EXAMINING PAST RESEARCH WITH NEW TECHNOLOGIES: THE EWING SITE REVISITED WITH ARCGIS

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David Ross Reed

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The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Arts with a major in Anthropology.

_____
David T. Hughes, Committee Chair

_____
Peer Moore-Jansen, Committee Member

_____
Orren Dale, Committee Member

DEDICATION

To Shannon, my wife, who I met while working on this project. She has been with me every step of the way and who not only shared my frustrations, she let me vent them in a productive manner. She kept me motivated and sane. I do this for her.

To Lily, my daughter, who was born while I undertook this task. She was at my side while I wrote. And though she was too young to know it, all I had to do was look at her peaceful sleeping face and it gave me the strength to continue on.

To Parker, my son, who was the added bonus and push I needed to finish this. This project will allow him to enjoy a tremendous childhood with a father not burdened by school work.

To Erin, my best friend, who started me on this remarkable journey that has led to me new chapters in my life and opened up new avenues that I never thought possible. I am not Bill!

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ABSTRACT

During three summers in the late 1960s, the Ewing Site was excavated in the Four Corners area of Colorado and was archived at Wichita State University. Since that time, archaeological recovery methods and analysis technology has changed. Along with other technological changes, Geographic Information Systems (GIS) Technology has had a profound impact in the worldof Cultural Resource Management. With the advent and implementation of this new technology, archaeology has found a faster and easier way of examining data across vast geographical areas.This allows for better probability studies for the location and protection of sites across the UnitedStates. Landscapes can be examined to determine how people moved across their environments such as hunting routes, natural resource usage, and migration studies.

Little has been done in applying this technology to older data and looking at site level spatial relationships. Using the Ewing site as a template, there are several questions that need to be addressed. The first is to determine if there is potential for the site to offer new information. Next we need to determine if there is enough information still available in order to make a proper assessment of the site. And finally we must ask, did we learn anything new? GIS must further our knowledge of the people who once lived there to make it worth the effort of applying to sites of this type. This information can be easily integrated at theinstitution level and incorporated into other larger GIS databases that include data from all over aspecific region. It could also be invaluable in sorting through vast collections that may have sat untouched since the Great Depression and the early days of the Works Project Administration.Salvage archaeology is an important aspect in the history of the profession within the United States, and gaining accurate and important information in minimal time would serve to advance archaeology as a whole.

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Section 1

INTRODUCTION

Archaeologists have long been detailed organizers of information. From the time material is pulled out of the ground, to the day the information goes to a publisher to be printed in a book, everything is scrutinized and accuracy checked. During the 20th century, countless archaeological sites were excavated for every possible reason. Many sites were excavated with proper techniques, some were given proper attention for research, and those lucky few were given eternal life through publication. Most (especially those during the WPA days) were relegated to sitting on a dusty shelf in a back room of a university, museum or forgotten federal building. Money and personnel constraints limit the ability to properly analyze these materials. What do we do with these old records? Over the years, these old collections are often transferred and moved and materials end up missing and lost. I contend that even old sites can be resurrected given a fairly reasonable level of preservation of the records for that site. New information can then be added to the overall picture for the geographic area that site is found in. In order to accurately check results, a site that has been well documented and published on was used to demonstrate the viability of such a project.

Even though all of the data in this paper has been procured from the Ewing site, my aim is not to describe the site and its history in great detail. Other publications are readily available to further expand the scope of this site. Instead, my intention is to demonstrate an alternate method of interpreting and delivering information from this site. The ability of GIS to quickly adapt to any new academic or environmental situation has been its hallmark for nearly thirty years. With a solid background on this site, it is a good candidate to demonstrate how GIS can

be incorporated quickly into older sites that have no similar background coverage and still make the site relevant and up to date. Using previous research and publications it is then possible to double check the findings and accuracy of a GIS database.

Section 2

HISTORICAL BACKGROUND OF GIS

Geographic Information System (GIS) technology has been in its modern form for over 25 years. As technology has gotten cheaper and information has become more readily available, this technology has become the flagship of archaeological investigation and reporting. GIS continues to be a dominant source of disseminating information in the fastest and most efficient means. Visual representation can give a variety of information at a glance making a picture truly worth "a thousand words".

Some GIS work requires knowing past patterns. (Hunt, 1992) These patterns have been established in the archaeological record through traditional field work and excavation. Applying these known patterns to check the work being done on GIS allows for future work to be done quicker and easier. Without having a previous pattern, such as settlement relocation, it can be difficult to appropriately predict where such sites would occur. But where variables are known, they can be entered into areas that are not known or are currently being researched and examined.

Not only does archaeology use GIS, but other areas of interest also use this technology to a great extent. Even commercial interests are well served through GIS such as, route analysis, formation analysis, site locality and time geography analysis. To illustrate, Schlotzsky's Deli successfully incorporated a GIS database to properly locate a new restaurant location in an effort to maximize and speed the decision making process (Richardson, 2008). Using parameters such as competitor locations, median personal income, traffic patterns and real estate prices, it was possible make quick work of what would most likely have been a daunting task. This is just a

small part of what GIS is fully capable of doing to enhance data and process it in the manner best suited to the problem at hand.

Predictive modeling has been the main application for GIS in archaeology for the last 20 years. Other uses have been examined and employed like site mapping but has not taken root to the extent that it has in other parts of the world such as Italy and England. It has been estimated that in the entire 20th century barely 600 projects in the United States have involved examination of geophysical data. Nearly 500 projects a *year* are completed using this method in Europe (Kvamme, p. 436). This not a failing for the appreciation of GIS in America, but more representative of the environment with which it is used. Archaeology in the US is often done in a mitigation setting. This means locating potential areas of impact accurately and with low cost. Areas of academic work are typically done in locations that are protected or on private land, and full disclosure of a site and the contents are not always allowed. The second most common use of GIS is as a data logger. During a mitigation study it is faster and requires less people to punch a few buttons on drop down menus while moving over a landscape than stopping to write details. Surveys can be done in half the time, with less people, and more accurate observations.

Site modeling is not a new application but has been slow in adoption in the US. The equipment and software are likely the biggest deterrents as companies and universities likely would not want to spend the money on a single site project and instead put resources in large scale settings. However, in places like Italy where someone has but to pick a spot and dig a hole to find artifacts, it is important to work faster and accurately. GIS is most beneficial when used from start to finish. But it can also be used retroactively. It is not regularly employed since people typically examine a site and move on to the next. But information can be disseminated faster and more knowledge gained through its use. After GIS is employed on past sites, this can

in turn be added to a larger database that a state or university would have built up in order to comply with federal and state regulations. Several states including Kansas, possess a large GIS database that can be accessed by authorized archaeologists that can quickly give visual representations and histories of sites that have been excavated.

More often today it is being argued that a proper determination of cultural importance cannot be made without more in depth analysis. Geophysical analysis can directly increase our knowledge of a landscape without being intrusive. In a 2001 survey of Ozark National Forrest, nearly 40,000 holes were dug. Of these, only 400 had artifacts associated with them. This accounts for a one percent hit rate within the park. In large scale surveys, there are far better ways to spend time and resources than digging random holes. Likewise, a five percent excavation of a particular area can often completely negate any work you are attempting to do. Past uses of the landscape can vary so greatly that it is possible that holes can be dug within a meter of a feature and it could be completely missed.

When you take into consideration the limitations of test digging and traditional sampling strategies, a great deal of information can be missed. Incorporating new methods, which can be slightly more expensive initially can pay huge dividends in the end. The example below provides an example of what a five percent survey can show. Figure 1 and 2 shows what the incorporation of geophysical examination can do for a study. This particular example relies on soil resistivity. The difference in a five percent field survey versus a full survey are obvious. However, GIS can help eliminate areas of study based on parameters that have been previously determined through academic discussion. Past resources and landscape utilization for a population can be used for a baseline and certain areas can be excluded for examination while others can be intensified. (Kvamme, 2001)

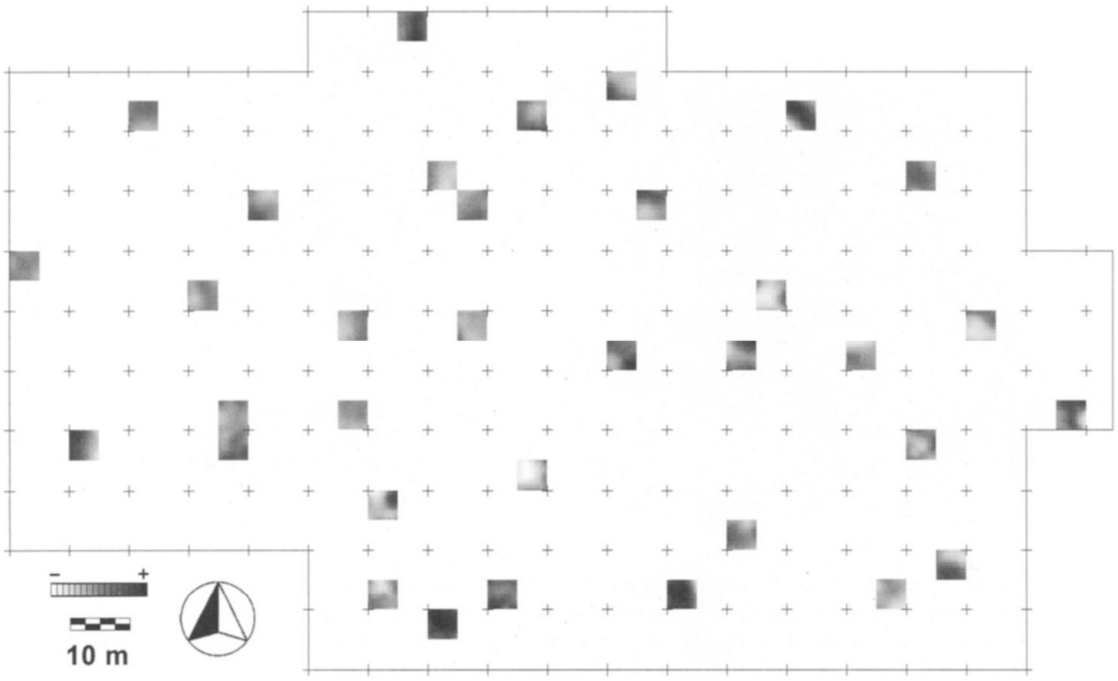


Figure 1.A five percent random sample of non-contiguous survey blocks illustrates many features of potential interest in a resistivity data set, but their relationships with other features and the overall content and layout of the site is impossible to realize (the complete data set revealing the entire structure of this site is given below).

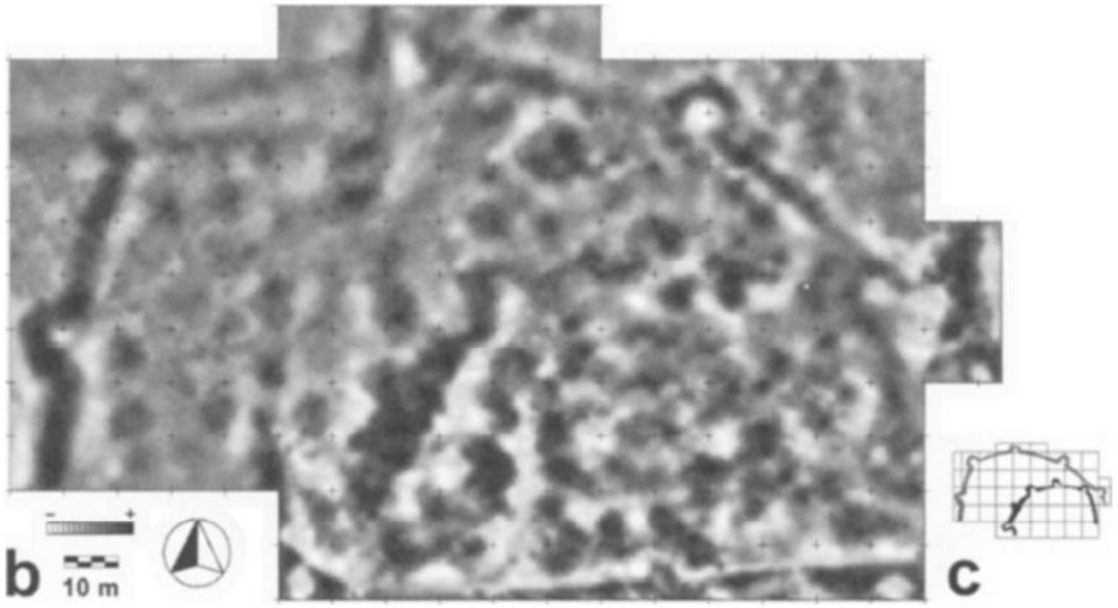


Figure 2.Resistivity data collected at Whistling Elk Village (39HU242), South Dakota. (b) the final image showing the fortification systems and the distribution of numerous houses after significant com-puter processing; and (c) interpretation of fortification ditches and bastion distributions. An example of how random sampling of a site can often not provide a comprehensive view of an archaeological site. (Kvamme 2001)

Predictive modeling has become the main use for GIS in North America. We strive to find more sites to protect. But can we learn more from the sites that we already have? Is it possible to look at the micro-site level to pursue questions concerning preservation and past environmental usage? To increase the accuracy of predictive models, it becomes necessary to learn more about the people you are attempting to predict. In order to do that you must first understand what was happening at the site when it was occupied. It is generally accepted that an understanding of a site can only be gained through its contextual connections within a landscape. There exists a complex pattern of spatial, temporal and cultural links that establishes that connection.

Because of the ability of GIS to work in a large scale environment there is a notion/habit that because GIS handles big we must THINK big. Not only is it valuable for accuracy across great distances, but also in small confines. Rather than think in scale, we should think in accuracy and relevance. There is an argument in the post-processual community that is more concerned with landscape and environment and not so much with the individuals that roam across it. But GIS has the ability to do both. We can incorporate data about people and landscapes and come up with fundamental archaeological questions that can be answered. Do the landscapes provide what the people need? Are their features that might be found to be sacred by people? On a large scale, does a site attract or repel people? How do sites interact with each other?

"Early concepts of off-site archaeology" have matured into a general acceptance than an understanding of a site can only be gained through its contextual connections within its landscape, which comprises a complex web of spatial, temporal and cultural links. Part of the understanding is necessarily concerned with location and white a sites is where it is (Mehr,

2006). First you must identify what is taking place on a site. Temporality is specific to the site, not the landscape. For example, a burial site can repel, attract, or act as a boundary for people. Archaeology and ethnographic analysis are still important in creating your model. It is not possible to simply set up a map and incorporate current social norms into the past. Historical context must be maintained in order to properly apply properties to specific GIS parameters. (Rocky Mountain) variables for different kinds of sites are also different, a camp site is different than a religious site and will require different variables to predict properly.

A researcher has to keep a dynamic modeling process in order to constantly keep confidence high and probabilities constant. In other words, a researcher must allow the model to be flexible to allow for the input of new information and also allow for manipulation of that information in more than one way. "The most helpful information would be in continually re-evaluating the level of confidence in the results of an existing predictive model that has been updated to reflect the new information" (Mehr 2006). Site level information could potentially change, ultimately changing your model. GIS at every level can ensure that your models stay relevant. People working on site material can upload their results. This allows for immediate up to date information. Area and landscape wide models can be modified to reflect even greater detail. Simply clicking on a polygon would allow a researcher to check the results of a site or gather whatever relevant information they like.

GIS has taken on a quantitative aspect. What resources do people use on a landscape? How many miles are they from those resources? The site level analysis is irrelevant unless the results can be incorporated into a larger model. Site level should be included in models in order to properly understand the landscape from top to bottom. GIS should be used to answer why questions, not just what. When using GIS, more data is always a good thing. GIS has the ability

to process and display vast amounts of information within its framework. The inherent complexity of human interactions both between themselves and the environment make GIS a good fit. The appropriate incorporation of new data at every level, will give better accuracy of overall landscape use and ultimately give a greater predictive model.

Section 3

FURTHER APPLICATIONS OF GIS

The versatility of GIS has can be seen throughout archaeology. It does not necessarily need to be relegated to landscape analysis and population dispersion. This chapter discusses other uses for GIS within anthropology but not necessarily the investigation of integration of the technology into excavations that have previously been done.

View shed analysis can be extremely helpful to prove or disprove a theory about what a site might represent. A 2005 article by Byerlyfocuses on Bonfire Shelter. This site has been speculated to exhibit signs of a bison jump. The problem with the site is that it is further south and earlier than any other currently known bison jumps. The GIS was used in order to pursue this model and demonstrate that it was possible by incorporating cost benefit analysis.

Humans are notoriously lazy by nature. The model examined the terrain around the site in conjunction with the probable human population for the area for that time and over ease of herding a large buffalo herd off a cliff. The model also had to incorporate line of site for both humans and bison. Bison would not willingly run towards a cliff they could see. Humans would have to play a role in knowing how this animal would react and address their strategy to compensate.

In the past, Bonfire Shelter had to rely on a "subjective assessment of the landscape and the nature of the archaeological deposits" to determine if this was a bison jump. Incorporating an objective GIS model with concrete landscape pathways and least cost pathways can ultimately provide conclusive proof. Sixteen possible routes were identified that could lead bison to an area that would coincide with the jump. GIS was able to extrapolate vantage points not only for

humans but also the bison. After each route was subjected to the analysis it was easy to demonstrate a plausible course of action for people attempting to drive buffalo off a cliff.

GIS has helped eliminated many problems that would have been difficult to overcome in doing an analysis of this type. Subjectivity could creep into the testing process by under or over analyzing the landscape. The length of time needed to test each of the sixteen pathways would have also pushed time constraints. Being able to quickly modify a model and obtain new results is the hallmark of GIS. Another aspect to make note of, is that the archaeological process is not lost in this project. It is imperative to understand the way humans controlled bison populations and hunting techniques in the past. Recognizing bone assemblages and signs of butchering from similar signs is also mandatory.

Archaeology is not the only branch of anthropology that can benefit from GIS analysis. The complex issue of examining bones in biological anthropology can be greatly aided. A cutmark analysis of bison bones was carried out in 2002 by group of researchers (Abe et al, 2002). Their aim was twofold. This first was to discover the butchering process used by ancient people. The second was to see if there was a difference in butchering technique based on the ultimate use of the bone.

The analysis of the butchering process was strictly quantitative while the results would be the subjective aspect. Using a diagram of bison bones that had been incorporated into GIS as a raster, photographs of the bones recovered from the site were overlaid on the diagram. Making the photographs slightly transparent, they were able to begin to see a pattern develop. To further enhance the results, the bones had been photographed on four different sides to allow a pseudo three-dimensional view of each bone.

This method was extremely beneficial as it removed the problem of bone scatter. Attempting to reassemble individual bison was irrelevant. They were able to determine frequency of cutting areas and found specific places where bones were typically cut. Finally they were able to attach a database to each photograph that documented the cut length and depth, providing information on how the bones could have been formally prepared at butchering.

Without GIS, this particular method would have been virtually impossible. It is incredibly difficult to have photographs of thousands of bones at four angles all incorporated into one non-computerized database. The ability to constantly manipulate the database and allow multiple users to participate in the updating process increased the likelihood of success. In the future, this type of analysis could prove to be invaluable in showing how different societies butchered and what parts of an animal were most valuable. This method could also be used to examining flint knapping techniques.

One article attempted to pursue a line of investigation similar to that done in this paper. On the island of Kythera in Greece (Bevan 2002), there was an attempt to define cultural sites temporally and spatially based on surface scatters. The author states that the problem lies in the overall survey areas which included a multicultural area that had been occupied on and off for over 1000 years. Because of this problem, it was difficult to define a particular area based on pottery alone.

The solution was to ultimately look for areas of uniformity. The hypothesis is that homogenous areas show a more consistent cultural occupation, whereas a heterogeneous cluster is more likely to be a trash dump or travel route.The ability of GIS to help locate areas of homogeneity is invaluable. Allowing for a third temporal dimension is extremely beneficial as it

is then possible to see when homogeneity drops off in favor for heterogeneity or perhaps a new homogeneous layer altogether

This type of investigation is more suited to small scale sites. They are able to be excavated in detail and dispersion and heterogeneity is not an issue. The ability to localize cultural aspects of a given area are of great interest to this paper. Given the nature of constant population movements during the Pueblo II and III phases, it is important to demonstrate how new cultural elements come into play and where they have the greatest impact within a site. While the temporal scale of Ewing is less than 100 years, it can actually make the cultural lines more apparent in that there is less admixture and movement of artifacts afterwards.

GIS can also help identify settlement choice patterns and prove or disprove what we think we know about past cultures. There are numerous factors that can affect how humans determine where they will live both environmentally and ideologically. Compiling numerous resources into one GIS database allows for easier examination. Using modern historical cultural analogues and ethnographies, it is possible to make a reasonable model of the past.

In order to determine pre-historic OnondogaIndian settlements a model was constructed (Jones 2006) that could incorporate several factors that directly influence this particular cultural group. Three factors that were deemed most important: defense, soil, and climate. But how important were each of these factors? A GIS database can help analyze patterns and help figure out if it was important to farm or to be protected.For the aspect of defense it was important that the Onondoga were able to see their neighbors from higher elevations. High levels of warfare necessitate this need in order to allow for allies to be summoned in a time of need. Therefore settlements had to be located near an area that could provide that important aspect. The land had to be arable to sustain the population and the climate had to allow for a proper growing season.

After assigning values to his database that represented the desirability of the landscape to the Onondoga, he was able to predict where the Onondoga would most likely set up their villages. However, after taking his database and comparing it with known archaeological sites of these villages, he discovered that they were wrong. But how could GIS get it wrong? It was discovered that Onondoga placed soil and climate above defensibility of their villages. Typical Onondoga had large palisades that helped aid in protection and it was assumed that the higher the palisades the more formidable the enemy. In this case, it was to devote more time to farming than to defense. A greater wall meant less likelihood of attack. Jones also discovered forest regions were favored and that having line of site to your neighbor doesn't necessarily equal better defense.

Section 4

HISTORICAL BACKGROUND OF THE EWING SITE

The Four Corners area has the distinction of having one of the first designated national monuments at Mesa Verde. Since its establishment in 1906, work has been done in the area to survey and catalog archaeological sites in order to better promote understanding of this prehistoric area. In the summer of 1907, Edgar Lee Hewett from Harvard and three students, Vay Morley, Alfred Kidder, John Fletcher set out to survey the part of the Four Corners area. They started in Mancos Canyon, and then systematically worked their way to Yellow Jacket creek.

Major work would not begin until the 1950s when Joe Ben Wheat began to survey the area and commenced work at several sites along the Yellow Jacket drainage. Since that time, numerous sites have been excavated and documented such as Porter Pueblo, the Stevenson Site, Gilliland Site, Square Mug House and the Ewing Site.

With extensive work being done in the Four Corners there was a necessity to create a framework to better discuss the findings in the area. In 1927, the first Pecos Conference was held. At this conference a classification system was outlined and solidified. The initial purpose of the system was to demonstrate a chronological aspect to technological innovation through the Four Corners area. This system has lost its impact with regards to technological investigation and innovation, but still holds a very important labeling system in order to temporally define a site.

Table 1. Cultural Chronology Four Corners Region (Kreutzer, 1996).

2000 1900	Pueblo VI	Modern Pueblos; Dealings with United States government
1800 1700 1600 1540	Pueblo V	Modern Pueblos; Dealings with Spain, Mexico, New Mexicans
1500 1400 1300	Pueblo IV	Great centers abandoned; Zuni, Hopi, Acoma and Pecos pueblos occupied; Arrival of Spaniards and decline of autonomy; Corrugated wares no longer produced
1200 1100	Pueblo III	Large multi-storied communities; Intense horticulture/agriculture; Great population centers at Chaco Canyon, Mesa Verde, Yellow Jacket and Canyon de Chelly peak
1000 900	Pueblo II	Growth of small villages into larger communities; Masonry units widespread; Cliff dwellings; Kivas and great kivas become central to life; Evidence of class distinction
800 700	Pueblo I	Move from sub-terranean pit houses to above ground jacal structres; Emergiance of kivas; Trade of decorated and undecorated pottery wares; Reservoirs and irrigation systems
600 500	Basket Maker III	Pottery emerges and becomes widespread; Pithouse villages; Bow and arrow; Domestic turkey; Kiva prototypes
400 300 200 100 AD 0 BC 100 200 300 400 500 600 700	Basket Maker II	Hunting and gathering; Atl-atls; Basket makers - no ceramics; Rock shelter and some pit house dwellings
800	Basket Maker I?	Nomadic hunters and gatherers; Archaic Desert Culture/Oshara Tradition

The revised version today includes a more flexible approach to the cultural developments through time. At each level there is a typical architectural aspect that begins to appear. Inhabitants of this region kept a standardized layout for virtually all villages and towns. Rather than focusing on pottery and stone wear changes, these architectural features can tell us a great deal of information on social structure and migration flow. There is a definite progression from simple pithouses in Basketmaker II to large scale multi-storied towns during Pueblo IV.

During the Piedras and Arboles phases (950-1050 AD), people began to move out of the New Mexico area into Colorado. Evidence suggests that the end of Pueblo II was a period of uncertainty and unrest in the region. People began to move away from smaller settlements in outlying areas, and began to converge in largerand better defended areas. Warfare becomes more evident in the archaeological record. Within 30 years, most people would begin to reclaim abandoned areas that were thought to be good areas of farming

Farming conditions between Pueblo I and II contributed to sparse populations and smaller town sizes. Toward the end of Pueblo II, conditions got more favorable and architectural designs began to shift. Initially, masonry style homes were only one block wide made of sandstone. Later these would widen to accommodate more floors. Masonry pilasters also begin to appear in kiva construction.

By the tenth and eleventh centuries smaller sites show a decline in overall populations as people began to move to larger communities. At this time, Chaco Canyon arose. It is likely as the Pueblo I period drew to a close, people may have migrated to the Chaco drainage area. "The influx of Puebloan groups already experienced in village aggregation and ritual intensification on the community level may have provided at least some of the impetus for the development of the large tenth and eleventh century communities of Chaco Canyon" (Adler, 1986).

Substantial population shifts seem to have occurred elsewhere in the Mesa Verde area at about this time (900AD) as well as movement away from large villages and large roomblocks to smaller settlements and settlement units. Ewing continues to reflect the dispersed pattern that is common in Pueblo II villages. They were typically smaller and more common than "great house" villages.

Typically by 1150 AD, most dwellings were constructed on canyon rims and canyon heads. This is true for Yellow Jacket. During this time, enclosing walls become a more standard feature within the village. Ewing has an enclosing wallpresent in the southern cluster of houses. However it does not enclose the entire site.

"In theMcElmo-Yellow Jacket district and the eastern portion of the Montezuma creek district, many sites have both Pueblo II and Pueblo III components. On most sites there is not enough surface evidence to determine if these components represent continuous use or a series of occupations separated by periods of site abandonment" (Adler, 1986). This could certainly be the case for Ewing. The absolute occupancy time frame is roughly 80 years, but it is likely that the site could have been abandoned for at least a quarter of the time.

From Pueblo I to III, the ratio of rooms to kivas is 6 to 1. This is typical practice until Pueblo IV. This indicates that the localized lineages were in charge of ceremonial duties and allowed small hamlets to remain autonomous (Rohn, personal communication). At Ewing, the masonry construction phase has a ratio of 1 kiva for 3 rooms. The post house phase has a ratio of 1 kiva to 5 rooms. This indicates a strong similarity to other Pueblo II and III sites in the area. It is not clear if the kivas that were constructed during the post house phase were still in use during the masonry phase. While it is unlikely, if it was the case, then the ratio during the masonry phase would be lowered to 1:2.

Section 5

EWING DESCRIPTION AND EXCAVATION TECHNIQUE

Description

The Ewing site was excavated during the three summers of 1966, 1968, and 1969. It is located in the Four Corners region of Colorado along the Yellow Jack Creek. The creek is part of the San Juan River drainage system in Montezuma County. The site itself sits on a plateau above Yellow Jacket Creek. Vegetation varies in this area. Higher elevations contain pinion and juniper trees. Lower elevations consist of desert grasslands that are not heavily water dependent such as sagebrush. The rainy season in southwest Colorado typically occurs during the months of June and July. This short season brings heavy rainfall which can sometimes cause severe erosion and damage crops.

The site originally sat in a plowed bean field. Its presence became known by the farmer having to avoid the masonry walls of the buildings located there. Ewing consists of two clusters of rooms and kivas. They are located approximately 100 meters apart from each other. These structures are located on a plateau overlooking Yellow Jacket Creek.

Ewing is regarded as a transitional site. Based on dendrochronology samples collected by Rohn, Ewing was occupied between 1040 and 1120 A.D. and most likely abandoned by 1150 A.D. This time frame puts Ewing squarely between Pueblo II, which runs from 900 to 1050 A.D. and Pueblo III which starts around 1100 and runs to about 1350 A.D. Ewing contains elements of both phases and abandonment and resettlement aspects very important in understanding these phases.

Pueblo II is not as well understood as Pueblo I and III. However, at this time, most settlements consisted of one or two habitation structures. Typically a kiva would be located near

the housing units. Some sites contain "great kivas" but Ewing is not one of them. The kivas at Ewing appear in roughly the same progression as habitation construction. They are all approximately 9-10 meters across.

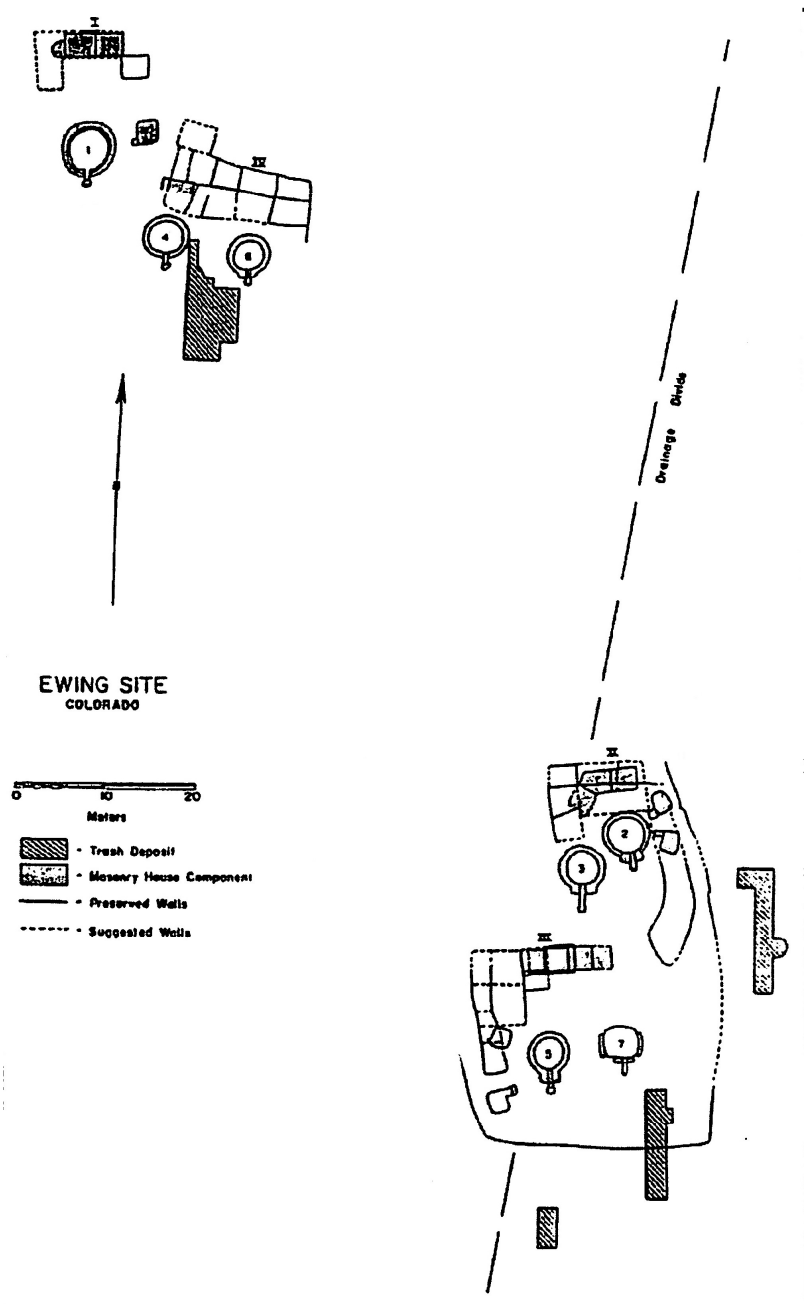


Figure 3.Overview of The Ewing Site (Courtesy Rohn).

The northern cluster contains two housing structures that have been designated House I and House IV. Three kivas are immediately to the south of these houses. These kivas have been designated as Kiva 1, Kiva 4, and Kiva 6. House 1 contains two elements. The first is a jacal style construction that contained four and possibly five rooms. The second element is masonry construction that was later built over the top of the jacal foundation. This masonry unit contains two rooms.

Kiva 1 is the only kiva on the site to have been remodeled. It shows contemporaneous dates with the original jacal construction of House I. The remodel occurred at roughly the same time as the construction of the masonry house built on the foundations of House I. Thus it is likely that both of these structures were used, abandoned, and then reoccupied with modification to the existing structures at the same time. All kivas are roughly three meters in diameter..

House IV contains 10 possibly 11 rooms. There is no evidence of a second story level to this house. The kivas immediately south are Kiva 4 and Kiva 6. These two kivas share construction dates with House IV. Not only do these three structures share similar dates, but according to Rohn (personal communication,2012) but they also share similar dates with the reoccupation of House I and Kiva 1. The construction phases have been linked together based on samples that were submitted for dendrochronological evaluation

The southern cluster contains two houses and four kivas. They have been designated at House III and II and Kivas, 2, 3, 5, and 7. House II is the northern most structure and originally contained 3-6 room at the time it was built in the jacal method. At the same time, Kiva 3 was built just to the south. Later House II was burned and a masonry component was built in its place which contained three rooms. During this period, Kiva 2 was built just to the northeast of Kiva 3. House III might contain as many as twelve rooms. Like House II, it was also burned

and a masonry element added. Kivas 5 and 7 are to the south and they were both built at the same time as House III.

The highest concentration of features and trash mounds are located in the southern area of the site. Kiva 7 is the only Kiva with a slightly different shape from the other six. During the time of Ewing, Kivas 5 and 7 fell into disuse even as others were being built. Ultimately, Kiva 7 would become a trash pit and the fill from the construction of other kivas ended up here.

Ewing contains 20 different styles of ceramics. However, there are five main styles that are far more prevalent than the other 15. Mancos is considered the best ceramic for identifying a Pueblo 2 site. It is by far the largest category identified in previous research. Ewing has two varieties of Mesa Verde Corrugated on the site, Mancos and Mesa Verde. These corrugated styles represent the largest quantity of sherds found at the site, but there is a substantial number that cannot be appropriately identified with the correct variety.Being a transition phase site, there is much temporal overlap among the ceramic types. The overlap occurs squarely between late Pueblo 2 early Pueblo 3. There are some minor ceramics that are found on the site that suggest possible ceramic exchange through migration and trading populations. A comprehensive view of ceramics at Ewing can be found in Chapter 9.

The standard Pueblo 2 layout consists of a double row of contiguous surface rooms. These rooms often contain both living areas and storage units. Kivas are typically located in front of the surface rooms and generally facing towards the south (Figure 4). Located around these two primary structures are various workspaces. These can consist of mealing rooms for the process of grain, areas for ceramic manufacture and various other working areas designed to suit whatever purpose is needed. Trash mounds are always nearby and vary in size based on the population. Finally there is a stockade that will partially or completely enclose the settlement

(Lister, 1966). Ewing has all of these elements. The stockade is found in the southern section and only partially surrounds the complex.

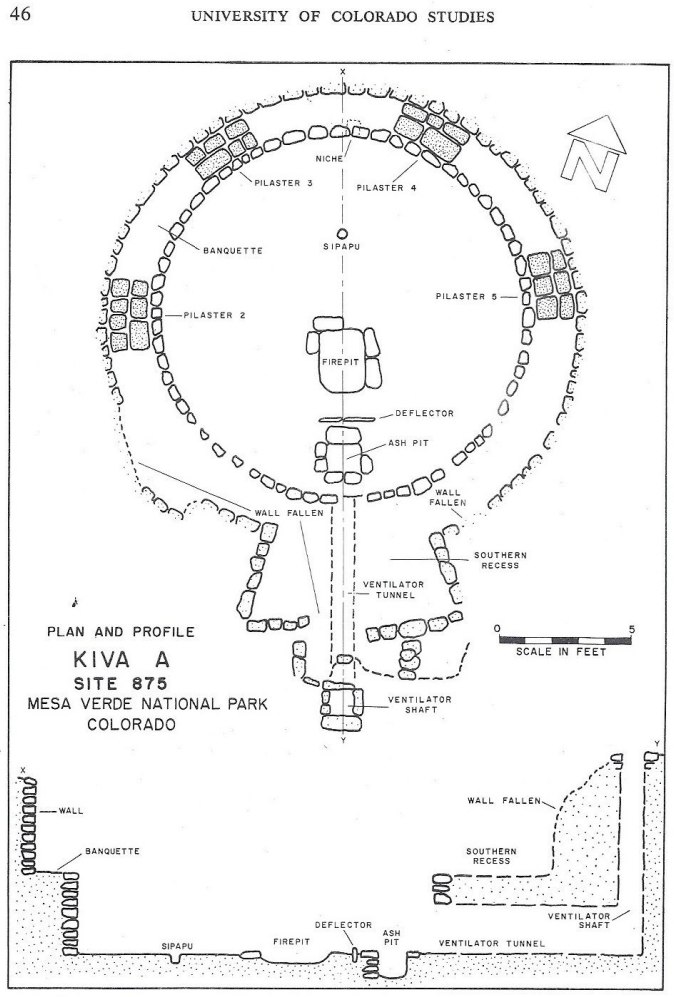


Figure 4.Typical Kiva layout (Lister,1966).

Ewing exhibits a Pueblo 3 characteristic through the ceramics found on the site. Corrugate pottery begins to appear at the end of Pueblo 2 and into the early years of Pueblo 3. (Lister, 1966) There are several reasons why there was a switch to a corrugated style. This corrugation allowed for better reinforcement on the neck of jars by having areas of greater thickness. It exposed more of the surface area of the ceramic to heat those allowing for a better curing process. This in turn would increasethe durability and longevity of the pottery. Lastly it

allowed the increase size of the ceramics to be more easily handled. The textured surface did not make it as slick to hold on to.

Excavation technique

Ewing has a very unique excavation style. It is a large site, spread across a very big area. The sheer volume of artifacts associated with it, coupled with crew size and time constraints led to various provenience description methods. The northern half of the site has a different grid system than the southern half. The northern half employs an alphanumeric system such as A1, B2, C3 while the southern half uses a more common method of 1N2E, 2N3E. Both grid systems were plotted off standard datums, but the datum is different for both sections of Ewing.

Locations within the Houses sometimes used the grid system, and sometimes it used landmarks within the room of that particular house. Some areas outside of the houses were designated "areas" or "features" and did not have grids at all. Kivas did not use a grid system at all, instead, relying on landmarks within the kiva itself. These landmarks typically included distances from hearths, ventilator shafts and positions within the banquettes (refer to Figure 5.2).

Virtually none of the artifacts were given depth measurements. Typically a depth would be referred to as a distance above the floor or on the floor itself. The various methods of description would pose a giant obstacle in making this site working with GIS. However, this makes Ewing a good example for how to make GIS work for intersite documentation. Even with these methods, it can still be done. Table 2 is a screen grab of the database showing the various locations that artifacts were given in the field. Note the non-uniform nature for every column. This is not an indication of inaccurate field methods, just different and slightly more complicated for site recreation. Rohn (personal communication) indicated that the primary focus was recovery of the artifacts before the site was destroyed by the owner.

Table 2. Example of various location descriptions.

Trash Mound 2	Square H-6	Level 1
Feature 3	Fill	
House 4	Room 6	Fill
House 2	Area 2	120cm S Wall, 40cm E upright slab
Kiva 1	Fill Pit NW banquette	
Kiva 3	Rich trash fill	
Feature 20		
Kiva 3	8cm above floor	70cm SW lower S corner, 145cm E hearth center
Feature 19	Behind Stone wall, trash fill	
House 2	Area 7	
House 3	Room 2	107cm from W wall, 97cm from S Wall
Kiva 1	Pit on NW banquette	
Kiva 3	Ventilator Shaft Floor	S. Recess
Kiva 3	Floor	Item 4b
Kiva 3	Floor	Item 4c
House 2	Area 5	Above Room C, 1620cm N House 3, 50cm W NS line
Kiva 3	Rich trash fill	
BS 1		1130cm N House 3, 45cm W NS line
House 1	Area 4	
Feature 19	Level 2	
Feature 22		
House 3	Room 2	Floor

RESULTS: ARTIFACT DISTRIBUTION ANALYSIS

The maps in this chapter were created by using the procedure described in Chapter 7. While there are nearly 500 different artifact labels, only eighteen were selected for use in this paper. These eighteen comprise the artifacts that would be considered most important by a typical researcher. They have been placed in alphabetical order to make future perusal easier. Tree ring dates are available for this site. If locations were made available, it could easily be plotted on the map. This would allow for GIS to demonstrate, in a quick manner, the construction phases that this site went through.

The two following examples represent the analysis that can be done by ArcGIS. Further examples are detailed in Appendix A. Being primarily a farming community it was expect to find manos well distributed throughout the site (Figure 5). This turned out to be the case. There was no specific cluster around known grain processing areas as described in other theses. Neither the northern nor southern had a higher level.

Sherds (Figure 6) were included in this analysis to demonstrate a key point. Every location excavated at Ewing possessed at least some sherds. Plotting their locations is pointless. A researcher must separate out the ceramic types and look at densities. With a site saturated by over 40,000 ceramic sherds, it is imperative to use a more detailed analysis

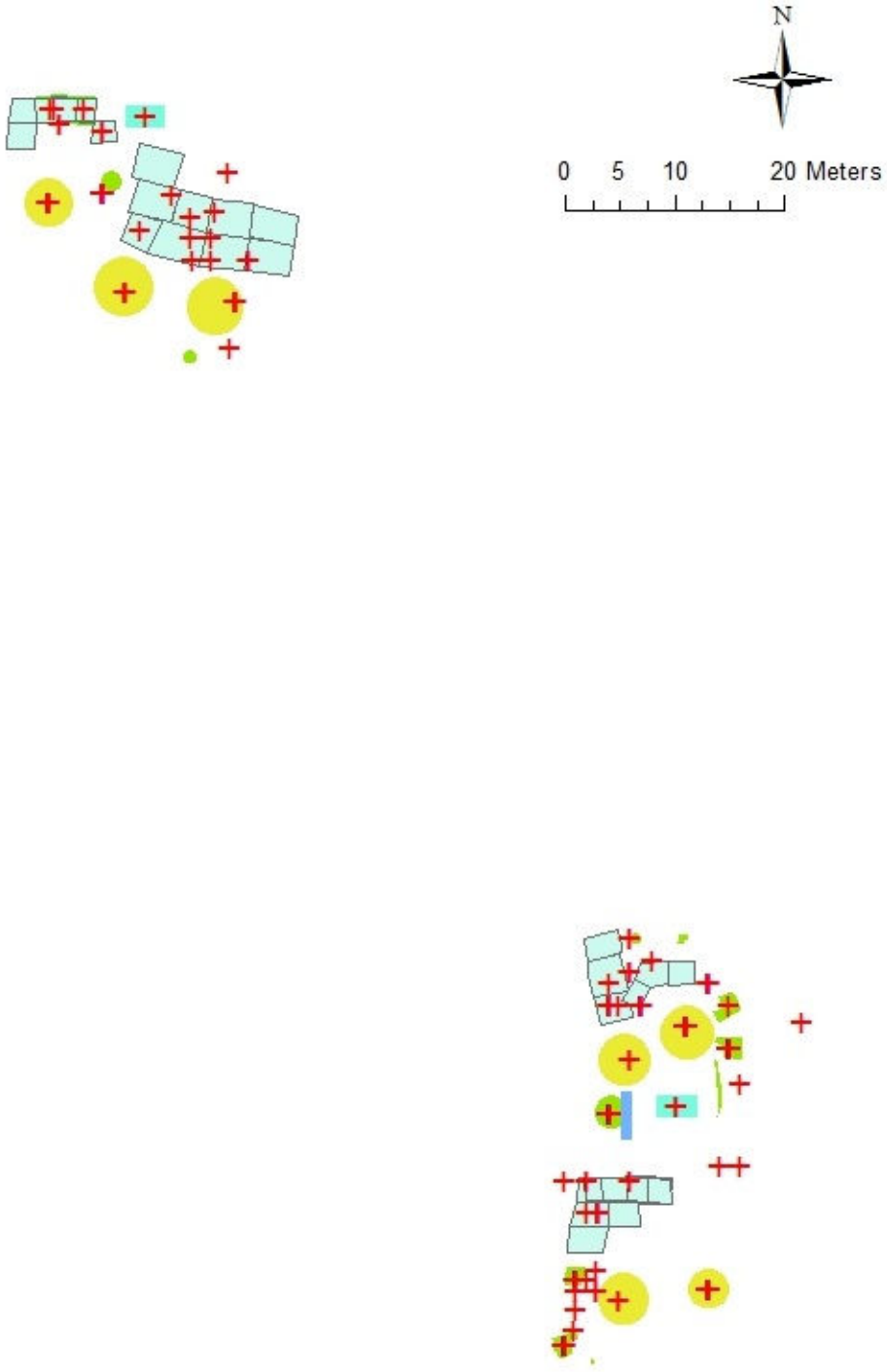


Figure 5. Red crosses denote the location of manos found throughout Ewing.

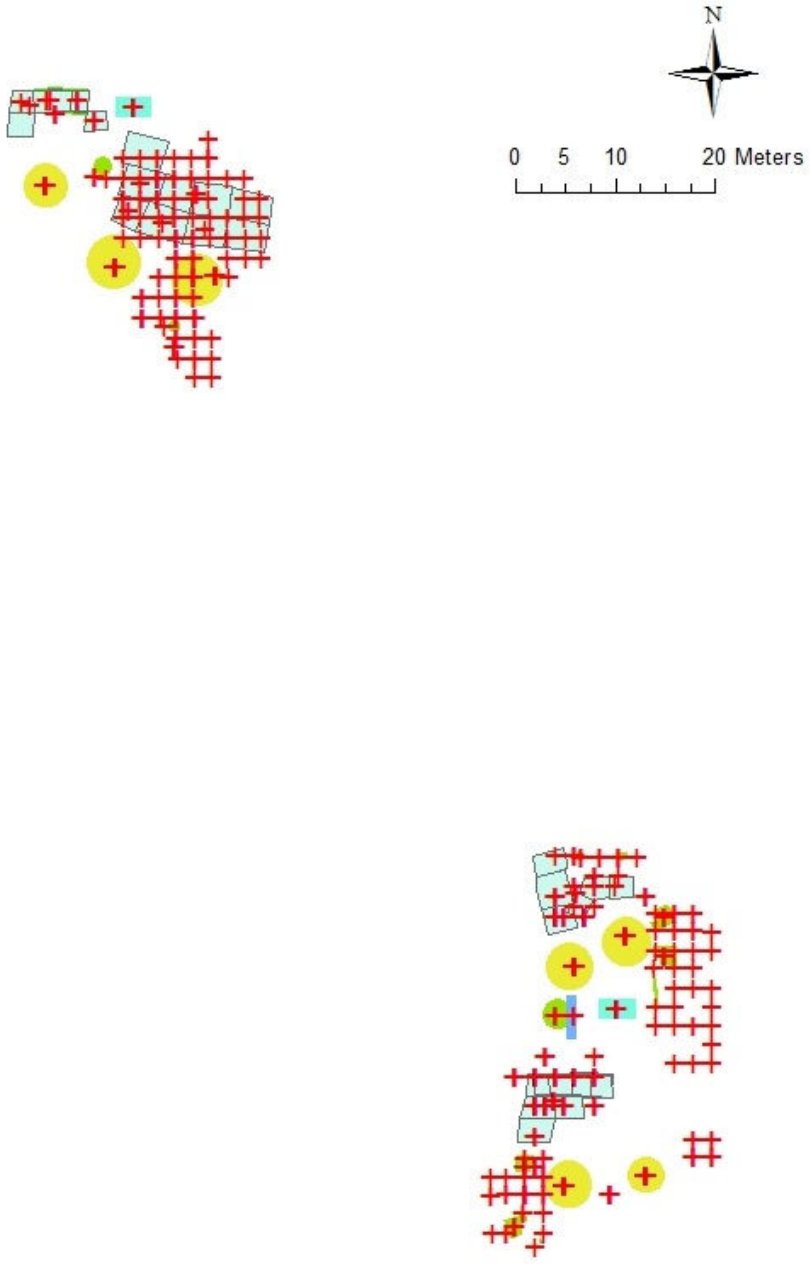


Figure 6.Sherds were included in this analysis to demonstrate a key point. Every location excavated at Ewing possessed at least some sherds. Plotting their locations is pointless. A researcher must separate out the ceramic types and look at densities. With a site saturated by over 40,000 ceramic sherds, it is imperative to use a more detailed analysis.

Using the complete artifact database, it becomes obvious that plotting ceramic locations is not helpful at all. Every possible location contained at least one ceramic sherd. It is mandatory to filter out the unnecessary ceramics that are statistically small. This database also does not allow for analysis of numerical distribution of the sherds. Using the tabulation database it is possible to filter out each ceramic type, create a new feature class and then ultimately turn them on an off in the table of contents. These distributions can be visually appealing and allow for quick recognition of patterns within the site.

Section 7

RESULTS: CERAMIC DISTRIBUTION ANALYSIS

The following maps are assemblage representations of the major ceramic components of Ewing. The goal of this thesis is not an analysis of the ceramics. Kreutzer's 1999 thesis provides all information on this topic. My goal is to show that a visual analysis is possible and can provide information easier and more detailed than what would normally be done in a standard report. Kreutzer did a distribution analysis based using only the houses. Her final results consisted of a table. The GIS maps will cover the site in its entirety and allow for comparison of ceramic type distribution throughout the site at a glance. Kreutzer's work is an excellent example of how a typical archaeological report can be improved with the advent of a GIS application. Often a reader will have to flip between pages or make notes in order to make a better visualization in their head while a GIS map can do that in an instant.

Kreutzer also performed an analysis of what vessels each sherd came from. She placed the sherds into three different categories: bowls, jars, and dippers. There was a sporadically used category that contained pukis and effigy vessels. While this analysis does not distinguish between these different categories, using the methods laid out in this thesis will provide future researchers the tools needed to make such an analysis easy work.

The first two maps represent the results of the entire ceramic assemblage. The various types were broken down into separate categories and discussed in Appendix B. To complement the maps, a brief description of the ceramic will be provided with each in order to demonstrate the temporal aspect changes of the ceramics. The site itself contains approximately 20 distinctive ceramic types. Of these approximately 10 have insufficient numbers that would make them important on this site. For example, Bluff, Sosi, Tsegi and Tusayan style ceramics account

for less than 1% of all pieces collected at the site and thus can be deemed statistically inconsequential. In an effort to be concise, only the major ceramic styles will be discussed.

In order to obtain these results it was necessary to sort out the ceramic types from the full list. The procedure is quite simple and straight forward. Select the primary ceramic table that has all types included. Open the attribute table and open the table options and do a search by attributes. Build a query that will search for the required ceramic type. Once you obtain your results, switch the attribute table to the "selected items" view. Go back to table options and export your results ensuring that only the selected records are exported. In ArcCatalog they can be imported back by simply converting them to an XY layer (See chapter 14 for procedure).

The first analysis that was required was an overall view of the ceramic assemblage. David Hill (1984) identified Houses II, III, and IV, Kivas 2,3 and 7 as major ceramic manufacturing areas within the site. After performing a search to demonstrate where all ceramics were found, it can easily be seen where the major clusters of ceramics were located. The southern half of House IV and Kivas 2 and 3 are especially concentrated with high densities of ceramic pieces. (Figure 7) In an effort to show the information in a different way, a map containing percent of total assemblage for each location was also created. This gives the reader to see where the largest percent of ceramics were located. (Figure 8) It is easy to see that roughly 30% of all ceramics recovered were found in the southern half of the site near Kivas 2 and 3.

Next, different types were analyzed. Several variants of these types were identified and to be thorough, each variant was also mapped. Since not all variants are made during the same time frame, it was possible to try and locate clusters of these variants to see if the site was used at different times. For example, if Mesa Verde, McElmo variant was more concentrated in the

south, we could hypothesize that more people were living in this area. This could be a way to track population settlement movements throughout the site.

One thing to consider while looking at these maps is the accuracy of location placement. There were several areas that could not be well defined and where instead left out. Some of these locations were generalized such as “Between Houses IV and II”. This is encompasses all the space between the north and south sections and is therefore meaningless to try and address a helpful spatial distribution. There were several areas around House IV and a trash mound that could not be accurately located. However, the ceramic amounts were negligible and should not impact the overall analysis.

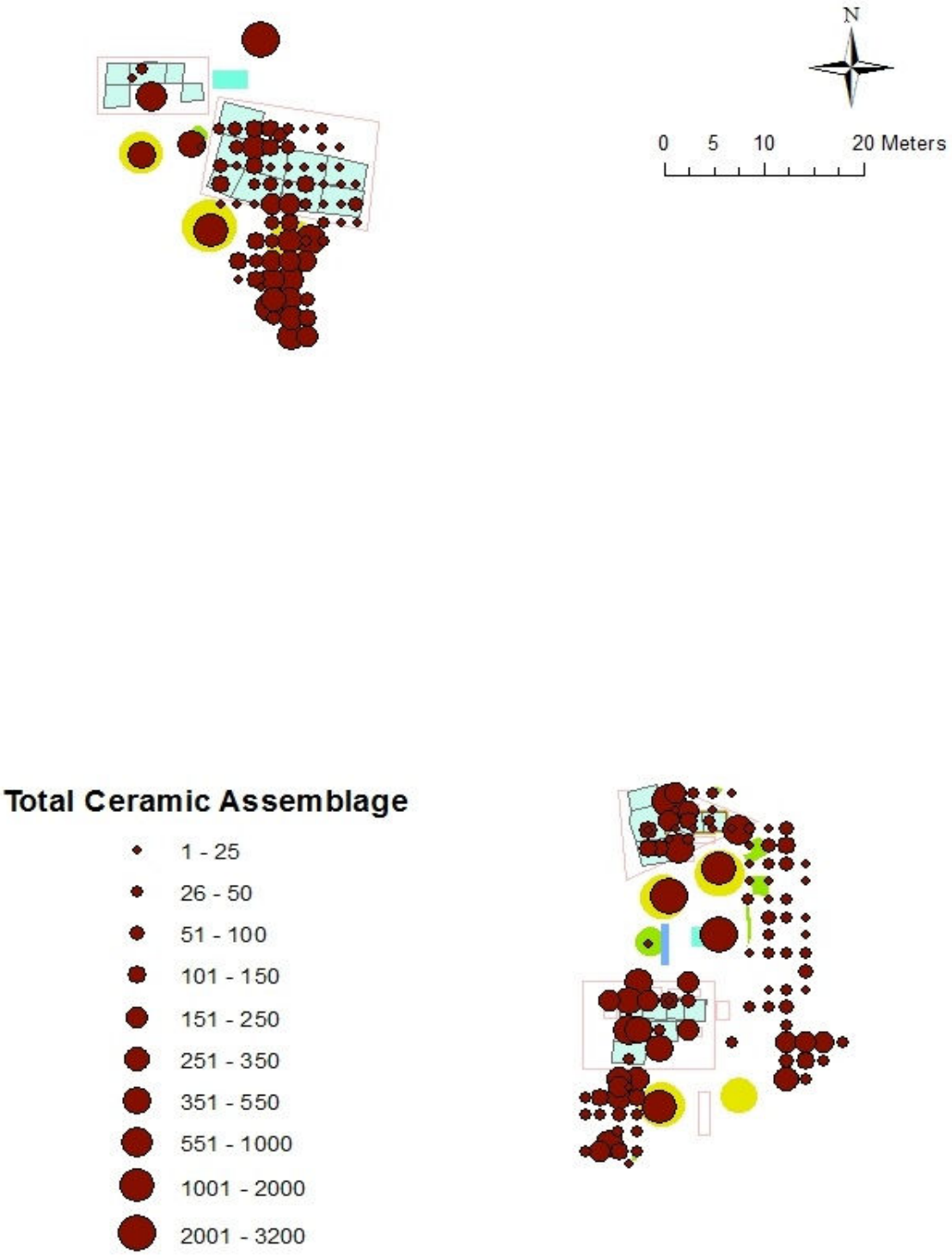


Figure 7. Analysis results for complete distribution of ceramics at the Ewing Site.

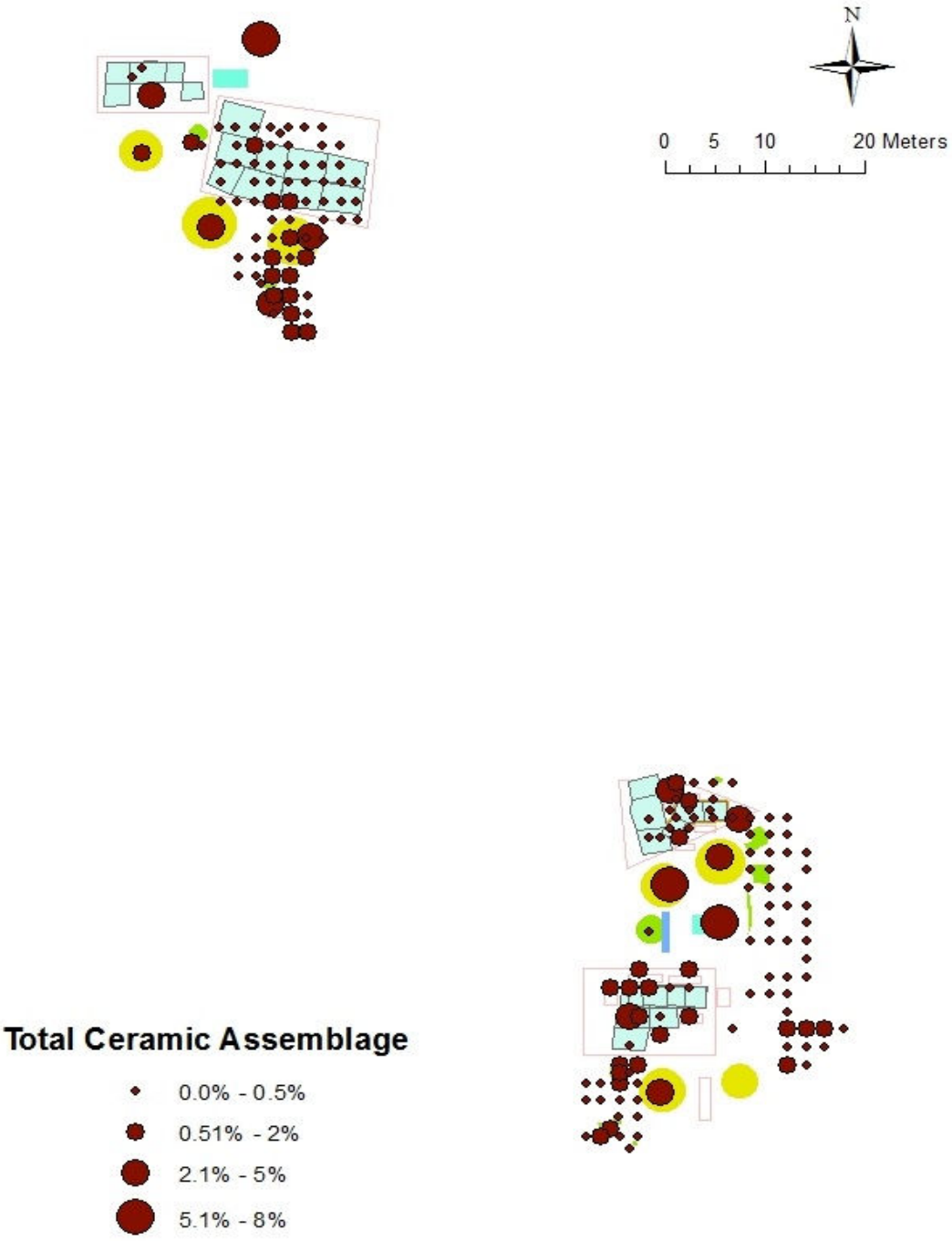


Figure 8.Ceramic dispersion analysis in percentage format.

Section 8

STATISTICAL RESULTS AND CLUSTERS

Statistics

ArcGIS has the ability to perform many different areas of analysis. In addition to representations of density, GIS has the ability to perform rapid statistical analysis and to create maps that represent "hot spots." Covered in this chapter are the results of these procedures and how they can benefit research.

To create a statistical analysis is one of the easiest things to do in ArcGIS. By simply opening the attribute table of a particular layer, clicking on the proper column, and selecting "statistics" you can get descriptive statistics about that particular layer. In this chapter, the statistical aspect was pulled from the same layers that maps from Chapter 7were created from.It is a very simple process to demonstrate the statistical analysis.

Each chart represents a ceramic type with the label being on the top right side. To the left are the critical details of each layer. Two helpful details are the "sum" and "count" rows. Count represents the amount of locations each type was found in. For example, Mancos (Figure 9) was found in 176 different locations. This can be helpful when compared against another ceramic type. Mancos sherds were found in 211 locations, which is only slightly more than Chapin (Figure 10). However, the sum total of Mancos is 9588 making it over three times as common. This would immediately alert the researcher to the fact that the density of Mancos per location is far higher than Chapin. Appendix C contains more ceramic types that have also been converted to table format for statistical analysis.

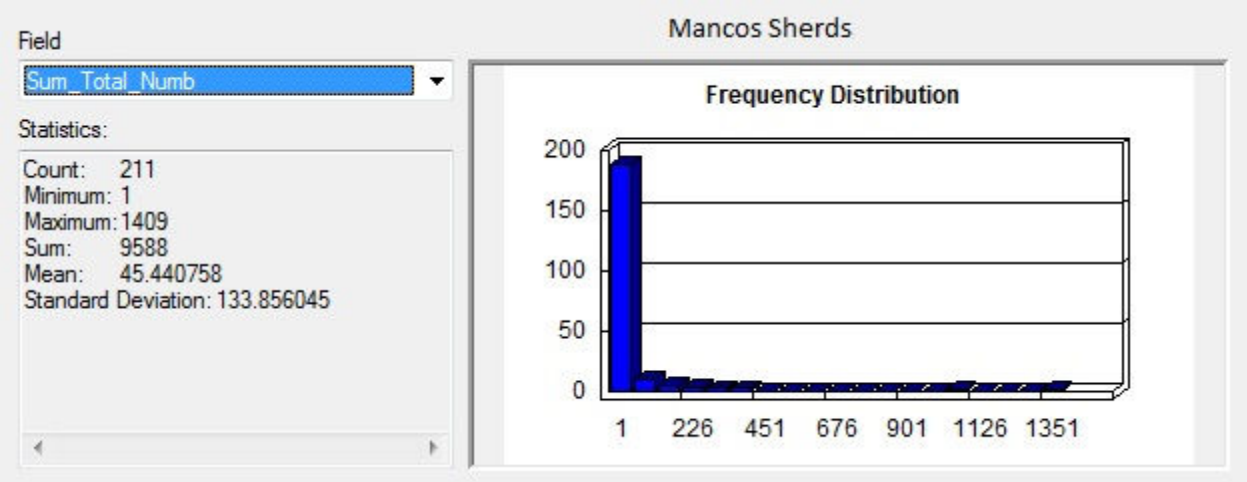


Figure 9. Statistical analysis of Mancos sherds.

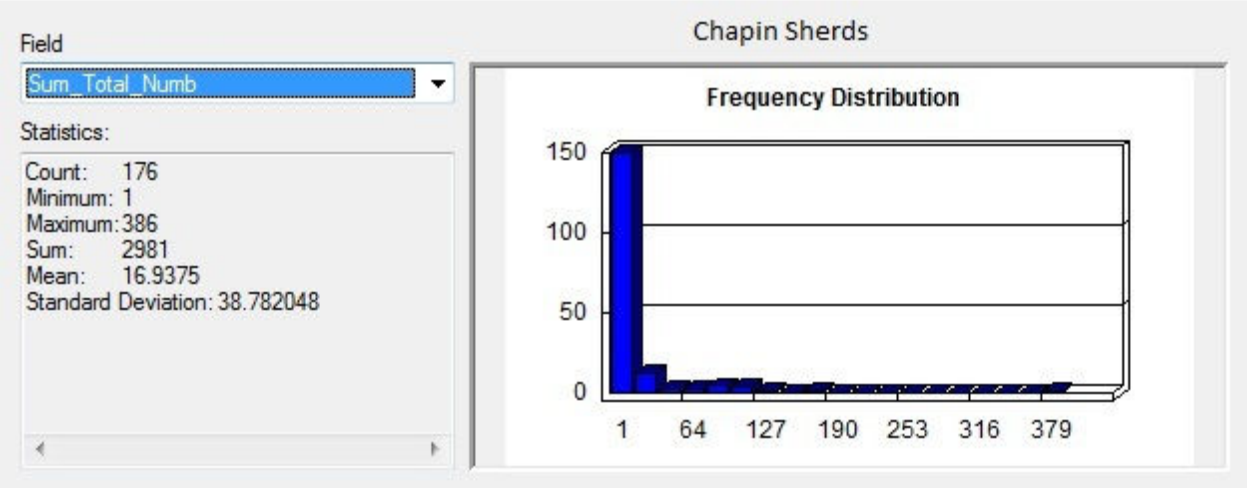


Figure 10. Statistical analysis of Chapin sherds.

Clusters

According to ESRI cluster analysis is helpful "to identify the locations of statistically significant hot spots or spatial outliers." This means a map can be quickly made that will help identify where we are most likely to find a specific item. In this case, ceramics were used. In

this section, only the top four ceramic types were used. The reason is that this analysis will work better with larger numbers. In light of this, the different variants within Mesa Verde and Mesa Verde Corrugated were not used and instead were lumped together to help get a more accurate picture.

To create a cluster map, click on the "geoprocessing" tab at the top of ArcMap and select "search for tools." In the search box, type "cluster analysis" and you will get a search result. (Figure 11) Locate and select the "Anselin Local Moran I" option. A box will appear (Figure 12) and you will then select the layer you wish to analyze. It is imperative when working in small geographic areas (such as an archaeological site) that the distance and threshold is set to 0. This removes the standard geographic area default that ArcGIS has. A site has a smaller area than the default and it must be set small enough to recognize clusters at small distances. After all items have been set, press "Ok" to finish. A new layer will be created and it's a simple method of switching to layout view, adding a legend and exporting the map.

The results of the cluster analysis show probable locations for ceramic types (Figure 13). All of them have very high probability of being located in the southern area of Ewing and typically in Kivas 2 and 3. Only two of the ceramic types have a notable high probability in the northern section, Chapin and Mesa Verde Corrugated. These maps could help identify potential areas of increased production or population centers. However, in archaeological excavations these maps may not be as useful as other analysis types discussed in this paper. The cluster analysis is geared toward future work within the site or application to other sites. As Ewing has been excavated in full and no two sites are identical, the cluster analysis is just a pared down distribution analysis which could not be applied anywhere else. Non-archaeological models are better suited to use this analysis style.

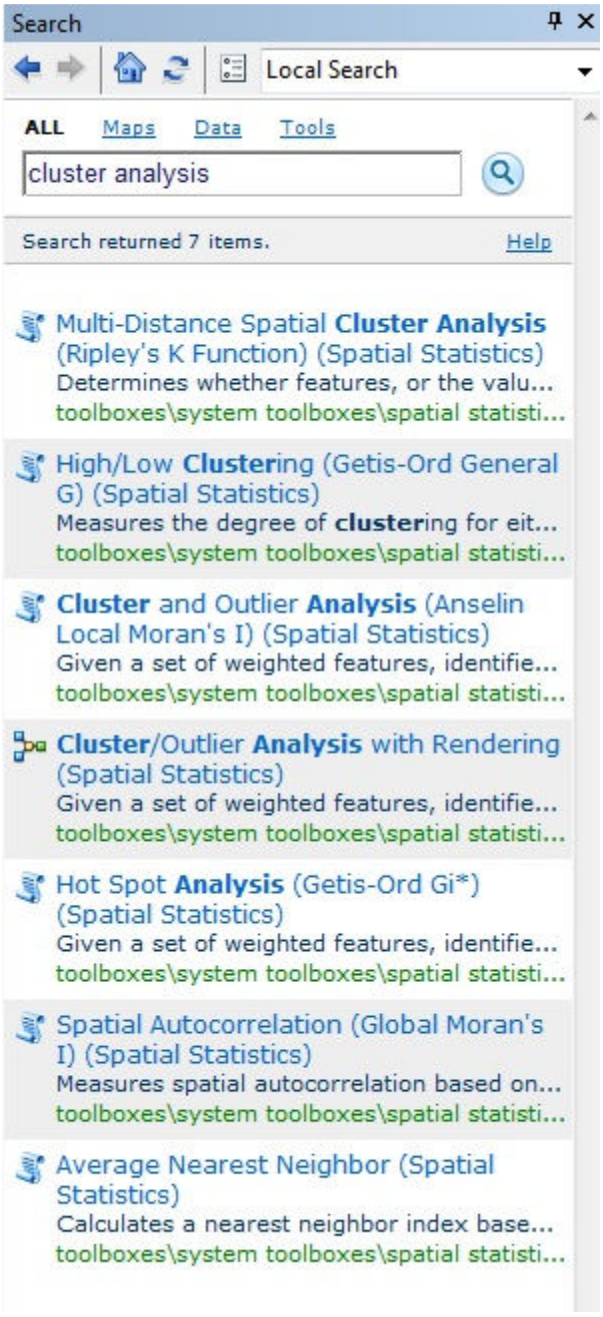


Figure 11.Search results containing Cluster and Outlier Analysis.

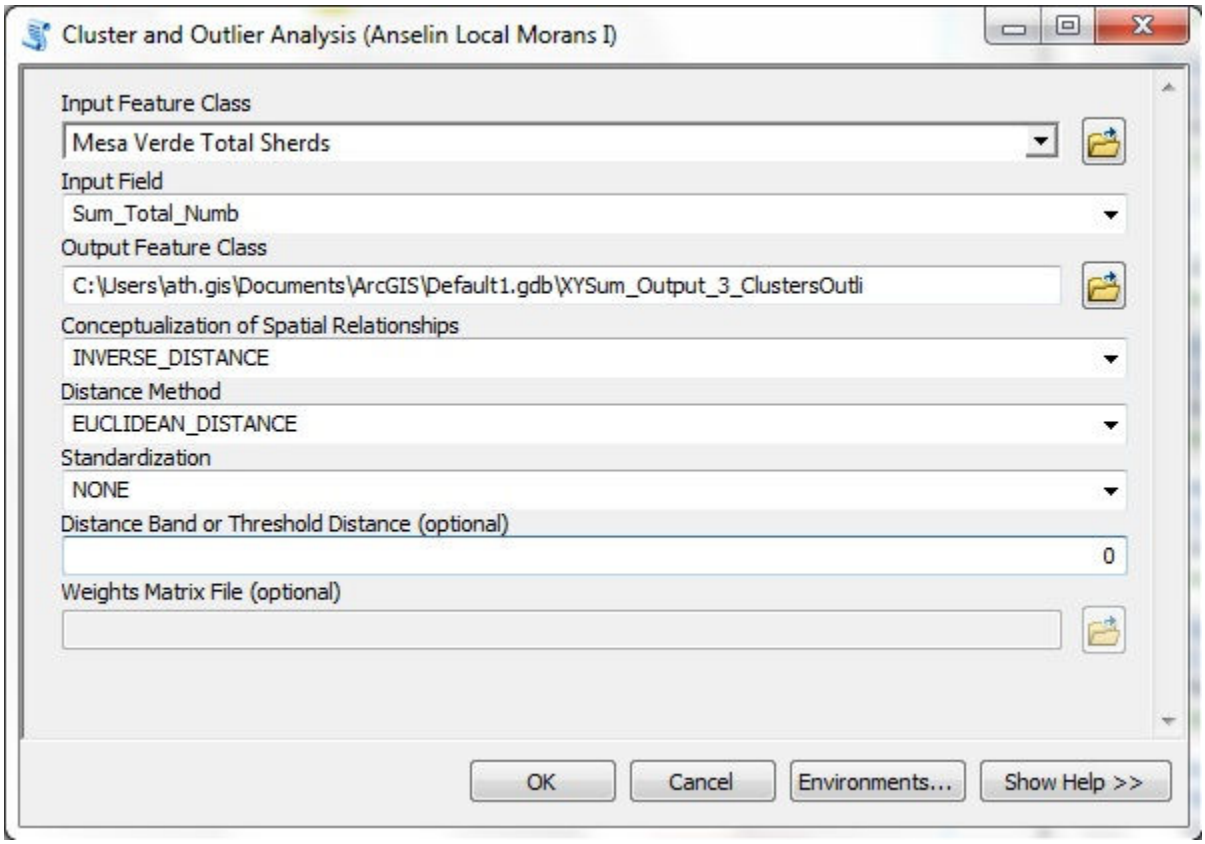


Figure 12.Cluster and Outlier option window.

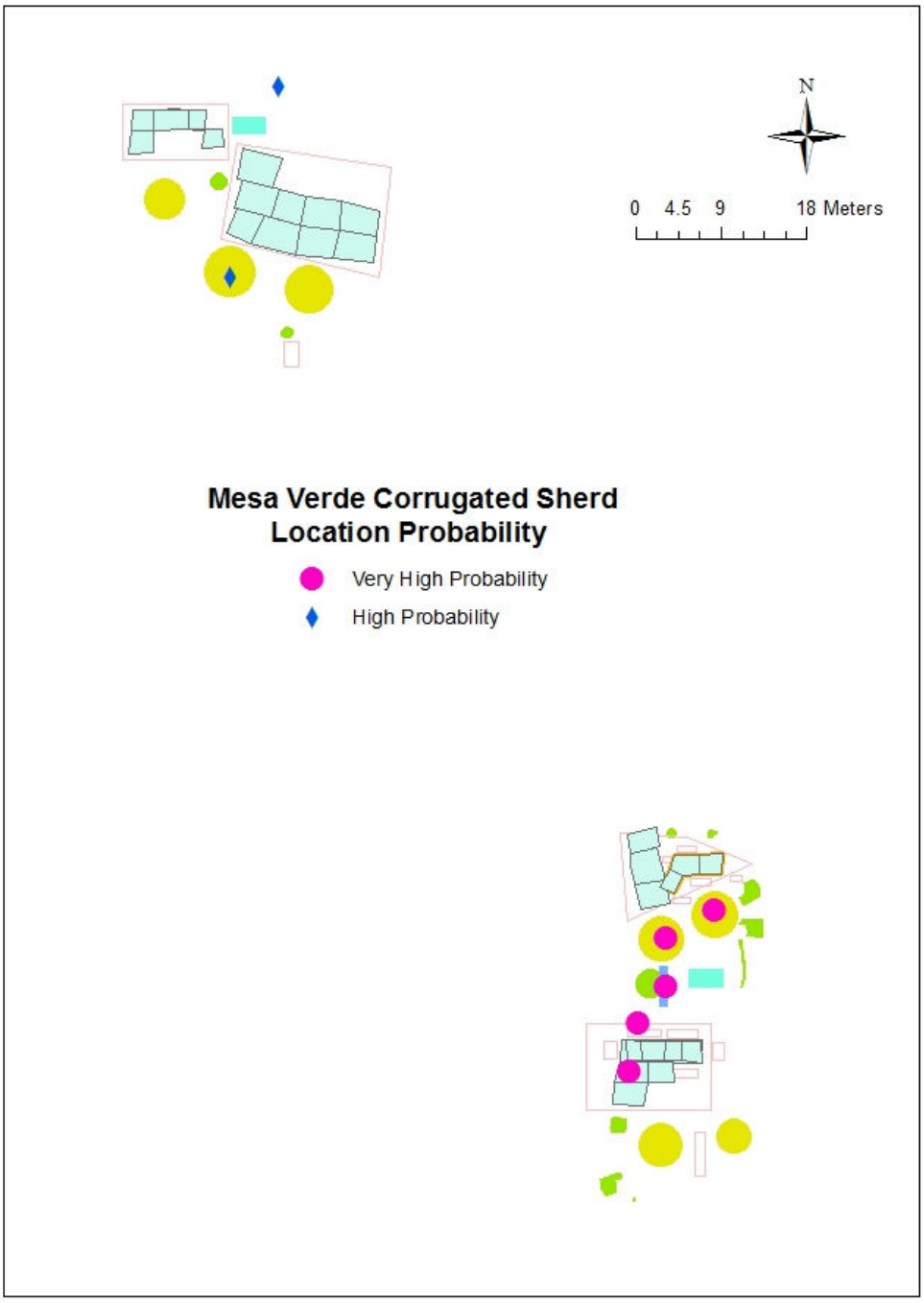


Figure 13.Results of cluster analysis for Mesa Verde Corrugated sherds.

Section 9

DISCUSSION

There are two main issues that will directly impact the integration process of data into GIS format. The first is the level of competency of the GIS user. At the beginning of this project I was not a novice, but I was also not a regular user. This hindered my ability to locate or perform certain aspects of geospatial analysis. For example, it took many hours of trial and error to get my grid pattern laid out properly. An experienced user could have done this in half the time. Creating shape files as layers and placing them on top of map features also took considerable time that an experienced user would have probably had little issue with.

At the end of this project I have learned a great deal about the nuances of ArcGIS and the little things that have to be double checked in order to save time in the long run. One prime example is to ensure that you are updating the correct raster when adjusting spatial properties. On numerous occasions I would find myself trying to locate a map feature, only to examine the map more closely and realize that I had inadvertently moved it. This mistake was costly; I had to move one raster back to its proper location and then move the correct raster to the location I originally wanted. The abilities of a GIS user are easy to control. Obviously, the more complicated the site, the better it would be to give the project to an experienced user.

Another issue that can create difficulties within ArcGIS is the record keeping process. It is important to keep duplicates to a bare minimum. This will eliminate confusing the program or getting improper visualizations. Having a standard description throughout the site is mandatory. Interchanging words is unacceptable. If an archaeologist feels in the future even a remote chance of GIS being use, all crew members must be made aware of the importance of standardization.

The second issue concerns the site itself. Site data is far more difficult to control many years later in a lab 1500 miles away. In the case of Ewing, the data is 45 years old. The records for this site are by no means absent. However, it is sometimes difficult to interpret some of this information as certain aspects are incomplete. Based on the tendencies of GIS, it is important to use Ewing as an example of a short checklist of things that will make GIS integration far easier.

The material provided did not contain locations for every feature and post hole. Several features have unknown locations and yet have numerous artifacts associated to them. Feature 6 is a prime example of this. There were several other locations that were described such as trash mounds and "broadsides" but no map was provided that could show the relevant locations. Finally there were numerous instances of locations lying between houses. This generalized location is not very helpful in archaeology and in GIS it does not provide the accuracy that could be fully achieved.

There were also several locations that were not known. Half of all features could not be reasonably located, some trashmounds and various other "areas" were not incorporated. Rather than making haphazard guesses as to the real location, they were omitted. Examining the artifact and ceramic databases showed that removing them would not create an overall deficiency in the outcome of the distribution analysis.

In order to properly take full advantage of GIS and its rapid application, strict standards must be maintained throughout the site. If one style of excavation is started it must stay the same. This is to allow for easy link of spreadsheets with polygons. Don't let GIS dictate how to excavate, just don't switch provenience styles.The first mantra every archaeologist learns is "Location, Location, Location". Provenience has to be specific and detailed for a site to have any relevance in its historical and archaeological context. The change in grid style labeling has

proven to be confusing and overly elaborate. These two radically different grids also provided different datums. Attempting to visualize the site and to locate items in a spatial context in an efficient manner is virtually impossible.

This problem did provide a unique insight into the application of GIS. Attempting to make a meaningful map with varying mapping techniques could have proven cumbersome in the past. Labeling alone would have been a daunting task. Straightening out all the inconsistencies requires much patient and a bit of having to redo your work. GIS often doesn't immediately recognize a solution, and an alternate has to be constructed. However, once this environment has been properly constructed in GIS, it is simple to allow the data to be manipulated in whatever manner the user sees fit.

Maps must be placed within the proper datum series as well. There are numerous ones available through ArcGIS. There is no correct answer as to which one should be used, but the NAD1983 set is typical for this application. The site should also have the correct zone placement. Within the continental United States there are zones 10-19. Having incorrect zones can complicate matters when attempting to shift rasters into their proper alignment. It is possible to sometimes tie in a site to a USGS datum point and to then base your site datum off of that. Ewing was not one of these sites, nor is it necessarily important to have done so. Using a UTM quadrangle map can easily rectify and speed up the spatial orientation of any site.

Changing grid styles can complicate issues. This was the biggest issue for this project. Artifacts gathered on the grid pattern were easy to incorporate. Artifacts gathered through room designations were more problematic. Rooms, houses, features, and kivas all had to be manually given latitude and longitude coordinates. Whereas the grid system had it built in by ArcGIS. It required more steps and the artifacts had to be sorted out of one single database into two separate

ones; one for the room designations and one for the grid designations. Once the two databases were given their appropriate latitude and longitude coordinates, they were recombined into one again. This also held true for the ceramics database. So instead of only having to incorporate two distinct databases into GIS, it was actually four.

At some point, too much detail is not necessary. One feature description that was used often at Ewing, and proved to be too confusing to be of use was that of "posthole". As an archaeologist, it would definitely be a good way of describing a feature in the field. However, not all postholes had locations. Many times they were described in relation to each other and the maps available did not provide a comprehensive layout. There were also no depth measurements on many. While many of the postholes could be placed into generalized areas, it would be time prohibitive to designate over 50 separate post holes. It would be beneficial to have a completely different database just for this feature. In the future, it could be added into a database without compromising the integrity of the site.

Lack of scale map drawings proved to be the second biggest hurdle in this project (the first being the different grid system). Luckily, ArcGIS has the ability to render various rasters into different scales. Using the overlay method proved to be quite good, although the accuracy in some areas could be as much as five centimeters out of place. This doesn't prove to be a problem in this type of project. This project aimed to get generalities about artifact distribution. The only real way to get accuracy within one centimeter is to employ GIS from the start of the project. Instead we must look at the validity that the artifacts are located within a reasonable area.

While these do not impact an overall interpretation of the site, they can make GIS less accurate. Given the nature of descriptions for artifact locations it is virtually impossible to make

a uniform three dimensional map that can accurately show the site through a temporal lens. However, many rooms do contain a uniform level description and given enough time each individual room could be made to show occupational deposition through the lifespan of the site.

As many of the maps were not complete, not all locations were known. Several areas, trashmounds and features did not have definite locations. This does not prove to be a problem with this project. GIS has the innate ability to allow for immediate updates and analysis. In the future, should any new maps or information come to light that can show corrections to existing locations or can located unknown positions it will be of no trouble whatsoever. This project demonstrates the flexibility that all archaeological surveys need. Ewing in particular was done over several years. As field crews come and go and as the project takes on a life of its own on the ground, so too must the database be fluid enough to continue to be of any relevance.

Section 10

SUMMARY FOR FUTURE MICRO LEVEL GIS STUDIES

There are several key things to be looking for when deciding on a good site for a micro level GIS study. First and foremost would be a standardized grid system. This allows the user to completely eliminate all shape files associated with building structures. The map would be the overlay that the grid is tied to and all artifacts could be seen on the map regardless of a shape overlay on the map itself.

Second, a standardized level format would be extremely beneficial. Today most levels are done in five or ten centimeter increments. With this standard a shape file could be made for each level. This would allow for searches to be done temporally and essentially would allow a research to peel back the layers of a site. A three dimensional map could also be constructed showing densities and more patterns in a given space through time would be easily noticed.

Third, small scale sites would not be appropriate for a GIS database. A small kill site or camp site would not benefit from this level of analysis. A single kiva or a building that contained less than three rooms also would not give much information than could be done by hand. However, sites that contain multiple buildings, kivas or have an extended human occupation would be excellent candidates. A kill site that is revisited over many years would benefit from a multilevel or three dimensional analysis.

The fourth requirement would be an artifact database that is easy to manipulate. The analysis mixed with various terms of description make Ewing a complex site to deal with. After many months of going over these databases it is easy to distinguish individual personalities with writing styles and provenience descriptions. Having a site that is relatively uniform from excavation to analysis is a must. If analysis is performed, such as the ceramics were, it is better

to keep the results in a separate database to allow future research to incorporate each database individually.

Section 11

GIS AND ARCHAEOLOGY IN THE FUTURE

Wright (1997) published an article that reported on a blog that he posed the question on whether GIS was a tool or a science. Since GIS would have no standard way of incorporating it into a hypothesis, the results are the only thing that can be applied to a scientific method. He suggests that GIS is akin to the telescope, it becomes a tool to propagate knowledge, to encourage discussion, and to bring new questions to light. On the opposite side of the argument is the ability for GIS to perform complex algorithms that can quickly identify patterns not only with human populations but also within geographic systems. Ultimately, because GIS is used by multiple disciplines, its role can be wide ranging.

GIS within an anthropology department could be of great benefit for not only archaeology, but biological anthropology. Faculty would see this "as a research specialty and encourage students to make significant contributions as tool makers" BUT"research is measure by the accumulation of knowledge rather than by the improvement of tools"(Peterman, 1992). If GIS is a tool, you measure the improvement of the tool, you want to improve the tool. If GIS is a science, you seek to gather more information and increase knowledge. GIS as a science depends on the rigor with which it is used, and the scope of its functionality within a project. But you have to decide that as you go. Since it varies from project to project you can't say GIS is a science, it would have to be used the same way every time. Since no two sites are the same, it is more helpful to have a framework to guide you, rather than a rigorous method that must be adhered to.

Landscape analysis is a critical component of archaeology. In the past we have relied on our understanding of resource management and cultural adaptation to help us form perceptions

of how landscapes were used by past people. Should we use GIs to create cognitive maps or as Witcher asks, "If we can map physical landscapes, why can we not give cartographic form to more abstract landscapes, such as power, resistance and ritual?" GIS is designed to display facts. These facts are fairly rudimentary, such as Artifact A was found at location 1, or Location 1 is this X miles from Location 2, but when taken as a whole, these facts can form a pattern.

Pattern interpretation relies not on the data itself, but on past experience with which your data may be measured. Comparisons always invoke theoretical thought. Since no two landscapes or sites are identical, conjecture is always required. Based on the researcher and the knowledge that has been published, analysis can sometimes be problematic. The question that researcher asks of the facts may also inadvertently guide them in a direction away from other facts. While it is not intentional, facts can be easily over looked, especially in a GIS format where factual information can be enormous.

Wheatley and Gillings(1999) notethat the majority of the GIS applications deal with inter-site landscape approaches, while intra-site applications are very limited. This.theyargue, reflects the inability of GIS to deal with the four dimensions (adding depth and time to horizontal space) involved in excavation. However, from experience in converting Ewing to a GIS database, a three dimensional aspect is possible at the site level. It requires a very uniform method of excavation and since this does not apply to Ewing, it would be impossible to add this aspect. Methods do exist to allow excavators the ability to maintain that uniformity in removing artifacts. To plot all artifacts in a three dimensional frame after the fact would be time consuming by a GIS analyst, but by no means impossible. The easiest way, would be to employ GPS at the start of a project that can accurately measure everything at a site. This can later be seamlessly integrated into a GIS database will little extra work.

Section 12

CONCLUSION

While not necessary for my own project, it is easy to rapidly include excavation photos into the various layers. These could include the appearance of the site before and after, artifacts in situ, or any other notable anomalies discovered. By simply moving your mouse across an interactive map, you can absorb more details faster about the site you are examining. This easy use also allows for lay people to understand what it is they are looking. Furthermore, the representation of a simple artifact number can be enhanced by seeing the actual item. This allows the user to see the item directly on the screen without having to search through boxes; hoping the item has not been moved or lost. Preserving the past and helping the public understand its importance has always been the goal of archaeology. The quick dissemination and easy access to this information will provide a greater understanding in the public's eye.

Within the scope of this project, it is possible to deduce that occupants of Ewing began to arrive in the mid-11th century. They brought with them the Chapin Gray style of pottery. Dendrochronology suggests that the site was built at roughly the same time. However, based on ceramic distribution, House I was first, with House IV and III following soon after. Kivas 1, 4, 5, 6, 7 were built at the same time as each corresponding house. This community was stable and eventually moved from Chapin to Mancos style ceramics.Later House II was constructed with Kiva 3. This would indicate an influx of people and a possible transition to a new ceramic style, possibly Mesa Verde. Eventually, House I would be burned and reconstructed in a masonry style with Kiva 1 also undergoing an upgrade. House II was remodeled and a masonry component install on its foundation along with the addition of Kiva 2. Kivas 5 and 7 fell into disuse with Kiva 7 becoming disposal area for fill from the construction of Kiva 2. At this point

Mesa Verde Corrugated ceramics were in full use and wide spread throughout the side, but heavily concentrated in the southern section. Towards the end of its occupation, the southern section shows the highest concentration of artifacts and can thus be inferred to be where the last inhabitants were living. By 1120 AD, these people left the southern section, never to return. This village had a lifespan of 80 years.

The limitations of this GIS database are not a result of incorrect or inaccurate archaeological methods. On the contrary, the sheer scale of this site pushes the limits of what can be done in three field seasons. Working as fast and with a small crew, Rohn was able to accomplish a tremendous feat. In 18 weeks, nearly 56,000 artifacts were recovered and preserved. Over 45 years have passed since that initial excavation and many people have worked on analyzing this site. They all contributed in part to this work. Most of the time, it was beneficial, however, there are times when maps are misplaced, items are shuffled around and lost, and analysis can be misinformed. All of these have to be taken into consideration.

The nature of ArcGIS allows for multiple methods of achieving a goal. There will no doubt be readers of this paper that are far more versed in GIS than me. Those readers may wish to evaluate my methods and determine that there are easier or different ways of doing this project. That is to be expected. The true goal of this paper is to determine if the project is worth doing at all. Through this project, I have personally become oriented with the many nuances, both frustrating and gratifying, that ArcGIS has to offer. All users of GIS at one time or another find themselves scratching their heads and wondering “why won’t it just do what it’s told”. If GIS is easy for you, then you’re doing it wrong.

Section 13

INCORPORATING INTO ARCGIS

The site maps that would allow for precise locations are not available at this time. However, this does not pose a problem. Rohn provided several well drawn overview maps that when used within GIS, make the maps work. While the overview provides only a general layout for the site, it exhibits many landmarks that can be used to overlay more precise maps. Included with the overview of the site were six individual maps of the different construction phases of Ewing. These six maps, when used in conjunction with landmarks of the overview allowed a reasonable interpretation for the location of each building.

By far, the most time consuming part of this project was the transfer of typed and hand written material into a digital format (Tables 3 and 5). This was done through the use of Microsoft Access and Excel. Both programs have benefits in its application to ArcGIS. Ewing contains nearly 40,000 objects. The handwritten artifact sheets were nearly 500 pages. This information had been compiled long before my arrival on this project and the format with which it was recorded was not under my control. I therefore completely transcribed the information into Excel and Access (Tables 4 and 6).

Table 3.Copy of original Ewing Artifact sheets.

N	Item	Provenience	Date
2815.	Discarded		
2816.	Hammerstone	House 4, Sq. L7	8/1/68
2817.	Finger Ring Fragment	House 4, Sq. L7	8/1/68
2818.	Flakes	Kiva 5, Fill, Southern Recess	8/1/68
2819.	Core	House 4, Sq. B6, Fill	8/1/68
2820.	Utilized Flake	House 4, Sq. B6, Fill	8/1/68
2821.	Utilized Flake	House 4, Sq. B6, Fill	8/1/68
2822.	Utilized Flake	House 4, Sq. B6, Fill	8/1/68
2823.	Scraping Plane	House 4, Sq. B6, Fill	8/1/68
2824.	Flakes	House 4, Sq. B6, Fill	8/1/68
2825.	Ground Stone Object	Kiva 5, E½, Zone 4, NW wall	8/1/68
[illegible]	Sherds	Kiva 5, southern recess ventilator	8/1/68
2827.	Utilized Flake	Kiva 4 & 5 Banquette Floor	8/1/68
2828.	Flakes	House 4, Sq. H4, 20-40 cm. Fill	8/1/68
2829.	Hammerstone	House 4, Sq. B8, Fill	8/1/68
2830.	Chopper	House 4, Sq. B8, Fill	8/1/68
2831.	Flakes	House 4, Sq. B8, Fill	8/1/68
2832.	Flakes	Posthouse 2, Sq. 0N,8E, Red Soil Layer, (0-8 cm.)	8/1/68
2833.	Saw	Posthouse 2, Sq. 0N, 8E, Red Soil Layer, (0-8 cm.)	8/1/68
2834.	Flake	Kiva 5, Fill above and between E and S pilasters	8/1/68
2835.	End Scraper	Kiva 4, Banquette, 55 cm. W. of NW end of NE pilaster, 20 cm. S. of Kiva Wall	8/1/68

Table 4.Screen Shot of New Database using Excel.

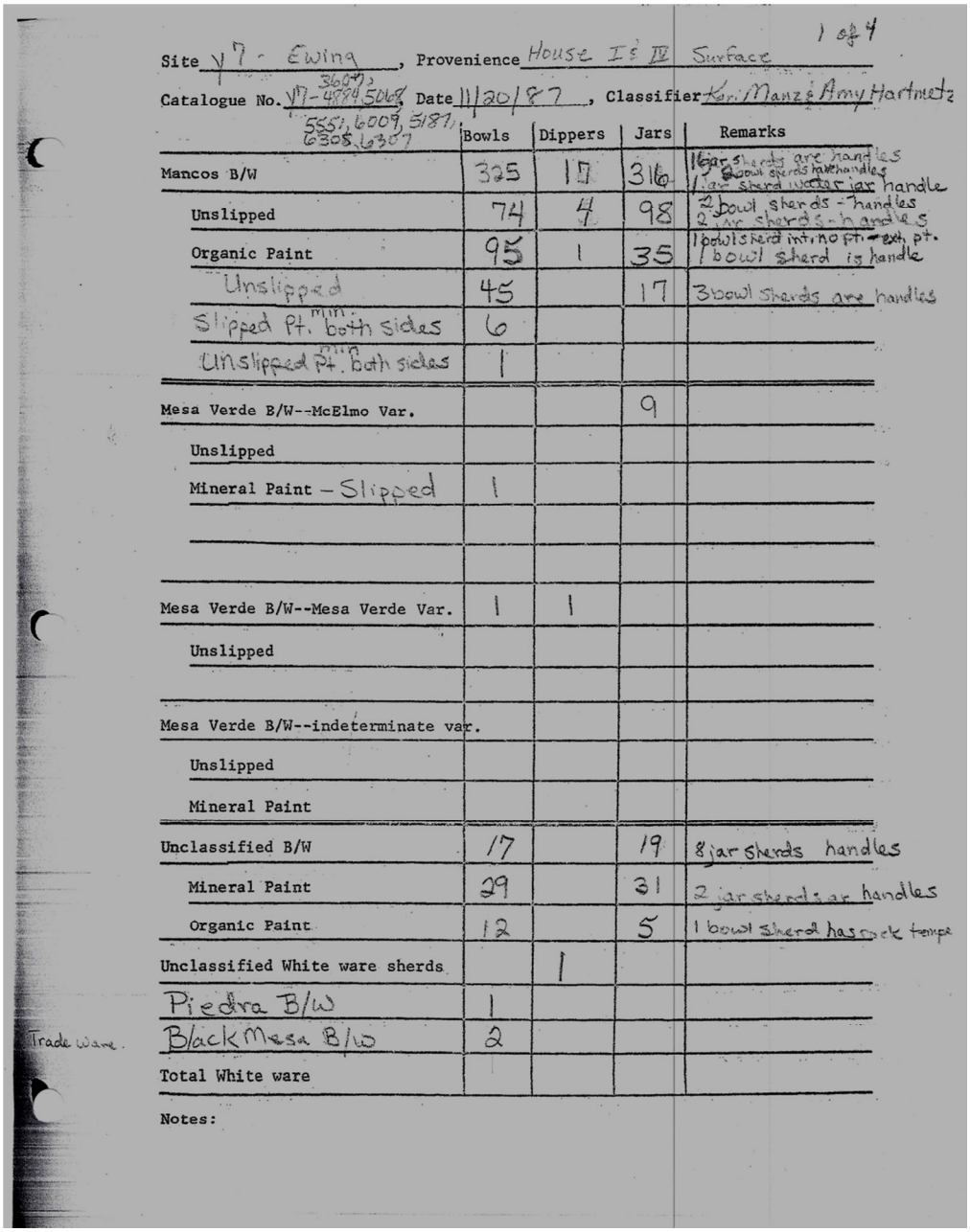
1922	2815	NULL			
1923	2816	Hammerstone	House 4	Square L7	
1924	2817	Finger Ring frag	House 4	Square L7	
1925	2818	Flakes	Kiva 5	Fill	Southern recess
1926	2819	Core	House 4	Square B6	Fill
1927	2820	Utilized Flake	House 4	Square B6	Fill
1928	2821	Utilized Flake	House 4	Square B6	Fill
1929	2822	Utilized Flake	House 4	Square B6	Fill
1930	2823	Scraping plane	House 4	Square B6	Fill
1931	2824	Flakes	House 4	Square B6	Fill
1932	2825	Ground Stone Object	Kiva 5	East half,	Zone 4, NW wall
1933	2826	Sherds	Kiva 5	Souther recess ventilator	
1934	2827	Utilized Flake	Kiva 4	South banquette floor	
1935	2828	Flakes	House 4	Square H4	Fill
1936	2829	Hammerstone	House 4	Square B8	Fill
1937	2830	Chopper/hammerstone	House 4	Square B8	Fill
1938	2831	Flakes	House 4	Square B8	Fill
1939	2832	Flakes	Post house 2	Square 0N8E	red soil layer
1940	2833	Saw/scraper	Post House 2	Square 0N8E	red soil layer
1941	2834	Flake	Kiva 5	Fill above and between E and S pilaster	
1942	2835	End Scraper	Kiva 4	Banquette, 55cm W of NW end of NE pila	20cm S of Kiva wall
1943	2836	Flakes	House 4	Square C8	
1944	2837	Grinding Slab	Kiva 4	Banquette Surface	16cm from wall, 50cm NE pilaster
1945	2838	Chipped slab	House 4	Square C7	
1946	2839	Flakes	House 3	Feature 30	
1947	2840	Sherd	House 3	Feature 30	
1948	2841	Utilized Flake	House 3	Feature 30	
1949	2842	Utilized Flake	House 3	Feature 30	
1950	2843	Utilized Flake	House 3	Feature 30	
1951	2844	Sherds	Post house 2	Square 3S8E	

Within Excel, I came up with column headings that would accurately represent the formula used on the handwritten pages (Figure 6.2). The column names were: item number, item description, Provenience, Secondary Provenience and Tertiary Provenience. These columns were most often used based on the level of detail each artifact received when being excavated. While the first provenience column was always used, secondary and tertiary were not completely noted in every instance. Two more columns were created based on the information within the handwritten sheets. These included: Depth below surface and Notes. Depth below the surface was used sporadically within the database, but was included in order to contribute to the accuracy of the electronic database. The notes column was the least used of all and had no bearing on the GIS database. As this would probably be the only time someone would digitize this information, it seemed wise to include all information for any possible future use.
With the hand tabulated ceramic sheets, I discovered it would be cumbersome to attempt to use Excel. After some research, I learned that it was possible to transfer Microsoft Access information into Excel, and from there it could be imported in ArcGIS. Within Access I created a set of headings that were similar to the artifact list in Excel. Along with the item number and location, I created drop down menus to aid in selecting the proper category for each item number.

There were 20 different ceramic types, four of those types had three variants. Each type also contained an additional three properties regarding slip style. After that, the vessel style that each sherd belonged to was recorded. If you were to use Excel for this, every combination would have to be accounted for. Using Access was far more manageable and more accurate. Once this was complete it was a simple method of using the drop down menu (seen in Figure 6.4) to select your ceramic type, again for variant type and finally for ceramic property. Once

this was completed, all of the records could be imported into Excel very easily. Excel could then be set up to tabulate all totals for every ceramic type. Once imported to ArcGIS, it was them possible to sort out each type very quickly and to create its own layer.

Table 5.Copy of Hand Tabulated Ceramics



1 of 4

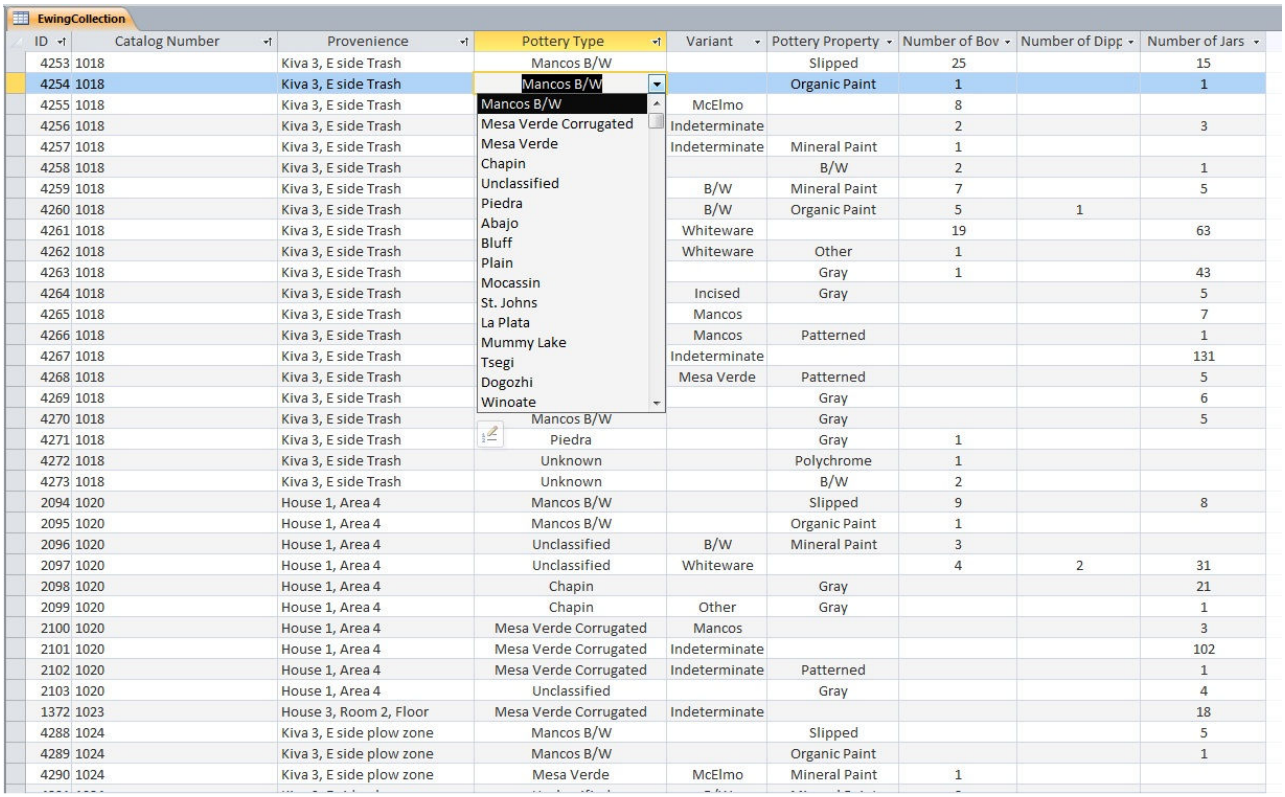
Site V7 - Ewing, Provenience House I's II Surface

Catalogue No. V7-4784, 5068, 3607, 555, 6009, 5187, 6305, 6307, Date 11/20/87, Classifier Kari Manz & Amy Hartmetz

	Bowls	Dippers	Jars	Remarks
Mancos B/W	325	17	316	16 jar sherds are handles; 3 bowl sherds have handles; 1 jar sherd water jar handle
Unslipped	74	4	98	2 bowl sherds - handles; 2 jar sherds - handles
Organic Paint	95	1	35	1 bowl sherd int. no pt. - ext. pt.; 1 bowl sherd is handle
Unslipped	45		17	3 bowl sherds are handles
Slipped Pt. min. both sides	6			
Unslipped Pt. min. both sides	1			
Mesa Verde B/W--McElmo Var.			9	
Unslipped				
Mineral Paint - Slipped	1			
Mesa Verde B/W--Mesa Verde Var.	1	1		
Unslipped				
Mesa Verde B/W--indeterminate var.				
Unslipped				
Mineral Paint				
Unclassified B/W	17		19	8 jar sherds handles
Mineral Paint	29		31	2 jar sherds jar handles
Organic Paint	12		5	1 bowl sherd has corrk temper
Unclassified White ware sherds		1		
Piedra B/W	1			
Trade ware. Black Mesa B/W	2			
Total White ware				

Notes:

Table 6.Screen shot of Access with new database model.



EwingCollection

ID	Catalog Number	Provenience	Pottery Type	Variant	Pottery Property	Number of Bov	Number of Dipp	Number of Jars
4253	1018	Kiva 3, E side Trash	Mancos B/W		Slipped	25		15
4254	1018	Kiva 3, E side Trash	Mancos B/W		Organic Paint	1		1
4255	1018	Kiva 3, E side Trash		McElmo		8		
4256	1018	Kiva 3, E side Trash		Indeterminate		2		3
4257	1018	Kiva 3, E side Trash		Indeterminate	Mineral Paint	1		
4258	1018	Kiva 3, E side Trash			B/W	2		1
4259	1018	Kiva 3, E side Trash		B/W	Mineral Paint	7		5
4260	1018	Kiva 3, E side Trash		B/W	Organic Paint	5	1	
4261	1018	Kiva 3, E side Trash		Whiteware		19		63
4262	1018	Kiva 3, E side Trash		Whiteware	Other	1		
4263	1018	Kiva 3, E side Trash			Gray	1		43
4264	1018	Kiva 3, E side Trash		Incised	Gray			5
4265	1018	Kiva 3, E side Trash		Mancos				7
4266	1018	Kiva 3, E side Trash		Mancos	Patterned			1
4267	1018	Kiva 3, E side Trash		Indeterminate				131
4268	1018	Kiva 3, E side Trash		Mesa Verde	Patterned			5
4269	1018	Kiva 3, E side Trash			Gray			6
4270	1018	Kiva 3, E side Trash	Mancos B/W		Gray			5
4271	1018	Kiva 3, E side Trash	Piedra		Gray	1		
4272	1018	Kiva 3, E side Trash	Unknown		Polychrome	1		
4273	1018	Kiva 3, E side Trash	Unknown		B/W	2		
2094	1020	House 1, Area 4	Mancos B/W		Slipped	9		8
2095	1020	House 1, Area 4	Mancos B/W		Organic Paint	1		
2096	1020	House 1, Area 4	Unclassified	B/W	Mineral Paint	3		
2097	1020	House 1, Area 4	Unclassified	Whiteware		4	2	31
2098	1020	House 1, Area 4	Chapin		Gray			21
2099	1020	House 1, Area 4	Chapin	Other	Gray			1
2100	1020	House 1, Area 4	Mesa Verde Corrugated	Mancos				3
2101	1020	House 1, Area 4	Mesa Verde Corrugated	Indeterminate				102
2102	1020	House 1, Area 4	Mesa Verde Corrugated	Indeterminate	Patterned			1
2103	1020	House 1, Area 4	Unclassified		Gray			4
1372	1023	House 3, Room 2, Floor	Mesa Verde Corrugated	Indeterminate				18
4288	1024	Kiva 3, E side plow zone	Mancos B/W		Slipped			5
4289	1024	Kiva 3, E side plow zone	Mancos B/W		Organic Paint			1
4290	1024	Kiva 3, E side plow zone	Mesa Verde	McElmo	Mineral Paint	1		

Pottery Type dropdown: Mancos B/W, Mesa Verde Corrugated, Mesa Verde, Chapin, Unclassified, Piedra, Abajo, Bluff, Plain, Mocassin, St. Johns, La Plata, Mummy Lake, Tsegi, Dogozhi, Winoate

Section 14

CREATING A GEODATABASE IN ARCGIS

Building the Database

There were many steps needed to create an accurate GIS database for the Ewing site. First and foremost was the creation of a base map. An accurate location for any site is a necessity in archaeology. Based on information obtained from Rohn, the proper USGS quadrangle was located on the USGS website. This website is invaluable in providing free map images to GIS users. The Arriola quadrangle was downloaded, imported as a raster layer, and the proper spatial grid was incorporated into its layer properties (Figure 14). In this case the NAD1983 was used. Ewing is located in an area of Colorado that places it within Zone 13 NAD1983. All subsequent maps were oriented to this spatial set.

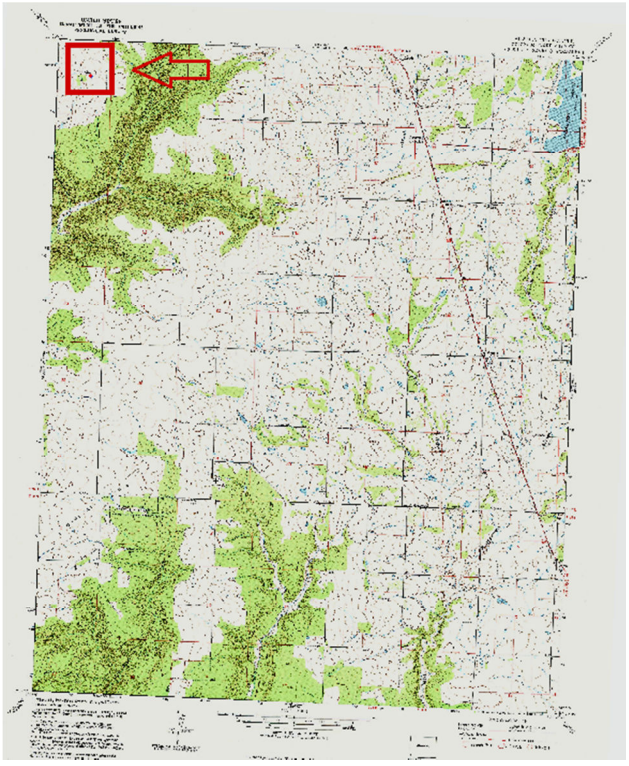


Figure 14.USGS Quadrangle Map Featuring Ewing Site.

After the quadrangle was set, layers were made that included an overview of the Ewing site. Rohn did not have the exact location for where the site was located so an educated guess was used based on the drainage line located on the map. The overview map was then placed at the correct scale in conjunction with the quadrangle map (Figure 15). Particular care was also used in placing this map at the correct orientation for north. Rohn was accurate in depicting the proper direction, and the map had to be slightly rotated to ensure accuracy.

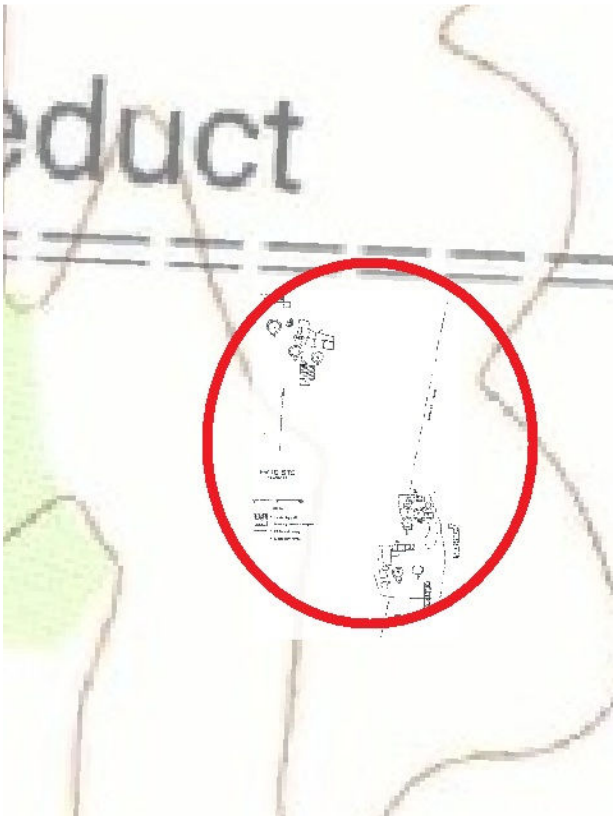


Figure 15.Zoom of Ewing placed on map.

The overview map was a general representation of Ewing. There were small inaccuracies that were discovered during the next phase of map integration. Dr. Rohn had seven maps that showed larger scale and more detailed features for the major structures of the site. Using the Ewing site overview map as a template, it was possible to place these seven maps within relative

position to each other (Figure 16). In some instances, there was a difference of one or two meters between buildings. Using georeferencing in ArcGIS, I was able to orient the maps that satisfied most of the location requirements without going out of scale or causing distortion within the maps themselves.

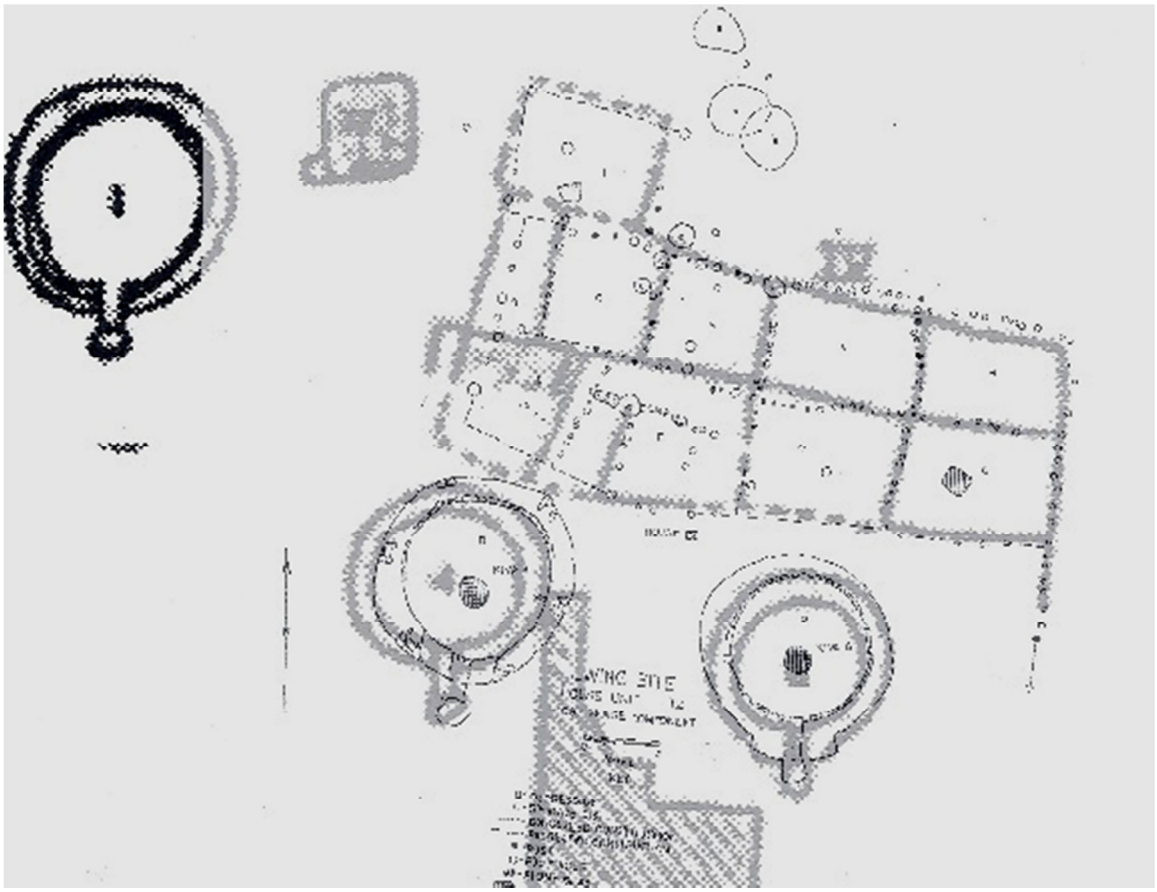


Figure 16.Overview map with House 4 detail overlaid.

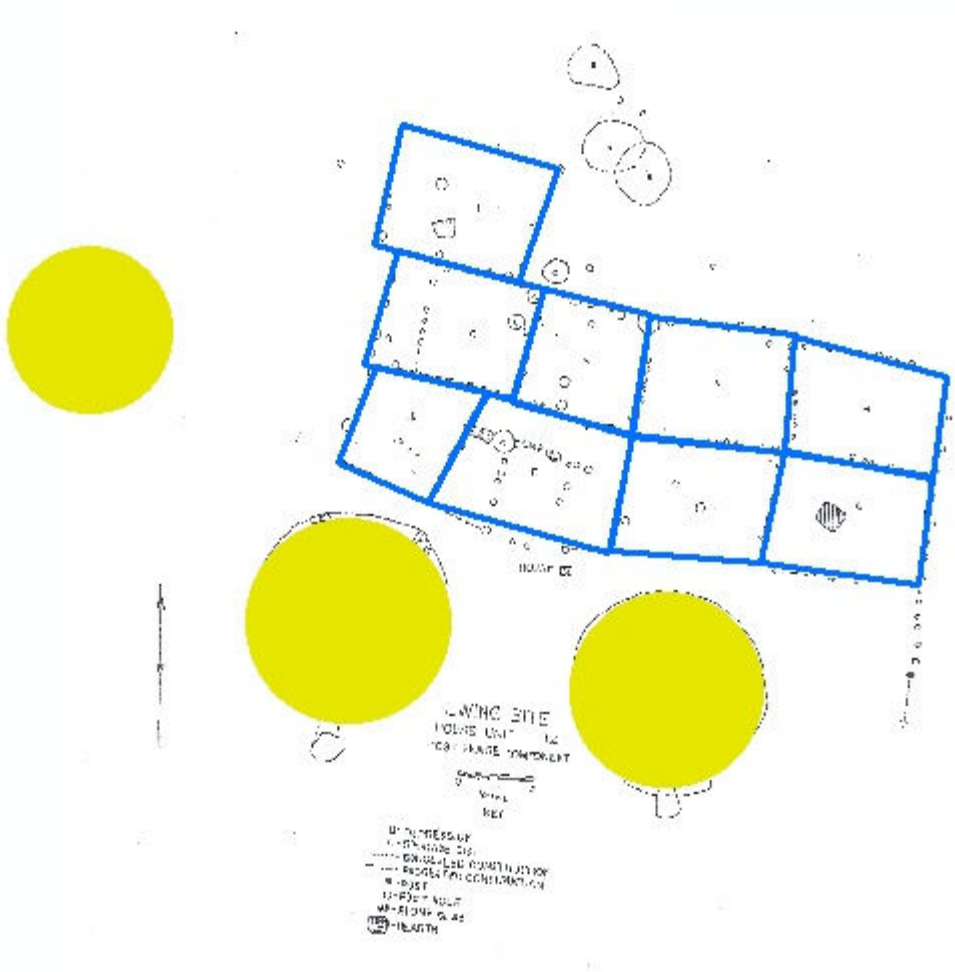


Figure 17.Polygons created over major structures. Circles denote Kivas. Squares denote Rooms.

After all of the maps had been properly placed within the quadrangle at the correct scale, it was my intention to trace each building as a shape file and create a new layer complete with spatial properties. The object here was to begin the integration process of artifact lists with the layout of the site in general. Using the editor toolbar within ArcGIS, I traced the outline of all buildings and kivas (Figure 17). Each polygon was given a designation within its attribute table that was also represented in the artifact database. This would allow a seamless link between the polygon and the database. Secondary proveniences were often well described, but never uniform. If someone were so inclined all of the kivas could be given features inside the overall

structure that would correspond to the information contained within Excel. Various structures were described for each kiva, such as ventilator shafts and banquettes. However, given the overall scope of this project, it did not seem necessary to use that level of detail.

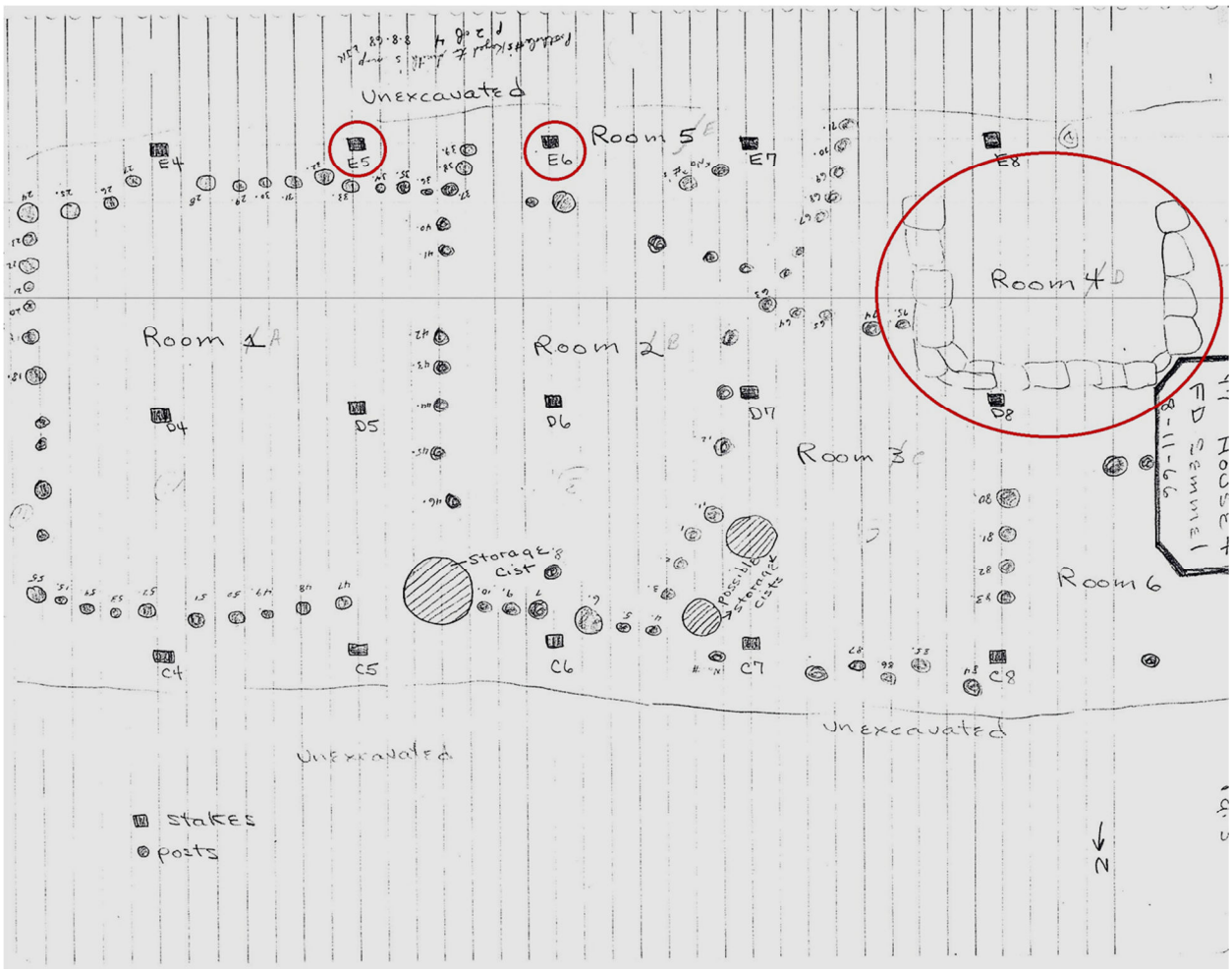


Figure 18.Structure used to align grid, original map. Circles denote markers used.

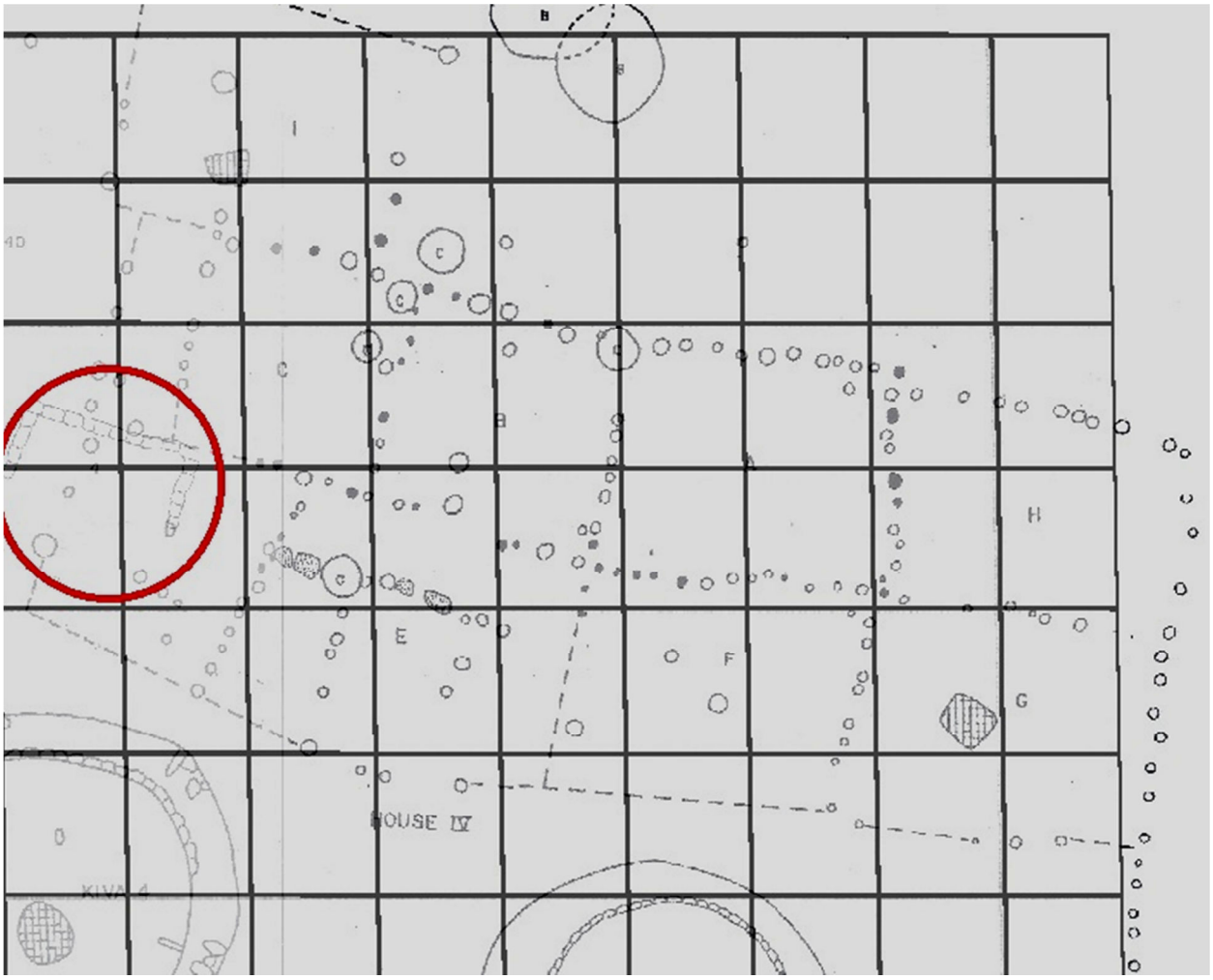


Figure 19.Corresponding structure from Figure 18 used to align grid in GIS.

Several hand drawn maps were made available. Most of these maps were not to scale and did not contain complete layouts of a particular structure. These maps did contain two items that were absolutely invaluable in creating an accurate layout of the site. Landmarks on the hand drawn maps could be recognized on the seven larger maps. The second items was grid markers were present on all of the hand drawn maps. Once these landmarks were identified, it was possible to make accurate estimates on how to place a grid system that accurately matched the hand drawn maps.

For example, Figure 18 is an example of a hand drawn map provided by Dr. Rohn. The circle indicates a "C" shaped stone structure located within House IV. The two smaller circles show the grid system that was on the ground at the time. Using the "C" shaped structure I was able to locate it on the more detailed House IV map (Figure 19). Once this was done, I was able to build a grid with coordinates represented in Figure 18. All that was needed was a handful of grid coordinates in order to fill in the rest within ArcGIS. Figure 20 is another example of a hand drawn map with a very obvious structural element circled that was also invaluable in setting up the grid system in the southern area of Ewing.

There was also some extrapolation of several places. Specifically all areas associated with house 2. This was done using tertiary descriptions of artifacts. Trench 4 was done the same way. However, its primary location was associated with house 1. In reality it is closer to House IV. Tertiary locations identified Kiva 6 and several surrounding grids that were in the area. It is possible that House IV was not uncovered at the time of first identification. The nature of kivas make them easier to identify based on surface shape and depressions that typically form over them.

A detail of great importance was the inclusion of grid markers. These grid markers were laid out in a scale pattern. These markers allowed for a grid to be aligned. The grid markers on various maps led to an interesting observation. In the northern section of the site (that contains Kiva 1, 4, and 6) a different grid style was used than the southern section. The northern side uses a grid system based on the alphabet. For example, the grid datum was placed approximately six meters northeast of Room H within House 4. This datum was then given the designation of A1. The two meters squares proceed southward alphabetically, with the second row being B, the third being C and so on. The rows ultimately reach letter "O" with the highest number being 11.

In the southern grid a different method was employed. The datum in this area was placed within one meter of the southwestern wall of Room A of House II. This datum was given a designation of 0N0E. From here the grid moves in all four compass directions. In order to properly align superimposed grids, this datum was the corner for 4 sections of grid that were overlaid the map in this southern section.

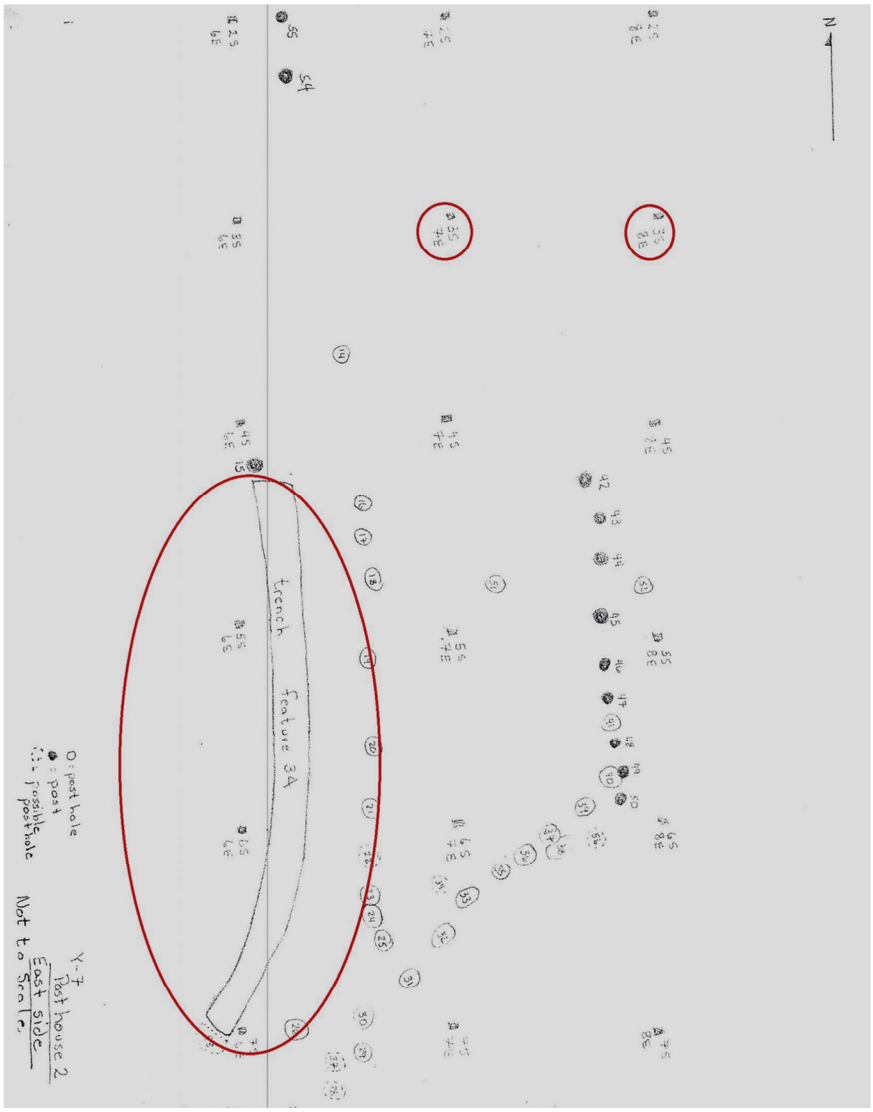


Figure 20.Additional Structural landmarks. Two small circles are two meters apart.

The two different methods would indicate a definite shift in excavation style and most likely represents different excavation seasons. The northern section was cataloged first and the southern section was discovered in later field schools. My hypothesis is that the full scale of the site was not realized until the southern half was discovered and the importance of the site was fully realized. With the doubling in size of Ewing after this discovery, a new approach had to be taken. This southern grid style is more common in modern excavation techniques as it allows for more accurate grid location when a central datum is known.

Once hand-made grids were placed over the entire site, a new Geodatabase was created in order to align the grid in a normalized spatial location. This would change the grid from a simple picture to an actual place in the world. A layer was created to make a new grid that was traced over the handmade grid using lines that were aligned to NAD1983 Zone 13N. After the grid was created, a second layer was created to provide coordinates at the intersection of each grid line. This would allow for correlation between the locations in Excel to a real location on the Ewing map.

Following this step, it became imperative to map out the locations of the major structures on the site. There were two methods that had to be used. This was based on the two different methods of excavation initially used by the crews in 1968. The first method to be discussed was employed because the proveniences used had room designations instead of grids. Using layout view and placing the latitude and longitude lines across the map, it was then possible to get the real locations of each room and kiva within Ewing (Figure 21). These locations then had to be incorporated within Excel by hand to join the artifacts to the locations within ArcGIS. This now meant that each room had a specific location within the USGS raster.

The second method was needed to associate the grid numbers with spatial numbers. To do this, the grid that was created (Figure 19) was modified with a second layer. A point layer system was created in order to assign spatial coordinates to them (Figure 21). At the intersection of all grid lines, a coordinate was placed which automatically gave it UTM coordinates (Figure 22). These points were then labeled to correspond to an actual provenience within Excel. The Excel sheet could then be linked through these points.

Figure 21. House I with UTM Coordinates (examples circled).

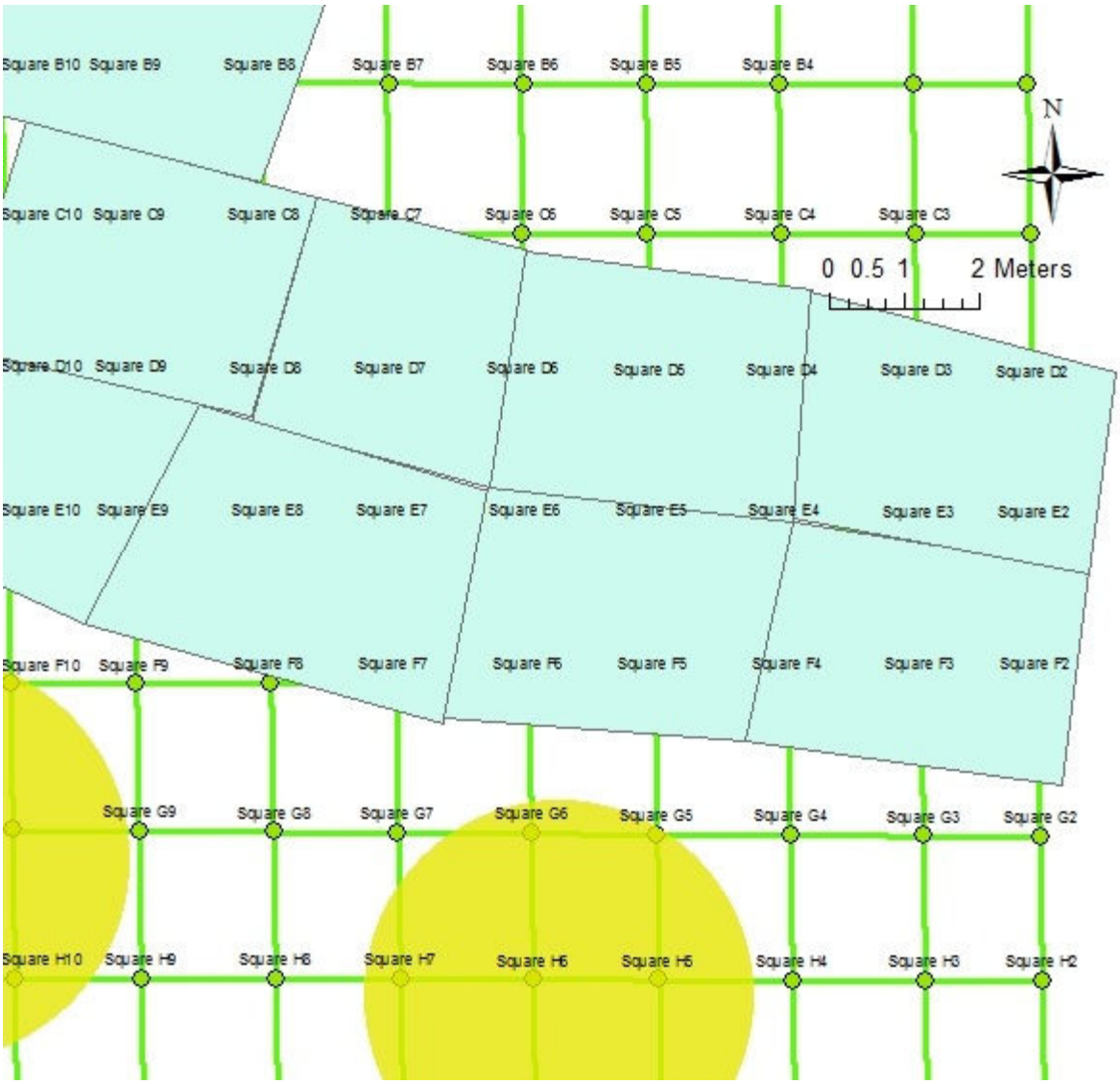


Figure 22.Kiva 6 and House IV with grid and point coordinates.

Importing data from Access and Excel is an essential step in the process. At this point, we must link the data in these tables to physical locations within ArcMap. The version that was used for this particular study was ArcGIS 10.0. ArcGIS does not recognize Access files and it is therefore necessary to import Access into Excel before the final integration can be completed. There are two methods that can be used in this phase. Information can be exported from Access

or Excel can be used to import. This particular file was exported to Excel. The process is simple and merely requires clicking on the "Export" tab and naming the new file.

Since ArcGIS cannot join multiple columns, instead merge locations as simply as possible in your spreadsheets. Then when polygons are named, keep the same format. The problem here is that there are locations that cannot be properly assigned to the formats that were drawn up on the map. Location descriptions were so varied this was very difficult to resolve. Some instances of this were arbitrary descriptions such as "NW quadrant above banquette" "Level 3" or "52cm from south wall." These are good for hand drawn maps, but inappropriate for GIS when a specific location format is required for automation.

Once all relevant information is in Excel format it is now possible to move it into ArcMap. In order to rapidly get the UTM latitude and longitude coordinates, you will have to join the spreadsheet with the layer within ArcMap. First the spreadsheet must be imported. In ArcCatalog, locate the geodatabase and right click. Select "import" and then select "Table Single" (Figure 23). You select single, because it is a single sheet out of Excel you are importing. If more than one sheet is needed in a database you can select "multiple". Once this is complete, go to ArcMap, click the catalog icon at the top right. Locate your geodatabase with the spreadsheet you imported. Drag it to your table of contents on the left.

Next, in ArcMap, in the Table of Contents, right click the appropriate table. Select Join. Select the column headings that will be the join points. (Figure 23) In this case "Secondary Provenience" with "Grid Number". Select "Ok" for all further options. Select "Keep all records". To check your work, open the attribute table for the join and you will now see XY coordinates that were assigned to the coordinate points are now joined to the secondary provenience of all artifacts.

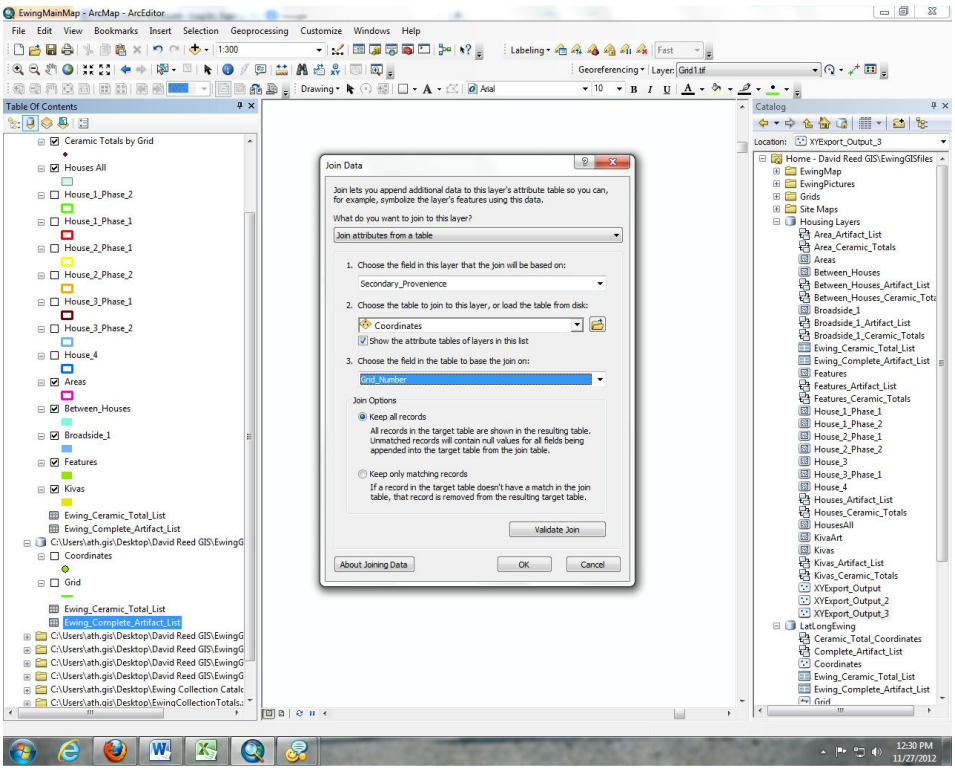


Figure 23.Screen shot of Join Data function.

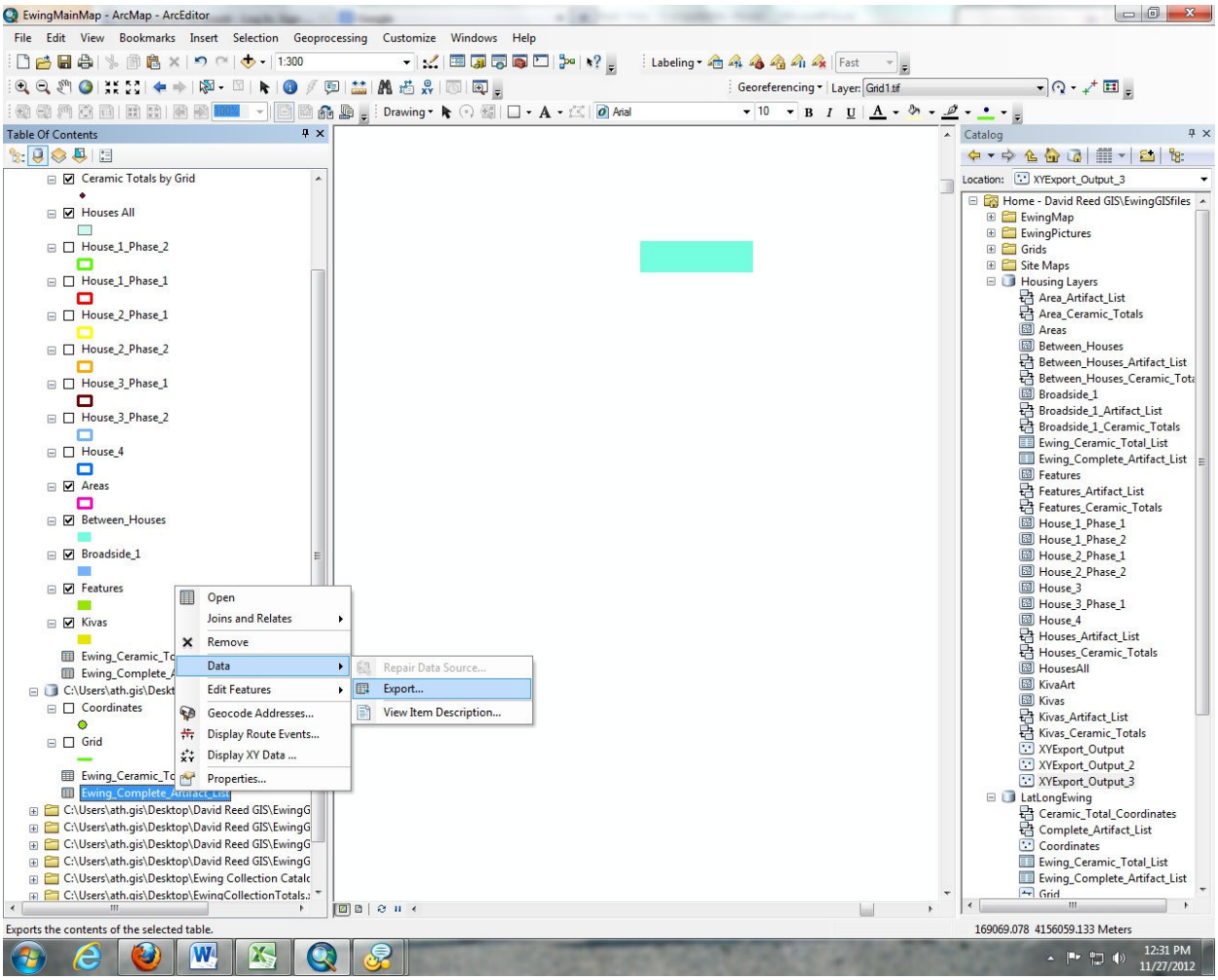


Figure 24.Location of Export feature in ArcGIS.

After that, right click the same table. Then select "Data" and then "Export" (Figure 24). Chose all records and when asked if you would like to add the table to the map select no. You will be doing this on your own shortly. In ArcCatalog, locate the export your just created. It will be labeled "XYExport_Output". (Figure 25) Right click the export and select create feature class from XY Data. Ensure that the X and Y data is linked to the appropriate table headers and you select the correct projection. Note the save location (ArcCatalog sometimes places this creation in odd places) and click ok. (Figure 26) Finally, locate the created feature and drag to

the Table of Contents in ArcMap. Relabel appropriately. You should now see all points in the correct position within the map. (Figure 27).

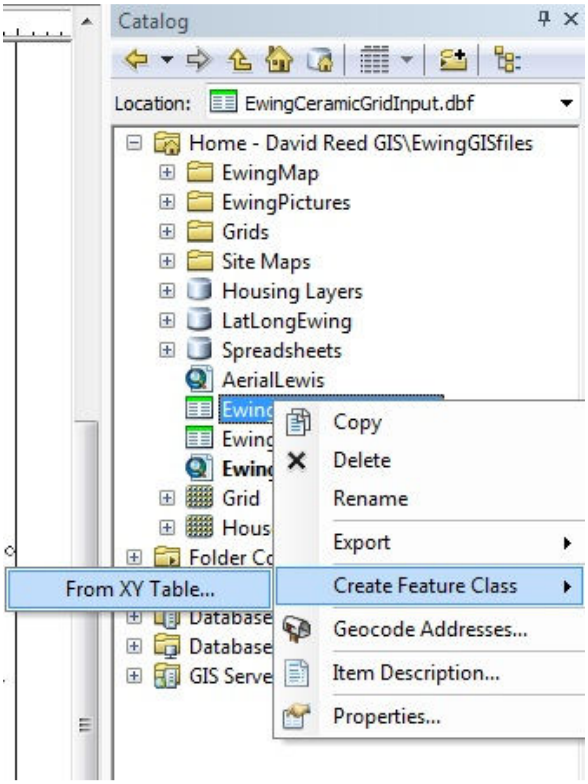


Figure 25.Screen shot for location of XY Table analysis.

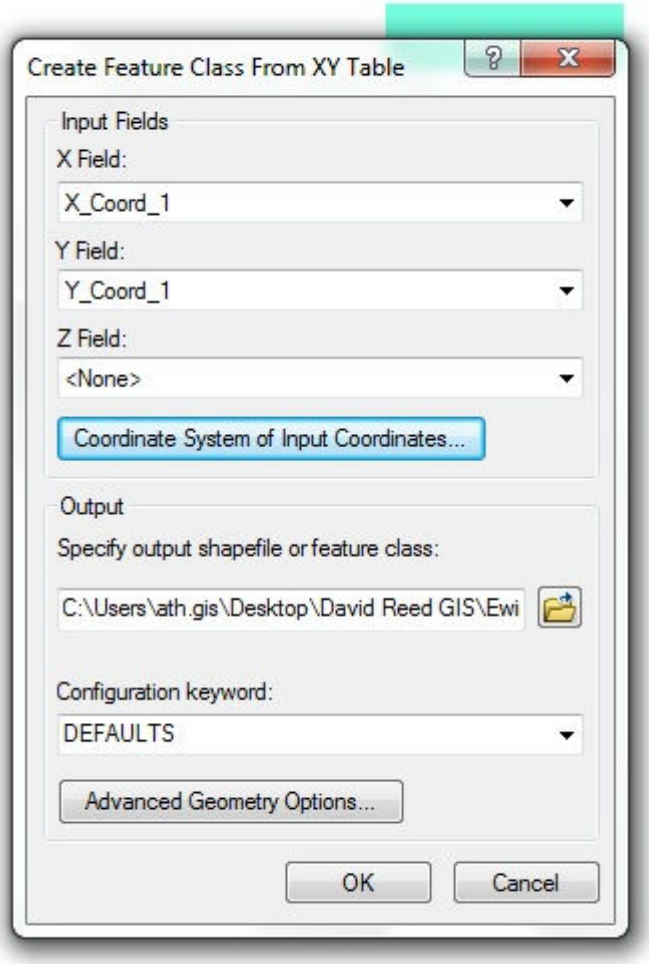


Figure 26.Create Feature Class Window.

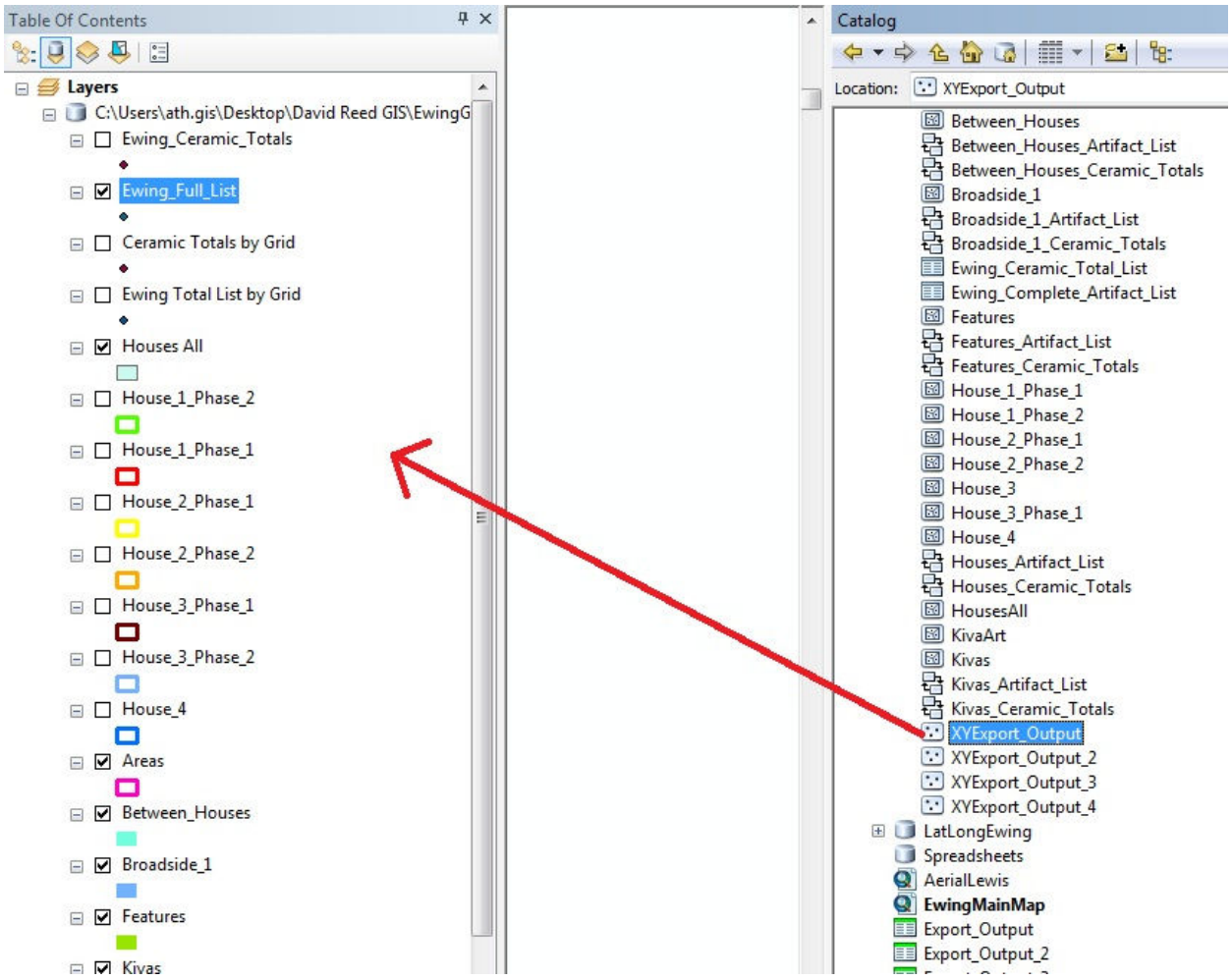


Figure 27.To add Export Out information, it must be clicked and dragged to Table of Contents.

The two different location protocols that were used in the original excavation proved challenging to overcome within the ArcGIS environment. In order to properly align the tables, it was necessary to keep grids and location labels as separate features while incorporating them into the map. There were two distinct tables drawn up for Ewing that I wanted to take full advantage of. The first was the overall artifact list. The second was the ceramic tabulations that were done in previous years. Both of these tables had grids and locations. So ultimately I would have four total feature points. To make it easier to do searches, I used the "merge" option in ArcGIS. This is found under "Arc Toolbox" then selecting "Data Management Tools" then

"General" then "Merge". There were two feature points of ceramics, and two for the full artifact list. I merged the two ceramic points and the two artifact lists. This makes symbology far easier and also doing queries.

Once the merges had taken place it was far easier to make the tables line up. It requires an additional step that cannot be performed in ArcGIS. The merged table must be exported into Excel. It is a very simple task. Right click on the merged layer, select edit. Proceed through the options to begin editing this layer. Open the attribute table, select all records right click on the right side and select "copy". Then open Excel and paste. That's it. The merge basically doubles all of the records. Once in Excel there were X and Y coordinate columns for grid oriented items and X and Y coordinates for location oriented items. Pick one set to work with. In essence you will be copying and pasting either the grid oriented coordinates to the locations or vice versa. This fills in all of the "null" boxes and there will now be a complete X/Y coordinate column. In essence this allowed me to do one query as opposed to two which cut my time in half. I also eliminated the possibility of forgetting a value or confusing myself with badly labeled feature points.

Creating a Relationship Class

A handy search tool in ArcGIS is the relationship class. This makes quick work of figuring out what artifacts are located in a particular area. For instance, if you are looking at the map, you can click on a polygon that represents a house, kiva or feature and quickly find and make a report of what artifacts are located in that specific polygon. This allows you to not have to bother with the doing a query through the artifact list. The added benefit is that doing a query through the artifact list will limit your ability to search for more than two artifacts. Multiple

reports will have to be generated, while a relationship class search will we require only one report to give you every item.

In ArcMap, click on the catalog window (Figure 28). Now in the catalog window, right click on the relevant Geodatabase, highlight "New" and highlight "Relationship class" (Figure 29). Then name the new relationship class something relevant and easy to distinguish. Next select the table you are using and then select the shape layer you want to associate it to. You can associate multiple layers to one table, just ensure that each relationship class has a different and relevant name to help keep everything organized. It is extremely important to note that in order to establish a relationship class, all information must be contained within one geodatabase for the class to be formed. (Figure 30) Next select "Simple" then click "Next" and then select "1 to Many" relationship. This is done because there are many artifacts with one location. Then, elect to add "no attributes". Finally select the attributes that are the same in both the table and the layer. In this case, "secondary provenience" is the common bond. Select "Next" to finish.(Figure 31).

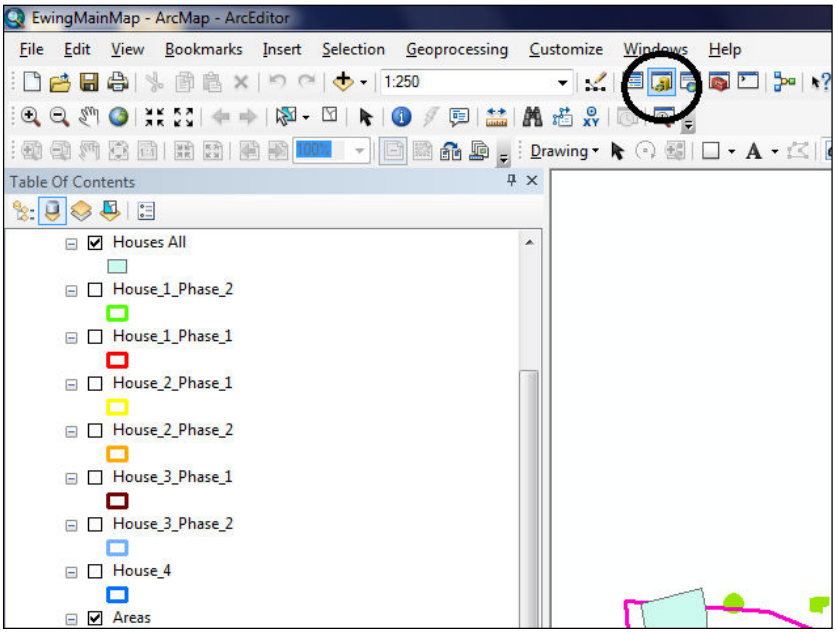


Figure 28.Location of Tool Box icon.

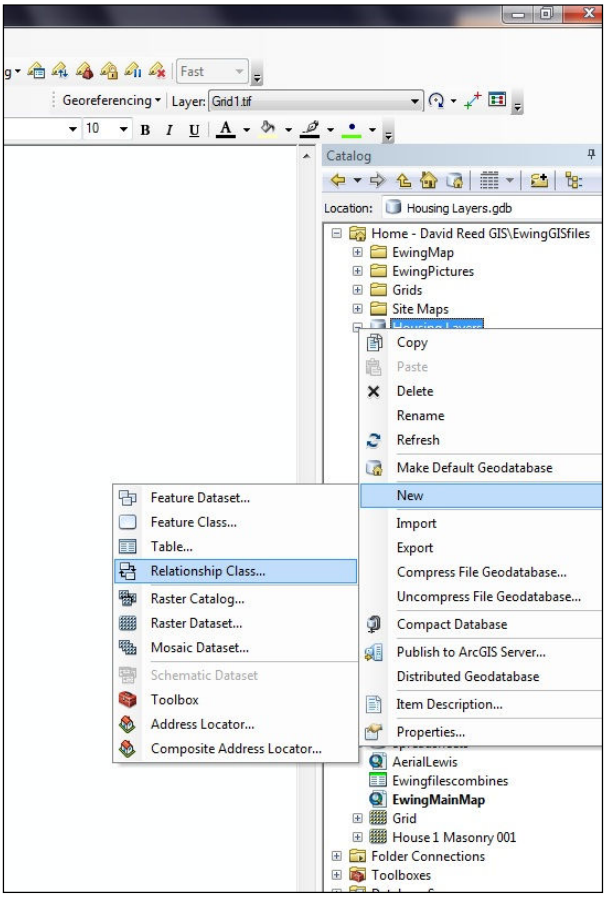


Figure 29.Location of Relationship Class option.

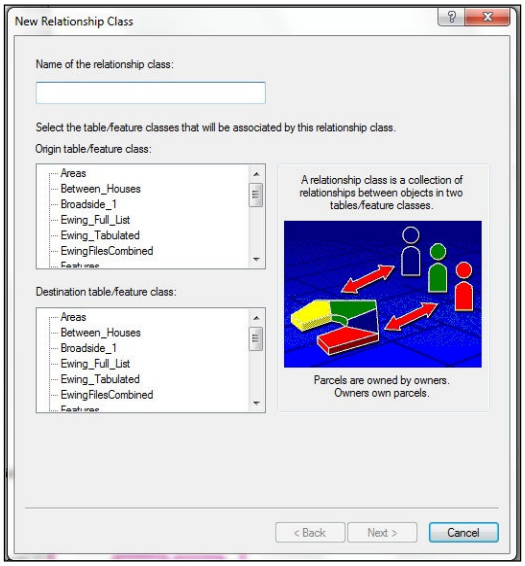


Figure 30.Window for selecting relationship class options.

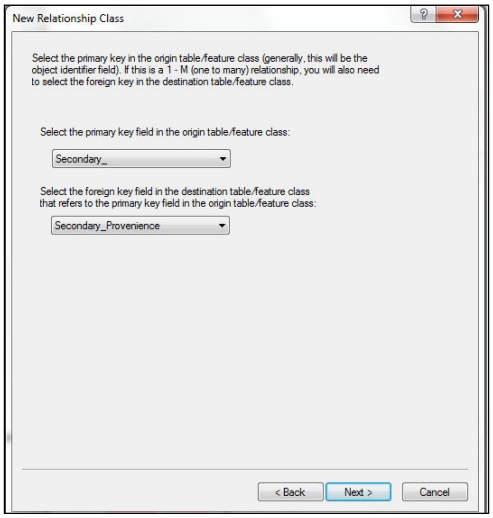


Figure 31.Final window to establish relationship class.

Using a Relationship Class

In order to use the relationship class, right click the layer that you created the class in and open the attribute table. Select the appropriate record and then click on the arrow on the "related tables" box. Select the relevant table if more than one is available. Once you click it, the select records will automatically pop up and you will have generated a list that includes only the artifacts for the polygon you want to include in your search. From this point on, a report can be created by selecting the "table options" box in the upper right, then scrolling down to "create reports".

Summarizing Multiple Location Totals

In the process of working with the ceramics database, a problem was discovered. When ceramics were excavated within a defined area, there was obviously going to be instances where they were collected in different places within that area. However, during the analysis phase, it turns out that the various ceramics were in fact the same. For example, (Table 7) Sherd A could be collected in Square M6. The next day, more sherds could be recovered and recorded as Sherd B. During analysis it would be discovered that Sherds A and B were of the same type. This meant that when the tabulations were done, you could have multiple artifact numbers for the same type of Sherd.It is therefore necessary to combine these duplicated records in order to create a more accurate visualization of the size. Without doing this, ArcGIS would place graphic representations within a specified area causing overlapping and a distorted visual representation. Two examples have been provided that demonstrate the overlapping issue. (Figures 33 and 34)

Table 7.Example of multiple totals from a singular location.

Table

Chapin Sherds

OBJECTID *	Catalog_Nu	Provenienc	Secondary_	Pottery_Ty	Pottery_Pr	Number_of_	Number_of1	Number_o_1	Total_Numb	Y_Coord_1	X_Coord_1	Sh
1	2985	House 4	Square M6	Chapin	Gray	0		28	28	4156118.8709	169095.0208	Poin
2	3238	House 4	Square M6	Chapin	Gray	1		5	6	4156118.8709	169095.0208	Poin
3	3238	House 4	Square M6	Chapin	Gray	0		1	1	4156118.8709	169095.0208	Poin
4	3237	House 4	Square M5	Chapin	Gray	0		14	14	4156118.8709	169096.7086	Poin
5	3236	House 4	Square L7	Chapin	Gray	0		13	13	4156120.8156	169093.2383	Poin
6	3236	House 4	Square L7	Chapin	Gray	0		1	1	4156120.8156	169093.2383	Poin
7	3235	House 4	Square L6	Chapin	Gray	0		19	19	4156120.8156	169094.9927	Poin
8	3235	House 4	Square L6	Chapin	Gray	0		1	1	4156120.8156	169094.9927	Poin
9	366	Trash Mound 2	Square L6	Chapin	Gray	0		3	3	4156120.8156	169094.9927	Poin
10	3234	House 4	Square L5	Chapin	Gray	0		13	13	4156120.8156	169096.6777	Poin
11	3153	House 2	Square K7	Chapin	Gray	0		6	6	4156122.8104	169093.2066	Poin
12	3252	House 4	Square K7	Chapin	Gray	0		1	1	4156122.8104	169093.2066	Poin
13	152	Trash Mound 3	Square K7	Chapin	Gray	0		6	6	4156122.8104	169093.2066	Poin
14	168	Trash Mound 3	Square K7	Chapin	Gray	0		1	1	4156122.8104	169093.2066	Poin
15	4827	House 2	Square S13	Chapin	Gray	1		0	1	0	0	Poin
16	4827	House 2	Square S13	Chapin	Gray	1		0	1	0	0	Poin

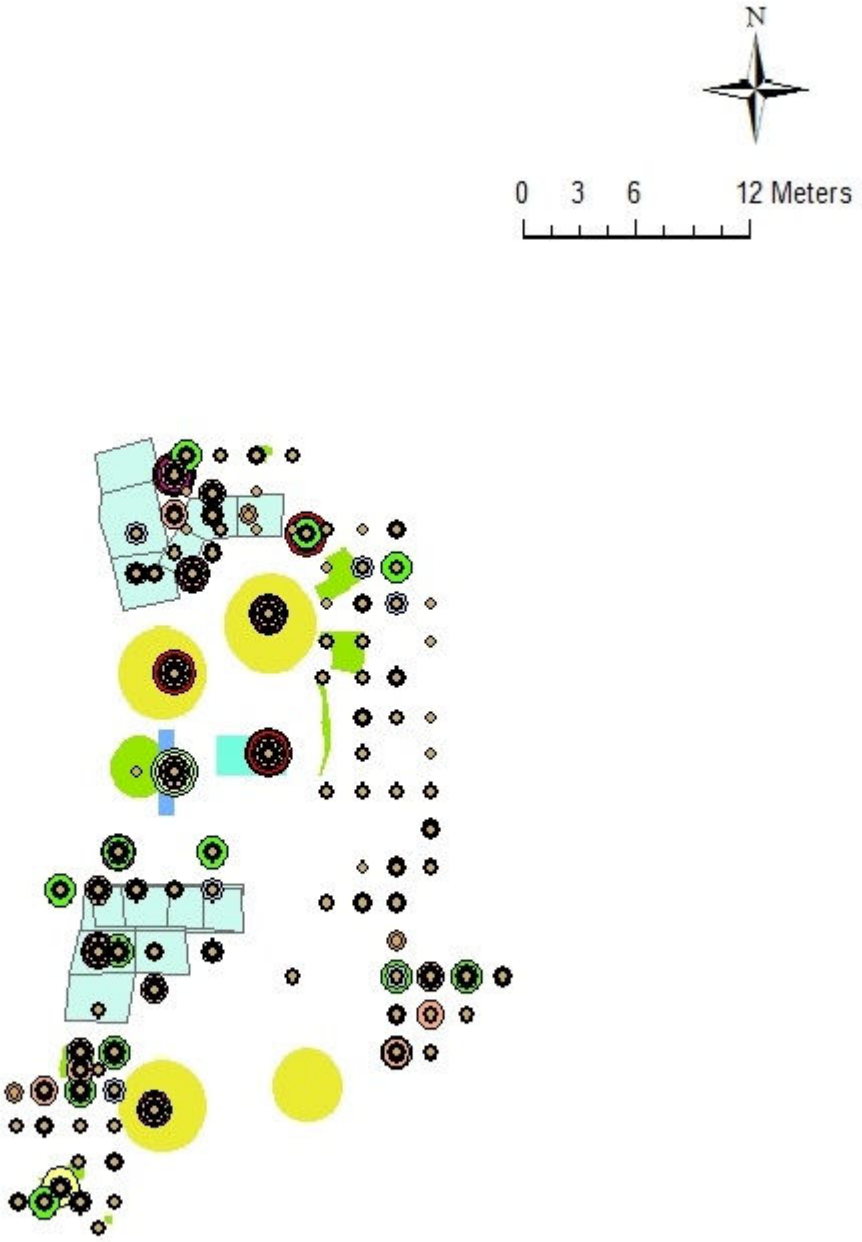


Figure 32.ArcGIS results in leaving multiple totals for singular locations. This creates overlapping circles and making visualization confusing.

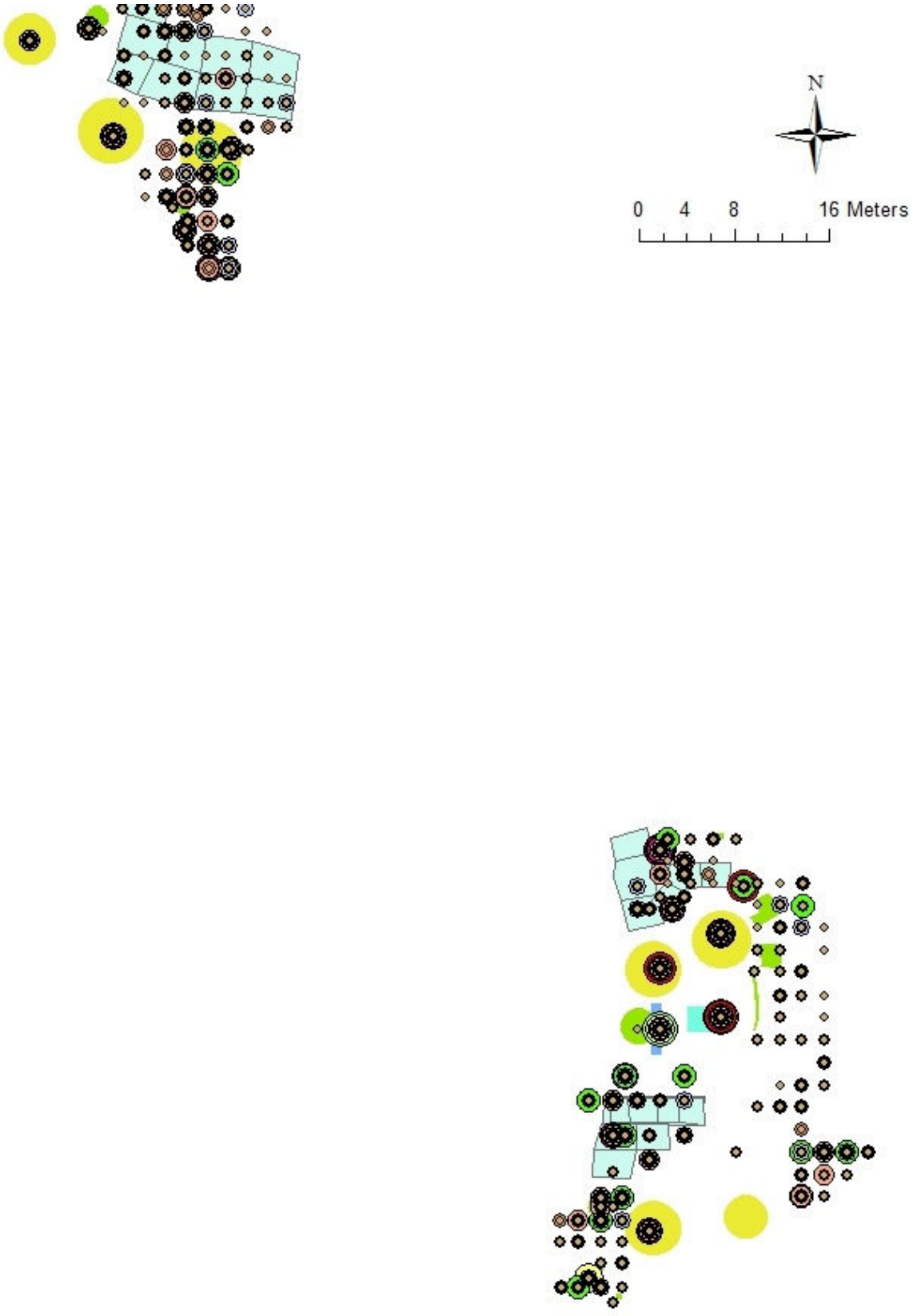
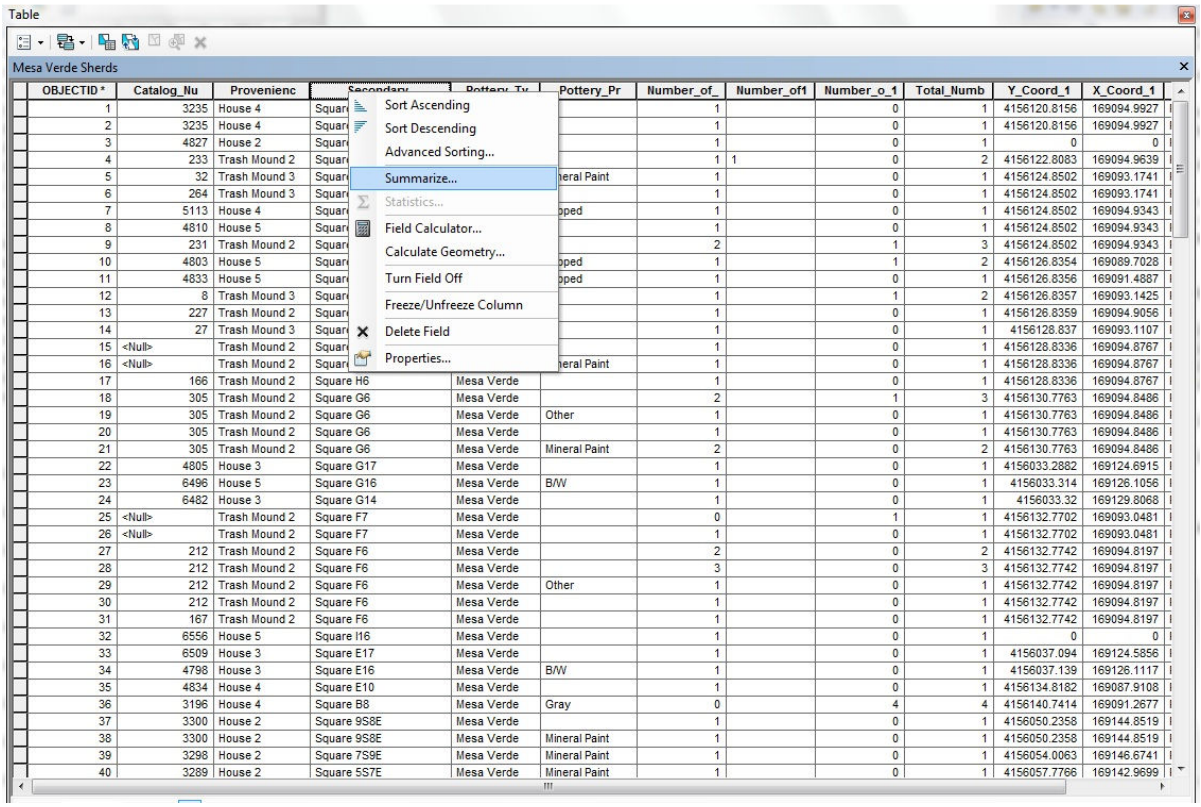


Figure 33.A second example of confusing visualization from a non-summarized table.

In order to process a summary, each pottery type was subjected to the same process. First open the attribute table of the type you wish to summarize. The example depicted (Table 8) is the Mesa Verde layer. Once open, right click on the field you wish to summarize and click on "Summarize". In this case it would be the "secondary" field because it is the field that has duplicate entries (Table 8).

Table 8.Location of Summarize feature.



OBJECTID *	Catalog_Nu	Provenienc	Secondary	Pottery_Ty	Pottery_Pr	Number_of_	Number_of1	Number_o_1	Total_Numb	Y_Coord_1	X_Coord_1
1	3235	House 4	Square			1		0	1	4156120.8156	169094.9927
2	3235	House 4	Square			1		0	1	4156120.8156	169094.9927
3	4827	House 2	Square			1		0	1	0	0
4	233	Trash Mound 2	Square			1	1	0	2	4156122.8083	169094.9639
5	32	Trash Mound 3	Square		eral Paint	1		0	1	4156124.8502	169093.1741
6	264	Trash Mound 3	Square			1		0	1	4156124.8502	169093.1741
7	5113	House 4	Square		pped	1		0	1	4156124.8502	169094.9343
8	4810	House 5	Square			1		0	1	4156124.8502	169094.9343
9	231	Trash Mound 2	Square			2		1	3	4156124.8502	169094.9343
10	4803	House 5	Square		pped	1		1	2	4156126.8354	169089.7028
11	4833	House 5	Square		pped	1		0	1	4156126.8356	169091.4887
12	8	Trash Mound 3	Square			1		1	2	4156126.8357	169093.1425
13	227	Trash Mound 2	Square			1		0	1	4156126.8359	169094.9056
14	27	Trash Mound 3	Square			1		0	1	4156128.837	169093.1107
15	<Null>	Trash Mound 2	Square			1		0	1	4156128.8336	169094.8767
16	<Null>	Trash Mound 2	Square		eral Paint	1		0	1	4156128.8336	169094.8767
17	166	Trash Mound 2	Square H6	Mesa Verde		1		0	1	4156128.8336	169094.8767
18	305	Trash Mound 2	Square G6	Mesa Verde		2		1	3	4156130.7763	169094.8486
19	305	Trash Mound 2	Square G6	Mesa Verde	Other	1		0	1	4156130.7763	169094.8486
20	305	Trash Mound 2	Square G6	Mesa Verde		1		0	1	4156130.7763	169094.8486
21	305	Trash Mound 2	Square G6	Mesa Verde	Mineral Paint	2		0	2	4156130.7763	169094.8486
22	4805	House 3	Square G17	Mesa Verde		1		0	1	4156033.2882	169124.6915
23	6496	House 5	Square G16	Mesa Verde	B/W	1		0	1	4156033.314	169126.1056
24	6482	House 3	Square G14	Mesa Verde		1		0	1	4156033.32	169129.8068
25	<Null>	Trash Mound 2	Square F7	Mesa Verde		0		1	1	4156132.7702	169093.0481
26	<Null>	Trash Mound 2	Square F7	Mesa Verde		1		0	1	4156132.7702	169093.0481
27	212	Trash Mound 2	Square F6	Mesa Verde		2		0	2	4156132.7742	169094.8197
28	212	Trash Mound 2	Square F6	Mesa Verde		3		0	3	4156132.7742	169094.8197
29	212	Trash Mound 2	Square F6	Mesa Verde	Other	1		0	1	4156132.7742	169094.8197
30	212	Trash Mound 2	Square F6	Mesa Verde		1		0	1	4156132.7742	169094.8197
31	167	Trash Mound 2	Square F6	Mesa Verde		1		0	1	4156132.7742	169094.8197
32	6556	House 5	Square I16	Mesa Verde		1		0	1	0	0
33	6509	House 3	Square E17	Mesa Verde		1		0	1	4156037.094	169124.5856
34	4798	House 3	Square E16	Mesa Verde	B/W	1		0	1	4156037.139	169126.1117
35	4834	House 4	Square E10	Mesa Verde		1		0	1	4156134.8182	169087.9108
36	3196	House 4	Square B8	Mesa Verde	Gray	0		4	4	4156140.7414	169091.2677
37	3300	House 2	Square 9S8E	Mesa Verde		1		0	1	4156050.2358	169144.8519
38	3300	House 2	Square 9S8E	Mesa Verde	Mineral Paint	1		0	1	4156050.2358	169144.8519
39	3298	House 2	Square 7S9E	Mesa Verde	Mineral Paint	1		0	1	4156054.0063	169146.6741
40	3289	House 2	Square 5S7E	Mesa Verde	Mineral Paint	1		0	1	4156057.7766	169142.9699

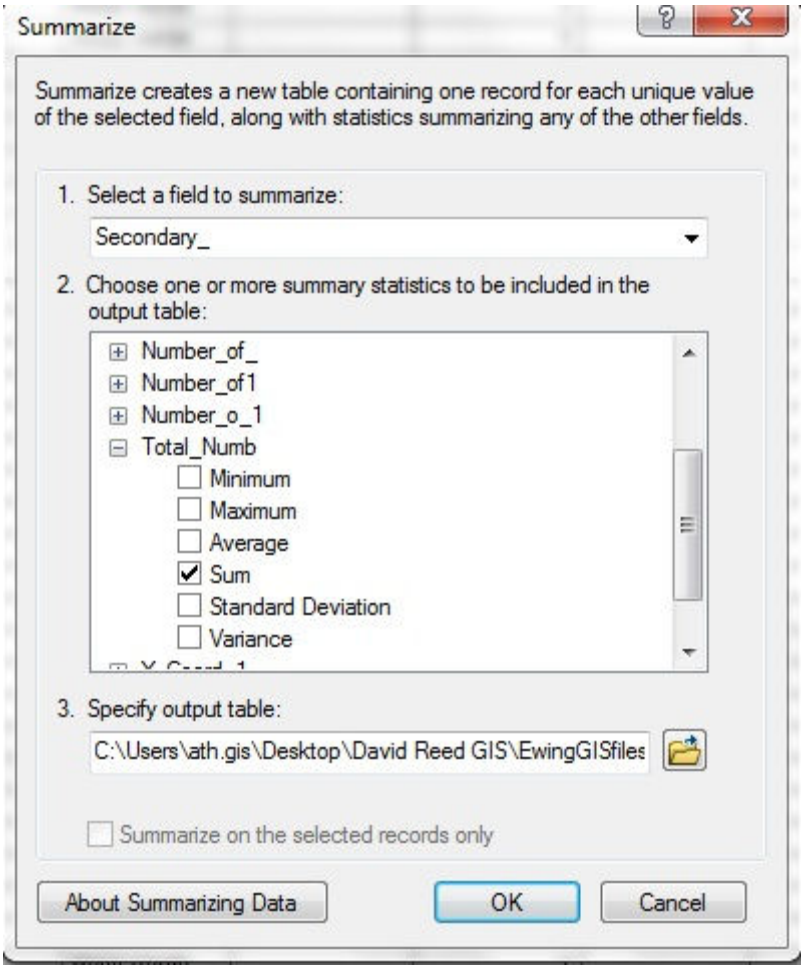


Figure 34.Window displaying options for summary.

Next, ensure that in box number 1, the field you wish to summarize is selected. After that scroll down to the field you wish to have summarized in relation to that field and select SUM. In this case, the "Total Number of Sherds" was appropriate because all of the sherds for each "secondary" field need to be added (Figure 35). Now at this point, you could select OK and a new table would be generated that has a single entry per "secondary" field and all of the totals would be summed. However, this table needs to be brought back into the map's table of contents and placed in the correct spatial projection. The original table has X and Y coordinates already on it. As a shortcut, while still in the summarize box, continue to scroll down to the "X_Coord" field, and select AVERAGE. Do this again for the "Y_Coord" field. This will average the

numbers within the X and Y fields. However, since they are all the same, the final number will be exactly the same. This allows the user to avoid having to manually re-enter all of the coordinates. Once this is done, select ok and a table will begin to be generated. ArcGIS will ask if you wish to add the table to the map. Decline this option as you will have to convert the table to a feature class layer in order for it to be useful. This is easier when done from the Toolbox menu than the Table of Contents. From the toolbox, right click the table you created, select "create feature class from XY table". In the X field drop down menu, select your average X_Coord field and do the same for your Y coordinates (Figure 36). Select ok, and drag the new layer to your table of contents. This quick summary will quickly give you a new layer of the same information but in a more streamlined view.

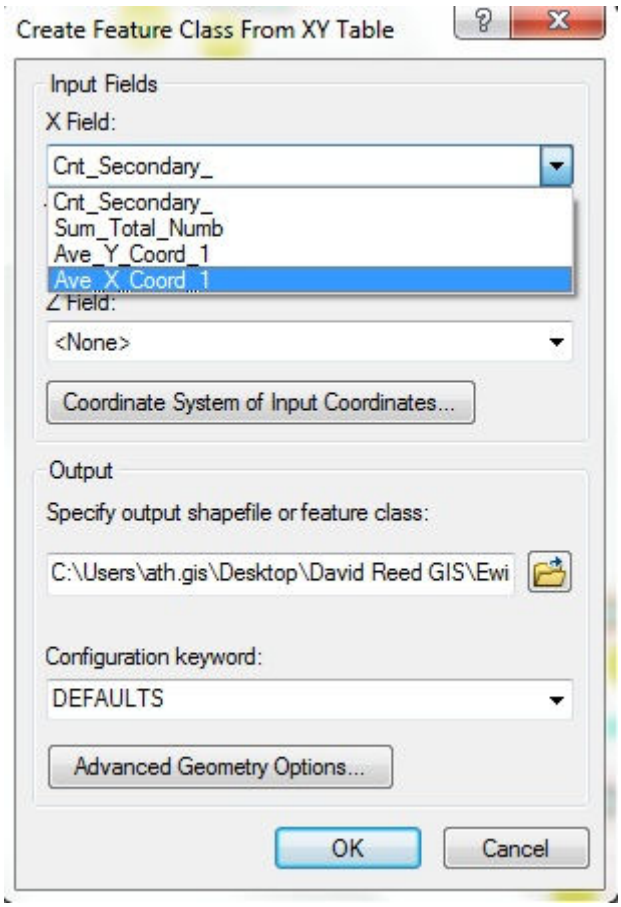


Figure 35.Creating Feature Class from XY table window.

The creation of two databases for Ewing necessitated the use of two different types of query building in ArcGIS. The first to be addressed was labeled as the "Ewing Full Catalog List" and contains the entire record of all artifacts that were pulled out of the ground. The sheets used for this project are not the original and are most likely a second generation copy made from original. This fact made accuracy paramount in transposing from a typewritten format to a final digital copy. However, this also proved to be a hindrance. With nearly 4600 artifacts listed, variation in item description was bound to occur. However, the Ewing database contained nearly 500 variations of artifact descriptions. Standardization was not part of the original process and artifact analysis apparently has been added to the database over the last 40 years.

Anticipating a future issue within ArcGIS, I took it upon myself to weed out inconsistencies that could be removed but also would maintain the integrity of the original sheets. One example was the use of "Sherds" in identifying ceramic pieces. Along with "sherds" several synonyms were used such as "pot sherds"or simply "ceramics. Sometimes the word fragment or partial was used and other times pot sherds was one word. In this case, all of these examples were changed to "sherds". Another example was the use of arrow head, point, and stone point. These three words were often accompanied by the words partial and fragmented. Instead, they were all changed to simply "point."

In some cases it was not in the best interest of the database to change the description. This was most evident in the various animal bones. Often they would be listed as the animal it came from. Sometimes it would be listed specifically as the animal and the bone type such as "rabbit tibia". These descriptions were not changed. Another included stone tools. Various items were found throughout the site such as abraders, scrapers and awls. These were not

changed in the database, but when a search was done, the search name was generalized to be labeled simply as “stone tools”.

How to perform a search

Right click the artifact layer you want to work with and select “properties”. Next click on the “symbology” tab and click “categories” and then “unique values”. At the bottom will be a box that says “add values” (Figure 37). Select add values. A box (Figure 38) will appear. ArcGIS will not often load a complete list so it is imperative that you select “complete list”. Once that is done, a list will appear that has every label that occurs within your attribute table. It is now just a matter of selecting the artifacts you wish to map and assigning appropriate symbols.

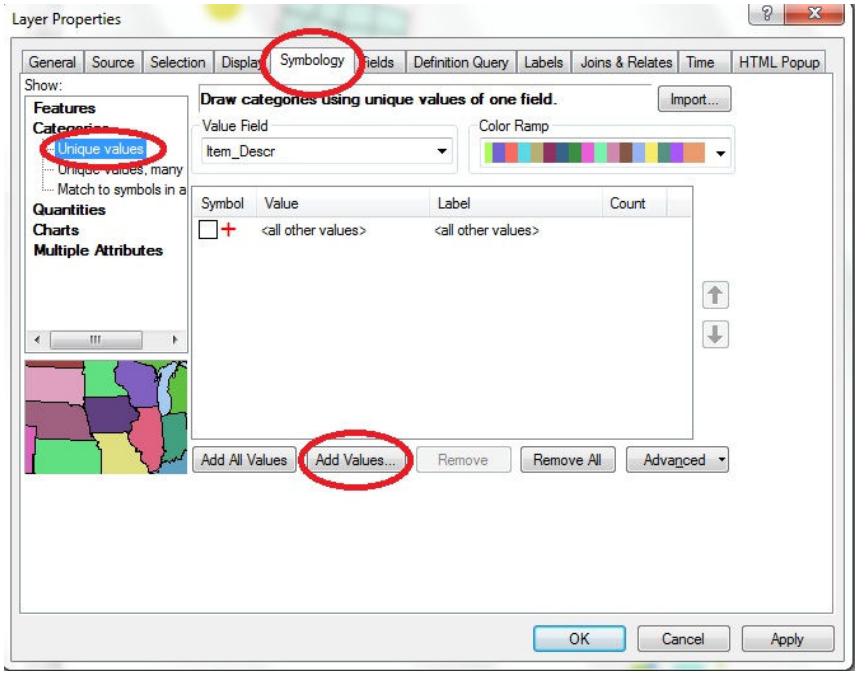


Figure 36.Location of “Add Values” option.

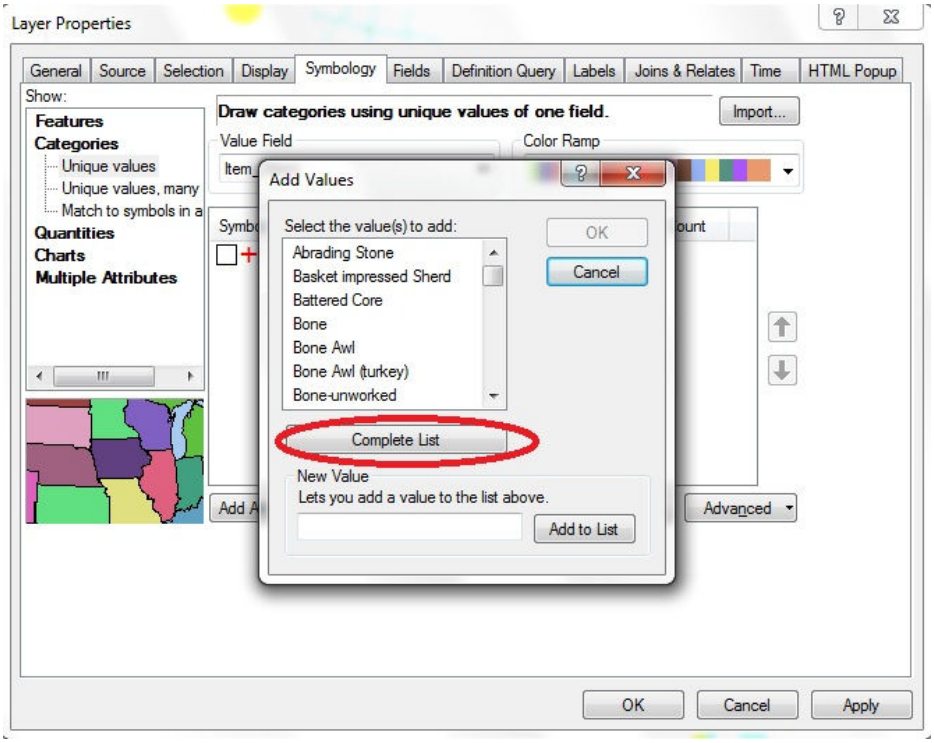


Figure 37.Complete List location.

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APPENDIXES

Appendix A

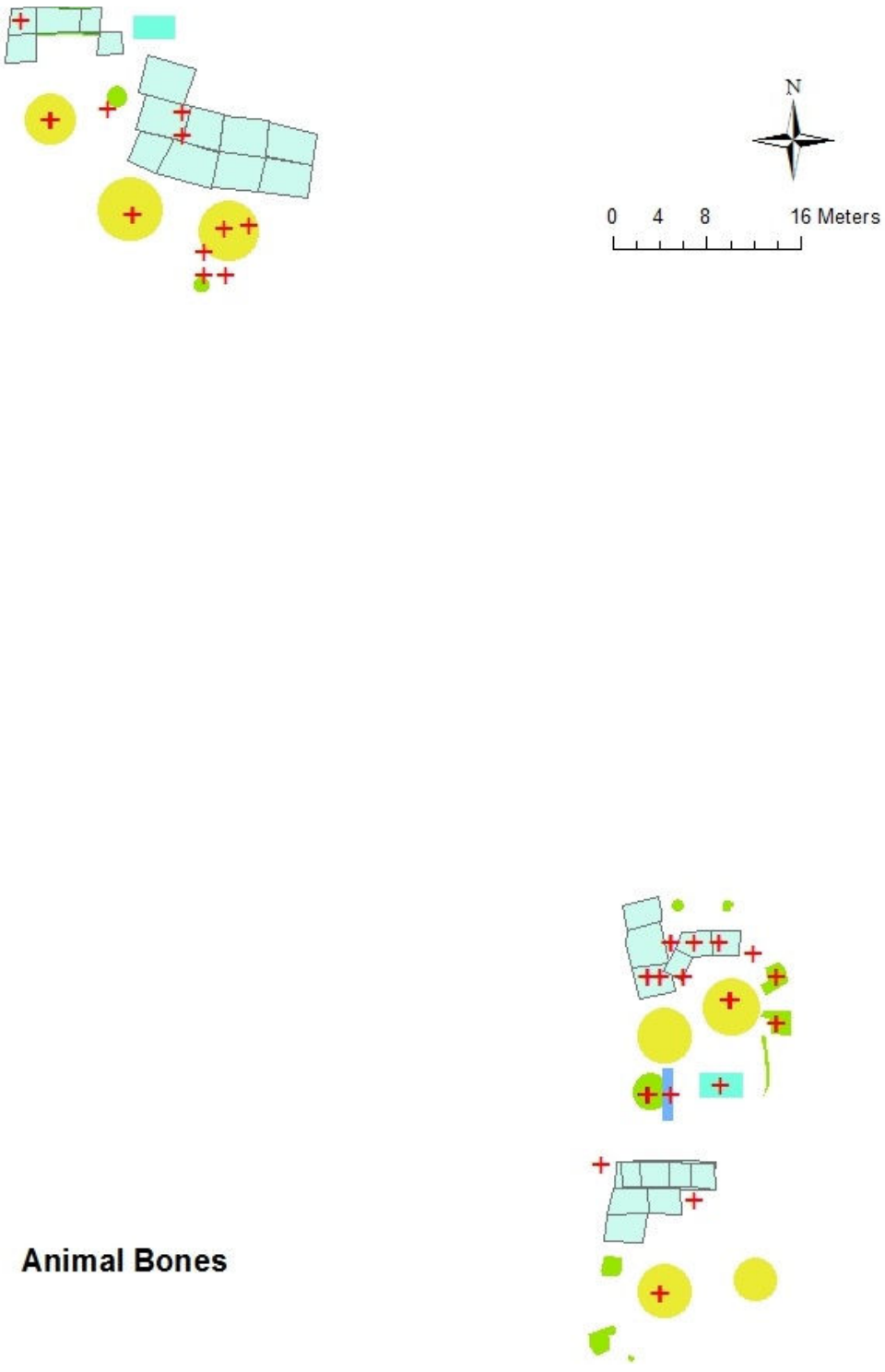


Figure 1.Animal bone locations occur mainly within close proximity to the structures. It would be assumed that bones would be widely scattered throughout the site.

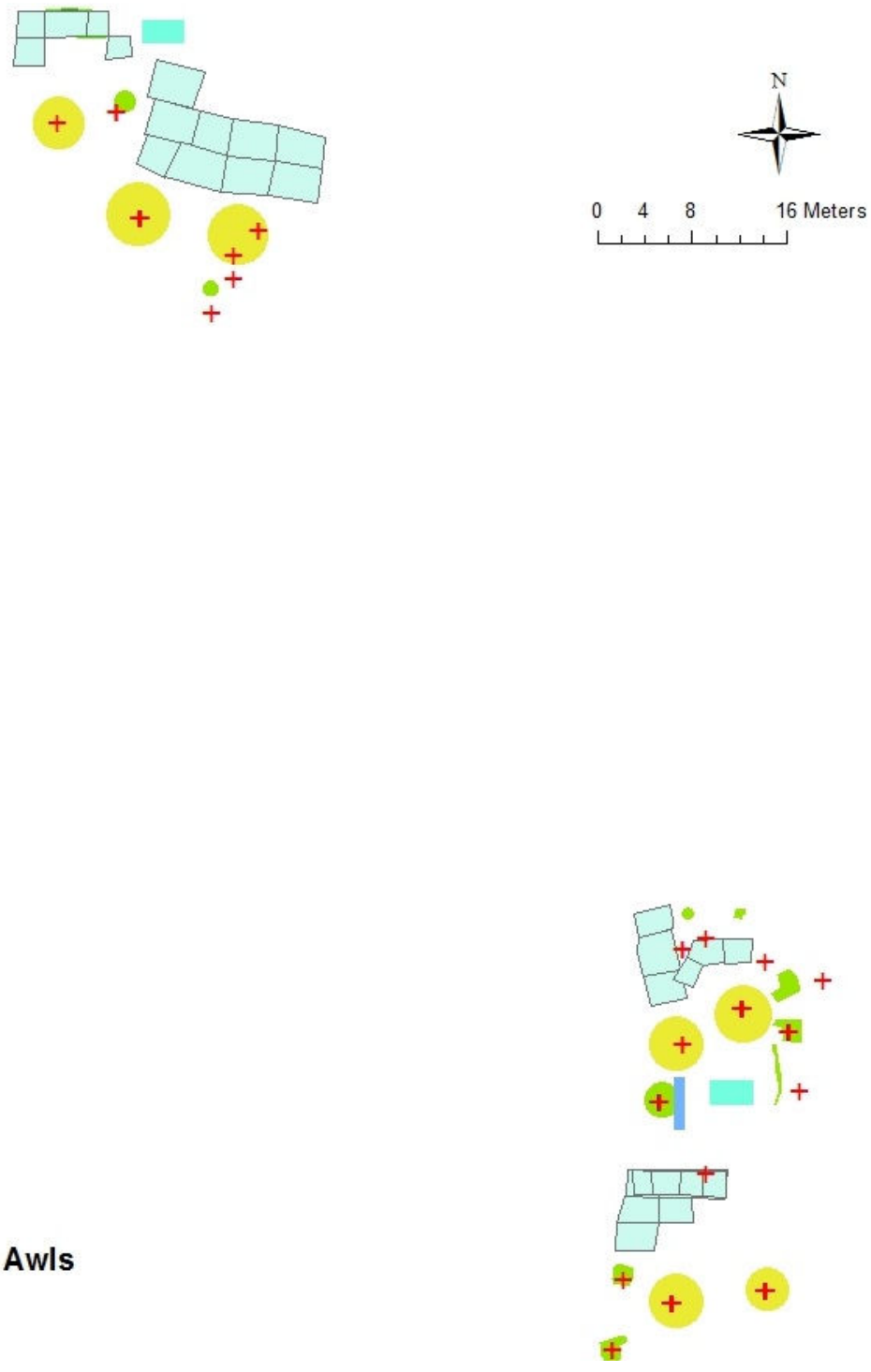


Figure 2.Awls are found well distributed throughout the site. Every kiva has the presence of awls, but not all homes do. This could indicate that clothing was made more often in the kivas.

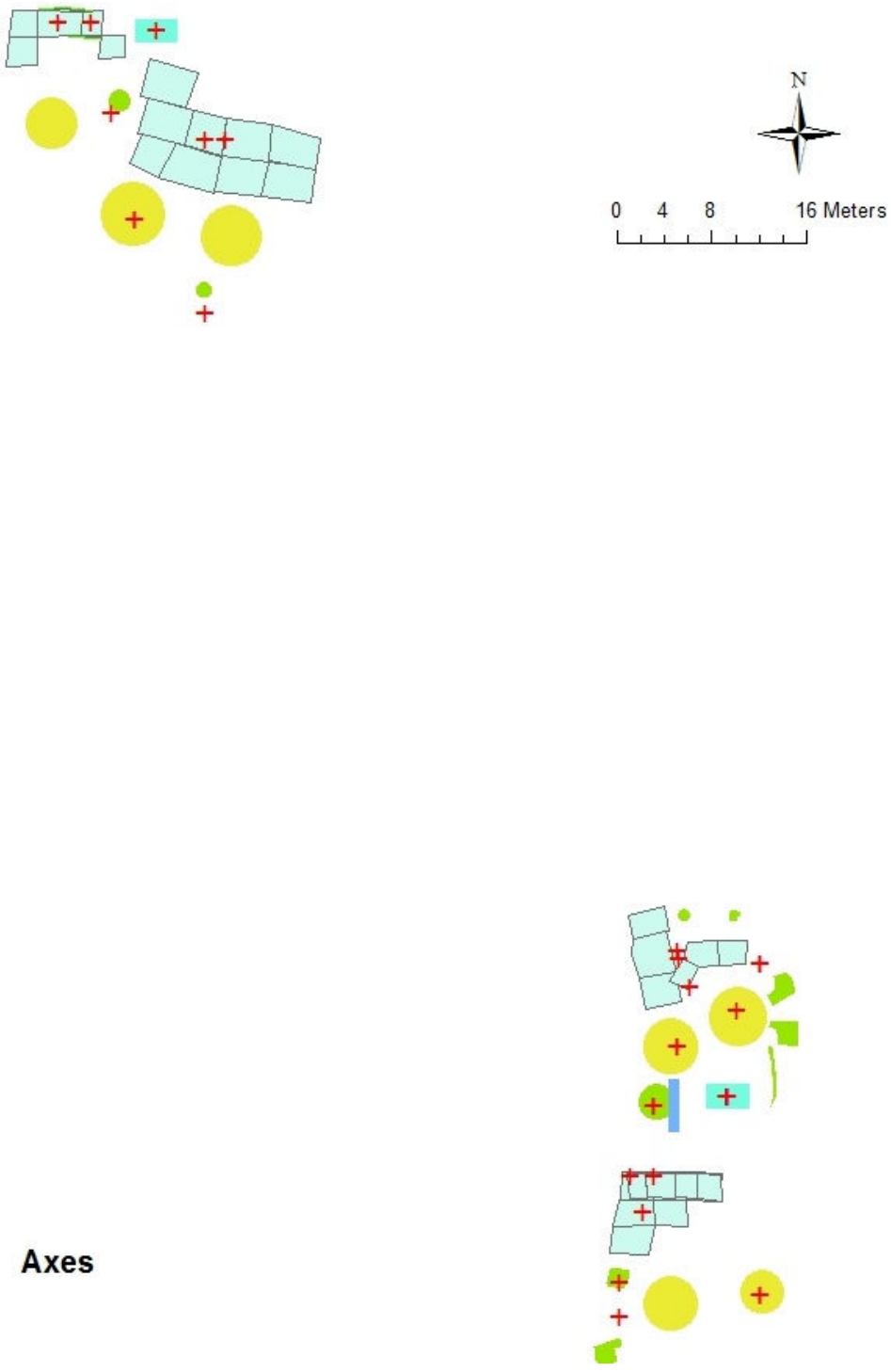


Figure 3.Axes are also found throughout the site. Since the initial phase for occupation of Ewing required timbers, it is not surprising to find this type of distribution.

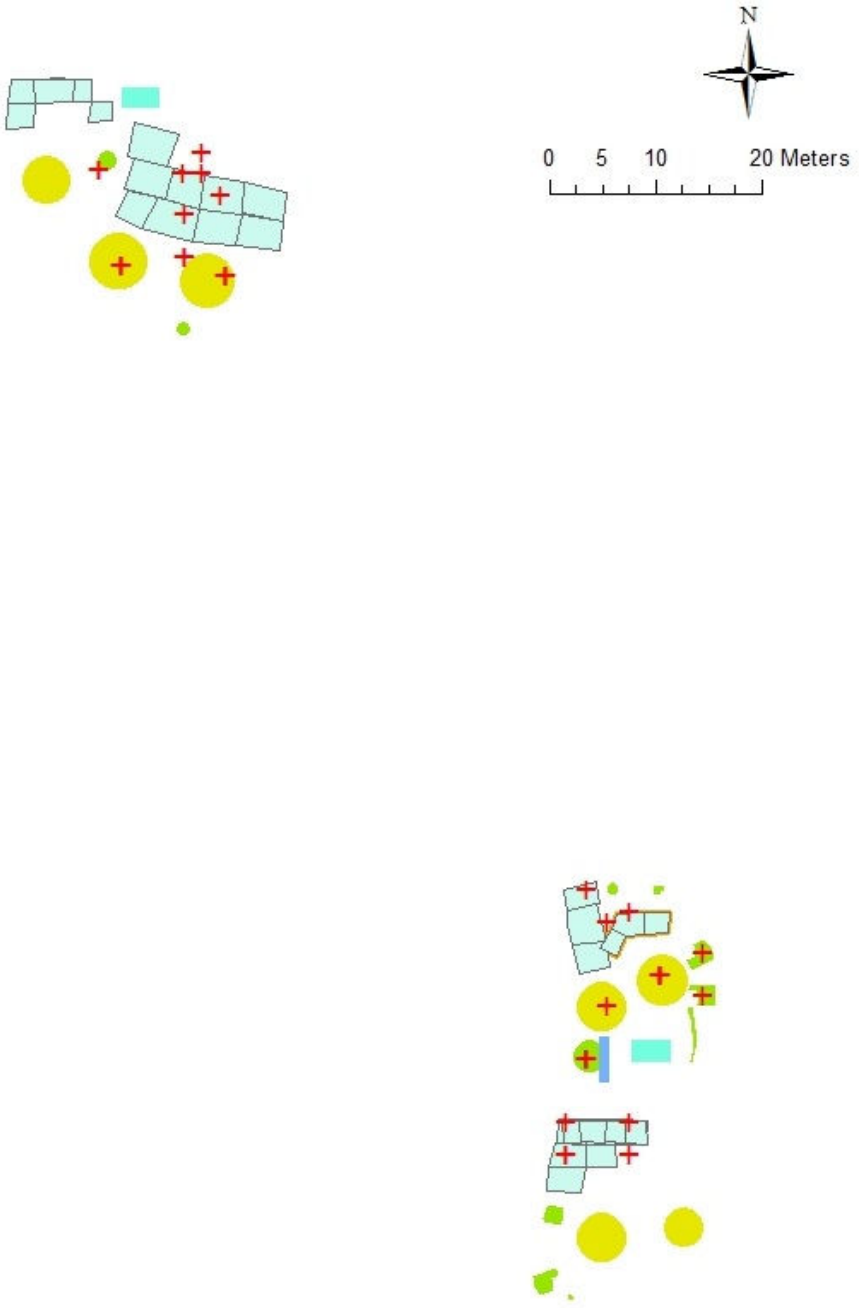


Figure 4.According to Dr. Rohn (personal communication, 2013), every structure at Ewing had been subjected to fire at some point. There is ample evidence of not only burned food, but also burned timber. In many cases, the databases do not indicated what the actual composition is. Therefore this layer contains all charcoal listed.

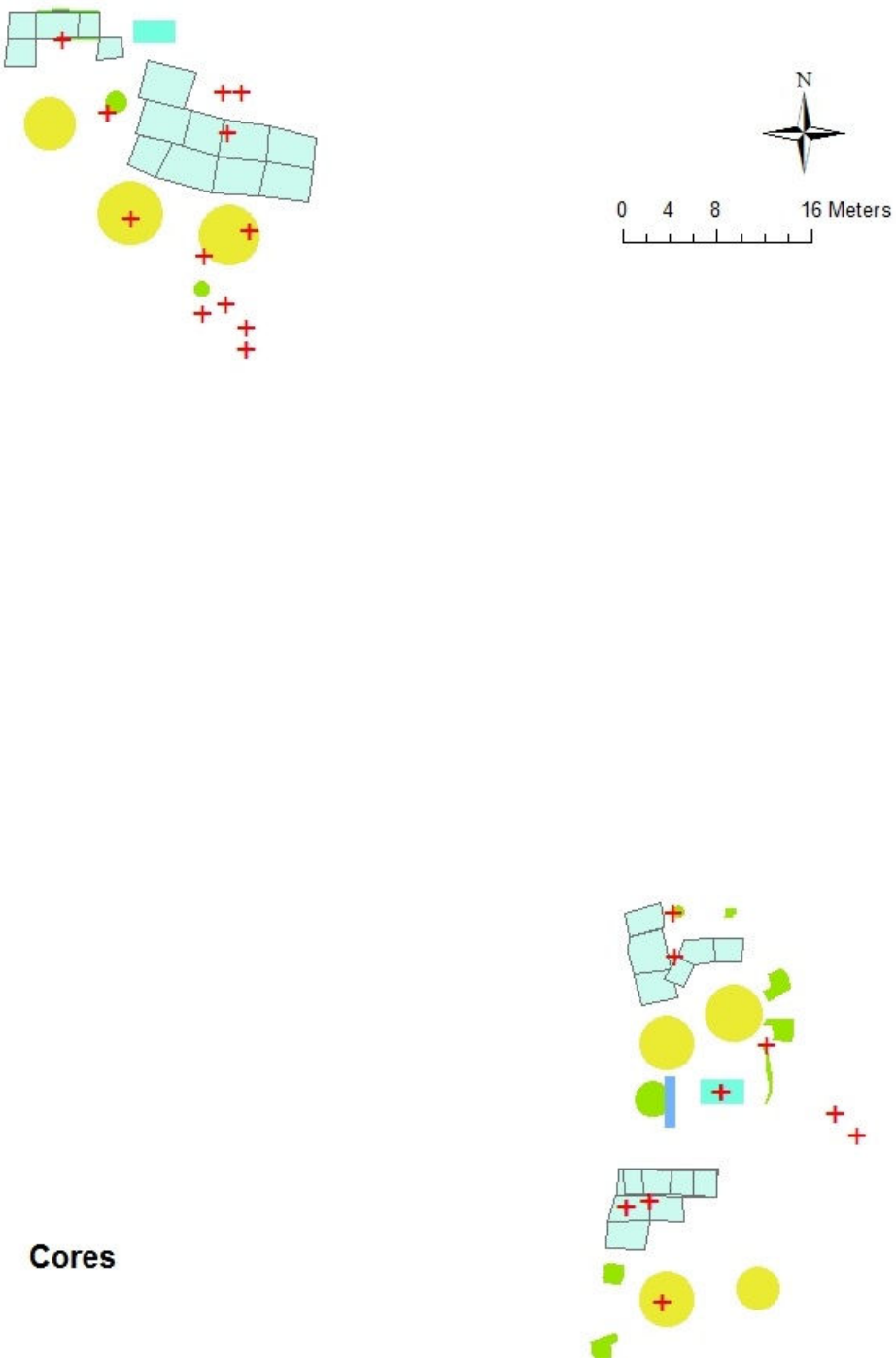


Figure 5.While this community was based more on farming than hunting, stone tools would be required for various activities. It is not surprising to see core fragments scattered throughout the site. However, there is a small cluster in the northern section of Ewing.

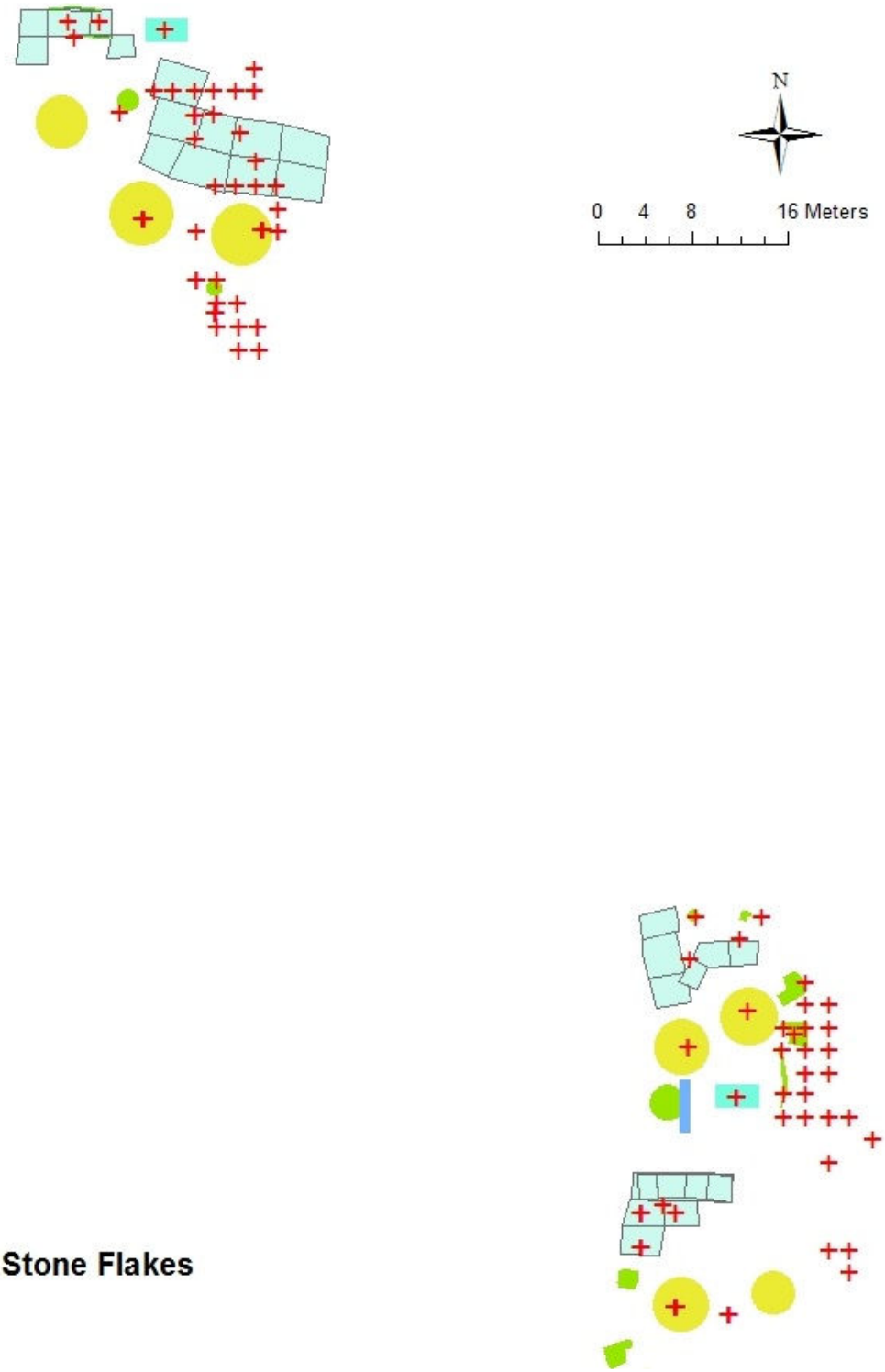


Figure 6.In conjunction with core fragments we see flakes completely covering the site. This is not surprising at all. An interesting aspect that could be address with GIS would be to analyze the flake count and look for high and low areas of flakes.

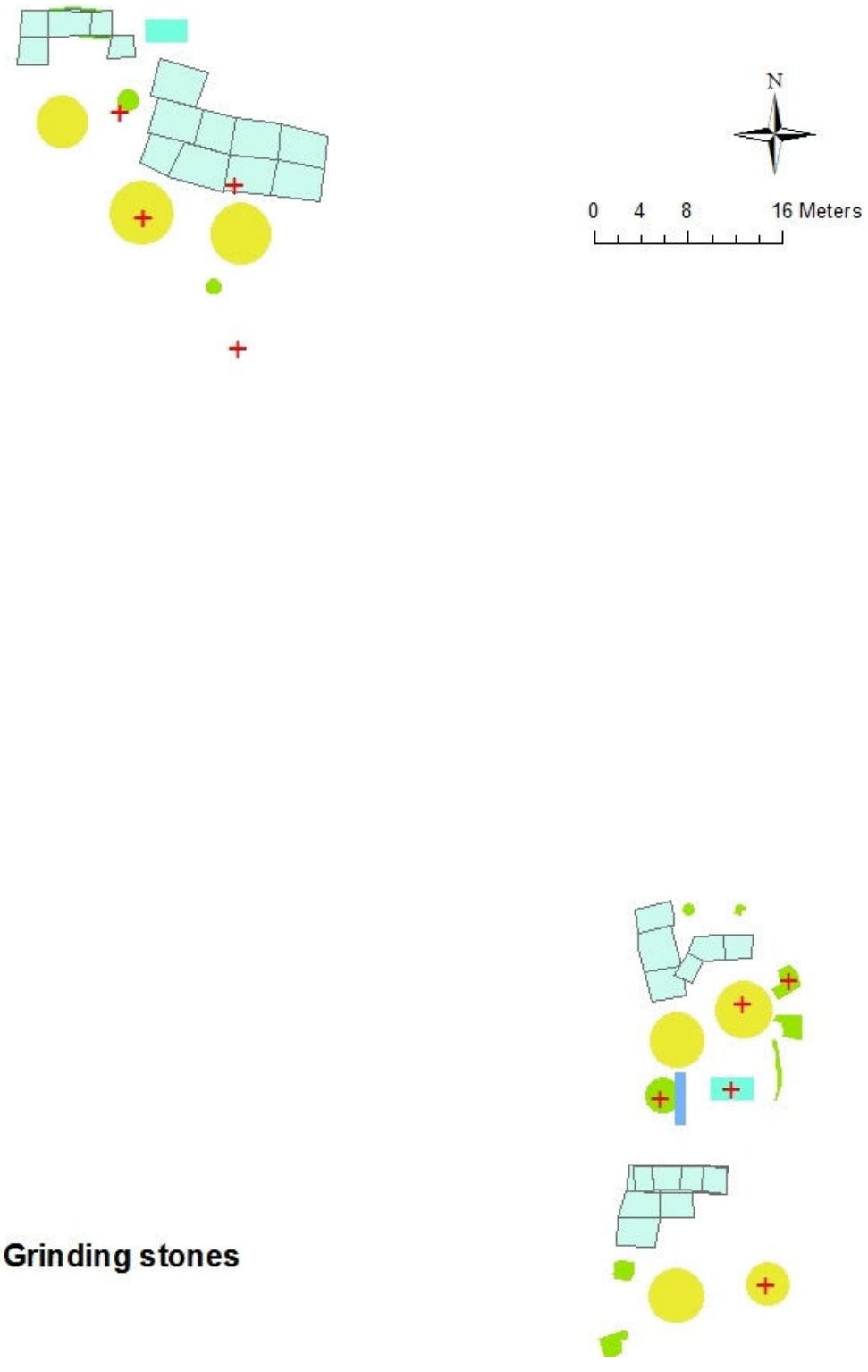


Figure 7.Grinding stones occur almost exclusively outside of homes. Most are located within close proximity to kivas.

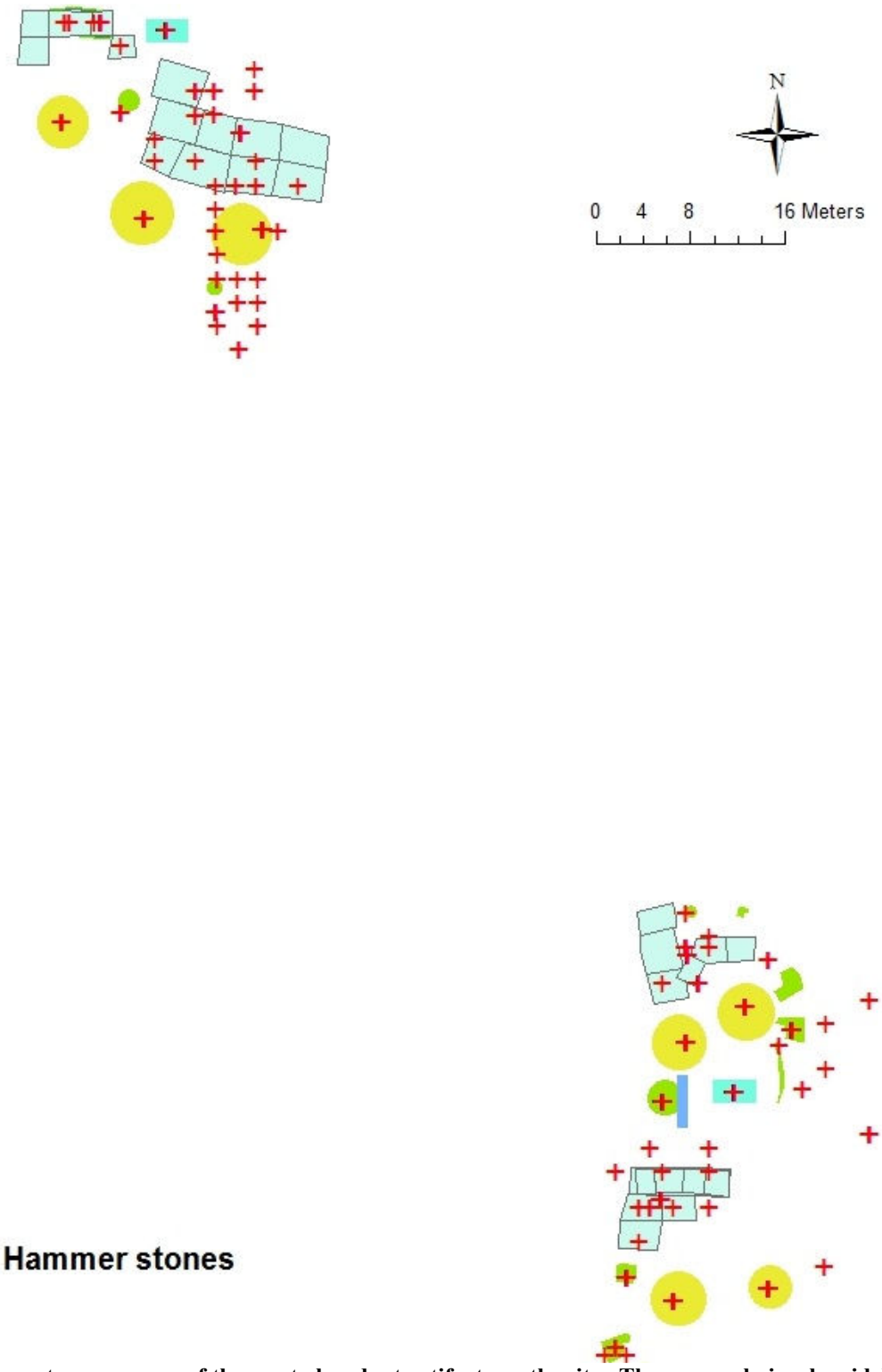


Figure 8.Hammerstones are one of the most abundant artifacts on the site. They were obviously widely used and for different activities.

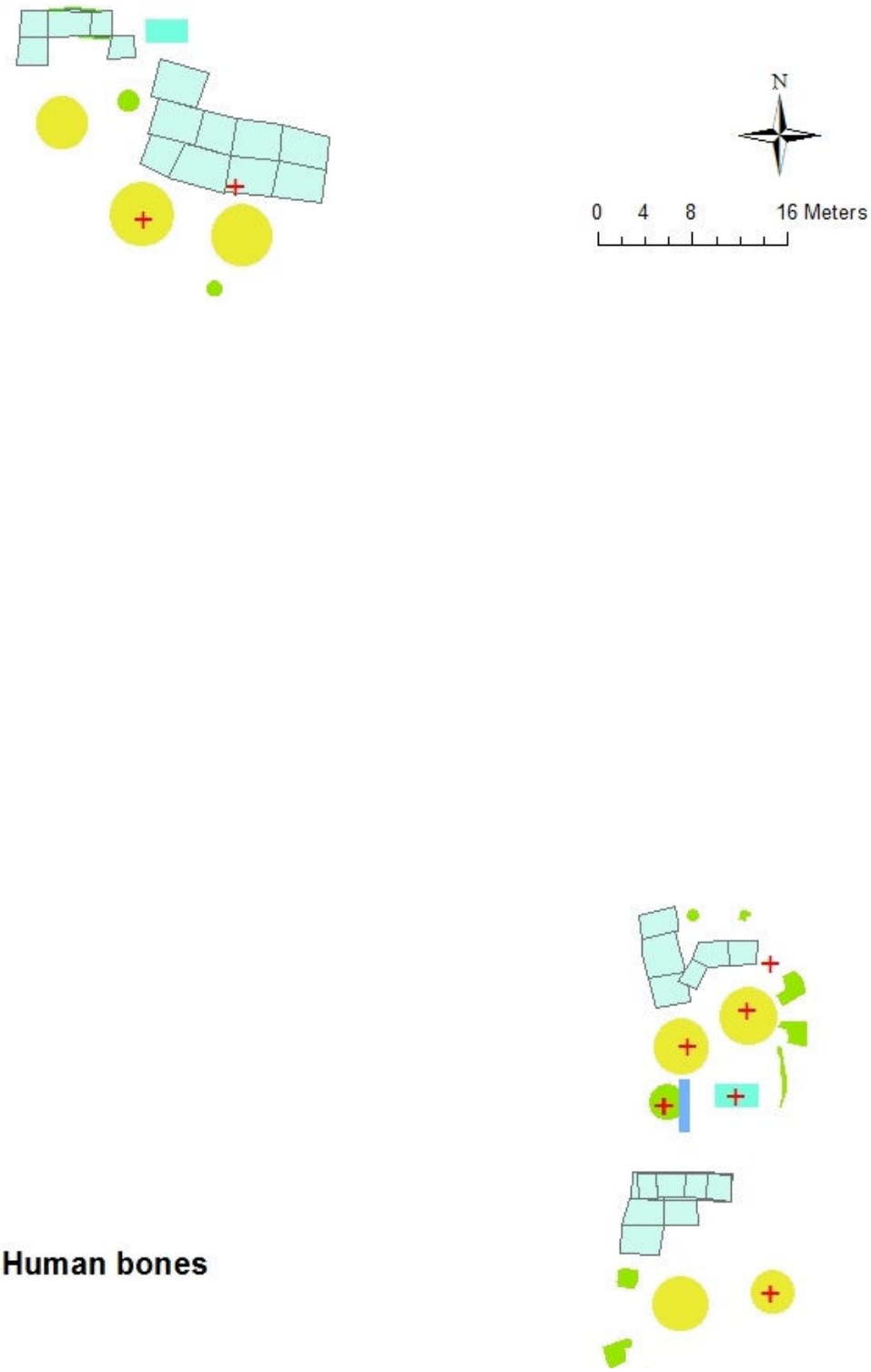


Figure 9.There were eight burials located at Ewing. Formal burials were all found in kivas, however there were some fragments that were found outside of the kivas. Human remains are almost all found in the southern half of Ewing.

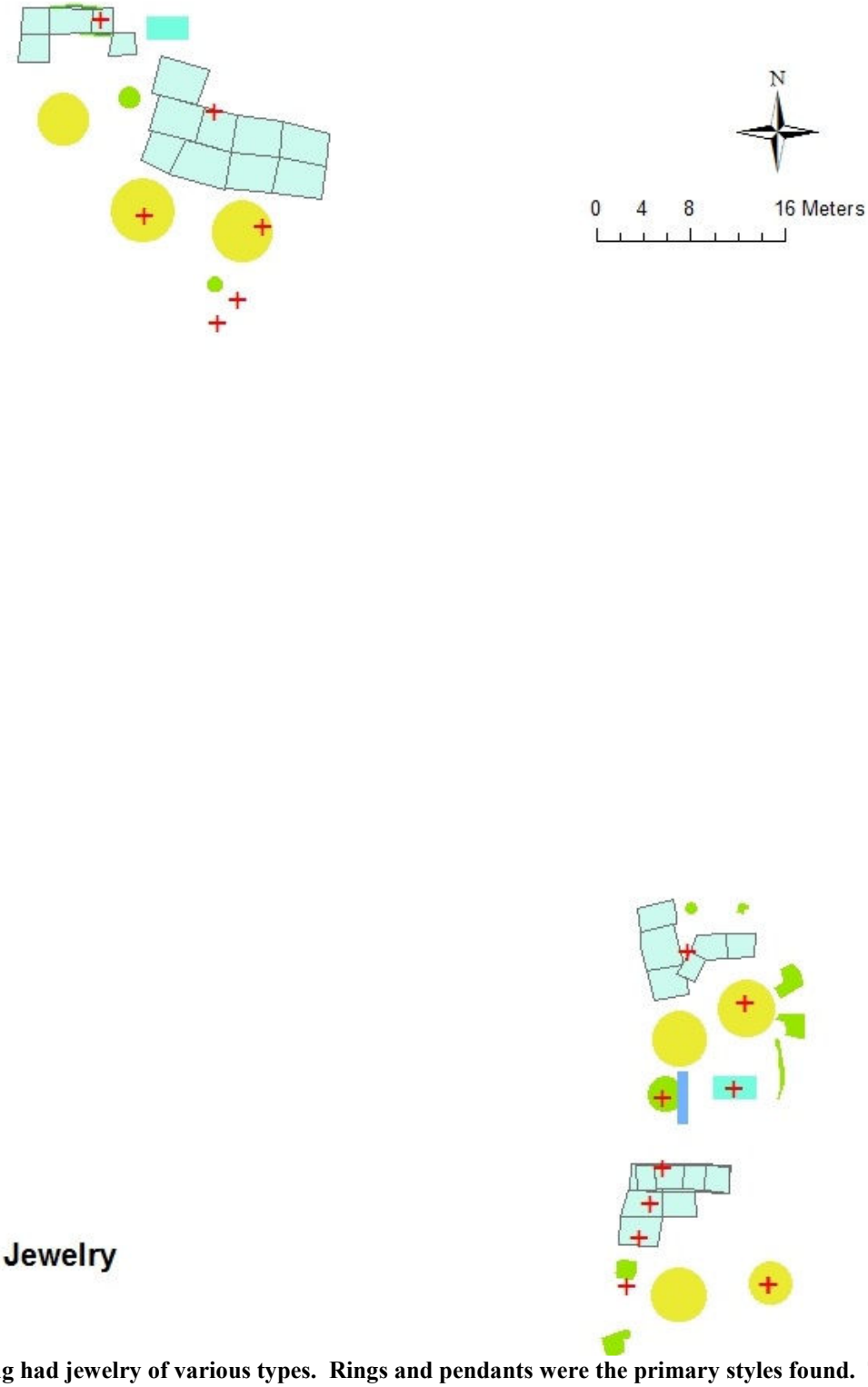


Figure 10.Ewing had jewelry of various types. Rings and pendants were the primary styles found. The artifact list had a multitude of descriptions for these. In an effort to get a better picture, all items that could be worn (not clothing) were lumped into this category to get an overall picture. In this case, there is a nice even distribution spread across the site.

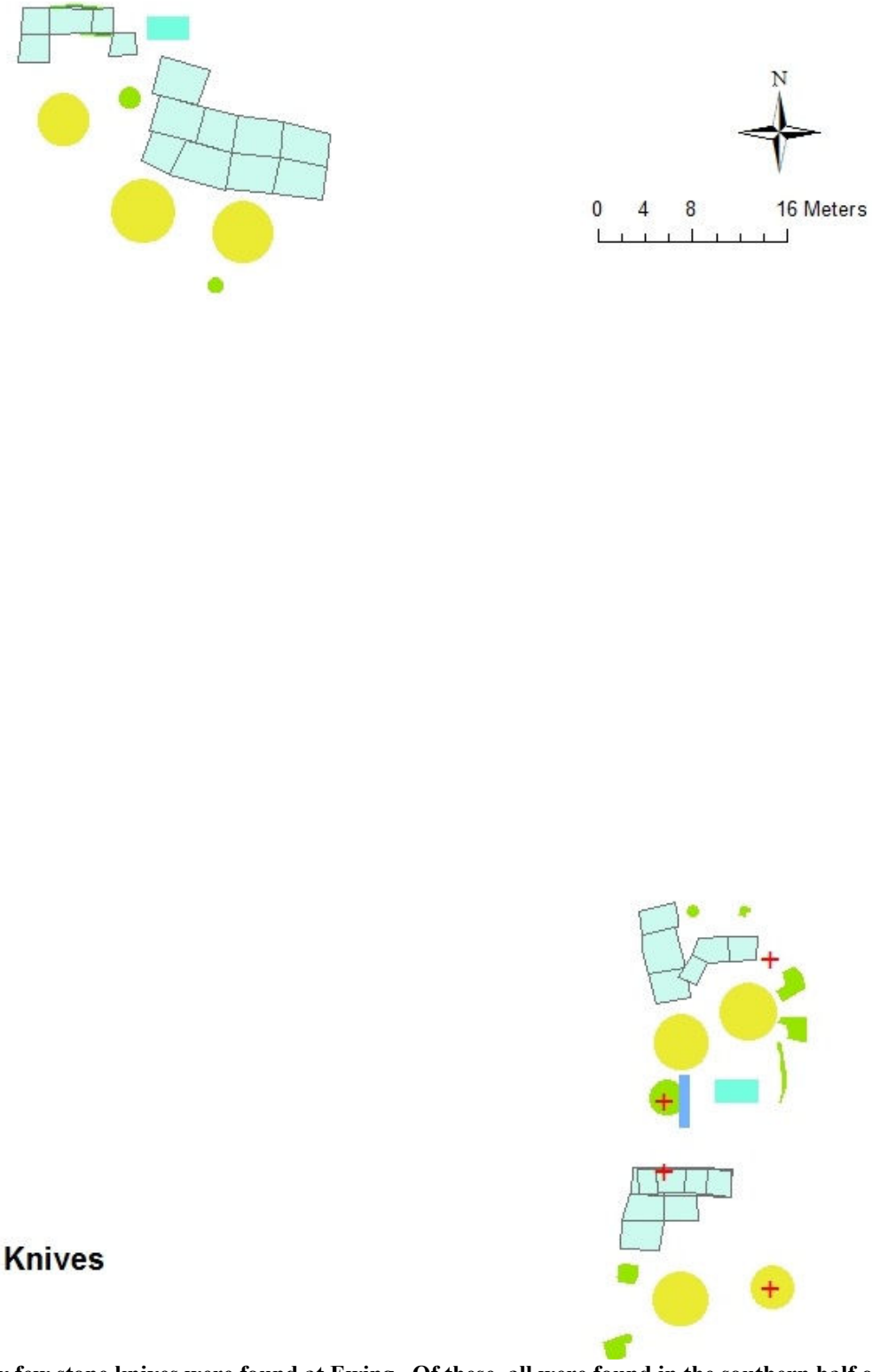


Figure 11.Very few stone knives were found at Ewing. Of these, all were found in the southern half of the site.

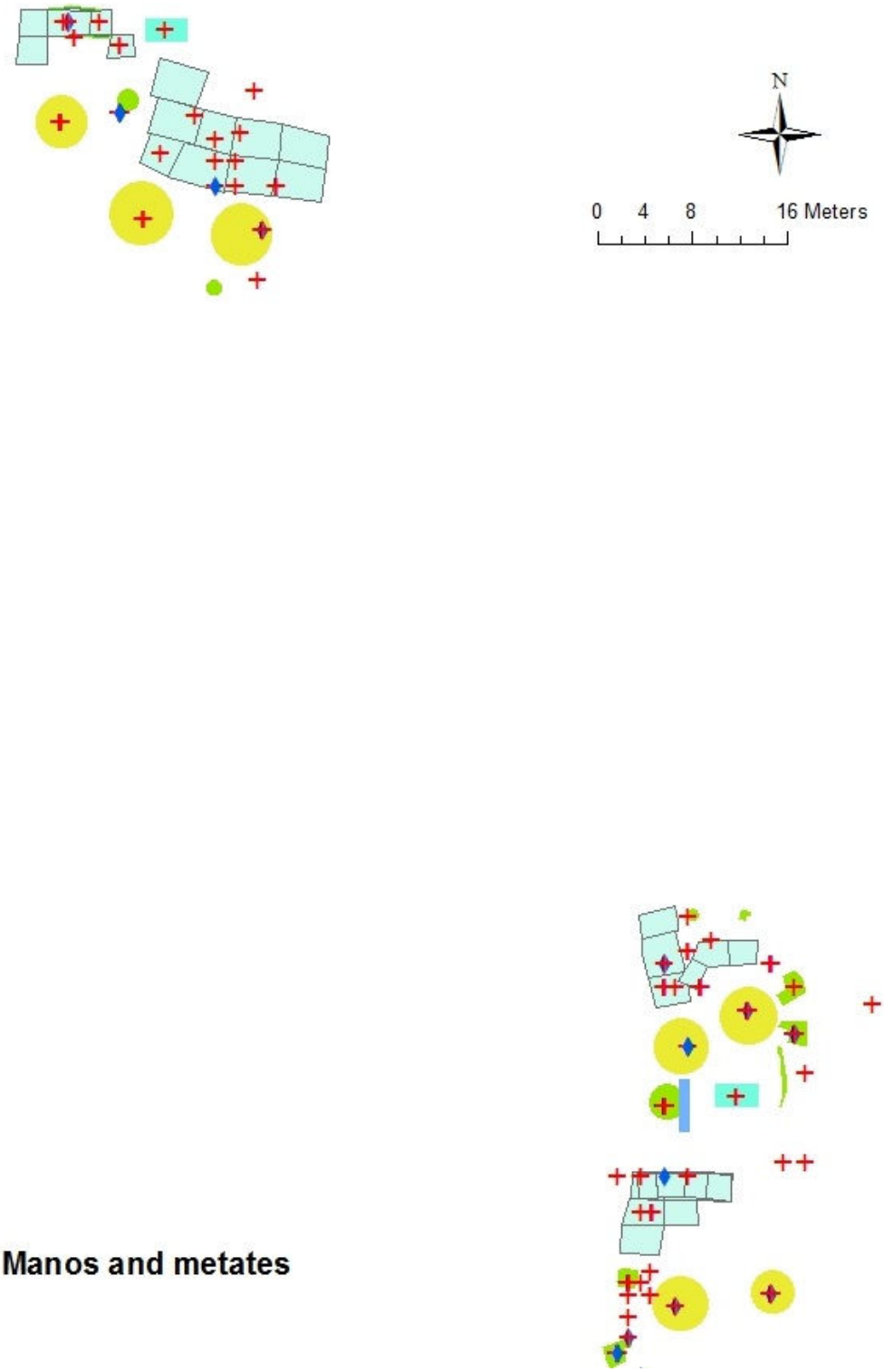


Figure 12.In an effort to look for a correlation between artifacts, manos and mutates were plotted on the same map. Manos are crosses and metates are diamonds. There was a definite match. Wherever a metate was discovered, at least one mano was nearby, usually more.

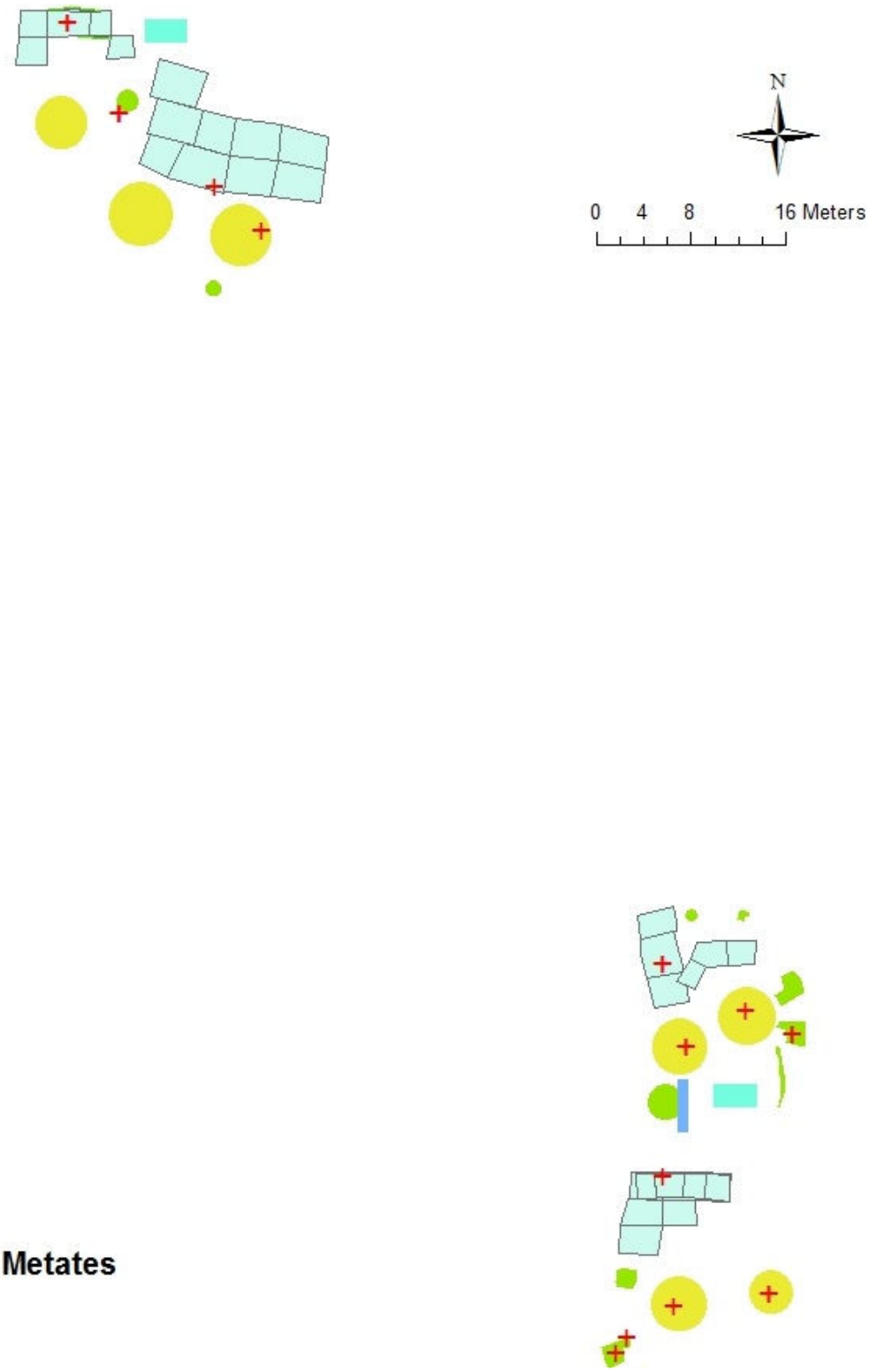


Figure 13.This shows metates by themselves. It is interesting to note that all the kivas in the southern section had metates while only 1 of the three in the northern section had them. Metates were typically larger, heavier and more durable items than manos. Therefore it is not surprising to see less of this artifact.

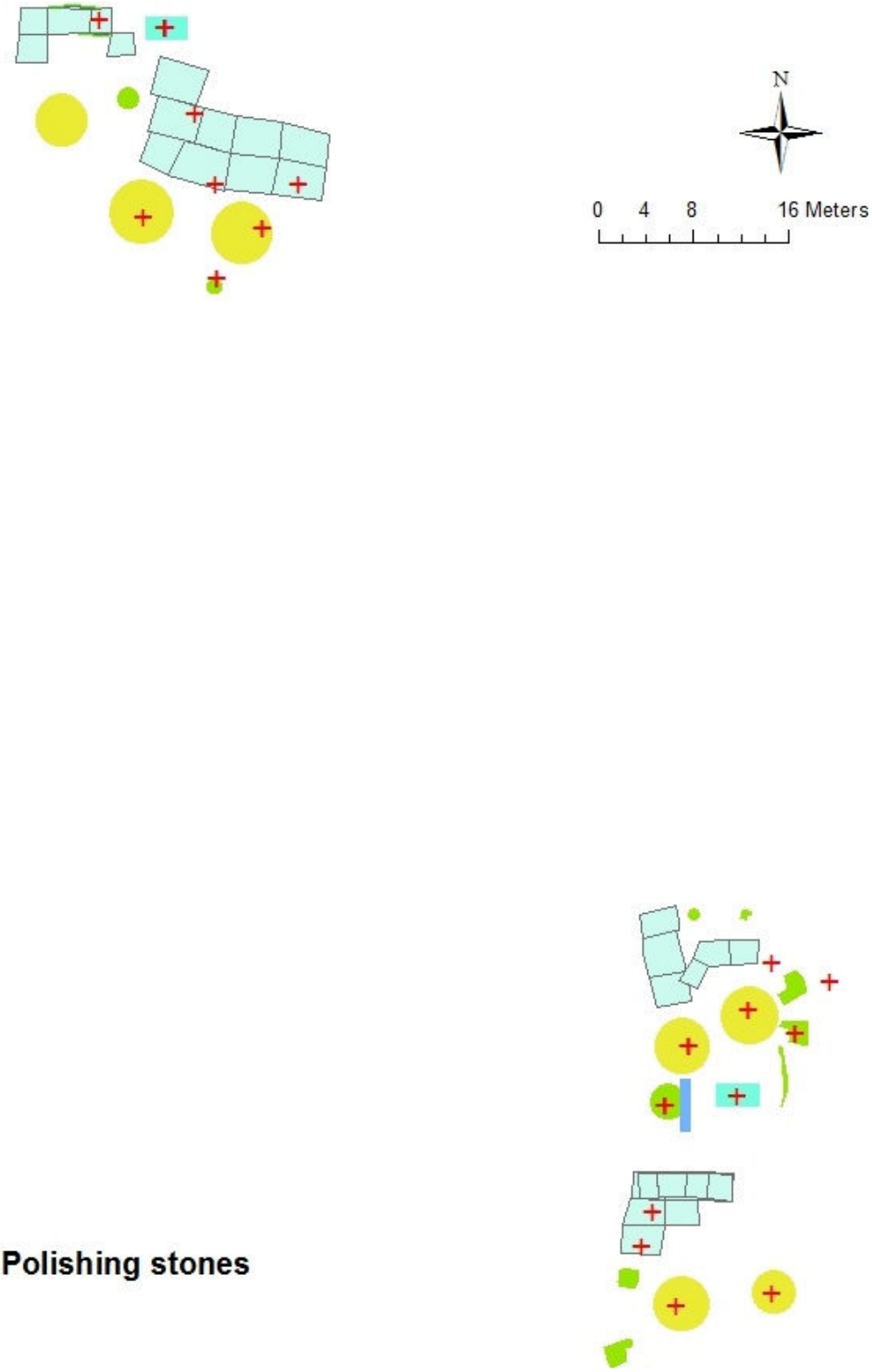


Figure 14.Polishing stones at Ewing were used in ceramic production. The distribution of these stones across the site is fairly uniform. All major structures except House II contained them.

Figure 15.Projectile points were not nearly as common at Ewing. With the exception of two, they were all found in the southern section. It is reasonable to assume, based on flake dispersion, that the points were being manufactured at the site but were being utilized in other places. Obviously during hunting expeditions, these points rarely returned with their owners.

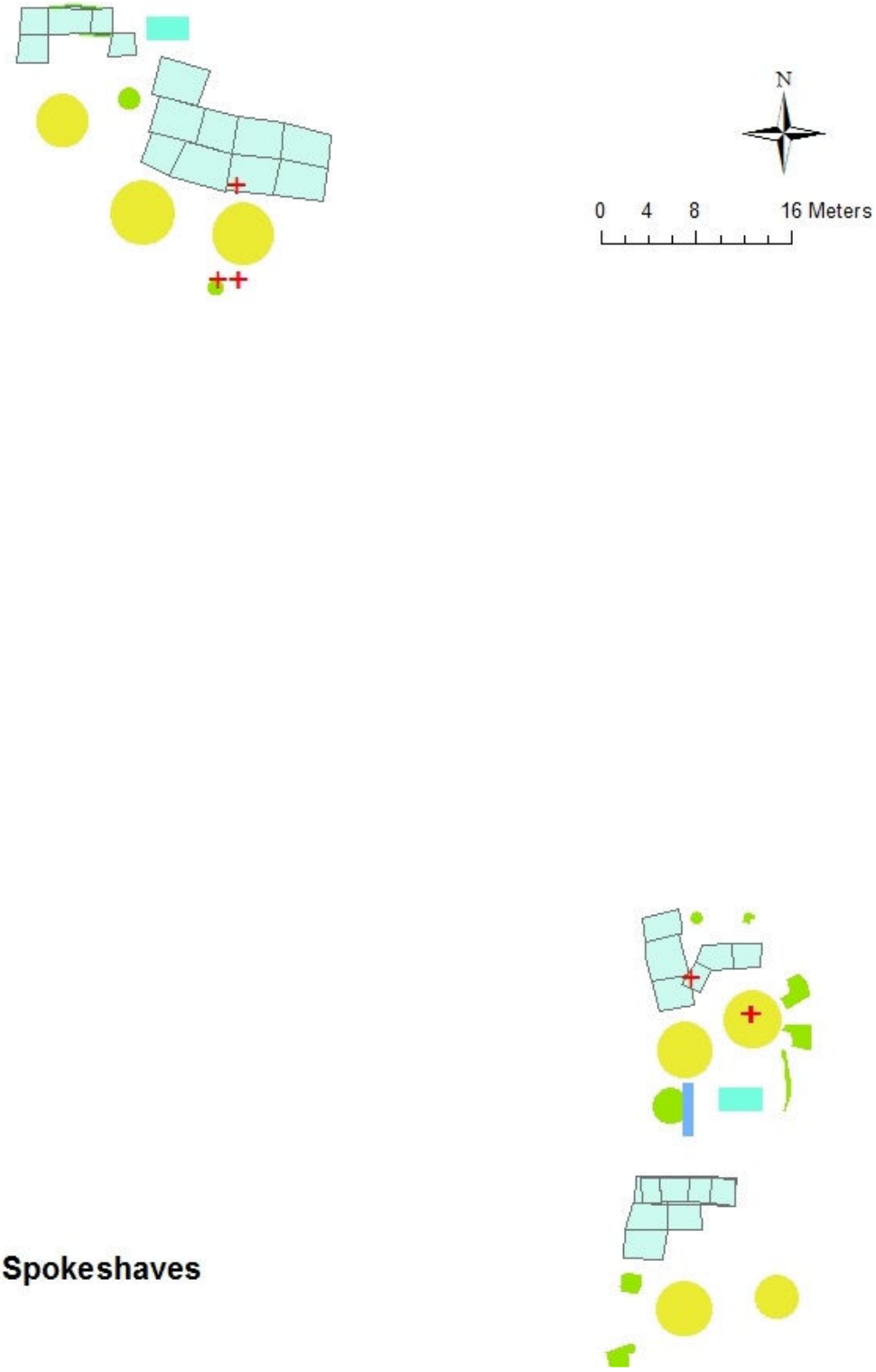


Figure 16.Spokeshaves could have been used two different ways at Ewing. The first would be for preparing branches for arrows. The second would be for preparing timber in production. The artifact sheets do not distinguish either of these uses, and there is no analysis readily available on this matter. However, it is interesting to note, just how few there actually are.

Appendix B

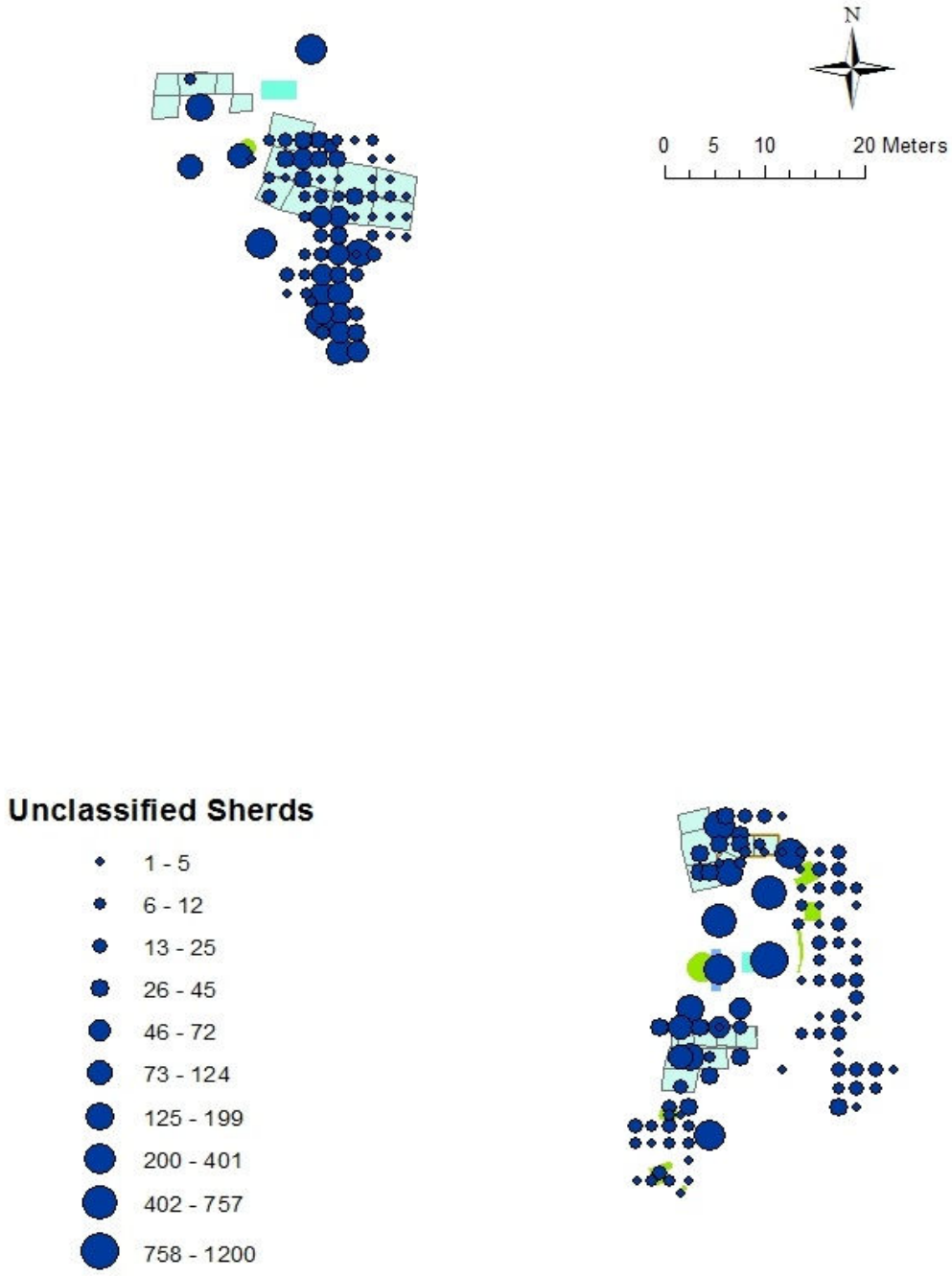


Figure 1.The "unclassified" sherd category was important to diagram. These are sherds that were not able to be placed within any ceramic typology. Typically they would be too small to provide accurate diagnostic information. Nevertheless, the sheer volume of sherds that were collected must be accounted for. There is no particular concentration that stands out from this comparison and would be the most expected and reasonable assumption to make even without maps.

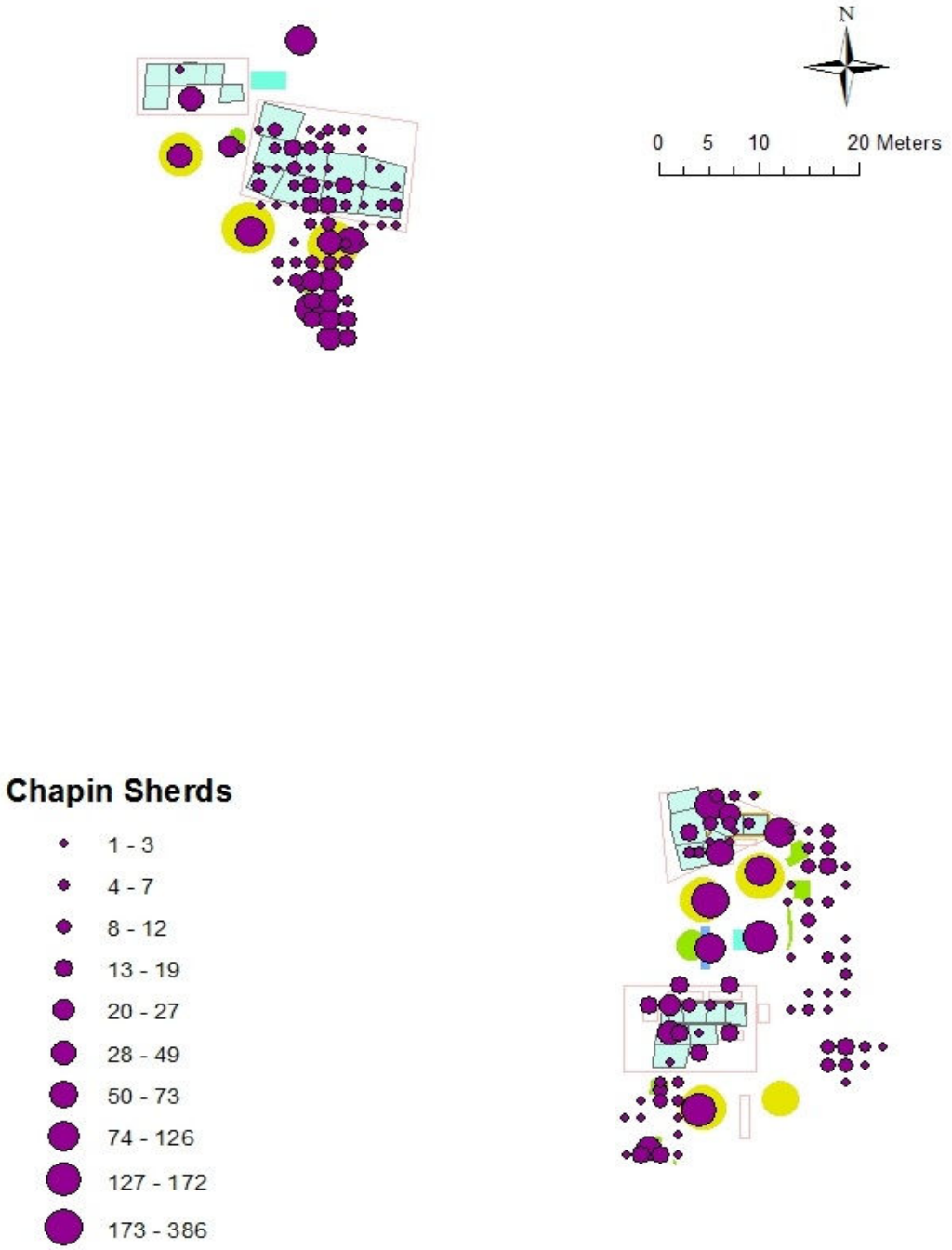


Figure 2.Chapin is considered the one of the earliest ceramic type at the Ewing site. Typical of Pueblo II and III, it is a gray ware ceramic that was manufactured in the region from approximately 950-1200 AD. This diagram shows the concentrations to be similar to the overall pattern of distribution for the site. The highest densities are still around House IV and Kivas 2 and 3. It is important to note that Chapin is scattered throughout the entire site as this does not happen with all ceramic types. Pieces of this type number 2981.

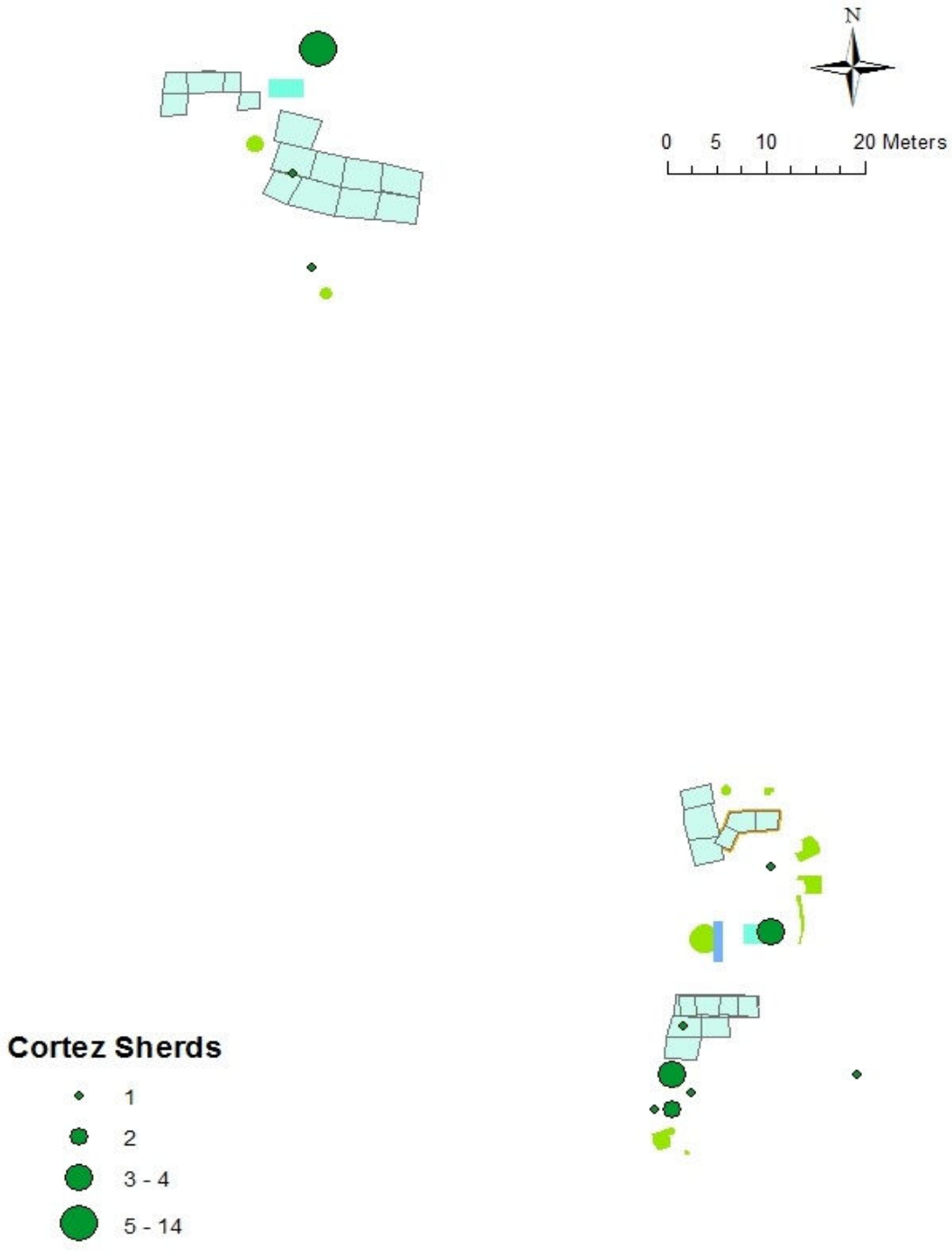


Figure 3. Cortez ceramics were included because they were a minor type, but which could be used to illustrate how small numbers can be helpful. This type is typically made from 900-1050 AD. It occurs in very small numbers but in equal amounts in both the northern and southern areas of the site. With its low numbers and uniform distribution, it could be signs of early trade or perhaps a type that was brought to the area by people who initially settled the site and later adopted Chapin as their primary ceramic type.

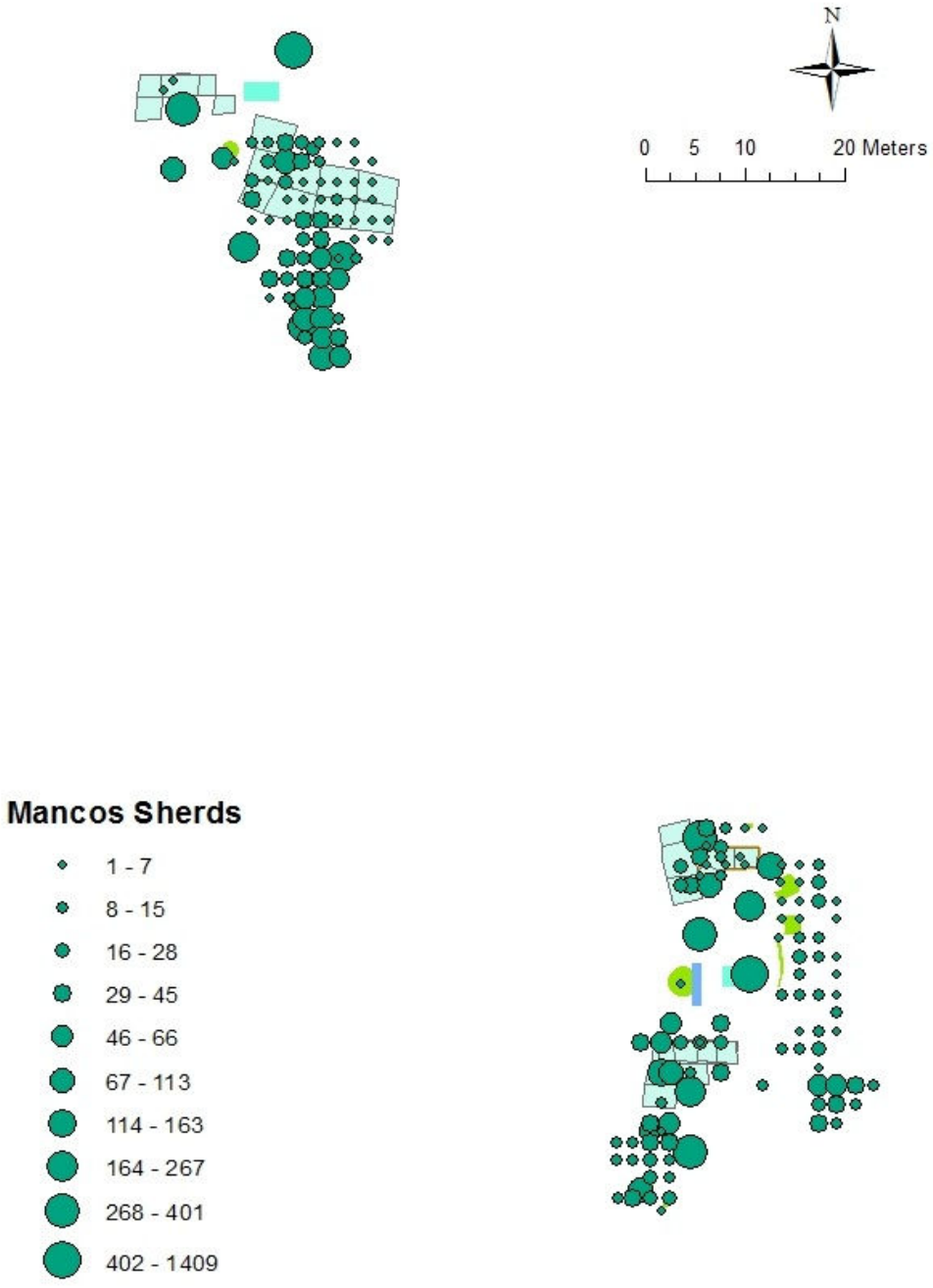


Figure 4.Mancos black and white pottery is considered a transitional ceramic type, Mancos was manufactured from 900-1150 AD during both Pueblo II and III periods. Although the distribution is spread out through the entire site, the numbers are roughly triple when compared to Chapin Gray numbering 9588 pieces. This could indicate a population influx, or a prolonged use of this particular ceramic type.

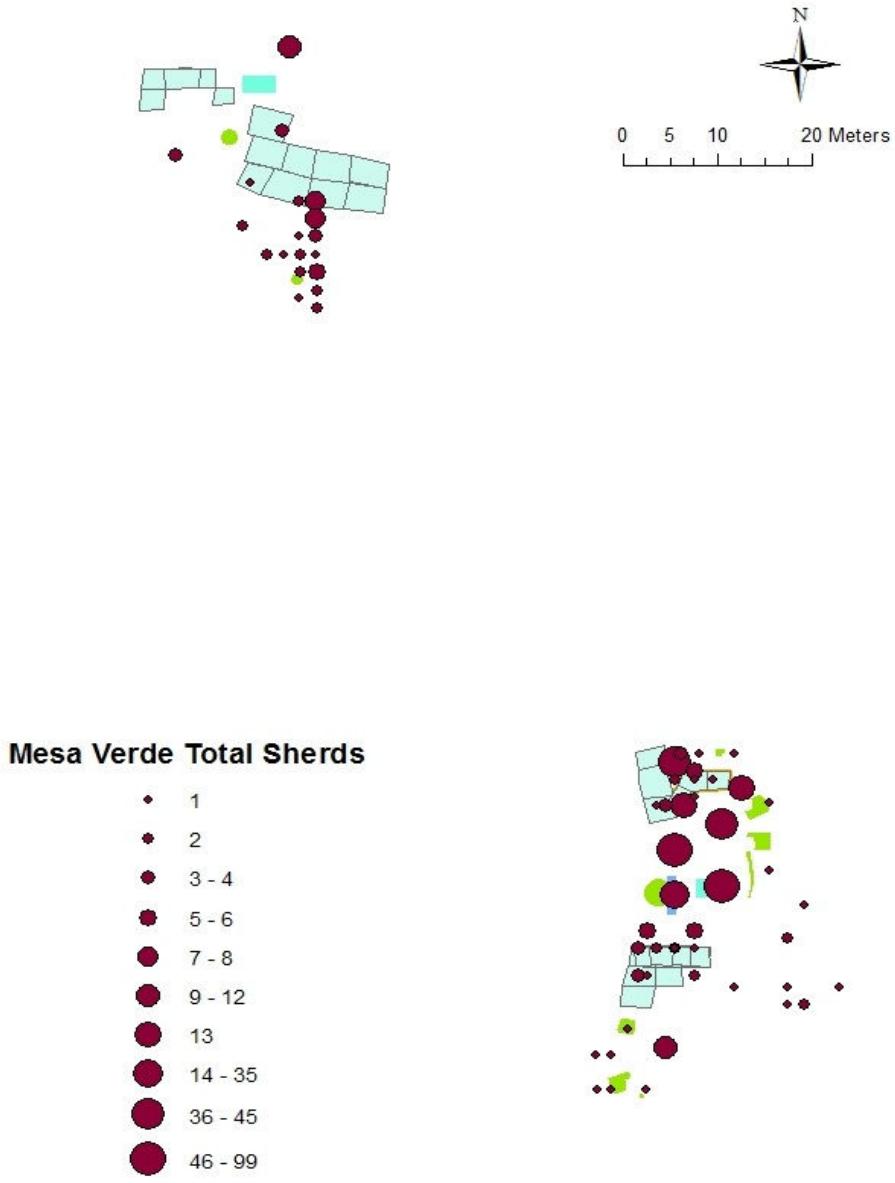


Figure 5.At Ewing there are two Mesa Verde ceramic varieties that were collected, McElmo and Mesa Verde. Even though there is much temporal overlap between them, the styles are distinctive and should be treated as such. Mesa Verde ceramics are useful for a GIS analysis as we can look at two similar styles and look for areas within Ewing to see if McElmo was prevalent in a particular area while Mesa Verde was common in another area of the site. This shows the total density of both types of Mesa Verde ceramics. The total number for both types is 465, with 343 being Mancos variety and Mesa Verde making up 62 pieces. There is a definite higher concentration in the southern half of Ewing with nearly 75% of all pieces located here. Virtually no pieces were collected around House I or Kivas 1,4 and 6. One final detail of note is the higher concentration of the Mesa Verde variant (9.14) in the southern area of the site. Mancos is distributed throughout. A jump in logic could suggest that as time progressed, the southern area of Ewing was the more populated while the northern structures fell into disuse.

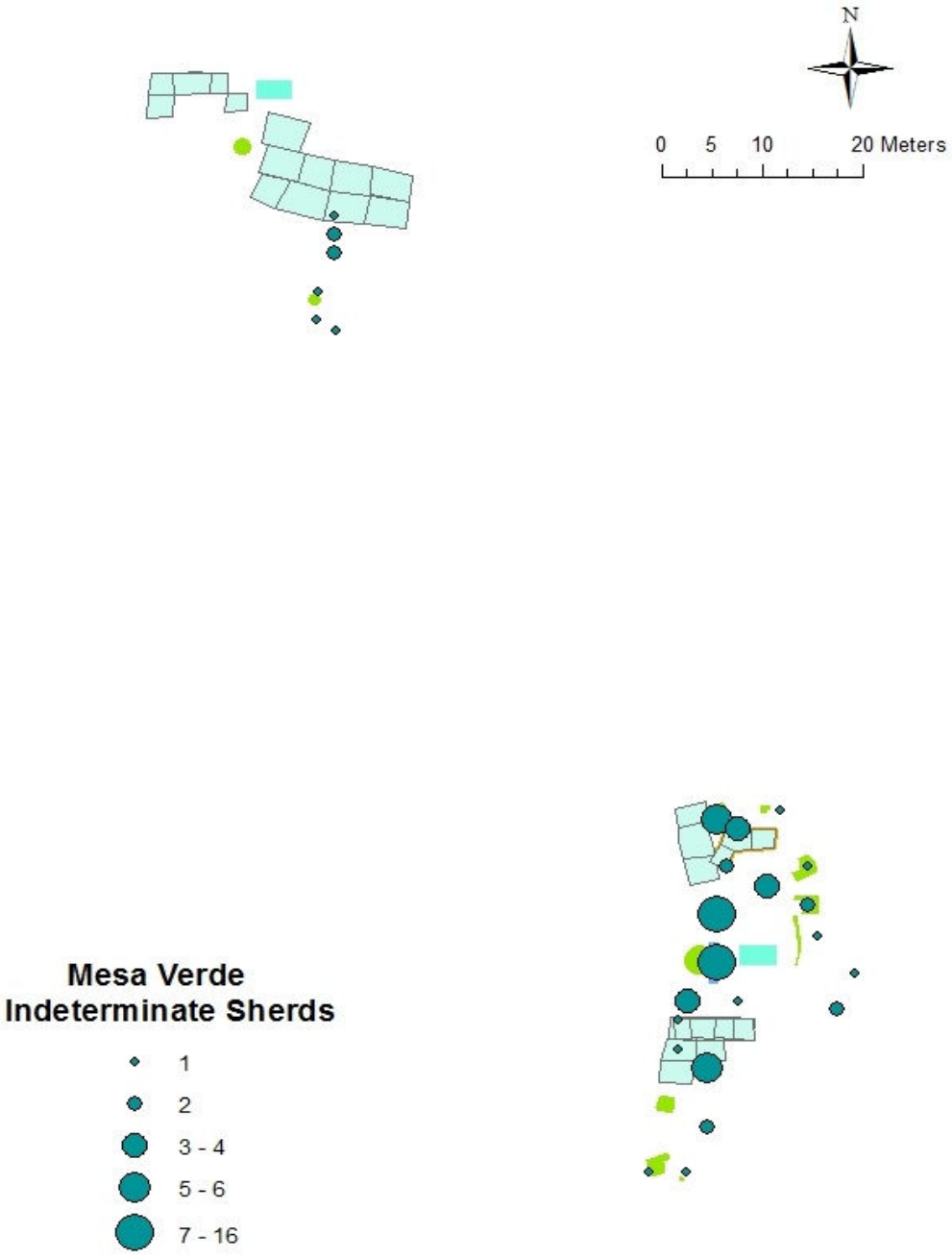


Figure 6. There were instances where Mesa Verde sherds could not be placed in one of the two categories. These were given a designation of "indeterminate". Their numbers were substantial enough to be counted (60 pieces). An early hypothesis in this paper was that using GIS could be used to see the ceramic distribution and make it possible to make a reasonable guess based on statistical analysis as to which category the unidentified sherds fell in.

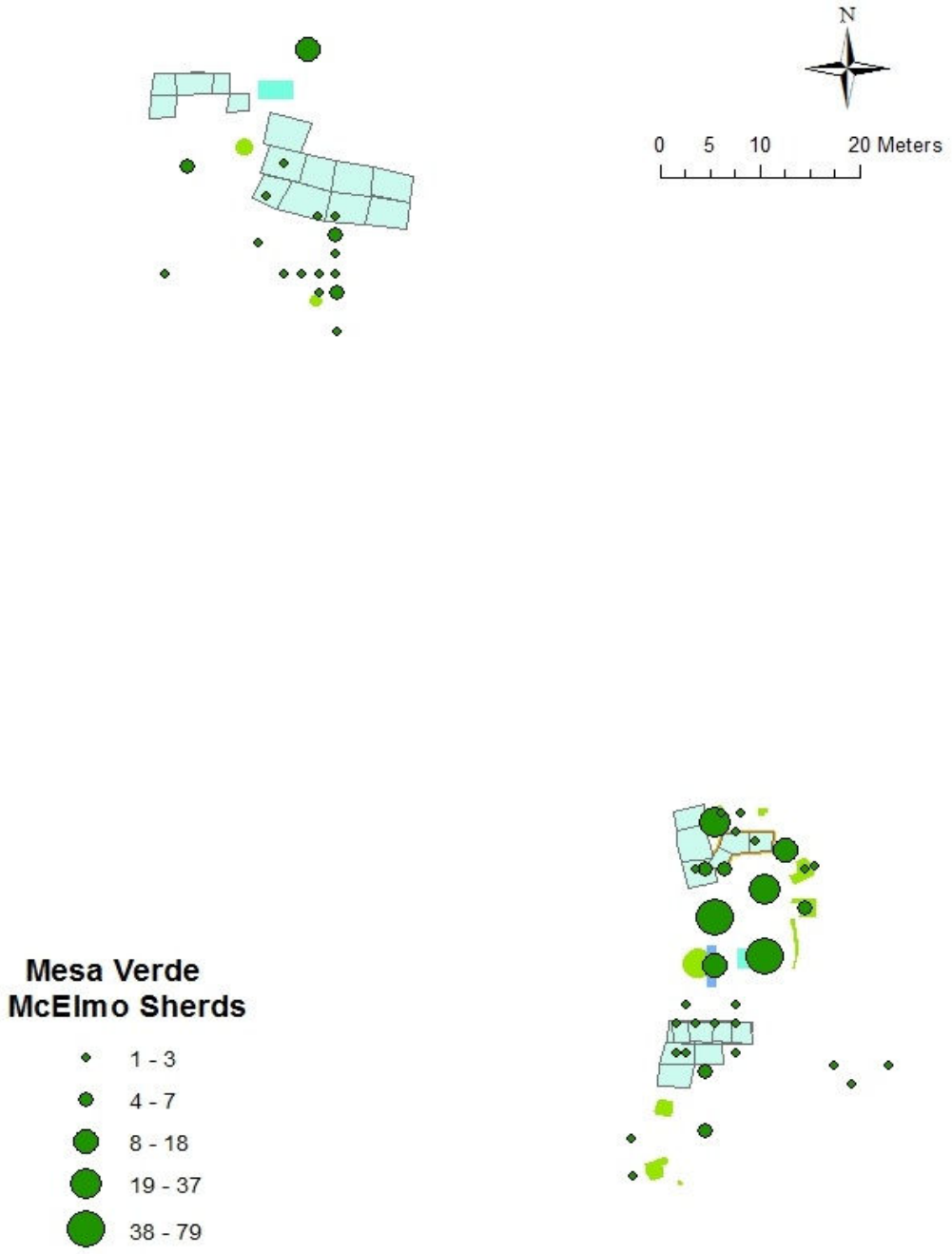


Figure 7.The first variant, McElmo, was typically manufactured from 1050-1300 AD. The cluster for these sherds was typically around the kivas in the southern area of the site with less than half being found in the northern area.McElmo is the older of the two and is typically a less refined version of the Mesa Verde variety.

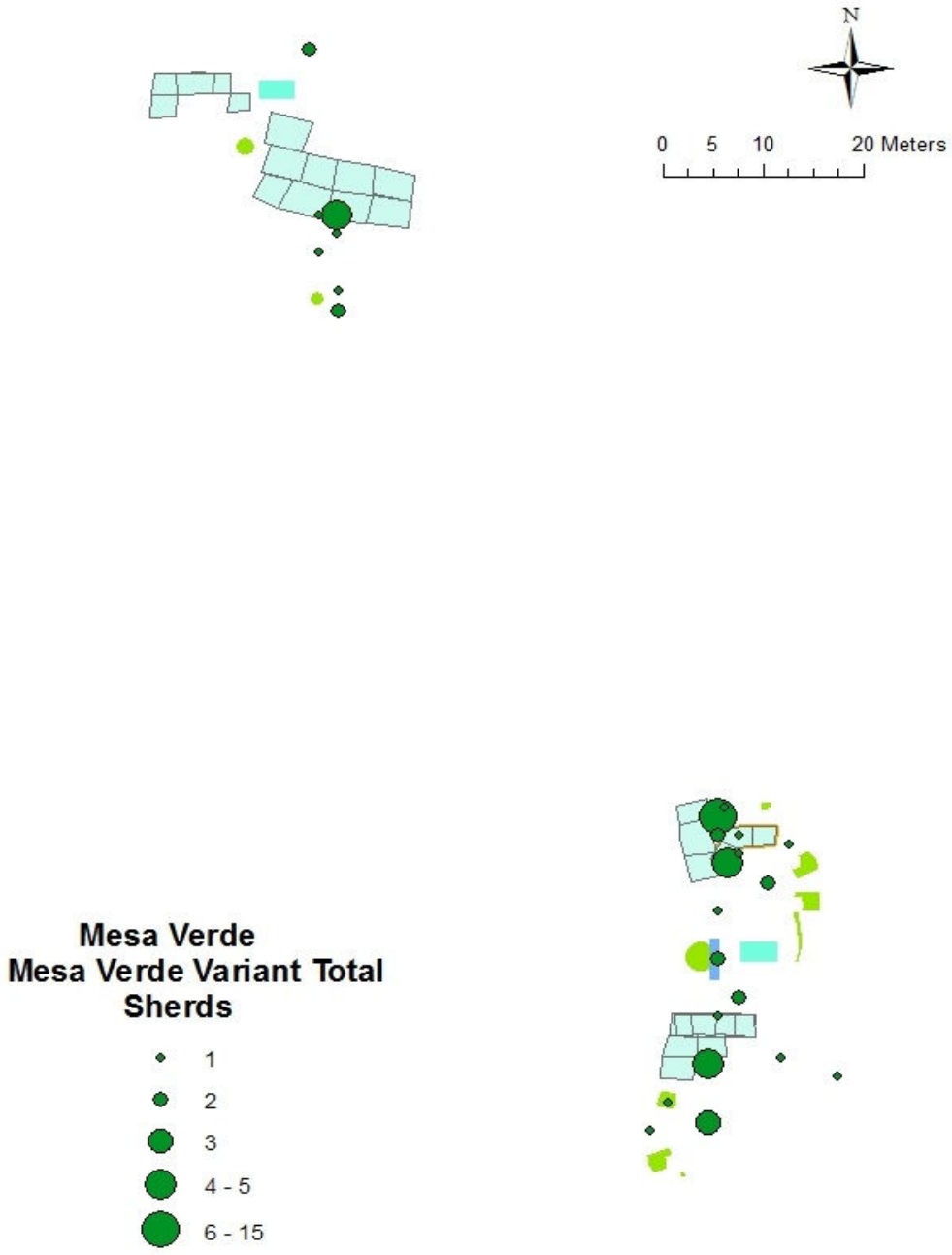


Figure 8. This type was manufactured from 1100-1300 AD. There was a shift in the densities with this type. While they were mainly in the southern section of the site, most were found within housing the housing areas instead of the kivas. After analyzing the distribution of both sherds, it seems that the hypothesis to figure out which category the indeterminate could not be proven. Both types had far too much overlap to prove anything conclusive.

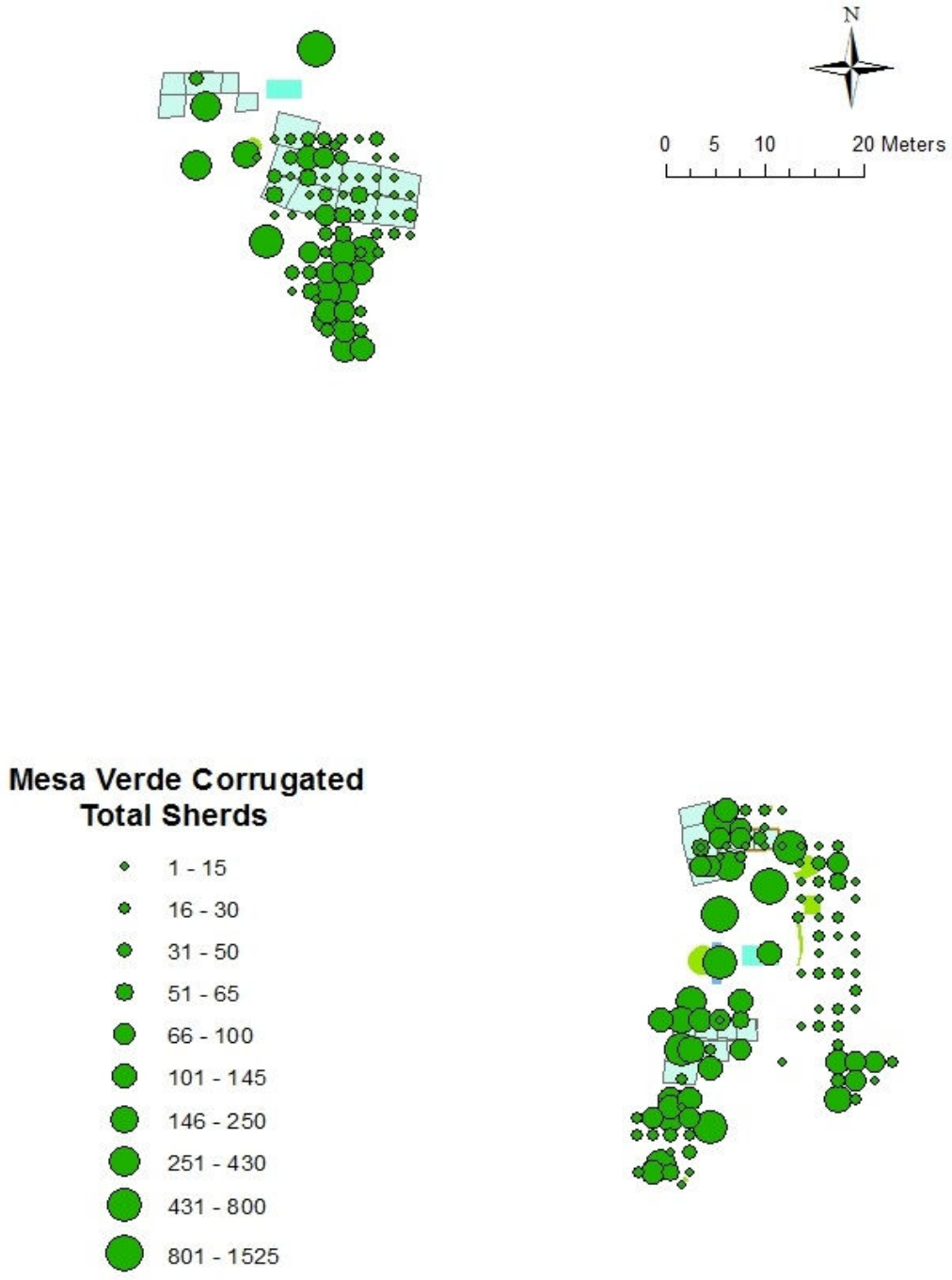


Figure 9.Mesa Verde Corrugated was by far the most prevalent on the site. As with the non-corrugated style of Mesa Verde, there are two styles associated with this classification at Ewing. The first is the Mancos variety that was manufactured from 900-1100 AD. The second is the Mesa Verde style that was manufactured from 1100-1300 AD and is more typical of Pueblo III. It is obvious how overall corrugated type is pervasive through the entire site. There are approximately 20,732 pieces represented in the map.

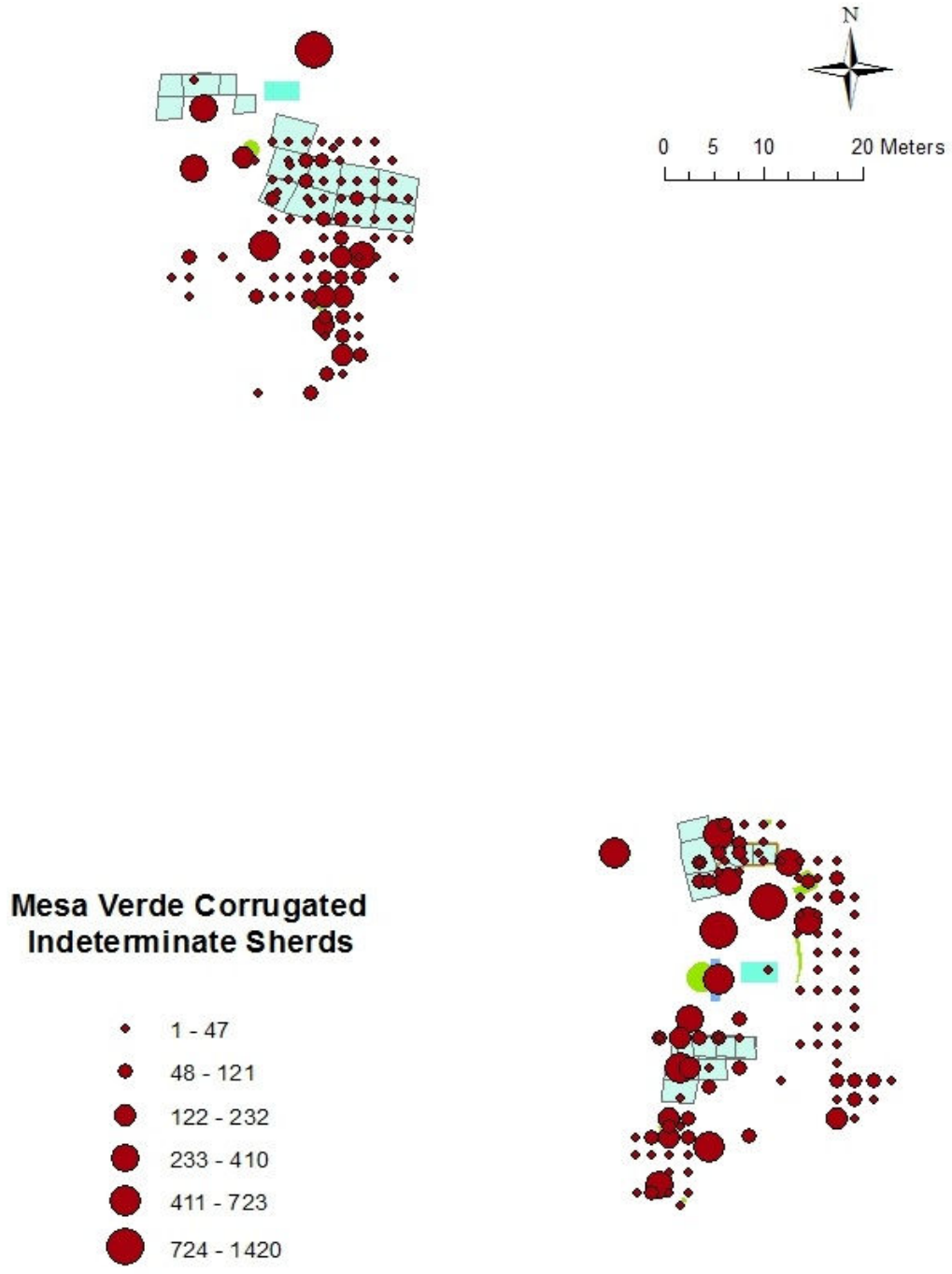


Figure 10. Indeterminate was a category for those corrugated sherds that could not be given the appropriate category. The numbers in this category outweighed the numbers for the both Mancos and Mesa Verde corrugated styles combined at 19,186. It is likely that the sheer volume of this type could be representative of a non-durable ceramic that had to be constantly manufactured. As with the non-corrugated style, it was hypothesized that it would be possible to determine which category sherds would go in based strictly on location densities. This proved to be false again.

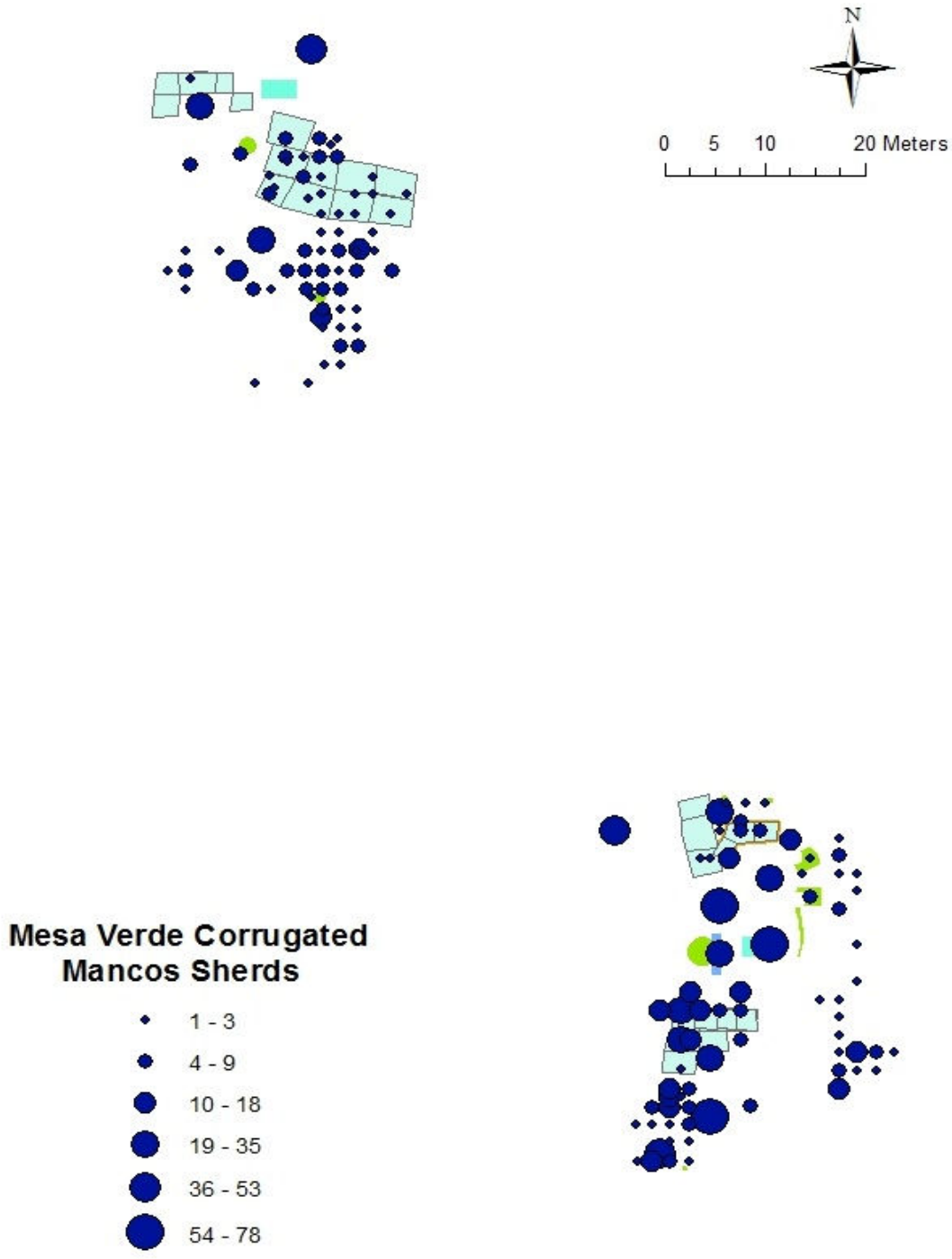


Figure 11.The Mancos style is distributed evenly across the whole site. This style of corrugated preceded the Mesa Verde style. There is not a specific area in which they cluster more or less than Mesa Verde Corrugated as a whole.

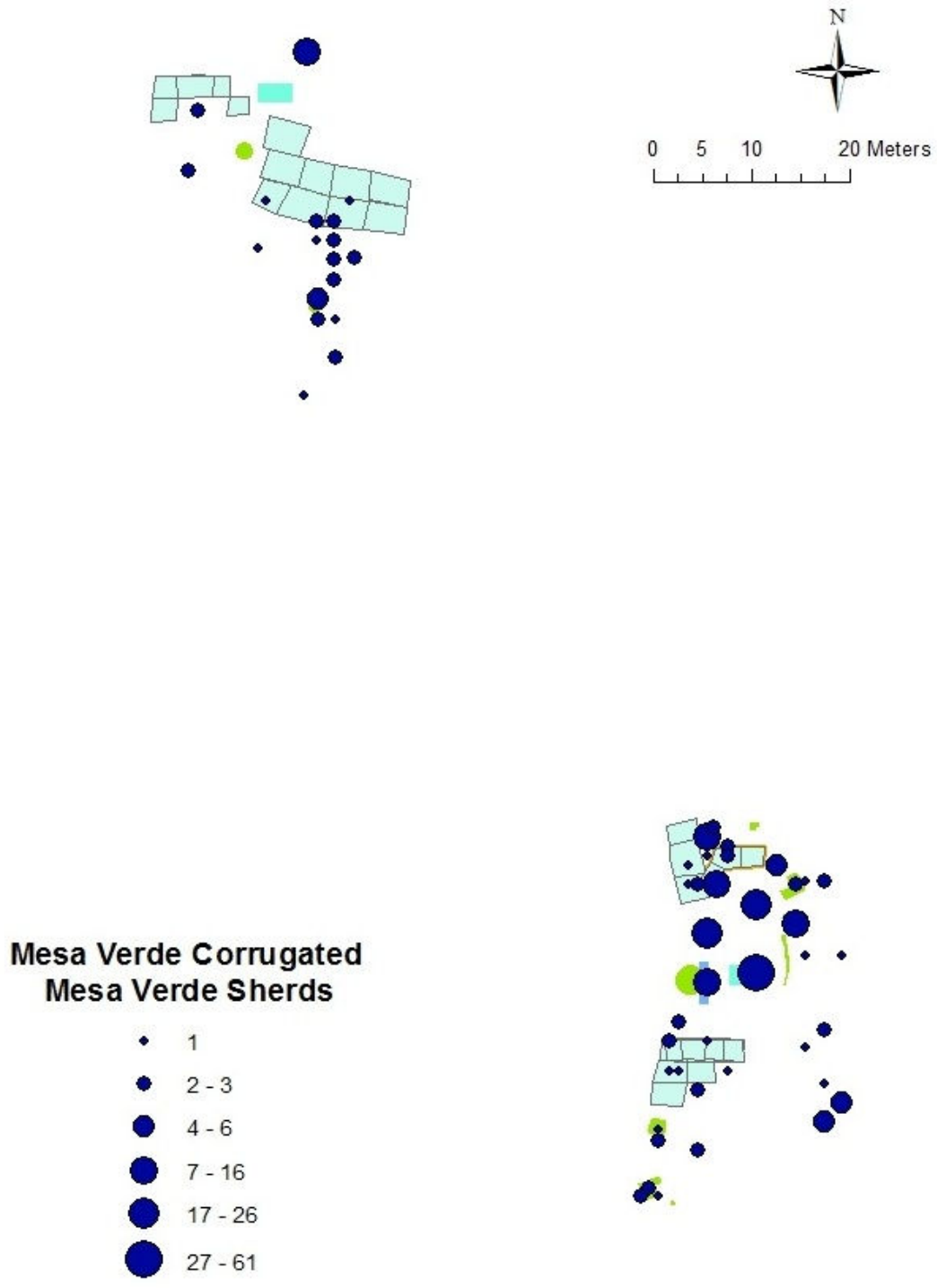


Figure 12.This Mesa Verde style was manufactured from 1100-1300 AD. The style of tends to cluster in the southern area of the site. Typically between the homes and near kivas. This could indicate a population shift toward the end of occupation for Ewing.

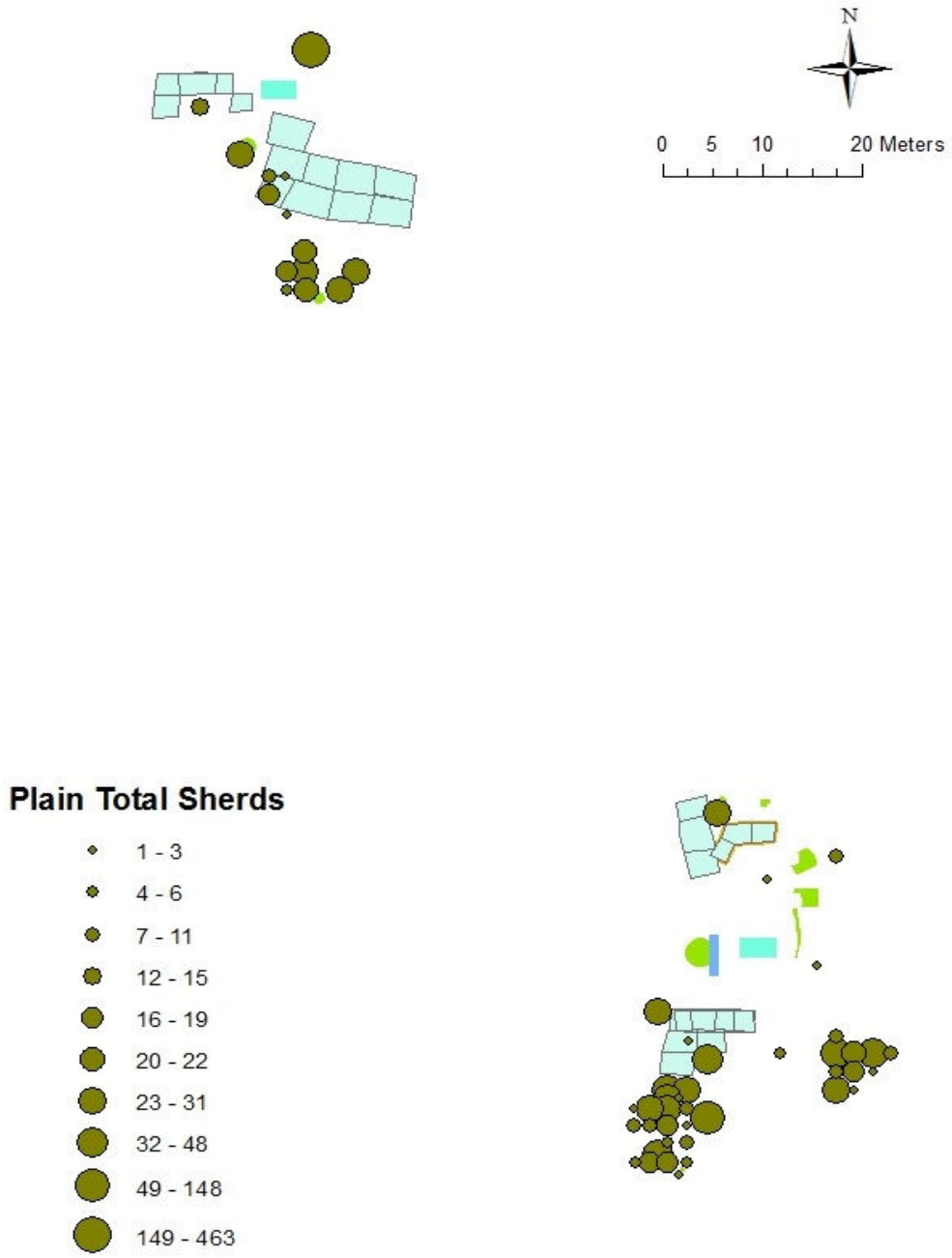
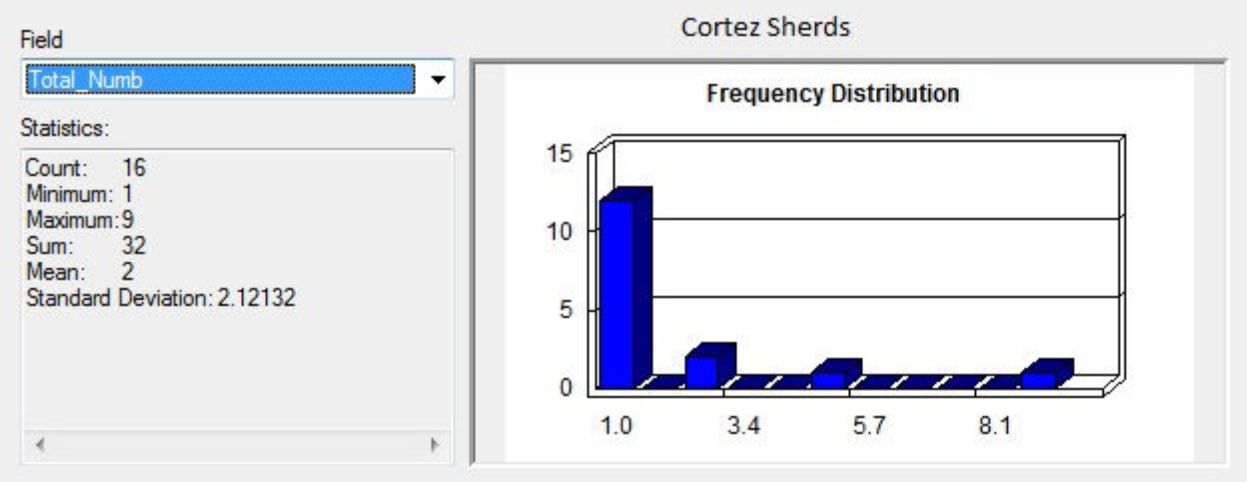
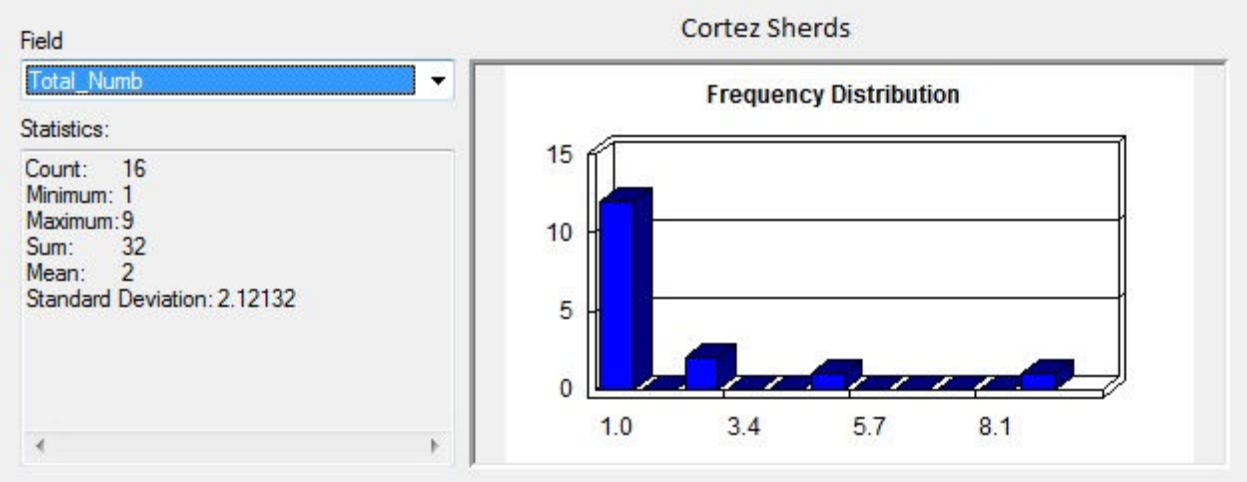
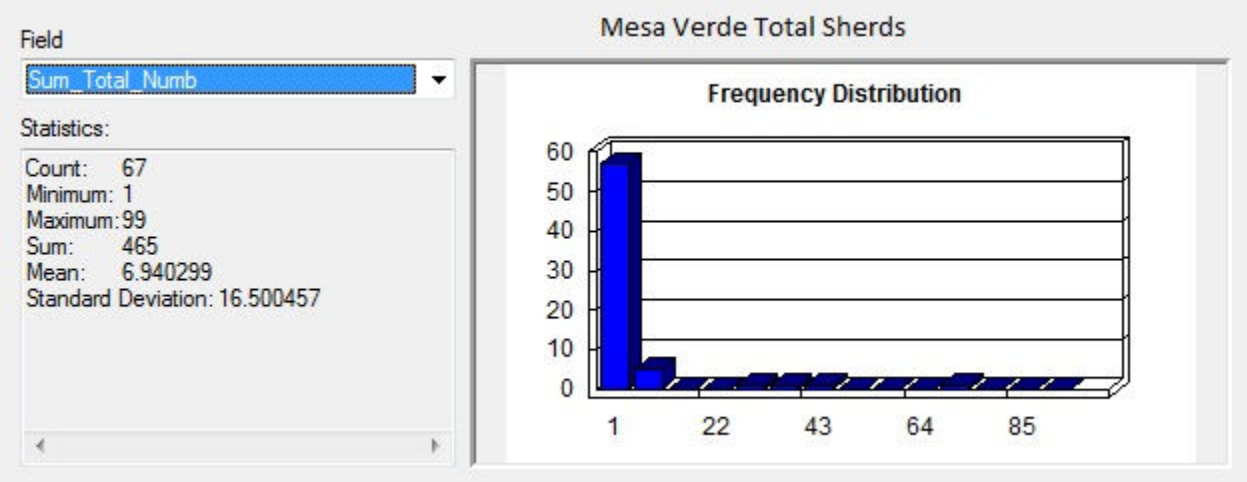


Figure 13.The final category was labeled "Plain sherds". This category was prominent in the database tabulation that was used for this thesis. It is not apparent what the characteristics for this category are. It could be that this was a catch-all for sherds that were diagnostic enough to be classified as a gray or black and white ware ceramic but which could not be placed within a particular group. Even without this knowledge the group was large enough at 1636 pieces, it had to be accounted for. It is interesting to note that this style clusters around kivas. Specifically Kivas 5, 6 and 7 have the highest levels. In fact, out of all the ceramic styles, only plain sherds were located at Kiva 7.

Appendix C


Field
Total_Numb
Statistics:
Count: 16
Minimum: 1
Maximum: 9
Sum: 32
Mean: 2
Standard Deviation: 2.12132
Cortez Sherds
Frequency Distribution
15
10
5
0
1.0
3.4
5.7
8.1


Field
Total_Numb
Statistics:
Count: 16
Minimum: 1
Maximum: 9
Sum: 32
Mean: 2
Standard Deviation: 2.12132
Cortez Sherds
Frequency Distribution
15
10
5
0
1.0
3.4
5.7
8.1

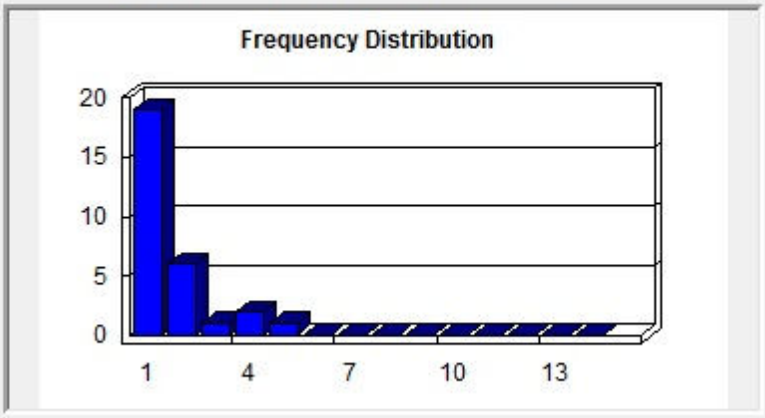

Field
Sum_Total_Numb
Statistics:
Count: 67
Minimum: 1
Maximum: 99
Sum: 465
Mean: 6.940299
Standard Deviation: 16.500457
Mesa Verde Total Sherds
Frequency Distribution
60
50
40
30
20
10
0
1
22
43
64
85

Mesa Verde - Mesa Verde Variant Sherds

Field: Sum_Total_Number

Statistics:

Count: 30
Minimum: 1
Maximum: 15
Sum: 62
Mean: 2.066667
Standard Deviation: 2.619584

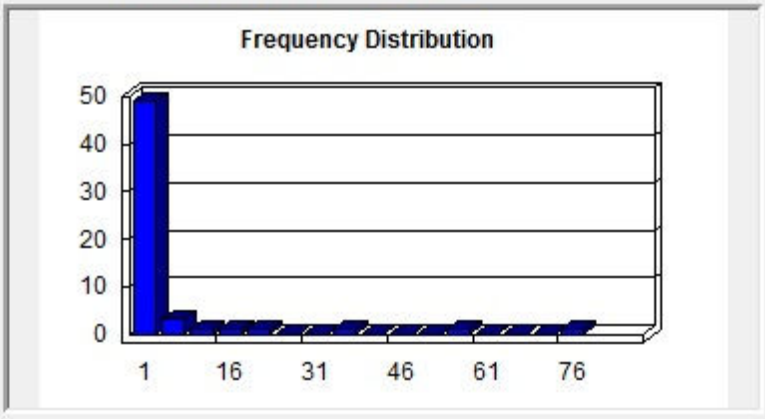


Mesa Verde - Mancos Sherds

Field: Sum_Total_Number

Statistics:

Count: 58
Minimum: 1
Maximum: 79
Sum: 343
Mean: 5.913793
Standard Deviation: 13.403917

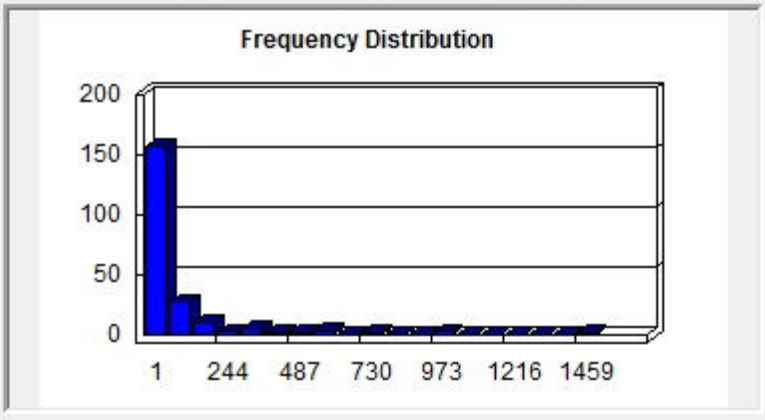


Mesa Verde Corrugated Total Sherds

Field: Sum_Total_Numb

Statistics:

Count: 207
Minimum: 1
Maximum: 1524
Sum: 18047
Mean: 87.183575
Standard Deviation: 176.885823

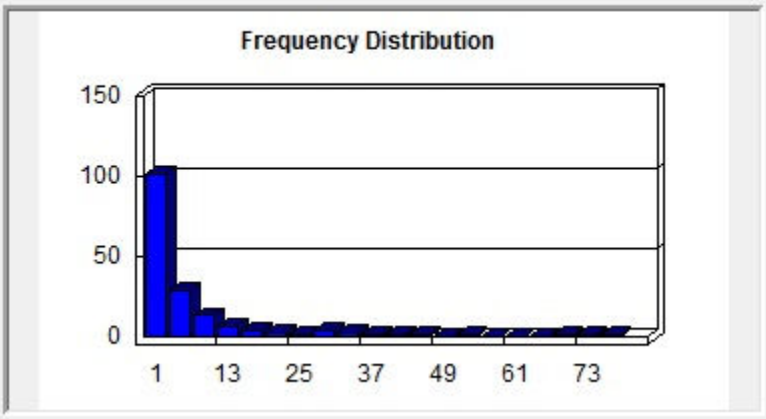


Mesa Verde Corrugated - Mancos Sherds

Field: Sum_Total_Number

Statistics:

Count: 166
Minimum: 1
Maximum: 78
Sum: 1271
Mean: 7.656627
Standard Deviation: 12.689866

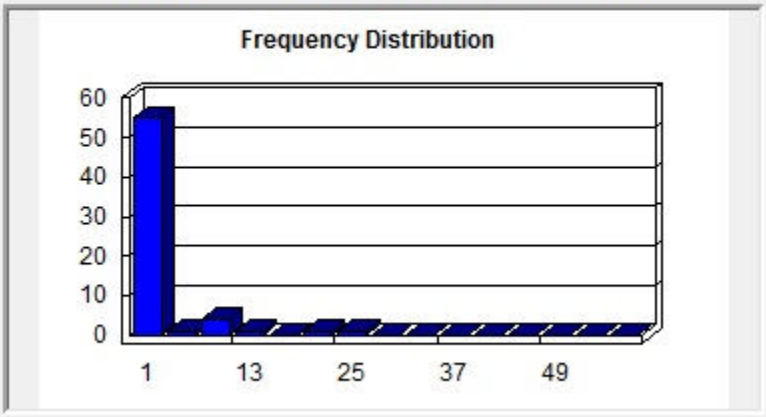


Mesa Verde Corrugated - Mesa Verde Sherds

Field: Sum_Total_Number

Statistics:

Count: 64
Minimum: 1
Maximum: 61
Sum: 275
Mean: 4.296875
Standard Deviation: 8.559862

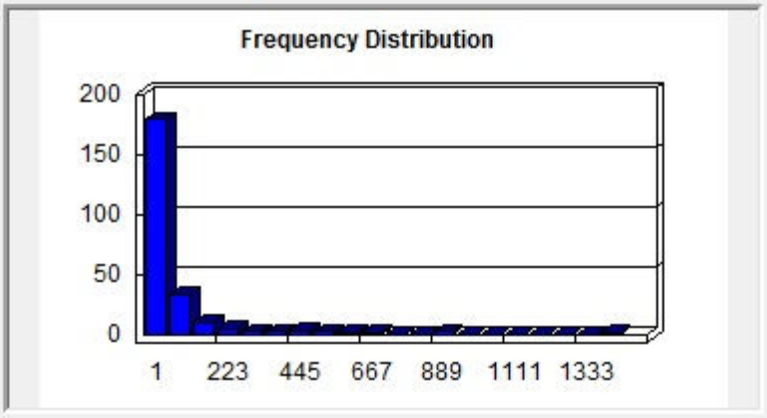


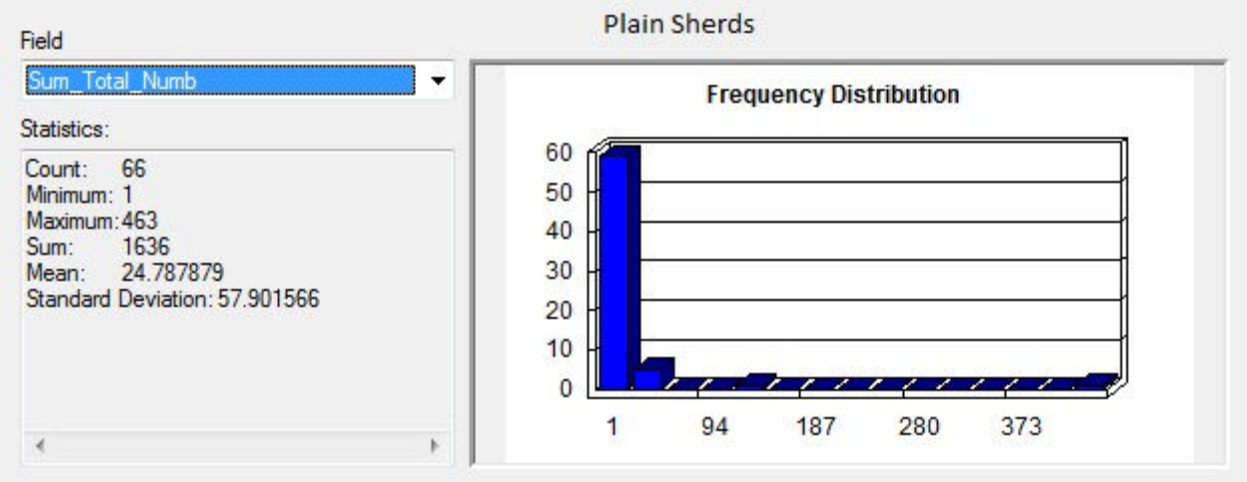
Mesa Verde Corrugated - Indeterminate Sherds

Field: Sum_Total_Number

Statistics:

Count: 240
Minimum: 1
Maximum: 1420
Sum: 19186
Mean: 79.941667
Standard Deviation: 159.556145




Plain Sherds
Field
Sum_Total_Numb
Statistics:
Count: 66
Minimum: 1
Maximum: 463
Sum: 1636
Mean: 24.787879
Standard Deviation: 57.901566
Frequency Distribution
60
50
40
30
20
10
0
1
94
187
280
373

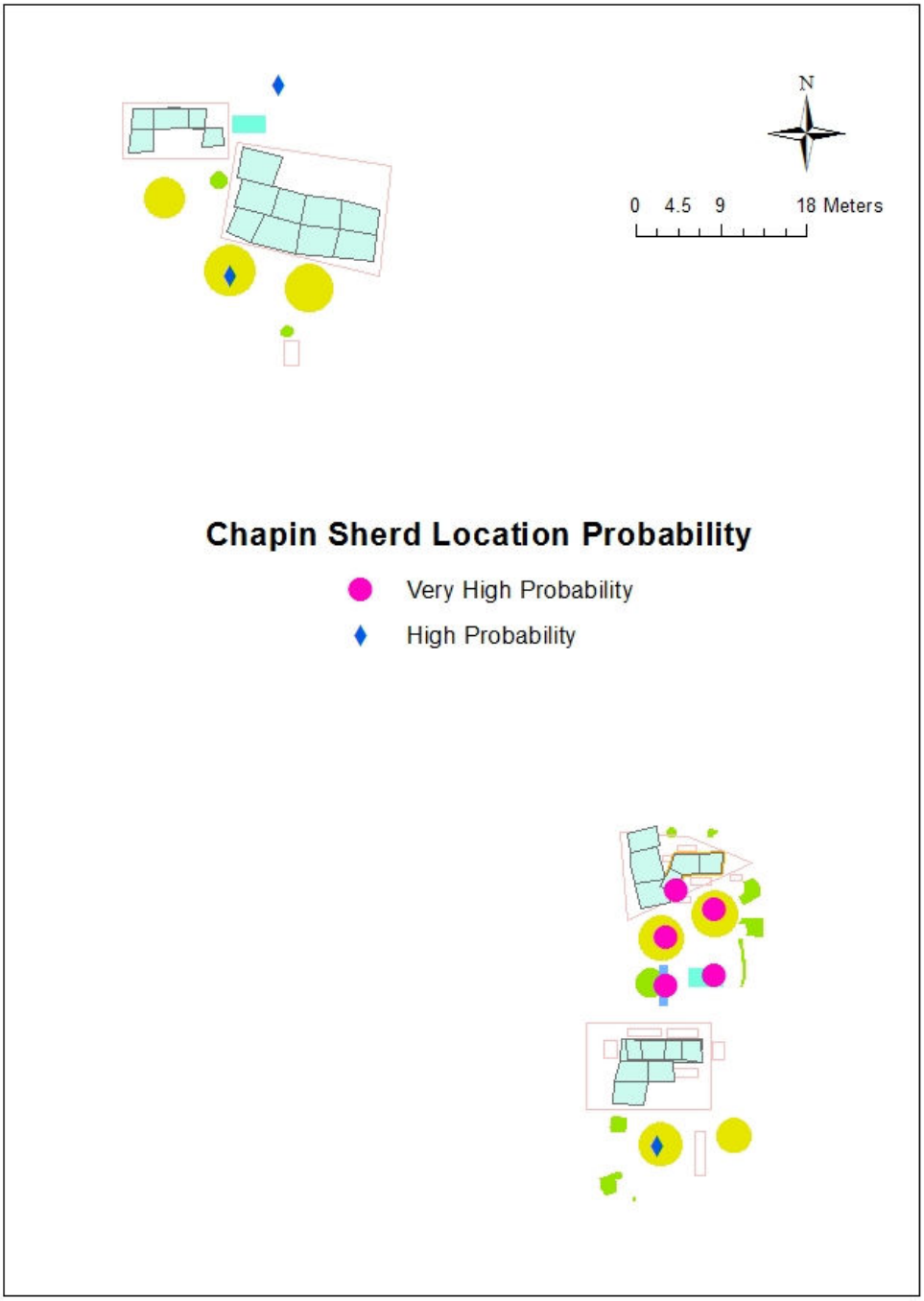


Figure 1.Results of cluster analysis for Chapin sherds

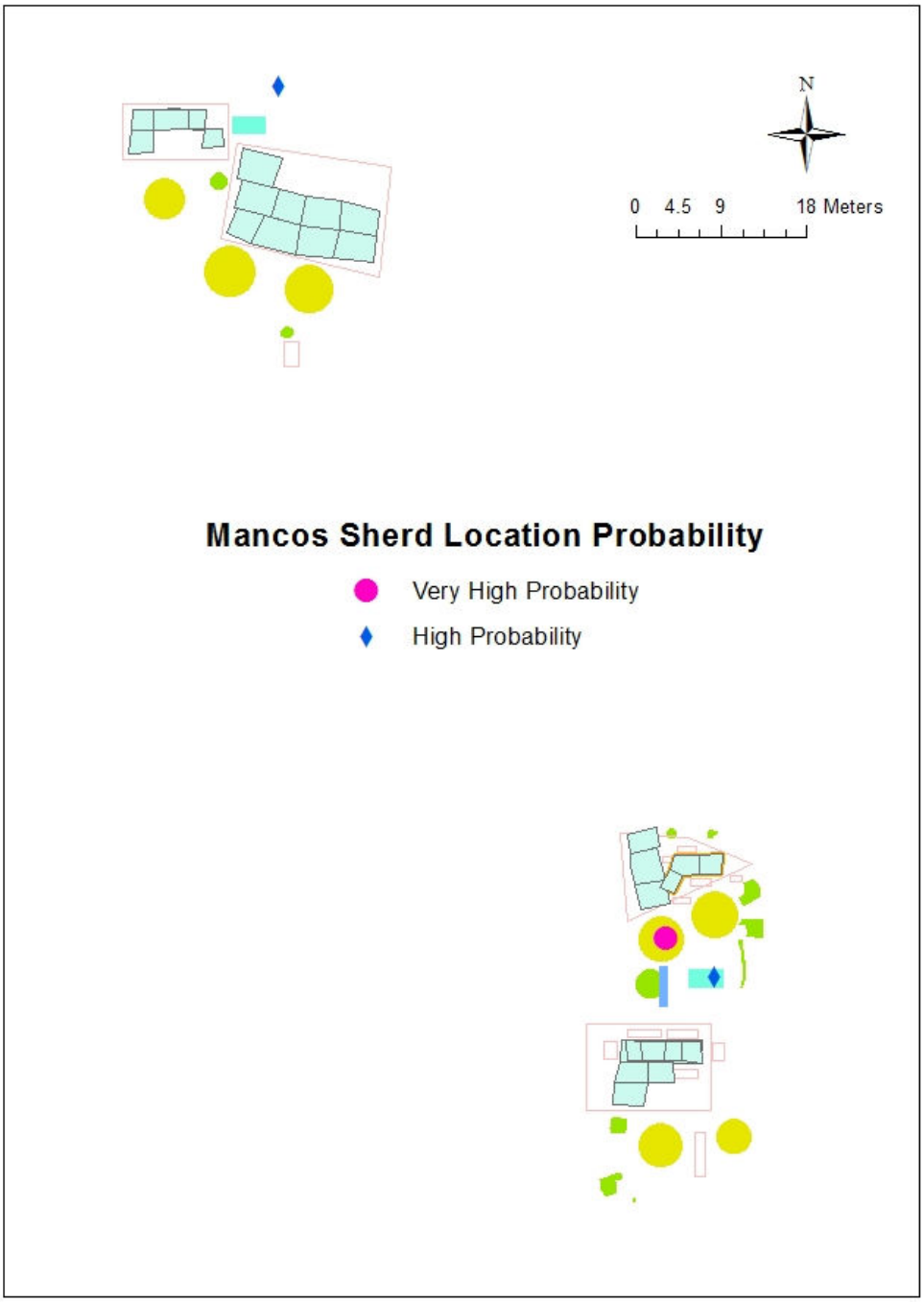


Figure 2.Results of cluster analysis for Mancos sherds

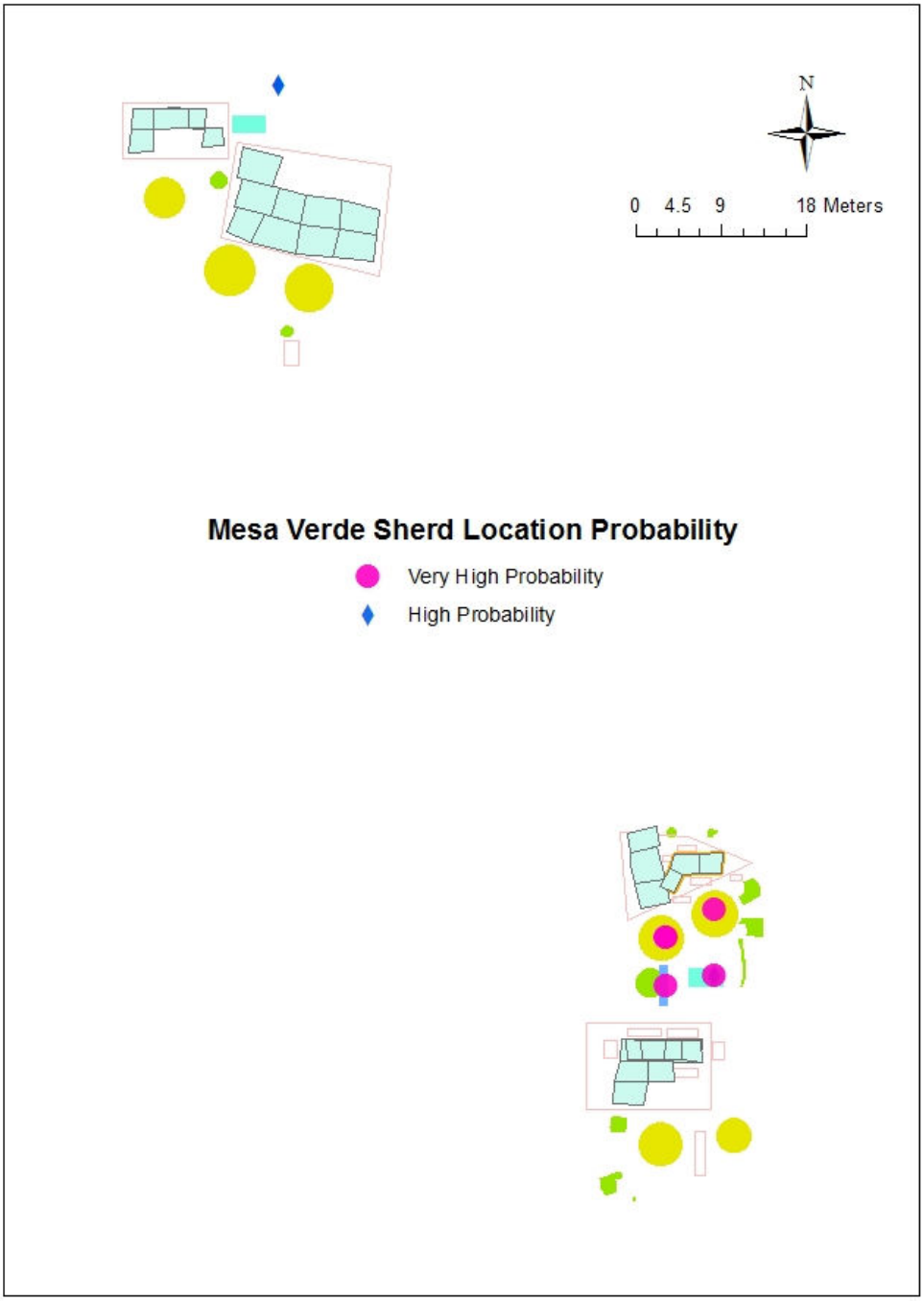


Figure 3.Results of cluster analysis for Mesa Verde sherds