The Littoral Foundations of The Uruk State: Using Satellite Photography Toward a New Understanding Of 5th/4th Millenium BCE Landscapes in the Warka Survey Area, Iraq

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1 AUTHOR:

Jennifer Pournelle
University of South Carolina

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THE LITTORAL FOUNDATIONS OF THE URUK STATE: USING SATELLITE PHOTOGRAPHY TOWARD A NEW UNDERSTANDING OF 5TH/4TH MILLENIUM BCE LANDSCAPES IN THE WARKA SURVEY AREA, IRAQ

Jennifer R. POURNELLE

INTRODUCTION

In examining the precursors of social complexity, in the Near and Middle East, consideration of riparian, lacustrine, estuarine, and riparian (referred to collectively hereinafter as "littoral") resource exploitation for the most part has been subordinated to close examination of agro-pastoral economic components characterized by grain cultivation and ungulate husbandry (Pollack 1992; Kouchoukos 1998; Zarins 1989).[1] Naomi Miller has succinctly summarized this overarching view: "By about 6000 BC, domesticated animals, notably sheep, goat, and cattle, had joined the familiar crop complex of Near Eastern cereals and pulses, forming the economic basis of later Neolithic society and the first civilizations" (Miller 1991:144–145).

Underlying prevailing models of the Mesopotamian path to complexity (e.g. Wittfogel 1959, Adams 1981, Park 1992) is the primary assumption that extension of sedentary agriculture made possible the hydrologic engineering used to intensively exploit arid settings wherein, as compared to equal hectarage in rain-fed agro-pastoral economies, exponential agronomic return was possible per unit labor input. Following Frankfort (Frankfort 1932: 18) and Perkins (Perkins 1949: 73), the southern Mesopotamian wetlands, recognized as a locus of presumptive colonization from elsewhere, were tacitly viewed as an impediment to expanded agropastoral production and hence expanded settlement until the region became sufficiently "dry" during the late-4th millennium BCE Uruk period (Nissen 1988).

These views have largely persisted, despite Murdock's noting as early as 1969 the high correlation between specialized *fishing* economies and early sedentism, even in non-maritime contexts (Murdock 1969); mounting evidence from the New World and Far East of pisco-molluscan exploitation as a basis for early sedentism and territorial consolidation in those regions (Aikens 1981; Moseley 1975; Akazawa 1981; Pearson and Underhill 1987); and the obvious riparian situation of the Old World's oldest known civilizations.

That the role of estuarine exploitation in early Near Eastern sedentism and social evolution has received insufficient attention is unsurprising, particularly given the timeframe of the bulk of regional excavation, concluded decades before the invention and introduction of systematic fine-mesh screening, floatation, and deflocculation for small and organic find recovery. However, during the past decade mounting evidence suggests that systematic examination of geomorphologic, archaeological, glyptic, and epigraphic data from fifth–fourth millenium BCE Mesopotamia will add a third necessary pillar to the agropastoral dyad so vigorously examined during the twentieth century.[2]

In this paper I review recent research conducted at the University of California, San Diego Mesopotamian Alluvium Project laboratory that reconstructs with far greater precision than that available to mid-twentieth century theorists the paleogeography of the Mesopotamian alluvium during the formative Chalcolithic. I offer an interpretive methodology especially appropriate to viewing regional scale interactive spheres inaccessible through single-site excavation, and establish a hypothesis emphasizing the essential nature, not merely of *water,* but of *littoral ecotones*, in supporting and shaping complex social institutions that underlay urbanization in southern Mesopotamia.

I use recent geomorphologic investigations that relate mid-Holocene Nile delta paleogeology to fifth millenium BCE site locations (Butzer 20001; van den Brink 1993; van den Brink 1989) as a model for interpreting recently declassified

[1] I am especially greatful to Guillermo Algaze, Robert McC. Adams, Tony Wilkinson, McGuire Gibson, Jennifer Hyundal, Nicholas Kouchoukos, Robert Englund, and Elizabeth Carter for substantive comments. Errors and omissions naturally remain my own.

[2] Regarding the greater Egyptian heartland, until the latter quarter of the 20th century similar arguments posited "a swampy Nile delta hostile to all settlement" (Rizkana and Seeher 1987: 21). Challenging this view are careful faunal analyses at deltaic (Maadi, Buto, and. Merimde) and lacustrine sites (Eiwanger 1984; Boessneck, von den Dreish, and Ziegler 1989). During the sixth and fourth millenium BCE, pluvial, mesic conditions prevailed, and the Fayum Depression/Lake (Birket) Qarun was connected to and received flood overflow from the Nile. Lake levels rose some 60m above present levels. At that time, fresh waters were surrounded by thickly vegetated shallows interspersed with thick reed beds, and tree-lined shores. Nile catfish (*Clarias* sp.) were the most common animal represented in both Fayum B (6170–5670 BC) and Fayum A (4341–3020 BC) faunal remains. At Fayum B these also included significant proportions of migratory waterfowl (Brewer 1989: 28). The faunal remains of the Nile Neolithic/Predynastic transition can be broadly characterized by an accumulation of fishing technologies, from seasonal opportunistic clubbing of catfish stranded in recessional pools, to shore netting of *Tilapia*, to deep-water angling/harpooning of Nile perch, especially in Upper Egypt. In the delta, while the latter Fayum A (late fifth/early fourth millennium BC) saw the introduction of ovicaprids at some sites, in only one case did this constitute a significant proportion of remains—and then only *after* a full complement of fishing technologies had been developed elsewhere.

Corona KH4B photography of the southern Mesopotamian alluvium, This exercise is especially useful in that the region so considered will remain closed to systematic coring operations for the foreseeable future. I conclude that south of the 32d parallel, during the Neolithic Ubaid 0–3 periods (6500–4900 BCE), archaeologically visible early villages were concentrated on river levees at locations bordering swamps and marshes. However, during Chalcolithic Ubaid 4 (4900-4350 BCE), as in the Nile delta, all but one new site, constituting half the extant sites in the survey area, were founded on exposed surfaces of Pleistocene 'turtlebacks'[3] that once overlooked anastomosing distributaries subject to seasonal flooding.

As in the Egyptian delta, the Mesopotamian inter-gezira depressions are probably buried under meters of alluvial accumulation, and we cannot know what sites are buried with them. Nonetheless, larger sites situated on the once-elevated turtlebacks are accepted as (proto-)typical. These presaged an explosion of new sites founded during the Early Uruk period, when virtually all identifiable turtlebacks became inhabited. I therefore argue that a significant component of the resource basis for precocious, large deltaic towns (such as Eridu) was probably derived from surrounding marshland; and conclude that only following Chalcolithic specialization and integration of, not two, but three specialized productive economies: horticultural, husbanding, and "littoral," could and did Mesopotamian urban civilization flourish.

THE MESOPOTAMIAN HEARTLAND REVISITED

Four factors are important to assessing the extent and character of surface water and vegetation in the archaic Mesopotamian southern alluvium (figure 1). The first is the timing, rate, and volume of Tigris and Euphrates water discharge, determined primarily by the quantity and seasonality of precipitation (and melting of the snowpack) in at their Zagros/Taurus headwaters—in turn affected by climatic oscillation of the Mediterranean storm track. Second is the amount, extent, and seasonality of rainfall on and east of the alluvium, primarily affected by northwest–southeast displacements of the summer Indian Monsoon. The third is the extent of saline penetration and tidal flushing, determined by the location and timing of marine transgressions and regressions at the head of the Persian Gulf. The fourth is the location of major Tigris and Euphrates distributaries, and their associated permanent marshlands. In this paper, while taking into account recent paleoclimatological and sedimentological work regarding the first three factors,[4] I introduce new evidence, derived from satellite photographic interpretation, regarding the fourth.

In brief, the alluvium is flat, and even small changes in precipitation and sea level markedly affect the degree and extent of inundation as well as local soil and water salinity. These are of course considerations exceptionally relevant to the location of specific communities; nonetheless, conclusions to date regarding "habitability" of the southern alluvium based on such geologic events have been driven largely by the imbedded notion that the earliest large, permanent settlements were a result of "colonization" under conditions newly, uniquely, or primarily favorable to agropastoral production—a position which, in light of findings of the last two decades, becomes increasingly untenable (Potts 1997: 47–55). Joan Oates' early views regarding the attractions of a rich hunting and fishing potential in southernmost Mesopotamia (Oates 1960) would seem over recent decades to have been born out in a number of Middle Eastern locales, where even well outside the alluvium, close association of large, sedentary sites to littoral settings has been noted.[5] Paleobotanical evidence suggests that, in general, the early-mid Holocene (7th-4th millenium BC) was a good deal wetter than at present, and that especially during the late 5th millenium the alluvium may even have experienced summer rains (el-Moslimany 1994; Hole 1998b; Miller 1998; Zarins 1990: 49–50).

Seeking to understand the origins and development of civilizations in the alluvial lowlands of the Tigris and Euphrates rivers, over two decades Robert McCormick Adams, Hans-Jeorg Nissen, Henry T. Wright, and MacGuire Gibson conducted broad scale regional settlement surveys that located, recorded, and dated thousands of archaeological sites, using these to date the relict water courses that intricately lace the region (Adams 1981; Adams 1965; Adams and Nissen 1972; Wright 1981; Gibson 1972). Adams was thereby able to document aspects of long-term settlement patterns and demographic changes in the Mesopotamian lowlands from the beginnings of settled towns to the present day. His work clarified how the natural environment of the area affected human life; what changing strategies Mesopotamian societies used throughout history to adapt to that environment; how successive Mesopotamian societies transformed that environment; and what selective environmental pressures existed in the region that favored the development of the world's earliest urban societies (Adams 1981).

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[3] Often conflated with the Arabic *gezira,* meaning sand island, which is misleading for two reasons. Firstly, *gezira* (with many transliteration variants) is broadly used to designate any island, plateau, or upland, including vast tracts of upper Mesopotamia. Secondly, turtlebacks are not necessarily sand, nor are they islands. Turtlebacks, in the sense used herein, are formed during pluvial periods, when meandering rivers downcut through (relatively) uniform alluvial surfaces, leaving former surfaces exposed above the newly formed floodplain. The channels between these exposures infill during subsequent conditions of alluvial aggradation, leaving weathered humps of the older surface protruding slightly above the newer alluvial plain—like a floating turtle's back, protruding above calm water.

[4] Potts and Kouchoukos provide critical summaries of relevant geomorphologic and paleoclimatic analyses, based upon Sanlaville 1989 and 1992, and el-Moslimany 1994. (Potts 1997: 31–42, 47–55; Kouchoukos 1998: 216–231). More recent work by Sanlaville (1996) and Aqrawi (1997, 2001) tends to reinforce these.

[5] The walls of precocious Jericho may have served primarily for flood control within a marshy alluvial fan (Bar-Joseph 1986). Sixth millenium BCE Umm Dabghiyah in the north Mesopotamian *Jezirah* was situated near marshland (Oates and Oates 1977: 116–117). Sedges (*Scirpus)* apparently comprised a significant dietary element at marshy Çatal Höyük (Hodder et al. 2001: http://catal.arch.cam.ac.uk/catal/Archive_rep01/content01.html). Fifth millenium BCE hunter-gatherer-herders processed grasses and cereals near playa lakes in the Rub al-Khali. Faunal remains at 4,340–4,040 BCE site K160 on the lower Khabur included burned clam shells and crab claw, indicating a permanent freshwater Khabur tributary at that time (Hole 1998a: 45).

Prior to Adams' studies, it had been generally thought that heavy alluvial deposits over the lower Mesopotamian alluvium would have made it impossible to determine the origins of deeply buried cities. However, the surface surveys conducted by Adams, Adams and Nissen, Gibson, and Wright have shown that this was not necessarily the case. Wind erosion periodically re-exposes long-buried artifacts that, when systematically collected, dated, mapped, and plotted with reference to ancient canal traces, reveal a distinct pattern of urbanization and extension of irrigation technology over a period of five millennia. Thus, the corpus of archaeological survey over Mesopotamia, although incomplete, has already proved to be an invaluable resource, adding a corrective rural and non-literate dimension to the predominantly urban, literate, elite focus of historical texts—which texts themselves lend invaluable interpretive dimension to the archaeological data.

A significant conclusion of Adams' work was that the present-day courses of the Tigris and Euphrates rivers are, geologically speaking, of recent and anthropogenic origin. Adams argued that the late mid-Holocene courses of these rivers ran nearly coincidently down a narrow corridor through what is now the lower Mesopotamian alluvium, which corridor is demarcated by ancient cities, strung like pearls along relict water courses. Adams was able to document thousands of now-deserted canals in association with these sites, and hypothesized linear connections between them. The accumulation, argued Adams, of silt carried and deposited by these irrigation activities gradually aggraded the central steppe through which the progressively canalized rivers and canal offtakes ran, ultimately forcing the "wild" rivers respectively westward and eastward (Adams 1981).

Fortunately, although the original air photos are no longer available, declassification of late 1960s–early 1970s-era 2-meter resolution Corona KH4B satellite photographs, available to the public through the Unites States Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center (USGS 1997), have allowed Adams and Pournelle to expand on Adams' original work. In 1998 I began an attempt to map comprehensively 5th–4th millennium BCE courses of the Tigris and Euphrates, from Samara to ancient Ur, reasoning that establishing an entire, connected system associated with period sites would clarify channel dating and subsequent anthropogenic geomorphology in a way impossible by localized analysis—particularly since the region is unlikely to open to systematic coring for the foreseeable future.

A Synthetic Protocol

South and east of a line between Shurrupak (vic. WS 020)[6] and Jidr (WS 004), an area where watercourses are from the earliest historical times epigraphically well-attested, much of the ground was covered by standing water, drifting dunes, and the accumulated alluvial silt. Recent understanding of the mid-Holocene marine transgression make clear the need to account for marsh, estuary, and deltal conditions now obtaining along, south, and east of the modern Shatt al-Gharraf, the lower Tigris and Euphrates, the Shatt al-Arab, and the deltal mouth on the Persian Gulf (Sanlaville 1996; Geyer and Sanlaville 1996; Kouchoukos 1998).

The joint Tigris-Euphrates delta, constrained in its outflow by the Wadi Batin fluvial cone west of Bubiyan Island, and by the Karkheh–Karun deltas emanating from the Susa plateau, is characterized by a littoral zone transitioning from fresh water marshes at the Tigris-Euphrates confluence at Qurna, through brackish channels south of Basrah and the Kurun confluence at Mhuhammera, to permanent salt marshes at the Persian Gulf head. Sanlaville, using soils classification, and Kouchoukos, using multispectral imagery vegetation classification, have clearly depicted the resultant, prevailing domain of permanent and semi-permanent marshes north of Basra, where annual floodwaters mingle, spread, and slow as they meet the strong action of tidal flushing.

The mid-Holocene marine transgression, pushing northward through the deltal cones during the 6th–4th millennium BCE and subsequently receding, would have pushed the estuary inland, so that conditions obtaining in 20th-century Tigris-Euphrates marshlands would have been extended northward and west of the Shatt al-Gharraf, into the Warka and Eridu survey areas (Sanlaville 1996: 96; Aqrawi 2001). Declassified Corona satellite photographs, imaged in 1968, before massive irrigation , drainage, and water diversion projects brought and end to millennia-old marsh formation processes, allow us to compare the geomorphology of "active" delta, marsh, and alluvium formation to that of the now-desert Chalcolithic urban heartland.

Relics of analogous features are attested in the archaeological record of the Warka and Eridu Survey areas, where the more comprehensive photographic record may be tested against the archaeological. Ground evidence includes artifacts from surface survey, faunal remains, stratigraphic profiles, and limited geomorphologic data. Relict landscapes are photographically revealed especially clearly following the May Euphrates floods that saturate soils, replenish groundwater, and temporarily cover tracts of what is now desert with sheets of water that ultimately drain through a series of seasonal swamps into Lake Hammar. Two zones of geomorphologic action are here examined: the lower delta, where sediment loads are dumped into the sea, and above it, the alluvial plain, a flood-prone region of channel and marsh formation.

Meanders: the Upper Alluvium

River meanders leave fossil traces up to several kilometers in width, characterized by concentric, bending stripes on their crests (Gasche and Tanret 1998: 5–7).Their contours can be preserved for millennia, due in part to their durable function in shaping subsequent agricultural systems, wherein they delineate systems of irrigation dikes and levees that hold recessional silt and demarcate field and crop boundaries (see

[6] WS: Warka Survey (Adams and Nissen 1972); NS: Nippur Survey (Adams 1981); ES: Eridu Survey (Wright 1981); KS: Kish Survey (Gibson 1972).

figure 6A). The breadth and periodicity of relict meanders is determined by volume and flow rate of water discharge (Adams 1981: 16–17). A relict channel succession north and east of Nippur that Adams had identified from air photographs (Adams 1981: 62, fig. 11) is comparable in size and periodicity to the modern Tigris channel downstream from the al-Kut barrage, which diverts considerable flow to the Shatt al-Gharraf and its interconnected irrigation system (figure 6B).

My earlier work focused on tracing river meanders down the entirety of the Mesopotamian alluvium. The conglomeration of these revealed relatively narrow belts within which riverbeds once meandered (Pournelle 1999). The entire (Samara—Adab) charted meander system corresponds generally to interconnecting watercourses posited by Adams among hundreds of Late Uruk sites, and to earlier posited riparian connections between Ubaid and Early Uruk towns such as Ras Al Amiya and 'Uqair (Stronach 1961; Adams 1981; Adams and Nissen 1972; Wilkinson 1990). Accepting Adams dating of these meander relics, by association of numerous sites along their bends, to the fourth millennium BCE leads me to assign a *terminus post quem* for the entire system to that period.[7]

Geomorphologic reconstruction of major fluvial systems from Samara south to Eridu (Northedge, Wilkinson, and Falkner 1989; Gasche and Tanret 1998; Wilkinson 1990; Adams 1981; Stone 2002) paint a revolutionary picture of the Tigris's overall contribution to alluvial settlement and irrigation during the subsequent third and second millennia BCE.[8] As the headwaters of the earlier system, while intermingled with anastomosing channels from the Anatolian Taurus, are primarily located in the Iranian Zagros, in present-day terms I too would refer to its major distributaries to the south and east as "Tigris" waters (Pournelle 2002, 2001a; 2001b, 1999). Of course, this Tigris/Euphrates admixture could have existed in substantially the same bed for centuries–even millennia–prior to the fourth millennium, but it was during this period that it appears to have last meandered in its fully wild state. Thereafter, more or less continuous human intervention profoundly affected the hydrologic evolution of lower Mesopotamia. However, south of Adab, few relict meanders are visible, leading me to turn to other indicators of geomorphology.

Turtlebacks

During the end-late Pleistocene Wurm marine regression, river distributaries scoured channels of up to forty meters depth, leaving terraces at former plain-level protruding above the water surface and dumping scoured sediments at deltal mouths, in a formative process seen today at Bubiyan Island at the modern head of the Persian Gulf. As the Pleistocene river channels meandered or anastomosed into new courses, valleys between these terraces infilled with subsequent alluviation and colluvial silts, leaving the impression of a uniform surface. However, during mid-Holocene flood seasons, the tops of these relict terraces, called "turtlebacks," being of slightly higher elevation, would remain dry while the surrounding plain became inundated by sheets of floodwater. In the Nile delta, Neolthic and early Chalcolithic sites, instead of being aligned along archaic watercourses discharging into the Mediterranean; followed chains of these Pleistocene "turtlebacks" extending *across* the alluvium, suggesting wet-season boat traffic (Van den Brinck 1983; Butzer 2001).

Active turtlebacks photographed from space with high resolution cameras show micro-drainage and differential dampening at their bases, making their slight relief above plain level detectable without detailed elevation data (Coleman, Roberts, and Huh 1986). This is also the case for many relict turtlebacks imaged during the spring spate, when floodwaters saturate lower-lying ground. This can be readily seen in a 1968 image of Telloh (ancient Girsu), where archaic city walls encompass one-third of a turtleback land area (figure 3A). within the Warka survey area, situated on a pronounced turtleback, the linear array of site WS 230 along internal canals, no doubt maintained to allow untrammeled boat access to surrounding marshes, is visible even to the untrained eye (figure 3B). Site WS 298, a low mound located *c.* 10 km northeast of Uruk, is similarly situated on turtleback facing a levee back slope.

Excavations at Tell Oueili (WS 460) confirm this photographic interpretation, and the underlying geomorphology analogous to similar sites in the Nile delta. At Oueili, Pleistocene buttes punctuate a Holocene surface incised to several meters depth by the Shatt al Kar east of the site. Oueili is situated atop one of these earlier surfaces, revealed by excavation as a buried turtleback, where it was most likely located for protection from seasonal flooding. A deep sounding showed 4 meters of alluvial deposition surrounding and eventually burying the channels that would have carried waters past its Ubaid 0 foundations (Porada, Hansen, Sunham, and Babcock 1992: 86; Geyer and Sanlaville 1996; Plaziat and Sanlaville 1991).

Discharge Splays, Levees, and "Bird's Feet"

Three relict features help to chart and date a relict fluvial system in its entirety. Easily detectable in that they leave indelible scars, are flood-season discharge splays preceding from levee ruptures (compare figures 7 and 8). These splays can become the source of new or diverted main channel flows, although, just as often, the sudden fanning drops sufficient alluvial silt that, as floodwaters recede, the natural levees may reestablish. We would expect no permanent sites on top of such features (although there may well be sites predating such extreme events *under* them), since active dramatic

[7] Tony Wilkinson cautions that, due to its large amplitude, we cannot rule out an earlier (Pleistocene) dating for this channel succession, which would later have become exposed by aeolian deflation, leaving subsequent Holocene sites pedestalled on its surface. (Wilkinson, pers. com., 2002). I will take up this discussion in detail in a subsequent paper.

[8] These are in braod agreement with conclusions based on study of toponyms in third- and second-millennium BCE cuneiform texts recording shipping and travel itineraries along stretches of the major watercourses (Nissen 1985; Steinkeller 2001). Stone 2002 critiques details of Steinkeller 2001, but agrees that the "Eastern Euphrates" attested in third millenium BCE texts was in fact a distributary branch of the Tigris.

annual flooding would make permanent habitation exceedingly hazardous and unlikely. We may thus take any site located on top of such fans as a *terminus post quem* for active inundation from the breach at their heads, which aids in dating the system of which they form a part.

Flood deposits along riparian distributaries over time build massive levees, as at present along the Tigris south of Amara (figure 4A). There, the agricultural zone extends east and west of the main water channel along the five km.-wide levee system. Excess water drains through light-colored tails of smaller canal levees into seasonal back swamps visible as silty, dark bodies. In otherwise arid zones, during the wet season relict levees appear on black-and-white photographs as brighter in color than surrounding soils. Their slightly higher elevation and greater degree of compaction means that they retain less moisture and dry faster than background terrain, and therefore reflect more light.

Careful examination of the putative Chalcolithic alluvial zone in the now-arid Warka Survey area revealed a five-kilometer-wide levee system, extending south-southeast from meander traces recorded by Adams vic. site WS 175, to a series of distributaries dissipating into relict marshland from site WS 427 to WS 447 (figure 2). The eroded natural levees approach five kilometers in width, indicating a past discharge capacity equivalent to that of the modern-day Tigris system. Particularly clear is a section between sites WS 375–WS 400, showing relict back swamps and offtakes for near-levee cultivation. The thin, black line of the Shatt al-Kar is all that remains to indicate that a once-mighty watercourse flowed here. A historical canal running atop the levee, the Shatt al-Kar could not possibly have transported sufficient silt to build the massive geologic structure depicted at figure 4B.

Active sediment deposition as great rivers abruptly slow on encountering slack water results in the multiple, bifurcating channels of a classic "bird's foot delta," as that of the present-day Mississippi river. The radial pattern of distributaries surrounding Warka speaks to its early situation in an active, alluvial environment. Home of the fourth millennium BCE Uruk urban expansion, the satellite photos reveal the city's placement not so much on the river as in it: the city's walls are clearly surrounded by a relict bird's foot delta extending into spring 1968 Euphrates floodwaters (figures 4, 12). This location would have conferred significant transportational advantage, as the irresistible logic of the riparian dictates that heavy, bulky goods may be moved more easily downstream than up, tending to favor import of raw materials and export of manufactures (Algaze 2001).

A Mesopotamian Littoral Economy

A gross explanation of the close fit of surveyed sites to relict Tigris/Euphrates meander systems down the center of the upper Mesopotamian alluvium could be that large Chalcolithic sites in this region were situated within (or on the levees of) river meanders at locations propitious for primitive irrigation, using what Wilkinson has described as human-assisted, semi-managed avulsion (Wilkinson 2002). But close examination of the paleogeology of the lower alluvium suggests that a larger role must be given to littoral ecotones as a "third pillar" of the formative Mesopotamian economy. I will now turn to interpretation of the satellite photographs in light of surface and excavation finds. This exercise suggests a settlement progression beginning in the Neolithic Ubaid with dependence on littoral biomass, and ending in the Early Bronze Age Late Uruk/Jemdet Nasr, with intensive usage of what by then had become agricultural zones.[9] For the earlier Neolithic (Ubaid 0–3) periods, as sea levels slowly rose from 15 meters below to within several meters of their current levels (Sanlaville 1989), mid-Holocene (6000/5500–3500 BCE) monsoon variations brought increased rainfall to the lower alluvium (el-Moslimany 1994; see Potts 1997 Chapter 1 and 52 *passim*). Because freshwater outflow to the Gulf is constrained by the twin cones of the Wadi Batin and Karun-Karkeh drainages, even absent the effects of tidal forcing concomitant with later progradation of the Gulf head, these comparatively pluvial conditions would have increased the likelihood of seasonal flooding and marsh formation.[10]

Neolithic Precursors

Available excavation evidence indicates a long period of Neolithic Ubaid adaptation to littoral conditions. No surface finds can be dated to Ubaid 0 (6516–5955 BC),[11] but the deep sounding at Tell Oueili (WS460), characterized even at this early date by extensive mud-brick construction, showed five meters of Ubaid 0 material remaining above the water table (figure 2, near E). Botanical finds included edible sedge tubers (Cyperus rotundus) and giant reed (Phragmites australis) (Neef 1989), both suggesting that water pooled near the site, which was situated on a Pleistocene turtleback surrounded by infilled channels (Huot 1989, 1991, 1996; Forest 1996) (figure 2).

Within the Warka survey area, two Ubaid 1 ("Eridu Phase," 5916–5236 BC)[12] sites—WS 267, and Haji Mohammed, which would undergo a flourit as the Ubaid 2 type site—were aligned north-to-south along a Tigris distributary that rejoins the Euphrates system after dissipating into marshlands (figure 2 line AC). A third site–the early foundations of the great 3d millenium BCE city of Larsa, bordered the marshes fed by the great Tigris distributary east of Uruk (figure 2, line BD). South of the Euphrates, type-site Eridu itself

[9] For the following discussion (Figures 13–15), I follow Nissen's ceramic seriation (Adams and Nissen 1972), and the Porada et al. 1992 as amended by SAR 1998 chronologies for Mesopotamia (Rothman 2001). I understand that reseriation based on Oueili finds revises the Nissen ceramic chronology; but such adjustments, while refining, will not alter the substantive conclusions made here.

[10] Flooding and marsh recharge is primarily related to melting of the Tigris and Euphrates headwaters snow packs, but increase in either early Fall (October-November) or late spring (March–May) precipitation even south of the 34th parallel reinforces and lengthens the regular flood seasons. Flooding and marsh formation associated with peak lower alluvium precipitation years occurred in 1870, 1894, and 1918–19. (McFayden 1938; Roux 1960: 30–31).

[11] All dates calibrated C14. Oueili: shell; Sawwan, Choga Mami: tree charcoal.

[12] Calibrated C14, tree charcoal. (Valladas, Evin, and Arnold 1996: 383)

straddled a Euphrates levee backslope bordering a marsh rim. Beneath later sacred areas were pedestalled mud structures, showing signs of burning, presaging a succession of temples with burnt offerings of fish (Safar, Mustafa, and Lloyd 1981; Porada, Hansen, Sunham, and Babcock 1992). "Eridu period peoples…had on hand copious marsh resources. A canoe model and numbers of perforated clay ovoids, perhaps net weights (Lloyd and Safar: 118, pl. III), from Eridu period levels suggest that the marshes were already being used in a sophisticated manner." (Wright 1981: 323).

By Ubaid 2 ("Haji Muhammad Phase," 5236—[5064?] BC) two more sites were added to the back slopes of the Uruk distributary levee AC, continuing a line northward. The more southerly (WS247) overlooked an (undated) marsh rim,[13] while at the juncture of this levee with an anastomosing distributary continuing southeastward to join the Tigris system (figure 2, line AB), the first (WS42) of what would become a complex of sites characterized by surface finds of spools and net weights also appears on its back slope. In 20th century marsh districts near al-Hiba (Lagash), characterized by a mixed agropastoral-fishing-reed manufactures economy, similar spools and weights are employed in spinning yarn for and weighting fishing and fowling nets (Ochsenschlager 1993).

Continuing linearly southeast, two additional sites (WS51, WS178) were situated along the levee/marsh rim AB. Spools were also noted at WS 298, while excavated bitumen toggles at Uruk, and the first appearance of "tortoise jars" at Eridu, were assigned to this period (Adams 1981; Porada, Hansen, Sunham, and Babcock 1992: 86). Ceramic evidence that the emphasis on levee colonization was directly tied to mastery and reliance on water travel as far away as the Persian Gulf is tantalizing. While most common at Uruk and Ur (Porada, Hansen, Sunham, and Babcock 1992: 86), founded during Ubaid 2 on a levee/marsh rim, "the Haji Muhammad style…is the first to occur in sites along and behind the Saudi Arabian shoreline, more than 600 km southeast of Eridu…[Chemical analyses indicate that the painted pottery there was of southern Mesopotamian manufacture, implying periodic visits by fishermen from settlements along the Tigris-Euphrates delta with craft sufficiently well-developed for them to master deep-sea travel." (Adams 1981: 58, citing Oates 1976: 22; Oates, Davidson, Kamilli, and McKerrel 1977). Near Ur, type site al-Ubaid, was founded on a low sand knoll (Hall 1930, Hall and Woolley 1927).

Ubaid 3 ([5064?]—4893 BC) surface finds are noted at one new site (WS4/Jidr) on the Tigris levee BD; one (WS275) on a turtleback at the back slope of the Uruk levee AC; and although Oueili (WS460) itself appears to have undergone an occupation hiatus, a new site (WS459) appears adjacent to Tell Oueili on the marsh rim E. At Eridu "tortoise jars" abound, temple platforms are raised, and clear evidence of mud brick directly associated with adjacent reed domestic construction is exposed (Safar 1950: 28) even as a flourit of Mesopotamian-manufactured (imported) pottery appears at Gulf coast sites.

Thus, throughout the latter Neolithic, archaeological evidence from the southern alluvium is consistent with our reconstruction of a riparian distributary system and concomitant marshy zone, shading from seasonal inundation to permanent lakes. At Ubaid-period Uruk, Hajji Mohamed, al-Ubaid, Ur, and Eridu, in addition to mud brick the deepest soundings all revealed remains of reed platforms, traces of reed structures, plastered reed walls, and reed matting plastered with dung, earth, or bitumen (summarized in Moorey 1994: 361). Inhabitants of the southern alluvium were apparently dependent upon liberal access to littoral biomass for food, construction material, and fodder (fish, fowl, pig, reed); water supplies and transport; and riparian (cattle) browse.

The Chalcolithic Transition

Ubaid 4 (4893—4357 BC) marks a more visible settlement trend. Thus far, the oldest period reached beneath the tens of meters of overburden at Uruk itself dates to this period. Surface finds show five new sites (WS137, WS160, WS218, WS260, and WS411) on turtlebacks, of which three abut levee back slopes. One (Raidu Sharqi) is added to a levee distributary at the marsh rim southwest of Uruk. Surface finds at site WS 218 included spools. At Oueili, added to the earlier botanical constellation of dates, tubers, and reeds are water-loving poplar (*Populus euphratica*) and sea club-rush (*Scirpus maritimus*), with a continuing faunal emphasis on cattle and pig (Neef 1989) (figure 8).

Eridu, 12 hectares in extent, sported a temple on a raised terrace and, for some individuals, substantial brick tombs. Boat models indicate that sailing craft had been developed; and quantities of marine fish were recovered in the temple precinct and from the alter, presumably laid as offerings. Botanical remains included dates. (Safar 1950, Safar et al. 1981; Wright 1981). Similarly, Ur and al-Ubaid had grown to about 10 ha. size (Hall 1931, Safar et al. 1981). Clay sickle distribution indicates extensive harvesting along back slopes (Wright 1981). Wear pattern and phytolithic analyses of similar sickles make intensive reed-harvesting for fodder and construction material likely (Anderson-Gerfaud 1983:177–91; Benco 1992:119–34).

By the Early Uruk period (4000–3500 BCE), as rising sea levels reached (3800 BCE) and then exceeded by one–two meters (3500 BCE) those of today, settlement was marked by a continuing colonization of turtlebacks. Progradation of the Gulf head as far north and east as modern Qurna would certainly have resulted in tidal flushing as far northeast as Ur, and perhaps as far as Uruk itself. This would have been accompanied by at least seasonal marsh formation over all but the highest ground of the Warka and Eridu survey areas, as the outlets of the combined Tigris and Euphrates discharge became flooded, slowing drainage to the sea.

[13] This area has repeatedly flooded, most recently during the 19th and 20th centuries, and remains unsurveyed, rendering dating of the marsh zone difficult at best without sediment sampling (Potts 1997: 39). However, as the prevailing geosyncline (Buday and Jassim 1987) would have tended to pool floodwaters predominantly west and south of the Uruk distributary–a process apparent along lower Tigris distributaries until the mid 1990s–I consider contemporary marshland formation in this zone exceedingly likely.

Two new sites clustered on the Uruk levee A vicinity fishing site WS42 (WS20, WS22), with two more on its back slope (WS23, WS24) perhaps fed by a minor canal, but net weights (WS26), and spools (WS20, WS24) attest a continuity of purpose with that earlier site. Site WS245 on the levee AC back slope exploits the same locale as Ubaid 2 site WS247. But in a completely new development, their linear arrangement suggests that regularized waterways up to twelve kilometers in length may have extended south from the Tigris tributary levee AB to sites WS107; WS109; and WS178-201-215; aligned toward turtleback sites WS137, WS160, WS218 (respectively) (figure 8). These linear arrangements need not be interpreted as canals extending through arid zones. Equally likely is that they represent permanent boat transport routes with villages along their banks, kept clear of reeds during wet seasons and allowing access to the river during dry. Similar village distributions are visible extending southward from the Euphrates as it wends through the eastern Iraqi marshes, for example vic. Kabaish (el-Chubayish) (Roux 1960; Salim 1962).

These presage a site explosion during the late Uruk (3500—3000 BCE). As sea levels and the Gulf shoreline fell back to approximately their present locations, over one hundred new sites spread fanlike north and east from the emergent city at Warka, south from the levee system tying the Uruk and Tigris channels, and eastward from the Tigris levee. Added to net weights (figure 2),[14] spools,[15] and spindle whorls[16] are a profusion of mace heads,[17] possibly indicators of local conflict (although they seem rather light weight for this purpose)or local office. Late Uruk (Uruk IVA) seals, sealings, and tablets recovered from excavations at Warka depict cattle emerging from reed byres, hunting scenes with pigs stalked among reeds, palms, and frogs, with many tablets showing the clear imprints of the reed mats upon which they lay as they dried (Boehmer 1999: 51–56, 66–67, 71–74, 90–104). Contemporary protoliterate economic texts include dozens of ideographs for reeds and reed products, pigs, waterfowl, fish, dried fish, fish traps, dried and processed fish flour, as well as those for cattle and dairy products (Englund 1998).

The site distribution implies a gradual withdrawal of the seasonal marsh zone southward, and opening up of land area amenable to grain cultivation. However, it could as well be an artifact of site visibility, indicating only the limits of aeolian scouring in exposing buried sites, that no *further* inundation occurred *after* the late Uruk, or both. Intensification of cattle production in riparian and littoral habitat would have simultaneously and steadily degraded browse and the watershed, necessitating intensified fodder gathering and production (Belsky 1999). The profusion of visible Late Uruk small sites could therefore be evidence that, concomitant with intensified agricultural production, reed and other marsh products were becoming intensively harvested to underwrite urbanizing consumption. Notable is a match between the geographic clustering of sites around centers on turtlebacks, with Adams' hypothetical Jemdet Nasr/EDI territories, based on site sizes and nearest neighbor analysis (Adams 1981: 20, fig. 8) (figure 2).

This would suggest that during the Chalcolithic Ubaid and Early Uruk, palm groves, gardens, temples, kilns, and other institutions, long consolidated on turtlebacks and levees away from seasonal inundation by peoples well-preadapted to thorough exploitation of marshland resources, presaged later political and economic organization.

RESOURCES AND (SOCIAL) ENGINEERING

Agricultural colonization of the southern Mesopotamian alluvium was made enduringly possible through exploitation by specialized communities of marsh fowl, fish, bitumen, shell, and reeds; by grazing herds on pastures left by receding flood backwash; and by trading boat cargoes with near river neighbors. Sixth- and fifth millennium settlements initially took localized advantage of productive riparian littoral ecotones. Through time, by practicing local, small scale damming and diking to build up permanently habitable platforms and control the rate and progression of flooding and runoff, they accumulated "hydrologic capital." This served not only toward possession of the most suitable landscapes, but in the invention of technologies for flood control. Construction of regularized dykes and channels accumulated irrigation and drainage technologies and concomitant institutions for labor mobilization.

Complementarity of resources would of course have provided local resiliency; but just as important would have been the replicability of these small, bounded, human-maintained ecosystems at each meander loop; on each turtleback, and at each levee junction, where locally shifting plans brought minimal acreage into well-drained cultivation. Specializations and complementarities, through reciprocal social institutions, could have been maintained on a sub- regional basis, beyond the reach of any locally destructive flood or drought. Communities sustained by marshland biomass and fed by the combination of farming-fishing-husbandry were enabled to produce sufficiently consistent agricultural surpluses and sufficiently robust trade networks to tilt the balance: Consolidation of local management structures that must have preceded the work of straightening and regularizing channels and building new canals that came to characterize and fuel urban growth during the third millenium BCE.

Just as excavation over-focused on massive temple and administrative architecture has skewed attention to and perception of the scope and scale of Mesopotamian domestic settlement, osteologial analysis over-focused on mammalian megafauna has skewed attention to and perception of the littoral component of domestic diet. "For the vast majority of the working population, the primary dietary protein source was dried fish." (Englund 2000, pers. com.) Fish, shellfish, turtle, waterfowl, and pigs; reeds, sedges, tubers, and seasonal

[14] WS110, WS219.

[15] WS28, WS48, WS191, WS219, WS282, WS297.

[16] WS137, WS181, WS185, WS219, WS260, WS274, WS407.

[17] WS109, WS129, WS152, WS162, WS219, WS230, WS242, WS260, WS262, WS274, WS276.

grasses sustained human and animal (especially bovid) populations and provided massive quantities of handicraft and construction material. Littoral ecotones constrained habitation; annual floods replenished marshes and recessional gardens; the watery environment provided lines of communication that ensured rapid transmission of technologies, trade goods, and peoples themselves—even as these factors concentrated resources, produce, institutions, and know-how into the hands of the few, setting the stage for hierarchy and heterarchy.

East of the Warka survey area, we can see clearly a relict levee, cut by modern canals, extending into a modern seasonal flood zone. Tel al-Hiba (Lagash) surmounts a Pleistocene turtleback appearing as an 'island' to the south (figure 9). Numerous linear sites are visible along the levee, and multiple occupation mounds are visible on the turtleback. During the historical Early Dynastic III period (2600–2350 BCE), sea levels once again rose one meter above present, and thus a similar hydrologic regime to that of the late Chalcolithic probably prevailed. ED III faunal remains included not only seven species of marine mollusk shell (which could merely have been imported for bead manufacture) (Carter 1990; Kenoyer 1990), but two of marine fish, as well as duck, coot, cormorant, flamingo, gull, and spoonbill–the latter particularly preferring open marshes, shallow lagoons, and estuarine mud flats (Mudar 1982: 29–30, 33–34).[18] Analysis of faunal remains from 1970–71 excavations of distinct temple and administrative/residential precincts showed a decided differentiation in their distribution. All fish, fowl, and mollusk (shell) were found in the administrative/residential zone; none in that of the temple. This marked differentiation in consumption was reinforced by mammalian finds. In the temple precinct, ovicaprids comprised a proportionally higher; bos a slightly higher, and sus a significantly lower percentage than finds in the residential/administrative precinct (Mudar 1982). It is tempting to conclude that (elite) mutton and beef had become appropriate; pork less so; and fish inappropriate as temple offerings and priestly food; a marked reversal from the Ubaid precincts at Eridu—and one marking the transition from a time of Neolithic social integration served by fish as everyman's food, to one of Early Bronze Age consolidated social hierarchy marked by fish as poor man's food.

Al-Hiba was hardly unique in its littoral reliance, which continued through the third millenium BCE. Cylinder sealings from the ED III Seal Impression Strata at Ur depict reed structures (333–344), cattle fed in and lead from reed byres (337, 342, 344); personages poled along fish-filled watercourses in high-prowed boats (300), fishing from small watercraft (310), and persons carrying tribute of fish and waterfowl (302, 303). Robert Englund has treated at length regulation and management of late third millenium Ur III fisheries (Englund 1990). Umma texts record quotas for production of reed, bitumen, boats mats, and standardized fish baskets (de Genouillac 1920: 6036). Proto-Elamite lexical lists record 58 terms relating to wild and domestic pigs; 'professions' lists record offices including 'fisheries governor' and 'fisheries accountant' that endure one and one-half millennia to the Old Babylonian period.

This subsequent administration of marshland resources was not a mere addendum to a better-studied agropastoral irrigation economy. Its managerial origins in Chalcolithic hydrostrategies were *a priori* dependent upon a littoral landscape—one that we have here attempted to better reconstruct; one that endured in various forms for seven millennia; and one that during the 20th century AD was finally managed to extinction (GOI 1956; UNEP 2001).

[18] Of note is the lack of Ubaid or Uruk finds, indicating that in Chalcolithic times the Gulf transgression either precluded permanent habitation altogether, or confined it to relatively small areas, not subject to seasonal inundation, now deeply buried beneath subsequent occupation debris. That the earlier periods are represented at nearby Tello (Girsu) and Shurgal (Nina) supports the latter probability.

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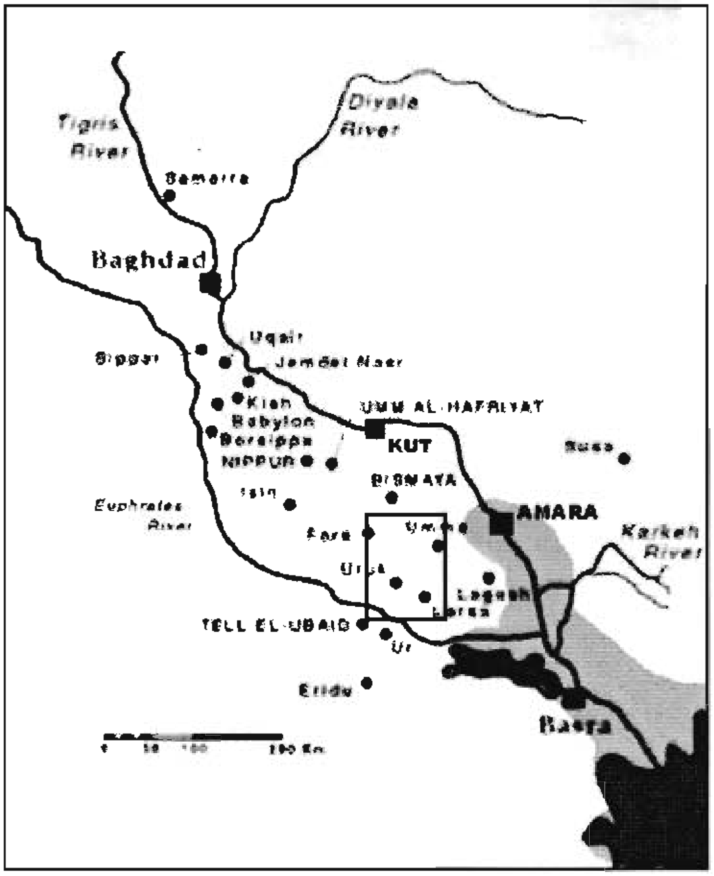

Figure 1: Archaeological sites of alluvial Mesopotamia, showing major settlements and hypothetical extent of the Persian Gulf ca. 3200 BCE. This study focuses on the Warka (Uruk) survey area, red box. After Oriental Institute 1998.

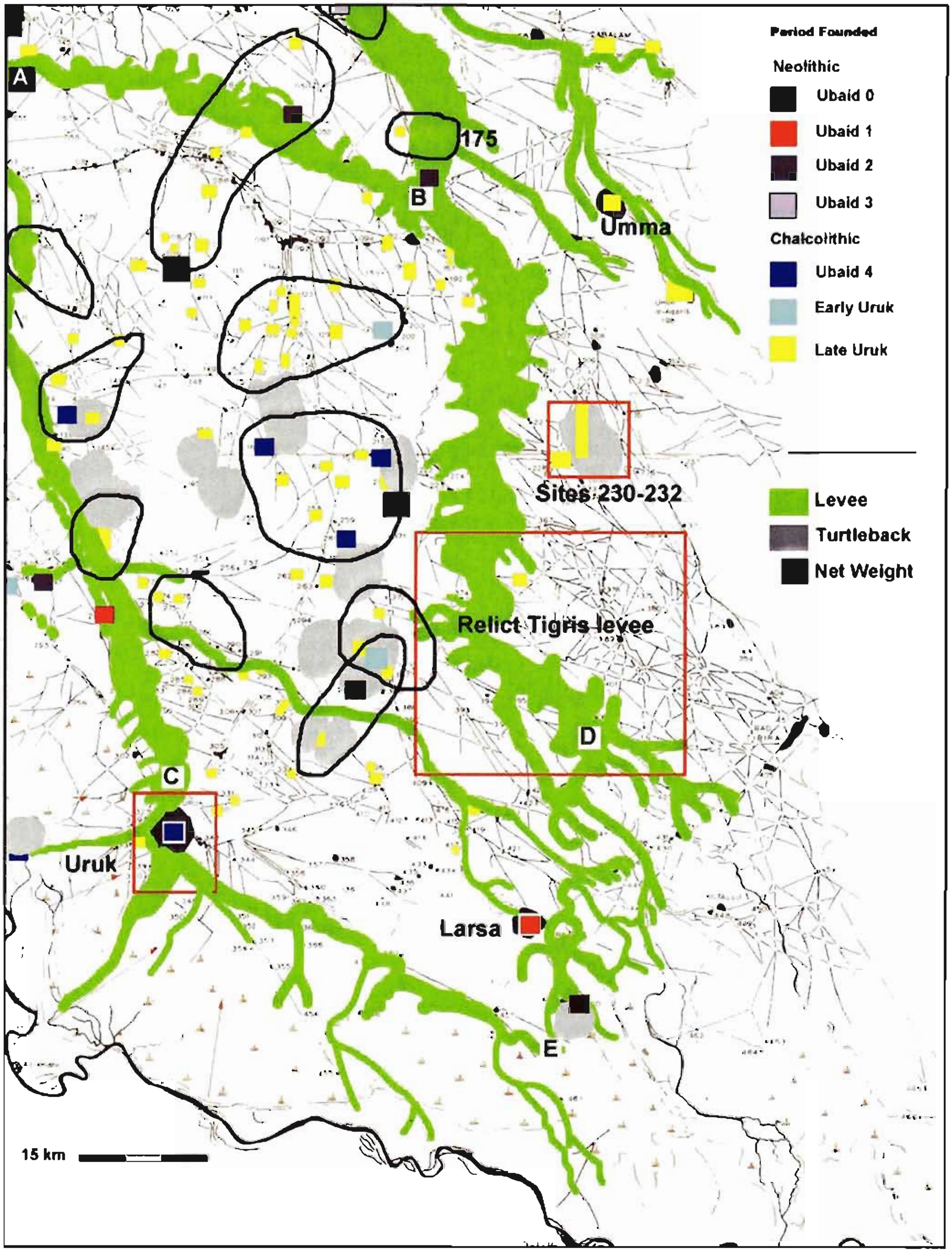

Figure 2: Relict levee systems, Warka survey area. Sites occupied during the Uruk period (4th millenium BCE), with Jemdet Nasr period "nearest neighbor" groupings. Legend (right) indicates earliest settlement period. Boxed insets enlarged in subsequent figures. After Adams 1981.

Figure 3A: Telloh (ancient Girsu) appears to float on an island within irrigated croplands. The archaic city walls encompass one-third of the turtleback land area. Source: KH4B_1103-1A-D041-057 (May 1968). 3X enlargement to scale ~1:75,000

Figure 3B: Sites WS 230–232, arrayed along internal canals within a turtleback. The high water table following spring floods damps dust and reveals fine details of relief invisible at other seasons. Dark body at left is a cloud shadow. Source: KH4B_1103-1A-D041-057 (May 1968). 3X enlargement to scale ~1:75,000.

Figure 4A: Tigris south of Amara vic. Qalat Salih. The cultivated agricultural zone extends east and west of the water channel along the c. 5 km.-wide levee system. Excess water drains through light-colored tails of smaller canal levees into seasonal backswamps visible as silty, dark grey bodies. Only two centuries ago these fields were year-round marshlands. Source: KH4B_1103-1A-D041-055 (May 1968).
2X enlargement to scale ~1:75,000.

Figure 4B: Relict levee between sites WS 375–WS 400. Better-consolidated levee soils are less water-permeable, and hence appear lighter in color. Source: KH4B_1103-1A-D041-058 (May 1968).
2X enlargement to scale ~1:75,000.

Figure 5A: The Kut barrage on the Tigris between Sheikh Sa'ad and Ali al Carbi drains excess flood discharge into Lake as Sa'adiya. The barrage maintains and augments a natural flood splay. Source: KH4B_1103-1A-D041-056 (May 1968). 2X enlargement to scale ~1:75,000.

Figure 5B: Relict discharge splay vic. NS 1420. Source: KH4B_1103-1A-D041-056 (May 1968). 2X enlargement to scale ~1:75,000.

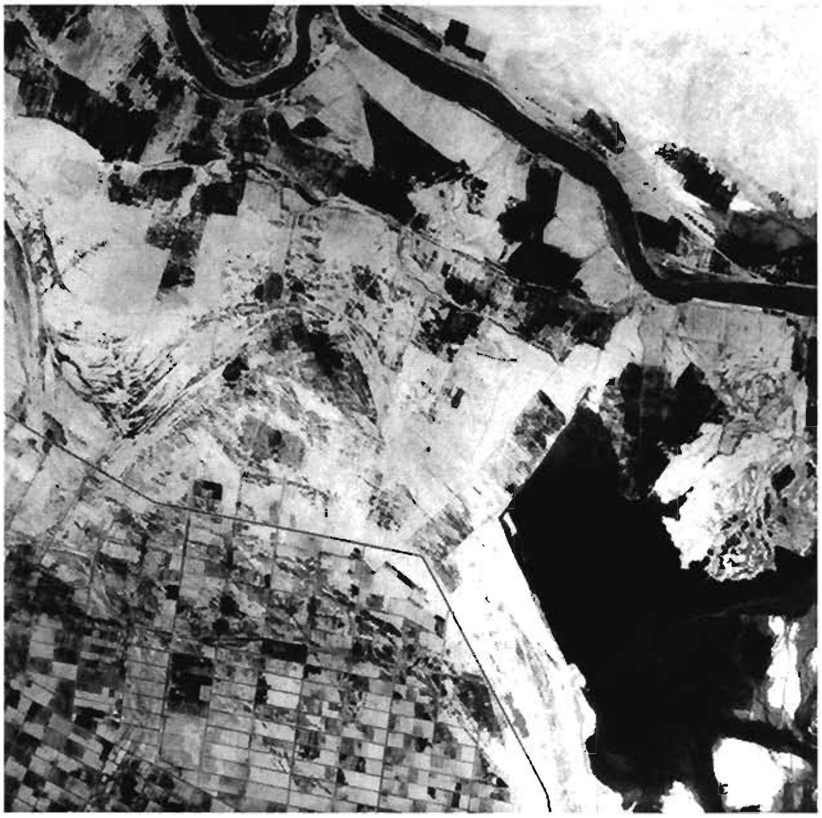

Figure 6A: Modern Tigris east of al Kut, with relict (9th century AD) course to the south.
Source: KH4B_1103-1A-D041-058 (May 1968). 2X enlargement to scale ~1:75,000.

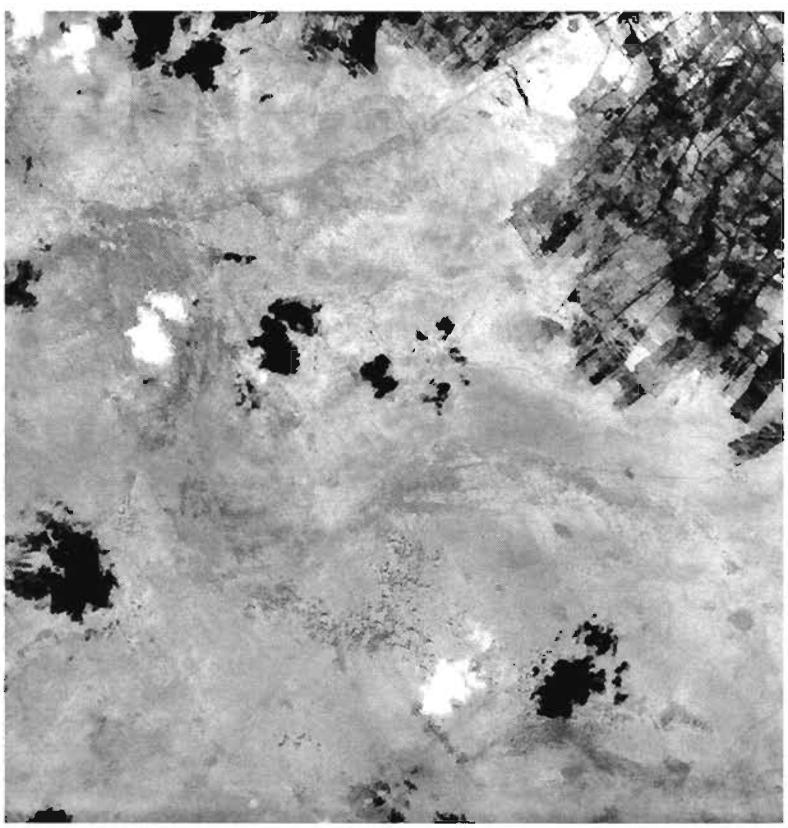

Figure 6B: A relict meander system appears to weave between cloud and shadow northeast of Nippur. While this may represent an underlying Pleistocene fluvial feature, close association of multiple Uruk period sites suggests that it continued to carry water well into the 4th millenium BCE. Source: KH4B_1103-1A-D041-054 (May 1968). 2X enlargement to scale ~1:75,000.

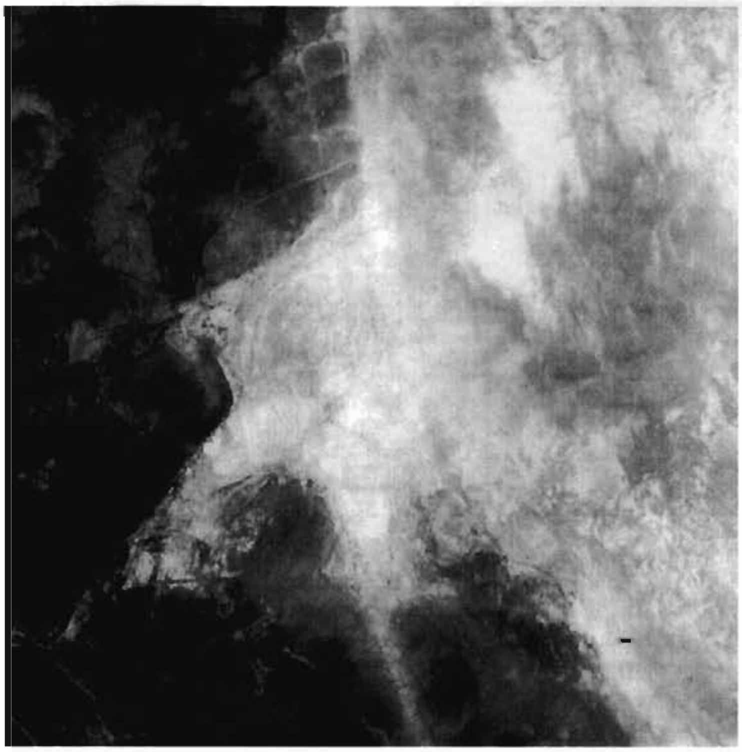

Figure 7A: Warka, surrounded by a relict "bird's foot delta" levee system revealed as late summer dries surrounding marshes and lowers the water table. Darker areas are marginally lower and wetter, lighter areas higher less permiable and dryer. Source: Corona KH4B Mission 1107-1, Frame 139 (August 1969). 4X enlargement to scale ~1:75,000.

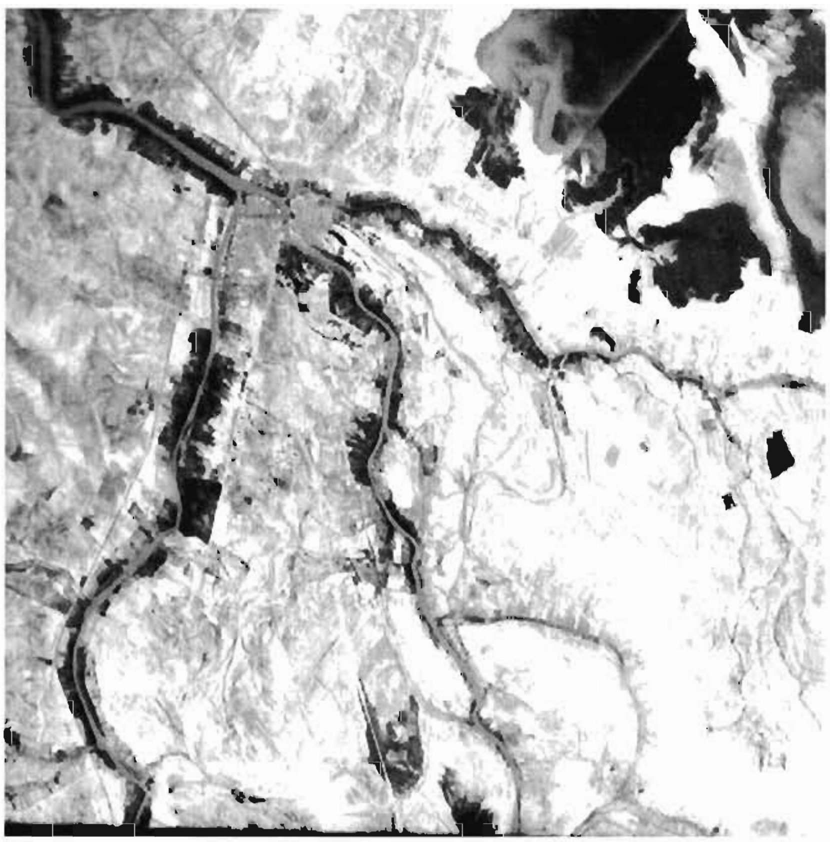

Figure 7B: Amara, straddling Tigris distributaries arrayed in a "bird's foot" delta rapidly built up and extended by riverbank rice cultivation. Source: KH4B_1103-1A-D041-056 (May 1968). 4X enlargement to scale ~1:75,000.

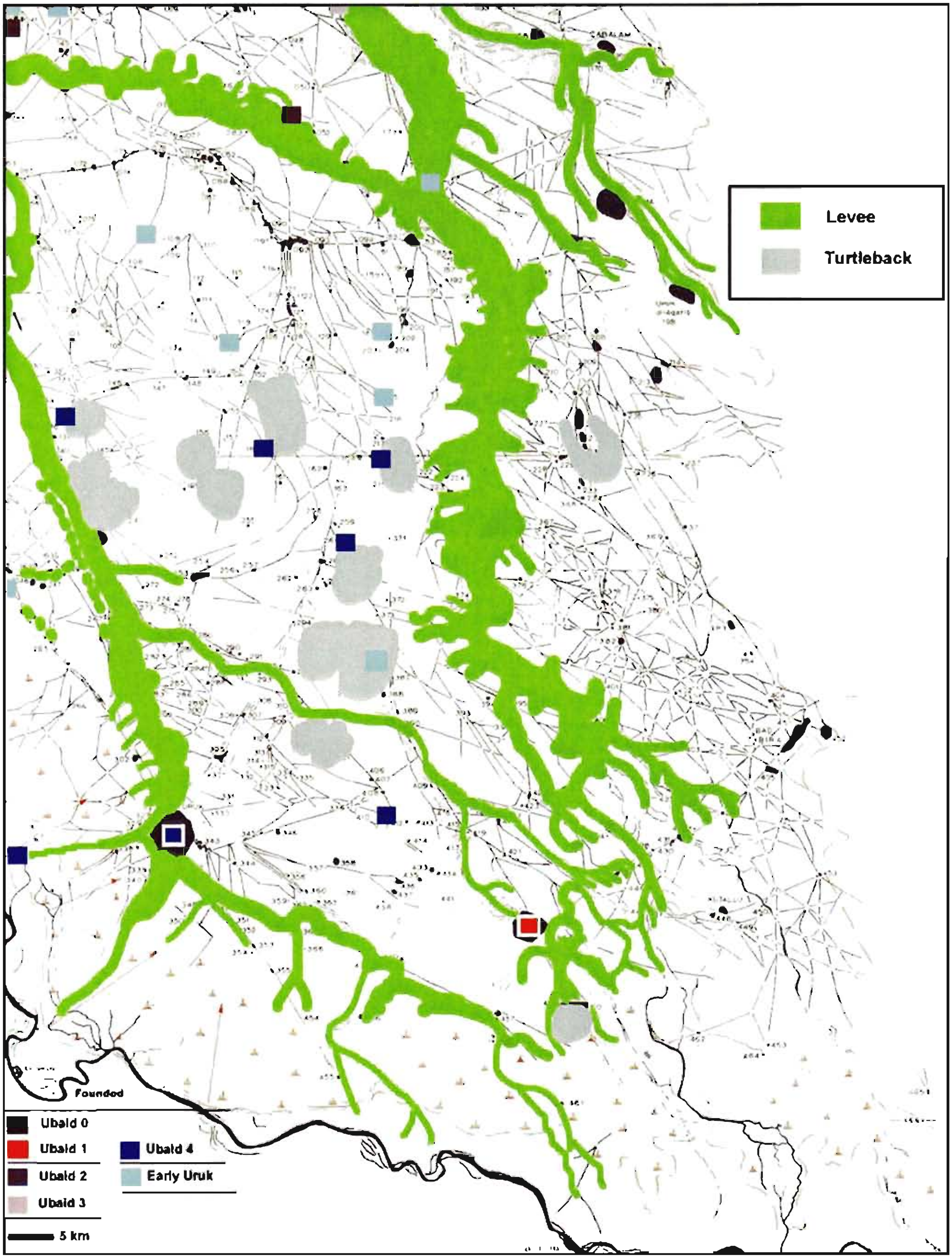

Figure 8: Warka survey area: Sites occupied during the Ubaid 4–Early Uruk periods (late 5th-early 4th millenium BCE). Legend (bottom) indicates earliest settlement period. After Adams 1981.

Figure 9: Relict levee, cut by modern canals, extends northeast-southwest through seasonal flood waters (black). Tel al-Hiba (Lagash) surmounts a Pleistocene turtleback appearing as an island to the south. Note linear sites visible along the levee, and multiple occupation mounds visible on the turtleback.
Source: USGS (Corona KH4) KH4B_1103-1A-D041-058.
2X enlargement to scale ~1:75,000.