State-Sponsored Irrigation Systems in the Assyrian Heartland, 702-681 BC:

Reconstructions Using Declassified Intelligence Satellite Imagery and Aerial Photography

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INTRODUCTION

Upon accession, the Assyrian king Sennacherib (704-681 BC) moved the imperial capital to a new location at Nineveh (modern Mosul, Iraq). Within the city, he built a massive new palace with walls covered with carved reliefs, many parks and gardens, and encompassed it all in a city wall enclosing 750 hectares. His engineers planned and constructed a series of irrigation canal systems in its hinterland (Fig. 1), which were adorned with carved reliefs of the king in the presence of the gods of Assyria.

This project's goals were to map systematically the surviving traces of this irrigation system and to place them within the larger framework of the Assyrian economy (Ur 2005, Wilkinson et al. 2005).

PREVIOUS RESEARCH

Before this project, the canal system had been reconstructed from two sources:

1. The inscriptions of the king himself, found written in cuneiform texts on clay tablets and on the irrigation features themselves;

2. The remnants of canals, weirs and aqueducts, visited opportunistically by travelers and archaeologists since the 1850's.

The British archaeologist Austen Henry Layard was the first scholar to visit the canal head at Khinis in 1851 (Fig. 2). In the 1930's, a team from the University of Chicago excavated an aqueduct along the Khinis canal (Fig. 3) and reconstructed its course (Jacobsen and Lloyd 1935). Other elements were briefly visited by David Oates and Julian Reade in the 1950's to 1970's (Oates 1968, Reade 1978). Reade (2000) pulled together the various features and used cuneiform sources to propose a four-stage developmental sequence from 702 BC to 688 BC.

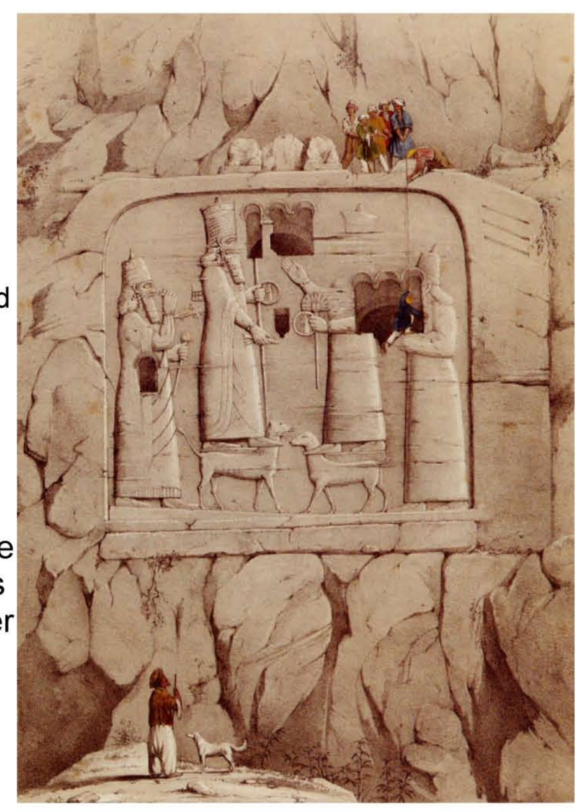

Fig. 2. Austen Henry Layard being lowered by Kurdish villagers to read inscriptions carved over the canal head at Khinis in 1851.

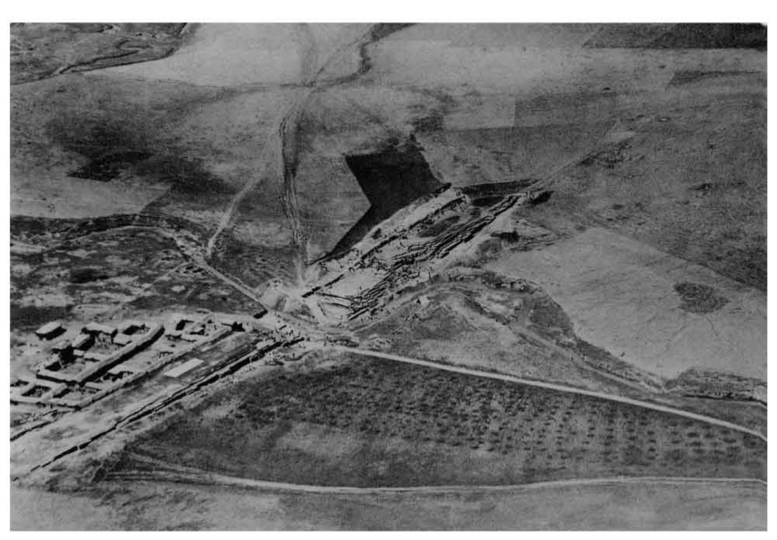

Fig. 3. Excavations at the aqueduct at Jerwan. The aqueduct spanned a *wadi* (seasonally flowing drainage). The continuation of the canal can be seen as a dark line running toward the top of the image.

After over a century, the scholarly consensus was that the network of canal systems was primarily intended to irrigate luxury parks and gardens within the city of Nineveh, and to a lesser extent, to irrigate orchards and cereal fields in the immediate hinterland of the capital (Bagg 2000, Reade 1978)

METHODS

Since archaeological fieldwork by foreign researchers in Iraq has been suspended since 1990, this reassessment relied on remote sensing datasets in a GIS framework. Two datasets proved to be useful:

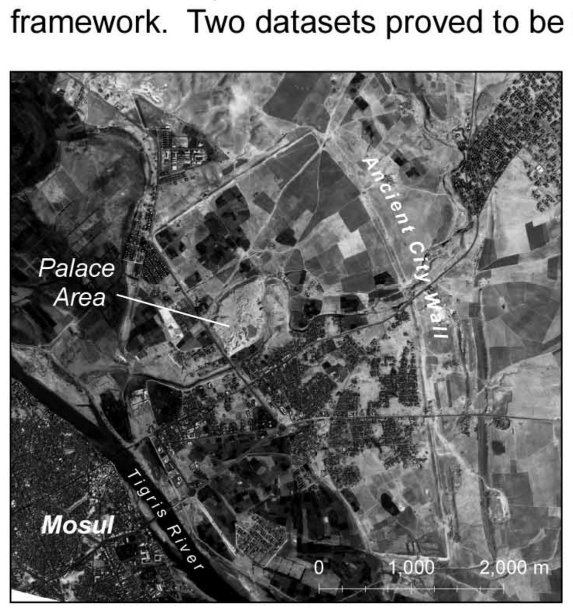

Fig. 4. KH-7 image of the Mosul-Nineveh area. DZB403100057H014, taken 20 August 1966.

1. Recently declassified CORONA and KH-7 intelligence satellite photographs taken by the US in the 1960's and early 1970's (Fig. 4). These recently available sources are powerful tools for archaeologists working in regions where low level aerial photographs have traditionally been denied to foreigners (see review in Fowler 2004).

2. Low level aerial photographs acquired by a private firm in the mid-1950's.

These datasets were of high enough resolution (2 m or better) to resolve archaeological phenomena. Furthermore, they have the advantage of age: they predate the agricultural intensification and the expansion of towns and cities that has destroyed or obscured much of the archaeological record in the last half-century. These images were georeferenced in ERDAS Imagine 8.7 with control points derived from orthorectified panchromatic SPOT imagery. The output CORONA and aerial photographs are 2 m resolution.

Potential ancient canals were located visually. Their signatures were characterized at known locations where canals had been identified on the ground. Other areas of northern Assyria were then scanned for similar features. Hydrological features such as canals could be distinguished from depressed trackways and natural drainage features by referencing a digital elevation model: canals generally ran parallel to topographic contours, whereas roads could run up and over watersheds, and natural drainage was always perpendicular to the slope (Fig. 5)

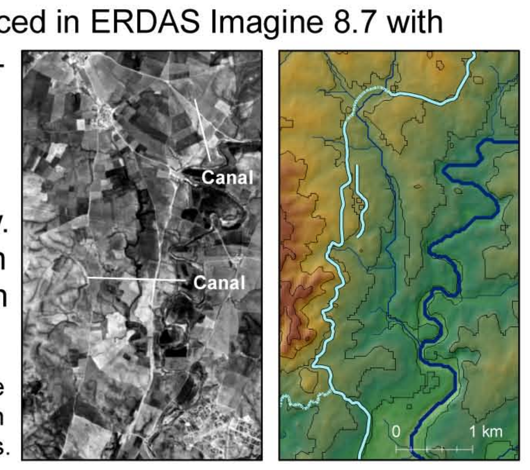

Fig. 5. May 1972 CORONA (1117-1025DF149) of the middle Kisiri canal (left) and the topography of the region (right). 10m contour intervals.

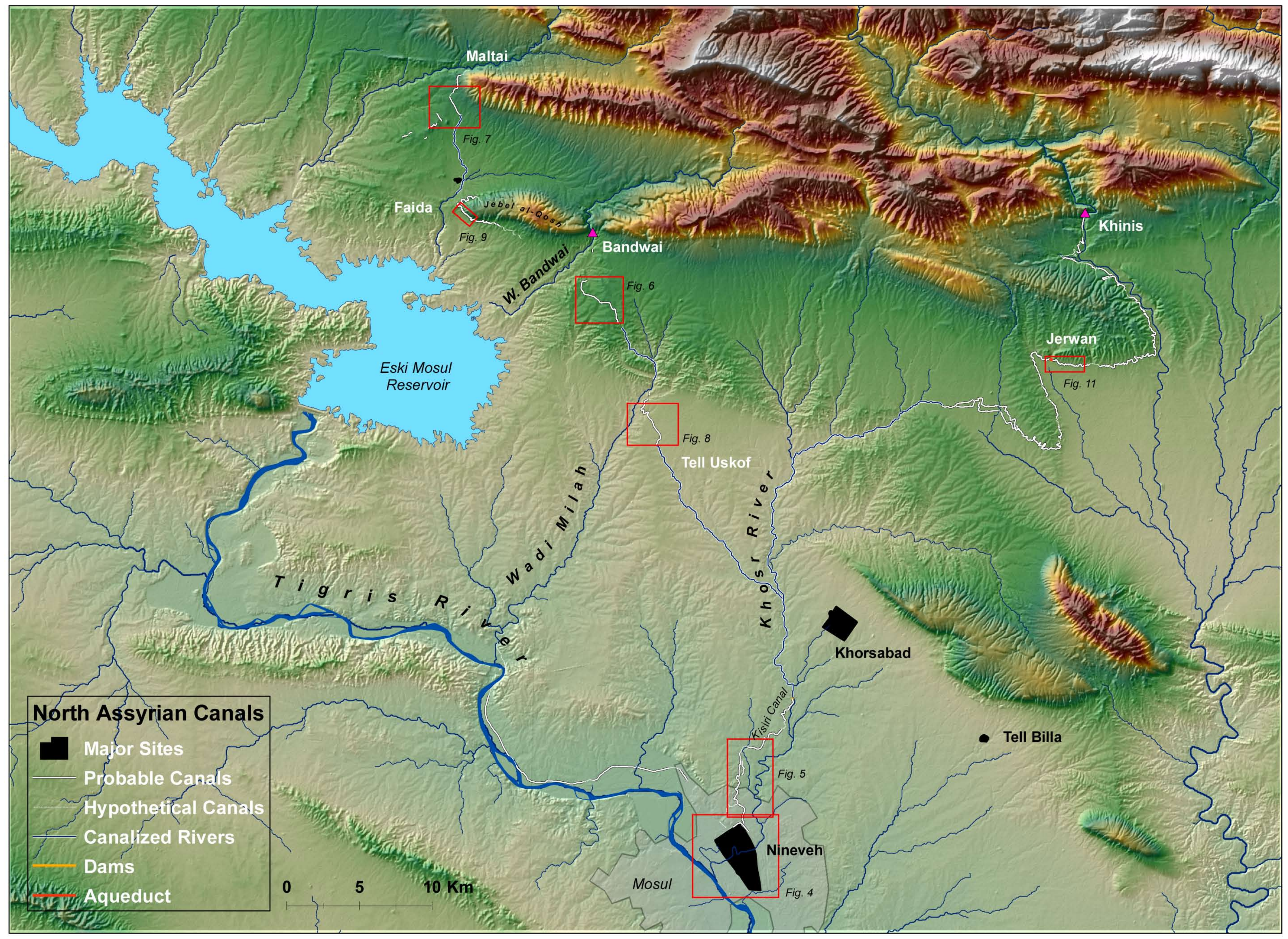

Fig. 1. Topography of Northern Assyria (modern northern Iraq).

RESULTS

All remnants of Sennacherib's canals previously identified on the ground were recognized and accurately mapped on CORONA and aerial photographs. Furthermore, a range of new irrigation canals could be recognized. In the 1970's, Julian Reade (1978) noted that all known (at the time) canal traces were associated with carved rock reliefs, and proposed that other known reliefs might have unrecognized canal traces nearby. This remote sensing-based assessment verifies Reade's proposition.

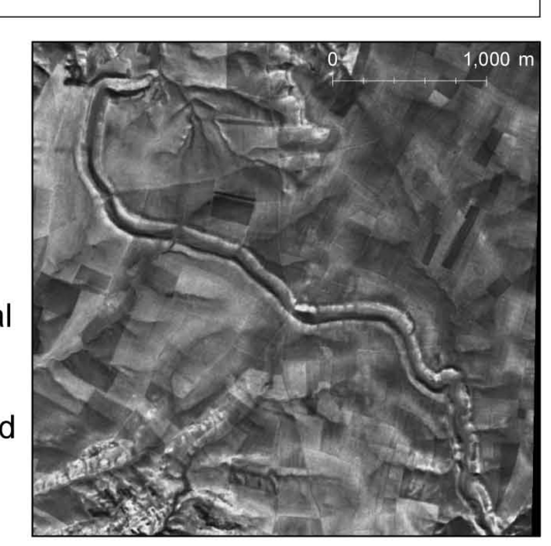

Fig. 6. The cross-watershed earthwork near Bandwai. CORONA 1108-1025DA007 (Dec 1969).

Sennacherib's canal systems were composed of two primary canal forms:

1. Major cross-watershed earthworks. The largest and most impressive was recognized on the ground below Bandwai in the 1950's (Oates 1968) (Fig. 6). It was excavated 20 m into the watershed between two drainage basins, and carried water from the Wadi Bandwai to the Wadi Milah. Two similar but previously unrecognized earthworks can be found beneath Maltai (Fig. 7) and above Tell Uskof (Fig. 8). The latter connected with the Bandwai earthwork to move water into the Khosr system, but the former appears to have been part of an independent system. The width of these features on the imagery (up to 100 m across) is probably related to the need for maintenance and not the width of the actual channel.

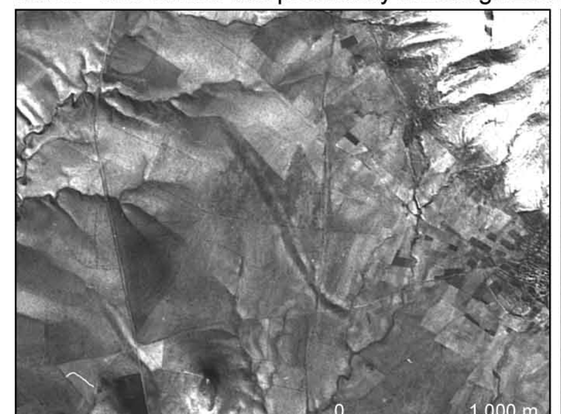

Fig. 7. Earthwork below Maltai (CORONA 1102-1025DF007, Dec 1967).

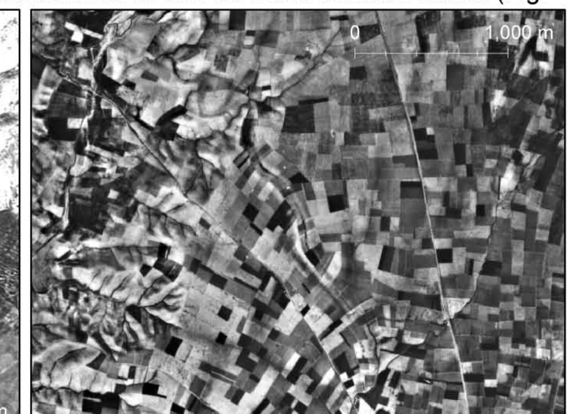

Fig. 8. Earthwork above Tell Uskof (aerial photograph taken Spring 1955).

2. Smaller channels 6-20 m wide and up to 2 m deep. Unlike the earthworks, the courses of these canals were almost wholly dictated by local terrain. The best-studied on the ground originated at a weir near Khinis. It ran over 90 km and crossed an aqueduct near the village of Jerwan (see Fig. 3). A morphologically similar canal near Faida tapped a spring on the north side of the Jebel al-Qosh and moved its water to irrigate land on the south side (Fig. 9).

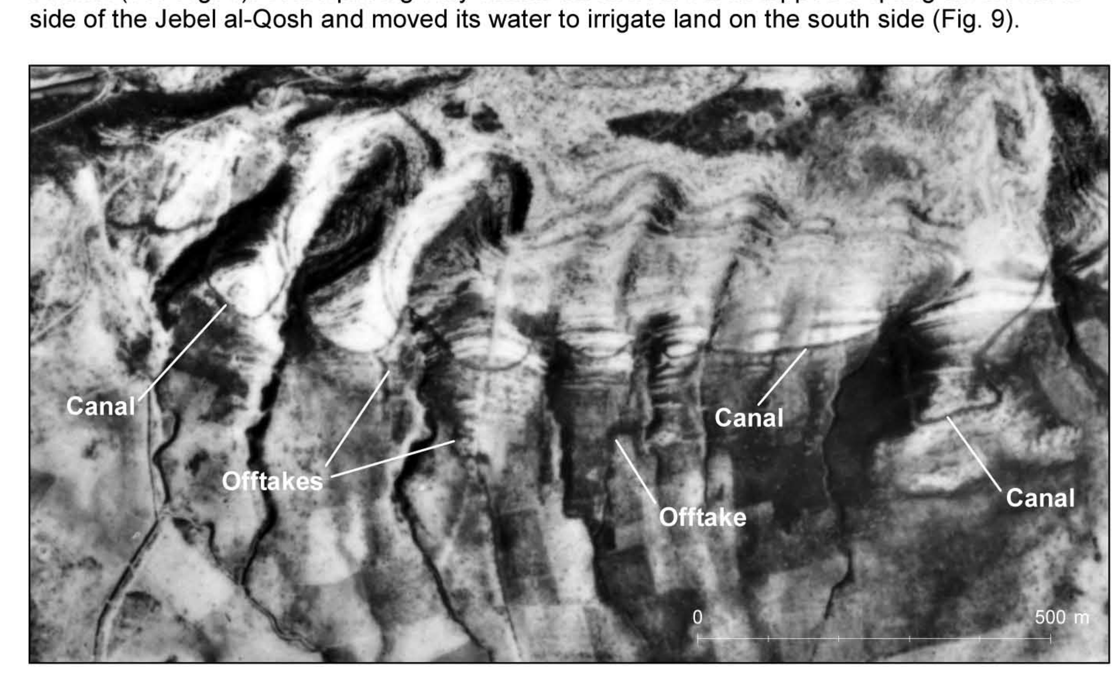

Fig. 9. Small canal on the south side of the Jebel al-Qosh. Note that the course of the canal is dictated entirely by the topography. Spring 1995 aerial photograph.

In total, the canals recognized via remote sensing sources run for over 100 km, and represent an enormous investment in manpower (Table 1).

Stage	*Year*	*Length* (km)	*Gradient* (m/km)
1. **Kisiri Canal**	702	13.4	0.95 (al-Shallalat-fork)
2. **Musri System**	694	-	-
3. **Northern System**	ca. 690	46.4 (total)	
Maltai		4.2	4.0
Faida		9.7	1.6
Bandwai		5.0	0.8-1.0 (earthwork)
Uskof		4.4	1.2 (earthwork)
Tarbisu		23.1	0.6
4. **Khinis Canal**	ca. 690-688	55.0	0.9 (Gomel-Jerwan)

Table 1. The four stages of Sennacherib's canal system; years based on Bagg 2000: Table 5

DISCUSSION

Scholarly consensus has been that these canals were non-economic luxuries (Bagg 2000, Reade 1978). Royal inscriptions and palace reliefs describe elaborate parks and gardens (Fig. 10), and Sennacherib attempted to reconstruct the landscapes of the conquered lands of the Assyrian Empire. These landscapes included the marshes of Babylonia, the replication of which would have required abundant water.

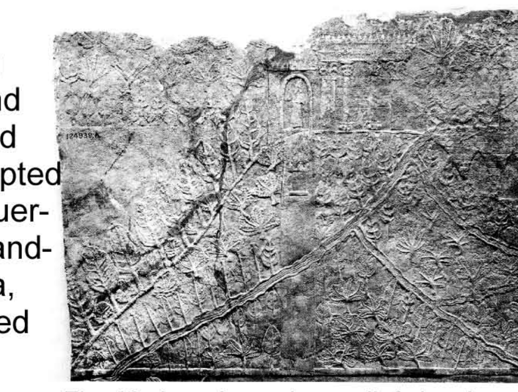

Fig. 10. Assyrian palace relief showing a garden with an irrigation channel flowing over an aqueduct.

Contrary to this consensus, this reassessment suggests that Sennacherib's canals were being used to irrigate fields at great distances from the imperial capital at Nineveh. Small offtakes and local distributaries were installed on the Faida canal and especially on the Khinis canal near Jerwan (Fig. 11). In the case of Faida, the offtakes are associated with carved reliefs, which suggests that such local irrigation was in the original design of the system and was authorized by the state.

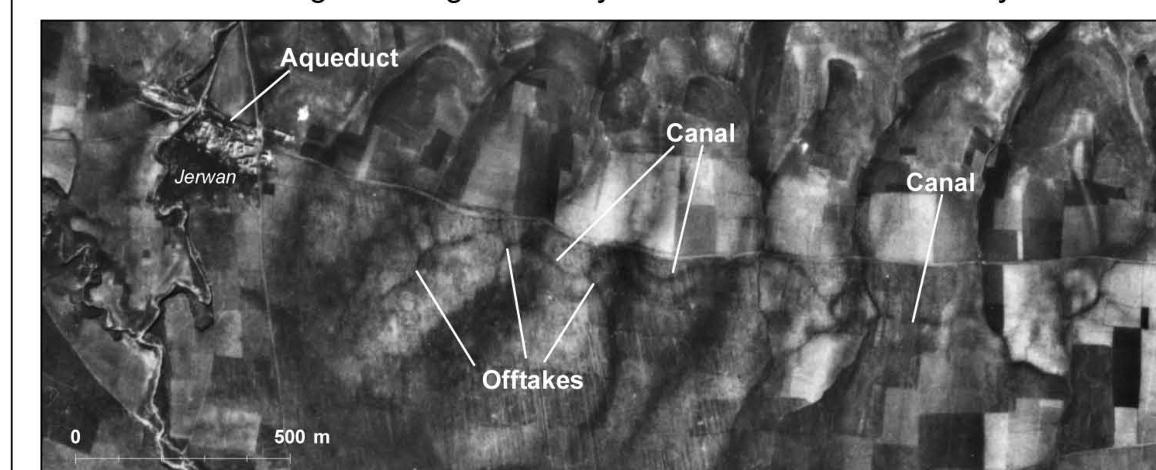

Fig. 11. Offtakes for local irrigation along the Khinis canal near Jerwan. Aerial photograph, 1955.

Who, then, was benefiting from this elaborate network of canals? There has been no systematic archaeological settlement survey in the Assyrian heartland, but settlement patterns from surveys around Tell al-Hawa (Wilkinson and Tucker 1995) and Hamoukar (Ur 2002) give a glimpse of settlement contemporary with Sennacherib's canals (Fig. 12). In both areas (facing each other across the Syrian-Iraqi border) the pattern is of homogeneously small villages or hamlets evenly spaced across the plain. This arrangement is an ideal distribution of agricultural labor. It differs dramatically from the Early Bronze Age (3rd millennium BC) pattern of nucleated settlement in a few large centers.

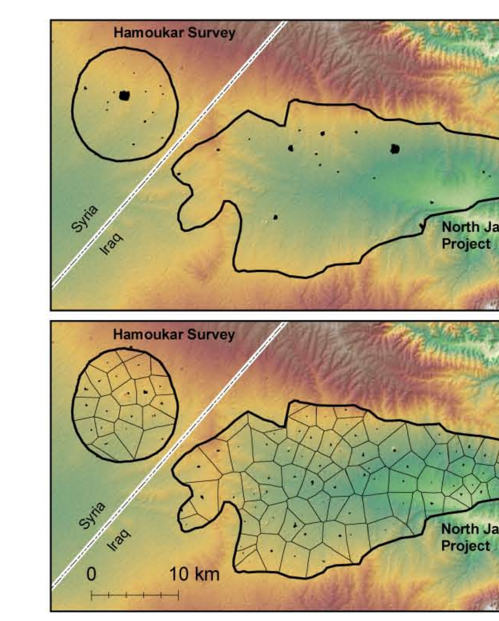

Fig. 12. Early Bronze Age nucleation (top) and Neo-Assyrian dispersal (bottom, with theissen polygons)

CONCLUSIONS

To understand the function of, and motivations behind, the irrigation systems and settlement patterns as reconstructed by this study, they must be put into their historical context. The Bible and Sennacherib's own inscriptions describe his policies of deporting the populations of captured towns and regions as he expanded the Assyrian empire (Fig. 13; see Oded 1979). These captives were often resettled elsewhere in the empire, but the majority were brought back to Nineveh and the surrounding region. It is possible that we are seeing the settlement footprint of such policies in the systematic distribution of human settlements in the region around the capital as documented around Hamoukar and Tell al-Hawa (Ur 2005, Wilkinson and Barbanes 2000, Wilkinson et al. 2005).

Fig. 13. Assyrian palace relief of captive families being deported.

The agricultural productivity of these resettled persons would have been maximized by the presence of reliable irrigation water supplies. It is now clear that a broad area of northern Assyria benefited from the state irrigation systems, and that this would have included resettled deportees. The combination of reliable water supplies and efficiently distributed labor would have enabled the great agricultural surpluses required by the new imperial capital at Nineveh.

The landscape of the Assyrian heartland thus appears to have been highly planned, from the deliberate reorganization of its hydrology to the imposed patterns of settlement.

ACKNOWLEDGEMENTS

The CORONA and KH-7 imagery used in this research appears courtesy of the USGS and is now held by the University of Chicago Oriental Institute's Center for the Archaeology of the Middle East Landscape (CAMEL). The aerial photographs are used by kind permission of the British School of Archaeology in Iraq.

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