Stony Brook University

THE APPLICATION OF GIS AND REMOTE SENSING TO THE ARCHAEOLOGY OF IRAQ: A CASE STUDY FROM SOUTHERN MESOPOTAMIA

A Thesis presented

By

Zaid I. Ibraheem

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Abstract of the thesis

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This thesis tests the possibility of employing GIS tools and remote sensing methods to make the data included in the Atlas of the Archaeological Sites in Iraq (henceforth referred to as the Atlas) usable in today's electronic world. The method uses georeferenced and high resolution Digital Globe imagery to help identify the true location of the sites recorded in the Atlas. These methods were tested in two areas, that around the site of Girsu, and that around the site of Isin.

Two methods were tested. In the first, comparisons were made between modern features recorded in both the maps and the satellite imagery which allowed the identification of nearby archaeological sites. The second method involved georeferencing the maps published in the Atlas based on locations which could be identified on both the maps in the Atlas and in the

imagery. The results of a broader application of this research would be a digital atlas of archaeological sites, where information on size and site location based on imagery can be joined to the information on the periods of occupation of the sites published in the Atlas. These data would then provide important tool for both site protection and research into ancient Mesopotamian settlement patterns.

I dedicate this study to my people, who have been suffering through many hardships and tragedies. I wish for them a new period of flourishing, prosperity, and happiness. May we soon again see the smiling faces and joking character that Iraqis have been known for.

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Acknowledgments

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I am greatly thankful to the indescribable support of my family and especially my mother, which had a great effect on my work even from far away. I am also thankful to all my colleagues and friends back home in the Department of Archeology and the Iraqi National Museum, especially the staff of the Iraqi National Museum Library; I have been encouraged not only by their words but also when I simply think about their friendship and brotherhood. For those who lost their lives among them, in the past few years I regret that I will never see them again. May God bless their souls.

I appreciate the company of my colleagues and friends Ghufran Ahmad, Lina Mahmood, and Sereen al-Zatary, who surrounded me with an enjoyable, congenial atmosphere throughout my period of study. I wish them all good in their academic path.

Finally, I wish to be forgiven for forgetting any of the important individuals because of whom this work could be achieved.

Chapter One

Objective

This project seeks to exploit the information contained in the archaeological maps of Iraq published in the *Atlas of the Archaeological Sites in Iraq* through the use of remote sensing methods, and, to a certain extent, newer maps of the region. The Atlas shows the locations of a large number of archaeological sites and provides information on their periods of occupation. The maps, however, are often inaccurate due to the difficulties of surveying and mapping in the 1960s, long before the age of GPS. In this project I use data from high resolution satellite imagery to identify the geographic coordinates of the sites recorded in the Atlas in two different areas within southern Mesopotamia, in order to establish a model which can be applied to other parts of the country.

The need for such a project is critical in the current political climate. Although political instability was evident before the onset of military operations in 2003, leading to further isolation from the international archeological community, the onset of the war and all the turmoil it produced negatively affected the archeological sector. Post-war circumstances have blocked access to the Mesopotamian sites. The lawlessness and instability is not only evident in the political and social fabric of the country but has impacted its archeological sector. Under these circumstances, Iraqi archaeology can most easily advance if modern archaeological methods, including GIS and GPS, are used to manage its unique cultural heritage. This project provides a method for taking the paper records of archaeological site locations and bringing them into the digital age.

Sources

In this project, I will depend on two primary datasets. The first is the Atlas (*Atlas of the Archaeological Sites in Iraq*) and the second are images taken from Digital Globe Imagery. As a secondary resource I will use relatively new Iraqi maps of southern Iraq.

1. a. ***Atlas of the Archaeological Sites in Iraq***

This atlas was completed in 1976 by teams of archaeologists and engineers. It was developed in response to the needs of the archeological community to integrate maps accumulated in the Department of Investigation and Protection of the Archaeological Sites, located in Baghdad. The atlas includes all survey efforts that had been completed during the fifty years before 1968. The goal of the workers on this project was to collect all the maps, revise information and organize them as an atlas, making it easier for scholars to investigate issues that were beneficial for their particular research. Seven thousand archaeological sites were observed before 1968 and have been included in the atlas. The smallest unit in the atlas is the sub-district, which is also the smallest administrative unit in the country. A large scale map represents the district map. The province map comes as the second biggest map, while a map of the whole area of Iraq the largest scale map in the atlas. Figs. 1, 2, 3, and 4 show maps of the four levels of administration from the Atlas. This quaternary division system is a traditional Iraqi method that is still being used today. The Atlas does not, however, cover all of Iraq, only those sub-districts which were subjected to detailed archaeological surveys. Due to space limitations, the Atlas designers preferred not to write names of archaeological sites onto the maps. Instead, they gave each archaeological site, tell, or location a triangular sign. Each triangle has a number attached to it on the map; a list of these numbers with their sites names is located beside each map or at the bottom of the page. Furthermore, square symbols on each map are used to indicate the locations

of modern villages and circles are sometimes used to indicate a position of cities, districts, sub-districts, or provinces (Directorate General of Antiquities 1976: 1&2), (see Fig. 1). The maps in the Atlas have a sketchy appearance and the scales are not uniform across the maps.

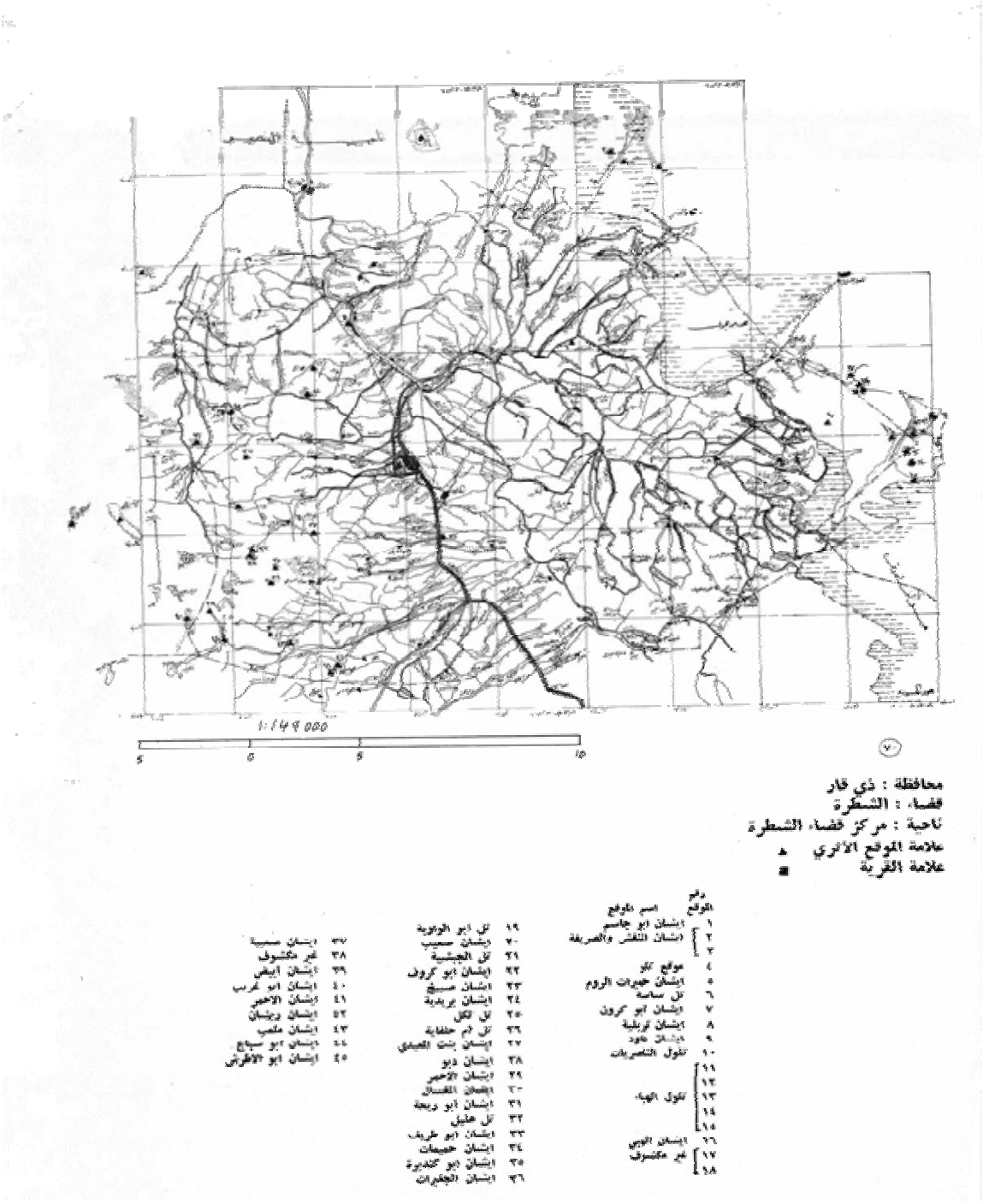


Fig. 1: One of the southern sub-districts, called Center of Shatra District

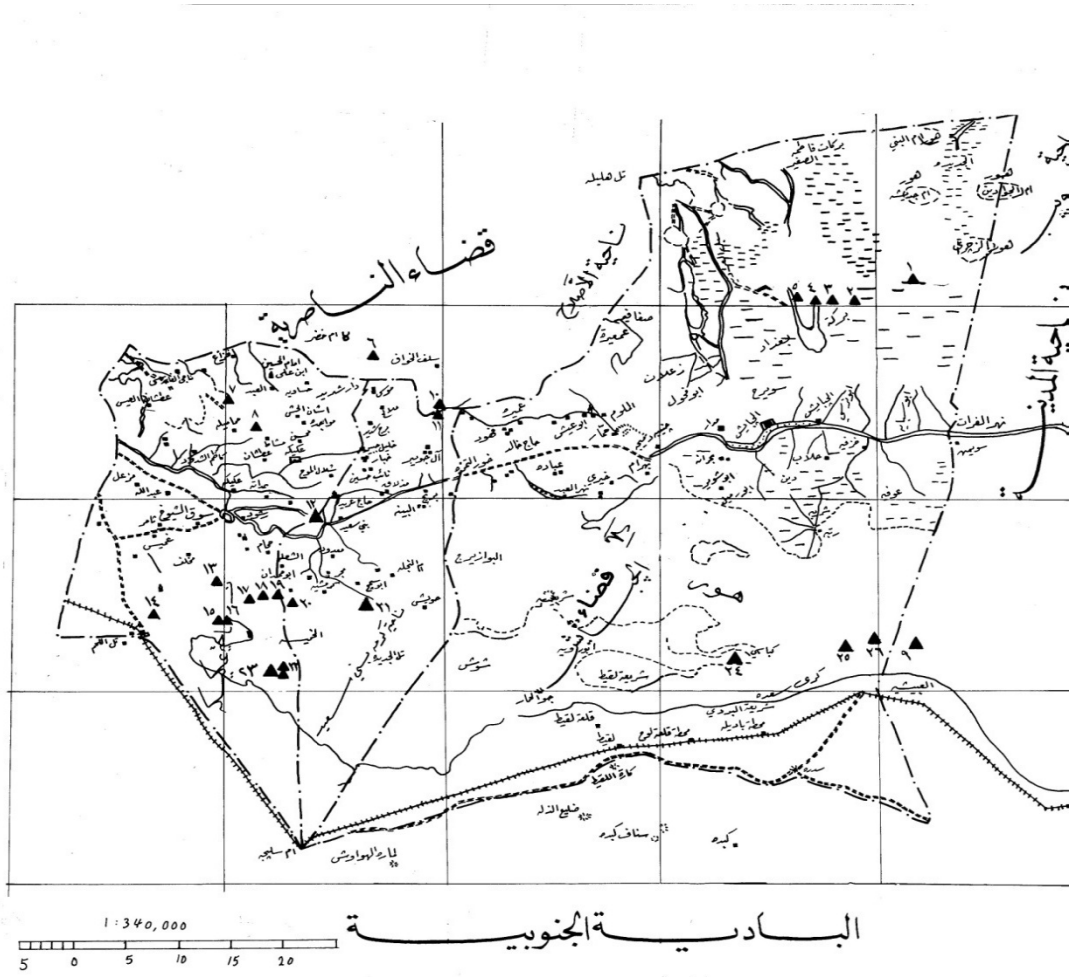


Fig. 2: al-Cheapish, one of the districts in the southern desert region

Fig. 3: Thi Qar province. This map represents the second biggest scale in the atlas

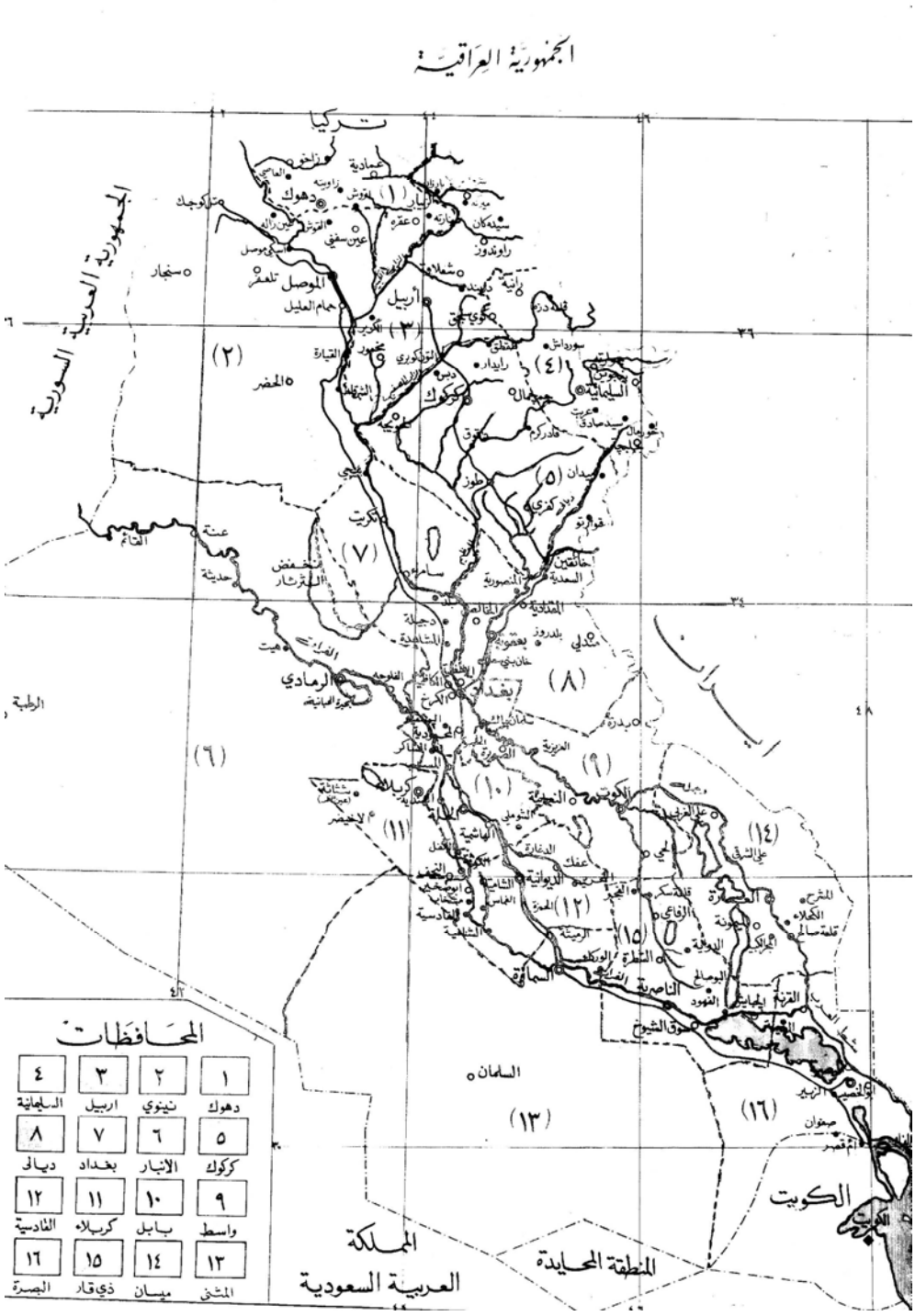


Fig. 4: The area of Iraq, as it appears in the Atlas

b. **The Guide Book of Archaeological Sites**

This is a publication that includes an extensive list of surveyed archaeological sites, both those included in the Atlas and information on sites from other resources and references. These lists consist of all known sites as of 1969. The unique aspect of this data source is its provision of additional information other than site names, such as the file number of each archaeological site, the name of the village where each site is located, the number and the date of the official newspaper in which each site was first declared. Finally, and most importantly, the list provides information on the periods when each site was occupied, information which is not available elsewhere. Dating information for these sites ranges from the Early Paleolithic through the Islamic era. Each of these time periods was given a number to indicate the particular period. For instance, the number ten corresponds to the Old Babylonian Period in the list. Therefore, when the number a site has the number ten beside it; it means this site belongs to the Old Babylonian Period. Similarly, if a site has more than one number, it means the site has more than one occupation layer and that each of these levels corresponds to one of the Mesopotamian historic eras (see Table I A&B).

محافظة اربيل ـ قضاء مخمور ـ ناحية مخمور

الاضبارة	اسم الموقع	القرية	رقم الجريدة	تاريخها	الادوار التاريخية
١٤٧	صرناج صغير (تل)	صرناج صغير	١٩٩٣	٩٤١/٢/٩	١١،١٠،٤
١٨٢	صرناج كبير (تل)	صرناج كبير	»	»	حديث
٢١١	الصغيرة (خربه)	الصغيرة	»	»	١٢
٥٥	عبطان (خربة)		»	»	
٢٠٨	عتيرة (تل وخرائب)	عتيرة	»	»	١٠ـ١٢
١٨٧	عثمان (خربة)	عثمان	»	»	١٠ـ١٢
٧٧	عدو (خربة)	علي رش	»	»	حديث
١٢٠	عزيز بهرام	شوره بلكه	»	»	
١٠٩	عزيز عبدة (خرائب)	عزيز عبده	»	»	١ـ٦
١٠٦	علي خضر (خربة)	كرد جال	»	»	
٧٦	علي رش (خربة)	علي رش	»	»	١ـ٦
١٤٣	العنز (خرائب)	حمده ستير	»	»	٥
٧٤	علياوة (خربة)	علياوه	»	»	١٨
٧٥	علياوة والشيخ جولي (خرائب)	علياوه	»	»	١٨
١٤٠	عمر اسماعيل (خربة)	كراو	»	»	
١٦٤	عمر آوه (خربة)	عمر آوه	»	»	٤
٦١	عمر (خربة)	دوسره الفوقانية	»	»	
١١٨	عمر (خربة)	عدلـه	»	»	١٠ـ١٢
١٣٠	عين كاوه (خربة)	عين كاوه	»	»	٤
١٤٨	غديلة (خربة)	غديلة	»	»	١٠ـ١٢
١٨١	الغزال (تل)	الغزال	»	»	١١ ، ١٢
١٨٦	فاره (تل)	فاره	»	»	١٠ـ١٢
٨٥	فتاح (خربة)	جوكش	»	»	حديث
٠٩	فقي حسن (خربة)	هنجيروك	»	»	١٠ـ١٢
٧٣	قادر بلاني (خربة)	كرد كرادي	»	»	١٠ـ١٢
١٠٠	قادر عمر (خربة)	كوك تبه	»	»	١٠ـ١٢
٦٦	قاله كرده (خربة)	مخمور	»	»	
٥٧	قبره اسيلكه (خربة)	قوجه سيلكه	»	»	٤ ، ١٨
١٥٨	قرون الحمر (خربة)	قرون الحمر	»	»	١٨
٥٦	قوجه سيلكه (تل)	قوجه سيلكه	»	»	١١ ، ١٢
١٢٨	قوشنه (خرائب)	قوشنه	»	»	١٨،حديث

Table I A: A sample page from the lists shows information about archaeological sites located in Makhmoor sub-district in Makhmoor district in Arbil Province

Arbil Province - Makhmoor District -Makhmoor Sub-District.

FILE	SITE NAME	VILLAGE	NEWSPAPER #	ITS DATE	TIME PERIODS
147	Sirnaj Sagheer (Tell)	Sirnaj Sagheer	1993	2/9/1941	4,10,11
182	Sirnaj Kabeer (Tell)	Sirnaj Kabeer	1993	2/9/1941	Recent
211	Al-sagheera (Khirba)	Al-sagheera	1993	2/9/1941	12
55	Abtaan (Khirba)		1993	2/9/1941	
208	Ateera (Tell& ruins)	Ateera	1993	2/9/1941	10 to 12
187	Othmaan (Khirba)	Osman	1993	2/9/1941	10 to 12
77	Ado (Khirba)	Ali Rash	1993	2/9/1941	Recent
120	Azeez Bahraam	Shoora balka	1993	2/9/1941	
109	Azeez Abda (ruins)	Azeez Abda	1993	2/9/1941	1 to 6
106	Ali khidir (Khirba)	Krd Jaal	1993	2/9/1941	
76	Ali Rash(Khirba)	Ali Rash	1993	2/9/1941	1 to 6
143	Al-anz(ruins)	Hamda steer	1993	2/9/1941	5
74	Alyawa(Khirba)	Alyawa	1993	2/9/1941	18
75	Alyawa&Shaykh Jooli(ruins)	Alyawa	1993	2/9/1941	18
140	Omar Ismaeel(Khirba)	Kraw	1993	2/9/1941	
164	Omar Awa(Khirba)	Omar Awa	1993	2/9/1941	4
61	Omar (Khirba)	Dosra Al-foqania	1993	2/9/1941	
118	Omar (Khirba)	Adla	1993	2/9/1941	10 to 12
130	Aeen Kawa(Khirba)	Aeen Kawa	1993	2/9/1941	4
148	Ghdeela (Khirba)	Ghdeela	1993	2/9/1941	10 to 12
181	Alghazal(Tell)	Alghazal	1993	2/9/1941	11,12
186	Fara(Tell)	Fara	1993	2/9/1941	10 to 12
85	Fattah (Khirba)	Joksh	1993	2/9/1941	Recent
89	Fqi Hassan(Khirba)	Hinjerok	1993	2/9/1941	10 to 12
73	Qadir Blaani(Khirba)	Krd Kradi	1993	2/9/1941	10 to 12
100	Qadir Omar(Khirba)	Kok Tapa	1993	2/9/1941	10 to 12
66	Qala Krda(Khirba)	Makhmoor	1993	2/9/1941	
57	Qbra Aseelka(Khirba)	Qoja Seelka	1993	2/9/1941	4,18
158	Qroon Al-homor(Khirba)	Qroon Al-homor	1993	2/9/1941	18
56	Qoja Seelka(Tell)	Qoja Seelka	1993	2/9/1941	11,12
128	Qoshna (ruins)	Qoshna	1993	2/9/1941	18,Recent

#	Time Period	#	Time Period	#	Time Period
1	Old Stone Age	8	Early dynastic	15	Seleucid
2	New Stone Age	9	Sumer & Akkad	16	Parthian
3	Hassunah	10	Old Babylonian	17	Sassanid
4	Samarra, Halaf, Eridu	11	Kassite	18	Islamic
5	Ubaid	12	Assyrian Empire	19	Recent
6	Warka	13	New Babylonian		
7	Jemdet Nasr	14	Achaemenid		

Table I B: Translation and illustration of the information listed in Tab. I A

2. Satellite Photography from Digital Globe Corporation

Satellite imagery will be used in this project to provide locational data for the sites. Two imagery collections will be employed. The first group covers an area in the vicinity of Girsu and the second of the area around Isin. These areas were chosen because high resolution Digital Globe imagery was available. Although Landsat (30m resolution), Aster (15m resolution), Spot (10m resolution), Corona (2m resolution), and Aerial Photographs (1m resolution), could potentially provide the project with the data needed for this study, Digital Globe imagery has the best commercially available imagery, surpassing current accessible photography. Its resolution has reached 0.6 meter (see Fig. 5). Digital Globe imagery comes already georeferenced, unlike Corona, the other high resolution imagery.

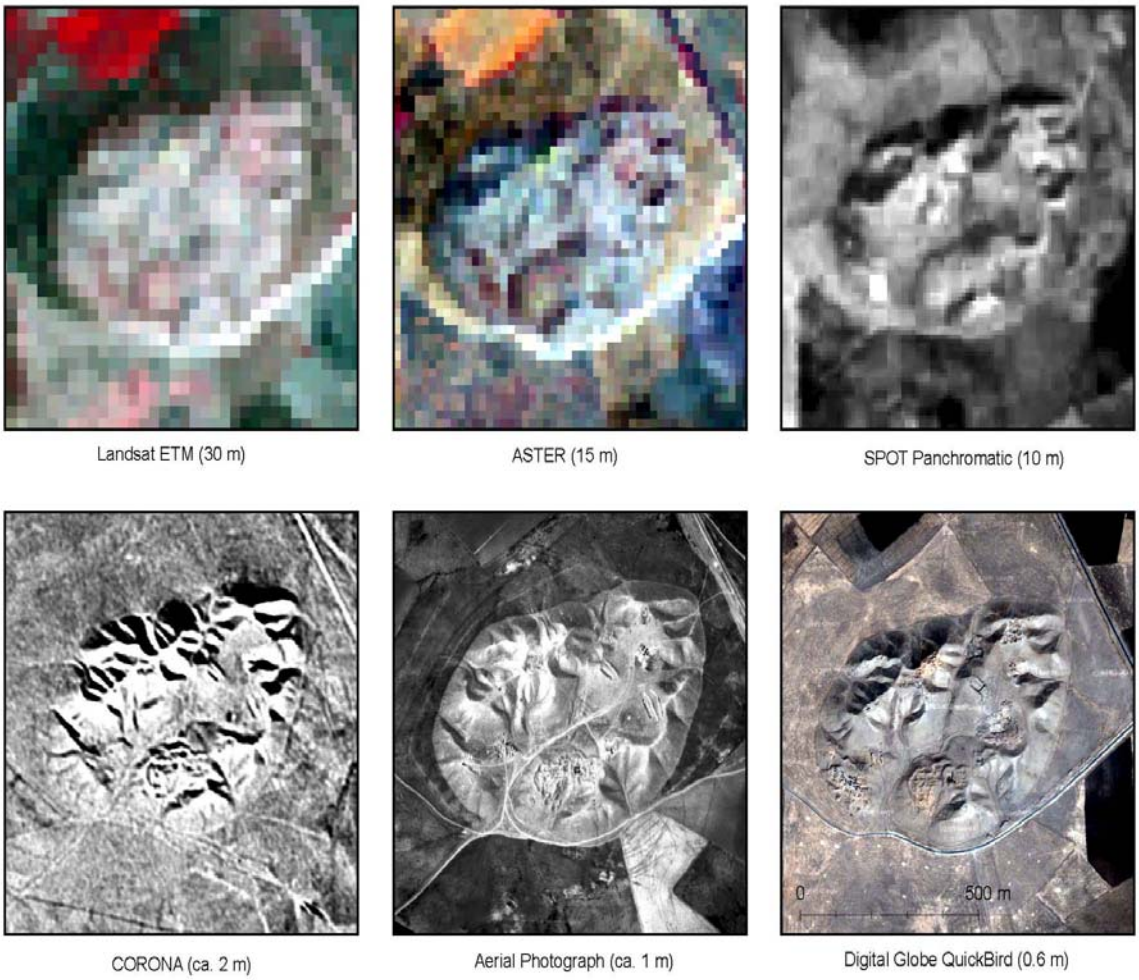


Fig. 5: Spatial resolution comparison among six data sources (Tell Brak, Syria)

3. Recent Maps of Iraq

This project will also use recent 1:100.000: maps of Iraq, but they will be used only to check the correct alignment of the maps in the Atlas, and to obtain newer views of the project area when needed. These maps were developed in the nineteen eighties, for use by the Iraqi military. They show many natural and man-made features, such as canals, rivers, marshes, villages, cities, bridges, paved roads…..etc. Fortunately, they also include numerous major archaeological tells which can be useful in determining exact locations in comparison with the maps in the Atlas (see Fig. 6).

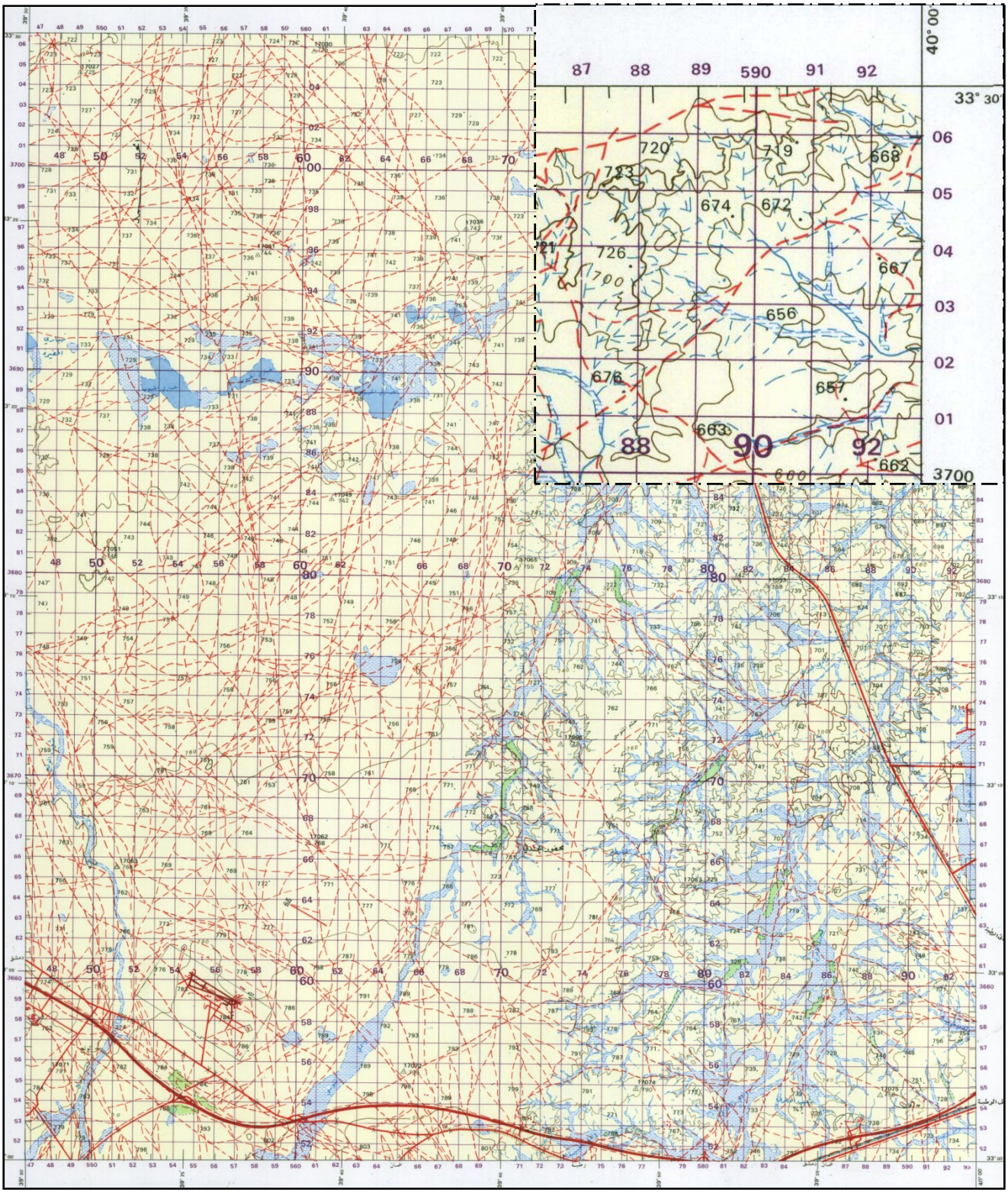


Fig. 6: One of the newer Iraqi maps represents Jendli region, which provides precise locations in latitude and longitude

Tools

ERDAS IMAGINE 9.1 and ArcGIS 9 are the remote sensing and GIS programs used in this project. ERDAS IMAGINE was used to manipulate the satellite images and for georeferencing. ARCMAP was employed to create shape files providing precise locations of the archaeological sites.

Critical Issues in the Main Sources

Even though the atlas and the satellite imagery are two different sources, the project will depend on them as one collective unit. Each of the two sources will complement each other. The maps in the Atlas provide a large number of archaeological sites have been identified and the accompanying gazetteer provides additional important information, such as site dating. On the other hand, theses maps do not have geographical coordinates on their quad sheets and the maps are often distorted. In contrast, the satellite photos provide accurate coordinates for each point. It is by using these two sources together that an accurate picture of ancient settlement in Mesopotamia can be achieved.

Chapter Two

Area I-Girsu

The capability of using satellite imagery to provide true coordinates for the sites recorded in the Atlas of Mesopotamian Sites will be examined on two different geographical areas. The first region is that around Girsu. Selecting this map of this particular area with various regions of intensive irrigation and naked land would add more experimental aspect to the project.

Geographical View

Area I in this project is the area around Girsu in southeastern Iraq (Fig.9), and is 2,586 sq.km. in size. The site of Girsu is located in the northwest corner (see Fig.8).

In the Atlas the al-Nasir sub-district map within the Thi Qar Province covers much same area as the available satellite imagery shown in Fig.8. There the area around Girsu covers 1,848 sq. km.of the area covered by the satellite imagery (Fig.10). Fig.11 shows the overlap between the satellite imagery and the map from the Atlas.

The map published in the Atlas of al-Nasir (Fig.10) includes details of the major canals and their branches, especially in the area around the site of Girsu and to the west and south of it. The largest of these rivers is al-Gharaf, running southward to the west of Girsu, together with many of its tributaries in the east and the west. However, the western portion and the south-western corner of the map appear relatively empty, since these were desert areas unlike the densely irrigated areas around Girsu. But this does not mean that these areas were not both

irrigated and occupied in the past. They were, as demonstrated by the presence of archaeological sites in the area. Our challenge, therefore, is to succeed in accurately georeferencing the map, both the areas with detailed modern topographic information, and the empty desert area.

The map includes the locations of fifty-nine registered archaeological sites which are distributed throughout the area. These sites are numbered and marked with a solid black triangle. Other sites are also shown on the map. These are surrounded by dotted lines and lack numbers, which means that information on their size and date of occupation is not included in the publication (see Fig.10).

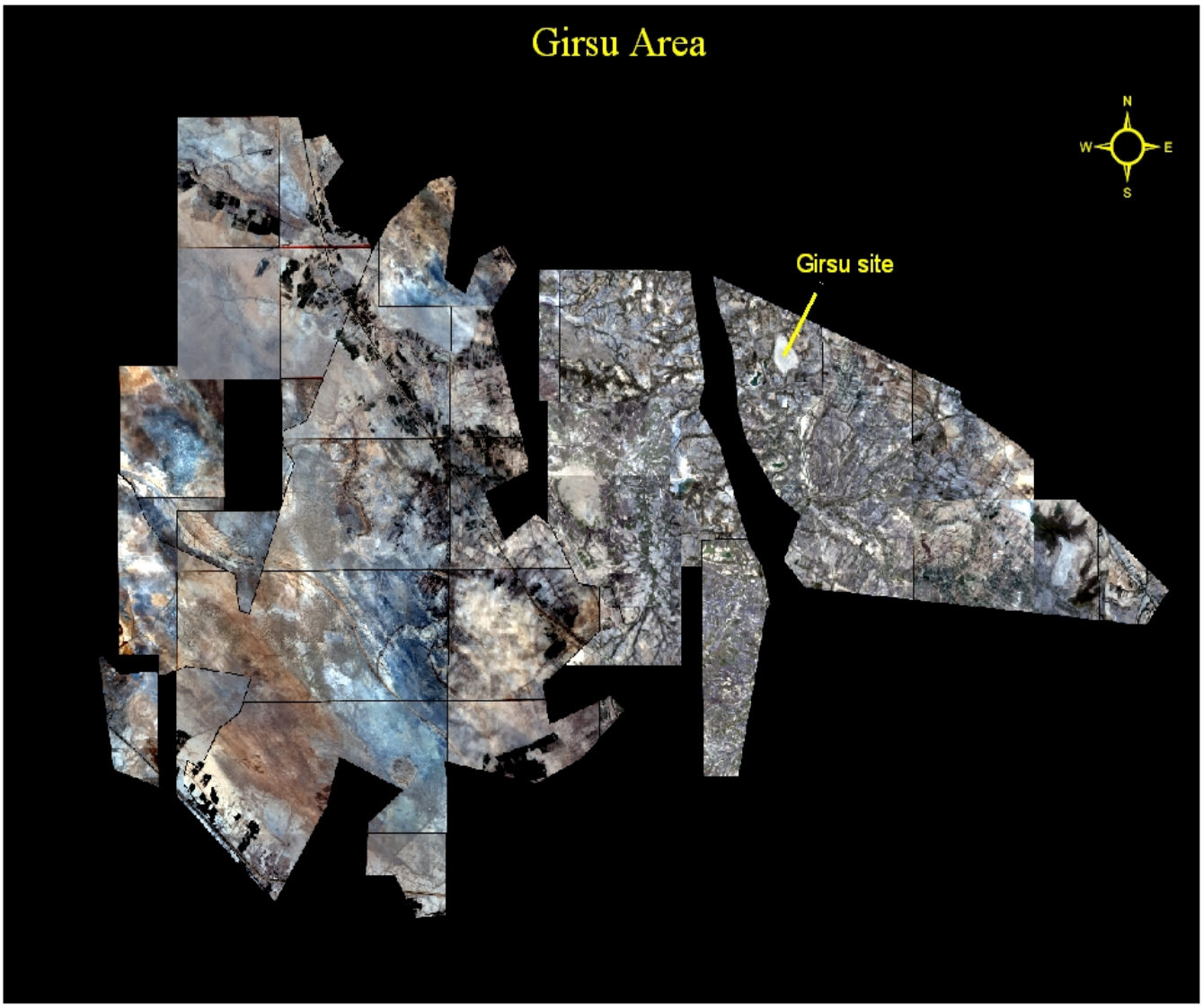


Fig. 8: Available Digital Globe Imagery of the Girsu region

Fig. 9: The position of Girsu on the map of Iraq

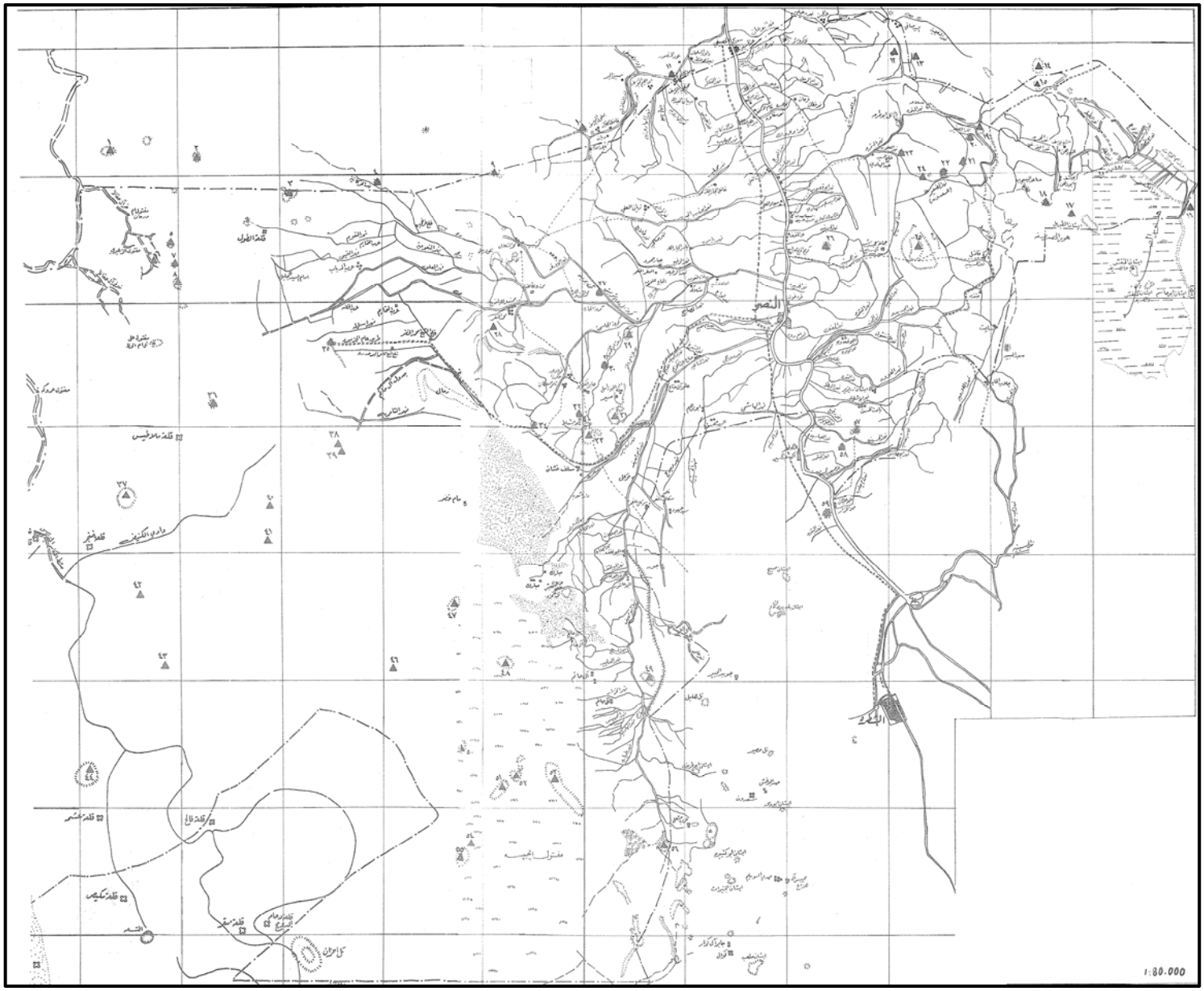


Fig. 10: The al-Nasir sub district in Thi Qar province

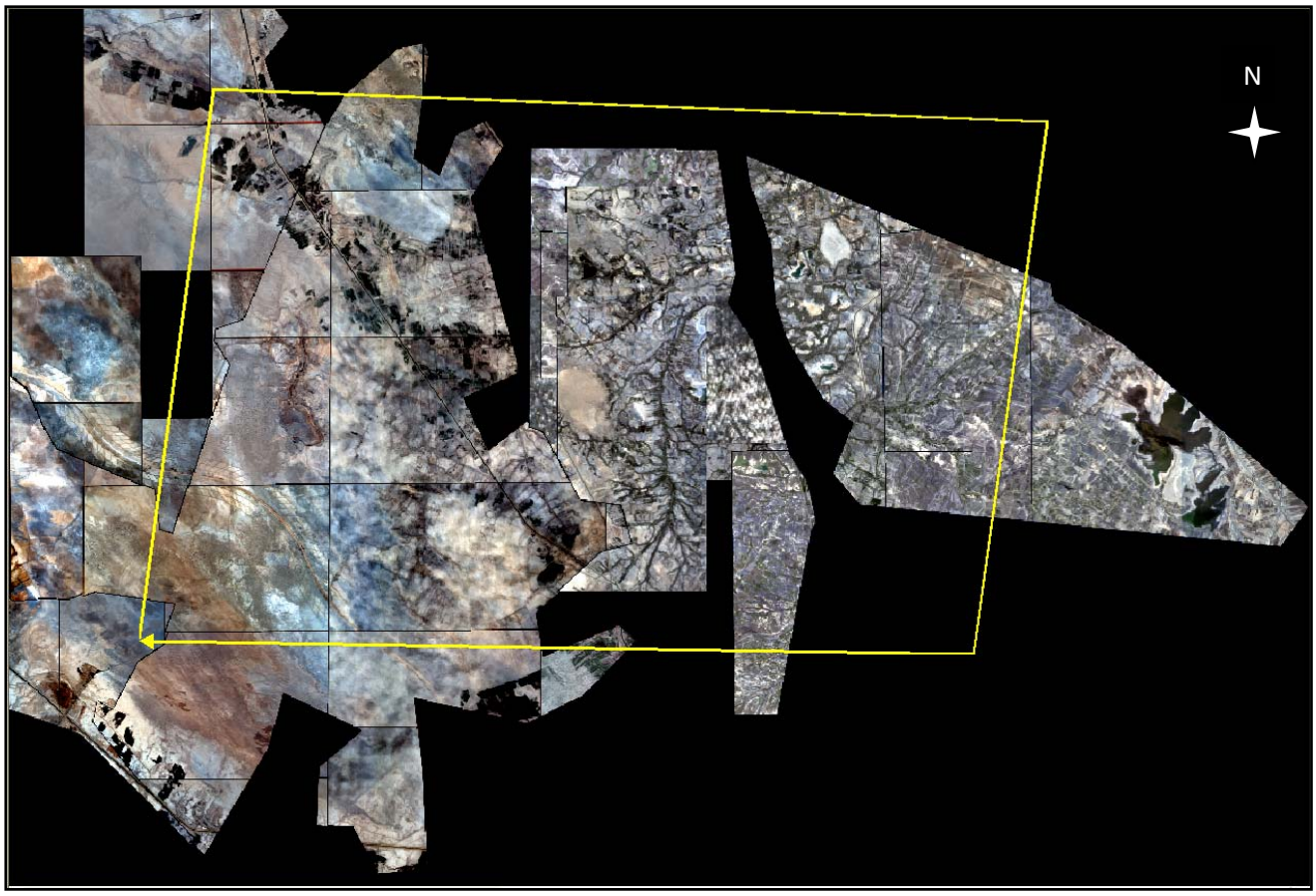


Fig. 11: Girsu: The approximate overlapping area bordered by the yellow line

Matching Map and Imagery in Area I

Our goal was to match the archaeological sites, shown on the map of al-Nasr with the satellite imagery from the same geographic area. Two methods can be used to accomplish this procedure.

A. Canals and Rivers as Guidance

Many archaeological sites are located on the edges of tributaries or nearby them. These water routes can be either ancient or modern. The modern rivers, canals, or streams are clearly visible in the satellite photos, so using these photos offers a good potential to connect them with the old water ways, shown in the map. This technique requires finding water sources relevant to the locations of archaeological site(s) in the Atlas and then find the corresponding canals on the satellite image. This makes it possible to find the locations of the archaeological sites by matching the lines of the rivers, canals, or streams. For example, three sites were identified by tracking a canal that is adjacent to the sites in both the Atlas map and the satellite imagery. This canal runs from west to east north of the site of Girsu (see created shape file of the canal in Fig. 12-B). The fourth site was detected to the west of Girsu in between a small river bifurcation. This could be done because the irrigation canals in this particular part of the Atlas map have not been altered since the 1960's. After identifying these sites on the satellite photo, all available information was transferred from the Atlas and remodeled digitally onto the satellite imagery. This information can be displayed on the satellite photo, or organized into digital charts (Fig. 12 A & B).

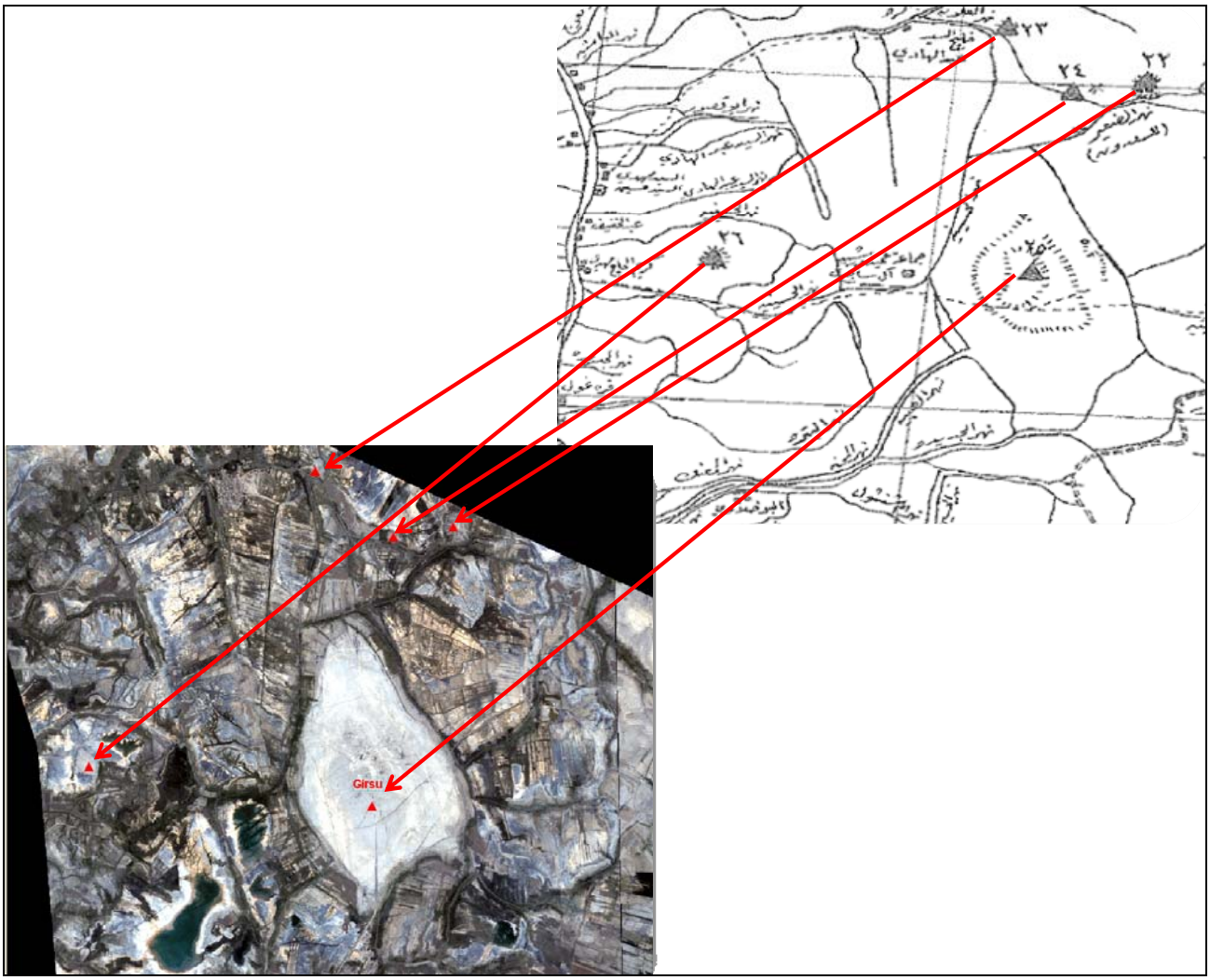


Fig. 12 A: Observing archaeological sites on the satellite photo based upon their identified location on the old map

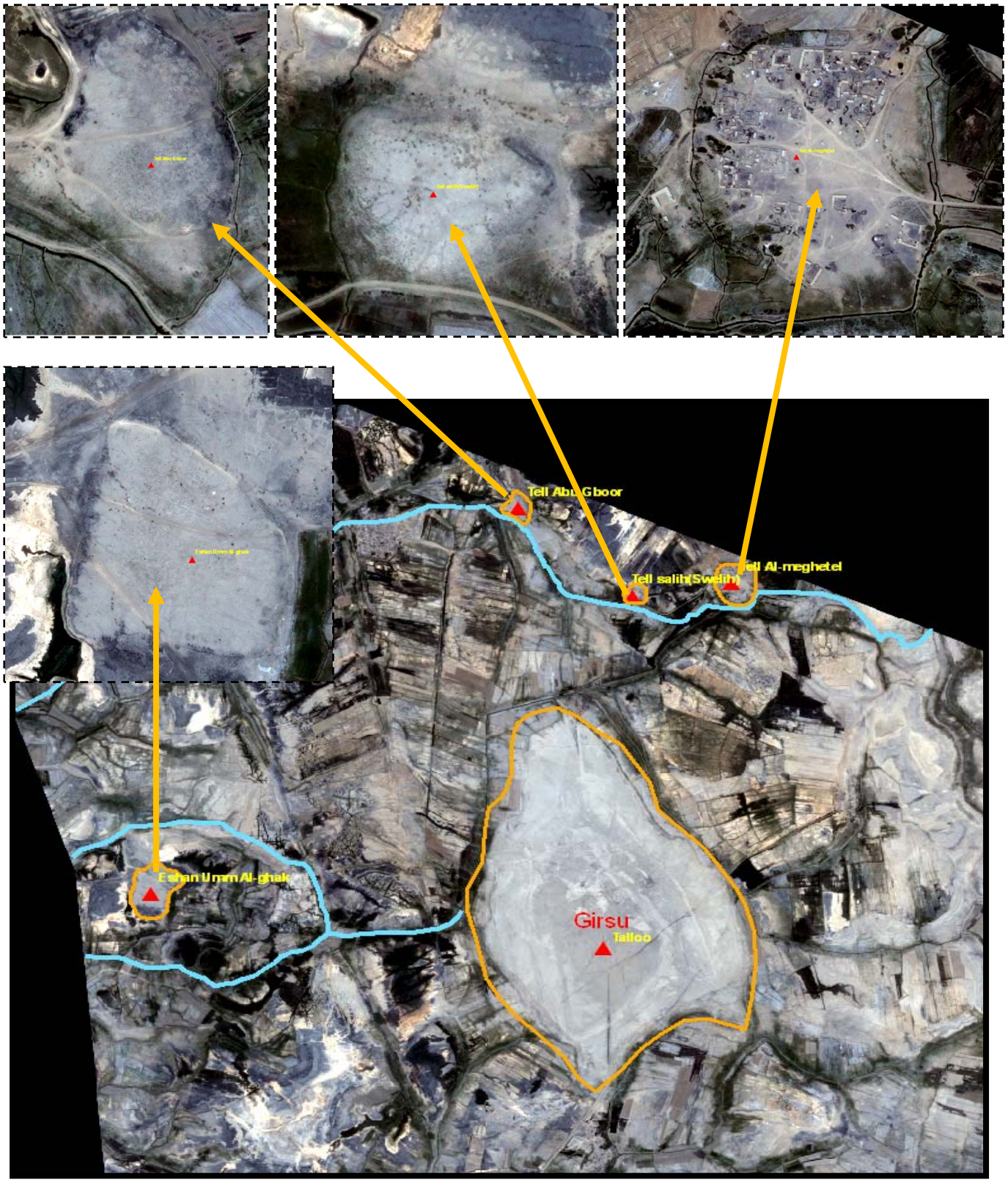


Fig. 12 B: Illustration of sites discovered around Girsu

Evaluation of the Method

The use of this first process for identifying sites in the satellite imagery proved to be quite accurate. The number of sites identified on the satellite photo matches their exact locations in the Atlas. However, this method is time consuming, since each site has to be identified on an individual basis. Furthermore, the lines and the direction of some of the watercourses which have served as our guides may not have been consistent over time, given the long 35-40 year time gap between the Atlas and the imagery. Some watercourses may have moved over time, whether due to natural processes or active reworking. Moreover, new canals may have been dug and others may have been allowed to silt up. These processes are typical for irrigation in the flat and consistent desert areas of southern Iraq (Postgate 2004: 6, Adams & Nissen 1972: 4). These possible changes of rivers, canals, or streams can lead to confusion when viewing satellite photos of a particular area, leading to inaccurate positioning of archaeological sites. These possible changes of rivers, canals, or streams can lead to confusion when viewing satellite photos of particular area, leading to inaccurate positioning of the archaeological sites. Therefore, this method should only be used in areas where the irrigation networks have remained unchanged.

B. Georeferencing the Atlas Maps

A second approach involves transferring geographical coordinates from the satellite imagery onto the map of the al-Nasir sub district published in the Atlas. This procedure results in a version of the map from Atlas which is georeferenced and therefore can be linked directly with the satellite imagery, a key step for identifying archaeological sites in the satellite imagery.

Georeferencing requires choosing at least three similar points in both the Atlas map and the satellite photo. Additional points may increase accuracy. These points must be selected at clearly identifiable points on both the atlas map and the imagery, such as a small structure, the head of canal, road intersections or an archaeological site. In addition, the three georeferencing points should be broadly spread over the two maps in order to provide better precision to the procedure.

Georeferencing al-Nasir

As mentioned above, the map of al-Nasir sub district, and indeed all of the maps in the Atlas, lack geographical coordinates. Fortunately, the intersecting irrigation canals in the northeastern part of the map provide many places where it is possible to match details of watercourses between the map and the satellite imagery in the area around Girsu. What is more difficult, however, is the situation in the southwest and northwest part of the map, which lack the density of watercourses that were found in the other areas. Nevertheless, it was essential to identify points in this area for successful georeferencing to be achieved.

As a result of this endeavor, the al-Nasir map now has real geographical coordinates with a defined measurement system (UTM/WGS), (see Fig. 14). This allows the checking of the locations of the archaeological sites on both the map and the satellite photos. By placing the double viewed inquire cursor on the position of any of the archaeological sites within the georeferenced al-Nasir map, the cursor will automatically move to the same position of that site within the satellite photo. The site of Girsu shown in Fig. 13 is an ideal example for this method.

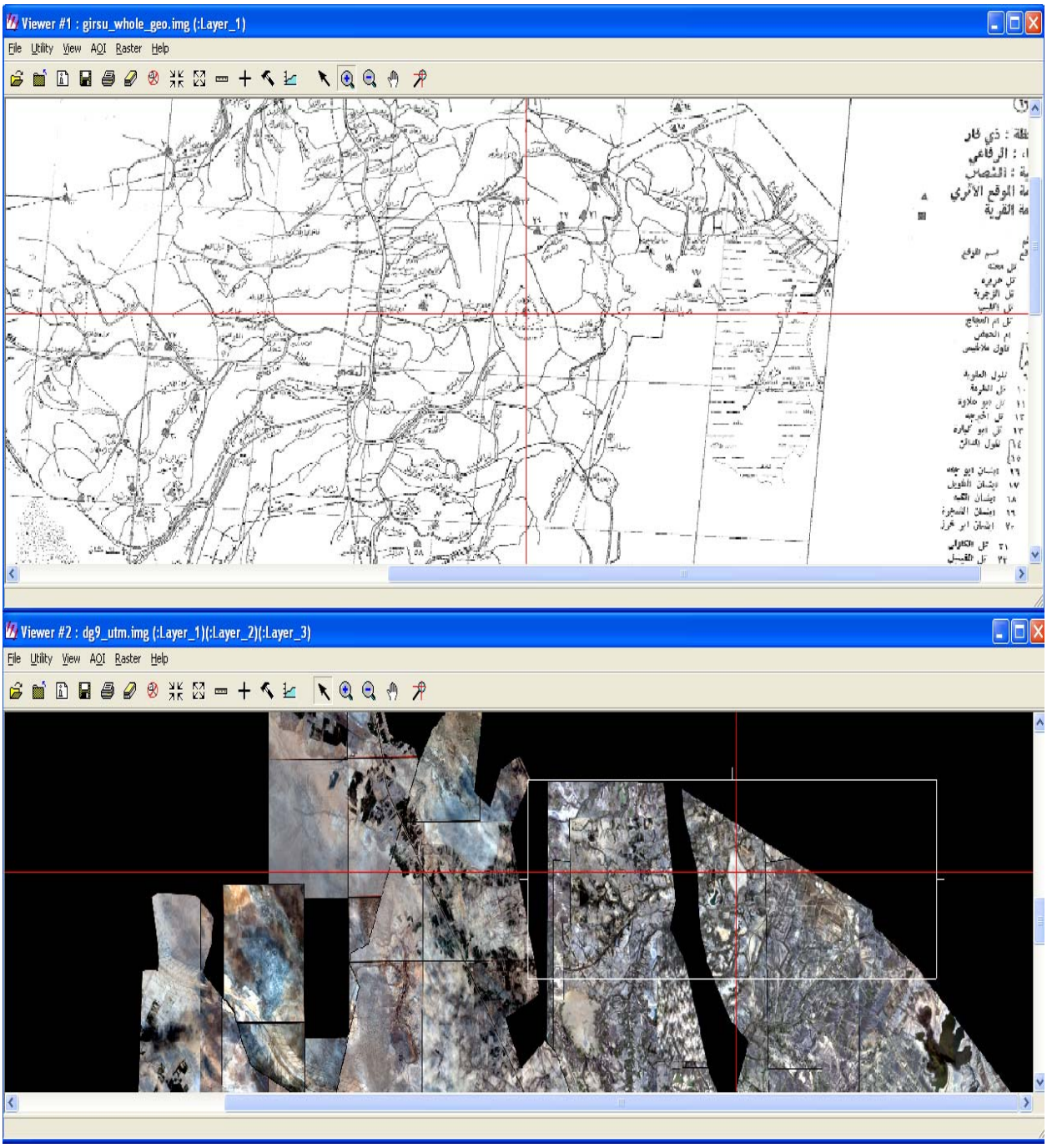


Fig. 13: A geographical link between the georeferenced map of al-Nasir and the satellite imagery: the inquire cursor (in red) identifies Girsu in both viewers

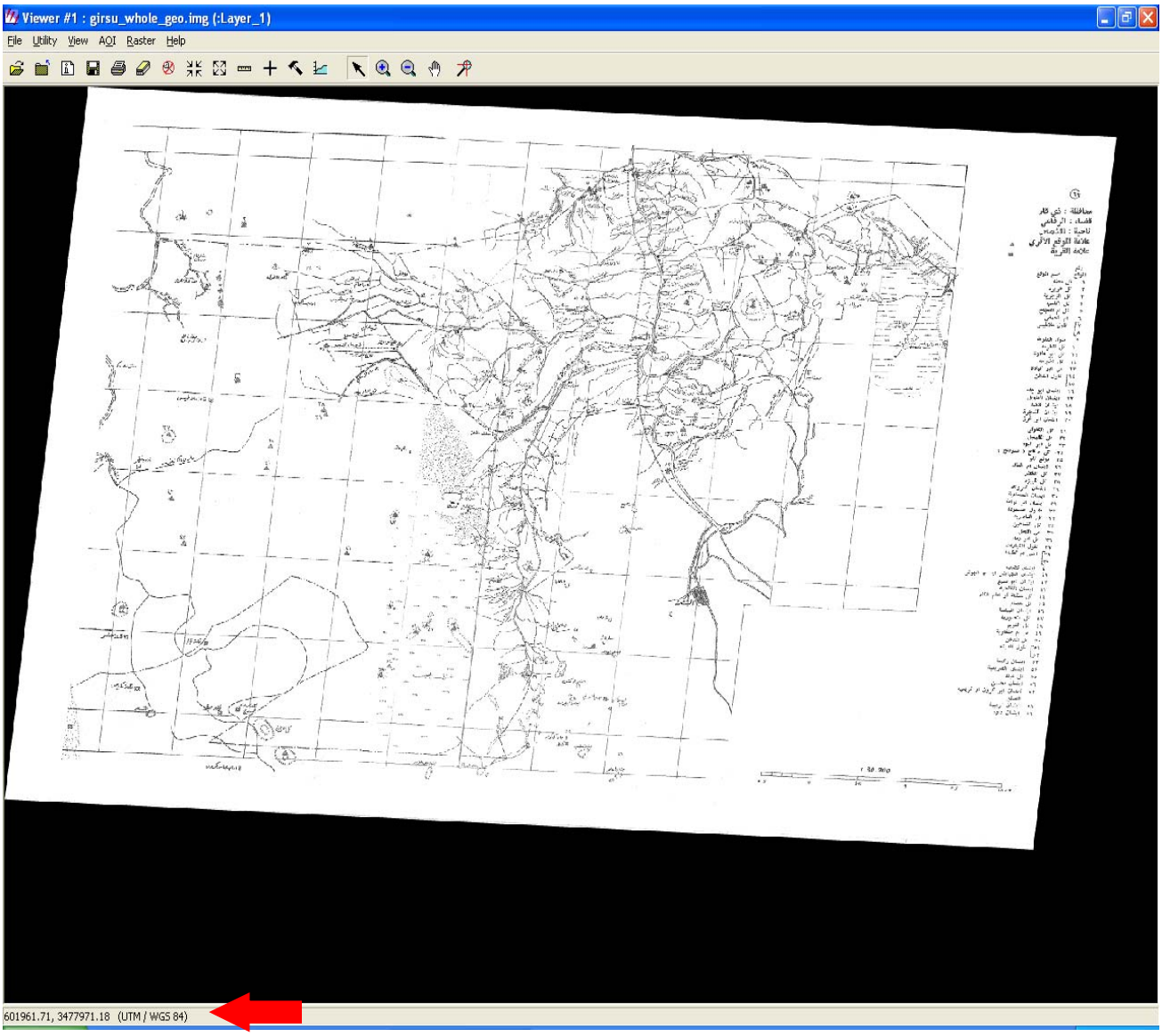


Fig.14: Georeferenced Map of al-Nasir, showing its UTM Coordinates

Evaluation of the Method

This method of georeferencing is superior over the first technique in two ways:

1- Speed: Once georeferencing is accomplished, the imagery and the map can be linked geographically allowing the correct location of all of the archaeological sites within the satellite images to be determined. This element is missing in the first method.

2- Accuracy: The repetitive success in matching points on the map with obvious mounds in the satellite imagery strongly indicates that the georeferencing is correct.

This suggests that the method of georeferencing is preferable. However, the first method of following watercourses is still beneficial as an additional check on the accuracy of the match between imagery and map.

Results from Area I

Our work on the al-Nasir sub-district developed map and the satellite imagery produced the following results:

1- Identifying the correct geographic positions of 56 archaeological sites of the 59 archaeological sites recorded in the map contained in the Atlas. The remaining 3 sites were not found due to the unavailability of satellite photos in their vicinity.
2- The development of a shapfile with the location of these sites (see Fig. 15).
3- Combining information from the two sources. Site location and site size were developed from the satellite imagery; whereas, the site name and the periods during which the site was occupied were obtained from the Atlas and its gazetteer (see Table II).

GIS georeferencing was successfully implemented in Area I. Notably, it was effective in determining the position of the archaeological sites in the empty regions (west of Girsu) that lack irrigation canals/rivers as guidance. Furthermore, this method made the information in the Atlas usable.

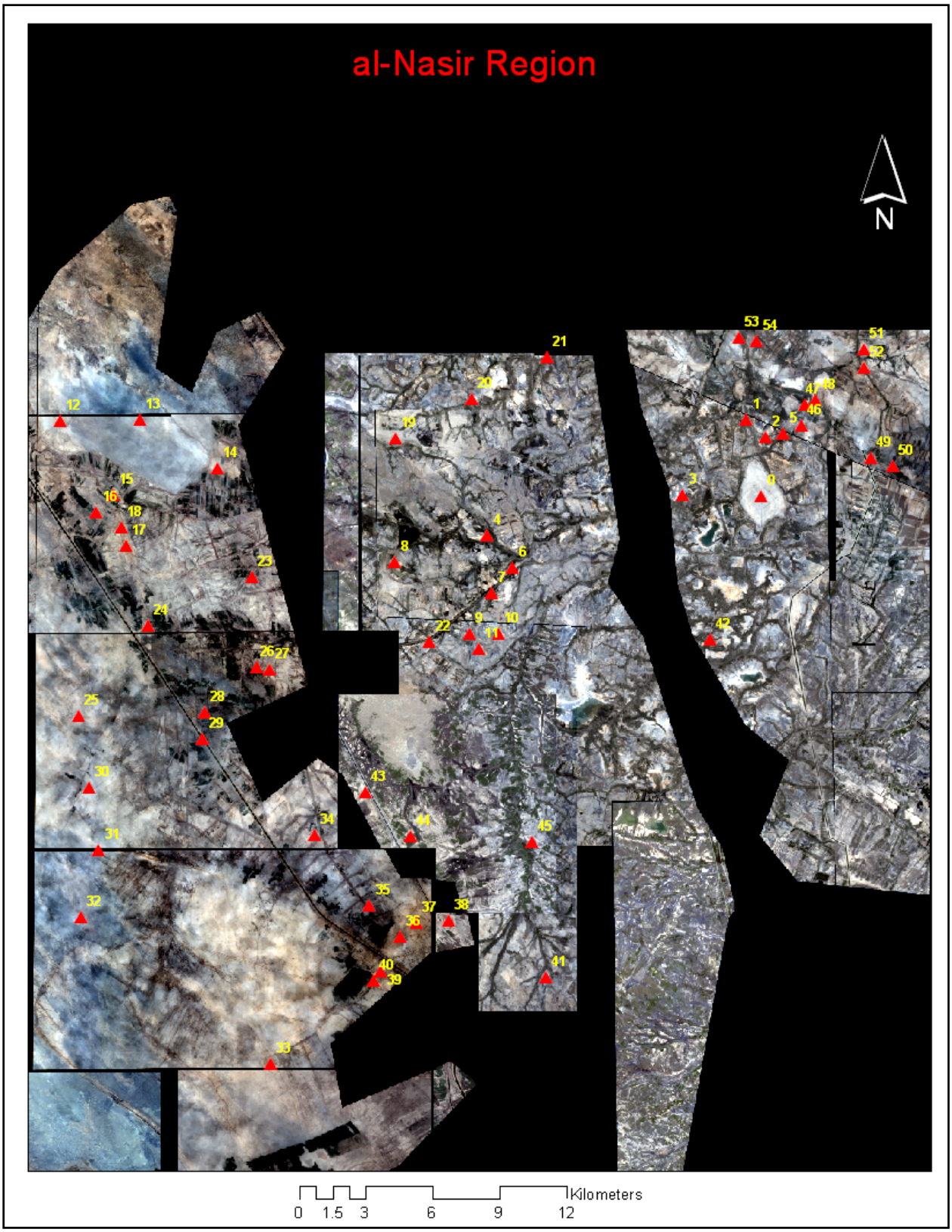


Fig. 15: Digital placement of archaeological sites with their ID in al-Nasir region

FID	Shape	Id	Size_hec.	Looted	R.Looting	POINT_X	POINT_Y	Name	TimePeriod
1	Point	1	2.80	No	0	611101.679792	3495755.2233	Tell Abu Gbeor	Sasanian, Islamic 636-1700 A.C
2	Point	2	1.77	Yes	10	611984.952664	3494992.39312	Tell salih(Swelih)	Early Dynastics 300-2400 B.C, Old Babylonian 2000-1600 B.C
3	Point	3	7.57	Yes	5	608242.810092	3492386.41977	Eshan Umm Al-ghak	Sumer&Akkad 2400-2000 B.C, New Babylonian 625-539 B.C, Parthian 148 B.C- 126 AC, Islamic
4	Point	4	4.03	Yes	20	599455.976278	3490562.6873	Tel al-mukhtir	N Babylonian , Achaemenian 539-331 B.C, Sasanian
5	Point	5	11.08	No	0	612759.397201	3495106.904	Tell Al-meghetel	Unknown
6	Point	6	2.35	No	0	600592.42549	3489086.21537	Eshan Al-aruka	N Babylonian , Achaemenian
7	Point	7	2.27	No	0	599658.93804	3487927.58647	Eshan Al-sayadya	Sumer&Akkad or O Babylonian
8	Point	8	0.62	No	0	595286.855659	3489336.44118	Tell Almbezr	E Dynastics , O Bakylonian , N Bakylonian , Islamic
9	Point	9	3.50	No	0	598842.632397	3486134.55168	Maftool Masood	Prehistoric, E Dynastics
10	Point	10	9.44	No	0	599362.400564	3486136.58964	Eshan Abu Traba	Sumer&Akkad or Ur III, O Babylonian , N Babylonian, Parthian
11	Point	11	18.62	No	0	599058.376216	3485477.58203	Tell Al-nasyria	Sumer&Akkad, O Babylonian, N Babylonian
12	Point	12	3.98	Yes	40	580271.048273	3495703.6953	tell Mehna	Sumer&Akkad
13	Point	13	10.32	No	0	583852.558712	3495733.29235	Tell Hrera	Unknown
14	Point	14	27.73	No	0	587339.392202	3493583.84857	Tell Al-zajrya	N Babylonian , Achaemenian, Parthian, Sasanian
15	Point	15	7.62	Yes	50	582669.77243	3492372.53978	Tell Um Al-ajaj	Jamdat Nasr 322-300 B.C, E Dynastics
16	Point	16	1.55	No	0	581897.424303	3491608.64059	Um Al-hm(th)	Jamdat Nasr- Sumer&Akkad, Islamic
17	Point	17	42.27	Yes	10	583237.733674	3490085.68365	Telool Malatees	Jamdat Nasr, E Dynastics
18	Point	18	41.99	Yes	30	583006.738471	3490896.65305	Telool Malatees	Jamdat Nasr, E Dynastics
19	Point	19	33.36	Yes	20	595346.79788	3494906.09281	Telool Al-elwya	Ubaid, N Babylonian , Parthian, (?)
20	Point	20	5.27	No	0	598758.636359	3496668.9476	Tell Al-terma	Achaemenian, Parthian
21	Point	21	1.25	Yes	5	602160.290659	3498560.33952	Tel Abu Halawa	Unknown
22	Point	22	0.40	No	0	596874.876312	3485767.0517	Tell Al-shaheen	Parthian - Islamic
23	Point	23	0.93	No	0	588900.233439	3486690.74194	Tell Al-fahal	Ubaid, E Dynastics, Sumer&Akkad, Islamic
24	Point	24	6.36	Yes	3	584214.447071	3486515.89969	Tell Abu Zmal	N Babylonian, Sasanian or Islamic
25	Point	25	3.70	No	0	581091.370019	3482426.58524	Telool Al-gayerat	N Babylonian , Achaemenian, Sasanian, Islamic
26	Point	26	2.55	Yes	50	589080.145707	3484631.63946	Eshin Um gtefa	Ubaid, Warka 3800-3200 B.C, E Dynastics, N Babylonian
27	Point	27	1.92	Yes	30	589688.659762	3484519.63119	Eshin Um gtefa	Ubaid, Warka 3800-3200 B.C, E Dynastics, N Babylonian
28	Point	28	1.28	No	0	586757.179727	3482581.66283	Eshan Lateef	Ubaid-Jamdat Nasr
29	Point	29	?	No	0	586579.979196	3481387.44566	Eshan Al-chbaiesh orAbu Al-hoosh	Warka, E Dynastics
30	Point	30	0.48	No	0	581582.774807	3479201.96693	Eshan Abu sabi(?)	Jamdat Nasr- Sumer&Akkad,Achaemenian, Islamic
31	Point	31	4.56	No	0	582006.080094	3476429.11613	Eshan Al-falhya	O Babylonian, Kassite 1600-911 B.C, N Babylonian, Islamic
32	Point	32	22.79	Yes	15	581189.705429	3473407.71002	Tell Sikna or Emaam Al-kar	Warka, O Babylonian, Islamic
33	Point	33	46.88	Yes	35	589710.433677	3466767.92433	Tell Esaam	No suggestion in the Atlass
34	Point	34	2.14	Yes	10	591678.453498	3477062.4536	Eshan Al-Betha	N Babylonian , Achaemenian
35	Point	35	0.60	No	0	594163.380074	3473917.59401	Tell Al-mdakhen	No suggestion in the Atlass
36	Point	36	39.62	Yes	70	595558.705174	3472518.39608	Telool Al-Madyna	Sasanian, Islamic
37	Point	37	46.25	Yes	20	596278.672793	3473153.18443	Telool Al-Madyna	Sasanian, Islamic
38	Point	38	42.12	Yes	85	597745.312725	3473244.73031	Eshan Rkeaba	Unknown
39	Point	39	5.84	Yes	55	594683.452205	3470933.34994	Eshan Al-sereafya	No suggestion in the Atlass
40	Point	40	1.74	No	0	594338.052488	3470536.76842	Tell Abla	No suggestion in the Atlass
41	Point	41	19.22	Yes	30	602111.97792	3470714.83672	Eshan Mehsin	O Bakylonian, Sasanian or Islamic
42	Point	42	2.68	Yes	5	609463.788644	3485845.89383	Eshan Abu groon orTameema	Sumer&Akkad, N Babylonian
43	Point	43	5.36	No	0	593987.512013	3479012.07065	Tell Mansurya	No suggestion in the Atlass
44	Point	44	2.62	No	0	596003.821664	3477055.02156	Tell Al-twaem	No suggestion in the Atlass
45	Point	45	16.51	Yes	10	601464.686584	3476755.40725	Um Haitawya	Warka, Sumer&Akkad
46	Point	46	3.25	No	0	613580.364231	3495470.71816	Tell Al-kawly	Jamdat Nasr- Sumer&Akkad
47	Point	47	4.72	Yes	5	613768.498031	3496426.43698	Eshan Abu khiraz	Warka, Sumer&Akkad, O Babylonian
48	Point	48	4.02	Yes	2	614201.008464	3496619.55651	Eshan Al-shajara	Not found
49	Point	49	5.17	Yes	3	616894.121858	3494048.19073	Eshan Al-kuiba	Warka, O Babylonian, N Babylonian
50	Point	50	2.63	No	0	617706.705298	3493647.09862	Eshan Al-taweel	E Dynastics , O Babylonian , Kassite
51	Point	51	22.33	Yes	2	616371.427441	3498916.32056	Telool Al-Madain	Sumer&Akkad, Urlll, O Babylonian
52	Point	52	1.79	No	0	616393.446955	3498068.79749	Telool Al-Madain	Sumer&Akkad, Urlll, O Babylonian
53	Point	53	1.67	Yes	10	610782.406557	3499410.85999	Tell ekherja	Not found
54	Point	54	2.23	No	0	611579.87136	3499268.95451	Tell Abu gbara	O Babylonian , N Babylonian, Achaemenian
55	Point	55	2.79	Yes	30	622251.476289	3493801.28395	Eshan Abu jiffa	Ubaid, E Dynastics, Parthian

Table II: Database of the combined data for Area I sites

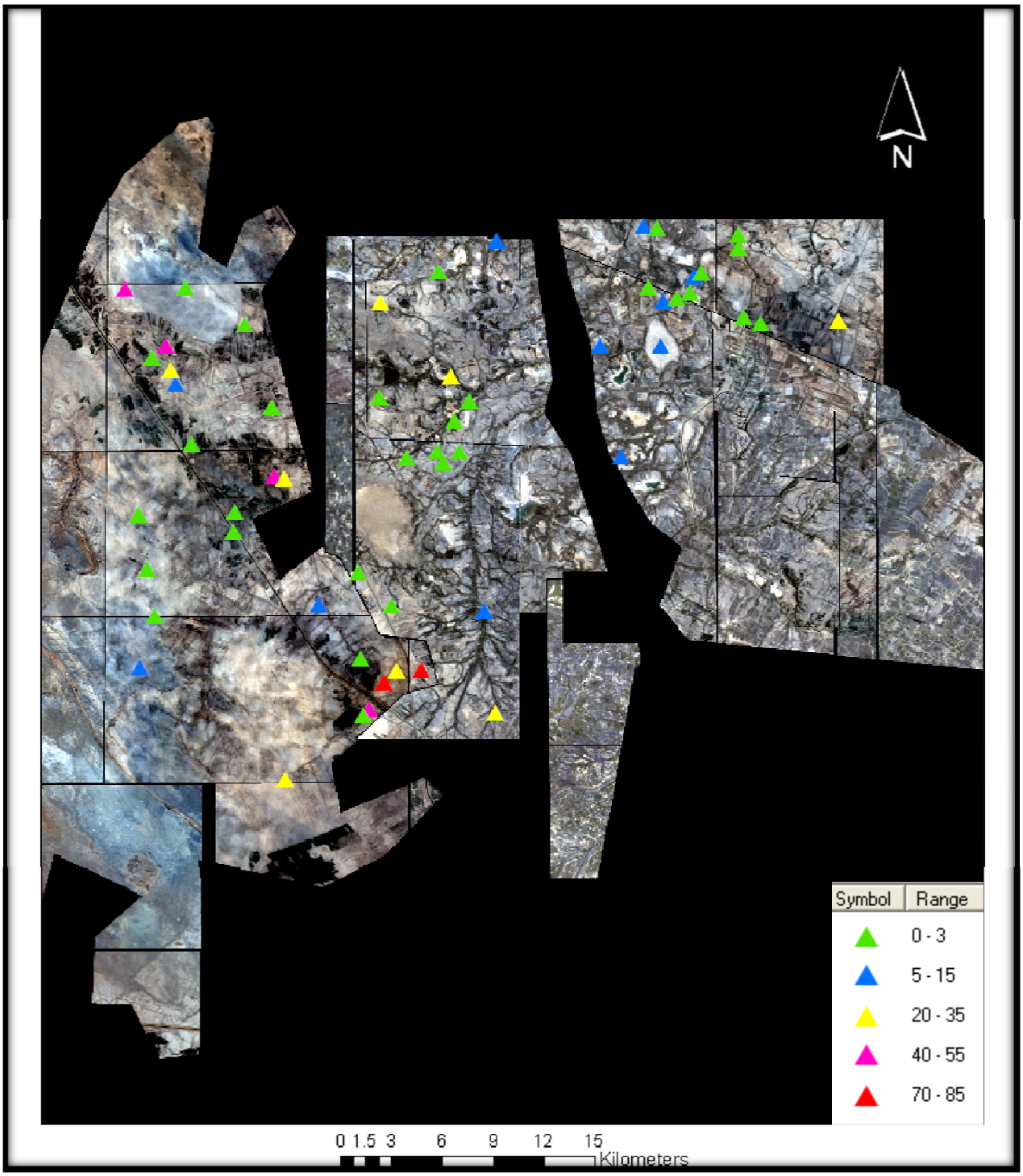


Fig. 16: Application of looting rate (percentage ranges) in Area I sites

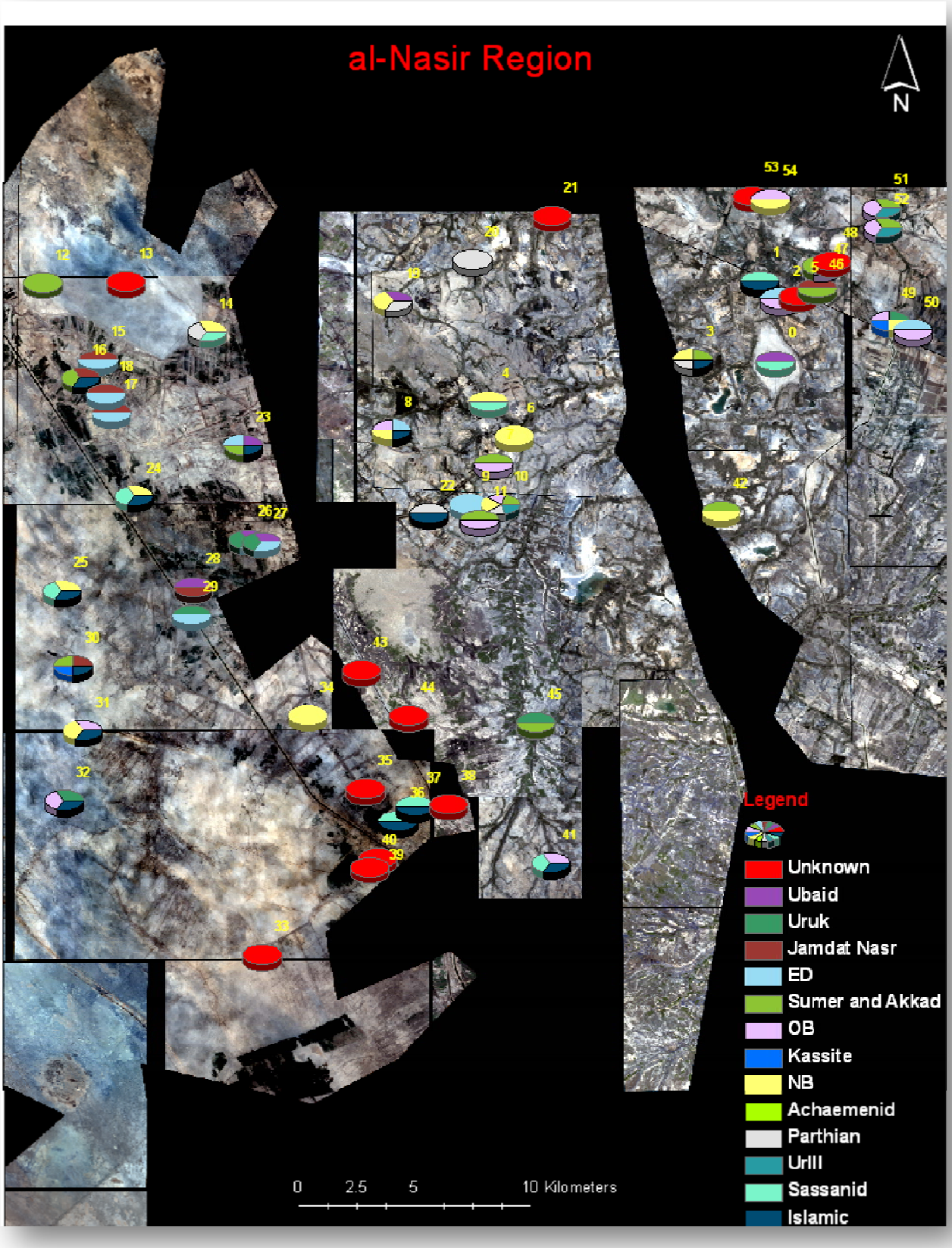


Fig.17: Periods of occupation in Area I

Chapter Three

Project Testing on Area II

Having demonstrated that these techniques can make the data in the archaeological atlas usable in an irrigated area, we needed to test our ability to use these data in an area where there are fewer physical features that can link the older maps with modern imagery. We therefore chose the area around the site of Isin for this exercise.

Geographical View

Area II represents the lands surrounding the site of Isin. In the available satellite imagery, this area extends diagonally from the northwest to the southeast for 418 sq. km. The site of Isin is located in the northern part of the area (Fig. 18). This area is located in southern Iraq about 164 km. (102 mi.) south of Baghdad, and 92 km. (57 mi.) northwest of Girsu (Fig. 19).

The Isin area in the Atlas is found on two different map sheets. The first is the map of Albdear sub-district, which is located in Efaj district in al-Qadeseya province. This map covers a broader region than the satellite imagery. The northern part of the satellite photo only overlaps the old Albdear map in its southwestern part (see Fig. 20). The Albdear map has extensive irrigation canals spreading throughout the central and western parts of the map, while small marshes and unregistered mounds exist in the east of the area. Fifty-five registered archaeological sites are positioned all over the map. However, only the handful of sites is in the area where the imagery and map overlap will be included.

The second map of Area II in the Atlas is al-Rometha district in al-Muthana Governorate. This map shows a wide distribution of major water courses all over the area. In addition, this region includes 60 registered archaeological sites concentrated mainly in the center (Fig. 21). The quad sheet covers the whole middle and southern part of Area II (see Fig. 22).

Having two maps from the Iraqi atlas for one area (Area II) is advantageous to the project. While the general overview of this project looks as if it involves two case studies (Girsu and Isin), in fact, all results and analyses at the end of the project will have been obtained from three maps of two regions (al-Nasir, Albdear and al-Rometha). This will ensure that the project will have greater certainty and accuracy in its results.

The goal of this endeavor is to apply the same procedures that were used on Area I to test whether they could be used in other regions. The Isin area presents more difficulties than the Girsu region, and should demonstrate whether this approach is likely to be effective throughout Iraq.

Fig.18: Area II from the satellite shows the site of Isin bordered in red

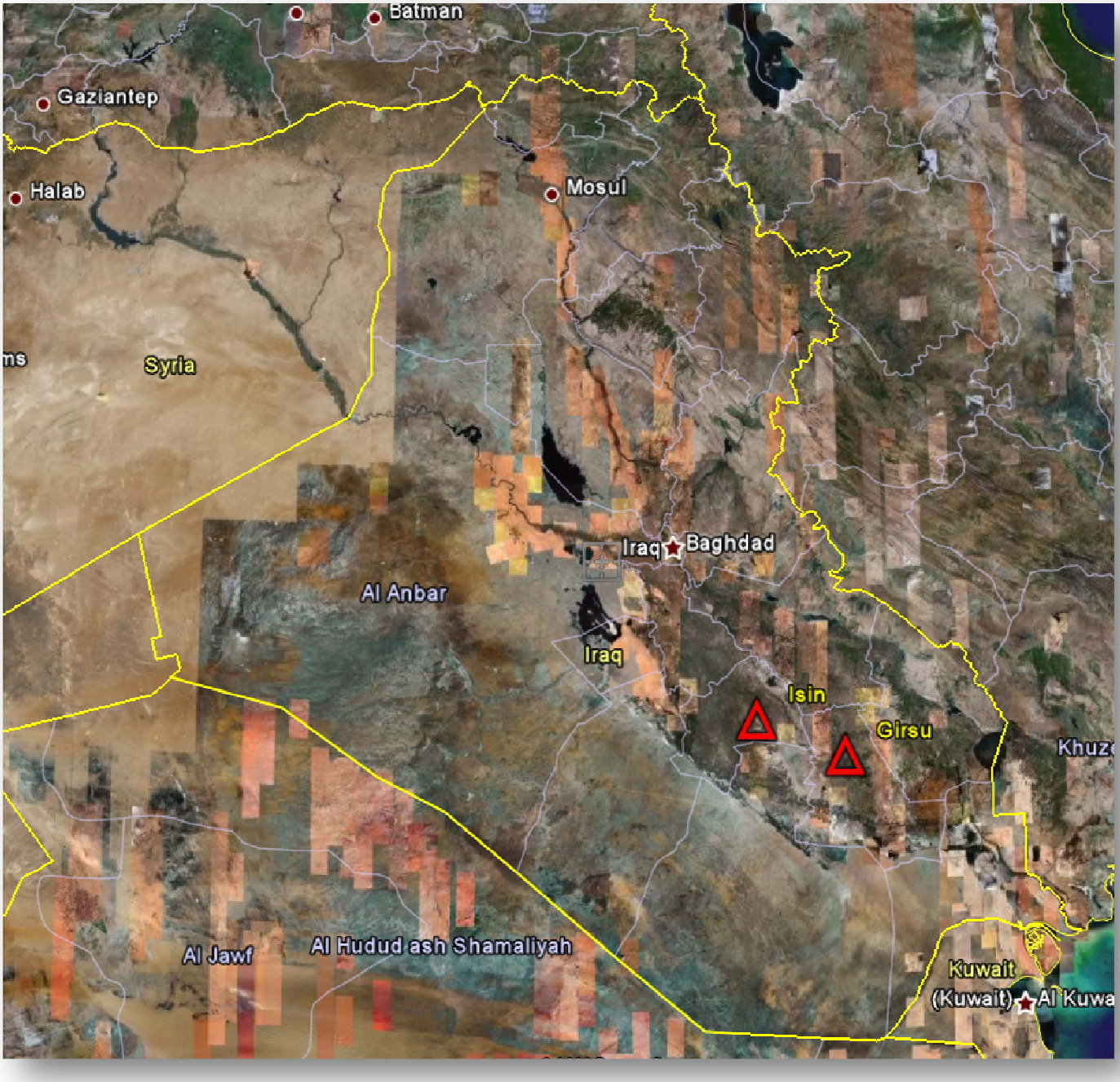


Fig. 19: The position of Isin on the map of Iraq.

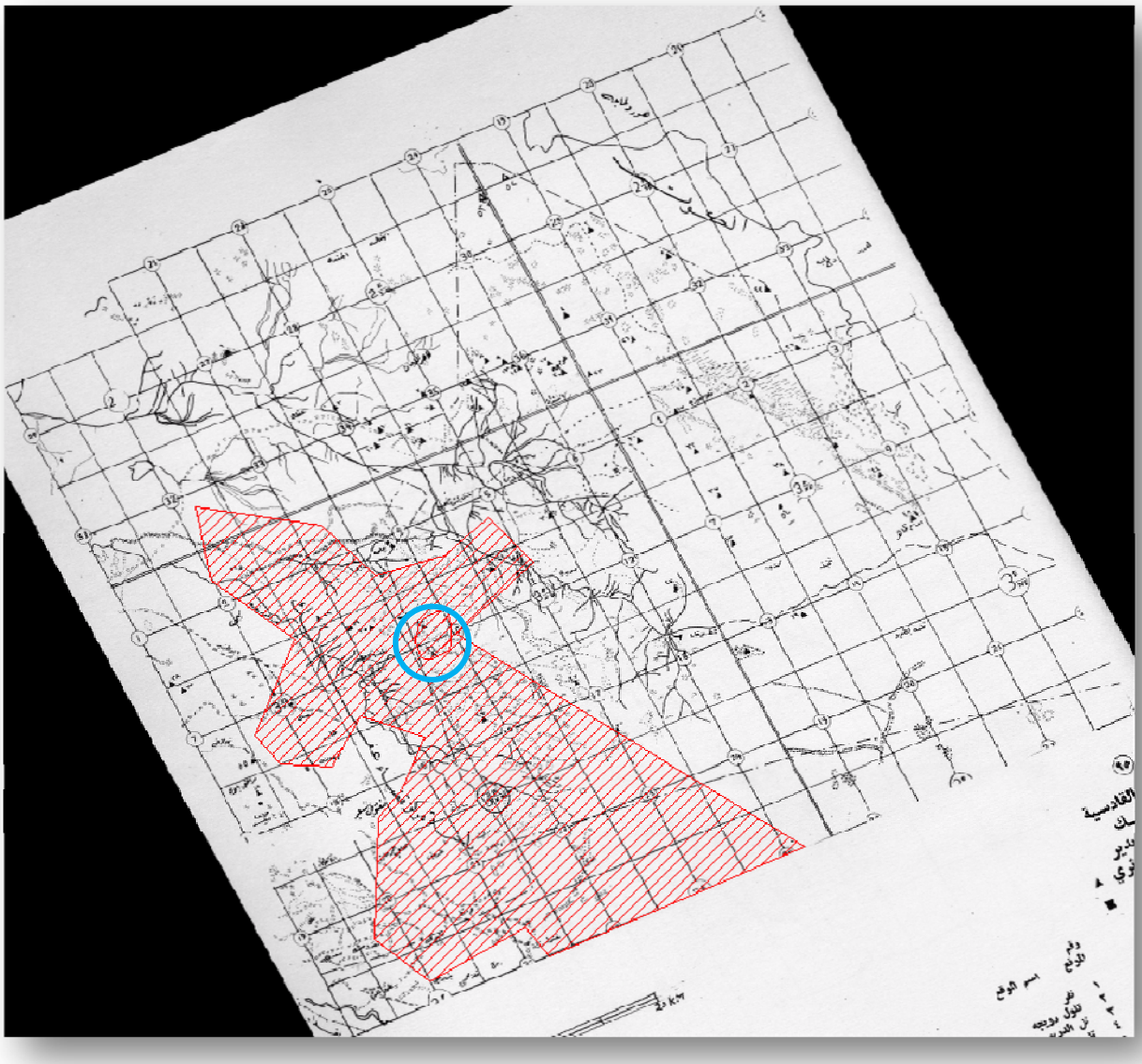


Fig. 20: The overlapping area of Albdear is shown as red polygon. The site of Isin is circled in blue

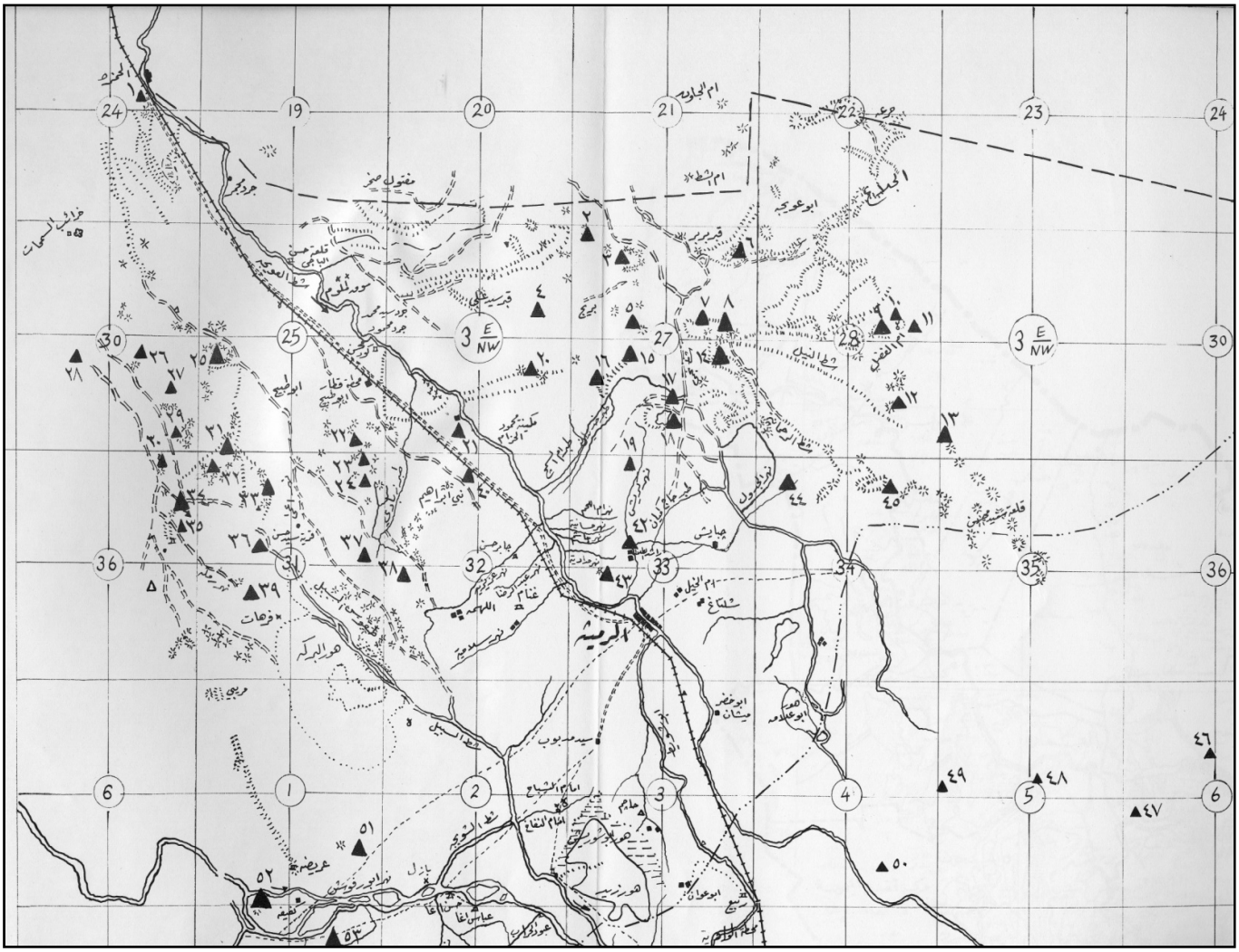


Fig. 21: Old map of al-Rometha district representing the middle and southern parts of Isin area in the Iraqi atlas. The site of Isin is located to the north of this map

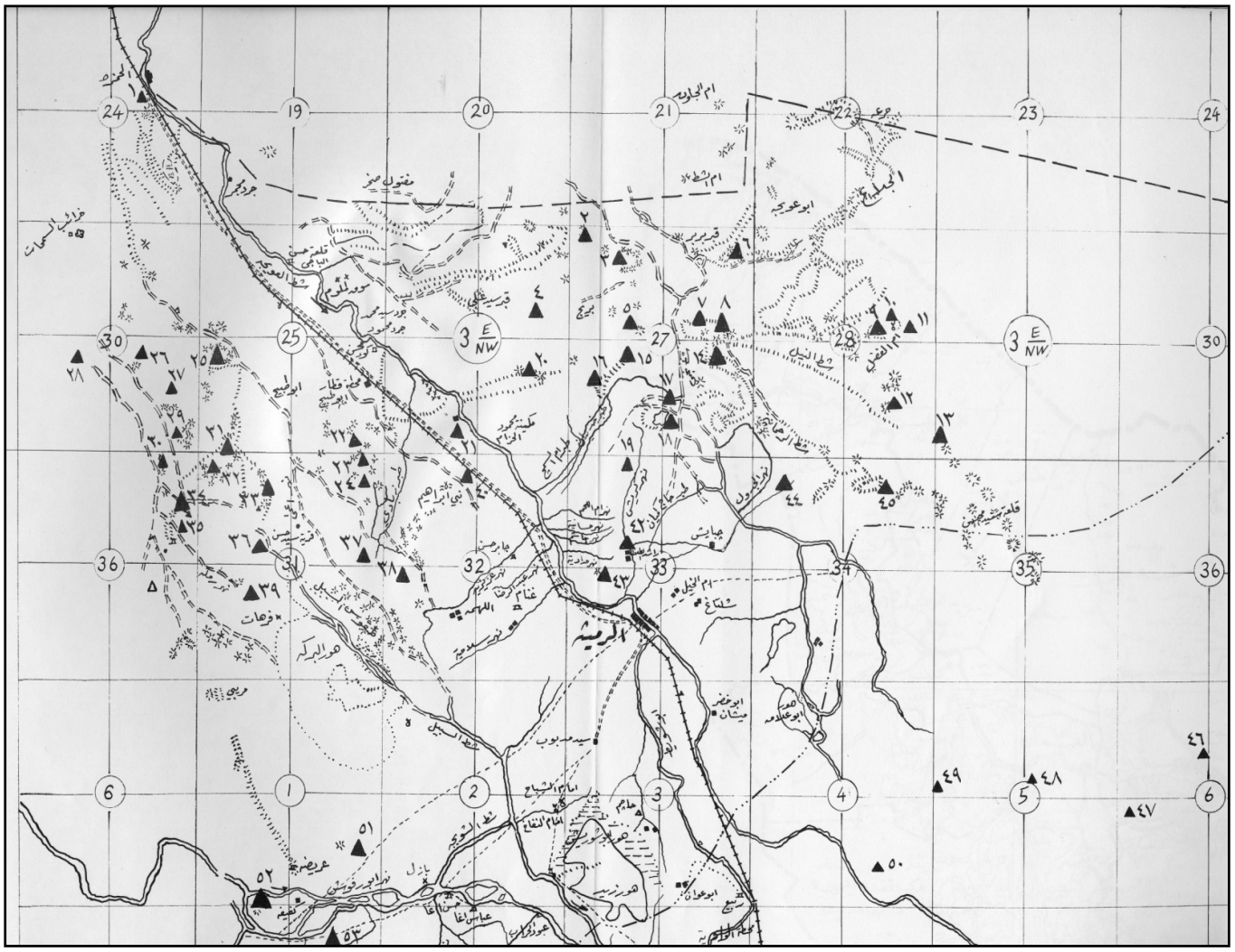


Fig. 22: Overlapping area in al-Rometha enclosed in red polygon

Georeferencing Albdear

Albdear is the upper part of Area II that contains the site of Isin. The shape of the available imagery is not ideal, since it is long and narrow in the northwest, making it difficult to spread the points in this area. On the other hand, the presence of some watercourses in this area meant that we could identify the locations on the imagery of sites recorded in the Atlas based on their position relative to these modern features (Fig. 22). Once these sites had been located in this way, they could be used in the georeferencing of the entire image (see Fig. 23).

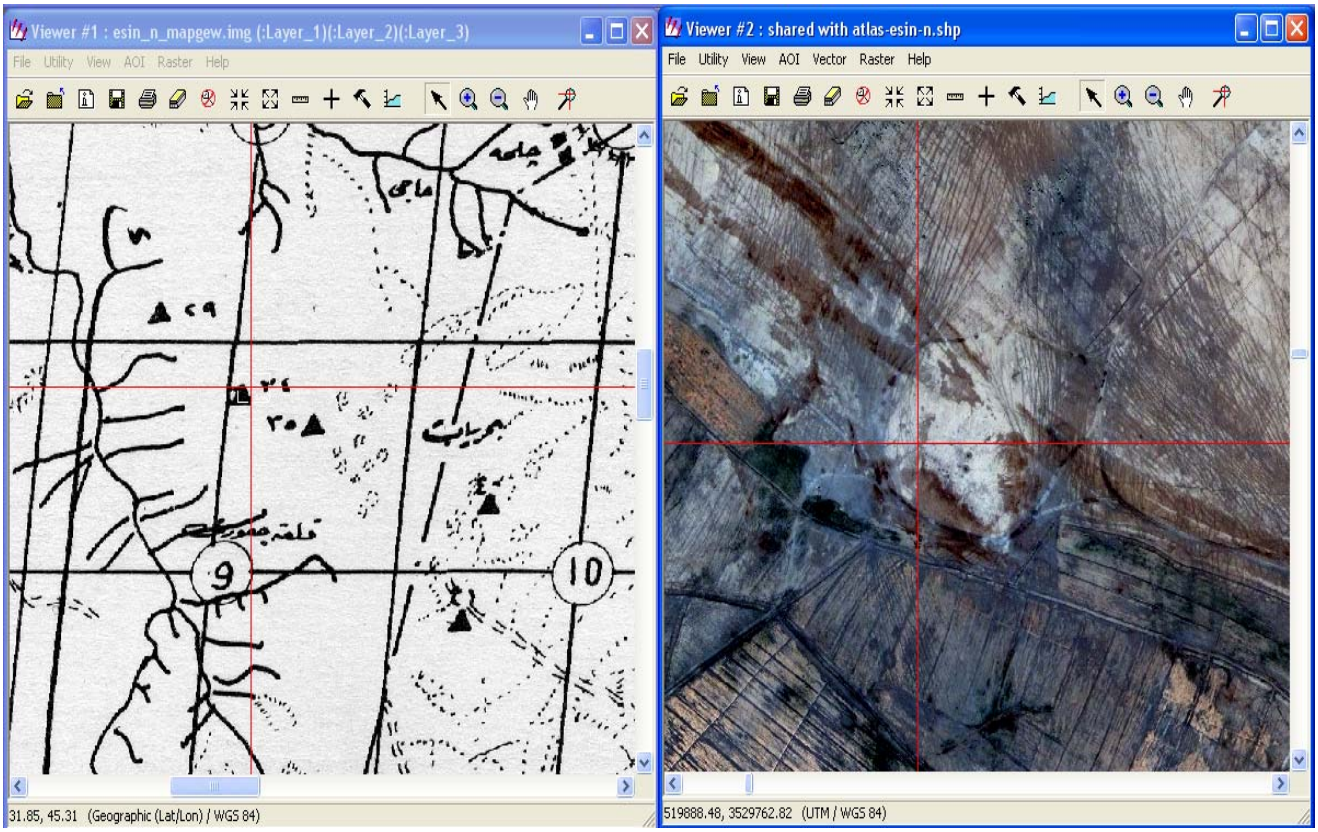


Fig. 23: Geographical link between the georeferenced Albdear map and the satellite photo proving the successful operation of georeferencing. The inquire cursor points at Telool al-Homor site in both viewers

Results from the Northern Part of Area II

The georeferencing of the map in the Atlas of the Albdear sub-district allowed the following:

1- Detecting the location of all 9 archaeological sites included in the shared area of the Albdear map sheet and the satellite imagery.

2- Developing a shapefile with the locations of these nine sites (see Fig. 24).

3- Developing an associated database combining the locational data, degree of looting observed, and site size based on the satellite imagery and the site names and periods of occupation provided by the Atlas (see Table III).

4- Using these data to create maps of area II-north showing site looting, percentage of looting and periods of occupation, (see Figs. 25-26).

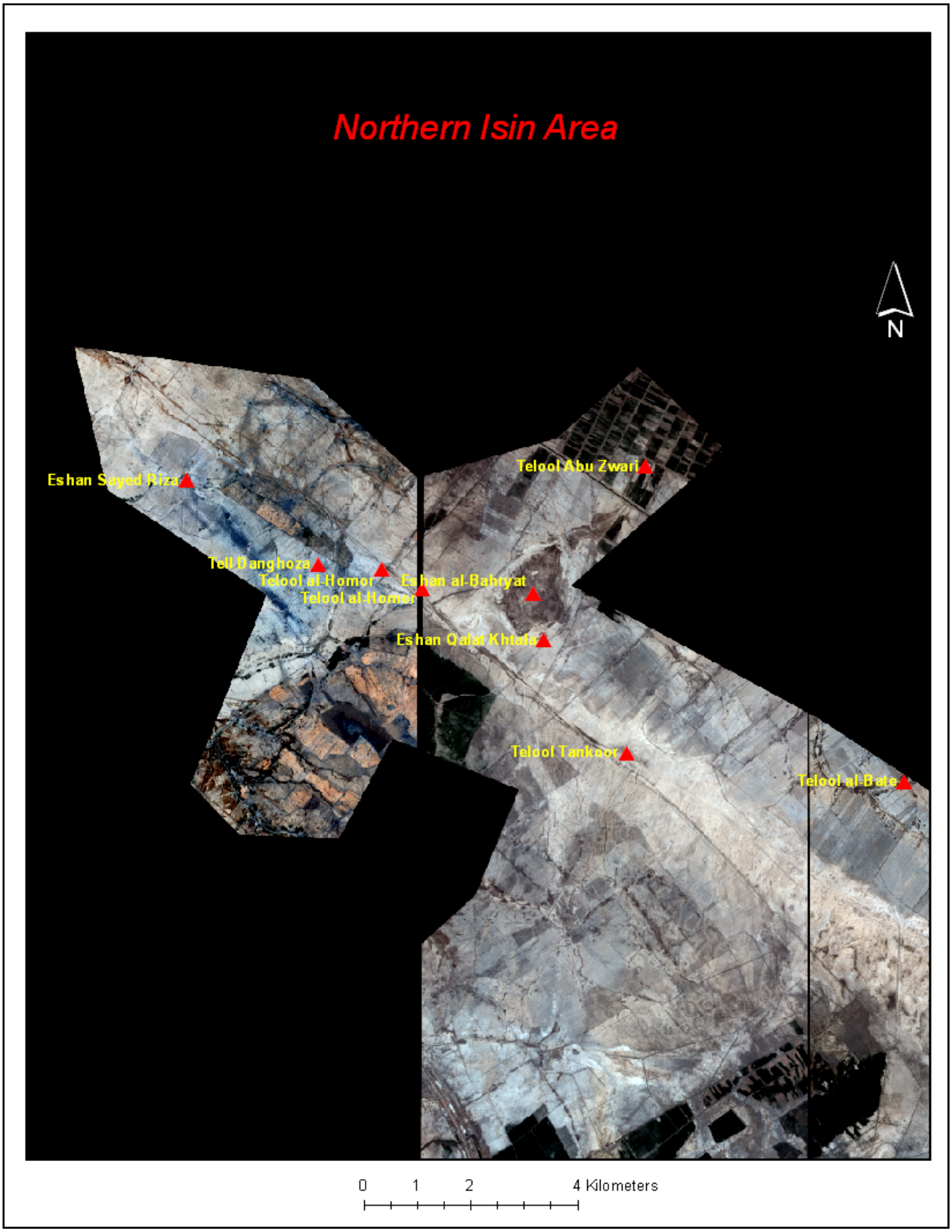


Fig. 24: Site locations in Northern Isin region

Attributes of Shared with atlas-Esin-N

FID	Shape *	Id	Looted	Name	R_Looting%	Size-hec.	POINT_X	POINT_Y	TP
0	Point	0	Yes	Eshan al-Bahryat	80	202.75	525470.313477	3527802.90854	Ubaid, Warka, Early Dynastics, Old Babylonian, Kassite
1	Point	1	Yes	Eshan Qalat Khtala	50	2.73	525663.180573	3526923.61573	No suggestion in the Atlass
2	Point	2	Yes	Telool Tankoor	30	56.31	527211.65443	3524809.43435	No suggestion in the Atlass
3	Point	3	No	Telool al-Bate	0	1.43	532422.52965	3524271.1351	No suggestion in the Atlass
4	Point	4	Yes	Telool Abu Zwari	20	2.60	527573.789251	3530172.44773	Achaemenian, Sasanian
5	Point	5	No	Telool al-Homor	0	1.19	523396.598715	3527876.70047	No suggestion in the Atlass
6	Point	6	Yes	Telool al-Homor	20	1.79	522621.472318	3528244.24615	No suggestion in the Atlass
7	Point	7	No	Tell Danghoza	0	1.7	521431.694439	3528334.11762	Sasanian
8	Point	8	Yes	Eshan Sayed Riza	15	2	518960.876248	3529914.11723	Islamic

Record: 9 Show: All Selected Records (0 out of 9 Selected) Options

Table III: Area II-north combined data in a digital chart

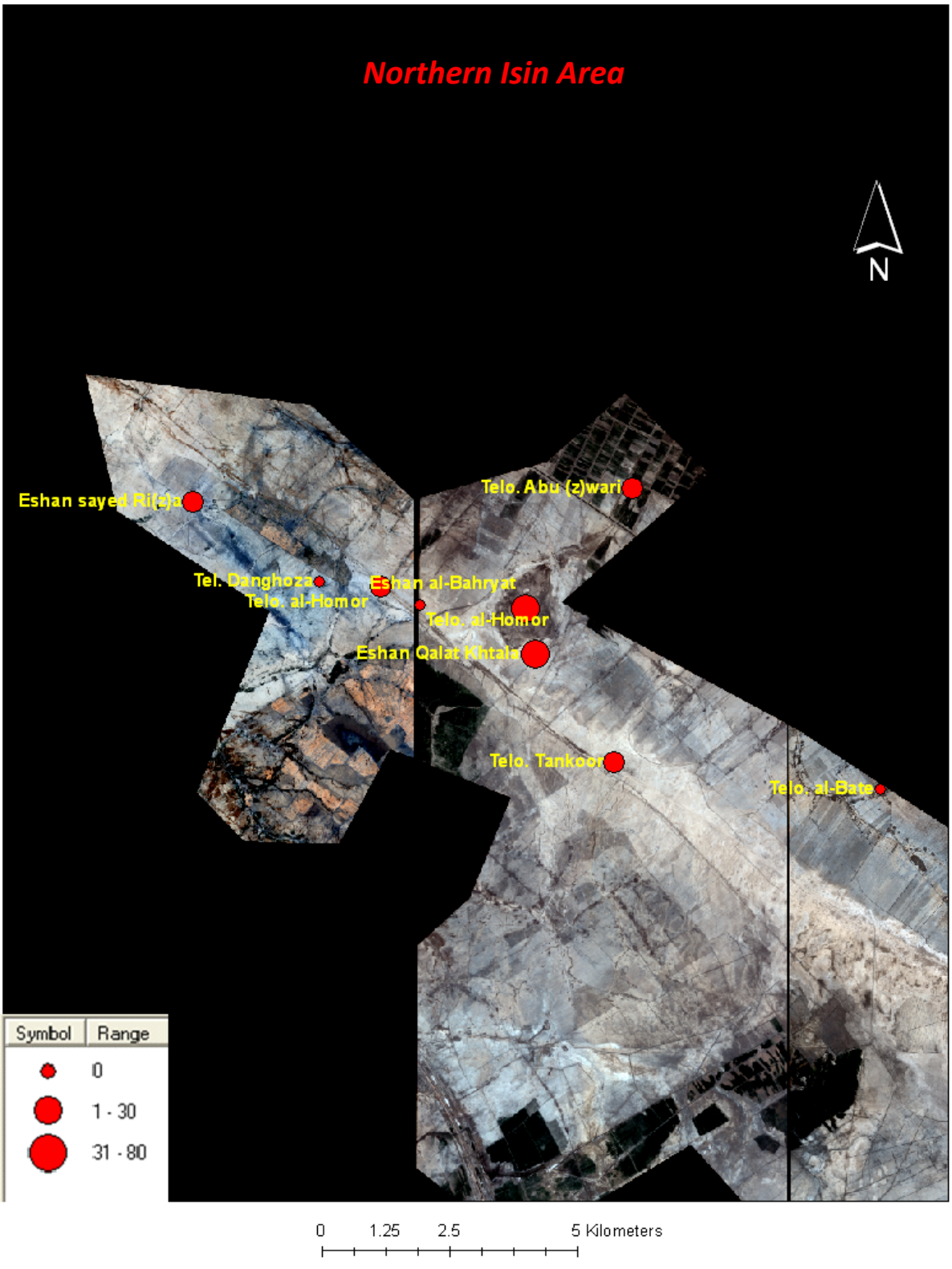


Fig. 25: Looting evaluation (percentage ranges) in north Isin region

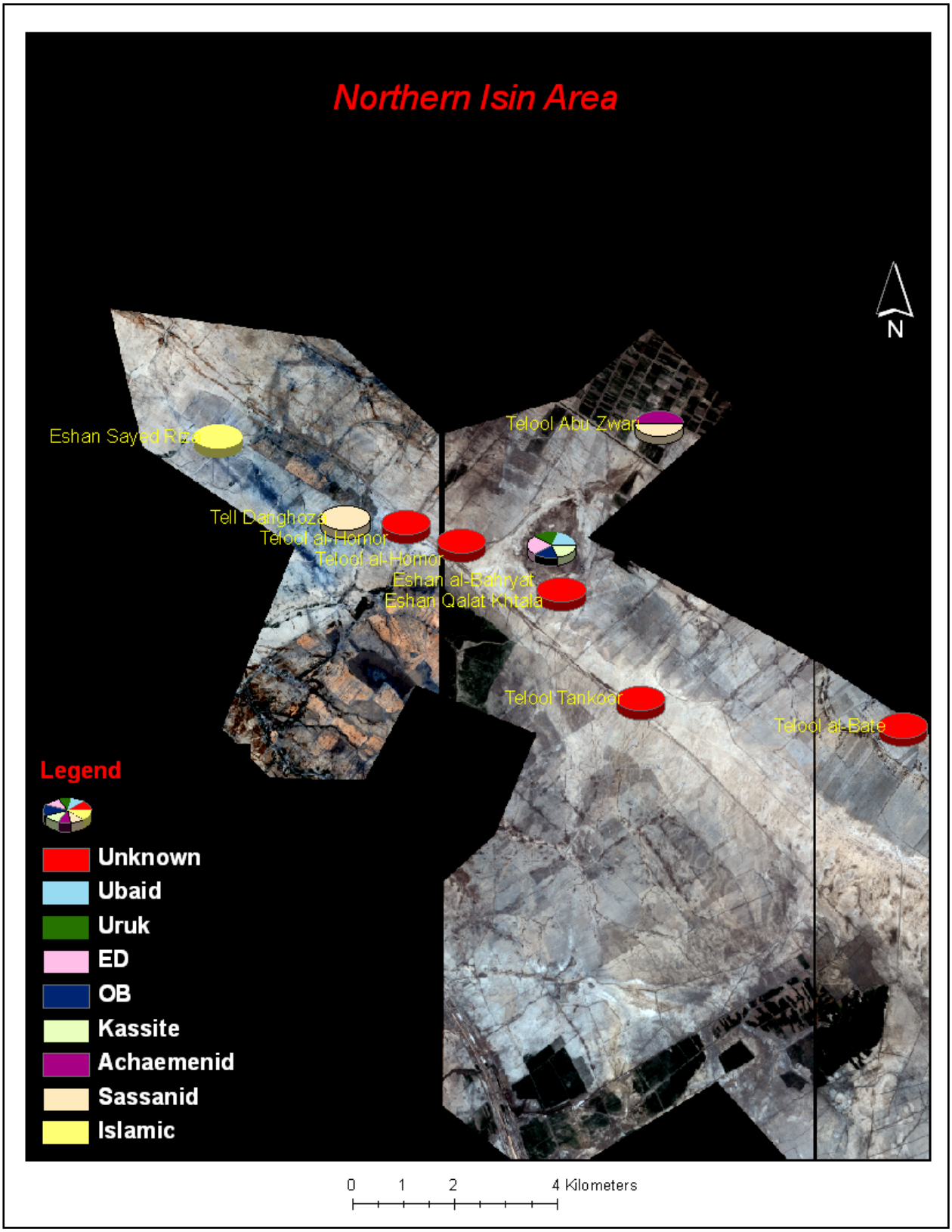


Fig.26: Periods of occupation in northern Isin area

Georeferencing al-Rometha

The Atlas map of the al-Rometha district covers the whole middle and southern parts of Area II. This map can be considered as a perfect map sheet for georeferencing due to its rectangular shape, variety of observable features on the ground, the broad distribution of its archaeological sites, and the presence of modern canals. All these should be beneficial when applying georeferencing. However, it was found that the poor accuracy of the map in the Atlas made it largely impossible to georeference it in the normal way. No one-to-one relationship could be found between the data in the Atlas and that in the satellite imagery (see Figs. 27&28).

In order to overcome this problem, a more advanced level of georeferencing had to be used. This process consists of choosing 8 or 12 specific points, rather than 4, before running the operation. This serves to average out any errors that might exist in the original map. In addition, newer Iraqi military maps with precise geographical coordinates assisted in improving the performance of the procedure (Fig. 29). Since it is easier to find shared points between two maps than it is between a map and satellite imagery, the al-Rometha georefrenecing was related to the Iraqi military maps of the same area. The Atlas map of al-Rometha district responded to the newly employed techniques. The transfer of the coordinates did not have the same level of accuracy as it had in the case of al-Nasir in Area I and Albdear in Area II-north. This is due to an inaccurate geographical grid setting on the map published in the atlas. Nevertheless, the operation was sufficient to allow us to correctly identify the archaeological site locations, even if the map and the imagery did not place them in exactly the same place.

A. Incorrect **B. Incorrect**

C. Correct

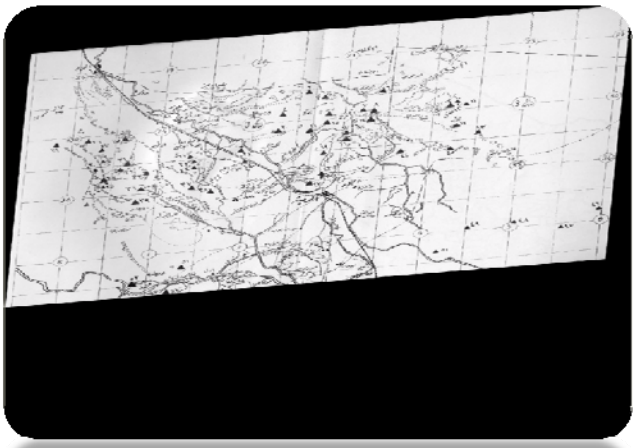


Fig. 27: Samples of incorrect and correct data transfer through georeferencing

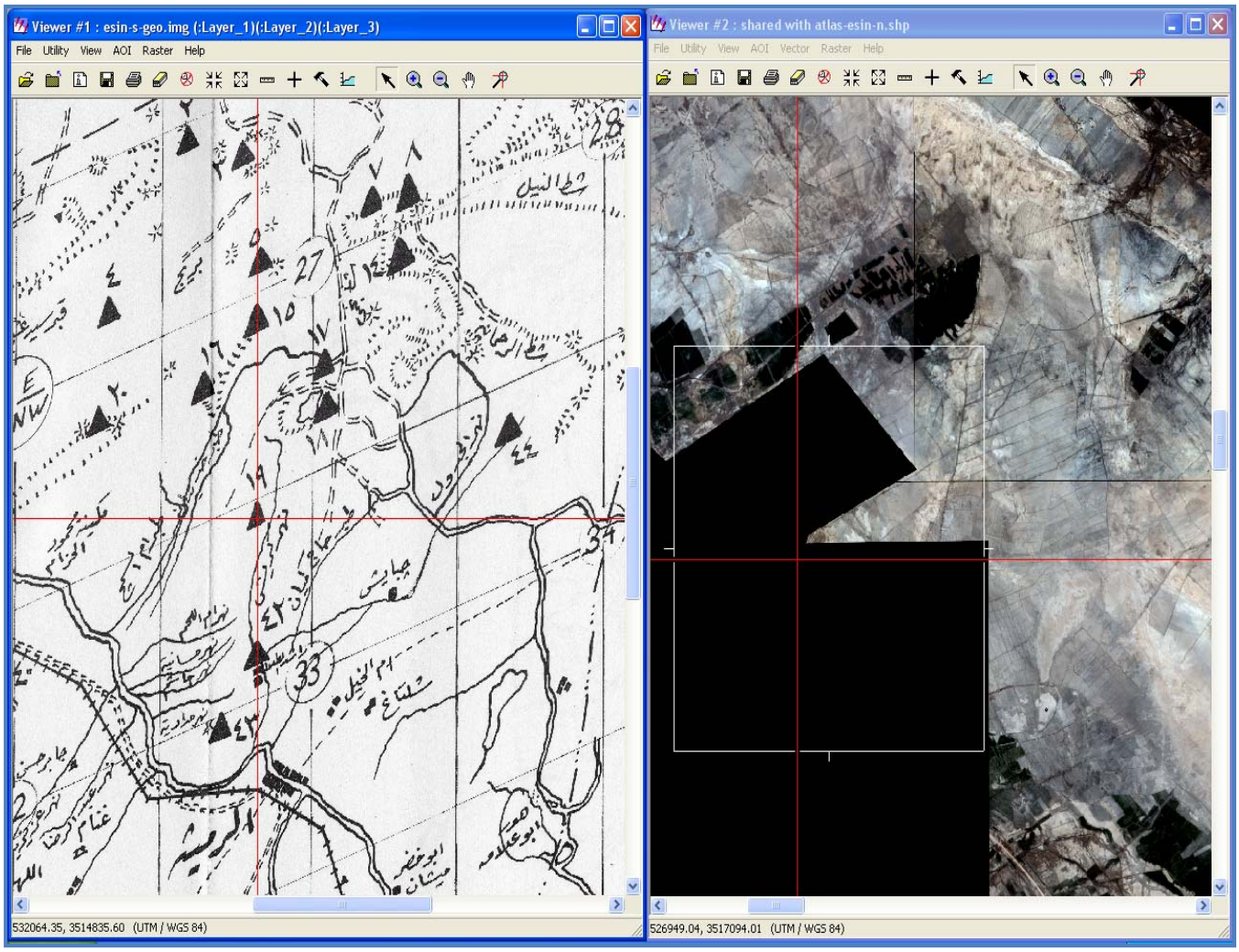


Fig. 28: Inaccuracy of the inquire cursor giving a misleading location of an archaeological site

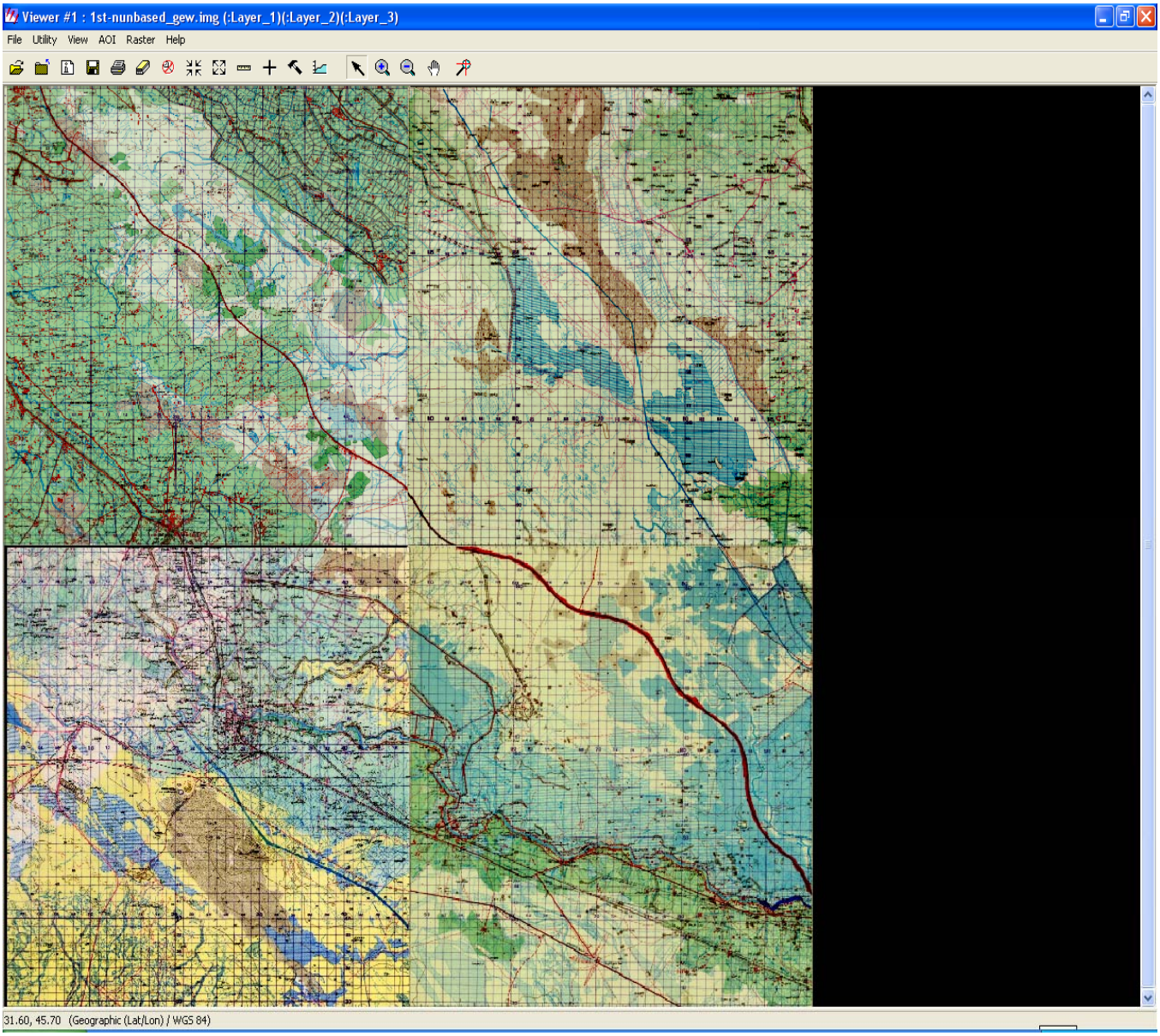


Fig.29: Four quad sheets of old Iraqi military maps that assisted the project procedures

Results from the Southern Part of Area II

The georeferencing of al-Rometha map in the Atlas resulted in the following:

1- Identifying the locations of all 16 archaeological sites included in the area of overlap between both al-Rometha and the satellite imagery (see Fig. 30).
2- Developing an associated database combining the locational data, sit size and degree of looting observed based on the satellite imagery and the site names and periods of occupation provided by the Atlas (see Table IV).
3- Using these data to create maps of area II-north showing site looting, percentage of looting and periods of occupation (see Figs. 31-32).
4- GIS analysis shows that this region has a domination of Islamic era in its sites periods of occupation (Fig. 32).

Thus, the use of remote sensing and GIS was successful in connecting the information available in the satellite imagery with that of the maps in the Atlas for our Area II, in spite of the inaccuracies of the maps.

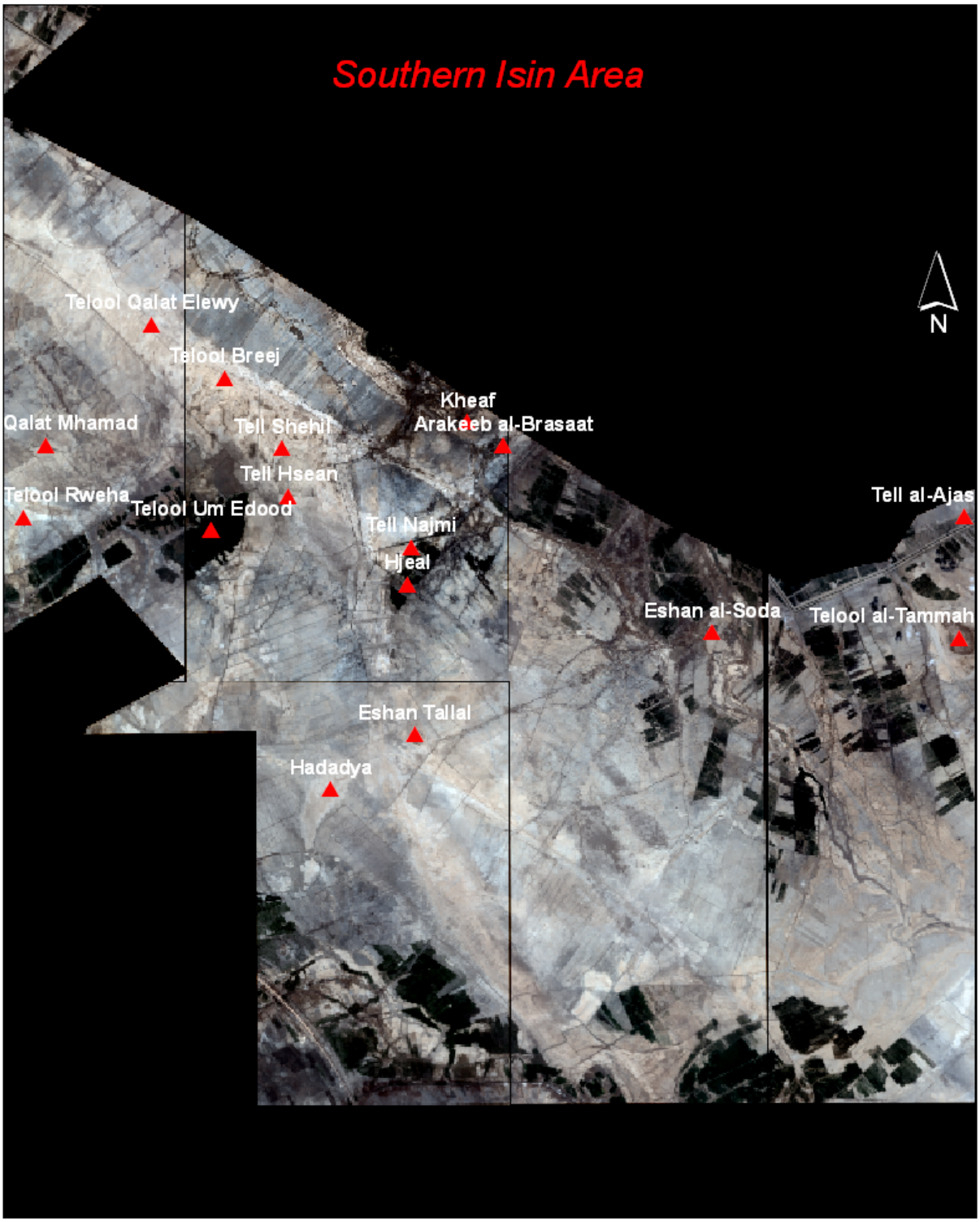
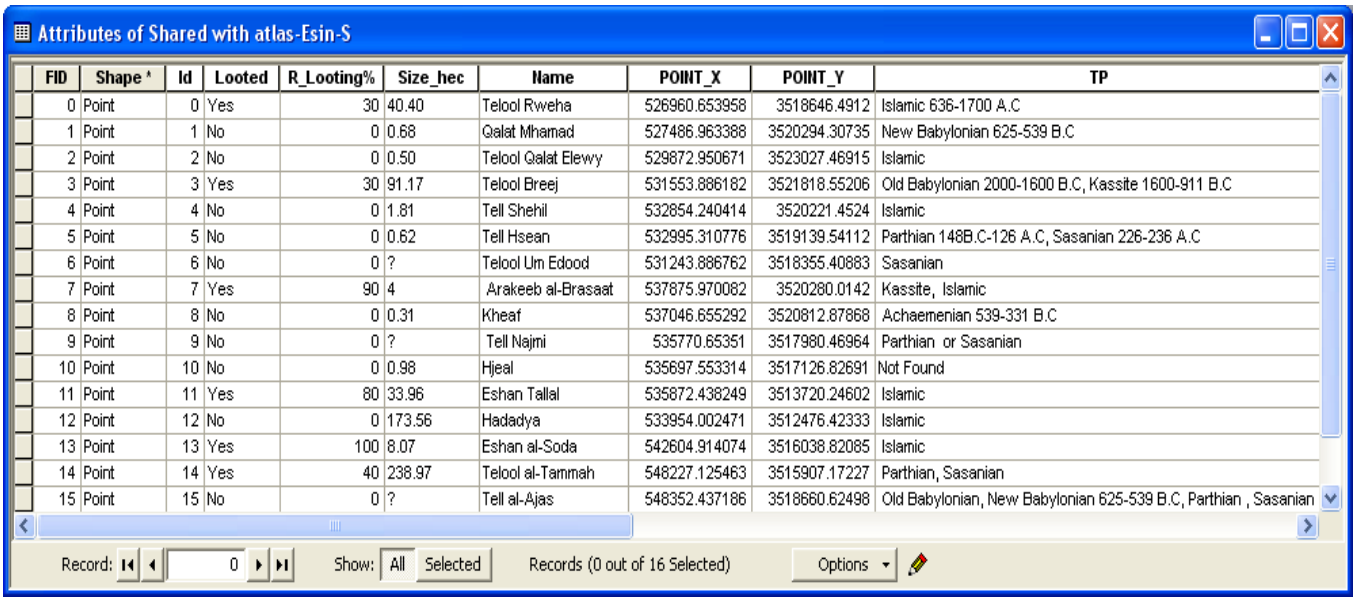


Fig. 30: Site locations in the southern Isin area. The site of Isin is located to the north-west of this map



Attributes of Shared with atlas-Esin-S

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1	Point	1	No	0	0.68	Qalat Mhamad	527486.963388	3520294.30735	New Babylonian 625-539 B.C
2	Point	2	No	0	0.50	Telool Qalat Elewy	529872.950671	3523027.46915	Islamic
3	Point	3	Yes	30	91.17	Telool Breej	531553.886182	3521818.55206	Old Babylonian 2000-1600 B.C, Kassite 1600-911 B.C
4	Point	4	No	0	1.81	Tell Shehil	532854.240414	3520221.4524	Islamic
5	Point	5	No	0	0.62	Tell Hsean	532995.310776	3519139.54112	Parthian 148B.C-126 A.C, Sasanian 226-236 A.C
6	Point	6	No	0	?	Telool Um Edood	531243.886762	3518355.40883	Sasanian
7	Point	7	Yes	90	4	Arakeeb al-Brasaat	537875.970082	3520280.0142	Kassite, Islamic
8	Point	8	No	0	0.31	Kheaf	537046.655292	3520812.87868	Achaemenian 539-331 B.C
9	Point	9	No	0	?	Tell Najmi	535770.65351	3517980.46964	Parthian or Sasanian
10	Point	10	No	0	0.98	Hjeal	535697.553314	3517126.82691	Not Found
11	Point	11	Yes	80	33.96	Eshan Tallal	535872.438249	3513720.24602	Islamic
12	Point	12	No	0	173.56	Hadadya	533954.002471	3512476.42333	Islamic
13	Point	13	Yes	100	8.07	Eshan al-Soda	542604.914074	3516038.82085	Islamic
14	Point	14	Yes	40	238.97	Telool al-Tammah	548227.125463	3515907.17227	Parthian, Sasanian
15	Point	15	No	0	?	Tell al-Ajas	548352.437186	3518660.62498	Old Babylonian, New Babylonian 625-539 B.C, Parthian , Sasanian

Record: 0 Show: All Selected Records (0 out of 16 Selected) Options

Tab. IV: Digital list of the combined data of the southern part of Area II

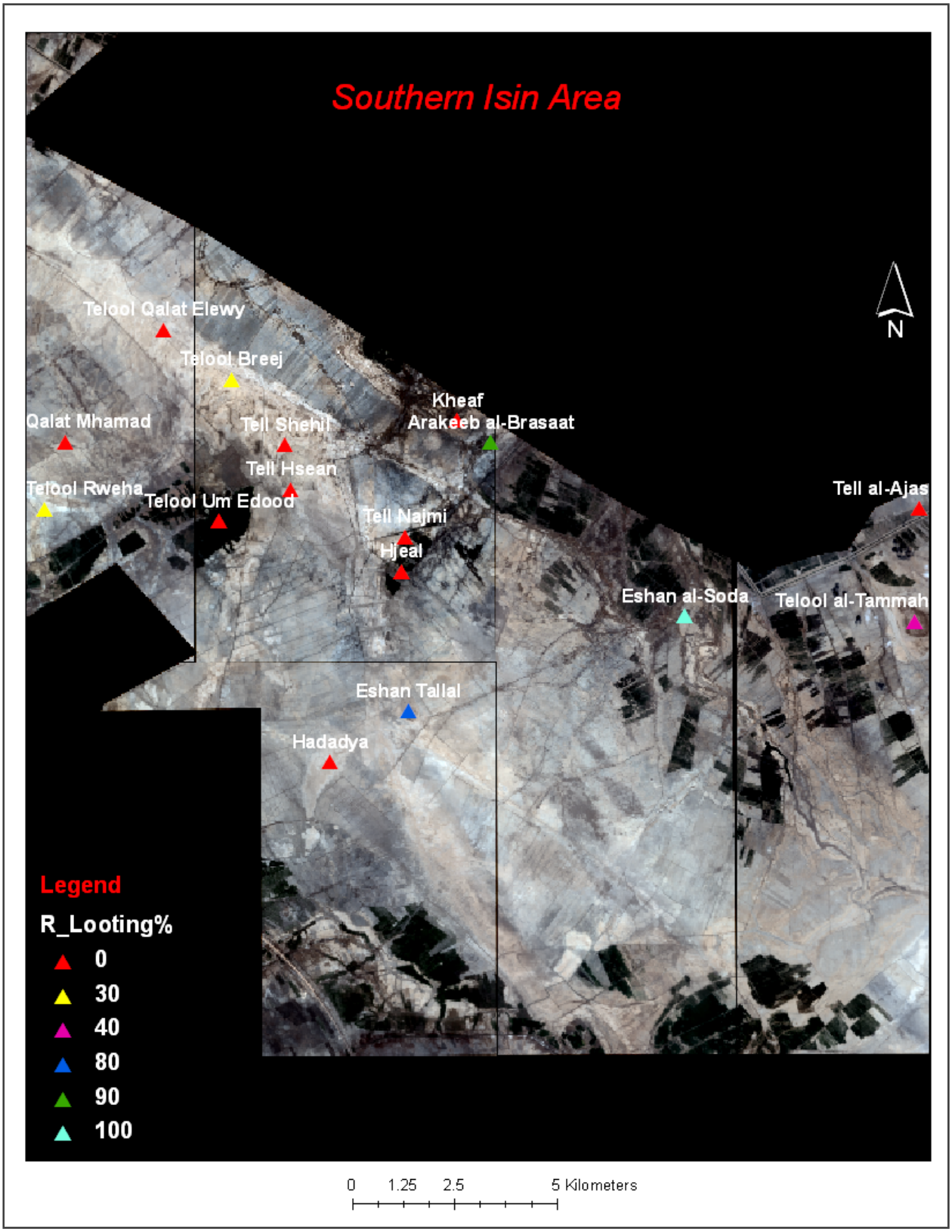


Fig. 31: Looting rates in southern Isin area

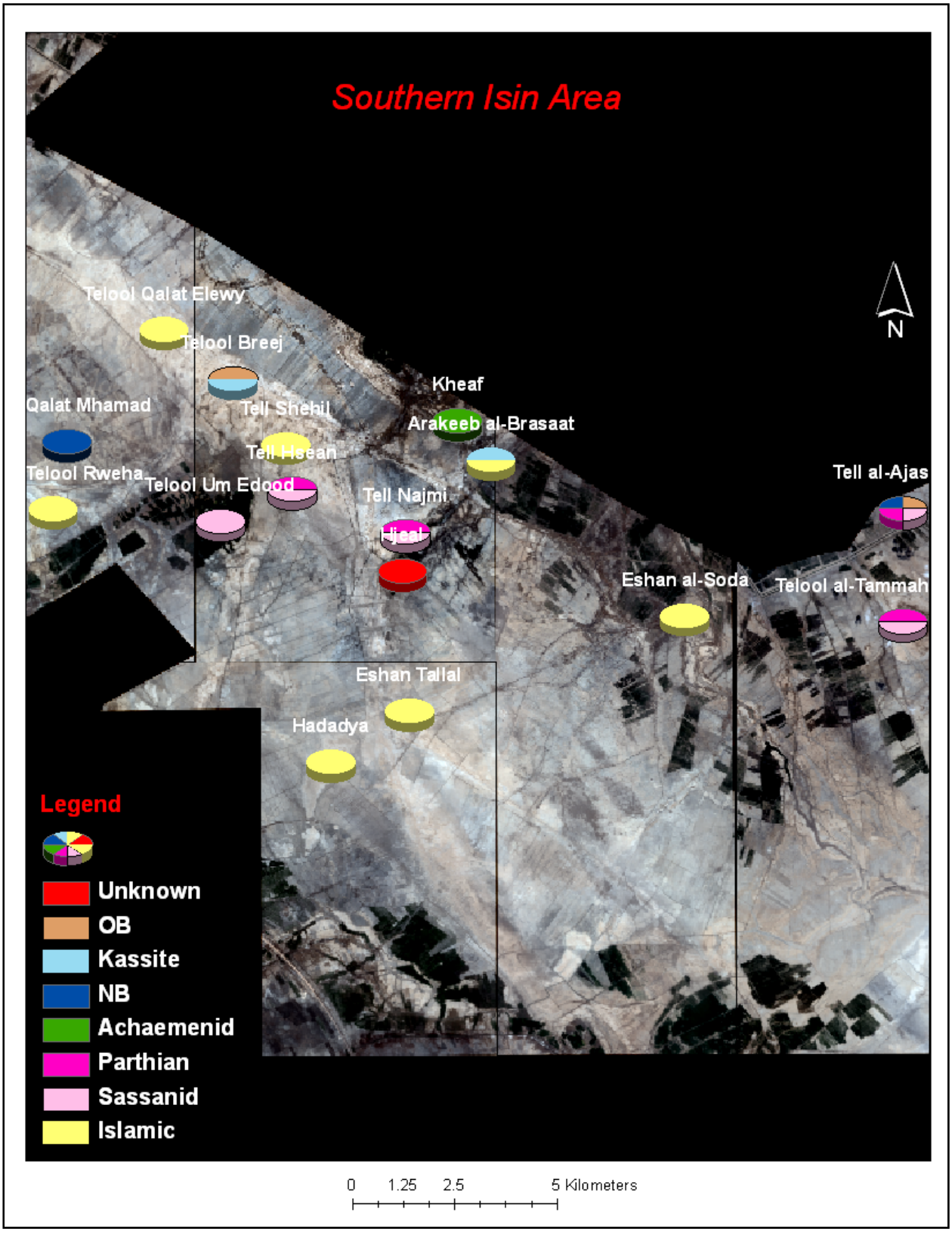


Fig. 32: Periods of occupation in southern Isin region

Chapter Four

Detection of New Sites

While investigating site locations within Area I based upon the Atlas map sheet, we came across a few mounds near the site of Girsu. The appearance of these locations suggested that they are likely to be archaeological sites. After comparing the mounds' positions with the Atlas data, it appeared that these sites have not been recorded, either within the Atlas, or in its gazetteer. Nor were these mounds recorded in the more recent survey conducted by the Nasiriyah museum. This fact provided an inspiration to continue the search for potentially new archaeological sites which may have not been surveyed before within the Girsu area.

New Sites Observation and Documentation

The procedure here was to use the satellite imagery, and an understanding of what archaeological sites look like from space to identify areas which may represent hitherto unknown archaeological sites. Clearly these will need to be ground truthed before we can be certain that they are, in fact, sites.

After surveying the whole region of Girsu, the operation resulted in the detection of 252 potential new archaeological sites (see Fig. 33). In some cases were can be fairly certain that we are indeed looking at archaeological sites, others are less certain. The confidence of the identification of the archaeological sites varied from 50-100%. A score of 50% was given to those types of sites that have a high potential of being artificial mounds, while the 100% was assigned to those locations that have been looted recently since such looting is only found on

archaeological sites. Other sites were given scores between 60% and 90% according to their appearance.

The new sites were developed into a shapefile with its associated database recording the site ID, looting evaluation in the area as well as of each individual site, the UTM coordinates of the site, the certainty of site identification and site measurements (see Table V).

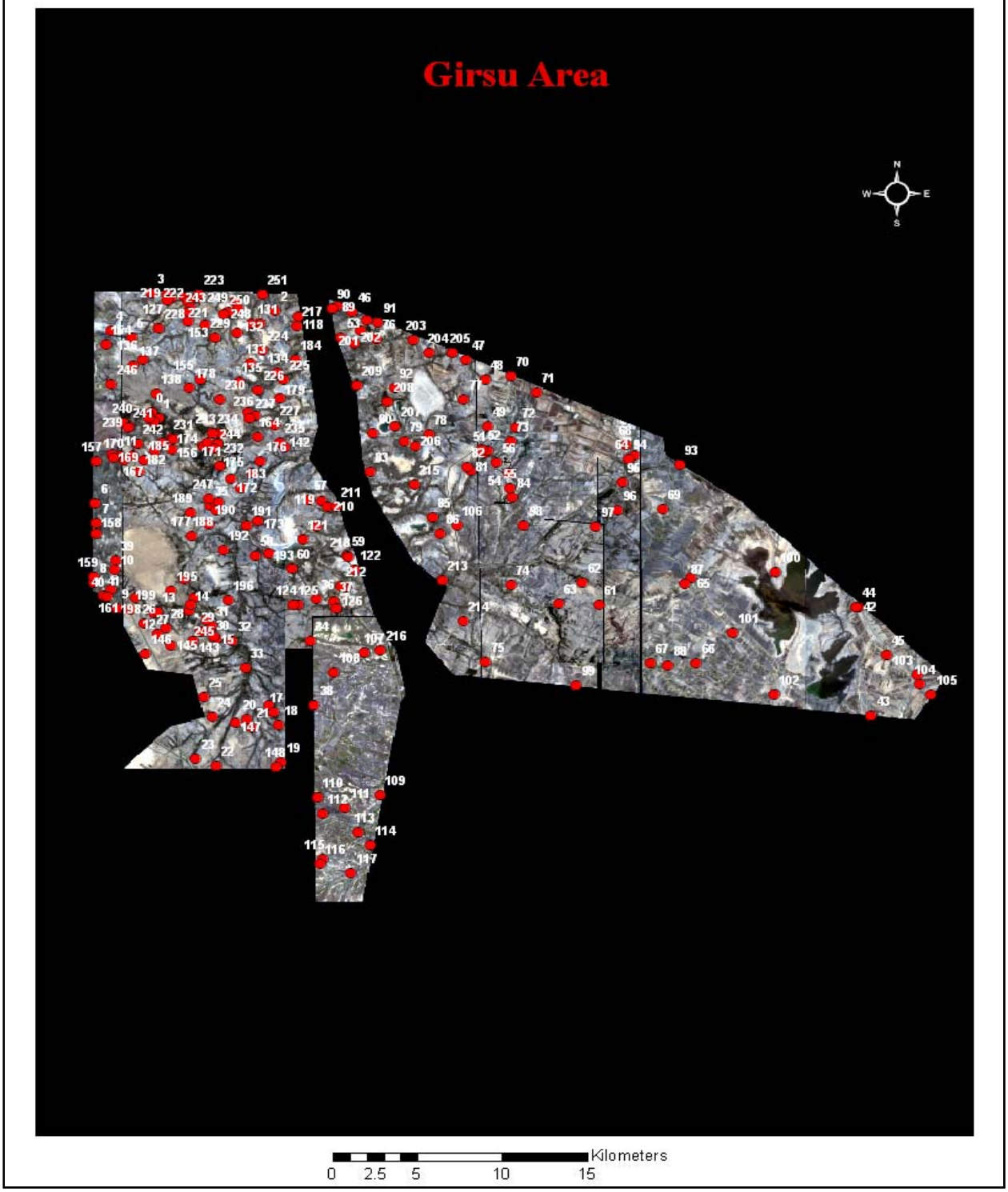
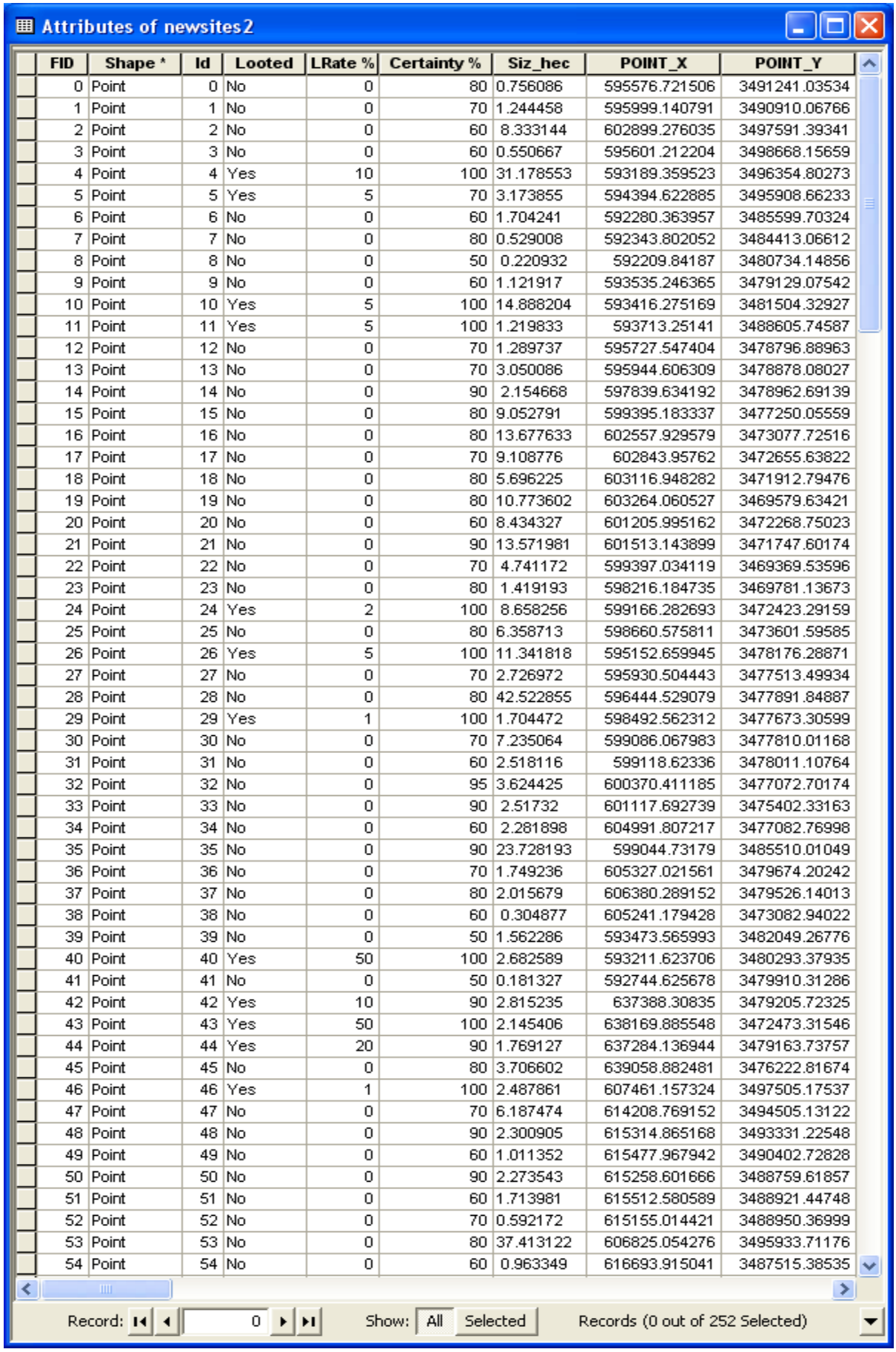


Fig. 33: The location of the new sites on the satellite photo of the Girsu area



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4	Point	4	Yes	10	100	31.178553	593189.359523	3496354.80273
5	Point	5	Yes	5	70	3.173855	594394.622885	3495908.66233
6	Point	6	No	0	60	1.704241	592280.363957	3485599.70324
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9	Point	9	No	0	60	1.121917	593535.246365	3479129.07542
10	Point	10	Yes	5	100	14.888204	593416.275169	3481504.32927
11	Point	11	Yes	5	100	1.219833	593713.25141	3488605.74587
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13	Point	13	No	0	70	3.050086	595944.606309	3478878.08027
14	Point	14	No	0	90	2.154668	597839.634192	3478962.69139
15	Point	15	No	0	80	9.052791	599395.183337	3477250.05559
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18	Point	18	No	0	80	5.696225	603116.948282	3471912.79476
19	Point	19	No	0	80	10.773602	603264.060527	3469579.63421
20	Point	20	No	0	60	8.434327	601205.995162	3472268.75023
21	Point	21	No	0	90	13.571981	601513.143899	3471747.60174
22	Point	22	No	0	70	4.741172	599397.034119	3469369.53596
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24	Point	24	Yes	2	100	8.658256	599166.282693	3472423.29159
25	Point	25	No	0	80	6.358713	598660.575811	3473601.59585
26	Point	26	Yes	5	100	11.341818	595152.659945	3478176.28871
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28	Point	28	No	0	80	42.522855	596444.529079	3477891.84887
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36	Point	36	No	0	70	1.749236	605327.021561	3479674.20242
37	Point	37	No	0	80	2.015679	606380.289152	3479526.14013
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39	Point	39	No	0	50	1.562286	593473.565993	3482049.26776
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42	Point	42	Yes	10	90	2.815235	637388.30835	3479205.72325
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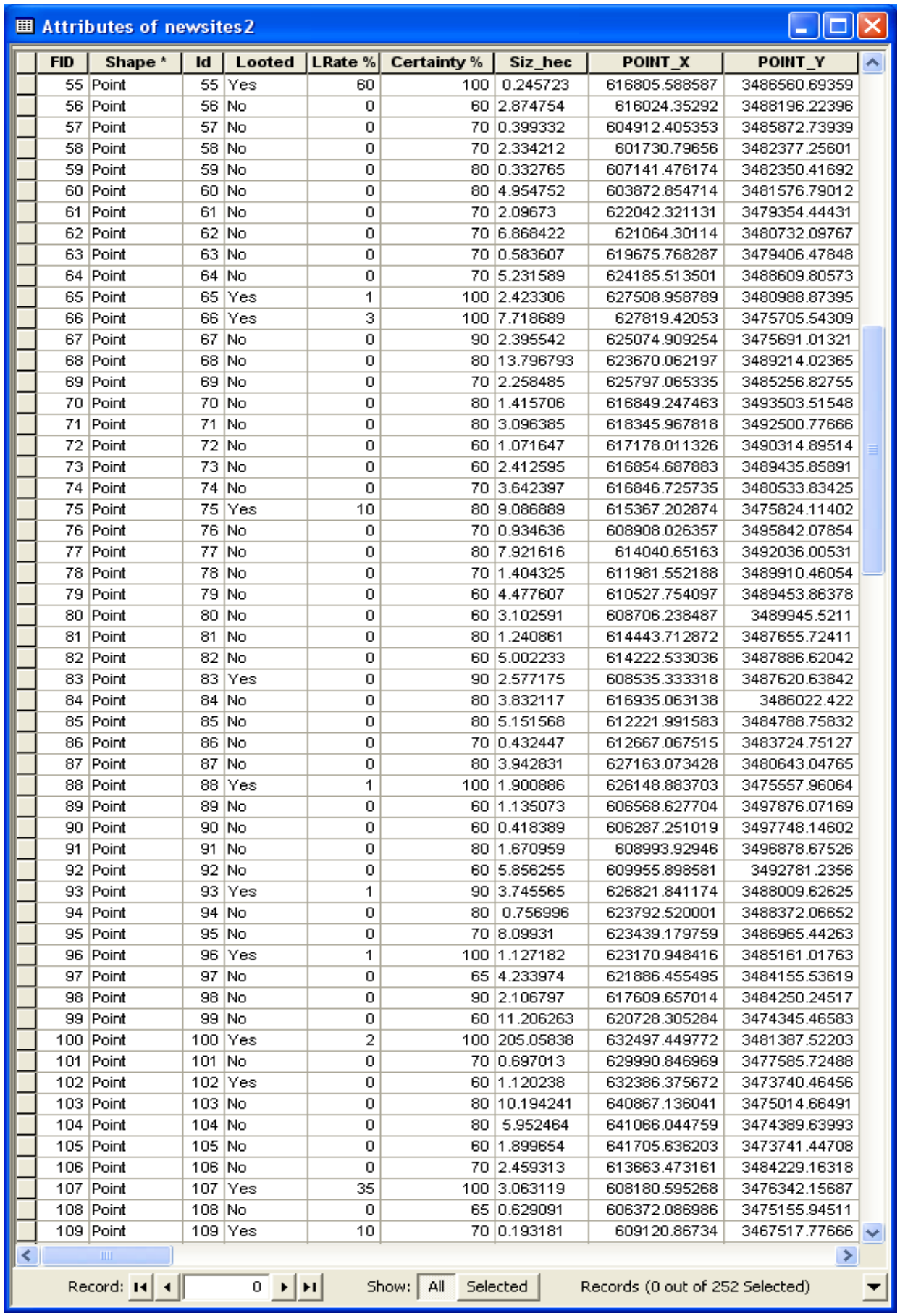

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65	Point	65	Yes	1	100	2.423306	627508.958789	3480988.87395
66	Point	66	Yes	3	100	7.718689	627819.42053	3475705.54309
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77	Point	77	No	0	80	7.921616	614040.65163	3492036.00531
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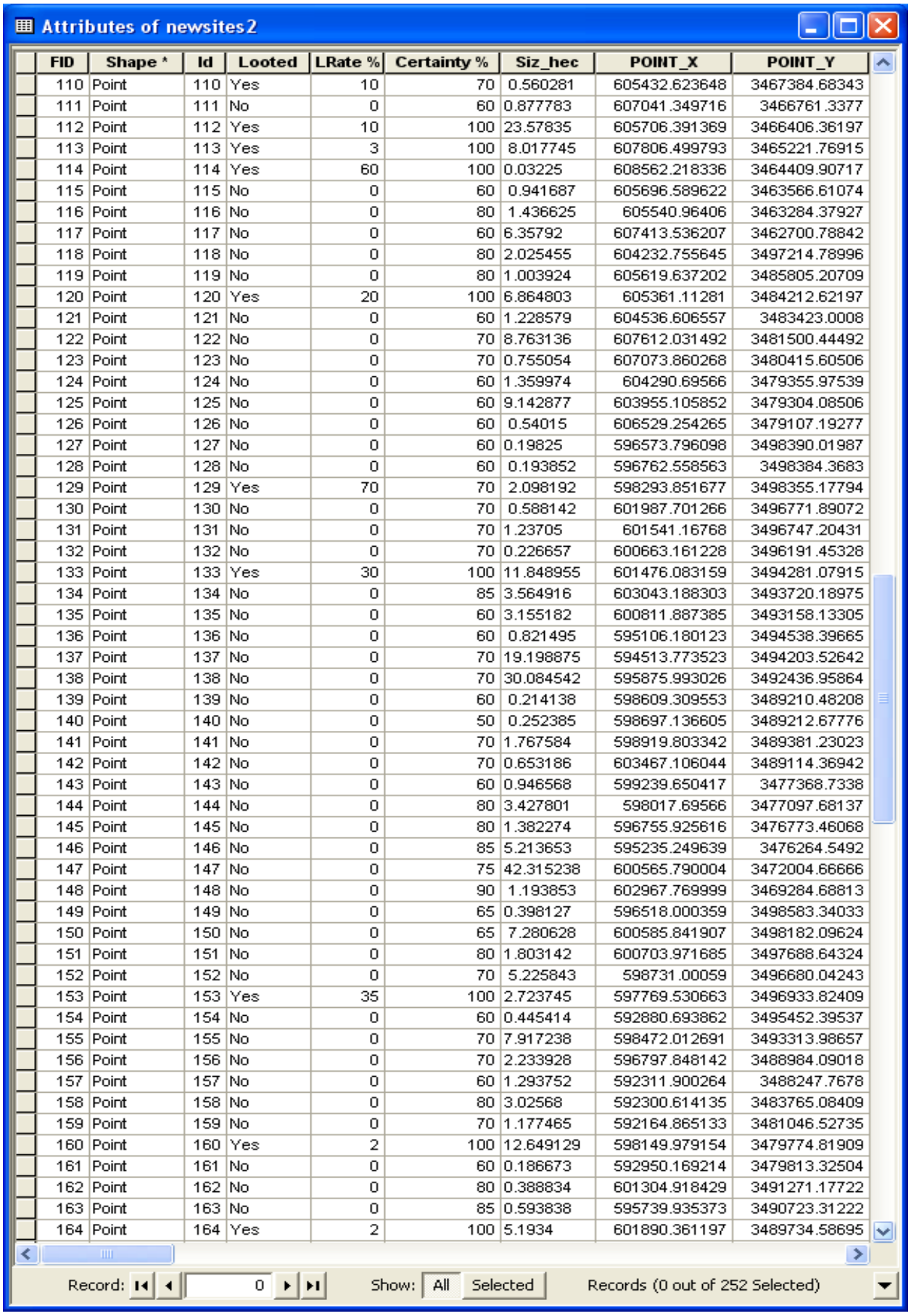

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112	Point	112	Yes	10	100	23.57835	605706.391369	3466406.36197
113	Point	113	Yes	3	100	8.017745	607806.499793	3465221.76915
114	Point	114	Yes	60	100	0.03225	608562.218336	3464409.90717
115	Point	115	No	0	60	0.941687	605696.589622	3463566.61074
116	Point	116	No	0	80	1.436625	605540.96406	3463284.37927
117	Point	117	No	0	60	6.35792	607413.536207	3462700.78842
118	Point	118	No	0	80	2.025455	604232.755645	3497214.78996
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132	Point	132	No	0	70	0.226657	600663.161228	3496191.45328
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159	Point	159	No	0	70	1.177465	592164.865133	3481046.52735
160	Point	160	Yes	2	100	12.649129	598149.979154	3479774.81909
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162	Point	162	No	0	80	0.388834	601304.918429	3491271.17722
163	Point	163	No	0	85	0.593838	595739.935373	3490723.31222
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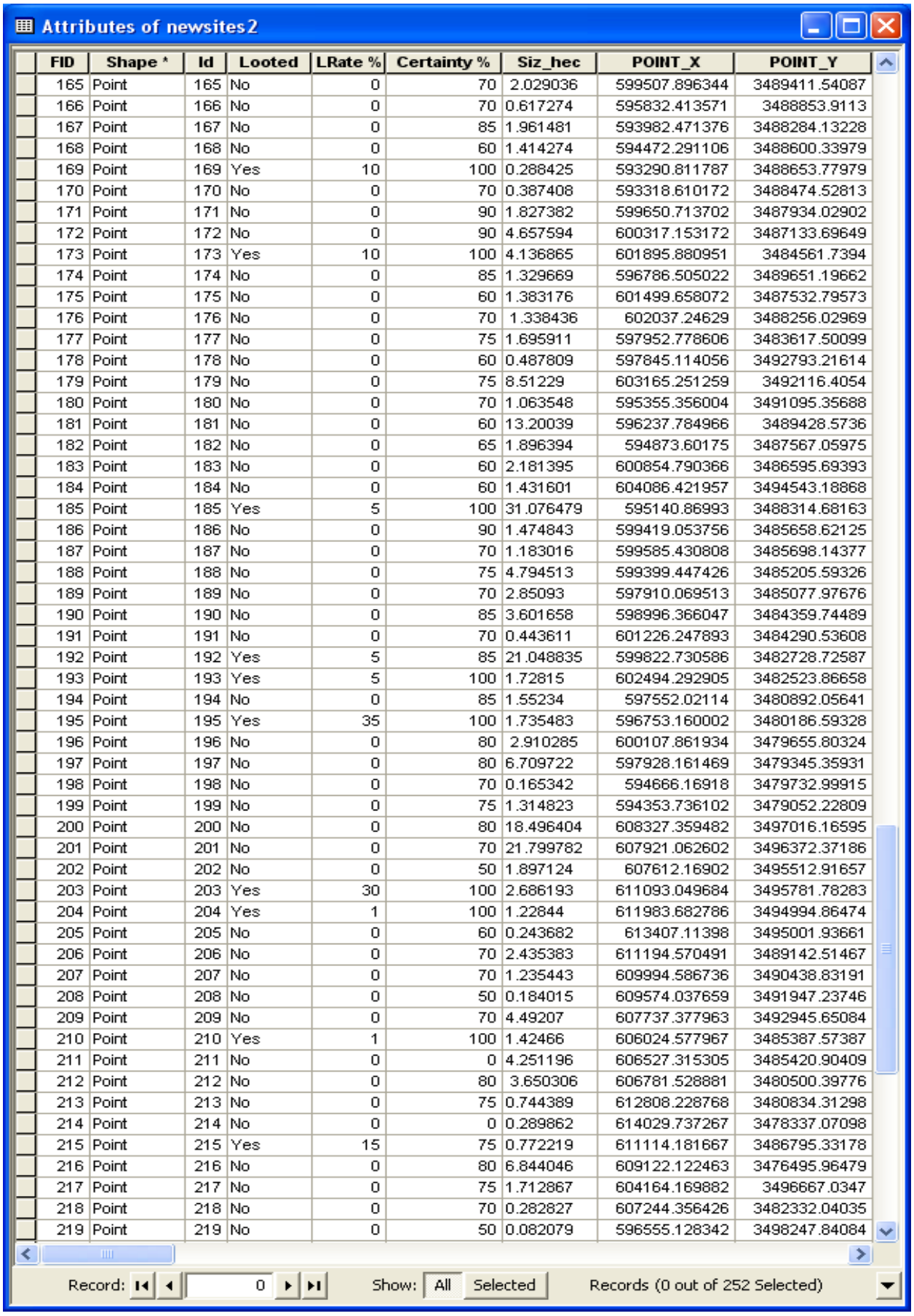

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170	Point	170	No	0	70	0.387408	593318.610172	3488474.52813
171	Point	171	No	0	90	1.827382	599650.713702	3487934.02902
172	Point	172	No	0	90	4.657594	600317.153172	3487133.69649
173	Point	173	Yes	10	100	4.136865	601895.880951	3484561.7394
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178	Point	178	No	0	60	0.487809	597845.114056	3492793.21614
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185	Point	185	Yes	5	100	31.076479	595140.86993	3488314.68163
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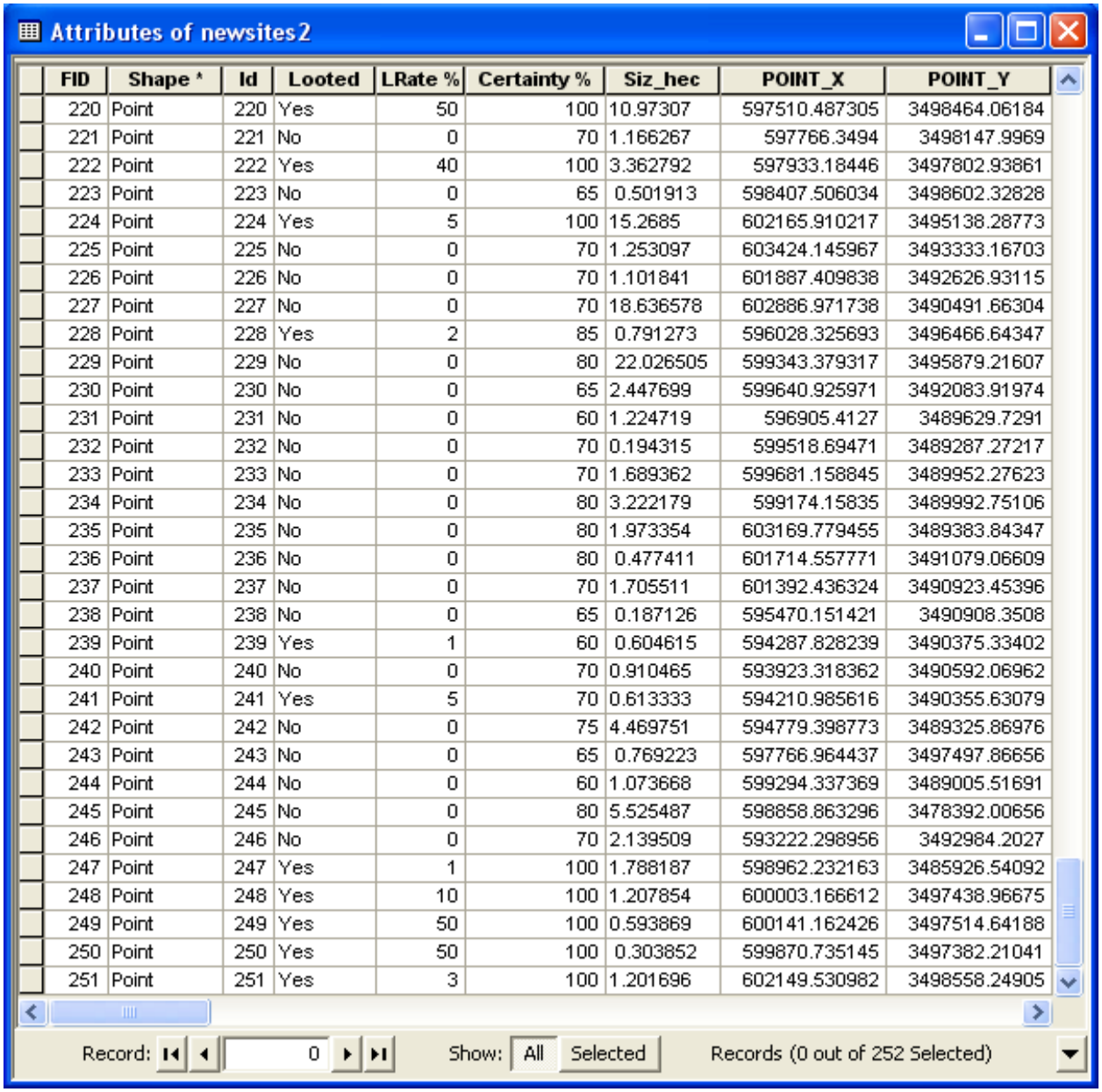

Attributes of newsites2

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223	Point	223	No	0	65	0.501913	598407.506034	3498602.32828
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228	Point	228	Yes	2	85	0.791273	596028.325693	3496466.64347
229	Point	229	No	0	80	22.026505	599343.379317	3495879.21607
230	Point	230	No	0	65	2.447699	599640.925971	3492083.91974
231	Point	231	No	0	60	1.224719	596905.4127	3489629.7291
232	Point	232	No	0	70	0.194315	599518.69471	3489287.27217
233	Point	233	No	0	70	1.689362	599681.158845	3489952.27623
234	Point	234	No	0	80	3.222179	599174.15835	3489992.75106
235	Point	235	No	0	80	1.973354	603169.779455	3489383.84347
236	Point	236	No	0	80	0.477411	601714.557771	3491079.06609
237	Point	237	No	0	70	1.705511	601392.436324	3490923.45396
238	Point	238	No	0	65	0.187126	595470.151421	3490908.3508
239	Point	239	Yes	1	60	0.604615	594287.828239	3490375.33402
240	Point	240	No	0	70	0.910465	593923.318362	3490592.06962
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248	Point	248	Yes	10	100	1.207854	600003.166612	3497438.96675
249	Point	249	Yes	50	100	0.593869	600141.162426	3497514.64188
250	Point	250	Yes	50	100	0.303852	599870.735145	3497382.21041
251	Point	251	Yes	3	100	1.201696	602149.530982	3498558.24905

Record: 0 Show: All Selected Records (0 out of 252 Selected)

Table V: Database of new sites in the Girsu area

Aspects of Southern Mesopotamian Sites from the Air

The visibility of the archaeological sites can vary in the satellite imagery. Nevertheless, most sites share the general characteristics of their appearance in the satellite photos regardless of the circumstances. Obviously, sites cannot be observed when the imagery was taken on a cloudy day or when there was a dust-storm. A more significant factor that influences the visibility of archaeological sites is the percentage of soil moisture. As is well known in the archaeological community, wet soil provides better visibility of a site's boundaries and features. (Fig. 34).

An archaeological site in an arid region.

An archaeological site in a moist territory.

Fig. 34

Despite the various appearances of archaeological sites, the aerial survey of the Girsu area could offer illustrations of site indications and aspects in southern Mesopotamia. These patterns also imply some guidelines that are beneficial when searching for archaeological sites through the satellite imagery. Following are six such guidelines:

1. **Looting:** When random holes are observed on a small area within the satellite photo, it is a clear indication as to the location of an archaeological .site (see Fig 35). Looters know where the archaeological sites are and do not waste their time digging holes elsewhere. When holes are dug to extract soil for making things like mud-bricks, the holes tend to be larger, shallower and spread further. This can be seen in some satellite imagery.
2. **Ancient structures:** Due to the frequent aerial and rain erosion in the southern region of Iraq, ancient structures, paths and rain channels on tells are sometimes visible. This is also considered a clear indication of the existence of an archaeological site (see Figure 36).

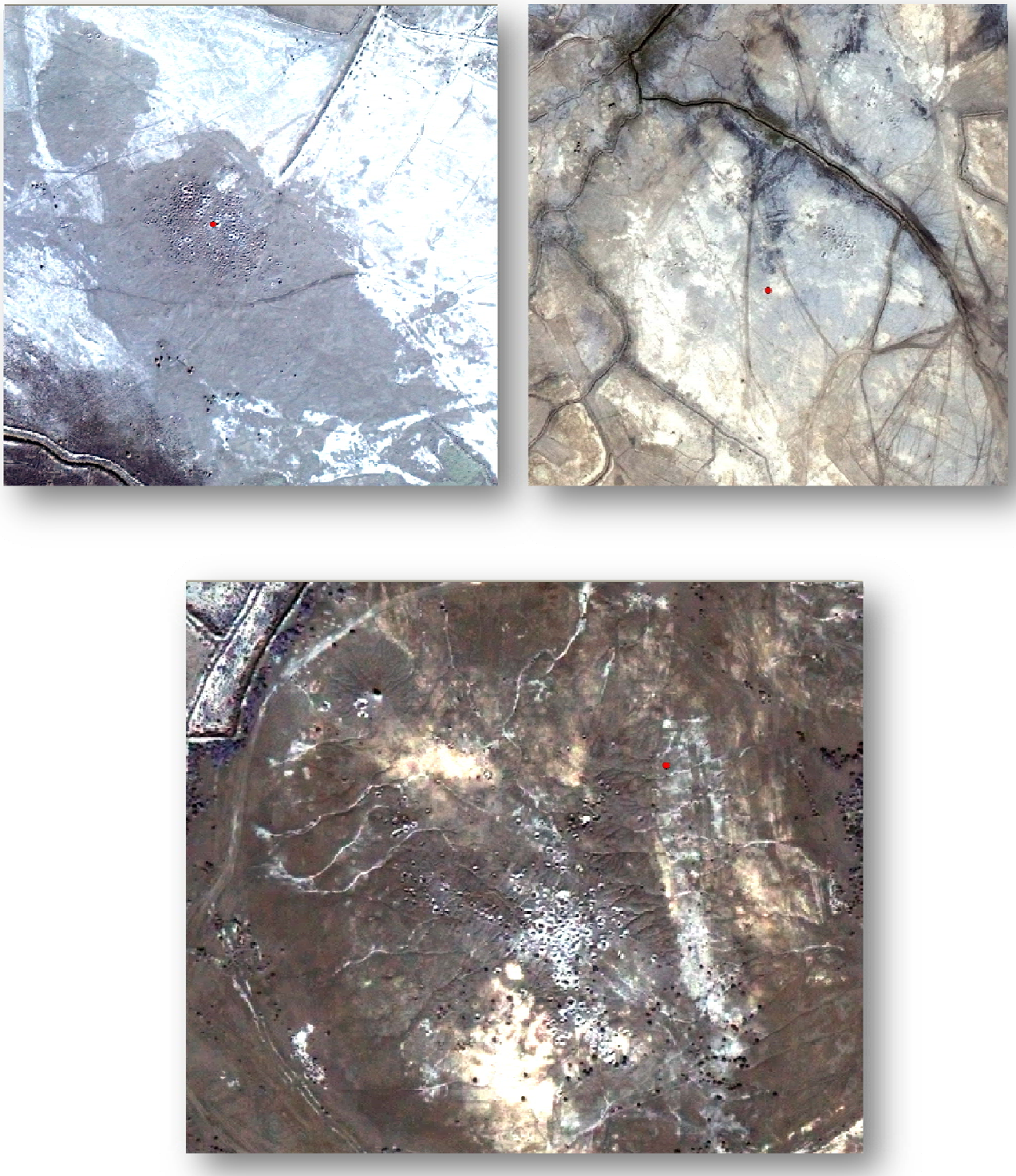


Fig. 35: Looting holes in three different sites detected by the aerial survey in the Girsu area

Fig. 36: Two visible ancient structures on two newly surveyed archaeological sites from Girsu region. The old buildings are circled in red

3. **Walk ways:** Due to the height of most archaeological sites in southern Iraq and for their convenience, people and herds tend to go around tells rather than over them. Because of this, we can see from the air the paths around or at the edges of the archaeological sites. Hence, the traces of these paths can be helpful in identifying archaeological sites. This fact can be also applicable to irrigation canals. It is easier for farmers or the government to extend the canals through the flat area and avoid any high ground (Fig. 37).

Fig. 37: Two sample archaeological sites showing paths and canals surrounding the sites

4. **Color contrast:** When performing a ground survey, the color of the archaeological site's soil might not look remarkably different from the area surrounding it. From the air, however, the site often looks quite different (Ur 2003: 103). Consequently, archaeological locations can be detected through their color difference or contrast from the area around them (see Fig. 38).

Fig. 38: Two archaeological sites appear lighter in color than the area surrounding them

5. **Shape:** One additional factor is the rounded or oval outline that is typical of archaeological sites in this area (Fig. 37-38), and the mounding that is evidence on most of the archaeological sites' surfaces (Fig. 39).

Fig. 39: A rounded surface of one of the archaeological sites as indicated in the Girsu survey

6. **Cultivation:** Both due to the antiquities law and the impractibility of irrigating raised land, farmers are often obliged to leave archaeological sites as uncultivated areas in the middle of their fields. This makes these sites quite easily visible from the air (see Fig. 40).

These observations are designed to help in the process of identifying new sites from the air, which can then be ground truthed by the local members of the State Board of Antiquities and Heritage.

Fig. 40: A samples of archaeological sites located in cultivated area

Estimating Looting in the Girsu Area

Illegal digging took place in the south of Iraq after the Gulf War in 1991and more intensely just before and after the invasion in 2003 (Stone 2008: 125). This crisis has received the attention and sympathy of the archaeological community around the globe. Specialists in Iraqi archaeology have provided scientific reports, which included evaluations of the looting in southern Iraq from and after the year 2003. Illegal digging has done massive damage to the archaeological sites but although archaeologists have been struggling to provide ways to prevent further damage to the Iraqi sites, some in the media have underestimated and doubted the existence of this disaster.

The aerial survey of the Girsu region provides further evidence for the destructive archaeological looting in southern Mesopotamia. The looted archaeological sites that have been detected in this area have never been surveyed before. Among the 252 probable new archaeological sites observed in the Girsu region, 55 were looted in various degrees. We do not know when the looting took place, but we do know that these sites have not been included in any previous account of looting. Table VI shows the looting details and fig. 41 the distribution of looted sites. The GIS analyses also show that the looters were interested in digging sites which are on the average larger than the others in area (see Fig. 42 & Table VII).

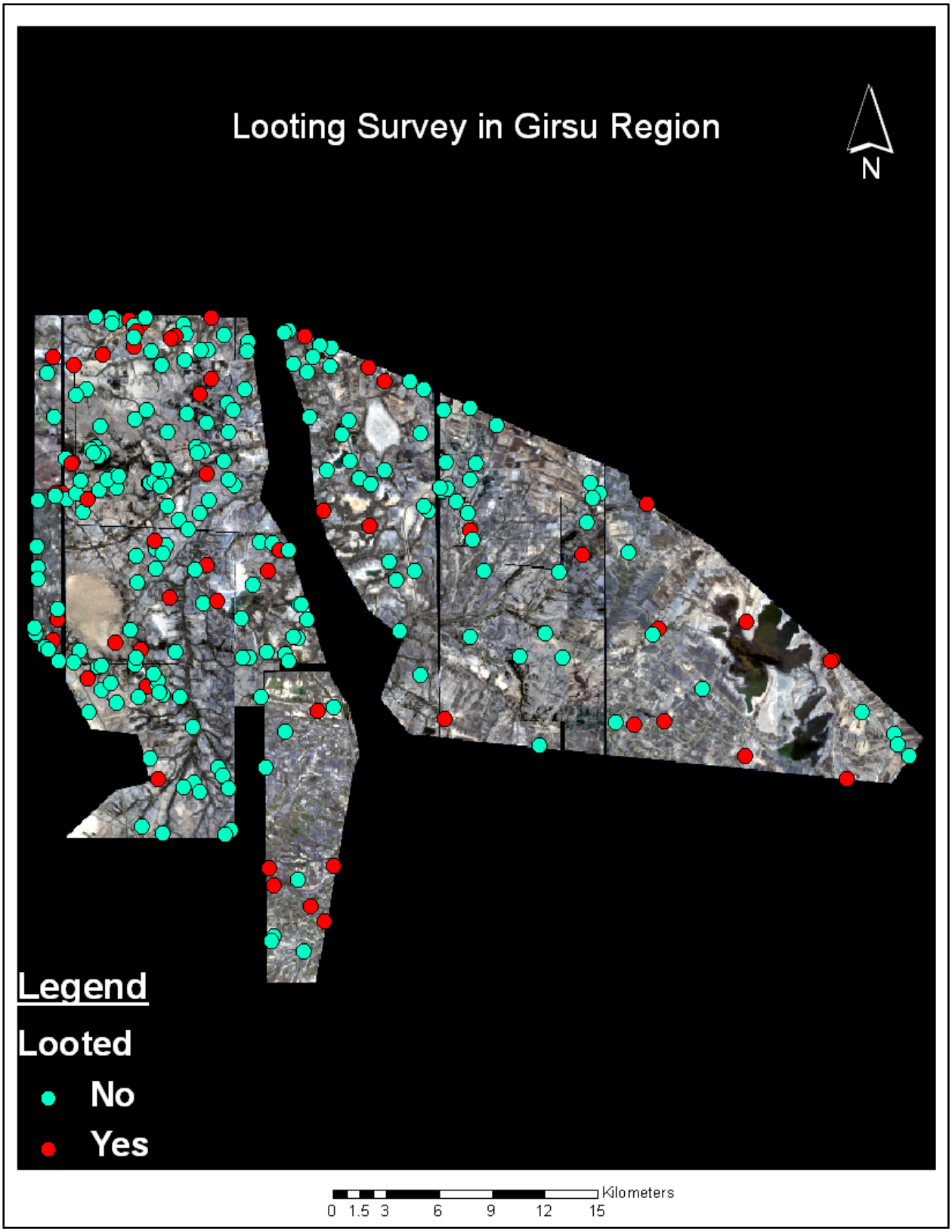
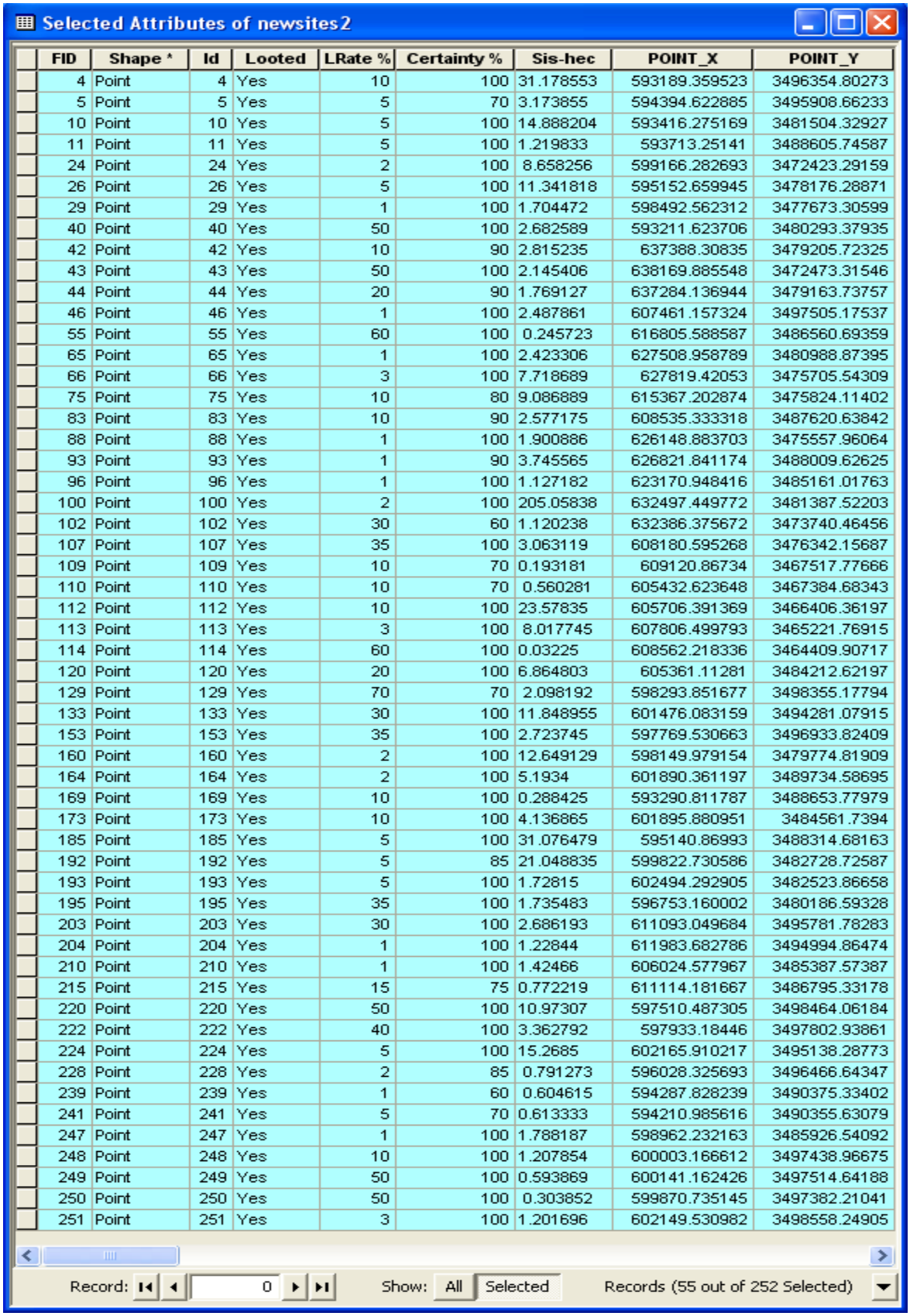

Looting Survey in Girsu Region
N
Legend
Looted
No
Yes
Kilometers
0 1.5 3 6 9 12 15

Fig. 41



Selected Attributes of newsites2

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10	Point	10	Yes	5	100	14.888204	593416.275169	3481504.32927
11	Point	11	Yes	5	100	1.219833	593713.25141	3488605.74587
24	Point	24	Yes	2	100	8.658256	599166.282693	3472423.29159
26	Point	26	Yes	5	100	11.341818	595152.659945	3478176.28871
29	Point	29	Yes	1	100	1.704472	598492.562312	3477673.30599
40	Point	40	Yes	50	100	2.682589	593211.623706	3480293.37935
42	Point	42	Yes	10	90	2.815235	637388.30835	3479205.72325
43	Point	43	Yes	50	100	2.145406	638169.885548	3472473.31546
44	Point	44	Yes	20	90	1.769127	637284.136944	3479163.73757
46	Point	46	Yes	1	100	2.487861	607461.157324	3497505.17537
55	Point	55	Yes	60	100	0.245723	616805.588587	3486560.69359
65	Point	65	Yes	1	100	2.423306	627508.958789	3480988.87395
66	Point	66	Yes	3	100	7.718689	627819.42053	3475705.54309
75	Point	75	Yes	10	80	9.086889	615367.202874	3475824.11402
83	Point	83	Yes	10	90	2.577175	608535.333318	3487620.63842
88	Point	88	Yes	1	100	1.900886	626148.883703	3475557.96064
93	Point	93	Yes	1	90	3.745565	626821.841174	3488009.62625
96	Point	96	Yes	1	100	1.127182	623170.948416	3485161.01763
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110	Point	110	Yes	10	70	0.560281	605432.623648	3467384.68343
112	Point	112	Yes	10	100	23.57835	605706.391369	3466406.36197
113	Point	113	Yes	3	100	8.017745	607806.499793	3465221.76915
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129	Point	129	Yes	70	70	2.098192	598293.851677	3498355.17794
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164	Point	164	Yes	2	100	5.1934	601890.361197	3489734.58695
169	Point	169	Yes	10	100	0.288425	593290.811787	3488653.77979
173	Point	173	Yes	10	100	4.136865	601895.880951	3484561.7394
185	Point	185	Yes	5	100	31.076479	595140.86993	3488314.68163
192	Point	192	Yes	5	85	21.048835	599822.730586	3482728.72587
193	Point	193	Yes	5	100	1.72815	602494.292905	3482523.86658
195	Point	195	Yes	35	100	1.735483	596753.160002	3480186.59328
203	Point	203	Yes	30	100	2.686193	611093.049684	3495781.78283
204	Point	204	Yes	1	100	1.22844	611983.682786	3494994.86474
210	Point	210	Yes	1	100	1.42466	606024.577967	3485387.57387
215	Point	215	Yes	15	75	0.772219	611114.181667	3486795.33178
220	Point	220	Yes	50	100	10.97307	597510.487305	3498464.06184
222	Point	222	Yes	40	100	3.362792	597933.18446	3497802.93861
224	Point	224	Yes	5	100	15.2685	602165.910217	3495138.28773
228	Point	228	Yes	2	85	0.791273	596028.325693	3496466.64347
239	Point	239	Yes	1	60	0.604615	594287.828239	3490375.33402
241	Point	241	Yes	5	70	0.613333	594210.985616	3490355.63079
247	Point	247	Yes	1	100	1.788187	598962.232163	3485926.54092
248	Point	248	Yes	10	100	1.207854	600003.166612	3497438.96675
249	Point	249	Yes	50	100	0.593869	600141.162426	3497514.64188
250	Point	250	Yes	50	100	0.303852	599870.735145	3497382.21041
251	Point	251	Yes	3	100	1.201696	602149.530982	3498558.24905

Record: 0 Show: All Selected Records (55 out of 252 Selected)

Tab. VI: Detailed information of the Looted sites in the Girsu area

Fig. 42: Rate of looting (percentage ranges) in the Girsu area

Attributes of Sum_Output_5

OID	Looted	Count_Looted	Average_Size-Hec
0	No	197	4.0723
1	Yes	55	9.0678

Record: 0 Show: All Selected Records (

Tab. VII: Analytical data on the new looted sites in the Girsu region

Chapter five

Conclusion

This project has shown how the use of remote sensing and GIS can be used to make old data usable as a first step towards building a GIS of known archaeological sites within Iraq. The shortcomings of the Archaeological Atlas of Iraq have long been a source of frustration to archaeologists. Without geographic coordinates on the maps, the extensive data it provides has been largely unusable. The combination of remotely sensed data and that contained in the Atlas provide a picture of ancient settlement in this key area. The methods tested in the Isin and Girsu areas can be transferred to other parts of Iraq, providing a broad digital picture of Iraqi settlement.

Furthermore, the use of remote sensing and GIS has shown productive results in recording the site looting in southern Mesopotamia. In the future, these tools can assist in preventing further damage to archaeological sites through aerial monitoring and early detection of illegal digging.

Based upon the success in the identification of previously unregistered sites in this project, I urge archeologists using GIS and remote sensing methods to identify and document all the possible sites. The approach should be conservative and inclusive and should include all sites that have the potential of being archeologically significant, not only those that have the full set of characteristics that assure their historical identity. These site locations could then be passed on to the inspectors working on the area for ground truthing.

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