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ABSTRACT

Small depressions are a widespread feature across the landscape of northwestern Belize. Initially considered by most to be the remains of seasonal ancient Maya water cisterns, recent studies have proposed multiple functions including trash dumps, quarries for construction material, and household gardens. Water storage was a known requirement for the ancient Maya, who inhabited an environment with a karstic landscape, semi-tropical climate, and pronounced dry season. Archaeological evidence of water management techniques including the creation of water catchments, drainages, and reservoirs has been demonstrated at numerous major lowland sites from the Late Preclassic into the Classic period.

A small depression located at the Medicinal Trail site in northwest Belize, near the major site of La Milpa, has been excavated and evaluated to determine its probable function. It appears that the depression served in some capacity as both a water reservoir and an area for working lithic material, as well as probably a trash dump. Its close proximity to surrounding structures, the necessity of rainwater collection and storage, and the presence of what appears to be a layer of sealant over the bedrock layer point to its use as a water reservoir. The high density of lithic debitage, tool fragments, and cores throughout the site, as well as the possible remains of a collapsed platform in an area where a large amount of lithic material was collected, support the idea that the site was used, at least in part, for stone working.

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CHAPTER 1
INTRODUCTION

Scarborough (1991a:101) defines water management as "the interruption and redirection of the natural movement or collection of water by society." To the ancient Maya, the control, manipulation, and storage of water were essential to their survival. Inhabiting an environment with a karstic landscape, semi-tropical climate, and extended annual dry season, water storage was an absolute necessity—one which they achieved through the creation of water catchments, drainages, and reservoirs. According to Harrison (1993), water management among the ancient Maya of the southern lowlands can be divided into two major and multiple minor functions. The first of these is the collection and storage of water for daily use, primarily for consumption but for other household uses as well (Harrison 1993; Scarborough 1991a). The second function, the control of water for assisting in the production of food, is far more complex. Although both of these functions directly relate to survival, they differ in their reflection of population sizes. A sedentary population of any size most likely requires the storage of water for daily use, while water control and management for purposes of agricultural intensity have a more direct relationship to population pressures (Sanders et al. 1979). Water management for agricultural purposes is the more complex issue, due to its direct relationship to variable soil conditions as well as to the distribution of natural bodies of water. The survival and prosperity of ancient Maya communities of any size—from major centers to rural settlements—was dependent upon the organization of water resources.

In this thesis, a small depression located at the Medicinal Trail site in northwest Belize, near the major site of La Milpa, has been evaluated to determine its most likely function. Both the Medicinal Trail and La Milpa sites are located within the Programme for Belize Nature

Preserve, a sizable rainforest tract "dedicated to preserving a large portion of a semitropical forest and its non-human inhabitants through a managed use of its resources" (Scarborough and Valdez 2003:3). The Programme's boundaries are arbitrary, with current archaeological research occurring to the north, south, and west of its immediate borders. R.E.W. Adams (Adams and Valdez 1993) identifies this greater region inclusive of adjacent portions of the northeastern Petén, Guatemala, and southeastern Quintana Roo, Mexico, as the Three Rivers Region. Although the Programme accommodates multiple research agendas conducted by diverse sets of principle investigators, the central themes of ecology and economy unite the projects within the Three Rivers Region. The Programme's unique approach centers on examining ancient Maya lifeways, largely through landscape alterations and a resulting interdependency, from a non-site-centered perspective.

The Medicinal Trail depression is roughly ellipsoidal in shape, with long (north-south) and short (east-west) axes of 15 and 10 meters respectively, and a depth of nearly 1.5 meters at its deepest point relative to the rim (Me-Bar 2004) (Figure 1.1). A small portion of the site was excavated by Me-Bar two seasons prior to my work in an initial attempt to determine its most likely function. Following excavations in 2004, Me-Bar noted similarities in both shape and dimensions between this depression and another located at the south end of the site of Dos Hombres. He concluded that the Dos Hombres depression was used first as a limestone quarry, then as an *aguada* (natural water holding depression), and finally as some sort of ritual site. The theory of its use for ritualistic purposes was based on the presence of an artificial cave at the eastern edge of the depression. Since no such "cave" exists at the Medicinal Trail depression, the possibility of this site functioning ritualistically was discounted, and Me-Bar's pre-excavation assumptions were that limestone had been quarried from it and that it had then been used as an

artificial *aguada*. The primary objective of his excavations was to prove this hypothesis. Continuing excavations at the depression, my goal was to excavate as much of the site as possible down to the bedrock layer in an attempt to determine its primary function.

Based on previously published work in the fields of Maya Archaeology and water management and prior to excavation, my initial hypothesis was that the depression had served as a reservoir (*aguada*) for wet-season water storage—either for potable or agricultural ends. The depression's close proximity to several terraces and house mounds, coupled with the absence of any apparent permanent water sources in the immediate vicinity, suggest its function as a principle source of water (Figure 1.2). Numerous *aguadas* in the immediate area of household plots or house mounds throughout the lowlands are noted (Bullard 1960; Matheny 1976; Scarborough 1993, 1998). Bullard, in connection with his survey in the northeastern Petén, reported that "there is a marked tendency for these house ruins to occur in the vicinities of present-day, and possibly former, water sources…It is my impression that the maximum distance from a water source was probably less than two kilometers" (1960:364). The structures nearest the Medicinal Trail depression fall well within this two-kilometer radius, with one sizable house mound group located approximately 40 meters to the southwest and a smaller house mound located only 20 meters to the north. Following Bullard's logic and the nearness of the depression to neighboring structures, the depression likely functioned, at least in some capacity, as an *aguada*. Citing evidence from the Preclassic site of Edzná, Matheny (1976) notes that approximately 25 large reservoirs in the northeast and northwest sectors of the site are usually accompanied by a group of mounds, while numerous small reservoirs are each accompanied by one or more house mounds. Scarborough (1993) also points out the importance of households

situating themselves as close to water as possible, highlighting the competitive aspects of neighboring households and a finite water supply.

The presence of a clayey layer of "sealant" overlaying the bedrock at the base of the depression is another possible indicator that the depression did serve as a water storage reservoir. As suggested elsewhere (Beach and Dunning 1997; Gill 2000; Siemens 1978; Scarborough et al. 1995), this clay plaster, whether naturally or unnaturally deposited, is shown to reduce the porosity of the limestone bedrock and aid in water retention at several sites in the southern lowlands including nearby La Milpa. Each unit in the Medicinal Trail depression was excavated to the bedrock to determine whether the clayey layer was present. Confirming the presence of this layer would lend further support to the hypothesis that the depression functioned as an *aguada*; its absence would call the theory into question.

A close examination of the bedrock throughout the depression would also reveal whether or not it had been artificially modified (or "carved") in any way, either as the result of quarrying the limestone for construction material or to serve as a channel to aid the inflow or outflow of water. Hester and Shafer (1984), reporting on the chert industries of Colha, argue that at least five *aguadas* scattered throughout the site are largely artificial, having been dug by the ancient inhabitants to obtain marl and building materials, and probably to secure large amounts of subsurface cherts. Pointing out the number of Late Preclassic workshop mounds found on the edges of these features, they clearly believe the formation of *aguadas* at the site resulted from this mining activity. In addition, Scarborough (1996) notes the conversion of huge quarry depressions to central precinct reservoirs in urban settings with monumental architecture such as Tikal. The fact that the relative ease with which limestone was quarried to produce reservoirs and dams (causeways), as well as the need for construction fill in constructing monumental

architecture, resulted in an approximately 1:1 relationship between reservoir volumes and temple/palace/house mounds in some communities (Scarborough 1983, 1991b) must also be taken into consideration. Finally, Gill (2000) asserts that, of the five principal types of reservoirs at Tikal, one was a quarry pit that was used to hold water after its limestone had been removed. Although the Medicinal Trail site area is a rural, agricultural community as opposed to a major urban center, it is possible to imagine this transformation from quarry to reservoir on a much-reduced scale. If the depression served as a water-holding tank and collected water from surface runoff, we would expect to find a channel to the southeast as the surrounding terrain on that side slopes gently into the depression.

Two final objectives of my work were to compile artifact densities, both lithic and ceramic, from various points within the depression, and to collect multiple soil samples to analyze for botanical and pollen content. If the depression did serve as a trash dump, as has been suggested for other small depressions in the central Maya lowlands (Weiss-Krejci and Sabbas 2002), or was the setting for craft or tool-working (Hester and Shafer 1984), the amount of lithic and ceramic debitage recovered would bear it out. The composition of the soil samples could also play a key role in determining whether or not the depression held water for any significant length of time. Recovered pollen or spore samples from certain water plants, including *Isoetes* sp., lechuga (*Pistia stratiotes*), and water lilies (*Nymphaea*), would strongly support the hypothesis. This particular vegetation exists both at the margins and on the surface of water reservoirs and plays an important role in water purification (Gill 2000; Harrison 1993; Lucero 1999; Matheny 1976, 1978; Pohl et al. 1996; Puleston 1977). It has also been suggested that water lilies can function as evaporation-retardants in certain circumstances (Ford 1996; Schele and Freidel 1990). If pollen is present within the soil samples, its condition could also be

indicative of the depression's use for water storage. Hansen et al. (2002) note that fair to excellent pollen preservation in the sediment of an *aguada* could result from a permanently wet, anoxic environment. If this were the case at the Medicinal Trail depression, the lack of available oxygen would render the water unpotable, but it would not affect its use for agricultural or other household purposes. Therefore, if the depression did hold water, pollen could be an indicator of the *aguada's* function: agricultural use, potable water source, or both.

In response to my initial hypothesis and its corollaries, this thesis is divided into six sections. First, background information on the different types of reservoirs and their functions, including physical description, existing commonalities, and usage patterns is presented. The following section is a discussion of various facets of the environment surrounding the Medicinal Trail depression, leading to a review of both Preclassic and Classic period Maya water management practices. Next, I outline my research methods including placement of units and excavation strategies. Following this section is a detailed description of the excavation units, soil composition, and a preliminary analysis of significant findings. Analysis of the composition and contents of each excavation unit is discussed next. Finally, I conclude by reviewing the results of the excavations, discussing whether the initial hypothesis was confirmed or refuted, what conclusions can be reached from the data, and where this study fits into the greater field of water management and its role among the ancient Maya.

Figure 1.1. Medicinal Trail depression, pre-excavation. The photograph is facing southeast.

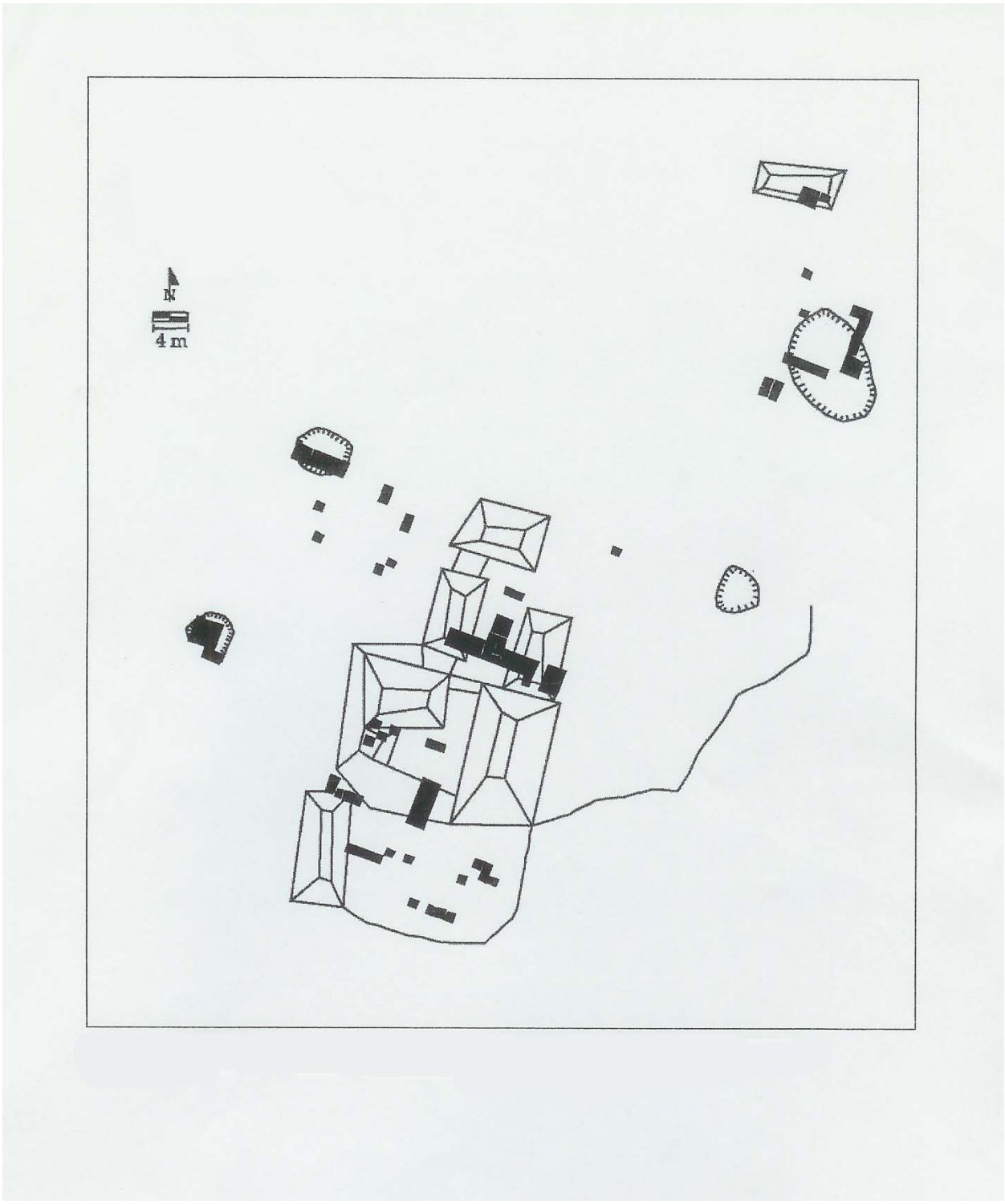

Figure 1.2. Tape and compass map of RB62, Operation 7 showing locations of sub-operations. The Medicinal Trail depression (Operation 10), including the location of Me-Bar's 2004 excavation units, is shown in the top right. (Adapted from Hyde 2005).

CHAPTER 2
ENVIRONMENTAL CONTEXT

The Maya lowlands are an extremely diverse series of microenvironments subject to thin soils, variable rainfall, and an extended period of water stress largely without immediate access to permanent water sources. The main factors responsible for the diverse patterning of microenvironments in Mesoamerica are "variation in rainfall, soil, geomorphic processes, and the slope gradients and drainage caused by structural hydrology" (Dunning and Beach 2000:181). Largely dominated by tropical and semitropical forests, the Maya managed a complex political economy based on a structured landscaping investment (Scarborough and Valdez 2003). The Maya systematically altered their surroundings over hundreds of years, producing an environmental setting profoundly different than what was originally settled or what has now been reclaimed. An examination of the key elements composing the environmental context of the Maya lowlands highlights the importance of water management and helps to clarify the possible role played by a single small depression in northwest Belize.

MEDICINAL TRAIL DEPRESSION

The Medicinal Trail Depression is located at the Medicinal Trail site in northwest Belize (Figure 2.1). Medicinal Trail is part of the Programme for Belize holdings in the Three Rivers Region, which also includes the sites of La Milpa, Ma'ax Na, and Dos Hombres, among others, occupied during the Classic through Terminal Classic periods (AD 300-900) (Dunning et al. 1999; Dunning et al. 2003; Scarborough and Valdez 2003). Named for the abundance of medicinal plants surrounding the site identified during initial clearing, Medicinal Trail appears to have been a small rural community on the outskirts of the major site of La Milpa. Located just a

few kilometers to the southwest, La Milpa is a relatively large site with continuous occupation from the Preclassic into the pre-abandonment Post Classic, experiencing a population spike in the Late Classic. By AD 700 a population of 50,000 is estimated at the site, spreading out in a 3-5 km radius from the center and declining at the margins of surrounding areas such as Medicinal Trail (Tourtellot et al. 1993). Available stored water at La Milpa, in the form of reservoirs, would not have been sufficient to support the smaller hinterland communities near its borders. As a result, other options such as the Turtle Pond *aguada* excavated and analyzed by Jennifer Chmilar in 2005, and smaller depressions such as that at Medicinal Trail undoubtedly played crucial roles in the survival of the surrounding lesser populations. In addition, household gardens also had a significant part in supplementing the food supply and as an economic source for individuals due to the lack of open space necessary for large agricultural fields. These garden plots, associated with house groups, were necessitated by the density and dispersion of the population at La Milpa (Lohse and Findlay 2000).

The Medicinal Trail site is located in the Three Rivers Region, an area heavily influenced by limestone faulting (Dunning et al. 1999, 2003). The greater Programme for Belize area provides a diverse set of habitats within a semitropical environment, with the variability within the Programme capturing a range of settings in microcosm, representative of the more widespread presence of these same settings elsewhere in the southern Maya lowlands (Scarborough and Valdez 2003). Scarborough and Valdez (2003) define four ecological zones as proposed by Brokaw and Mallory (1993): the La Lucha Uplands, the Río Bravo Embayment, and the Booth's River Uplands and associated depression.

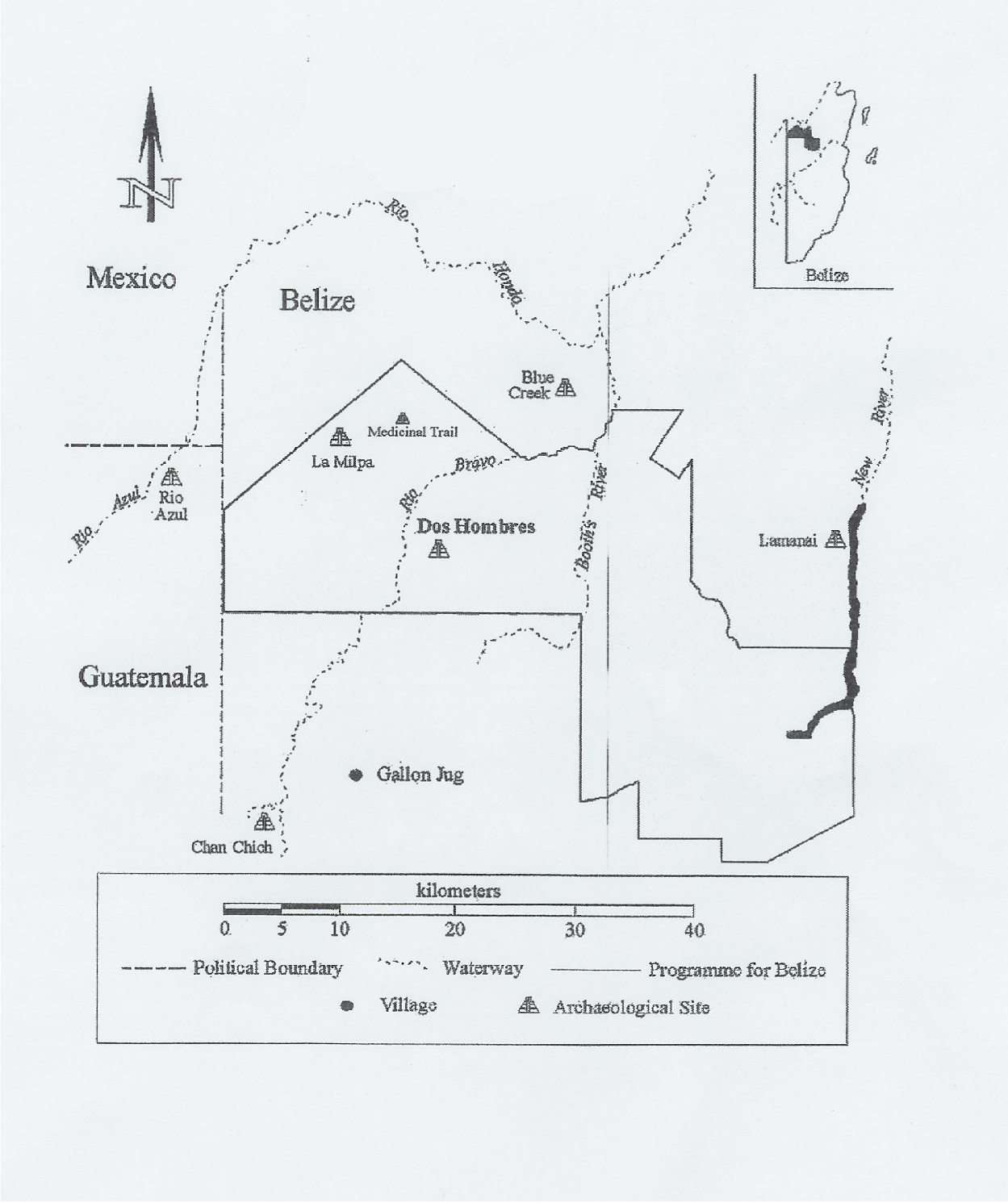

Figure 2.1. Map of the Programme for Belize Archaeological Project boundaries and nearby sites. (Adapted from *http://uts.cc.utexas.edu/~marl/location.html*).

The La Lucha Uplands, a continuation of the limestone plateau extending west into the Péten and north into Mexico, consists of upland forests with well-drained soils as well as sizable *bajos* (internally draining seasonal swamps). Some of the largest Maya centers in the Three Rivers Region are located in this area, including La Milpa and Ma'ax Na within the Programme's holdings. The Río Bravo Terrace Uplands lie to the east of the La Lucha Uplands and include the steep escarpment and drop to the Río Bravo. Much of this zone is well drained, and harbors transitional forest or vegetation between upland forest and swamp-margin scrub vegetation. A poorly drained, seasonally inundated floodplain of the Río Bravo, the Río Bravo Embayment lies below and east of both the La Lucha and Río Bravo Terrace Uplands. Shallow seasonal *aguadas* and lagoons, as well as marsh and swamp settings define it. The Booth's River Uplands, located farther to the east, contain the lowest elevations in the vicinity (less than 20m above mean sea level). Water accumulates within the graben valleys and localized low points on upland horsts, creating *bajos* and *aguadas* (Beach et al. 2003).

Three local rivers drain the area, though none are located in close proximity to Medicinal Trail. The first (and closest) is the Río Bravo, which flows from Guatemala southwest to northeast, and is known locally as Chan Chich Creek. It is located 9 km to the southeast of La Milpa (Scarborough et al. 1995). Booth's River is to the east and is joined by Chan Chich Creek. Finally, Río Azul (Blue Creek in Belize) flows eastward from Guatemala, joining the other two rivers to form the Río Hondo (Dunning et al. 2003).

Local vegetation surrounding the Medicinal Trail Depression is a subtropical moist forest with a medium-high, broadleaf, evergreen forest and a few dry season deciduous trees. The interior canopy of palm species includes corozo and hardwoods like cedar and mahogany (Beach et al. 2003; Dunning et al. 2003). Soils grade through lithic rendolls, rendolls, cumulic rendolls,

vertic rendolls, and vertisols, depending primarily on the movement of water through the soils. The primary difference between each of the soils is the amount of rock and clay composition. Lithic rendolls are comparatively elevated and contain more rock and less clay, whereas vertisols are located in low-lying, seasonally inundated areas, contributing to higher clay and lower rock content (Chmilar 2005).

A final factor to consider in any landscape analysis of the Medicinal Trail Depression is the level of both natural and human impact on the site in the 3000 years since the ancient Maya resided here. In addition to the naturally erosive effects of winds and rainfall, sporadic wildfires are known to sweep through the area, altering the vegetative landscape in the process. In the 1930s, a chiclero camp for the extraction of chicle resin was located in the vicinity. More recently, Mennonite farming has taken place in the surrounding areas, subsequently impacting the physical setting. Finally, other archaeological investigations at Medicinal Trail, adjacent to the depression, have been ongoing for the past few years. The physical clearing of the landscape necessary for this work to proceed, as well as the excavations themselves, have left obvious imprints on the area.

GEOGRAPHIC LOCATION

The Maya lowlands, extending over 68,000 km^2, are located between 14 and 22°N, entirely within the Tropics, and between 87 and 93°W (Scarborough 1993b; Harrison 1993). It is approximately 900 km from north to south and 550 km from east to west along the continental divide, near the Pacific coast, and roughly 400 km across the Peninsula of Yucatán (Gill 2000). Nearly half of the Maya area is found within modern Mexico, covering the majority of Chiapas and Tabasco and the entirety of Campeche, Yucatán, and Quintana Roo. The remainder is

comprised of Belize, the Department of the Petén in Guatemala, and the northern portions of Honduras and El Salvador. The area is generally divided into two sections: the northern and southern lowlands. The northern lowlands extend across most of the Yucatán Peninsula, while the southern portion cover the Department of the Petén and extend through Tabasco, southern Campeche and Quintana Roo, Belize, Río Motagua in Guatemala, and into a small portion of western Honduras (Chmilar 2005).

WEATHER AND CLIMATE

The impact of seasonality, rainfall, and climate on Maya civilization, and possibly collapse, has not suffered for lack of scholarly discussion (Bullard 1960; McAnany 1990; Adams 1991; Scarborough and Gallopin 1991; Scarborough 1991, 1993b, 2003; Harrison 1993; Ford 1996; Dunning et al. 1999; Gill 2000; Scarborough and Valdez 2003). The Maya area exhibits a mixture of a tropical and semitropical climate, owing to its location on the northern edge of the Intra-Tropical Convergence Zone (Chmilar 2005). Weather in the Maya lowlands is part of the North Atlantic weather system. *Nortes*, or northers, which occasionally blow in during the winter, are the only weather phenomena possibly originating in the Pacific. These are brief cold air outbreaks from the cold interior of the wintertime North American continent (Gill 2000). The lowlands normally lie in the belt of easterly trade winds, characterized by roughly six-month rainy and dry seasons.

Temperature variation is minimal between seasons, with interannual variability mostly a matter of rainfall differences. The lowlands lie at the northern edge of the tropical rainfall belt, south of an arid zone over the northwest coast and offshore islands (Gill 2000). Precipitation rates across most of the lowland region range from an average of 1,350 to 2,000 mm/year, with

the majority falling during the "rainy season" between June and January and the corresponding "dry season" receiving little rain (Ford 1996; Scarborough 1991; 1993b, 2003; Dunning et al. 1999; Scarborough and Valdez 2003; Harrison 2003). The driest period runs from March through May, with evaporation peaks in April and May (Ford 1996). On the Yucatán Peninsula itself, rainfall rates are extremely variable, with a high of over 4,000 mm at Ilusión, Petén, in the south and a low of less than 330 mm at the lighthouse on Cayo Arenas, one of the offshore islands to the north (Gill 2000:149). Regarding drought conditions in the lowlands, Gill (2000) also notes that severe drought may not have affected all areas equally in every drought episode. Some cities and regions would have been hit harder than others one time, with a different pattern of severity the next time. Where some areas may face severe drought, others will experience an abundance of water. To a large extent across the region, the following years are not dependent upon the previous; the resulting pattern of rainfall and drought is random.

GEOLOGY AND PHYSIOLOGY

Belize, Tabasco, the Pacific lowlands, the Caribbean coast of northern Yucatán, and Quintana Roo are bands of geologically recent alluvial deposits. The northern third of Yucatán Peninsula is Tertiary limestone and marl (*sascab)*, while the southern portion and the areas of Chiapas, Petén, and Belize are comprised of older limestones, with greater elevation and relief and more developed drainage. The hills of the southern Petén, the Alta Verapaz, and the foothills of the Maya mountains in southern Belize are formed from older and more elevated Cretaceous and Jurassic limestones, Triassic shales, and older sedimentary rocks lying still further south. The Maya mountains themselves are a northern isolated block of much older rocks, separated

from the Guatemalan Highlands, and are made up of sedimentary and metamorphic deposits and Paleozoic granites (Gill 2000).

Three areas of limestone, becoming successively younger in age and lower in elevation from south to north, form the land mass known as the Yucatán Platform. During the majority of its history it has remained a rigid mass, emerging from submersion by the surrounding seas as a stable tectonic unit. The result is a widespread area of low topography that makes up the Yucatán Peninsula, including the Petén. The southern end of the Yucatán Platform, forced against the Guatemalan Highlands, has buckled slowly into high ridges that have eroded into steep, forested hills. The northern end is the site of the Cretaceous extraterrestrial impact, the Chicxulub crater, believed to be responsible for the massive ecological catastrophe responsible for the extinction of the dinosaurs, among other life forms, approximately 65 million years ago (Gill 2000).

Four major types of land resources are found in the central Maya lowlands, differing in potential productivity under conditions of low and high labor input (Fedick and Ford 1990). The first is the well-drained uplands of the central lowlands, consisting of rolling limestone hills and ridges and shallow but fertile soils. Next are the slow-drained lowlands, commonly found in low lying areas within uplands and often representing transitional zones between well-drained uplands and various forms of swamps. These slow-draining lowlands can be found in extensive tracts, representing the prevalent land type of large areas. The riverine-associated swamps of San Antonio and Pulltrouser Swamp, both located in northern Belize and the subject of recent interdisciplinary investigations of wetland agricultural features and environment, represent a third type of land resource (Fedick and Ford 1990). Pulltrouser Swamp comprises three linked depressions between the New and Hondo Rivers in northern Belize, with its southern end lying within 200m of the New River. The swamps at San Antonio are directly associated with the

Hondo River. Both are strongly linked to local ground water levels and affected by the fluctuation rates of their associated rivers. The final type of land resource is closed-depression seasonal swamps. Much current knowledge of these swamps is based on studies within the Bajo de Santa Fe located near the site of Tikal (Fedick and Ford 1990) and the Far West Bajo near La Milpa (Kunen 2004), and research from the rural site of Guijarral (Kunen and Hughbanks 2003). These seasonal swamps are closed karstic depressions filled with deep deposits of impermeable clays. They are not associated with river systems, but support an elevated water level high above the basal water table. These swamps hold significant amounts of standing water during the rainy season but desiccate during the dry season except for occasional sinkholes.

The overall terrain of the region is strongly influenced by the underlying geology. Horst and graben topography exists due to tectonic movement, the faults producing large escarpments and valleys exhibiting vast elevation changes (Dunning and Beach 2000). Wetlands are karstic features with roughly 40% of the southern lowlands currently occupied by *bajos* (Scarborough 2003).

SOILS

As geology impacts terrain, the terrain, at least in part, determines the distribution of soil types in the lowlands. Northern lowland soils are shallow, well drained, and calcareous, while those in the southern lowlands are also calcareous, but deeper and more poorly drained. Soil formation is more apparent in sunken areas with greater deposition of sediment, directly contributing to the variety of soil types blanketing the Maya landscape.

Mollisols, among the world's most important and naturally productive soils, are the dominant soil type of the Maya lowlands, especially the well-drained uplands. Constituting only

1 percent of the world's tropical soils, the majority of which are highly weathered and slightly fertile, their yields are unmatched by those of other unirrigated areas (Dunning and Beach 2000). The mollisols of the well-drained uplands are fertile, dark-colored, and rich in organic matter. Their texture ranges from friable clay to clay loam, and their pH values range from neutral (pH 7) to slightly alkaline (pH 8) (Buol et al. 2003). Though shallow, these soils are highly productive under certain hand cultivation systems. Despite the lack of available phosphorous in these well-drained upland soils, modern Maya farmers consider them to be the most productive for 'traditional' wet season swidden cultivation (Fedick and Ford 1990).

Soils of the slow-draining lowlands comprise a mixture of poorly drained vertisols and mollisols grading toward vertisols. Vertisols expand and contract with wet and dry seasons due to their high content of swelling-type montmorillonitic clays. When dry they become extremely hard, developing their characteristic cracks; when wet they are plastic and sticky (Buol et al. 2003). While many vertisols (and mollisols grading towards vertisols) are relatively fertile, their agricultural development under hand cultivation is retarded by poor drainage and workability. In addition, the slow-drained lowlands are saturated or flooded and are too wet for swidden cultivation during the wet season (Fedick and Ford 1990).

Soils of Pulltrouser Swamp are a wetland variety of mollisols suited to the cultivation of a variety of crops under a raised or ditched field system (Fedick and Ford 1990). The near neutral pH values of the soils and their inherent fertility and workability, combined with relatively stable hydrological conditions, create a favorable environment for the development of wetland cultivation. The swamp soils of San Antonio are a wetland variety of entisols with high fertility and agricultural suitability similar to that of Pulltrouser Swamp.

Soils of the Bajo de Santa Fe, representative of closed-depression seasonal swamps, are vertisols. Many vertisols have high natural fertility and productive potential, but these display the worst characteristics of this soil order, with severe chemical and physical limitations (Dunning and Beach 2000). In terms of fertility, the major limiting factor is acidity: the Bajo de Santa Fe vertisols have pH levels ranging from moderately acid at the surface (pH 5.1) to extremely acid (pH 3.2) at a depth of 46cm (Fedick and Ford 1990). This creates toxic and infertile conditions that greatly decrease agricultural productivity. In general, Maya lowland soils are thin but fertile on hills and well-drained areas, with thick clays dominating in low-lying areas (Fedick and Ford 1990; Scarborough 1991, 1993b; Dunning and Beach 2000; Buol et al. 2003).

WATER AVAILABILITY

In addition to the lengthy annual period of desiccation, surface water is variably distributed in the region. The eastern and western perimeters of the lowlands are drained by perennial rivers, and a string of permanent lakes stretch across the fault zone of the central Petén. Surface water is absent from the interior Petén around Tikal, however, with no natural rivers or permanent streams. Drainage catchments are found in closed-depression swamps (i.e. Bajo de Santa Fe) that hold standing water in the wet season due to their deep, impermeable clays, but desiccate completely in the dry season to a useless cementlike hardpan (Ford 1996). Reservoirs are also an extremely important component of the landscape of centers of the interior Petén region, such as Tikal. Reservoirs are discrete and controllable, especially when they are located near and incorporated into the architecture of the major and minor centers of the ancient Maya. The critical absence of water for much of the year made water storage a top priority, and the presence of reservoirs helped to ensure drinking-water availability in the dry season.

Scarborough and Gallopin (1991) report that in those portions of the southern Maya lowlands without permanent water sources or associated with large household *chultunes*, but with abundant seasonal rainfall, reservoirs probably acted as centralizing stimuli for population aggregates. Others have supported the idea that the Maya had to create artificial storage zones in order to support clustered populations (Adams 1991). According to Gill (2000), the Classic Maya relied largely on *aguadas*, *chultunes*, *cenotes* (sinkholes), and on lakes and freshwater lagoons for their source of drinking water due to the underground water table being located at a depth unreachable to most of the Maya lowlands. The water table was accessible in the north only in the *cenote* zone, where the collapse of *cenotes* permitted access to the water table, in the far north and east where elevations approach sea level and the Maya could dig wells, and along the east coast where the water table reaches the surface as fresh water lagoons. *Cenotes* form when available water percolates down through the limestone and collects in underground caverns. When the roof of the cavern collapses, the water formation is exposed. When water does collect seasonally on the surface, it is frequently contained in *bajos* (Scarborough 2003b). *Cenotes* appear more often in the northern lowlands, while *bajos* are more prevalent in the central lowlands.

Aside from the seasonal availability of *aguadas* and *bajos*, water is accessible generally year-round in *civales* (Hansen et al. 2002; Scarborough 2003b). These features are treeless, wet areas of herbaceous vegetation much less extensive than *bajos*, yet almost always located within or adjacent to *bajos*. The marshy *civales* usually remain wet throughout the dry season in most years, and many of the natural water holes are found within them (Hansen et al. 2002). *Aguadas*, *bajos*, and *civales* are karstic landscape features occurring throughout the Maya lowlands. *Bajos* alone cover between 40 and 60 percent of the interior southern Maya lowlands, and occur in

depressions relative to the general terrain of the area. The clay soils of *bajos* swell and flood during the rainy season, with the ground drying out and cracking during the dry season. *Aguadas* originate through multiple actions and offer a dependable, multi-year water source (Chmilar 2005).

The primary river systems of the southern Maya lowlands are the Rio Hondo and Belize Rivers to the east and the Usumacinta and San Pedro Rivers to the west (Scarborough 2003b). Minimal drainage exists in the elevated interior lowlands where groundwater occurs upwards of 100m beneath the surface, approaching the surface near the coast. External drainages do exist, though they primarily drain only the eastern and western margins of the greater Maya lowlands. The western Usumacinta drainage transports the most water, but its incised channels and poorly defined floodplain prohibit well-developed canalization (Scarborough 2003b:23). The eastern Rio Azul/Rio Hondo system permits slow-moving, backwash, floodplain channelizing, but due to the absorption/dispersion characteristics of the porous limestone watershed, which permits a slow-release discharge during both the wet and dry seasons, little annual water fluctuation results (Siemens 1978). Generally, this condition precludes annual floodplain sediment renewal, preventing the use of complicated water diversion techniques.

The availability of water to the ancient Maya, or in fact the lack thereof, has been cited as one possible explanation for the Classic period collapse. Many of the same scholars have alluded to climate change and drought as key factors in the reduction of water available to the lowland Maya (Siemens 1978; Hodell et al. 1995; Dunning and Beach 2000; Gill 2000; Hansen et al. 2002; Lucero 2002; Scarborough 2003; Dunning et al. 2003). Falling sea levels coupled with a decline in annual precipitation led to increasing scarcity of water, and paleoecological studies have indicated that climate change was at least partially responsible for environmental

alterations, in particular the distribution of *bajos* and *civales* (Chmilar 2005). As a result, the ancient Maya of the southern lowlands were undoubtedly dealing with an environment prior to the collapse that was markedly different, at least in terms of water distribution, from that which is present in the region today.

VEGETATION

Diverse surface topography and water availability have resulted in a varied vegetative landscape across the Maya lowlands. The semitropical jungles of the Maya area are marked by high species diversity, but a low concentration of any given species in a localized area (Scarborough 1996; Scarborough and Valdez 2003; Dunning et al. 2003).

Four distinct zones, each with a unique vegetative regime, characterize the Maya area (Chmilar 2005). Broad-leaved, closed-canopy forest, achieving a maximum height in excess of 50m, characterizes the well-drained uplands of the central Maya lowlands. The dominant vegetation of slow-drained lowlands or low-lying *bajos*, on the other hand, is high marsh forest with a broken canopy and a variety of palms and hardwoods. Vegetation communities of riverine-associated swamps such as Pulltrouser and San Antonio are dominated by a rush-sedge community, with variations relating to unique water regimes ranging through palm forest and grass communities. The vegetation of the fourth zone, closed-depression seasonal swamps such as the Bajo de Santa Fe, is noticeably different from that of the riverine-associated swamps of northern Belize. Although given to holding water for nearly half the year, the mixed xerophytic forest they support is adapted to survive the dry season, during which soil moisture is held in an unavailable (hygroscopic) state by the heavy clays (Fedick and Ford 1990). This distinctive vegetation community is also adapted to poor aeration and severe soil acidity.

CHAPTER 3

MAYA WATER MANAGEMENT PRACTICES: A REVIEW

Humans require a minimum of 2 to 3 liters of water a day in a settled environment under normal living conditions (White et al. 1972:252). This fact alone underlines the crucial role water plays in human survival, regardless of levels of physical activity, differences in body type, or environmental conditions. Almost as important, at least in terms of a society's reliance on water, is the idea that water availability limits the location of permanent populations (Scarborough and Gallopin 1991:658). Scarborough (1991a:103) writes that the natural environment partially conditions water use, and that the "primary geomorphological variables" conditioning water management are topography and soil permeability (the latter measured by rates of seepage). Furthermore, a pronounced dichotomy exists between the natural environments in which early complex societies emerged. Ford (1996) suggests four major variables that contribute to the development of complexity: overall resource productivity, local resource control, resource diversity, and critical resource control. She argues that, although taken together these factors are key to the evolution of complex societies, the source of power largely depends on the effective control and management of critical resources. She defines critical resources as those related directly to subsistence, and suggests the distribution of water in the Maya lowlands as a prime example. Historically, complicated experiments in water management occurred in arid regions with both rugged and low relief, as well as in humid settings with gentle topographic contours. The Maya lowlands is the principal humid region in the New World where complex water systems evolved (Scarborough 1991a).

In the southern Maya lowlands, many of the largest centers and their densely settled hinterlands are located in fertile agricultural areas without permanent surface water such as lakes

or rivers, but with seasonal water sources including *aguadas* and *bajos* (Fedick and Ford 1990; Lucero 1999). Tikal, Caracol, Calakmul, Naranjo, and El Mirador are some examples (Folan et al. 1995; Matheny 1987; Scarborough et al. 1994, 1995). Although the Maya first settled along coastal areas and rivers, they moved inland during the Middle Preclassic period (ca. 900-400 BC) to fertile agricultural areas located in the karstic uplands like the Petén. The karstic hills also have *aguadas*, some of which can hold water year round (Ford 1986; Lucero 1999). El Mirador and Nakbe are two well-known large Preclassic centers in the Petén, both of which were abandoned at or near the end of the Preclassic period (ca. AD 150) possibly due to a failure of their water management systems in part caused by the build-up of silt (Matheny 1987; Scarborough 1993). Even today, a lack of permanent water sources and the desiccation of many *aguadas*, streams, and other surface sources during the dry season is a major hindrance to modern settlement of many parts of the Petén (Bullard 1960).

Pioneer groups also pushed inland due to increasing population growth, following the minor streams and associated swamp margins and adapting to the four-month long dry season by living near natural depressions that might hold water for an extended period (Scarborough 1998). These natural depressions, or reservoirs, were open catchment basins partially designed to collect wet season rainfall and hold sporadic surface runoff or water from more permanent canalized sources. Reservoirs in the Maya area were of several varieties. The *chultun*, large, bell-shaped cisterns of the dry northern Yucatan Peninsula, were designed to catch rainfall from a prepared platform surface (McAnany 1990). Reservoirs were also the result of monumental building activities, although natural drainage gradients were exploited. Elsewhere in the Maya lowlands, large depressions (*aguadas*) were frequently modified from the naturally low-lying terrain (Matheny 1978).

Water management in the Maya lowlands emphasized "collection over diversion, source over allocation" (Scarborough and Gallopin 1991:658). Examination of the ancient reservoir technology in these tropical wet-dry forests of the southern Maya lowlands supports that notion that rainwater storage basins were the major source of water for many sites during a 4-month dry season. The planning and placement required for the substantial reservoir construction at Tikal, Guatemala, the best documented large community in the Maya lowlands, reveals the significance of collection and storage and suggests centralized water management. According to Scarborough and Gallopin (1991), "this centralization, evidenced by the size, location, and density of reservoirs within the spatial core of the city, also implies political and economic control by an elite, a previously unexamined urban perspective." This relationship between the control and management of water and the consolidation of power has been examined previously by multiple researchers (see Ford 1996; Lucero 1999, 2002; Scarborough 1991a, 1993ab, 1996, 1998; Scarborough and Gallopin 1991; Scarborough and Valdez 2003).

As a critical and scarce resource during the lengthy dry season, water was politically manipulated by a Maya elite to centralize and control power during the Classic period. The essential need for water made water management in a delicate, water-stressed environment a powerful organizing force (Scarborough 1998). The creation and maintenance of water systems in the settlements and urban centers of the ancient Maya concentrated water in a quantity and quality unavailable naturally. By placing water and its management system in the center of their elevated Classic-period communities, the Maya allowed a controlling elite to direct the supply. Another key factor in the relationship between water control and power is the idea that the combined factors of seasonal drought and agricultural demands resulted in the seasonal nucleation around water sources and the seasonal dispersal of many farmers during the dry

agricultural season, a pattern particularly noticeable beginning in the Early Classic period (Ford 1996; Lucero 1999). This necessary seasonal mobility made it even easier for a controlling elite to direct and manage the dispersal of water among the populace. In discussing the development of complexity and resource control among the Classic Maya, Ford (1996) proposes that the "disproportionate investment in the public realm," represented by the monumental size of Tikal, demonstrates a significant difference in labor control by the local hierarchy when compared with surrounding areas of the lowland Maya region. The major clue in the question of how Tikal and other interior Petén centers consolidated their power so effectively is found in the distribution of water in the region. In addition to the lengthy annual period of desiccation, surface water is variably distributed in the region. Perennial rivers drain the eastern and western perimeters of the lowlands, and a string of permanent lakes stretch across the fault zone of the central Petén. The interior Petén around Tikal, however, is devoid of surface water, containing no natural rivers or permanent streams. Drainage catchments are found in the closed-depression swamps that hold standing water in the wet season due to their deep, impermeable clays, but desiccate completely in the dry period to a "useless cementlike hardpan" (Ford 1996).

The weather pattern of the Maya lowlands makes for a seasonal deficit of water at the height of the dry season, resulting in a serious drinking-water problem at that time. This seasonal water shortage clearly presented a major obstacle in the past, especially in the interior Petén. Likewise, the interior Petén was the last area of the lowlands to be settled in the "pioneering developmental period" and the first to be abandoned with the local collapse of the Maya civilization (Ford 1996). The dispersed nature of the elite hierarchy was inherently weak, and could have had a destabilizing effect on population integration. As a result, other mechanisms to effectively enforce controls on competing members of the elite had to exist. Consolidation of

control in the interior Petén relates directly to the nature of critical resources, "those resources that are vital to subsistence and discrete enough to be controlled by the elite" (Ford 1996). While agriculture was a focus of elite control for the Maya, as it was for complex societies in other areas of the world, the distribution of agrarian land in the Maya area is not sufficiently concentrated to manage directly. The critical absence of drinking water during the dry season, however, provided an important mechanism for control (Ford 1996; Lucero 1999; Scarborough 1996). As a daily survival requirement for humans, water is vital to dry-season subsistence and could be readily used as a control mechanism. Reservoirs are a very important part of the landscape of centers in the interior Petén, such as Tikal where a minimum of thirteen major reservoirs have been mapped (Carr and Hazard 1961). Reservoirs are also discrete and controllable, especially when located near and incorporated into the architecture of the major and minor centers of the ancient Maya. As part of the organization of centers, then, access to reservoirs was monitored and restricted without great effort. The centralized drinking-water resources could have solidified ties among members of the elite, while serving to integrate their constituent populations (Ford 1996, Lucero 1999, 2002).

Lucero (2002) contends that the scale of water control correlates with the degree of political power, reflected in three levels of Maya civic-ceremonial centers—regional, secondary, and minor. Regional centers such as Tikal, Calakmul, and Caracol were located in upland areas with large pockets of dispersed fertile land difficult to monopolize and lacking permanent water sources. The need for an adequate water supply in the area of these regional centers is directly related to annual rainfall. Secondary centers such as Lamanai, Dos Pilas, and Xunantunich are typically found in upland areas with dispersed pockets of agricultural land that supported local polities. Settlement was typically dense near centers and not as dense in hinterland areas. These

centers arose as secondary polities because of their rulers' participation in a royal interaction sphere established by regional rulers. Minor centers, including Barton Ramie and Saturday Creek, were located along the Belize River with extensive alluvium. These centers were located in lower elevations and had higher annual rainfall than the majority of regional centers (Ford 1996; Lucero 1999). These communities were also composed of relatively low-density dispersed farmsteads, a condition not conducive to aspiring leaders interested in monopolizing resources and acquiring surplus. Power derives from a complicated relationship among center location, seasonal water supply, amount of agricultural land, and settlement density. Maya elites, then, monopolized artificial reservoirs and other water sources during annual droughts, providing the means to exact tribute from subjects (Lucero 2002).

PRECLASSIC PERIOD WATER MANAGEMENT

Sizable communities anywhere in the world are necessarily located near sources of fresh water. In the lowlands, however, these sources were not always available naturally. The Maya were forced to create them. They controlled water in at least three ways: by draining excess water from inundated lands, by conserving soil moisture, and by collecting and storing water. Reservoir storage and canal diversion systems drew from small perennial drainages and seasonal runoff catchments. To a large extent, the water systems define the community in the Maya lowlands (Matheny 1978:186; Scarborough 1991a:125, 138).

Large-scale water systems first emerged in the Maya area by the Middle Preclassic. Early in the first millennium BC the Maya were already landscaping their environment, and by 1000 BC they had initiated runoff modifications (Gill 2000; Scarborough 1993b). The earliest evidence for water manipulation in the Maya lowlands is reported from Albion Island, Belize (Bloom et al.

1985; Pohl 1990) and more recently from Cobweb Swamp, Belize (Jacob 1991). The two central elements of water management, channelizing or ditching and basin construction, appeared prior to monumental architecture, as might be expected if population growth is highly dependent upon water management (Matheny 1982:163; Scarborough 1993b:28, 61). Late Preclassic hydraulic technology focused on developing low-lying depressions, or *bajos*, as water reservoirs. Scarborough has termed these concave microwatersheds (Scarborough 1994:188). The earliest landscape engineering took place at the margins of these *bajos*, direct developments of the earliest villages associated with ponded water. As early as the Late Preclassic, the Maya had begun to alter the lower areas of gently sloping landscapes to catch and divert water into artificial channels and reservoirs. These modifications created concave microwatersheds that channeled and retained the natural runoff from the surrounding higher elevations and held the collected water for extended periods through the dry seasons (Gill 2000).

Reservoirs in the Maya area were of several varieties. The large, bell-shaped cisterns (*chultunes*) of the dry northern Yucatán Peninsula caught rainfall from a prepared platform surface (McAnany 1990; Scarborough 2003). These tanks also had extremely narrow orifices to limit evaporation. In contrast, open-surface reservoirs were the result of quarrying for monumental construction, although natural drainage gradients were exploited (Scarborough 2003:50). Elsewhere in the Maya lowlands, large depressions (*aguadas*) were frequently modified from the naturally low-lying terrain (Matheny 1978). In addition, Harrison (1977) has theorized that even the internally drained swamps (*bajos*) covering extensive tracts of the Maya area today were altered to establish predictable water levels for supporting raised-field agriculture. The sites of Cuello and Nakbe represent Preclassic examples of water storage in both *chultunes* and quarried depressions (Scarborough 1991). By the conclusion of the Late

Preclassic, Cerros, Edzná, and El Mirador indicate significant alterations to their immediate environment with the excavation of canal and reservoir systems and the construction of causeways, used to dam or divert water through depressed zones (Scarborough 1994:187-188).

Cerros: At the Late Preclassic community of Cerros, Belize (c. 200 BC—AD 150), the volume of construction fill used in the built structures compared favorably to that removed from the extensively quarried canal and reservoir depressions. Through the manipulation of sills—horizontal blocks of stone extending into a tank or canal segment allowing access to the lower depths of the water-holding basin—and dams, water was conserved in "basin canals" during the dry season, and the community's center was drained during the wet season (Scarborough 1983). Research suggests that approximately 200,000 m^3 of quarried fill was removed from the site, with the systematic horizontal stripping of the underlying limestone producing a manmade watershed (Scarborough 1991a). The core area of the site enclosed by the main canal extended over 37 ha and contained 99 percent of the structural fill volume identified at the site, but registered only a 2m relief differential across its surface, excluding elevated structure height (Scarborough 1991b). Quarry fill was obtained predominantly from within the core area, and removed systematically to produce the catchment surface and depression volume that defined the water management system.

The main canal at Cerros was 1.2 km long, approximately 6m wide and 2m deep, and graded less than 1m from west to east (Scarborough 1993b). Rainy season runoff was directed into tanks and basins throughout the community due to the system of reservoirs, feeder canals, sills, and dikes. The contours at the site indicate that high ground connected all residential and civic space, while also providing ready access to water.

Another interesting feature of the site was a low relief area that featured a number of raised fields separated by a causeway (*sacbe*) from two reservoirs and a number of house mounds. The causeway was constructed mainly by quarrying the margins of the feature to create the adjoining low-lying areas. In addition to connecting the residential area to the northwest with a ballcourt group to the southeast, the road also functioned as a dike. Acting as a dam, it separated the private and (presumably) potable water source of the reservoirs from the more public and agricultural water source of the raised fields and main canal (Scarborough 1993b, 1994, 2003).

Cerros is a prime example of a Late Preclassic concave microwatershed, with its hydraulic system separated by an elevated road or dike into settlement-wide agricultural sources on one side and potable private household sources on the other. Canalization was well developed in this slow-moving, internally drained system (Scarborough 1991ab).

Edzná: At the much larger Late Preclassic site of Edzná, Campeche, the Maya used a system of linear canal reservoirs for potable water, as well as for transportation (Matheny 1976). Matheny (1976; Matheny et al. 1983) has reported that over 1.75 million m^3 of fill were removed in the construction of these monumental canal basins, a figure much greater than the volume of the Pyramid of the Sun at Teotihuacan. This water storage system was part of a planned city that covered about 17 km^2. Most of the water system was constructed during the Late Preclassic period, and there are several mounds of this period built on top of the canal banks (Matheny 1982). These canals are huge constructions, with one of them involving the removal of about 900,000 m^3 of water. The main canal at Edzná measures 12 km in length, with a depth of about 1.5m, and a width of 50m for at least half its length (Scarborough 1993b; Gill 2000). The canal

connects a large moat system at its north end, which joins at least twelve other canals converging on the city center in a spoke-like alignment that was associated with several residential reservoirs. The entire storage capacity of the canal basins was approximately 2,000,000 m^3 (Scarborough 1993b).

Multiple researchers have cited Edzná as evidence of deliberate water control (Matheny 1976, 1978, 1982; Matheny et al. 1983; Gill 2000; Scarborough 1993b). Reservoirs in the northwest region are at a higher elevation than connecting canals. As the water ran from these reservoirs to the south end of the canals near the city center, smaller "feeder canals" directed it to other reservoirs closer to public buildings and residences (Gill 2000). Interestingly, this is the reverse of the distribution process that would later be reported at Tikal. In addition, there is evidence of tanks that were probably used to clean the water collected in the northern canals. From these holding and cleaning tanks, water was directed to the other holding tanks, presumably for consumption (Matheny 1976:642, 1978:203; Scarborough 1993b:34).

The 31 canals and 84 reservoirs at the site provided water in excess of agricultural requirements, and were possibly also used for pot irrigation (Matheny 1976, 1978, 1982). Along with the hydraulic system, there was much soil manipulation by banking, platform building, small-dam construction, causeway building, and channel excavating. Edzná is an excellent example of a site where the basic layout of the city was closely integrated with the plan of the water system. The Maya manipulated the upper Edzná Valley in the Late Preclassic period to satisfy their food production needs and to provide water for a population that built hundreds of constructions covering 17 km^2.

El Mirador: Like at Cerros, *sacbeob* (causeways) traversed low-lying *bajo*-like settings in proximity to the central precinct of Late Preclassic El Mirador (Dahlin 1984; Scarborough 1983, 1991ab, 1993a, 1994). Similar to other Petén sites such as Calakmul and Tikal, El Mirador exhibited a dependency upon the reservoir system. Water supplies are the most limiting feature of this environment, with no perennial freshwater supplies existing near El Mirador or the major site of Nakbe, 13 km to the southeast (Hansen et al. 2002). Water-storage *chultunes* are common to the area, however, and six have been identified at El Mirador (Matheny 1982). In addition, three large reservoirs were discovered and found to transport water from adjacent building complexes and, in one case, from a partitioned *bajo*. The site rests on the immediate margins of a sizable *bajo*, which is traversed by four lengthy causeways radiating from the site center (Scarborough 1993b). Removal of quarried fill used in the construction of these causeways modified the existing depression (Dahlin 1983). Given the quantity of clay and limestone used in the construction of the structures at the site and the absence of large quarry scars (at least within the huge West Group), *bajos* are assumed to be the source for much of the fill used in constructing El Mirador (Scarborough 1993b). The causeways might also serve as accessways into the *bajos*, possibly representing the original, slightly elevated ground of the *bajo* surface. A desired gradient during the rainy season may also have been achieved by scraping the bed of the *bajo* floor. Not only would structural fill be made readily available for pyramids and courtyard groups, but also portions of the *bajo* would be used to promote agricultural ends. Scarborough (1983, 1991b) has noted that the lateral stripping of caprock for construction fill has been well documented at Cerros at a comparable period.

According to Matheny (1982), it is likely that the reservoir system at El Mirador was planned, and that the barrows for buildings and platforms were later made into reservoirs. The

strategic placement of building complexes that served as catchment areas was undoubtedly important to the success of these reservoirs. The energy and time necessary to construct some causeways may also reflect attempts to impound runoff or divert it to locations better suited for human use. Causeways functioned as dikes or dams in later periods (Scarborough 1993b).

CLASSIC PERIOD WATER MANAGEMENT

The underground (or phreatic) water table was out of reach for most of the Maya lowlands, and they were forced to adapt. For their source of potable water, the Classic Maya relied mainly on surface water reservoirs (known today as *aguadas*), subsurface cisterns (*chultunes*), sinkholes (*cenotes*), and lakes and freshwater lagoons (Gill 2000). Where the Late Preclassic Maya positioned their communities at the margins of *bajos* or related depressions, subsequent Classic period cities adopted a land-use strategy requiring construction of their largest and most densely concentrated civic centers at the summit of elevated hillocks or ridges (Scarborough 2003). The Classic-period, "built-urban" environment was more deliberate than the concave microwatersheds of its predecessor, and was characterized by sizable but elevated reservoirs. Excavated for the fill produced in constructing the monumental architecture of the major centers, these reservoirs were designed to receive the large quantities of runoff flowing seasonally over the great plazas, pyramids, and palaces. During the dry season, these convex microwatersheds permitted the directing of water downslope to residential consumers and *bajo*-margin agricultural plots (Scarborough 2003). In contrast to the Late Preclassic, Late Classic hydraulic technology permitted the Maya to build cities on high ground, essentially using the city itself as the watershed for the reservoirs created from quarries and borrow pits, or convex microwatersheds. The Classic period sites of Calakmul and Caracol each had artificial reservoirs

constructed adjacent to monumental palaces and temples (Lucero 2002; Scarborough 1998). Calakmul, which is surrounded by *bajos*, contains extensive canal systems in addition to 13 reservoirs and aguadas (Folan et al. 1995). Caracol has at least two major reservoirs next to temples and is surrounded by hillsides terraced for both agriculture and water control (Lucero 2002).

At Late Classic period (AD 600-900) lowland Maya sites such as Tikal, La Milpa, and Kinal (Scarborough 1993b, 2003; Scarborough and Gallopin 1991), runoff across the shaped surface of a convex microwatershed allowed for greatly improved control over the resource than did the earlier lowland systems. The small hills on which these sites rest, removed from permanent streams or springs, were heavily paved with plastered surfaces angled toward elevated reservoirs. The most elevated central precinct catchment at Tikal, for instance, covered an area of 62 ha. Because the impermeable plaza pavements and plastered monumental architecture reduced seepage loss, this area alone could collect more than 900,000m^3 of water (based on 1,500 mm of annual rainfall) (Scarborough 2003). The runoff from this and adjacent catchment areas easily filled the associated reservoirs and natural depressions (*aguadas*), leading ultimately into the adjacent swamps (*bajos*).

***Tikal*:** By the Late Classic period, Tikal displayed one of the most sophisticated water control systems in the New World (Scarborough and Gallopin 1991). According to Scarborough (1993b), a heavy investment in upland water control during the drought-like conditions hypothesized for the Early Classic period permitted the environmental and cultural alterations of the Late Classic. Large, well-defined reservoirs were identified very early at Tikal, where the Maya constructed a complex watershed designed to capture rainfall from the thick and

impermeable plastered surfaces covering the imposing architecture and spacious plazas. Building upon more than a thousand years of landscape modification, these Maya shaped the limestone hills to allow gravity to provide the core community with an adequate supply of water (Scarborough and Gallopin 1991; Scarborough 1996). The planning and placement required for the substantial reservoir construction at Tikal demonstrates the significance of collection and storage. The water management system was designed to accommodate the seasonal availability of rainfall, the absence of permanent streams or springs, and the gentle topographical relief of the region.

Six major reservoir catchment areas or drainage divides drain the summit of this artificially modified watershed and range in area from 9 to 62 ha (Scarborough and Gallopin 1991; Scarborough 1993b; Lucero1999; Gill 2000). The directed runoff from the summit of the site core easily filled the associated reservoirs. All sizable catchment areas ultimately terminated in *bajo*-margin reservoirs or natural *aguadas*, eventually leading into the flanking *bajos*. In addition, three reservoir types are documented within the catchment areas: (i) central precinct reservoirs, (ii) residential reservoirs, and (iii) *bajo*-margin reservoirs (Scarborough and Gallopin 1991; Scarborough 1993b; Scarborough 1996; Lucero 1999).

The six central precinct reservoirs are located near the summit of the city within the core or epicenter of the site. These reservoirs retained runoff from the largest and most completely paved reservoir catchment area, where more than 900,000m^3 of water could be collected from the entire catchment annually (based on 1500 mm of rainfall per year) (Scarborough and Gallopin 1991). The central precinct reservoirs appear to have stored major water reserves for the seasonal replenishment of the *bajo*-margin reservoirs, and the controlled release of water from elevated reservoirs to downslope flanks and adjacent *bajo* margins would have provided

potable water as well as moisture during the dry season. All central precinct reservoirs were formed behind well-defined causeways, which connected various portions of the city's core while also damming water within the major catchment area.

Residential reservoirs are located downhill from the central precinct within the most densely populated zone immediately outside the epicenter's public architecture. These depressions are generally smaller than the other reservoir types identified. Most are diminutive, with a diameter of less than 10m and a depth of 1m, and are located close to a house mound group (Scarborough 1996). These features, in addition to *pozas* (small household reservoirs) also identified at the site, appear to be strictly for domestic use. Neither of these features appear to have been replenished from central precinct reservoirs during periods of drought. Reservoirs of this type are common to nearly all sites in the Maya area (Scarborough and Gallopin 1991).

Near the foot of the ridge on which central Tikal sits, positioned approximately equidistant from each other and located roughly in the cardinal directions from the epicenter of the site, are the four *bajo*-margin reservoirs. These reservoirs have been identified as such due to their proximity to the *bajos* bordering the site, and include some of the largest reservoirs at Tikal. They are located away from the densest concentrations of house mounds in the central part of the site and are directly connected in at least two cases to the elevated central-precinct reservoirs by drainage channels. These basins are positioned to receive most of the runoff issuing from the edges of the outcrop defining central Tikal. Given their size and placement, they are viewed as holding tanks for the allocation of water to agricultural fields (Scarborough and Gallopin 1991; Scarborough 1996).

The Tikal system represents the most complex example of water management in the Maya lowlands. Although one of the largest Classic period cities, Tikal is not the only southern

Maya lowland site with neither rivers or springs nearby. Most Classic Maya cities of Tikal's complexity, if not its size, are located on natural promontories away from permanent water sources. Because of the size, density, and location of reservoirs within the spatial nucleus of the city, the water management system indicates resource specialization (Scarborough 1996; Ford 1996). By utilizing a gravity-flow system, the Maya of Tikal were able to provide residential populations within and near the central precinct with regularly replenished water stores during the dry season.

La Milpa: The site of La Milpa in northwestern Belize is a prime example of a convex microwatershed, and illustrates the sophistication of a reservoir-based water system dating primarily to the Late Classic period (Scarborough 1993b; Scarborough et al. 1995; Scarborough 1998). Like Tikal, it has revealed a complicated water system at a site with no permanent water source for four months of the year. The builders of La Milpa positioned the site on a natural hillock in order to best use the quarried surface for construction fill and the resulting reservoir and rainwater catchment surfaces. The "convex" topographic relief permitted greater control of runoff across this artificial microwatershed than was apparent at earlier Late Preclassic communities (e.g. Cerros, Edzná, etc.), which were dependent on natural "slope-margin runoff" carried into a low-lying site center (Scarborough et al. 1995).

The upper portions of local watersheds draining the site core at La Milpa were dammed in order to create reservoirs. The release of water from these reservoirs may have been controlled through the combined use of sluice gates and check dams (Scarborough et al. 1995). One function of this intricate water diversion strategy appears to have been to regulate soil moisture levels in pockets of flatter upland soils which appear to have been used as plots for intensive

agriculture (Dunning et al. 1999). The central precinct of the site dominates the summit of a small hill, with three reservoirs positioned at the tops of three gently sloping arroyos providing natural drainage for the site.

The majority of runoff from the main plaza associated with the grand architecture at the site was directed into the northwestern arroyo. Test excavations at the site revealed a 17.5m long, U-shaped dam at the plaza edge that would have aided in ponding and retaining water (Scarborough 1993b). The second reservoir dam was a severely eroded earthen feature. This reservoir is positioned to the south of the main plaza and received runoff from the southern third of the summit catchment. A series of sluices appear to have been intentionally cut through the embankment in an attempt to better control the passage of water. The third reservoir, located to the southeast, was relatively large and appears to have provided potable water to a complex of elite courtyard groups at its margins and further downslope. Each of these reservoirs drained into channels carrying water to the south and southwest.

Ridges occupied by courtyard groups and house mounds bordered the associated channels. Intermittent check dams controlled the velocity of the water as it flowed from the reservoir, preventing unnecessary rainy-season erosion. After exiting the reservoirs and the inclined channel drainage, water fanned out over a series of flats presumed to be fields. A system of shallow earthen canals and at least one *chultun*, believed to have functioned as a cistern based on its discovery within the drainage margins of the field zone, have also been uncovered at the site (Scarborough 1993b). Finally, an aguada, modified to improve water retention and apparently recharged during the rainy season by runoff from the south and southeast channelized arroyos, is also present.

The water system at La Milpa, like that at Tikal, was extremely complex. As demonstrated at other sites, the Maya created a microwatershed at La Milpa to accommodate the lengthy seasonal drought. In addition to the water conservation measures associated with reservoirs, planned channelization, diversion weirs, and the fields themselves, the importance of rainy-season erosion control is indicated at La Milpa (Scarborough et al. 1995).

Kinal: The site of Kinal, located 25 km southwest of La Milpa and 65 km northeast of Tikal, sits on a ridge dividing two massive *bajos* to the northeast and southwest. In contrast to the central precinct reservoir adaptation, in which water was collected from the summit catchment and held in large tanks for release downslope, the Kinal system was only dependent on the summit catchment for the diversion of runoff (Scarborough 1993b, 1996). The tanks at Kinal were positioned downslope from the central precinct, within the residential core but near the supposed location of fields. The channel gradient that fed the Kinal reservoirs was steeper than those identified at Tikal or La Milpa, and required methods of slowing the movement of water into the reservoir such as check dams, a one-piece diversion stone, and a pooling area, each designed to decelerate erosion (Scarborough 1993b:59). A dam or weir approximately 8m in length, which directed channel water from the central precinct into a very small silting tank before it entered the main body of the reservoir, has been exposed at the Kinal West Reservoir. In addition to preventing large particulate matter from entering the potable water supply, the reservoir was designed to systematically release water during the dry season. A V-shaped outlet was discovered, placed at a depth in the reservoir embankment indicating that the entire volume of the reservoir could be drained (Scarborough 1993b:31, 1996:59).

Despite the fact that no sizable central-precinct reservoirs have been identified at Kinal, water was captured from the numerous paved surfaces associated with the central precinct at the site and directed into residential/*bajo*-margin reservoirs. Although the Kinal reservoir system represents a less centralized form of water management than the Tikal and La Milpa systems, the care taken to control erosion and sedimentation was pronounced and well-defined at the site, reflecting the reservoir dependency of the lowland Maya.

The advancement of Maya civilization in the southern Maya lowlands was a consequence of several factors. One underrated influence was the availability and enhancement of water access. In addition to monumental building, the Maya had another, more immediate agenda in their landscape engineering. They replaced the natural terrain with a "carefully contoured cultural relief" by systematically quarrying at some locations and elevating at others (Scarborough 1993b:61). The lack of midden debris reported in the epicenter of Tikal (Harrison 1993) is one indication of the importance of such water catchment surfaces. The dispersed household and public building pattern in Maya centers reflects in part an attempt to maximize the quality of the water source, and the unintentional addition of household waste to the main water supply was clearly discouraged. Maya watershed management processes were accretional, with the Late Preclassic "concave" landscapes evolving into Classic period "convex" watersheds of urban proportions. Although these developments may have been partially triggered by climatic change, increases in population combined with the fluctuating availability of resources, unstable political relationships, alliance formation, and exchange access were clearly key players impacting settlement growth and development. Nevertheless, the seasonal water deficit represented a constant pressure upon an expanding state. The dispersed settlement pattern of the ancient Maya may have evolved in part as a consequence of the limited amount of permanent

water available on the karstic landscape (Scarborough 1994). As the sites discussed above show, relatively isolated natural *aguadas* and human-made reservoirs were focal points for household and small community development, but were inadequate for large urban populations.

CHAPTER 4
METHODOLOGY

Excavations at the Medicinal Trail Depression took place at the Medicinal Trail site, northwest Belize, over an extended six-week field season from mid-May through June 2006. Each sub-operation (subop) was excavated for a specific purpose, as described below. Primary tools used for excavation were large pick-axes, shovels, small hand picks, and a variety of brushes. Due to the relatively loose, non-clayey composition of the local soil, wire screens were sufficient for dry screening. Lithic and ceramic material, as well as any additional recovered artifacts, were collected in the field and transported to the R.E.W. Adams Archaeological Research Facility lab for analysis. Following the conclusion of the excavations, all subops were completely backfilled.

Prior to excavations, a grid was established at the depression (Operation 10) to control and track the placement of excavation units (subops). The starting point for the grid, or its 100/100 coordinate, was the same point used by Me-Bar during the 2004 season. This grid central point is located on the level terrain between Structure 7 of Operation 7 and the northwest side of the depression. It is oriented 20° east of north. This alignment was probably used by Me-Bar to tie into the same grid established by Hyde at Op 7, which Hyde initially based on the orientation of the mounds and courtyard located there. After the grid was established at Op 10, each subsequent subop was given a coordinate based on the location of the southwest corner of the unit. For example, the southwest corner of Subop A is ten meters south and four meters east of the grid central (100/100) point, so it's coordinate on the grid would be S90E96 (Figure 4.2).

EXCAVATION UNITS

Sub-operation A (S90E96): This initial subop was a 2x2m unit through the first three lots then a 1x2m unit through lots 4 and 5, opened in the southeast quadrant of the depression nearest its projected deepest point. The function of this unit was to establish a basic soil stratigraphic profile for the site, as well as to gain a preliminary understanding of the amount of ceramic and lithic material present.

Sub-operations B (S92E96), C (S92E95.5), D (S92.5E96), E (S92.5E95.5), F (S93E96), G (S93E95.5), H (S93.5E96), and I (S93.5E95.5): These subops were a series of eight 50 cm (0.5 m) x 50 cm units that formed a 1x2m pit located between subops A and J. Due to the extremely high density of lithic and ceramic materials collected from Subop A, these units were excavated in 50x50 cm blocks in order to establish very fine control over artifact densities. A secondary objective was to attempt to isolate a possible activity area within the site.

Sub-operation J (S94E96): This unit contained five lots, with lots 1 and 2 measuring 2x2m and lots 3-5 measuring only 1x2m. This anomaly is due to the fact that once we reached a depth of 18 cm, we realized that we were excavating into backfill from Me-Bar's 2004 excavation of Subop AB. As a result, we halted excavation in the northern half of the unit and continued to excavate down to the bedrock in the southern portion. The objectives of this subop were to continue to attempt to locate a possible activity area within the site, as well as to extend the previous subops toward the north end of the site.

Sub-operations K (S89.5E96), L (S89.5E95.5), M (S89E96), N (S89E95.5), O (S88.5E96), P (S88.5E95.5), Q (S88E96), and R (S88E95.5): These subops were a series of eight 50 cm (0.5

m) x 50 cm units that formed a 1x2m trench adjacent to the south side of Subop A. The units were divided into lots that terminated arbitrarily at depths of +/- 10 cm. Subops K, L, M, and N each contained four lots, terminating at bedrock at an average depth of 41.25 cm. Subops O, P, Q, and R each contained only three lots due to their location on a shallower upslope of the depression, and terminated at bedrock at an average depth of only 31.25 cm. Like subops B-I, these units were excavated in 50x50 cm blocks in order to establish very fine control over artifact densities.

Sub-operations S (S89.5E95), T (S89.5E94.5), U (S89E95), V (S89E94.5), W (S88.5E95), X (S88.5E94.5), Y (S88E95), and Z (S88E94.5): These were a series of eight 50 cm (0.5 m) x 50 cm units that formed a 1x2m pit adjacent to the south side of Subop A and the eastern side of subops K-R. The units were divided into lots that terminated arbitrarily at depths of +/- 10 cm. Subops S, T, U, and V each contained four lots, terminating at bedrock at an average depth of 46.25 cm. Subops W and X, located on the shallower slope, contained three lots each and ended at the bedrock layer at an average depth of 37 cm. Due to their location in an even more shallow area of the site, subops Y and Z were composed of only two lots, concluding at an average depth of 25 cm from the surface. Like the previously excavated 50x50 cm units, the purpose of opening subops this size was to establish greater control over artifact densities.

Sub-operations AA (S92E95), AB (S92E94.5), AC (S92.5E95), AD (S92.5E94.5), AE (S93E95), AF (S93E94.5), AG (S93.5E95), and AH (S93.5E94.5): These were a series of eight 50 cm (0.5 m) x 50 cm units that formed a 1x2m trench located between subops A and J and adjacent to the east side of subops B-I. Like the previously excavated units of this size, each

subop was divided into lots that terminated arbitrarily at depths of +/- 10 cm. Each unit contained four lots, terminating at an average depth of 45.75 cm from the surface. These subops were opened to connect subops A-J, resulting in a 2x6m trench excavated down to bedrock in the center of the site. The reason for opening subops of this size was again to establish greater control over artifact densities, with the expectation of encountering artifact amounts similar in quantity to those of subops B-I.

Sub-operation AI (S94E94): This was a 1x2m unit located contiguous to the southern half of Subop J on its eastern side. The subop contained four lots, terminating somewhat arbitrarily at soil changes, and with an average depth of 15.25 cm. The unit sloped drastically downward from east to west, with maximum depths of 61 cm in the eastern half and 97 cm in the western half. The presence of several large roots and root holes, averaging 11 cm in diameter, were noted throughout this unit due to its proximity to a large ceiba tree in the southeast portion of the site. These roots not only complicated work within this unit, but their presence prevented the possibility of further excavation in the area. This subop was opened to expand previous excavations to the eastern side of the site and to track material concentrations in this direction.

Sub-operations AJ (S88E96), AK (S90E90), AL (S90E88), AM (S92E92), AN (N102E100), AO (N102E98), AP (N102E96), AQ (N101.5E94), AR (N101E92), AS (S98E92), AT (S98E90), AU (S96E88), AV (S90E88), AW (S88E87.5), AX (S86E94), AY (S86E96), AZ (S86E98), BA (S86W102), BB (S88W102), BC (S90W102), BD (S96W102), BE (S98W102), BF (S100W102), and BG (N102W102): These subops were a series of 24 postholes opened around the perimeter of the entire site in order to determine future locations for the placement of

1x1 m test pits. Our goal was to expand several of the postholes into these small test units based on the highest material densities. Analyzing these test pits in relation to one another and the rest of our excavations would help us determine where certain activities such as the working of tools had occurred within the site and where further investigation may be necessary.

Sub-operation BH (S90.5E98): Subop BH was a 2x2m unit contiguous to the western side of Subops A and B. The unit contained four lots with arbitrary terminations every 10 cm and bedrock sloping downward from south to north and east to west. The depth in the southwest corner was 33 cm. This subop was opened in order to determine the spatial extent of a layer of cobbles exposed on the western side of Subops A and B. This cobbly layer was unique to the site, and we hoped that excavating this unit would help us better understand its presence and possible function.

Sub-operation BI (S88.5E100): This was a 2x2m unit located to the southwest of Subop BH, near the southwest rim of the depression. The unit contained three lots, terminating arbitrarily at +/- 10 cm, and had a depth of 27 cm. The purpose of this subop was to examine artifact densities in this area of the site as well as to partially connect our 2x7m trench to a portion of Me-Bar's prior work.

Sub-operation BJ (S96E98): Subop BJ was a 2x2m unit located to the northwest of Subop J. This deep unit included five lots with arbitrary terminations every 10 cm, and it had a total depth of 92 cm in its southwest corner. The unit sloped sharply downward from north to south, due to its location on the northwestern slope of the depression. This subop was opened in an attempt to

locate a second “post hole” related to Me-Bar’s discovery a few meters to the east. If the “compact, cemented structure” (Me-Bar 2004) did serve as a support for some sort of overhang, then a second one would have been needed. Me-Bar (personal communication 2006) suggested this as the most promising location.

Sub-operations BK (S95E90), BL (S89E89), and BM (S84.5E96): These were 1x1m units opened with the goals of identifying possible activity areas located around the rim of the depression (based on artifact densities), or evidence of unnatural modifications to the bedrock indicating channeling or quarrying. Each contained four lots with arbitrary terminations at +/- 10 cm in depth. Subops BK and BL each had a maximum depth of 32 cm, and they were located on the eastern and northeastern rims of the depression, respectively.

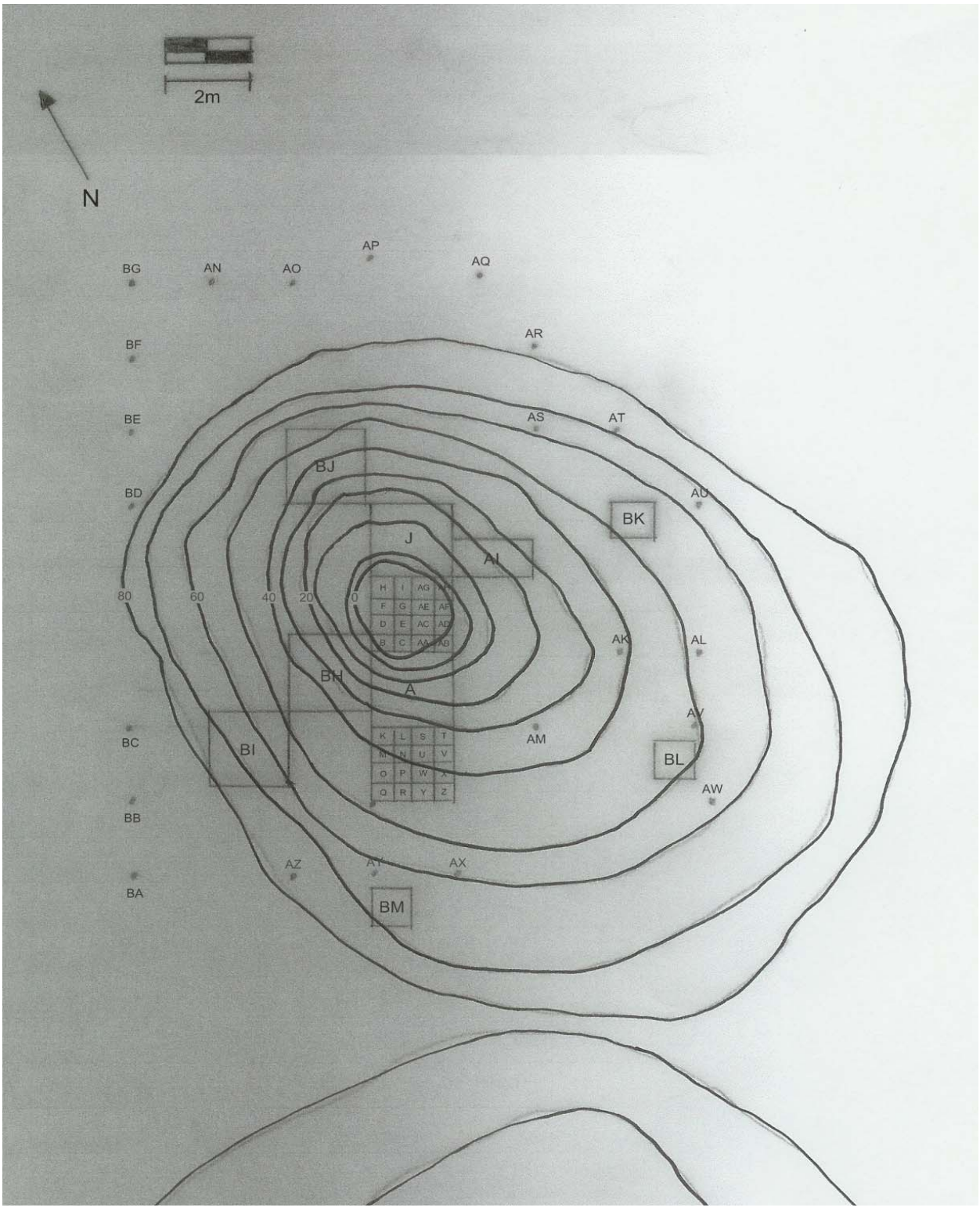

Figure 4.1. Contour map of the Medicinal Trail depression (Op 10) showing the location of sub-operations. Contour interval is 0.20m.

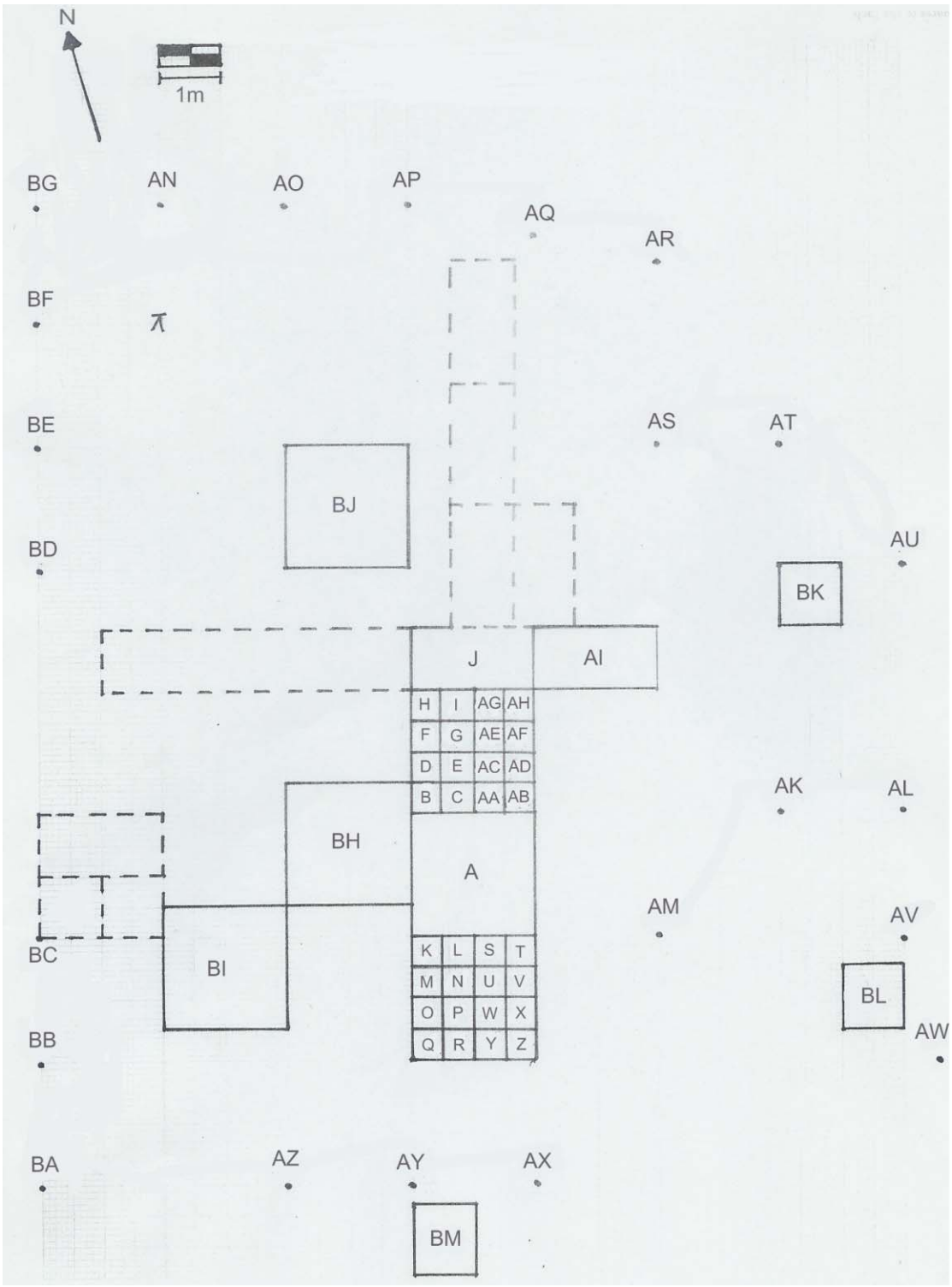

Figure 4.2. Layout of Operation 10 sub-operations. Dashed lines represent Me-Bar's 2004 excavation units.

Figure 4.3. Sub-operation A, a 2mx2m unit. The photograph is facing southeast.

CHAPTER 5
EXCAVATIONS

Sub-operation A

Subop A was a 2mx2m unit located in the southeast corner of the site. The surface of the subop, like that of the entire site, was covered by a minimal amount of humus and spotty, scrubby vegetation that was entirely cleared prior to survey and excavations. The unit was composed of 5 lots, with a total depth of 63 cm BD. Lot 1 began at the present surface of the depression and terminated at a depth of 14 cm BD. The soil composition of this lot was a dark brown/gray thin humus layer. A moderate amount of lithic and ceramic fragments, with diameters generally ranging in size from three to six centimeters, was collected from lot 1. Ceramic types included Subin Red, Achote Black, and Cayo Unslipped. In addition, small amounts of charcoal and lithic material that appear to have been fired were also recovered. Collected lithic material included the remains of four stone tools.

Lot 2 had a total thickness of 11 cm, terminating 25 cm BD, and was composed of interface material below the initial layer of humus. Like all of the lots within this subop, lot 2 began and terminated arbitrarily at observed changes in soil color and/or texture. The soil of this lot was medium to dark gray in color and relatively crumbly in texture, with vertical elevation within the lot increasing from north to south due to the subop's location on a slope. An increase in both lithic and ceramic material from lot 1 to lot 2 was noted. Ceramic types in this lot included Garbutt Creek Red, Achote Black, and Cayo Unslipped. This lot contained large amounts of fist-sized cobbles and multiple worked cores from the remains of eight stone tools, and boulders were exposed in both the northwest and southeast quadrants. In addition to an

amount of charcoal/carbon material similar to that of lot 1, a small obsidian flake was also recovered from lot 2.

Lot 3 was 18 cm deep and also composed of interface material. Its maximum depth was 43 cm BD. Soil color changed within this lot from medium/dark gray to light gray/white, with the texture of marl/limestone fragment inclusions. This lot was dominated by a heavy presence of gravel, pebbles, and cobbles, as well as a large amount of what appeared to be chert discard. The continued presence of lithic material that appears to have been fired and two stone tool fragments were also noted, as were multiple large terrestrial snail shells. Ceramic types present in lot 3 included eroded Late Classic sherds and an eroded basal flange with ash temper. The paste on this basal flange bowl is uncommon to the Programme for Belize project area (Lauren A. Sullivan, personal communication, 2006).

Lot 4 was a 1x2m unit located on the eastern half of Subop A. It had a total thickness of 10 cm and terminated at bedrock, 52 cm BD. This lot contained amounts of ceramic material much lower than the preceding ones with a noticeable increase in lithic cores. Ceramic types included eroded body sherds, Cayo Unslipped, and one Early Classic style rim. Lower densities of pebbles and gravel, as well a total absence of shell, also differentiate this lot from lot 3. Soil change continued with color ranging to lighter gray/white and texture becoming finer. A “trench” with a maximum depth of 85 cm dominated this lot.

Lot 5 was a 1x2m unit located on the western half of Subop A. It also terminated at the bedrock layer, 53 cm BD, and had a total thickness of 10 cm. The unit sloped downward from south to north, and it contained a round cavity in its northwest corner with a maximum depth of 1m BD. This lot contained amounts of lithic and ceramic material comparable to those of lots 1

4, including a single stone tool. Ceramic material within this lot was of the Cayo Unslipped type. A 3-liter soil sample was withdrawn from the northwest corner of the lot at a depth of 46 cm BD and the east wall of the unit was profiled (Figure 5.1).

Lot	1	2	3	4	5
Ceramics	31	191	203	113	8
Debitage	105	0	269	30	112
Tools	4	8	2	0	1
Total	**140**	**199**	**474**	**143**	**121**

Table 5.1. Artifact counts in Sub-operation A by lot.

Sub-operations B, C, D, E, F, G, H, and I

These subops were a series of eight 50 cm (0.5m) x 50 cm units that formed a 1x2m pit located between subops A and J. The units were divided into lots that terminated arbitrarily at depths of +/- 10 cm. Subops B, C, D, and E each contained five lots, terminating at bedrock at an average depth of 89.75 cm. Subops F, G, H, and I each contained only four lots due to their location in a shallower portion of the depression, and terminated at bedrock at an average depth of 82 cm. The initial lots of each subop were composed of a thin humus layer, with the rest of the lots composed of interface material.

Subop B was located directly adjacent to Subop A and, along with Subop C, was located the furthest south within this series of units. It contained a moderate density of lithic and ceramic material throughout and a cobble-sized worked lithic core in lot 3. Lot 3 was unique within this subop in that it contained small fragments of charcoal and the lone stone tool in the unit. Lot 1 was 11 cm deep; lot 2 was 9 cm in depth terminating at 20 cm BD; lot 3 ended at 34 cm BD with a depth of 14 cm; and lot 4 was 13 cm in thickness, finishing 47 cm BD. The maximum depth of

Subop B was 63 cm BD at which lot 5 terminated. The ceramics of Subop B consisted of eroded body sherds in lots 1-3 and 5, Red Slipped type in lot 1, and an Early Classic style rim in lot 2. No ceramic material was recovered from lot 4.

Subop C held only small amounts of lithics and ceramics throughout, but it also contained five small charcoal fragments within lot 4 at a depth of 46 cm. This subop had a maximum depth of 67 cm BD with lots 1-5 terminating at depths of 8, 18, 30, 46, and 67 cm BD respectively. Lithic and ceramic densities from lot 5 were lower than those from the preceding four lots. Eroded body sherds comprised the ceramic material collected from this unit. Small, thin sherds were taken from lots 1 and 4 and one of the sherds from lot 3 contained coarse paste and large visible inclusions. The remains of a single stone tool were recovered from lot 4. Subop C was placed contiguous to the north side of Subop A, lot 3.

Even fewer ceramic and lithic fragments were collected from Subop D, which was located directly adjacent to the north side of Subop B. Ceramic material consisted almost entirely of eroded body sherds with the exception of a single bowl rim with ash temper in lot 3. Subop D had a total depth of 120 cm BD with lots 1-5 varying in thickness from 10, 18, 10, 6, and 13 cm respectively. Lot 5 ended at a bedrock layer that sloped upward from west to east and from south to north. It also had a slight, concave depression in its southwest corner.

A very minor amount of lithic and ceramic material was recovered from Subop E, as was the case with Subop D. Cayo Unslipped ceramic body sherds were collected from lot 2 and eroded body sherds, some with pitted surfaces, were found in lots 1, 3, and 4. This unit was directly adjacent to the north side of Subop C and the east side of Subop D. Lot 1 was composed of a thin humus layer and had a total thickness of 17 cm. Lots 2-5 were composed of interface material, and had thicknesses of 13, 9, 16, and 8 cm in that order. Lot 3 contained one stone tool.

Lot 5 terminated at a bedrock layer that sloped from south to north, with rises on the north side and in the center. This subop had a maximum depth of 109 cm BD.

Subop F flanked the north side of Subop D and the west side of Subop G. It had four arbitrary lots terminating at a maximum depth of 94 cm BD. Lot 1 had a thickness of 10 cm; lot 2 was 12 cm thick; lot 3 had a thickness of 15 cm; and lot 4 was only 4 cm deep. No cultural material was salvaged from lot 1, with very minor amounts of lithic and ceramic material collected from the lower 3 lots. Ceramic material consisted entirely of eroded body sherds and one stone tool was collected from lot 3.

Located on the east side of Subop F and the north side of Subop E, Subop G was also composed of four lots containing very small quantities of material. Only a small amount of lithic material was recovered from lot 1, with minor amounts of both lithics and ceramics collected from lots 2-4. Two eroded body sherds were recovered from lot 2, Achote Black type ceramic material was collected from lot 3, and an eroded rim bowl and sherds with pitted surfaces were found in lot 4. The subop was 103 cm BD at its deepest point with lot thicknesses of 15, 9, 15, and 5 respectively.

Lower densities of cultural materials were collected from Subop H with only lithic material taken from lots 1, 2, and 4, but both lithic and ceramic fragments were gathered from lot 3. Ceramic types included Tinaja Red and an eroded basal flange. This unit was located contiguous to the north side of Subop F and the west side of Subop I and had a maximum depth of 103 cm BD. Lots 1-4 had total thicknesses of 17, 10, 14, and 10 cm correspondingly.

Subop I was placed adjacent to the east side of Subop H and the north side of Subop G. It had a total thickness of 60 cm and a maximum depth of 110 cm BD. A very small amount of lithic material was collected from lot 1, a minor amount of ceramic material was recovered from

lot 2, and small amounts of lithic and ceramic material were taken from lots 3 and 4. Ceramic material consisted of small eroded body sherds in lots 2 and 3 and a Late Preclassic rim form and eroded ring base in lot 4. The first lot was 17 cm deep; lot 2 had a depth of 16 cm; lot 3 was 9 cm thick; and lot 4 had a total thickness of 18 cm.

Lot	1	2	3	4	5
Ceramics	25	64	90	67	21
Debitage	63	43	58	43	18
Tools	0	0	3	1	0
Total	**88**	**107**	**151**	**111**	**39**

Table 5.2. Artifact counts in Sub-operations B-I by lot.

Sub-operation J

Subop J was a 2x2m unit through lots 1 and 2 and a 1x2m unit through lots 3-5, located contiguous to the north sides of Subops H and I. Composed of 5 lots, it had a total thickness of 51 cm and a maximum depth of 97 cm BD. Lots terminated arbitrarily at observed changes in soil composition and/or color. Lot 1 ended at a change in soil from dark brown humus to a less-compacted lighter dark gray soil. In addition to a small amount of lithic and ceramic material, a fairly significant amount of charcoal was discovered in this top layer. Ceramic material consisted of eroded body sherds. Lot 1 had a total thickness of only 2 cm, concluding at a depth of 48 cm BD.

Lot 2 was a 2x2m unit containing amounts of lithic and ceramic material comparable to the previous lot. Ceramic material again consisted solely of eroded body sherds and lithic material included two stone tools. It had a total thickness of 16 cm and ended at a change in the

soil from a moderately compacted dark gray layer to an even less compacted, slightly lighter gray layer. The ending elevation of this lot was 64 cm BD.

Lot 3 was a 1x2m unit 6 cm thick, with an ending elevation of 70 cm BD. Like lots 1 and 2, this lot contained material densities lower than those found in previously excavated subops. Ceramic types included Roaring Creek Red form and a jar rim. Lot 3 terminated at a change in the soil to a looser, lighter gray.

Like lot 3, lot 4 was also a 1x2m unit. It had a total thickness of 13 cm and ended at an elevation of 83 cm BD, where the soil changed to loosely-compacted/ashy and nearly white in color. This lot contained less lithic and ceramic material than the three lots that preceded it, although lithic material did include a single stone tool. Ceramic material included a jar fragment with ash temper and no slip remaining.

A smaller amount of lithic and ceramic material was collected from lot 5, along with a 3 cm long obsidian flake. Ceramic types consisted of eroded sherds with coarse paste and Red Slipped. This lot was also 1x2m with a thickness of 14 cm and an ending elevation of 97 cm BD. A large rock protrusion was located near the north corner of the east wall of the lot with a small cavity on its south side. This unit terminated at the bedrock layer and contained the lowest point excavated in the entire site.

Lot	1	2	3	4	5
Ceramics	12	9	28	49	13
Debitage	36	71	45	87	14
Tools	0	2	0	1	0
Total	**48**	**82**	**73**	**137**	**27**

Table 5.3. Artifact counts in Sub-operation J by lot.

Sub-operations K, L, M, N, O, P, Q, and R

Like Subops B-I, these were a series of eight 50 cm (0.5m) x 50 cm units that formed a 1x2m trench adjacent to the south side of Subop A. The units were divided into lots that terminated arbitrarily at depths of +/- 10 cm. Subops K, L, M, and N each contained four lots, terminating at bedrock at an average depth of 41.25 cm. Subops O, P, Q, and R each contained only three lots due to their location on a shallower upslope of the depression, and terminated at bedrock at an average depth of only 31.25 cm. The top lot of each of unit was composed of a dark brown/gray thin humus layer, with the remaining lots made up of looser interface material that was noticeably lighter in color, ranging from medium-dark brown/gray to light gray/white. These uniform soil changes were a common theme throughout the site.

Subop K was located directly adjacent to the southwest corner of Subop A. It had a maximum depth of 11 cm, terminating 11 cm below a newly placed datum. An increase in both ceramic and lithic densities over Subops B-J, similar to Subop A, was noted. Ceramic material from lots 1, 3, and 4 consisted of Tinaja Red and Achote Black types, some with eroded pitted surfaces, a Striated neck jar, and two eroded body sherds. No sherds were collected from lot 2. One stone tool was recovered from lot 1. A large amount of charcoal fragments was observed throughout the unit and a small obsidian flake was collected from lot 3. Lots 2-4 had thicknesses of 9, 14, and 11 cm respectively. The maximum depth of the unit was 45 cm BD.

Subop L, also located off the southwest corner of Subop A, was placed adjacent to the east side of Subop K. Both ceramic and lithic material was recovered from each lot of the unit at densities akin to those of Subop K. Lots 1 and 2 contained no ceramic remains, but lots 3 and 4 held sherds of the Garbutt Creek Red, Cayo Unslipped, and Tinaja Red types. Lot 2 held the

remains of two stone tools. This unit had a maximum depth of 38 cm BD with lots 1-4 measuring 15, 6, 10, and 7 cm thick. Unlike Subop K, Subop I contained no observed charcoal fragments.

The next subop, M, was opened on the south side of Subop K. It contained four lots with thicknesses of 10, 9, 12, and 11 cm, and it had a maximum depth of 32 cm BD. Again, amounts of recovered cultural material were comparable to those of Subops K and L. Ceramics included Achote Black type in lot 1, an Early Classic rim form with pitted surfaces from lot 2, Subin Red and Achote Black types in lot 3, and one ash temper with no remaining slip and Cayo Unslipped from lot 4. A relatively high density of charcoal pieces was also encountered in lot 2, along with three stone tools.

Subop N was located on the south side of Subop L and the east side of Subop M. The number of collected lithic and ceramic fragments was analogous to those of the preceding three units. Ceramics consisted of three eroded body sherds from lot 1, Garbutt Creek Red, Cayo Unslipped, and Tres Mujeres Mottled types from lot 2, undiagnostic eroded sherds including one with ash temper from lot 3, and Cayo Unslipped from lot 4. The unit had a total depth of 40 cm BD with thickness of lots 1-4 of 11, 7, 10, and 12 cm, respectively.

Established on the south side of Subop M, Subop O had a maximum depth of 33 cm BD. Comprising only three lots, a smaller amount of material was collected throughout this unit compared to the previous units in this trench. Within the subop itself, a measurably lower density of both lithic and ceramic material was discovered in lot 3 when compared to the two above it. Ceramic material included eroded pitted body sherds from lots 1 and 3 and both Achote Black type and an eroded basal flange from lot 2. Bedrock was reached at the terminus of lot 3; it protruded from the south and center to the north within the unit. The thicknesses of lots 1-3 were

10, 11, and 12 cm, respectively. A large rock was present in the southwest corner of the unit, initially encountered in the first lot and removed in the course of excavations.

Subop P also contained three lots, with thicknesses of 10, 13, and 10 cm. Bedrock was again reached at the bottom of lot 3, which had a maximum depth of 33 cm BD. This Subop was positioned on the south side of Subop N and the east side of Subop O. Densities of collected ceramic and lithic material were again comparable to those of the immediately surrounding units. Although no ceramic material was collected from lot 1, lots 2 and 3 contained eroded sherds with pitted surfaces, one bowl form with ash temper, and examples of Subin Red and Striated types. Lot 3 contained one stone tool.

Subop Q, placed on the south side of Subop O, comprised three lots and had a maximum depth of 32 cm BD. The lots had recorded thicknesses of 11, 11, and 10 cm in that order. Again, a similar amount of material was collected from the top two lots, but only a minor amount was recovered from the bottom lot. Ceramics from this unit included eroded body sherds with pitted surfaces and the Achote Black type.

Subop R, the final 50 cm x 50 cm unit of this 1x2m trench, was positioned on the south side of Subop P and the east side of Subop Q. Its three lots had thicknesses of 10, 9, and 8 cm consecutively, and the unit had a maximum depth of 27 cm BD. A lower amount of material was collected from this unit, with the density decreasing with depth. Ceramic material consisted of an eroded basal flange and eroded bodies that may include Late Classic material in lot 1, examples of the Subin Red type in lot 2, and two eroded body sherds in lot 3.

Lot	1	2	3	4
Ceramics	152	248	91	24
Debitage	177	310	175	44
Tools	1	5	1	0
Total	**330**	**563**	**267**	**68**

Table 5.4. Artifact counts for Sub-operations K-R by lot.

Sub-operations S, T, U, V, W, X, Y, and Z

These were a series of eight 50 cm (0.5m) x 50 cm units that formed a 1x2m pit adjacent to the south side of Subop A and the eastern side of subops K-R. The units were divided into lots that terminated arbitrarily at depths of +/- 10 cm. Subops S, T, U, and V each contained four lots terminating at bedrock at an average depth of 46.25 cm. Subops W and X, located on the shallower slope, contained three lots each and ended at the bedrock layer at an average depth of 37 cm. Due to their location in an even shallower area of the site, subops Y and Z were composed of only two lots, concluding at an average depth of 25 cm from the surface. Like neighboring subops K-R, the top lot of each of these units was composed of a thin, dark brown/gray humus layer with the remaining lots made up of a looser interface material ranging from medium-dark brown/gray to light gray/white in color with depth. The east wall of Subops T, V, X, and Z was profiled (Figure 5.3).

Subop S was located adjacent to the south side of Subop A and the east side of Subop L. It was excavated in four lots, with thicknesses of 7, 9, 12, and 20 cm, and had a maximum depth of 42 cm BD. The density of collected lithic and ceramic material was roughly equivalent to that of nearby subops K-R. Ceramic material from lots 2 and 3 consisted of an eroded basal flange and eroded body sherds with pitted surfaces. A 1.5-liter soil sample was also extracted from each of the four lots of this unit.

Subop T, positioned at the southeast corner of Subop A and the east side of Subop S, also contained four lots and terminated at a maximum depth of 40 cm BD. Lot 1 was 7 cm thick; lot 2 was 11cm; lot 3 had a thickness of 9 cm; and lot 4 was 19 cm deep. A slightly lesser amount of material than Subop S was collected from the unit. Ceramics from the middle two lots included eroded body sherds with pitted surfaces and at least one example of the Tinaja Red type.

The next unit, Subop U, was opened on the south side of Subop S. It had a maximum depth of 33 cm BD and lot thicknesses of 7, 10, 11, and 17 cm, respectively. Ceramic and lithic densities continued to decrease throughout this unit with only one small lithic flake and no ceramic material collected from lot 4. Ceramic remains included two eroded body sherds from lot 1, Subin Red and Cayo Unslipped types from lot 2, and a bowl rim and sherds with ash temper from lot 3.

Subop V terminated at a depth of 44 cm BD, with lot thicknesses of 11, 13, 13, and 9 cm respectively. It was placed on the east side of Subop U and the south side of Subop T. Ceramic and lithic material was recovered from each lot of the unit, but again in lesser amounts than those of Subops K-S. Ceramic material consisted of Early Classic eroded rim forms, some Late Classic body sherds, and examples of Subin Red and Achote Black types. One stone tool was recovered from lot 4.

Subop W contained only three lots and ended at a depth of 36 cm BD. Its lots had thicknesses of 10, 9, and 10 cm respectively, and it was located on the south side of Subop U. The bedrock at the base of this unit sloped sharply down from south to north, similar to Subops O and P. Lithic and ceramic densities were again low. Ceramic types included sixteen small eroded body sherds from lot 1 and six eroded body sherds from lot 3.

Subop X, opened on the east side of Subop W and south side of Subop V, had a maximum depth of 46 cm BD. Its three lots were 12, 11, and 12 cm thick. Again, the density of ceramic and lithic material collected from each lot of this unit was low with no ceramic material recovered from lot 3. Ceramics from lots 1 and 2 consisted of eroded body sherds and Achote Black type.

Subop Y had only two lots with thicknesses of 13 and 12 cm and terminated at a low point of 34 cm BD. Located contiguous to the south side of Subop W, this unit again contained very small amounts of cultural material. Recovered ceramic material included an eroded rim style and eroded body sherds.

The final unit in this series was Subop Z. Like Subop Y, it contained only two lots with measured thicknesses of 14 and 11 cm. It terminated at a maximum depth of 24 cm BD. Although both lithic and ceramic material was collected from each lot, densities were even lower than those of surrounding subops. Fewer lithic and ceramic remains were collected as we excavated from west to east across this slope on the depression's south side. Ceramics consisted of an eroded bowl rim and body sherds from lot 1 and eroded body sherds from lot 2. Charcoal fragments were observed in abundance throughout this series of subops.

Lot	1	2	3	4
Ceramics	86	88	73	13
Debitage	87	153	31	9
Tools	0	0	0	1
Total	**173**	**241**	**104**	**23**

Table 5.5. Artifact counts for Sub-operations S-Z by lot.

Sub-operations AA, AB, AC, AD, AE, AF, AG, and AH

These were also a series of eight 50 cm (0.5m) x 50 cm units that formed a 1x2m trench located between subops A and J and adjacent to the east side of Subops B-I. Like the previously excavated units of this size, each subop was divided into lots that terminated arbitrarily at depths of +/- 10 cm. Each unit contained four lots terminating at an average depth of 45.75 cm from the surface. A new datum was used to record elevations for these units; it was the northeast corner of Subop T. Lot 1 within each of these units consisted of a thin humus layer and initial dark brown, semi-coarse soil layer. Soil became lighter in color and looser in texture with depth. A soil profile of the east wall of Subops AB, AD, AF, and AH was composed (Figure 5.4).

Subop AA was opened on the north side of Subop A and the east edge of Subop C. It contained four lots, with thicknesses of 9, 13, 14, and 9 cm, and was 79 cm BD at its deepest point. Lithic and ceramic material was recovered from each lot at densities roughly equivalent to Subops A-I. Ceramic material consisted mainly of eroded body sherds with pitted surfaces. A small obsidian flake was collected from lot 2 at a depth of 50 cm BD approximately 18 cm below the pre-excavation surface of this unit. One stone tool was recovered from lot 2 and two were collected from lot 3.

Subop AB was located contiguous to the northeast corner of Subop A and the east side of Subop AA. Its four lots had thicknesses of 8, 14, 14, and 10 cm with lot 4 terminating 75 cm BD. To get some idea of the rough shape of the depression at this point, the beginning elevation of this unit was 33 cm below the datum point. The northeast corner of Subop T was located on the southern edge of the depression, an upslope location compared to this series of subops that were located downslope towards the center or low point of the basin. Ceramic and lithic remains were again collected from each lot of the unit in similar amounts to Subop AA. However, the number of recovered materials peaked in lot 2 before dropping noticeably in lot 3. Tinaja Red and

Garbutt Creek Red types and thin eroded jar fragments with sandy, ash temper were collected from the upper two lots, while the bottom two lots held only eroded body sherds.

The third subop in this series, AC, was placed on the east side of Subop E and the north side of Subop AA. It had a low point of 79 cm BD and was 40 cm deep. Its lots had thicknesses of 8, 13, 10, and 9 cm respectively. A similar quantity of cultural material was collected from each of the lots analogous to the amounts from the two preceding units. Ceramic material consisted of eroded body sherds and examples of Tinaja Red and Achote Black types.

Subop AD contained lower densities of material with only four small lithic flakes recovered from the first lot and no ceramic remains recovered from either the first or second lot. Lots 2-4 contained small to moderate amounts of material, somewhat less than that of Subops AA-AC. Ceramics from lots 3 and 4 included Cayo Unslipped and Sierra Red types, an Achote Black style bowl rim, and body sherds with eroded pitted surfaces. This unit was located on the east side of Subop AC and the north side of Subop AB. It was 45 cm in depth with lots of 8, 13, 15, and 9 cm thick. The ending elevation of lot 4 was 79 cm BD.

Subop AE was positioned on the north side of Subop AC and the east side of Subop G. It was composed of four lots with thicknesses of 16, 10, 11, and 10 cm. Its lowest point was 81 cm BD. Very small amounts of material, both lithic and ceramic, were recovered from this subop with lot 2 providing the least material. Ceramic material included eroded body sherds, a Late Classic style bowl rim, and examples of the Tinaja Red type. Material densities were more equivalent to Subop AD than to Subops AA-AC.

Very small amounts of both lithic and ceramic material were collected from the first three lots of Subop AF as well, with no ceramic remains collected from lot 1. Lots 2-4 contained ceramic fragments of the Achote Black and Subin Red types, an eroded basal flange, and

numerous small, eroded body sherds. Lot 4 also held one stone tool. Somewhat surprisingly, the fourth lot contained a fairly sizable amount of material in addition to a large biface. This Subop is highly representative of the seemingly random nature of material densities encountered throughout various portions of the site. This unit was situated on the east side of Subop AE and the north side of Subop AD and had a low point of 76 cm BD. Its four lots had thicknesses of 16, 13, 10, and 13 cm in that order.

Subop AG was opened on the north edge of Subop AE and the east edge of Subop I. Its four lots had recorded thicknesses of 11, 14, 11, and 10 cm, and it terminated at a low point of 81 cm BD. Densities of collected ceramic and lithic material were akin to those of the immediately surrounding units, tending to be low to medium, with the exception of lot 1 which held no ceramic material. Ceramics from lots 2, 3, and 4 consisted of eroded body sherds, some with pitted surfaces, and multiple heavily degraded red slipped sherds. Additionally, a 1.5-liter soil sample was collected from each lot within this subop.

Subop AH, the final unit in this series, also contained four lots with depths of 10, 10, 15, and 13 cm. The maximum depth of the unit was 86 cm BD. One small lithic flake was collected from lot 1, two ceramic sherds were taken from lot 2, and minor amounts of each were recovered from lots 3 and 4. Recovered ceramic material included eroded body sherds, an eroded basal flange, and an Early Classic style rim. This unit was located adjacent to the north side of Subop AF and the east side of Subop AG.

Lot	1	2	3	4
Ceramics	18	83	99	53
Debitage	15	116	87	44
Tools	0	1	2	1
Total	**33**	**200**	**188**	**98**

Table 5.6. Artifact counts for Sub-operations AA-AH by lot.

Sub-operation AI

This was a 1x2m unit placed adjacent to the southern half of the east side of Subop J. The unit contained four lots that terminated arbitrarily at soil changes and had an average depth of 15.25 cm. The unit sloped significantly downward from east to west with maximum depths of 61 cm in the eastern half and 97 cm in the western half. Lot 1 was 9 cm thick and made up of dark brown relatively coarse humus. A fair amount of lithic material, but no ceramic remains, were collected from this lot. Multiple shell fragments, most likely from terrestrial snails, were also observed. Lot 1 terminated at a depth of 41 cm BD.

Lot 2 contained an amount of lithic material comparable to that of lot 1, in addition to a fair amount of ceramics fragments. The ceramic pieces consisted of eroded sherds with pitted surfaces and an eroded rim fragment. This lot, like others at similar depths within the site, began just below the humus layer and was made up of a lighter brown, slightly less-coarse soil. The lot was 8 cm deep ending at an elevation of 49 cm BD. No shell was observed at this depth.

Lot 3 had a thickness of 14 cm and an ending elevation of 63 cm BD. In addition to a similar density of cultural material as lot 2, a small bone was collected from this lot. The bone measured only a few centimeters in length and roughly 1.5 cm in diameter and is believed to be from an Ocellated Turkey or other small mammal native to this area. This was the only bone recovered from the depression. Ceramic material from this lot consisted only of Late Classic

style sherds. The soil of this lot again became lighter in color with a less clayey texture and a finer structure as we reached the terminus of the lot.

Lot 4 also contained moderate amounts of lithic and ceramic material, as well as a fair amount of charcoal or burned wood fragments near the bedrock layer. Ceramic material from this bottom lot included examples from the Sierra Red and Subin Red types. The lot was 30 cm thick with an ending elevation of 93 cm BD, representing one of the deepest excavation units in the entire site. Soil was light in color, non-clayey in texture with a fine to very fine structure. This lot terminated at bedrock which sloped downward from west to east toward the center of the depression.

Lot	1	2	3	4
Ceramics	0	23	17	214
Debitage	51	65	0	400
Tools	0	0	0	0
Total	**51**	**88**	**17**	**614**

Table 5.7. Artifact counts for Sub-operation AI by lot.

Sub-operations AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, and BG

These units were postholes of varying depths and diameters placed around the perimeter of the site (Figure 4.2). The postholes ranged from 23 – 80 cm in depth, with an average depth of 58.9 cm and an average diameter of 26.7 cm. Diameters were measured from the top of each posthole, with efforts taken to maintain a uniform diameter all the way down to the bottom. The units terminated arbitrarily at root or rock impediments, the sterile, powdery marl layer, or, in some cases, bedrock. No datums were used to record elevations, with ending elevations simply

recording the depth below the surface for each individual unit. Due to the lesser volume of soil excavated from these units, smaller wire mesh screens were used to expedite the dry screening process.

Subop AJ was 28 cm in diameter and located 2m south of the southwest corner of Subop A, just off the southwest corner of Subop Q. It had a total depth of 27 cm at which point heavy, impenetrable roots were encountered prohibiting further excavation. A small amount of lithic and a large amount of ceramic material was recovered from the unit. Surprisingly, the remains of seven stone tools were also collected from this unit. Recovered ceramic material consisted of eroded body sherds, multiple eroded basal flanges, an Early Classic jar rim, a Late Classic style unslipped jar rim, and examples of Achote Black, Subin Red, and Garbutt Creek Red types. The large amount of ceramic material collected from this posthole, spanning multiple time periods and inclusive of many different types, is unique to the site. It appears highly likely that this location on the south rim of the depression represents a focal point for the discard of ceramic material.

Subop AK had a diameter of 28 cm and was located 4m east of the northeast corner of Subop A. It had a depth of 68 cm, at which point loose marl was reached and no further cultural material was found. A small amount of lithic material and two eroded body sherds were collected.

The next posthole, Subop AL, had a diameter of 28 cm. It was opened 2m east of Subop AK and 6m east of the northeast corner of Subop A. The unit had a maximum depth of 65 cm and it terminated at the point that a gravelly/loose marl layer was discovered. Low densities of lithic and ceramic materials were collected. Ceramic material included only four thin, eroded body sherds.

Subop AM was a 28 cm diameter posthole positioned 2m east of the southeast corner of Subop A. It had a total depth of only 34 cm terminating when a large rock prevented deeper excavation. A moderate amount of ceramic and lithic material was taken from this unit. Ceramics consisted of eroded pitted body sherds and an Early Classic rim.

Located 2m north of datum 1 (100,100), Subop AN had a diameter of 28 cm and an ending elevation 66 cm below the surface. This unit terminated when bedrock was reached and contained a small amount of lithic material and no ceramics.

AO was a subop 28 cm in diameter and 53 cm deep. It was located 2m slightly northeast of datum 1. This unit again terminated arbitrarily upon reaching the bedrock layer. A moderate amount of lithic and ceramic fragments, consisting of an eroded basal flange and other eroded body sherds, were collected. One stone tool was also collected from the unit.

Subop AP was 36 cm in depth and had a diameter of 28 cm. It was located on the south rim of the depression, 2m east of Subop AO and 2m slightly northwest of Subop AQ. This lot also ended at bedrock. Only a small amount of lithic material, including a mid-sized biface, was collected from this subop.

Subop AQ had a diameter of 32 cm. It was 78 cm deep terminating at the underlying bedrock. It was positioned 2m slightly southeast of Subop AP. Low densities of ceramic and lithic material were again encountered in this posthole. Ceramics included only three eroded body sherds, one with a small amount of red slip remaining.

Subop AR was a posthole 23 cm in depth that terminated at heavy root obstructions. It had a diameter of 23 cm and contained a large amount of lithic and small amount of ceramic material. Ceramics again consisted of only three eroded body sherds. This unit was located 2m slightly southeast of Subop AQ.

Situated 2m south of Subop AR, Subop AS was 70 cm deep and had a diameter of 24 cm. It terminated arbitrarily at bedrock and, like AR, contained material densities higher than previous postholes. Ceramic material included Cayo Unslipped fragments and eroded body sherds. Lithic material included one stone tool.

Subop AT was located 2m east of the previous posthole. It had a diameter of 28 cm and was 69 cm below the surface at its deepest point ending at bedrock. Unlike the two preceding units, this subop contained only minor amounts of lithics and no ceramics.

Subop AU was 69 cm deep with a diameter of 24 cm. It was located 2m southeast of Subop AT and also contained very small amounts of lithic material. A small obsidian flake was collected from this unit, which again concluded at the bedrock layer.

The next unit, Subop AV, was a deep posthole containing only minor amounts of lithic and ceramic remains. Ceramics consisted of four small eroded body sherds. It was 80 cm deep and had a diameter measuring 28 cm. Placed 2m south of Subop AL, it also ended at bedrock.

Subop AW was opened 2m marginally southeast of Subop AV. Bedrock was reached 69 cm below the surface. The unit had a diameter of 23 cm and contained negligible amounts of ceramic and lithic material. Recovered ceramics included only two eroded body sherds.

Subop AX was 54 cm at its deepest point and also terminated at the bedrock layer. It had a diameter of 28 cm and was located 2m south of the southeast corner of Subop Z. Again, small amounts of material were observed and collected from this lot. Ceramic material included examples of the Garbutt Creek Red type.

AY was a subop 62 cm deep and positioned 2m south of Subop AJ and 2m west of Subop AX. Its opening had a diameter of 25 cm and the unit ended at bedrock. Slight quantities of

lithics and ceramics were collected. Collected ceramic material consisted of one nubin foot and one sherd with ash temper.

Subop AZ was situated 2m west of the previous subop. It was 55 cm below the surface at its lowest point, terminating at bedrock, and had a diameter of 25 cm. Very few lithic and ceramic fragments were again recovered from within this unit. Ceramics included only two eroded body sherds.

Subop BA was next in the series of postholes. Located 4m west of Subop AZ, it had a diameter of 22 cm and a maximum depth of 54 cm. It also ended when bedrock was reached. Minor amounts of lithics and ceramics were collected from this unit. Ceramics consisted of two gunshot fragments.

Placed 2m to the north of BA, Subop BB had a diameter of 28 cm and a total depth of 48 cm. It, too, ended at bedrock. Like the previous few units, only a small number of material fragments were collected from this relatively shallow unit. The lone ceramic piece recovered was an Early Classic jar rim.

Subop BC was 60 cm below the surface at its deepest point, also concluding at bedrock. Its location was 2m north of Subop BB. Continuing the theme, only a few ceramic and lithic pieces were recovered from this lot. Ceramics again consisted of only two gunshot fragments.

Subop BD was opened approximately 6m north of BC. It had an ending elevation of 60 cm below the surface that ceased at bedrock. Minor amounts of material were collected including one eroded body sherd.

Subop BE contained only a few very small lithic flakes and no ceramic material. It was opened 2m north of Subop BD and had a diameter of 26 cm. It terminated at the bedrock layer 61 cm below the surface.

Subop BF again held slight amounts of lithic and no ceramic fragments. It was located 2m north of the previous unit and had a diameter of 28 cm. This unit ended 76 cm below the surface, again at bedrock.

Subop BG was the final posthole excavated. It was located 2m north of Subop BF and 2m west of Subop AN, completing a rough perimeter of postholes around the site. Like Subop BF, it also had a diameter of 28 cm, a maximum depth of 76 cm, and terminated at bedrock. It contained only a small amount of lithic material and no ceramics.

Sub-operation BH

Subop BH was another 2x2m unit located on the upslope of the depression on the west side of Subops A and B. It contained four lots and had a depth of 41 cm, terminating at the underlying bedrock layer. Soil within the unit was consistent with that encountered throughout the site, ranging from a thin, dark brown humus layer with a slight clayey texture and medium structure, through a lighter gray clay loam with finer structure, to a light gray, almost white finely-structured layer atop the bedrock.

Lot 1 was 10 cm thick with an ending elevation of 40 cm BD. It included the thin humus layer and the upper portion of the lighter brown layer beneath. This level contained a fair amount of pebbles and small cobbles, but nothing comparable in extent or quantity to that exposed on the west side of Subops A and B. A moderate amount of lithic material was collected from this lot similar to densities recorded in adjacent subops. Multiple small shell pieces were observed.

Lot 2 was 11 cm thick ending at 51 cm BD. Like lot 1, it included a fair amount of lithics as well as a few minor shell fragments. The soil again appeared to be slightly gravelly throughout, but it still lacked the significant amount of medium to large cobbles we anticipated.

Lot 3 ended 63 cm BD and had a thickness of 12 cm. Again, no large cobbles, stones, or boulders were discovered anywhere in this lot. The amount of lithic material and quantity of minor pieces of shell were consistent with the above layers.

This Subop concluded with lot 4 as bedrock was reached at 71 cm BD. The lot had depth of only 8 cm. The density of lithic material remained consistent, no shell was observed, and a moderate amount of ceramic material was collected. Ceramics consisted of an Early Classic rim form and Subin Red and Tinaja Red types. A few cobbles and small stones were observed in the eastern portion of the lot near Subops A and B, but not to the extent we were expecting.

Lot	1	2	3	4
Ceramics	0	0	0	172
Debitage	0	0	0	0
Tools	0	0	0	0
Total	**0**	**0**	**0**	**172**

Table 5.8. Artifact counts for Sub-operation BH by lot.

Sub-operation BI

Subop BI was also a 2x2m unit and was positioned further upslope than Subop BH, closer to the western rim of the depression. The northeast corner of the unit touched the southwest corner of Subop BH. Due to its location on the shallow slope, BI was composed of only three lots and was 44 cm deep. This unit terminated at bedrock and had soil colors and composition like that of the previous subop. A new datum was used to record elevations for this unit; it was located at the southwest corner of this subop.

Very high densities of lithic and especially ceramic material were collected from the surface of this unit. The amount of recovered ceramic sherds increased with depth through the

initial 11 cm thick lot. Ceramic material in this unit consisted of Achote Black, Subin Red, and Cayo Unslipped types, some with ash temper. Lithic material included the remnants of five stone tools. The ending elevation for lot 1 was 11 cm BD.

Lot 2 was 16 cm deep and had an ending elevation of 27 cm BD. This lot contained a sizable amount of lithic debitage but no ceramic material. Two bifaces and a small obsidian flake were also recovered from this depth. This lot was composed of medium to light brown, medium structured soil underlying the humus layer.

Lot 3 terminated at bedrock, which sloped downward from west to east and south to north toward the main trench (Subops A-AH). It had a total thickness of 17 cm and an ending elevation of 44 cm BD. Fairly large amounts of both ceramic and lithic remains were also collected from this lot, including two stone tools. Ceramic material included a lid fragment, an Early Classic grooved rim, a Preclassic rim form, and examples of the Subin Red type.

Lot	1	2	3
Ceramics	205	0	46
Debitage	262	84	125
Tools	5	2	2
Total	**472**	**86**	**173**

Table 5.9. Artifact counts for Sub-operation BI by lot.

Sub-operation BJ

BJ was the final 2x2m subop opened at the site. It was situated approximately 1 meter slightly northwest of Subop AJ in the middle of Me-Bar's previous excavation units. Soil color and composition was again consistent with that of the surrounding units. BJ was a very deep excavation unit, with a total thickness of 78 cm and an ending elevation of 92 cm BD. A new

datum was used to record elevations for this subop; it was located 2m directly south of the initial datum for the site.

Lot 1 was 9 cm thick, comprising the thin organic soil layer and initial interface material. It terminated 23 cm BD. A larger amount of lithic material was collected than ceramic in this initial lot, though sizable quantities of each were recorded. Ceramics included Subin Red, Tinaja Red, and Achote Black types. Lithic material included three stone tools.

Fairly large amounts of lithic and ceramic debitage were again collected from lot 2. Ceramic material consisted of an eroded basal flange and Achote Black and Striated types. This lot had a total thickness of 12 cm and a terminal elevation of 35 cm BD. It was made up entirely of dark brown soil with a slightly clayey texture and medium structure.

Lot 3 ended 43 cm BD and was 8 cm deep. Like the two preceding lots, it held high densities of cultural material including examples of Subin Red and Achote Black types.

Lot 4 had an ending elevation of 53 cm BD and a total thickness of 10 cm. Large amounts of lithic and ceramic material were recovered from this depth. Ceramic remains again included both Subin Red and Achote Black types.

The final lot in the unit, lot 5, terminated at bedrock 92 cm BD. It was an extremely deep layer measuring 39 cm in depth. Although each previous lot in this unit concluded arbitrarily at around 10 cm, this lot was taken all the way down to the bedrock layer in order to avoid having more than five lots in any unit and because the depth was believed to be not much more than 10 cm below the bottom of lot 4. Despite the great depth of this lot, an amount of lithic and ceramic material equivalent to the above lots was collected. Recovered lithic material contained one stone tool. Ceramics consisted of an eroded vessel base with a broken mammiform foot and Achote Black and Subin Red types.

Lot	1	2	3	4	5
Ceramics	175	74	53	31	121
Debitage	96	0	550	0	187
Tools	3	0	0	0	1
Total	**274**	**74**	**603**	**31**	**309**

Table 5.10. Artifact counts for Sub-operation BJ by lot.

Sub-operations BK, BL, and BM

These subops were 1x1m units opened on the east and south sides of the depression. Each unit comprised four lots that concluded arbitrarily every 10 cm. Due to their placements on the upper crest of the site, away from previous units, new datums were used to record elevations from each of these units. These new datums were located at the southwest corner of each subop. Individual datums were used due to tree and brush obstructions located between each of the units, due to their location around the upper extent of the site. Despite their location at elevations above all prior units, the soil profiles of these subops remained consistent. A dark, thin layer of humic material overlaid soil that was increasingly less coarse and clayey as depth below the surface increased.

Subop BK's four lots had thicknesses of 8, 9, 10, and 5 cm successively. The entire unit was 32 cm deep with a matching ending elevation of 32 cm BD due to the newly placed datum. Minute amounts of lithic remains were collected from lots 1 and 2 within this unit. Lot 3 contained only a few small lithic fragments, and lot 4 held no cultural material. The southwest corner of this subop was located 2m east of the northeast corner of Subop AI.

A fair amount of lithic material was obtained from each of Subop BL's four lots. These lots had total thicknesses of 12, 9, 7, and 4 cm respectively, and the unit terminated at 32 cm BD.

The west side of Subop BL was positioned 5m east of Subops V and X. Aside from the posthole subop AW, Subop BL represented the furthest east excavated area within the site, either by Me-Bar or myself.

The final excavation unit within the site was Subop BM. This unit was established just south of posthole AY, slightly over 2m south of Subops Q and R. The ending elevation of the unit was 46 cm below the newly established datum at the southwest corner of the subop. The four lots of the unit had depths of 10, 7, 12, and 17 cm with the bottom lot terminating at bedrock. Low densities of lithic and ceramic debitage were recorded for each. Ceramic material from lots 1, 2, and 4 consisted of eroded body sherds and Achote Black type fragments.

Lot	1	2	3	4
Ceramics	13	2	0	8
Debitage	11	18	0	3
Tools	0	0	0	0
Total	**24**	**20**	**0**	**11**

Table 5.11. Artifact counts for Sub-operation BK by lot.

Lot	1	2	3	4
Ceramics	0	0	0	68
Debitage	0	0	0	106
Tools	0	0	0	0
Total	**0**	**0**	**0**	**174**

Table 5.12. Artifact counts for Sub-operation BL by lot.

Lot	1	2	3	4
Ceramics	55	45	0	5
Debitage	18	22	11	0
Tools	0	0	0	0
Total	**73**	**67**	**11**	**5**

Table 5.13. Artifact counts for Sub-operation BM by lot.

Subop	Lot	1
AJ	Ceramics	4
	Debitage	252
	Tools	7
	Total	**263**
AK	Ceramics	5
	Debitage	8
	Tools	0
	Total	**13**
AL	Ceramics	6
	Debitage	29
	Tools	0
	Total	**35**
AM	Ceramics	13
	Debitage	25
	Tools	0
	Total	**38**
AN	Ceramics	0
	Debitage	11
	Tools	0
	Total	**11**
AO	Ceramics	14
	Debitage	20
	Tools	1
	Total	**35**
AP	Ceramics	0
	Debitage	6
	Tools	1
	Total	**7**
AQ	Ceramics	5
	Debitage	38
	Tools	0
	Total	**43**
AR	Ceramics	4
	Debitage	130

	Tools	0
	Total	**134**
Subop	Lot	1
AS	Ceramics	10
	Debitage	25
	Tools	1
	Total	**36**
AT	Ceramics	1
	Debitage	6
	Tools	0
	Total	**7**
AU	Ceramics	3
	Debitage	0
	Tools	0
	Total	**3**
AV	Ceramics	4
	Debitage	33
	Tools	0
	Total	**37**
AW	Ceramics	2
	Debitage	3
	Tools	0
	Total	**5**
AX	Ceramics	7
	Debitage	6
	Tools	0
	Total	**13**
AY	Ceramics	9
	Debitage	7
	Tools	0
	Total	**16**
AZ	Ceramics	4
	Debitage	4
	Tools	0
	Total	**8**

BA	Ceramics	3
	Debitage	4
	Tools	0
	Total	**7**
Subop	Lot	1
BB	Ceramics	13
	Debitage	2
	Tools	0
	Total	**15**
BC	Ceramics	2
	Debitage	8
	Tools	0
	Total	**10**
BD	Ceramics	1
	Debitage	6
	Tools	0
	Total	**7**
BE	Ceramics	0
	Debitage	4
	Tools	0
	Total	**4**
BF	Ceramics	0
	Debitage	0
	Tools	0
	Total	**0**
BG	Ceramics	2
	Debitage	15
	Tools	0
	Total	**17**

Table 5.14. Artifact counts for Sub-operations AJ-BG by lot.

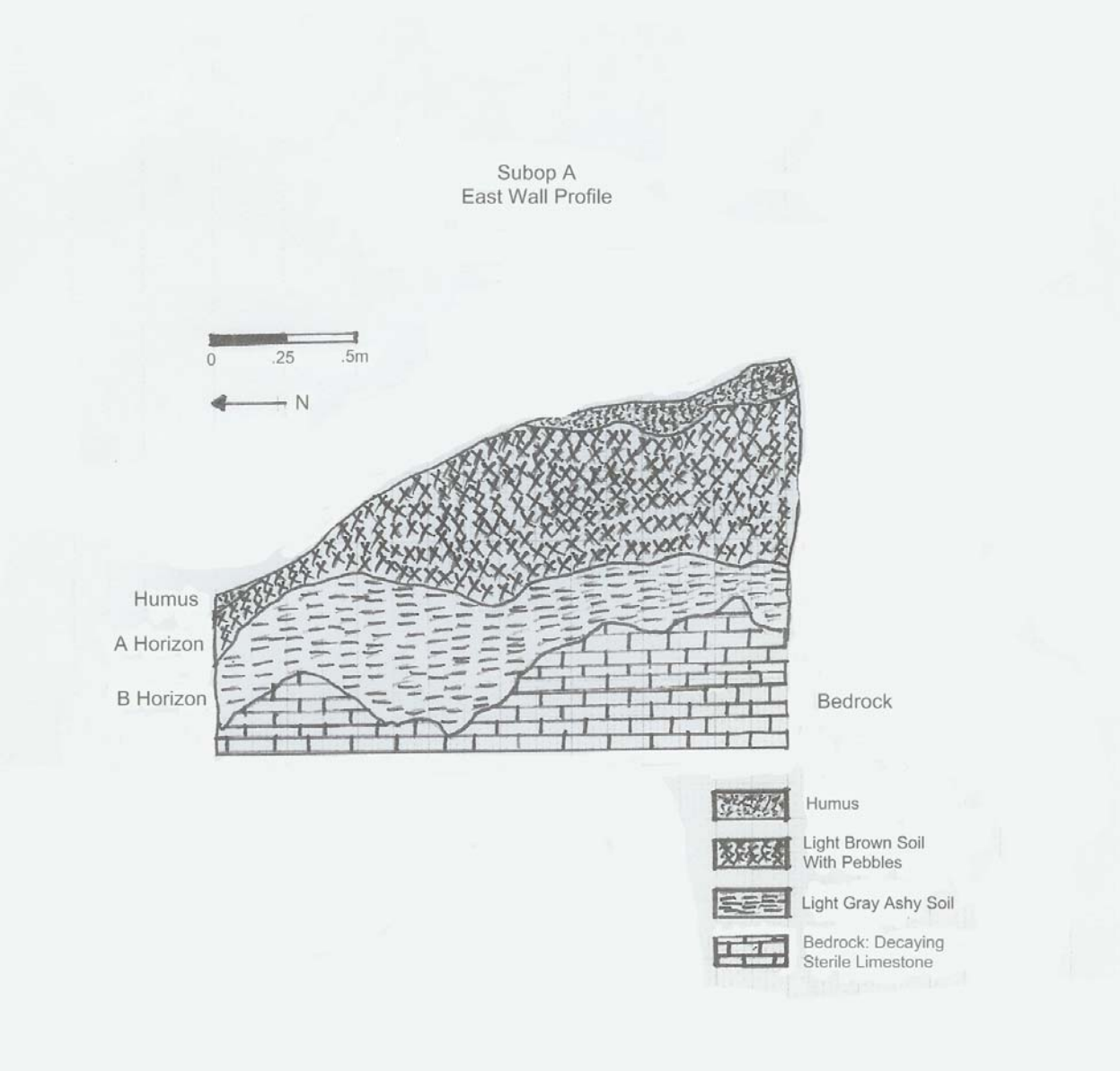

Figure 5.1. Sub-operation A, east wall profile

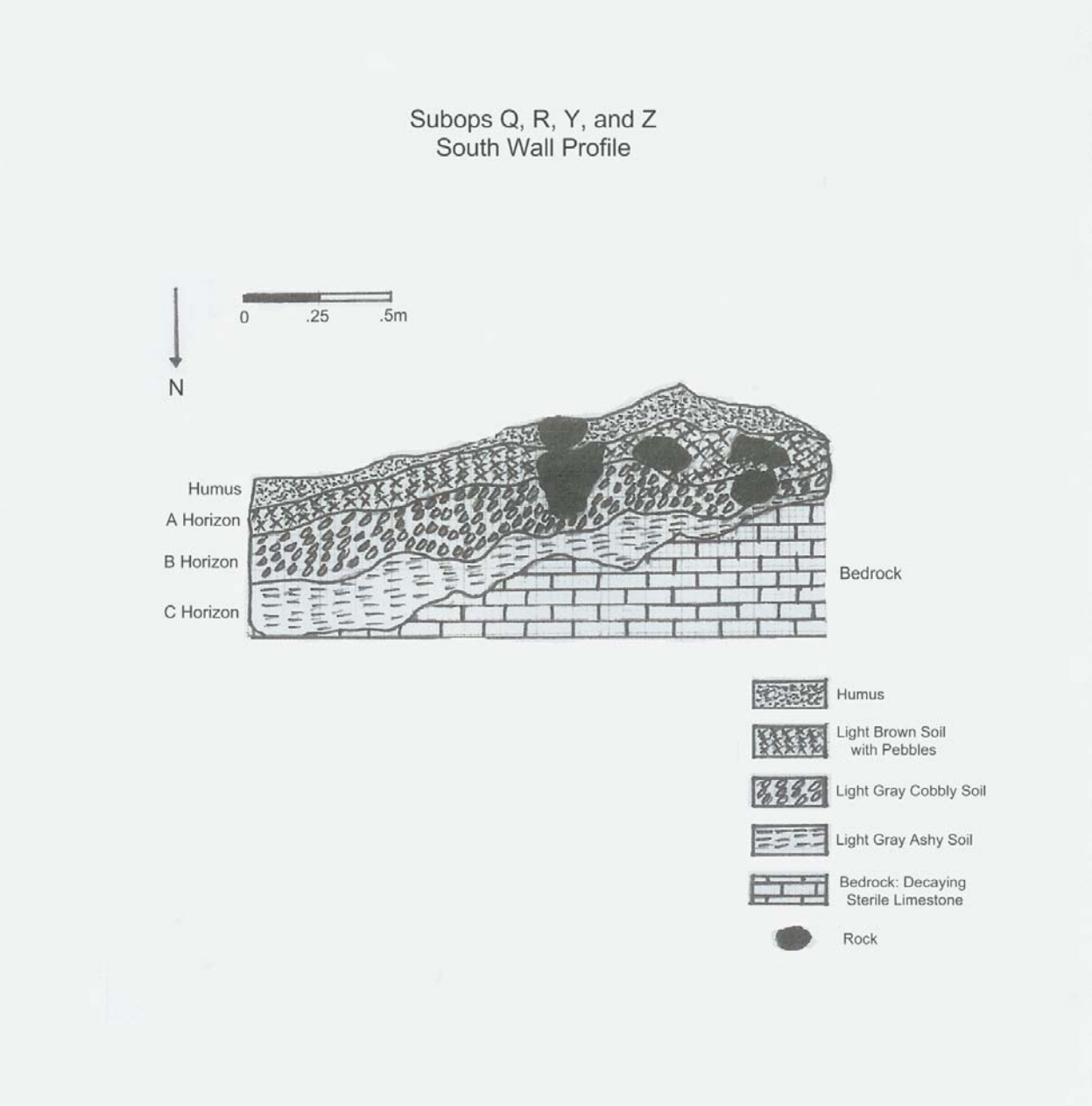

Figure 5.2. Sub-operations Q, R, Y, and Z, south wall profile

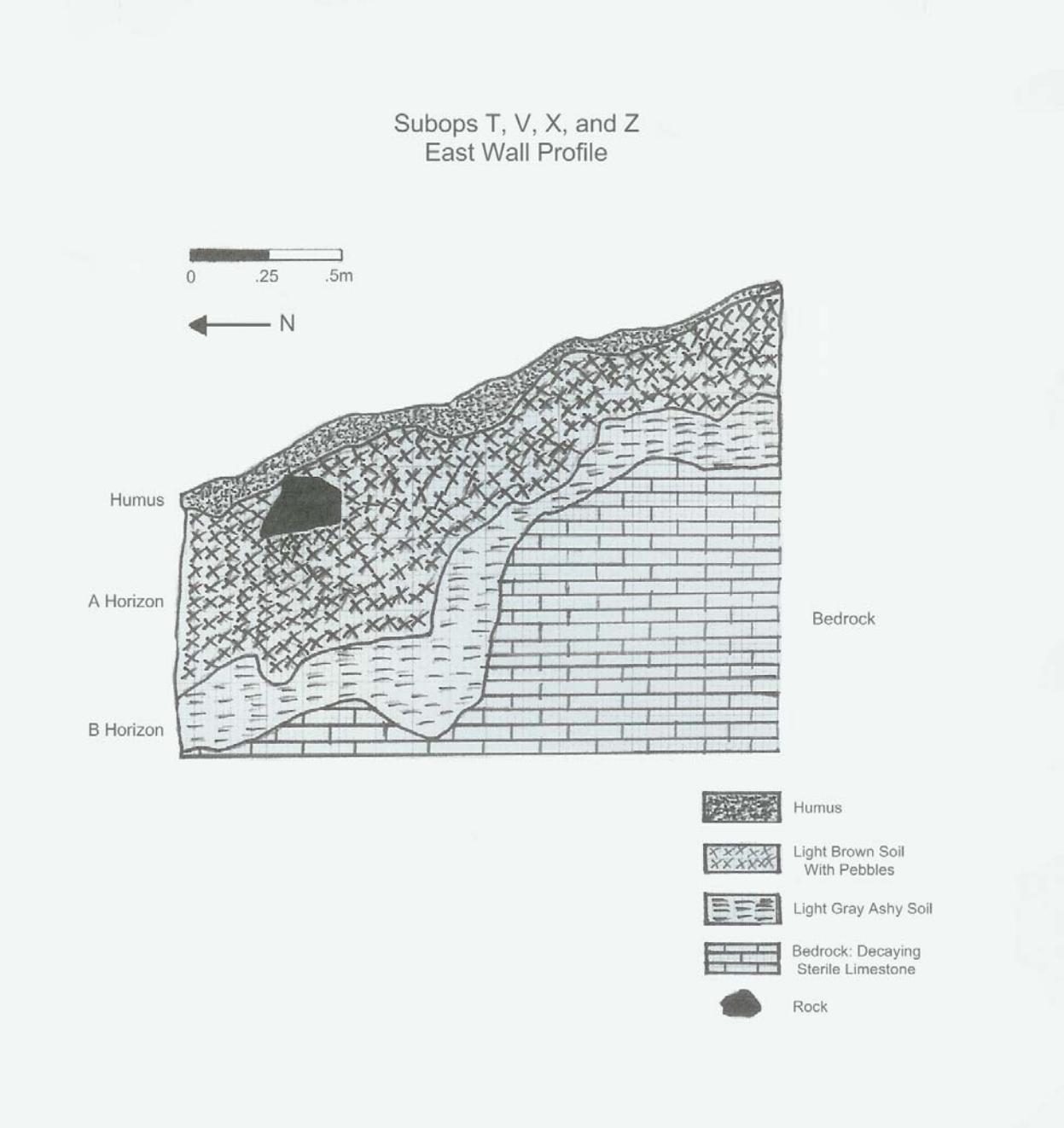

Figure 5.3. Sub-operations T, V, X, and Z, east wall profile

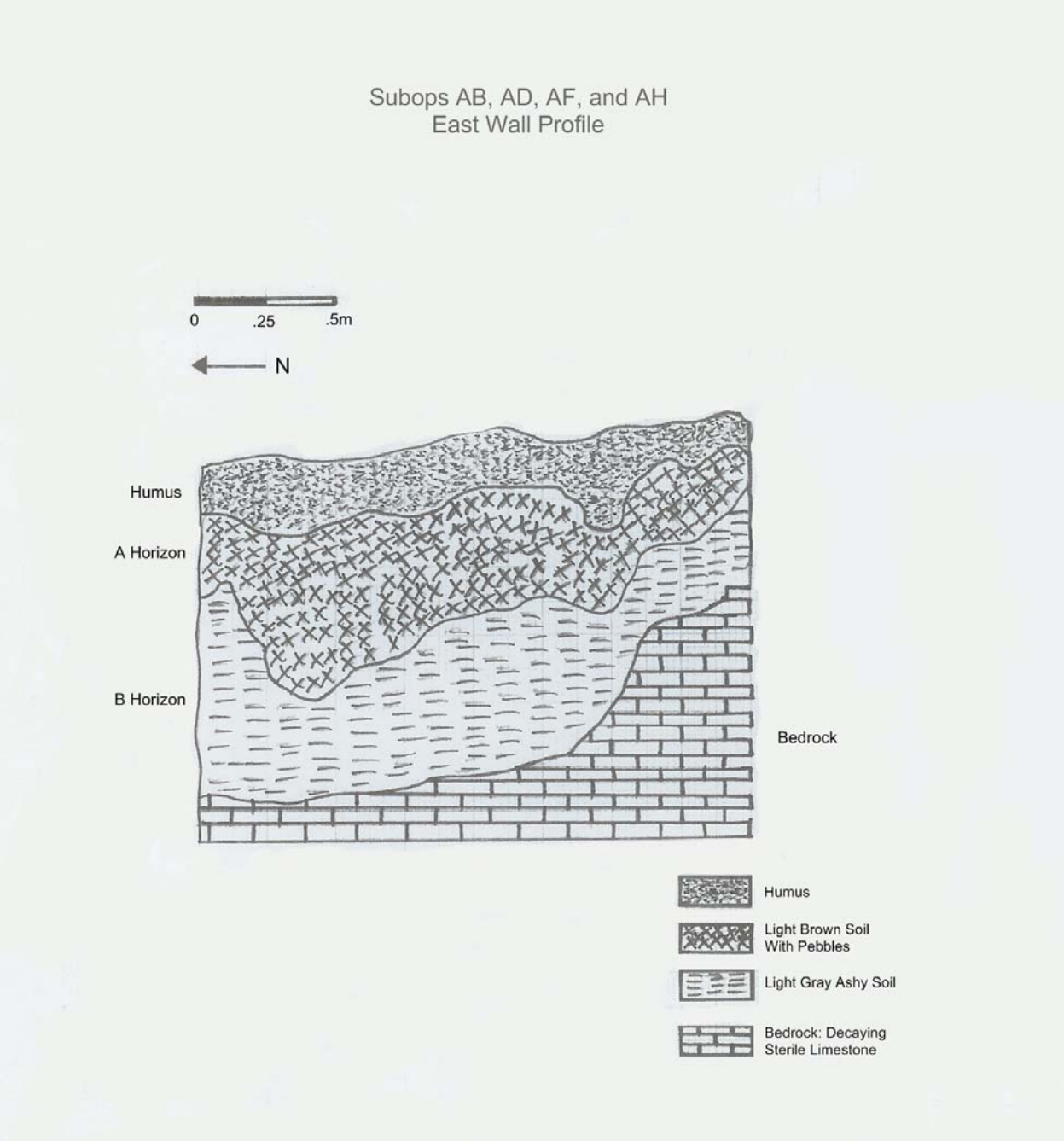

Figure 5.4. Sub-operations AB, AD, AF, and AH, east wall profile

CHAPTER 6
DISCUSSION

Sub-operation A

Based on the current topography, this initial unit was opened beneath the south slope of the site near the bottom or low point of the depression. As the first excavation unit in the depression, it was hoped that Subop A would provide clear examples of soil stratigraphy underlying the site and the amount of cultural material present at varying depths. A soil profile of the east wall of the subop was created to illustrate the composition of the soil at varying depths from the surface to bedrock (Figure 5.1). An inconsistent, thin, dark humus layer was followed by light brown pebbly soil, a light gray ashy layer, and finally bedrock.

On a larger scale, the purpose of this subop (as well as that of the other units) was to answer my preliminary research questions. My primary goals prior to excavation were: (1) to excavate down to bedrock as much of the depression as possible in order to visualize and map the rough dimensions of the *aguada*; (2) to then examine the exposed bedrock surface to see if it was artificially modified to aid in channeling; (3) to see if the bedrock surface had been overlaid with a clayey sealant to aid in water retention; (4) and to collect cultural material for analysis and the compilation of artifact densities throughout the site. Subop A was opened with all of these objectives in mind.

Lithic and ceramic material was present in all five lots of this subop with densities increasing with depth through lot 4. A noticeable increase in lithic material was encountered in this lot coupled with a decrease in the amount of ceramic remains. Taken together, these findings could indicate the use of stone tools for quarrying the limestone floor of the depression for precious building or groundstone artifact material and/or to expand its water-holding capabilities

(Folan 1982; Weiss-Krejci and Sabbas 2002). The collected lithic cores from the lower depths of the unit may be empirical evidence of these mining activities. Evidence of a possible unnaturally modified "trench" in the limestone lends credence to this possibility, although the feature exhibited no conclusive evidence of definitive tool marks. The extent of this feature was subsequently uncovered in excavation units on the north and south sides of Subop A. A small obsidian flake was collected from lot 2. Its presence is attributed to natural in-washing or discard from a nearby structure such as Medicinal Trail Operation 7 or the nearest house mound, especially if the depression functioned as a trash dump at some point. Relatively high sherd and debitage densities in the upper strata of this unit support this notion (cf. Weiss-Krejci and Sabbas 2002). Medicinal Trail is not located in an obsidian-rich area, nor was it a major destination for the trade of this precious material, so the presence of this minor flake resulting from nearby obsidian working can be discounted. The occurrence of small shell fragments throughout Subop A and other units across the depression seems to be insignificant. Small terrestrial snails are common across this landscape and are known to exist here both in the past and present.

A 3-liter soil sample was collected from lot 5 for later analysis (see Appendix A). The type of organic or botanical remains within the sample should help create a clearer picture of the depression's immediate surroundings as well as its function.

Sub-operations B, C, D, E, F, G, H, and I

These 50 cm x 50 cm subops, forming a 1x2m trench, were opened on the north side of Subop A nearer the base of the depression. The objectives of this series of units were again to compile artifact densities in order to isolate a probable activity area within the site and to examine the bedrock foundation for the reasons stated above.

Densities of ceramic sherds and lithic debitage varied widely through the lots of these subops. Subop B held moderate amounts of material throughout and a cobble-sized worked lithic in lot 3 at a depth approximately 30 cm beneath the surface. Its presence is indicative of either stone working at or near the site, the depression's use as a waste dump, or both. Decreasing amounts of material were collected from the remaining subops, fluctuating from minor quantities in Subops C and D to an almost total lack of material in Subops E-I. The general trend within the greater 1x2m trench, then, was a decrease in the densities of both lithic debitage and ceramic fragments down slope from south to north. Topographically, these eight units were established at the trough of the depression, terminating at bedrock at an average depth of 52.45 cm below the present surface. Subops B and C had the lowest ending elevations and were located at the deepest point of the *aguada* with Subops D-I becoming gradually shallower as excavations proceeded north through the units. The highest densities were recorded at the lowest depths, decreasing as depth decreased. Nevertheless, whether the material was put into the depression when it held water during the wet season, when it was desiccated during the annual dry period, or when it was just a concave trash dump without water-holding capabilities, ceramic sherds or lithic waste would have settled near the bottom.

The occurrence of charcoal pieces throughout these units, most likely resulting from localized fires sweeping through the area, again sheds little light on the role of the depression. Aside from ecogenic fire, high concentrations of charcoal fragments could reflect slash-and-burn agriculture or burning for forest clearance (Pohl et al. 1996; Johnston et al. 2001). Although both are indicative of human occupation, past or present, the only relationship between these activities and the depression is that they appear to have taken place in its general vicinity. If the vast majority of charcoal remains were discovered at or slightly above the bedrock, it could have

resulted from the stewards of the depression "firing" the surface to reduce its porosity (Scarborough, personal communication, 2007). However, due to the random nature of charcoal fragment distribution, this was not the case. Finally, the undulating, natural bedrock beneath these subops exhibited little sign of artificial modification.

A small soil sample (4.3 g) was collected from lot 5 of Subop C. It was subjected to light fraction analysis and retained for later study (see Appendix A).

Sub-operation J

Subop J was a 1x2m unit placed on the north side of Subops B-I, abutting Me-Bar's 2004 Subop AB. The twin goals of this unit were to expand excavation of the depression toward the north end of the site and again measure artifact densities with the aim of pinpointing the location of an activity area at the site.

This subop contained minor amounts of lithic and ceramic material similar to that of Subop D and, similar to our results from subops B-I, we also encountered a marked decrease in densities as we proceeded from south to north within the unit. However, this decrease could be due to our encountering of Me-Bar's backfill in the southern half of the subop. Interestingly, a difference was also noticeable in both ceramic and lithic densities as we excavated deeper into the unit, to the point that an extremely low number of materials were collected from lots 4 and 5. Lot 5, with a depth of 97 cm below the surface, proved to be the lowest point excavated in the entire depression. The bedrock in this unit exhibited signs of possible unnatural quarrying, but this hypothesis could not be verified. The rim of the depression was not excavated, so cut marks located there that would substantiate the quarry theory (cf. Weiss-Krejci and Sabbas 2002) were

not discovered. The bedrock base of Subop J, however, did display possible tool marks and flattened edges that could be indicative of quarrying.

Also of note was the continued presence of charcoal and another mid-sized obsidian flake within Subop J. The charcoal could again result from small-scale, random tropical forest fires, slash and burn practices, or burning for clearance. Any or all of these activities would produce charcoal in amounts observed. The obsidian flake, one of only a few recovered from various points within the site, could have resulted from trash dumping, discard or, less likely, from obsidian working in the area.

Sub-operations K, L, M, N, O, P, Q, and R

This collection of .5m x .5m units, located on the south side of Subop A, was opened to expand excavations south while maintaining very fine control over artifact densities. We expected to encounter densities either equivalent to or exceeding those of Subop A, and in subops K, L, M, and N we did encounter densities very similar to the initial subop. A high concentration of charcoal was noted in lots 2 and 3 of Subop K as well as in lot 2 of Subops M and N. The fairly consistent amounts of charcoal now observed on both the south and north sides of the site neither confirmed nor refuted our theories for their presence. If the bedrock surface was fired to improve water retention, or if the charcoal remained from some sort of fire episode in the vicinity of the depression, we would expect to find nearly uniform amounts of charcoal remains based on assumed regular depositional processes.

A third small obsidian flake was collected from Subop K, lot 3, at a depth of 34 cm from the surface. The first fragment was collected from Subop A, approximately 25 cm below the surface, and the second was found at a much lower depth of more than 90 cm beneath the surface

of Subop J. The seemingly random distribution of obsidian, both in location and depth, indicates that there is a fairly high likelihood that its presence in the depression is the result of discard or dumping. Much lower amounts of lithic and ceramic material were collected from subops O, P, Q, and R as we excavated from north to south. Densities continued to decrease with depth within each unit similar to our findings in Subop J. These results were not altogether unexpected, however, as we had now reached what appeared to be the southern rim of the depression and were excavating away from it. If we continue to assume that this rim of the depression represents a probable activity area (based on density of artifacts observed and collected), then our continually decreasing artifact densities away from this area, both to the north and to the south, are to be expected.

Sub-operations S, T, U, V, W, X, Y, and Z

Like the previously excavated 50x50 cm units, the purpose of opening subops this size was to establish greater control over artifact densities. It was also hoped that these excavation units, based on the density and location of ceramic and lithic material present, would either support or counter the theory that the south rim of the depression could have served as the focal point for tool working or trash dumping at the site. Although Subop S contained amounts of lithic and ceramic material comparable to subops K-M, densities declined markedly through subops T-Z. A small amount of lithic material and very few to no ceramic remains were recovered from these units, and even these low densities decreased from west to east within this series as we continued to excavate across this slope on the south rim of the depression. These findings seem to confirm the possibility that the area immediately surrounding Subop A, possibly to the south, functioned as an activity area, based on artifact densities.

Small charcoal fragments were detected throughout these units, again seeming to indicate localized burning at the site. At this point, the location of the charcoal in the upper strata of these units seems to negate the possibility of their presence resulting from ancient Maya bedrock firing. However, this thesis cannot be totally disproved, as the present location of the fragments could be the result of decomposition, root action, or other forms of bioturbation.

A 1.5-liter soil sample was taken from each of the four lots of Subop S. They were saved for later analysis (see Appendix A).

Sub-operations AA, AB, AC, AD, AE, AF, AG, and AH

These 50 cm x 50 cm units were located on the east side of Subops B-I. Connecting Subops A and J, these pits resulted in a 2x7m trench excavated down to bedrock in the center of the site. The reason for opening subops of this size was again to establish greater control over artifact densities with the expectation of discovering artifact amounts similar in quantity to those of Subops B-I. What we observed was fairly high fluctuation in both lithic and ceramic densities throughout this series of subops ranging from little or no recoverable material in some lots to relatively high densities in others. In addition, no measurable differences were recorded in the densities relative to depth or direction within the subops comprising this 1x2m trench. Overall, artifact amounts were not measurably different from those in Subops B-I.

A small obsidian flake, the fourth recovered in our excavations, was collected from lot 2 of Subop AA. Lot 4 produced a large biface from Subop AF. The presence of this biface, in addition to others, supports our hypothesis that one of the possible uses of the site was as an area for working tools. A 1.5-liter soil sample was extracted from each lot of Subop AG. These four small samples were preserved for later analysis (see Appendix A).

Sub-operation AI

This 1x2m unit, positioned on the east side of Subop AJ, was opened to expand excavations east of the 2x7m trench cutting through the center of the depression and to observe and record material concentrations in this direction. Fair amounts of lithic and ceramic sherds were collected from the unit with the notable exception of a total lack of ceramic material in lot 1. A relatively sizable amount of charcoal was observed throughout, in addition to several small shells and shell fragments. Both partial and complete shells were observed in a few other subops and, again, are most likely the remains of terrestrial snails. Of particular interest within this subop was a small bone (8 cm in length) collected from lot 3 at a depth of 31 cm. It appeared to be from an Ocellated Turkey or other small mammal native to the area. Although unique to our excavations, the bone was not subjected to any further laboratory analysis due to the known presence of many small mammals in the area. The bone had no bearing on our investigations or the function of the depression.

Sub-operations AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, and BG

The objective of these postholes, placed around the upper perimeter of the depression, was to determine future locations for the placement of 1x1m test pits. The goal was to then expand several of the postholes, based on the highest material densities, into these small test units. The 1x1m pits were preferred to larger 2x2m units due to the smaller material densities we would expect to find at these higher elevations based on previous excavations near the upper rim of the depression (specifically, Subops Q, R, Y, Z, and the eastern portion of Subop AI), and due

to time constraints. Based on the material densities within these future 1x1m units, we anticipated narrowing potential locations for ancient activity areas.

Lithic and ceramic material densities ranged from very low to high with no apparent pattern between the locations of the postholes and their densities. Findings of note within these subops were a mid-sized biface from Subop AP, slightly above the northern rim of the depression, and a small obsidian flake from Subop AU, above the east side of the depression. Subop AP was located in the north end of the site between Operations 7 and 10, and the biface discovered here indicates this could have been an area for tool working. Interestingly, Me-Bar reported a huge amount of debitage in this area, as well as the possible remains of a collapsed stone platform, during his excavations in 2004. It is possible that this biface and lithic debitage are contemporaneous and that the stone platform was the setting for tool working at the site. Regardless, the combined findings of Me-Bar and myself reinforce the theory that the depression served, at least in some capacity, as an area for the working of stone tools near an aquatic setting. Conversely, the possibility of the depression functioning primarily as an organic refuse dump (as opposed to a potable water source) and also as a tool workshop can probably be discounted, as the setting would be a foul-smelling and uncomfortable environment in which to work.

Sub-operation BH

This 2x2m unit was located on the western half of the depression touching the west sides of Subops A and B. Upon completion of excavating a portion of the west wall of Subop A and the entirety of units B, D, and F, an uneven layer of cobbles was discovered embedded in and protruding from the west side of these units. This cobbly outcropping was unique to the site, and Subop BH was initially opened to determine its extent and possibly its function within the

depression as well as to satisfy the previously mentioned excavation objectives. Me-Bar's previous work at the site had uncovered "some sort of rock ledge" (Me-Bar 2004) with a pile of collapsed rocks very close to this subop, and we excavated under the assumption that these cobbles might be connected to his findings. Unfortunately, the fist-sized stones were fewer in number and more random in distribution than we had expected, and it remains unclear as to whether or not their presence was merely the result of rock fall or other common action or collapse from a platform or ledge located near the western rim of the depression.

A moderate amount of lithic and ceramic material, similar to adjacent subops, was collected from the unit. More shell was observed in lots 1-3. These findings continue to support the theory that the depression served as a comfortable area for working tools and a site for the dumping of inorganic garbage or discarded material, in addition to a water feature. Organic waste would contaminate the potability of the water source.

Sub-operation BI

This subop was positioned slightly above and adjacent to the southwest corner of Subop BH on the upper slope of the southwest rim of the depression. The objectives of this unit were twofold: (1) to continue to measure and record artifact densities in this portion of the site, and (2) to partially connect our excavations with part of Me-Bar's 2004 work. When completed, Subop BI connected our Subop BH with one of Me-Bar's 2x2m units located on top of the western slope of the depression. We now had a good portion of the west side of the depression excavated, branching off from our 2x7m trench cutting through the center of the site. A large amount of lithic and an even larger amount of ceramic material was collected from the unit, notably increasing with depth. Multiple bifaces and another small obsidian flake were also collected.

These findings, combined with similar results from the previous subops nearest this southwest end, indicate a high likelihood that this portion of the depression served as an activity area.

Me-Bar's 2004 excavation unit directly upslope and to the west of Subop BI was opened with the intent of examining the bedrock in search of a channel for the inflow of water into the depression. We both believe that if a channel existed this would be its most likely location due to the lower elevation of the immediate area on this side of the site. After an examination of the bedrock, he found no evidence of a channel. We also looked for signs of either a natural or modified channel at the bases of Subops BI and BH, but found nothing in either. Despite this side of the depression being the most likely location for a channel, heavy vegetation and time constraints prohibited opening more units here.

Sub-operation BJ

Subop BJ was located on the north end of the site. A 1x5m trench from Me-Bar's excavations was located one meter south of BJ, with another series of his units positioned just to the east. Within his trench of units east of Subop BJ, Me-Bar uncovered a "compact, cemented structure" (Me-Bar 2004) that he first believed to be a post-hole for the support of an overhang. Despite the fact that Me-Bar now believes the "post-hole" was nothing more than the remains of burned, hardened clay surrounding a small tree or large root that was burned out, Subop BJ was opened to assess the previous theory. If the remains did function as a support for some sort of overhang, then a second one would have been needed. Along with Me-Bar (personal communication 2006), this is where we determined its most likely location. However, after completely excavating the unit we found no evidence of anything resembling his previous finding, further discounting the post-hole hypothesis.

A very high density of lithic material and a moderate amount of ceramic sherds were collected from the unit, similar to Me-Bar's findings in this area of the site. If we were to agree with Me-Bar's initial premise that his discovery was in fact a posthole, supporting a cover for a work area in this portion of the site, then the large amount of lithic discard collected here during both excavations could possibly be explained. Even if the "structure" was simply an example of fired clay surrounding a root that was burned out, which is the more likely explanation, the possibility remains that the large amount of lithic material in this area still resulted from tool working.

Sub-operations BK, BL, and BM

These 1x1m units were placed on the east and south sides of the depression with their locations based on the largest material densities recorded from the postholes (Subops AJ-BG) positioned around the perimeter of the depression. All three units were opened with the objectives of recording artifact densities to help map probable work areas and to examine the bedrock for evidence of human-made modifications or channeling. In addition, a secondary objective of Subops BK and BL was to expand excavations into the eastern portion of the site; an area that remained largely untouched due to extremely heavy vegetation and a large ceiba tree restricting digging. Subops BK and BL represented the furthest east either Me-Bar or I excavated at the site, and Subop BM represented the furthest southern point.

Both lithic and ceramic densities increased as we excavated from east to south around the depression rim, from Subop BK, to BL, and finally BM. Unfortunately, densities were not high enough within any of the units to indicate probable areas of high activity around the edges of the

site. Also, no strong evidence of channeling or quarry scars was apparent within the bedrock of these subops.

CHAPTER 7
CONCLUSIONS

Water management was a crucial factor in the development of the ancient Maya. In an environment with largely unproductive soils, annual seasonal drought, and a harsh karstic landscape that prohibits major natural accumulations of perennial water sources, the control and management of water attest to its powerful, organizing force (Ford 1996; Scarborough et al. 1995; Scarborough 1998). Examination of the ancient reservoir technology in the tropical wet-dry forests of the southern Maya lowlands reveals that rainwater storage basins were the major source of water for many sites during a four month dry season (Scarborough and Gallopin 1991; Weiss-Krejci and Sabbas 2002). In addition to serving as potable water sources, many of these small reservoirs also provided irrigation water for agriculture. This organization of water sources, then, appears to have been necessary for ancient Maya settlements of any size to survive. Due to the necessary role water plays in the sustainability of human life and the development of advanced societies, it is hardly surprising that so many scholars have cited drought and/or the inability to store reserves of water through consecutive years as contributing factors in the "collapse" of the Classic period Maya (Beach and Dunning 1997; Beach et al. 2003; Dunning and Beach 2000; Gill 2000; Harrison 1977; Hodell et al. 1995; Kunen 2004; Lucero 1999, 2002; Scarborough 1993b, 1994, 1996, 1998, 2003; Scarborough et al. 1995; Scarborough and Gallopin 1991; Siemens 1978).

In this thesis, I have examined a small depression located at the Medicinal Trail site in northwest Belize to determine its most likely function. After excavating the majority of the depression, recovering cultural material, and evaluating the resulting data, the evidence points to this depression being modified and used by the ancient Maya as a potable water source during at

least a portion of the year, a lithic activity area or workshop, and a subsequent trash dump. In addition, other hypothesized uses for the depression including a limestone quarry, clay mine, collapsed *chultun*, or ritual site have been discounted.

The depression's close proximity to several terrace and house mounds, along with the absence of any apparent permanent water sources in the immediate vicinity, suggest its function as a potable water source for the surrounding small agricultural community. The presence of small reservoirs, or *aguadas*, near household plots or house mounds throughout the lowlands has been noted multiple times (Bullard 1960; Matheny 1976; Scarborough 1993, 1998). In addition, its calculated capacity of 88m^3 would have provided a fairly significant amount of potable water to the nearby residents.[1] The total volume of 88.357m^3 (88,357 liters), or over 23,000 gallons, would have provided over 46,000 person/day servings maximum. A full reservoir, then, with no evaporation could provide over 120 people with enough water each day for one year.[2] When considering the relatively minor population the reservoir would have served, its capacity compares favorably to that of other reservoirs in the region also thought to have served as potable water sources such as those at the Wari Camp, La Milpa East, and East Transect sites (Weiss-Krejci and Sabbas 2002) and Tikal (Gallopin 1990). While these reservoirs had much larger capacities, they were also required to provide water to far larger populations. By comparison, the nearby Turtle Pond *aguada* had a calculated capacity of 785m^3 and most likely supported a substantially larger population than the Medicinal Trail reservoir.

[1] Reservoir capacity was estimated by taking the formula for an elliptical cone, H(1/3)∏(A/2)(B/2), where H is the height and A and B are the length and width of the ellipse, respectively, and modifying it to accommodate the fact that smaller reservoirs tend to be more spherical in shape. The derived formula, H(1/2)∏(A/2)(B/2), was used to calculate the capacities of both the Medicinal Trail reservoir and Turtle Pond *aguada*. This formula employs a constant (1/2) which is halfway between the constants (1/3) and (2/3) of the formulas for a cone and a hemisphere, respectively.

[2] The current estimated standard of 64 oz. (1/2 gallon, based on eight – 8 oz. glasses/day) of water per day per person was used to calculate the maximum person/day servings.

The presence of a clayey layer of "sealant" overlaying the bedrock at the base of the depression, shown to reduce the porosity of the limestone bedrock and aid in water retention at several sites in the southern lowlands including nearby La Milpa, is another positive indicator that the depression functioned as a water storage reservoir. Though sometimes difficult to differentiate from the softer, naturally decaying limestone bedrock, this gray sealant was found at the base of multiple units throughout the depression, indicating that the exposed limestone was modified to improve its water-retaining capabilities. Finally, the high density of ceramic sherds recovered throughout the reservoir also lends credence to the water storage hypothesis. Among the ceramic remains were numerous jar fragments, bowl rims, and body sherds that could have been employed in the collection and transport of water from the site and either unintentionally deposited in the course of this function or intentionally thrown in upon breaking.

Despite the fact that this evidence points to a water storage function for the reservoir, the small size of the *aguada* and the relative porosity of the underlying limestone bedrock (even with the clay sealant) indicate that it would have been difficult for the tank to retain water throughout the lengthy annual dry seasons in which it would have been employed. It was perhaps during these dry periods that the reservoir served in other capacities, including as a lithic activity area. The amount and nature of lithic material recovered from the depression support this lithic workshop hypothesis. Although present throughout nearly every unit, higher densities of lithic material were found toward the south and southeast portions of the depression, pinpointing these specific areas as possible locations for lithic work. However, fluctuating material densities across the site unfortunately prohibit the definitive placement of lithic activity areas (Figure 7.1).

A total of 57 tools, generally poor to very poor in quality, were recovered from the depression. With the exception of one chalcedony scraper, all the tools were composed of chert.

They can be divided into three typological classes: bifaces, informal and expedient tools, and cores (Hyde 2007). Biface tools make up 53% (n=30) of the tool assemblage, more than half of which are forms related to agriculture: oval bifaces and bifacial celts. The remainder of the biface types present occurs in small quantities. Informal and expedient tools make up 23% (n=13) of the tool assemblage recovered at Operation 10. This category is primarily scrapers (n=5) and utilized flakes (n=6), with one drill and one stemmed blade. The scraper sample is diverse in the type and quality of material used to make these tools. By contrast, the utilized flakes are all made of bad to intermediate chert. Cores make up 19% of the tool assemblage (n=11), consisting of three different types: unidirectional flake cores (N=2), multidirectional flake cores (n=5), and bifacial cores (n=4). None of these cores are specially prepared cores (Hyde 2007). These cores can best be described as improvised cores used to produce flakes that could in turn be used as expedient tools. All the cores are made from chert cobbles and vary in quality from very bad to intermediate. Chert and chalcedony flakes comprise the remainder of recovered lithic material. The lithic assemblage of Operation 10 at the Medicinal Trail site is best characterized as being dominated by bad quality chert material used to produce bifaces for local consumption and agricultural usage. Additionally there appears to be limited core reduction occurring, most likely for expedient tools such as scrapers and simple utilized flakes (Hyde 2007).

The presence of both stone tool fragments and lithic debitage found in close association with each other, coupled with the belief that the area would have been a shaded, comfortable setting for tool-working, further support the theory that the depression served as a site for lithic tool-working. Also, the input of this inorganic waste material would not have contaminated the water stored in the *aguada*, allowing for its continued use as a potable water source.

A final use for the depression appears to have been as a trash pit or site for dumping inorganic waste. The extremely high densities of both lithic and ceramic material throughout the depression combined with the nature of the discarded fragments support this conclusion. Though the presence of some of the ceramic material can be attributed to incidental breakage (and ultimate discard) in the course of collecting water, the high density of multiple types of body sherds and flanges dated from Late Preclassic to Terminal Classic points to a lengthy, more random period of discard activity. Although the majority of ceramic material dated from the Late/Terminal Classic time period (Tepeu 2/3), material dating from both the Late Preclassic (Chicanel) and Early Classic (Tzakol) periods was intermixed and randomly distributed throughout the depression, again indicating dumping activity. Recovered lithic material displayed much the same patterns, with debitage, tool fragments, and multiple bifaces scattered throughout the depression in seemingly random fashion. In addition, high sherd and debitage densities in upper strata of depressions, like those encountered here at the Medicinal Trail depression, have previously been noted as indicating their use as trash dumps (Weiss-Krejci and Sabbas 2002). The collection of multiple minor obsidian flakes and a single small animal bone, whose presence cannot otherwise be explained, lend further support to the trash pit hypothesis.

Other possible uses for the depression, including a limestone quarry, clay mine, collapsed *chultun*, or ritual site, were disproved during the course of excavations. A lack of cut marks exposed on the rim of the depression or on any of the underlying bedrock negated the rock quarry theory. The absence of natural clay inclusions throughout the subsoils of the depression contradicted the clay mine premise. The lack of a collapsed bedrock layer on top of cultural material invalidated the collapsed *chultun* hypothesis. Finally, the absence of any incensario or censer fragments, caves like at the Dos Hombres site (Me-Bar 2005), or dedication caches like

that encountered by Trachman at Grupo Agua Lluvia (Trachman 2007) disprove the notion that the reservoir served in some ritual capacity.

This thesis has provided a detailed examination of a small reservoir modified by the ancient Maya to serve both immediate physical needs as well as cultural functions. Water is an essential requirement for human life, and this and other studies of Maya water management practices and resources help to illustrate the many ways in which the Maya adapted to and modified their environment to accommodate an unreliable water supply.

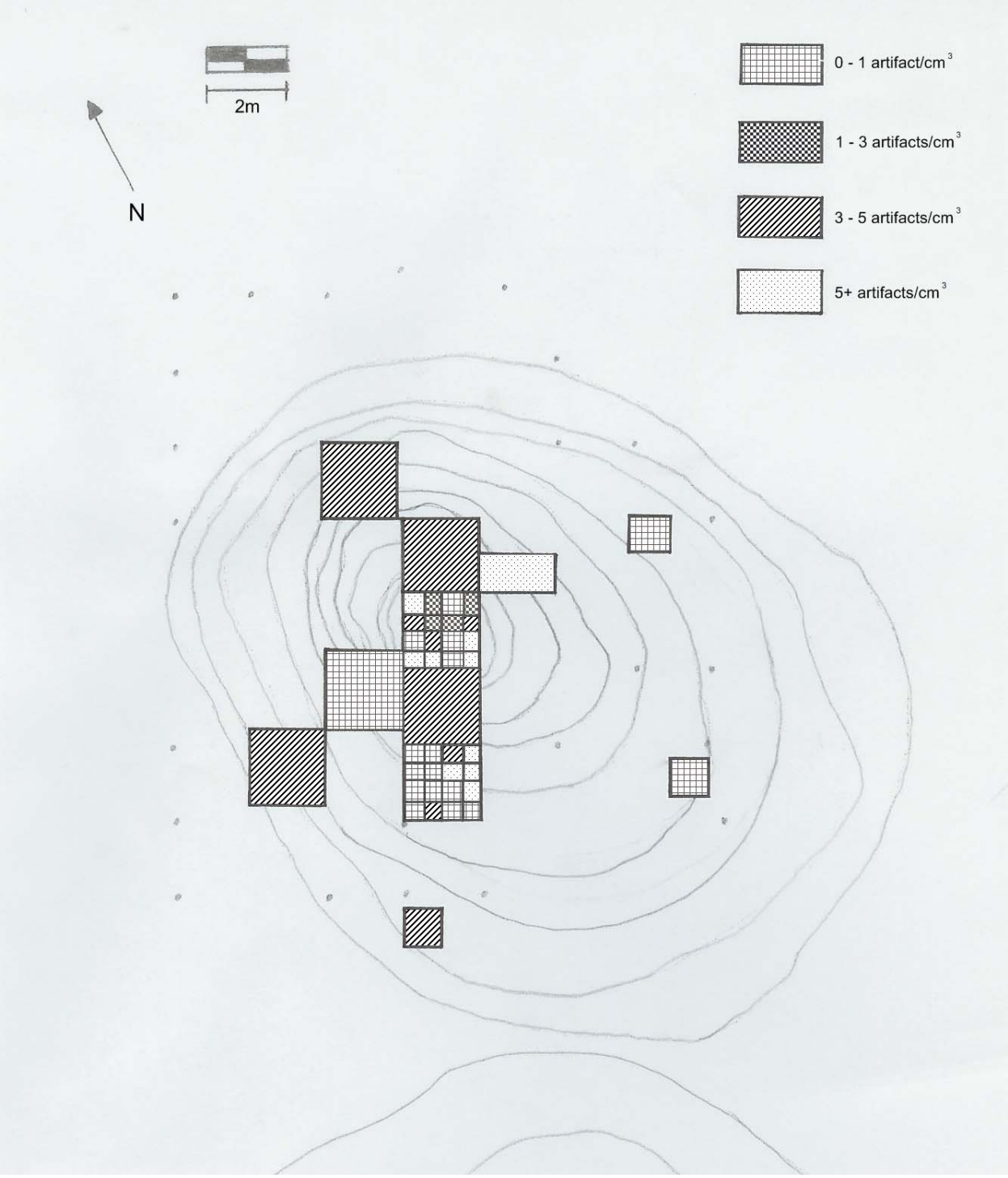

Figure 7.1. Map showing the density of artifacts within each excavation unit.

Date	Period	Ceramic Phase
800 - 600 BC	Middle Preclassic	Swasey
600 - 400 BC	Late Preclassic	Mamon
400 BC - AD 250	Late Preclassic/Early Classic	Chicanel
AD 250 - 650	Early Classic	Tzakol 1/2/3
AD 650 - 850	Late Classic	Tepeu 1/2/3
AD 850 - 900	Terminal Classic	
AD 900 - Spanish Conquest	Postclassic	Limited Occupation

Table 7.1. Maya chronology and associated ceramic phases in the Three Rivers region.

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APPENDIX A
SOIL ANALYSIS

Although all soil samples recovered from the Medicinal Trail depression this season were floated, bagged, and retained, due to time and equipment constraints only one small flotation sample was fully analyzed. David Goldstein and Gardner Brandt of Northeastern Illinois University subjected a 1.5 l sample taken from lot 5 of Subop C, located roughly in the center of the depression, to flotation and analysis.

After running the sample through the Flote-Tech model A-1 machine, a 0.425mm mesh was used in the base of the unit. This is a finer grade than the 1.0mm mesh that the unit is initially equipped with. Additionally, the flow was reduced to the lowest possible setting to reduce agitation. The sample was then caught in a fine polyester gossamer mesh and set aside to air dry in a shaded area. Once catalogued, the sample was passed lightly through a standard series of graduated sieves for better viewing, 4.0-0.425mm mesh. Though 100% of the 4.0, 2.0, and 1.0mm fractions were reviewed, only 30% of the 0.425mm fractions were analyzed. The 4.0 and 2.0mm samples were reviewed for wood, charcoal, seed, and any plant or animal remains, while the 1.0 and 0.425mm fractions were reviewed for seeds only. The sample fraction smaller than 0.425mm was retained for future analysis, pollen or phytoliths.

Overall, the sample consisted of small limestone chunks are hard clays. A number of small pieces of wood charcoal were suspended in the matrix. The wood charcoal was minute, indicating that it was deposited in the sample in a heavily eroded state. Multiple modern roots and small land snail shells were recovered from the 4.0 and 2.0mm fractions. Seeds were recovered from the 4.0, 1.0, and 0.425mm fractions. One possible palm seed fragment was recovered from the 4.0mm fraction that was labeled cf. Arecaceae. As of yet, there is no

determination. Goldstein and Brandt report several types of recovered palm seeds in their dataset, many of which are pending determination. Palms are used and tended by the modern Maya in and around settlements, both of which are similar to activities that occurred in the past. A second unknown seed, no determination as yet, was recovered from the 0.425mm fraction. Unfortunately, the amount of material recovered indicates that determination is not likely. Photographs of both are attached below.

A total of 9 seeds with the determination of cf. Onagraceae were recovered in the sample. Photographs of these seeds are also located below. These are seeds from a plant currently being investigated as part of the evening primrose family. Goldstein reports that although the plant's wild modern relative has yet to be located either in the Programme for Belize area or the Yucatán, it appears that its presence is a strong indicator of human activity and presence. One possibility is that it is of the *Oenothera* genus, but its exact significance or its relationship to human activity in this time period is unclear. It has been found at several sites in the survey area, including in and around the Blue Creek site area. It has also been found in conjunction with both feasting and domestic middens at the Barba Group (RBS2) and Guijarral (RB18). These seeds (n=155) appear to be more ubiquitous at domestic loci (n=124) than at feasting loci (n=31). At present, within our project, Goldstein believes that this apparent distinction is significant, as this particular taxon is one of the most recovered among the dataset.

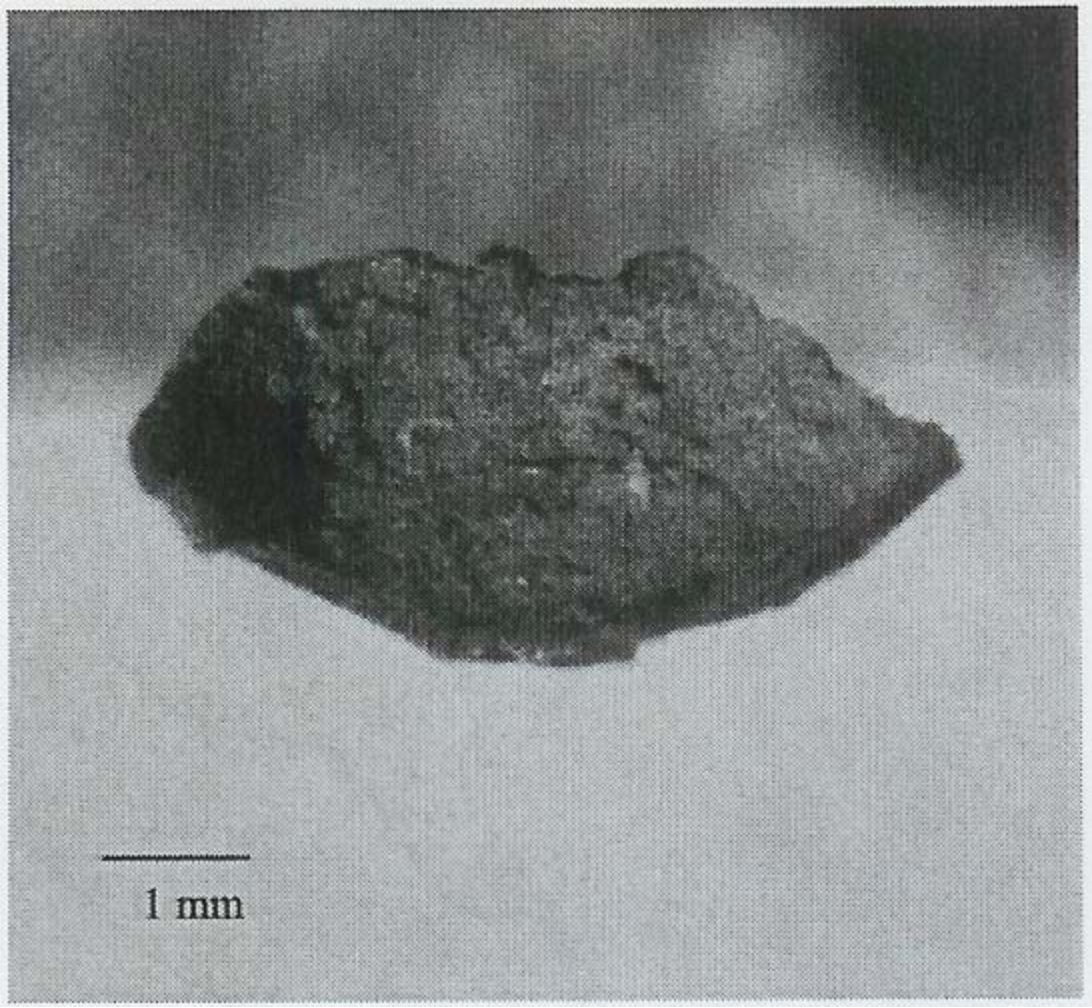

Figure A.1. cf. Arecaceae: obverse

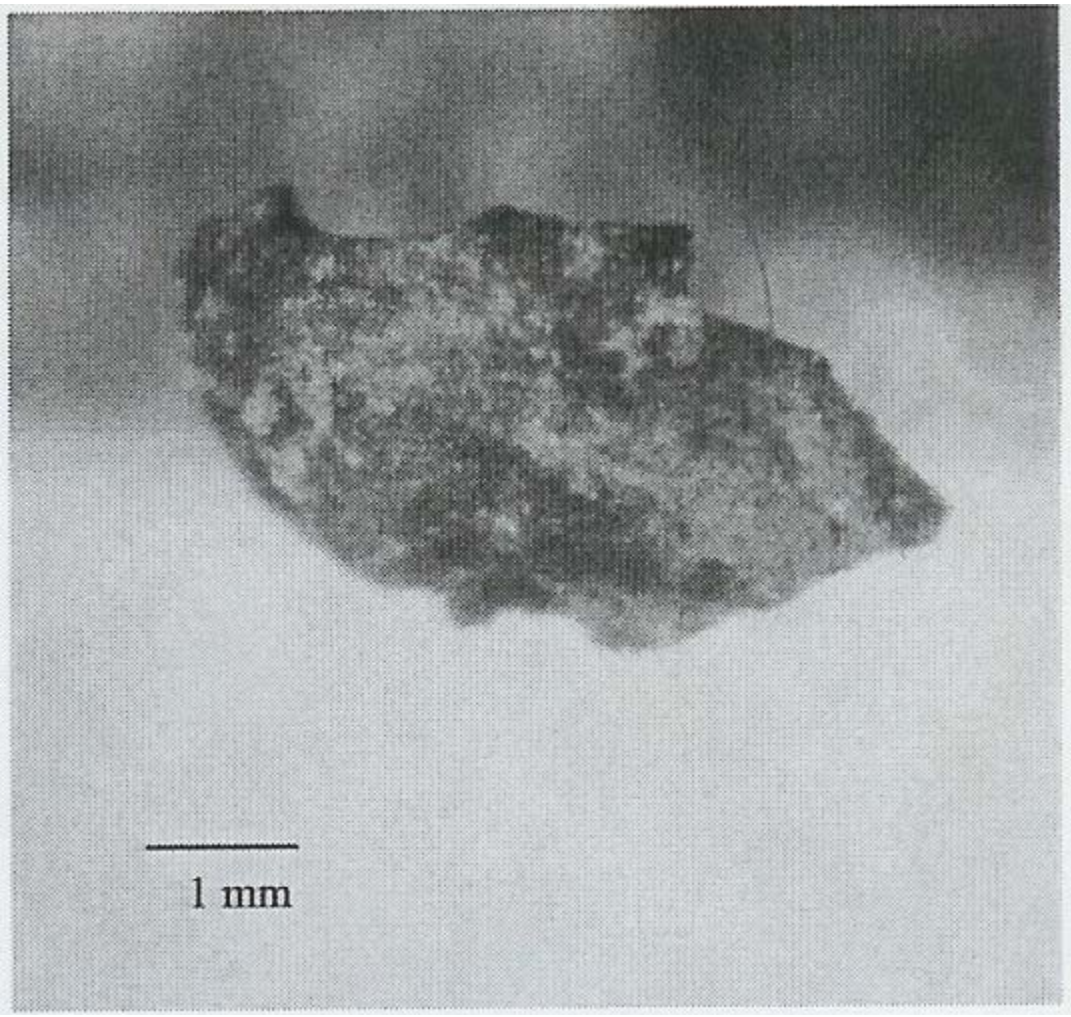

Figure A.2. cf. Arecaceae: reverse

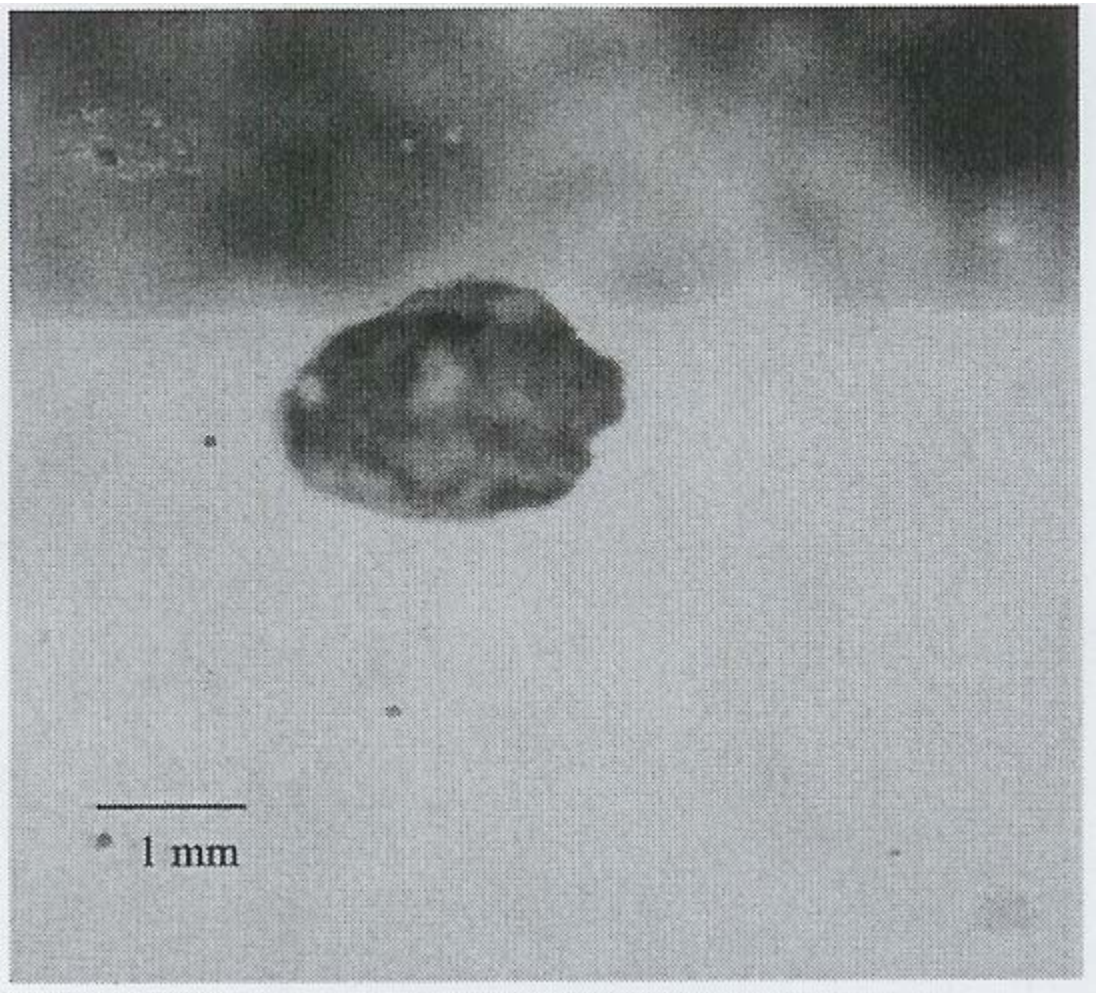

Figure A.3. Unidentified seed fragment

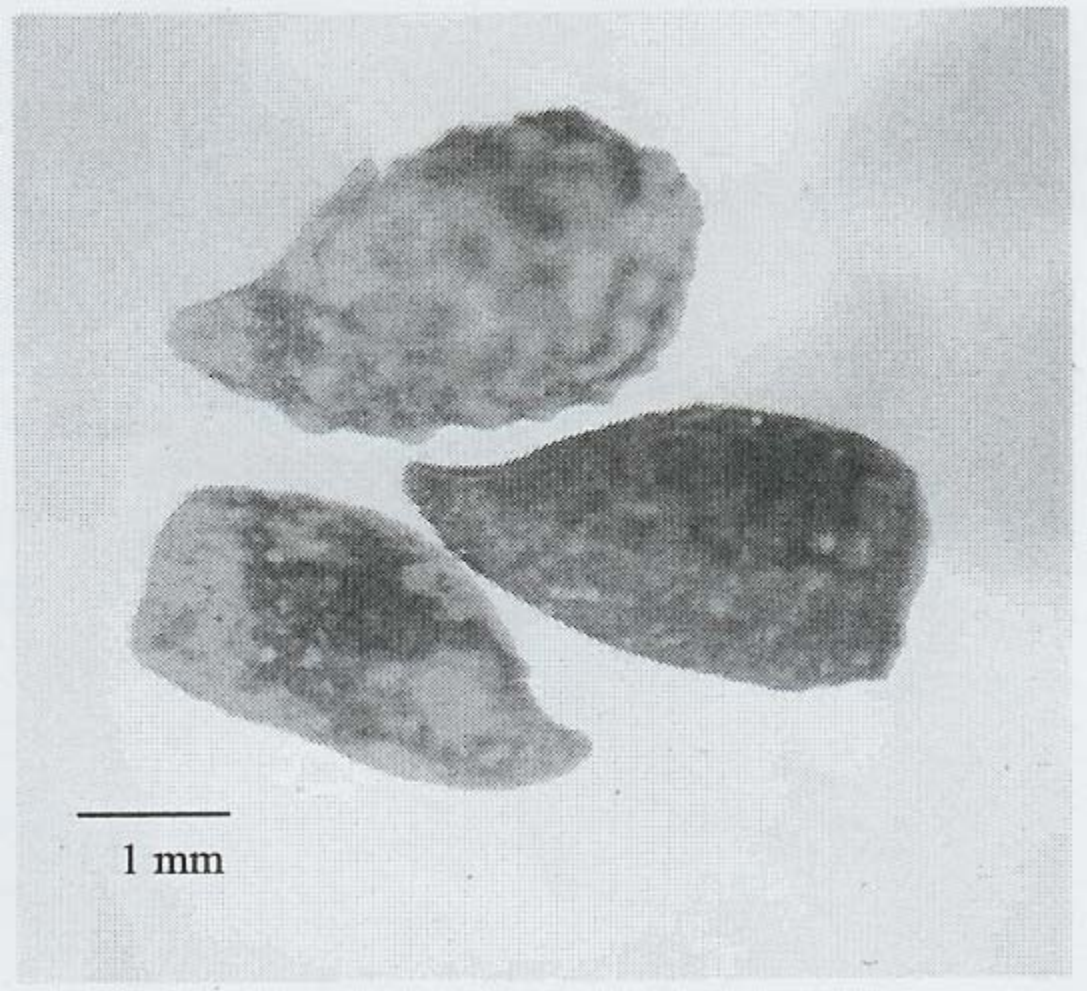

Figure A.4. cf. Onagraceae