SH46-12-02
Bad-Tibira (town)	SAT 2 0844	o. 1–4	AS05-00-00
[Eduru]-e'amara (village)	BPOA 7 2239	o. 6–r. 1	AS05-00-00
Kamari (large village)	Babyl. 8 Pupil 10	o. 1–5	AS07-00-00
	BPOA 6 1014	o. 1–6	AS02-10-00
	UTI 3 1643	o. 1–. 1	SS01-00-00
	UTI 5 3416	r. 6–7	SS03-00-00
Maškan (town)	BPOA 6 1144	o. 3–r. 2	AS02-00-00
	MVN 13 282	o. 1, o. 5–r. 2	SS03-00-00
	RIAA 124	o. 1–2	SS04-00-00
	SAT 3 1396	o. 1–r. 2	SS03-08-00
Nanatum (hamlet)	MVN 16 0753	o. 1–r. 6	????-11-00
	Nik. 2 141	o. 1, r. 1–2	SS03-12-00
	SAT 3 1349	o. 1–6	SS03-00-00
	UCP 9-2-2 104	o. 1–6	SS03-00-00
Usur canal[1]	Princeton 2 476	o. 1–8	SS04-10-00

[1] The Usur canal (i_7-U_3-sur) is most likely located in the Girsu/Lagaš province, since most text references derive from its archive. There are five text references to its barrage in the Umma records, which might indicate that part of the canal was located in the Umma province, possibly bordering Girsu/Lagaš, as the component sur = border might indicate, accessed Nov. 10, 2013).

(main Tigris branch and Shat al-Gharraf), the difference between high and low water levels varies only from 1.4 to 1.66 m and showed considerable consistency in these fluctuations over a period of 15 years (1918–1932) (Ionides, 1937: 180, see Fig. 7).

Thus, assuming that the ancient Tigris in the area of Umma consisted of multiple channels, the fluctuation of the water levels would have been far less severe and more manageable. This would have made keeping permanent structures in the river more feasible. Still, my analysis showed, that *one-fourth* of the 3690 text attestations pertain to flood control, indicating that it was a major concern in late third-millennium BC southern Mesopotamia. The methods which are recorded in the ancient sources were very similar to those documented ethnographically (Fernea, 1970: 158–59; Mann, 1921: 170–171, 181, 186–187, 207–208, Rost and Hamdani, 2011: 213–214). These methods consisted of containing the river's water on the one hand by constructing flood dikes (eg_2-zi-DU) along the Tigris or surrounding agricultural fields (eg_2 a-$ša_3$ field name) and reducing the river's water volume to prevent flooding downstream. Reducing the amount of water in the river was achieved by either flooding fallow fields (a–de_2), also called haphazard irrigation in modern time (Poyck, 1962: 52), or diverting the rising water (a zi-ga dib) via intentional breaches in the rivers levee. An example of such practice is described in the following text example:

MVN 21 101
12 workmen for × days leveling the 'intentional breach' of the Tigris (and) diverting the rising water.
Supervisor (was) Lugal-itida
(tablet was) sealed by Lugal-nesag(e)
In the year: "Year after the year the Amurru wall was built"
Seal: Lugal-nesag(e), scribe, son of Lubanda

While the exact translation of Sumerian term 'intentional breach' (U_3)[14] is somewhat debated, two texts[15] locate three of those 'breaches' in the vicinity of the village Eduru-^{d}Šulpa'e. The fact that this is also the location of one of the major Tigris barrages suggests that U_3 describes a managed (intentional) breach in the river levee, which allowed water to be diverted into nearby depressions or wetlands as a flood protection measure.

The ancient records indicate, that this "in-built" flood prevention measures were not the only one in use. There is an indication that so-called inundation canals, which were in use in Iraq until very recently, were also used in ancient times. Examples of such canals can be seen on Fig. 8.

Inundation canals have a very shallow and very wide cross-section, and are designed to fill up with water once the river level rises to a specific threshold. Excess water is removed from the river automatically and transported to depressions and wetlands away from the settlements and agricultural areas.

A set of nine texts (see Table 5), which record the construction of the so-called Engabara-canal, suggests that we are dealing with an inundation canal.

For one, the dimensions of the canal, as recorded in text MVN 21 215, indicates that it was a wide (6 m) but very shallow canal of only 0.3 m in depth – a construction design that is typical for an inundation canals.

MVN 21 215
8 m length – the volume of excavated earth was 16 m^3 (responsible) foreman was Lu-dingira
12 m length – the volume of excavated earth was 24 m^3

[14] Studevent-Hickman (2011) suggests that U_3 describes the spoil bank/levee of a canal or river that is also used as a causeway (see also Steinkeller, 2011: 386–387). However, the evidence presented here suggests that it is a specific location in/at the Tigris levee that allowed for diverting water as a flood prevention measure.

[15] UTI 4 2926: 1–9, UTI 3 1807: 1–8, discussed by Steinkeller (2011: 387), who follows Studevent-Hickman's suggested translation. The two texts describe workers driving a herd of cattle on a path, back and forth between the village Eduru-^{d}Šulpa'e and the hamlet Ašag-Lamah. The path most likely ran along the Tigris as both locations are known to have abutted the Tigris. The crossing of the three installations (U_3) near the village Eduru-^{d}Šulpa'e is specifically mentioned, as it involved some doing to get the cattle across. In the light of the evidence presented above, I argue that U_3 does describe intentional breaches in the Tigris levee that would cut through roads running alongside the river's levee.

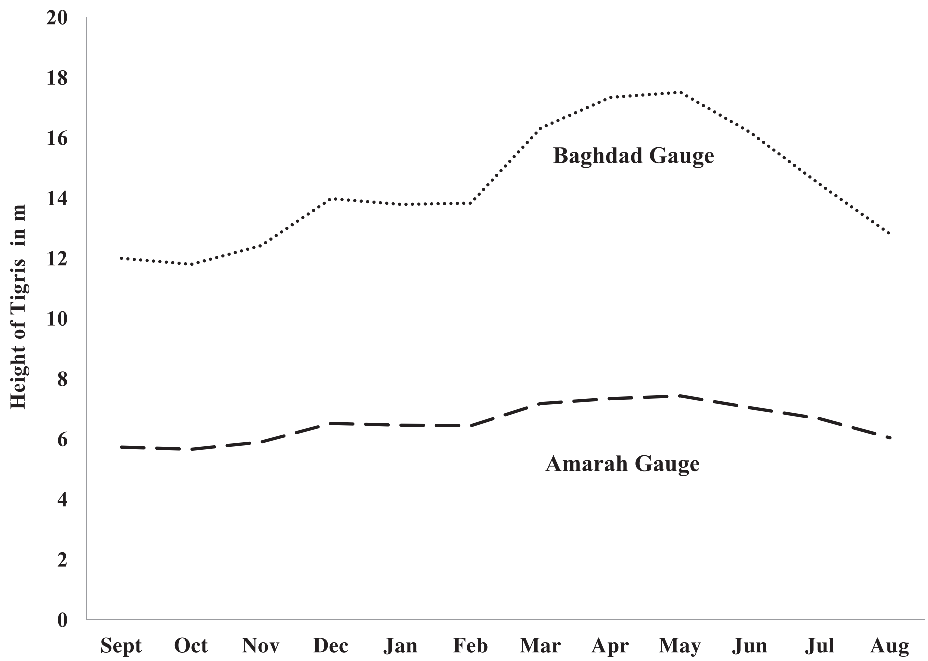


Fig. 7. Difference in water levels of the Tigris at Baghdad (1906–1932) and at Amarah (1918–1932).
Source: Ionides, 1937: 45, 153, 180, table 96, 98, 191.

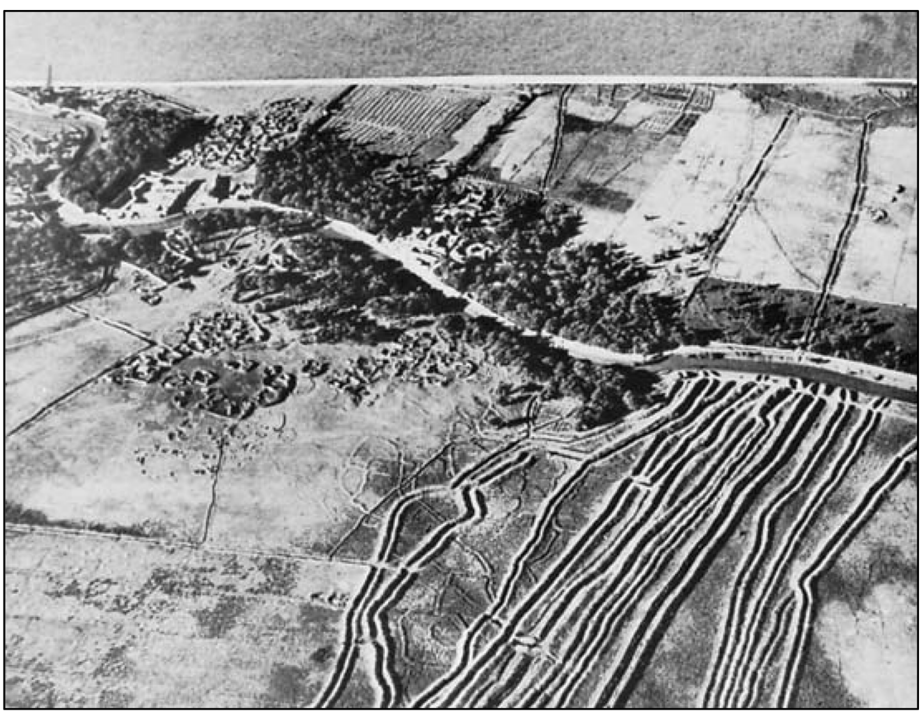


Fig. 8. Inundation canals near the Euphrates River, Iraq (Encyclopædia Britannica Online).

(responsible) foremen was Lugal-itida
9 m length – the volume of excavated earth 18 m^3 (responsible) foreman was Šeš-kala
6 m length – the volume of excavated earth was 12 m^3 (responsible) foreman was Lugal-kuzu
In total: **36 m length, 6 m width, and 0.33 m depth** and the total volume of excavated earth was 70 m^3 – the outlet of the Engabara canal.
In the month of Dumuzi (XII = March)
In the year: “Simanum was destroyed”

There are no further attestations of this canal in the Umma record, which suggests that we are not dealing with an irrigation canal, as maintenance would have eventually become necessary and would have

Table 5
The construction (ba-al) of the Engabara canal.

Publication	Line	Date	Total volume in m^3
BPOA 1 0855	o. 1–5	SS03-00-00	39.75
SAT 3 1350	o. 1–3	SS03-00-00	18
BPOA 6 1283	o. 2–4	SS03-00-00	16.5
BPOA 7 1790	o. 1–3	SS03-00-00	27
MVN 16 0832	o. 3–4	SS03-00-00	69
UTI 5, 3136	o. 1–2	SS03-00-00	2.25
UTI 4, 27 551	o. 1–4	SS03-00-00	114.75
MVN 21 215	o. 1 – r. 7	SS03-12-00	70
BPOA 7 1889	o. 1–4	SS04-00-00	13.5
Total			370.75

[1]This texts describes the excavation of another hydraulic device called barla whose function remains unclear even after systematic study of all the available references (Rost, 2015: 167).

thus been recorded. A further indication that we are not dealing with an irrigation canal is the timing when the construction took place. The canal was constructed in March/April at the end of the third and the beginning of the fourth year of King Šu-Sin's reign. The timing of this work is, however, at odds with the overall tight labor bottleneck during that time of the year, as harvest and flood protection works had to be carried out simultaneously. In addition, construction work on the irrigation system is usually done during the agricultural off-season in early/late fall. Constructing a canal during March/April would only make sense if it served the purpose of flood control.

In addition, the name "Engabara-canal" suggests that it drained excess water into the large wetland Engabara, which was located east or southeast of the city Umma, from which most of the reed supply documented in the texts derived (see Map 2). The Engabara had an approximate size of 0.92 km^2 or even larger (Sallaberger, 1992: 123; Steinkeller, 2001: 37, fn 55). It can be assumed that the Engabara canal was not the only inundation canal in the Umma province. Unfortunately, text MVN 21 215 is one of the very few texts that does provide exact dimensions of a canal, allowing for such distinctions to be made. It might be that such inundation canals were installed next to the big barrages and provided the much-needed mechanism that allowed for the control of the rivers' water level year round, while at the at the same time mitigating the risk of flood damage at these key points in the system.

Table 6
Size and time frame of work crews stationed at the raising water of the Tigris.

Date	Publication	Line	# Work days	# Men	# Days
AS06-12-00	Princeton 1 384	o. 1–3	30	15	2
AS06-12d-09?	BPOA 1 1322	o. 1–4	287	13	6
AS06-13-00	CBCY 3, NBC 00 530	o. 1–4	157.5	13	4
AS08-00-00	UTI 6 3810	o. i. 21 – o. ii. 1–3	168 2/3	7 2/3	22
SS01-00-00	MVN 21 148	o. 1–8	393	15	26.2
SS02-00-00	UTI 3 1694	o. 5 – r. 2	160	16	10
SS03-00-00	Princeton 1 500	o. 1–3	150	10	15
SS04-00-00	UTI 6 3811	o. 1–3	168	12	14
SS05-00-00	SA 078 (Pl. 081)	o. 1–3	150	10	15
SS06-00-00	MVN 20 210	o. 1–3	1568	49	32
SS06-00-00	MVN 21 111	o. 1–2	180	12	15
SS06-00-00	SAT 3 1699	o. 1–3	180	12	15
SS06-01-00	BPOA 6 0495	o. 1–3	150	10	15
SS06-12-00	Nik. 2 104	o. 1–4	120	6	20
SS06-XX-XX	SAT 3 1689	o. 1–2	180	12	15
SS07-00-00	MVN 21 123	o. 1–2	300	20	15
SS07-01-00	MVN 21 118	o. 1–2	420	28	15
SS07-12-00	UCP 9-2-2 091	o.	210	14	15
SS09-01-00	BPOA 1 0950	o. 1–2	300	20	15
		Average	277.5	15.5	15
		Median	30	6	2
		Mode	150	49	15
		Max	1568	12	15
		Min	30	13	15
		Stdev.	326.6	9.5	7

In areas, where flooding is a problem, monitoring the river's water level at key points of the system is necessary to encounter any problems before they become major disasters. This was also the case in ancient Mesopotamia. The flood watch entailed monitoring the rising water level at the bank of the Tigris (a zi-ga gu$_2$ Idigna) over a period of one to two months (Rost, 2015: 169–177). Twenty one percent of the 28 texts

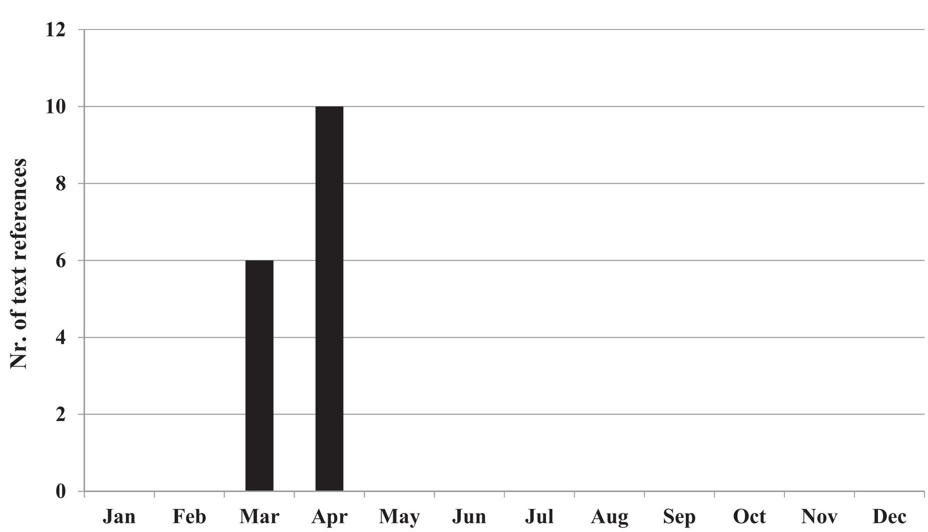


Fig. 9. Monthly distribution of the task of 'being stationed at the rising water of the river/canal' (a zi-ga gub gu$_2$ i$_7$). Sample size is 16 out of 38 text references (42%).

Table 7
Work crews under the official Lugalemah(e), Lugal-hegal and Lugal-nesag.

Date	Text	Line	Translation	Work crew supervisors	Authorizing and sealing official
3rd year of King Šu-Šuen's reign	BPOA 7 2362	o. 8–9	62 workdays: stationed at the rising water of the river Tigris	Šarakam	Lugalemah(e)
	UTI 4 2728	o. 1–3	50 workdays: dismantling the Tigris barrage at the dŠulpa'e [village]	Lugal-Ištaran	
	BPOA 1 0894	o. 1–2	25 workdays: dismantling the Tigris barrage at the dŠulpa'e [village]	Lugal-ezem	
	BPOA 1 0484	o. 5– r.2	9 workers for 18 days dismantled the Tigris barrage at the Sisa-canal	Arad	Lugal-hegal
4th year of King Šu-Šuen's reign	BPOA 7 2253	r. 1–2	4 workers for 2 days dismantled the [Tigris] barrage at Šulpa'e village	Ipa'e	Lugalemah(e)
	RB 92 571	o. 1–3	x workers for 8 days were stationed at the rising water at the bank of the Tigris	Lugal-ezem	Lugal-hegal
	RB 92 571	r. 2–3	x workers for 5 days dismantled the Tigris barrage at Apisal	Lugal-ezem	
	MVN 16 0775	o. 1–2	18 workers for 5 days dismantled the Tigris barrage at Apisal	Lugal-kugani	
	UTI 5, 3077	o. 5–r. 1	17 workers for 5 days dismantled the Tigris barrage at Apisal	Lu-Šara	
	UTI 6 3811	o. 1–3	12 workers for 14 days levelled the **U** (?) of the Tigris to divert the rising water	Lugal-itida	Lugal-nesag(e)

references to monitoring the water levels in the Tigris are dated by month and fall into March/April (see Fig. 9[16]).

This flood watch consisted of work gangs with an average size of 15 workers (see Table 6). The work crews were stationed at the Tigris levee and other locations for about two weeks. At times, as was the case in King Šu-Suen's (SS) sixth and seventh year of reign, the flood watch was in place for one or two months with a fairly large number of people (e.g., 49 in SS06). Different work crews were placed simultaneously at various high-risk points, while others alternated in patrolling the river levee to cover a period of 1–2 months (see Rost, 2015, Appendix D., Table D.1).

These work gangs would also be the ones who would intervene when the river was threating to overtop its banks. As can be seen in Table 7, the flood must have been particularly severe in the third and fourth regnal years of King Šu-Suen reign, calling for the partial or entire demolition (ku_5) of some of the major Tigris barrages at Apisal and Eduru- dŠulpa'e and the Sisa-canal. These two years are the only time that an intervention, which entailed the demolition of major Tigris barrages was necessary to cope with major flood events. There are no other records within the Umma corpus that document the dismantling (ku_5) of barrages on that scale. The records in question are sealed by three high level agricultural administrators Lugalemah(e), Lugal-hegal, and Lugal-nesag (see Table 7) and allowed for reconstructing the events. The various work gangs and their supervisors were first stationed at the Tigris levee to monitor the rising water (a zi-ga gu_2 Idigna gub-ba) for a period up to two months.[17] As the river threatened to overtop its levee, the same group of workers and their supervisors dismantled the big Tigris barrages in order to remove the blockages in the river. It is clear, that the combination of monitoring the river's water levels and the occasional demolition was a vital measure to counterbalance the strategic placement of barrages and was key to the smooth functioning of the system that was designed to accommodate the demands for irrigation as well as navigation with that of flood control.

9. The water management scheme in its wider political context

Managing the river as comprehensively as can be gleaned from the ancient texts required not only the technical and hydraulic knowhow, but also a huge investment in man-hours and construction materials. Furthermore, the logistics involved in the recruitment and management of administrators and workers as well as the acquisition, transportation and deployment of the vast amount of construction materials required a sophisticated system of coordination. Such coordination was realized in the Ur III Period with a highly sophisticated system of accounting. Moreover, as any manipulation of the river will affect both – it's upstream and downstream behavior, there is a need for a coordinated approach on a regional level to assure the smooth functioning of the water management scheme. The question one might ask is why the provincial government of Umma went to such great length to control the river as comprehensively and at such a great expense as the sources suggest. I argue that, the specific demands of the organization of the Ur III economy required such comprehensive management of the river. That is, waterborne transport was essential for the functioning of the Ur III economy.

The economy of the Ur III state rested upon a region-wide taxation system, called bala in Sumerian, which means "rotation" or "transfer" in the broadest sense (Sharlach, 2004). This system had elements of a

[16] For detail Rost, 2015: Appendix V.

[17] UTI 6 3810: o.i 17–o.i 20 "6 a_2-1/2 14 a_2-1/3 u_4-55-$še_3$ a_2-bi u_4-421 [2/3]-/kam [a]-da gub-ba kun-zi-[da] / $[i]_7$ Idigna A-pi_4-sal_4^{ki}" "6 (workers employed) half-time, 14 (workers employed only for one-third time), amounting to 421.33 labor days stationed at the water at the Tigris barrage at Apisal," See also BPOA 6 0253; BPOA 7 2225: o.3–o.6.

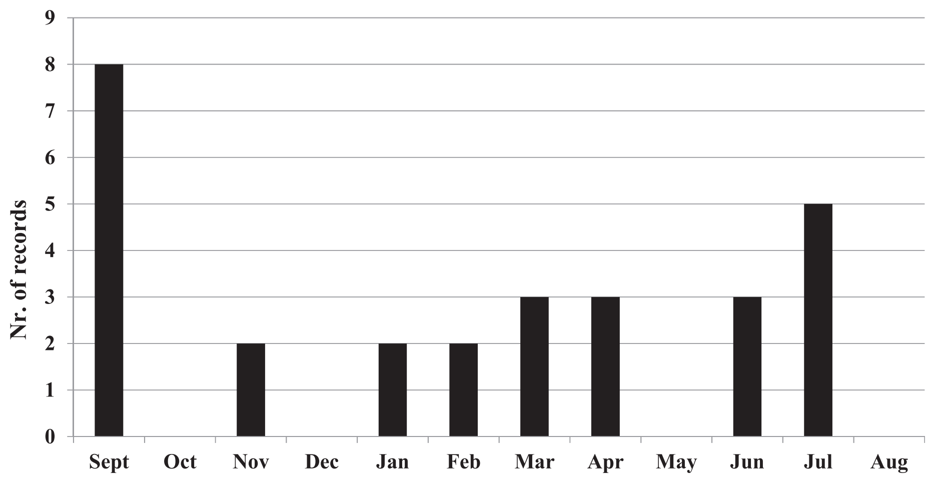
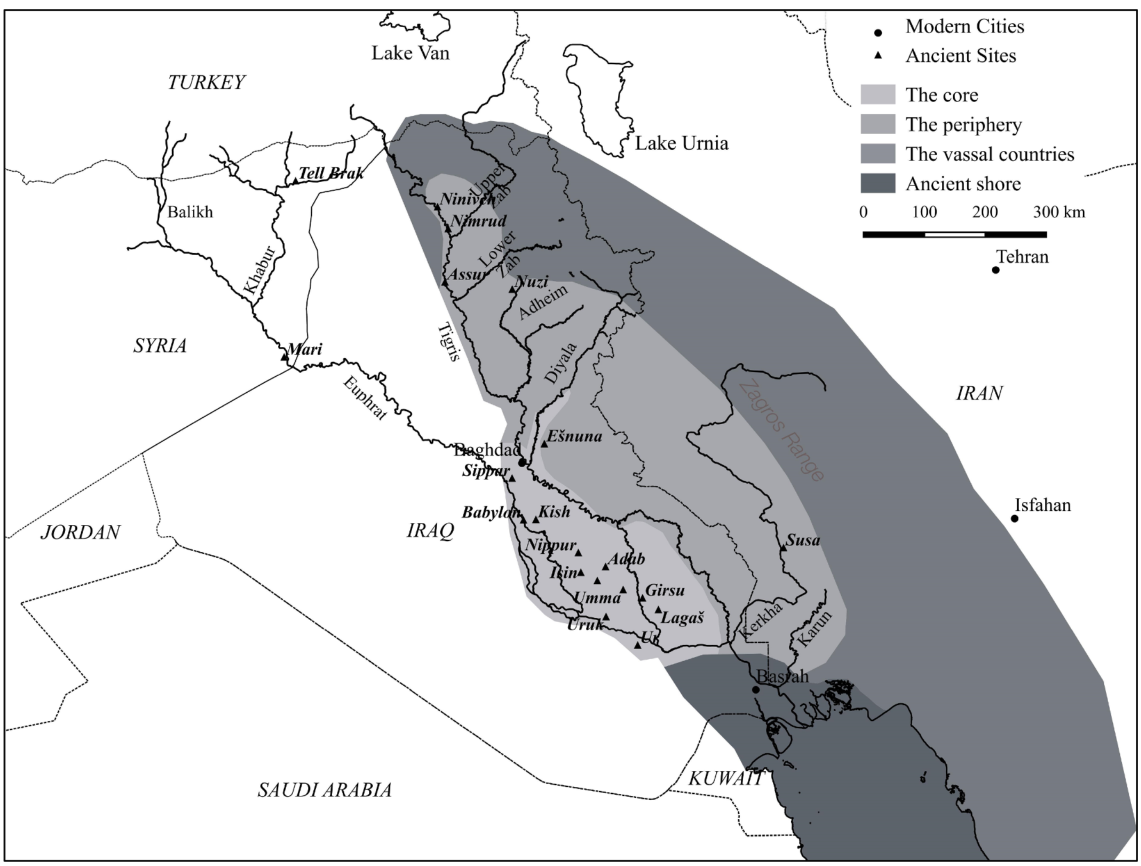


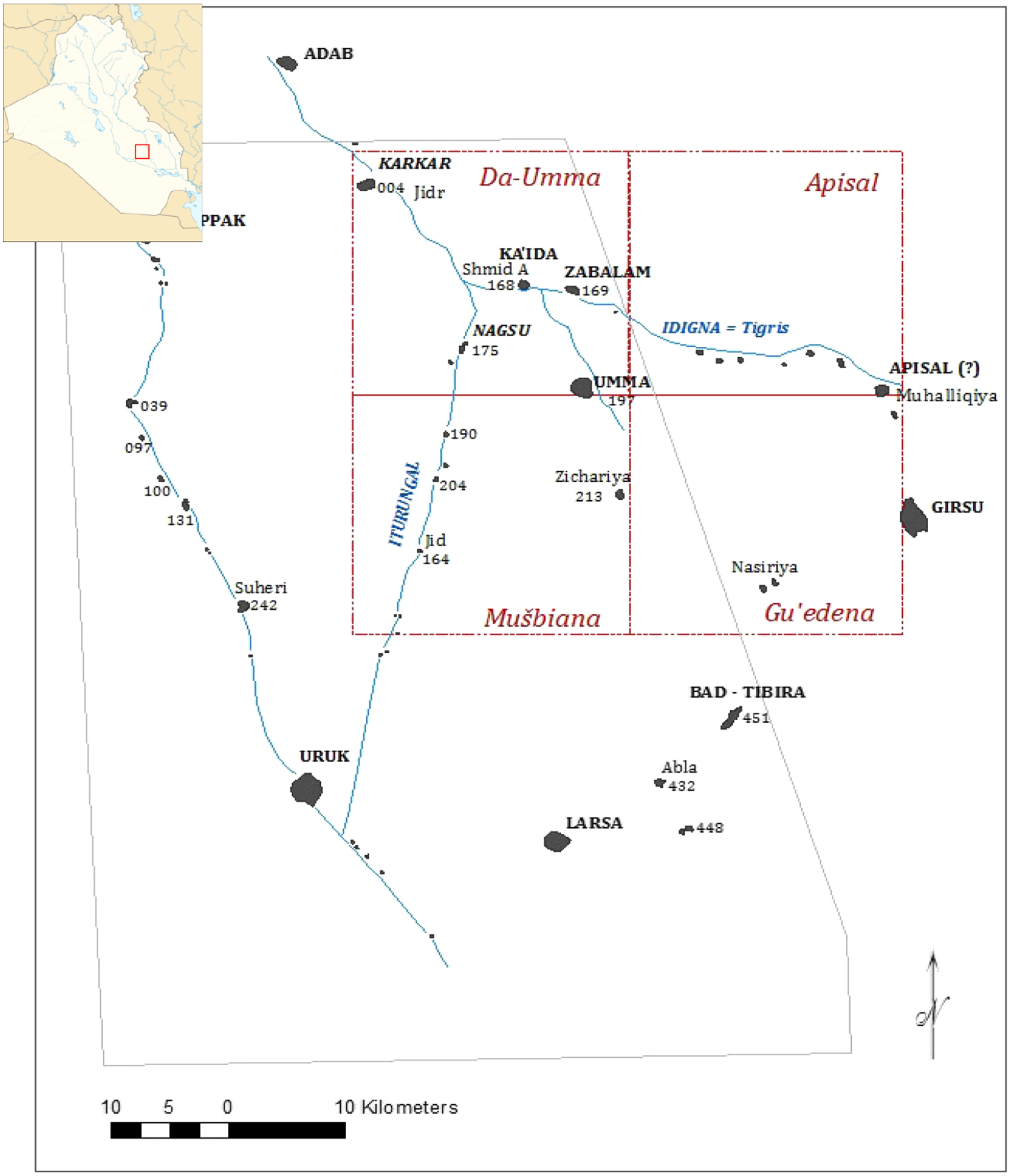
Fig. 10. Dated records of shipment of grain (ma$_2$ še) within and from the Umma province. Sample size is 28 out of 70 text references (40%).



Map 1. The territorial extent of the Ur III State (based on Dahl, 2007: 6 and Steinkeller, 1987: 23, 31).

redistributive system, in particular for livestock (Sallaberger and Westenholz, 1999: 195–196; Sharlach, 2004: 20–21; Steinkeller, 1987: 28–30) but its primary function, according to Sharlach (2004: 21), was “the forced contribution of the province’s wealth to support the central government.” The provinces were obliged to supply the central government with a quota of goods per year, consisting mainly of barley, livestock, and other goods (e.g., reed, timber, commodities), as well as corvée labor, particularly for “national building projects” (Sharlach, 2004: 29; Steinkeller, 2013). The size of the bala payment for Umma is difficult to estimate due to the lack of summary accounts. However, there is evidence from the neighboring Lagaš province that shows that its bala contribution amounted to 48% of the entire grain production. It is very likely that Umma had to contribute similar amounts (Sharlach, 2004: 30). While some of the bala deliveries remained in storehouses of the provinces themselves to support state employees, most of the bala deliveries, were transported out of the province, primarily on boats (Sallaberger and Westenholz, 1999: 191–196; Steinkeller, 2007: 191–195, 1999: 293–294, 1987b: 23–30). Texts recording boat itineraries document the transport of large amounts of grains all the way up to Nippur on regular basis.

The wide-ranging movement of goods, in particular grain, was made possible by efficient and low-cost waterborne transportation (Algaze, 2008: 50–62; Sharlach, 2004: 86–90). As is shown by Fig. 10 grain was shipped all year round within and from Umma during the Ur III period. Noticeably is the larger number of shipments in September, which might be related to the overall demand for seeds at the beginning of the



Map 2. Umma province. In red: hypothetical borders of the province and its districts. In blue: suggested location of ancient watercourse (after Steinkeller, 2001: 50; Adams and Nissen, 1972: 36, Fig. 17). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

agricultural cycle. The average capacity of cargo boats during the Ur III period varied between 30 and 40 tons (Sharlach, 2004: 86–90; see also Adams, 2006: 140–141) and, when fully loaded, would have required a water depth that was lacking during the summer months.

Thus, it is very clear that a mechanism to kept water levels high enough to allow for the shipment of grain at this time of the year was required, which I argue was provided by the placement of large barrages in the Tigris discussed above.

10. The provincial administration of the water management scheme

Given the importance of water born transportation for the functioning of the economic system, it is not that surprising that provincial government headed by the governor was intimately involved in that management of water courses. The work related to the management of watercourses and irrigation in the province Umma was primarily administered by the agricultural bureau of the governor-run sector. The agricultural sectors of each of the four districts of Umma (Da-Umma, Apisal, Gu'edena, and Mušbiana, see Map 2) was run by a hierarchy of officials, which consisted of scribes, agricultural administrators, and supervisors of work crews and employed laborers (Vanderroost, 2012). Many of the high-level administrators that appear in the records as overseeing and authorizing work projects related to water control as well as grain cultivation were members of the gubernatorial family, some of whom (e.g., Akala, Dadaga) became governors of the Umma province. This shows that the local ruling elite was intimately engaged in the management of water control and cultivation as they were involved in many other import sectors of the local economy (Dahl, 2007; Vanderroost, 2012).

The adopted labor management system was highly complex, exhibited a high degree of labor division and was organized in a decidedly centralized, top-down fashion. Officials at the upper level of the administrative hierarchy conducted surveys in order to assess the amount of work to be done, which was then divided up and assigned to individual work crews who carried out the work under the supervision of a foreman. The workflow was realized by means of centralized, multilevel bureaucracies, extensive record keeping and archiving, and complex computational procedures (Rost, in press).

11. The role of the central government

The role of the central government in local affairs as well as in the management of watercourse on the regional level is much harder to assess due to the lack of documents. The majority of the available documents come from the archives of the provincial capitals, Umma and Girsu/Lagaš, and from one state administrative center Puzriš-Dagan (Molina, 2008: 52). Thus far, no "national archive" has been found that would allow for determining the role of the central government in the management of watercourses on the local or national level with any kind of precision. The only evidence so far of direct interference by the central government in provincial water affairs, appears to have been the resolution of high-profile water conflicts (e.g., between towns). Reserving conflict resolution for the central government might have also been partially economically and politically motivated. Unresolved conflict could have seriously crippled the watercourse management system and slowed agricultural production, which was to be avoided at all costs, given the importance of both for the functioning of the Ur III economy.

In addition, Ur III kings, first and foremost king Urnamma, the founder of the Third Dynasty of Ur do claim patronage over the construction of canals or water-control devices (Rost, 2015: 246–250). However, such claims come from literary sources, such as royal hymns, which do not provide any concrete details on the magnitude nor the level of actual involvement of the central government in such work projects. Rather, the theme of having initiated the construction of overland canals is employed to portray the king as the provider of agricultural abundance, which is a very common theme in royal rhetoric used to legitimize the power yielded by Mesopotamian rulers (Winter, 2007, see also Harrower, 2016). However, given that the water course management system rested on a diligent coordination of water masses upstream and downstream, it can be assumed that there had to be some arrangement at the national level – in particular between provinces relying on the same water source. The evidence suggests, for this system of water control to function smoothly (on the national level or better the lower Tigris watershed) the central government had to be involved if not only to enforce the compliance of all the water users involved.

12. Conclusion

Adopting a centralized mode at the provincial level appears to have been necessary to implement the watercourse management system described in this paper. Coordinating the requirements of river navigation, irrigation, and flood control required planning on the provincial, if not national level. Blocking the flow of the river as comprehensively as the texts suggest needed to be coordinated with the water users downstream as, for example, the neighboring province Lagaš to the south of Umma. For this system to be effective, all inlets of canals and watercourses needed to be closed off, which in turn allowed for water withdrawal that did not interfere with waterborne transportation. Flood control had to be coordinated, as localized protection measures could seriously interfere with the overall success of the system. Uncoordinated damming, as has also been discussed by Fernea (1970: 28) for the western branch of the Euphrates with multiple temporary barrages, led to the silting up of a natural canal. Eventually the channel shifted through avulsion, leaving entire tracts of land without water. It is possible that Sumerians understood this danger and adopted a more centralized management scheme in order to avoid this pitfall.

Moreover, the centralized mode adopted in the Ur III period seems to have been the result of the socio-political and economic complexity of the Ur III state that mediated how the riverine environment was managed. River navigation had always been an important aspect of the economy of Mesopotamian communities and states (Algaze, 2001), but was particularly crucial for the functioning of the Ur III economy. The bala taxation system was based on kind, which entailed the transport of goods on a massive scale and formed the financial foundation of the Ur III state (Sharlach, 2004: 159–161). This foundation could only be maintained by a steady flow of goods from the provinces, which entailed avoiding major losses in output of agricultural goods as a result of flood damage. Most importantly, however, turning these contributions into a financial asset of the state was dependent on a low-cost transportation infrastructure within the state as well as into other regions of potential trade partners. Thus, the results suggest that the centralized control in the management of water courses in Southern Mesopotamia was the result of how essential water supply, flood control as well as water born transportation was to the health of the economy of the Ur III state.

The findings of this paper suggest that the management of ancient irrigation needs to be analyzed within the larger hydraulic context. When focusing on irrigation alone, as many earlier studies have done, the complexity of the water control scheme of which irrigation is an integral part, might easily be overlooked. In turn, the role of the state cannot be adequately assessed when focusing only on the management of irrigation. While the role of the central government in this case study remains somewhat elusive, the evidence shows that the state did provide the legal framework, which allowed the system to operate smoothly. Furthermore, assessing the role of the state and its institutions in the management of water need to take the larger political and economic context into consideration. This case study showed, that it was neither the environmental conditions nor the size of the system itself that warranted centralized control. Rather, the choice in economic system, which was developed to support the state apparatus, required a complex water management scheme that was capable of coordinating the demands of irrigation with the requirements of flood control and navigation.

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Appendix A. Supplementary material

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