THESIS

TESTING THE WATERS: A SPATIAL ANALYSIS OF AN ENGINEERED WATER MANAGEMENT SYSTEM AT ANGAMUCO, MICHOACÁN, MEXICO

Submitted by

Nicholas Simpson

Department of Anthropology and Geography

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Master's Committee:

Advisor: Christopher Fisher

Stephen Leisz

Michael Falkowski

ABSTRACT

TESTING THE WATERS: A SPATIAL ANALYSIS OF AN ENGINEERED WATER MANAGEMENT SYSTEM AT ANGAMUCO, MICHOACÁN, MEXICO

The prehistoric Purépecha site of Angamuco is located on the eastern edge of the Lake Pátzcuaro Basin in Michoacán, Mexico, the geopolitical core of the Late Postclassic Purépecha Empire. The site is situated on an ancient volcanic lava flow known as a *malpais* with no nearby sources of perennial surface water to support the large population present. The region's climate is marked by a wet and dry cycle, wherein 80% of the precipitation received by the basin falls between the months of May through August. This thesis attempts to delineate the natural hydrology of the landscape at Angamuco and to identify and quantify the water management system engineered by the inhabitants of the site to retain surface runoff throughout the course of the annual dry season. Using LiDAR data acquired for Angamuco and algorithmic tools in ESRI ArcMap 10.6, the hydrology of the site can be visualized in order to extract and quantify the spatial and volumetric characteristics of the reservoirs at the site. By combining the volumetric reservoir data, hydrologic data, and climatic data for the region, a more dynamic picture of prehistoric water management begins to emerge. The analysis of these datasets provides evidence that the landscape at Angamuco was modified to optimize water retention at specific locations and that the water retention features are of adequate size and volumetric capacity to sustain a large population over the course of the dry season. Additional field research might greatly supplement the data presented here to provide a clearer picture of the complex water management strategies of the prehistoric inhabitants of Angamuco.

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CHAPTER 1 : INTRODUCTION

Throughout human existence, access to water has been a necessity for the survival and proliferation of every population. This is especially true for complex societies and prehistoric urban centers, where large populations must be sustained by constant and reliable sources of water. Water control in complex societies is associated with all levels of society and is tied intrinsically to sustenance of a large populations through potable drinking water, cooking water, and agricultural irrigation. Access to water and the investigation of the complex landscapes which accommodate water collection and allocation are crucial issues for assessing sustainability (Scarborough et al., 2012). This thesis aims to investigate the complex hydrologic topography and water management system at Angamuco, a large prehistoric city located on the eastern edge of the Lake Pátzcuaro Basin (LPB) in Michoacán, Mexico.

Studies of water management in Mesoamerica have become quite common, particularly for sites in the Maya region, which exhibit a pronounced wet and dry season as well as a lack of perennial sources of fresh surface water. Recent studies into water management in Mesoamerica have uncovered highly diversified water management systems at sites like Edzna (Matheny et al., 1983), Tikal (Scarborough and Gallopin, 1991), and Copan (Davis-Salazar 2003). Scholars investigating water management systems in Mesoamerica have focused on physical alterations to the environment for quite some time (e.g. Matheny 1978). Only recently have scholars scrutinized alterations to the physical environment from anthropological and interdisciplinary approaches (Scarborough, 2006).

The built environment at Angamuco exhibits such an opportunity to investigate water management from a multidisciplinary approach. The advent of LiDAR (Light Detection and

Ranging) applied to archaeological investigations has proven to be a paradigm changing technology (Chase et al., 2012) which is now allowing researchers to analyze entire landscapes in a relatively short period of time compared to traditional survey methods. LiDAR data obtained for Angamuco over the course of two flights (2011 and 2013) have made a significant impact on the way researchers can interpret the built environment at Angamuco. The built environment has been argued by scholars to be more than simply the result of passive functional purposes, but rather features are constructed with complex sets of purposes which are greatly influenced by the cultural milieu to which they belong (Rapoport 1969). Further, these features are influenced by the very nature of the landscapes upon which they are constructed and include both utilitarian, functional, and non-adaptive traits (Rapoport, 1969; Moore, 1996). Indeed, the landscape at Angamuco has a high degree of influence over the architecture and infrastructure developed over the long course of the city's occupation.

This thesis hopes to further our understanding of urban development and sustainability in the LPB by examining the LiDAR data for Angamuco through hydrological modeling and subsequent analysis of the resulting datasets. The objective of the hydrological modeling performed for this thesis is to address three primary lines of inquiry:

1. To delineate the hydrology across the site including water flow accumulation, micro-watershed basins, and catchment areas

2. To identify, extract and quantify potential reservoir and other water management features across the site

3. To use both datasets including hydrology and volumetric characteristics of proposed reservoirs to answer anthropological questions regarding access to water and population estimates for Angamuco

The primary method for delineating the hydrology of the site is with the suite of tools found in the ESRI ArcMap 10.6 Hydrology Toolbox. Chapter 4 of this thesis will explain the methods used for determining the hydrologic nature of the site using varying scaled parameters and the ways these changes in scaled parameters alter the resulting raster datasets created. Below I will outline the general course of the structure of this thesis.

Chapter 2 of this thesis will delve into the geographic and environmental context of Angamuco. In this chapter I will delve into the physical location of the LPB within the greater context of Mexico and Mesoamerica. I will describe the physical environment at Angamuco, including the type of landscapes and environmental zones within the LPB as well as the soil types that have been recorded for the region. I will also discuss briefly the climatic history of the LPB and the ways that the climate likely impacted the water development of the water management system at Angamuco. The following portion of Chapter 2 will discuss the cultural background and very broadly define the current narrative for the settlement of the LPB, cultural development through time, and the ultimate formation of the Purépecha Empire. I will additionally describe Angamuco itself in terms of its specific location within the LPB, previous work that has been done at the site and some of the spatial organization of the communities found at the site.

Chapter 3 will provide an overview of some of the many diverse forms of water management systems found throughout Mesoamerica and the ways that water management are integrated into ritual and everyday life. The chapter will begin with a brief overview of the many forms of water management and retention systems as well as their perceived functions at various sites. These water management features are focused primarily in the Maya region, which is the best studied in terms of water management and also exhibits sites reliant on rainwater to sustain large urban populations. The next portion of Chapter 3 will delve into some of the predominant theories behind analyses of the built environment. I will also discuss how water in the Maya region was regulated by elites and used as a source of power. I will also present several case studies from around the world that exhibit the ways different cultures use water control in a ritual context and the ways these examples relate to the broader Mesoamerican tradition. This section will include a discussion about the known rituals and cosmology surrounding water found in the *Relación de Michoacán*, which may elucidate how the inhabitants of the LPB viewed and treated water resources. Following this section, I will provide a counter perspective to the ideas that elites in the Maya region maintained control over water management by citing current research at the site of Caracol in Belize (Chase, 2016).

Chapter 4 will describe the methods used to generate datasets from which subsequent analyses may be performed. It will begin with an overview of LiDAR as a method for collecting spatial data and how it has been applied in archaeological contexts. I will also briefly discuss the process of correcting some of the digital errors encountered following the data processing of the raw LiDAR data. The next section will explain in detail the process for performing the hydrologic modeling used in this thesis. I will also describe the methods used for extracting and quantifying identified reservoir features and the system I developed for assigning reservoirs unique identifiers so that they can be easily searched and their attached data readily available. I will also define the study area chosen at the site for subsequent analyses.

Chapter 5 will present the results of the hydrological modeling performed for the site and the potential reservoirs identified using the methods described in Chapter 4. I will also describe the variety of water management features identified at Angamuco and some of the general patterns found across the site. The reservoirs identified will be divided into categories based on their perceived functions and spatial location around the site. I will additionally describe some of the architectural patterns that were broadly identified during the course of feature identification. Following the discussion of the reservoirs, I will discuss the way that the hydrology of the site influences many of the ater management features within the study area defined in Chapter 4.

Chapter 6 will follow to discuss some of the implications of the results of the datasets created for this thesis. I will briefly discuss the types of inferences that may be drawn about the nature of social organization from observances of the water management system at Angamuco, drawing from the dominant theoretical perspectives regarding water management in Mesoamerica. I will also discuss the ways that the reservoirs and their metrics can be used with existing climate data for the LPB to develop tentative population threshold estimates using water availability as a limiting factor. The next section will discuss some of the limitations of using explicitly LiDAR data for drawing inferences about social organization and population dynamics.

The concluding chapter for this thesis will briefly reiterate some of the points made throughout the thesis and summarize the data produced during the course of research. I will additionally provide directions for future work which will greatly supplement the results of this thesis. The aim of this entire work is to provide a baseline dataset from which anthropological questions can be evaluated through the lens of the hydrologic landscape and water management system found at Angamuco. This work is by no means exhaustive but will attempt to help place

Angamuco within the broader context of large urban settlements found in Mesoamerica and globally, but also to make some tentative statements about the nature of social organization and population dynamics within the LPB.

CHAPTER 2 : BACKGROUND

At the time of Spanish contact (ca. AD 1520s), the Lake Pátzcuaro Basin (LPB) was the geopolitical core of the Purépecha Empire. The lake basin was home to several thousand inhabitants that were spread across multiple settlements including Urichu, Ihuatzio, and the Purépecha capital of Tzintzuntzan. Very little is known about the formation of the Tarascan state compared to other regions in Mesoamerica and very limited research has been conducted within the LPB compared to other regions in Mesoamerica, such as in the Basin of Mexico, or the Maya region of the Yucatan and Guatemalan highlands. However, in the latter part of the twentieth century, more attention has been devoted to the study of the Pátzcuaro region by a number of scholars and institutions (Platt Bradbury 2000; Fisher et al. 1999; Pollard 1980; Pollard 2008).

2.1 Geography and Environmental Context

The ethnohistoric and linguistic records, along with the continuously growing body of archaeological evidence suggest that at the time of European contact in the New World (1520 AD), the Purépecha Empire controlled a large portion of western and west-central Mexico. Their territory extended beyond the Lerma River to the north and the Balsas River to the south (Espejel Carbajal 2008; Gorenstein 1985; Gorenstein and Pollard 1983; Valdez et al. 1994; Macías Goytia 1990; Pollard 1993; Silverstein 2001; Warren 1985). The western extent of the empire consisted of Lake Chapala and the Coalcoman region of Jalisco, with a southern portion that extended to the Pacific coast, while the eastern boundary began at the settlement of Acambaro, continuing south of the Balsas River (Figure 2.1). The sociopolitical core of the Purépecha Empire was located within the LPB, which is located in the northern central part of Michoacán. This small lake basin is about 934 km^2 and has elevations ranging from 2035 to 3200 meters above sea-level (m asl) and an average elevation of 2369 m (Platt Bradbury 2000; Israde-Alcántara et al. 2005; Metcalfe et al. 2007). Lake Pátzcuaro itself is a distinctive C-shaped lake that is approximately 100 km^2 in area with an average depth of 8-12 m, though climatic fluctuations have caused considerable increases and decreases in the lake level over several millenia (Platt Bradbury 2000; Chacón Torres 1993; Fisher et al. 2003). The present-day lake elevation is about 2035 m asl and is continuing to recede due to a greater annual loss of water from evaporation and agriculture than annual inputs from rainfall.

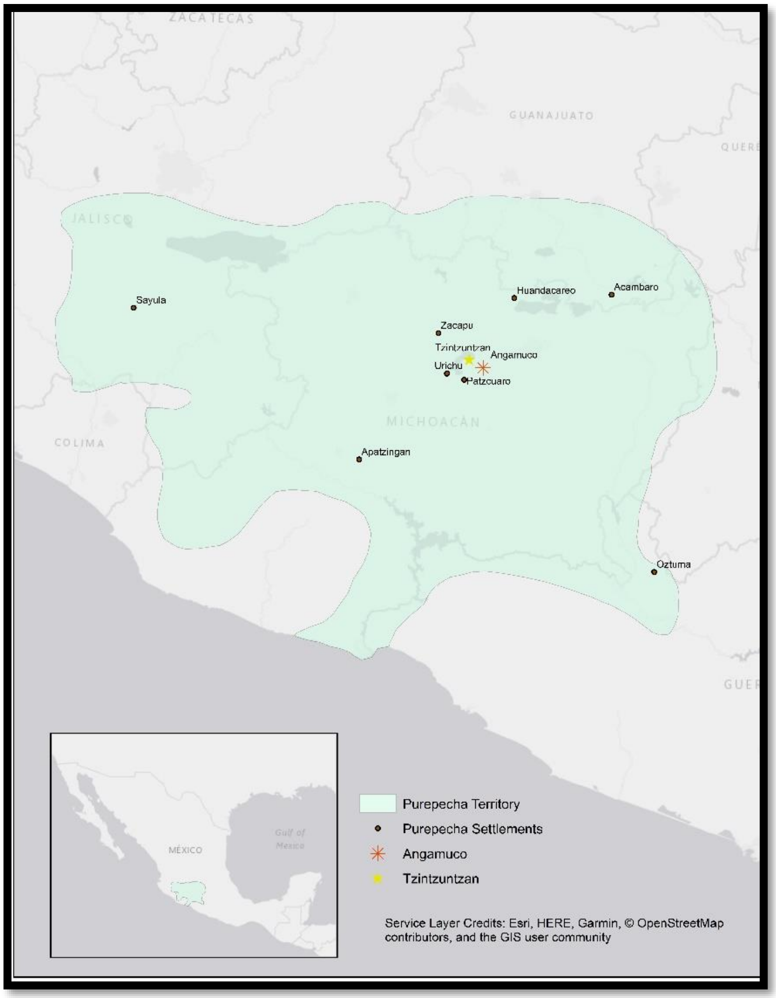

Figure 2.1: Extent of Purépecha Empire- adapted from Pollard (1993)

During the prehistoric occupation of the lake basin between 100 BC and 1520 AD, the lake level fluctuated quite drastically, reaching its lowest elevation of 2028 M asl during the Early Urichu phase of the Early Postclassic (900-1100 AD) and its highest elevation of 2043 M asl during the Tariacuri phase of the Late Postclassic (1350-1525 AD) (Haskell and Stawski 2017). During the Late Postclassic, when lake levels were at their highest, the estimated distance between the shoreline and the edge of the Angamuco *malpais* is anywhere between 2.5 and 10 km, depending on where the measurement was taken.

The LPB is situated in the Trans-Mexican Volcanic Belt, within the Michoacán-Guanajuato Volcanic field. The region is tectonically active today and volcanic activity has been recorded in the area as recently as 1943 with the formation and eruption of Paricutin 50 km west of Lake Pátzcuaro (Platt Bradbury 2000). It is thought that the basin itself was formed sometime during the Pleistocene through lava flow action and tectonic uplift that dammed and compartmentalized existing drainages of the Rio Lerma, along with Lakes Zirahuen and Cuitzeo (Barbour 1973; Platt Bradbury 2000; De Buen 1943; Israde-Alcántara et al 2005). The isolation of Lake Pátzcuaro from surrounding drainage basins is evidenced by the distribution of the pescado blanco (*Chirsotoma*), which is endemic to the region and exists in all of the surrounding lakes (Barbour 1973).

2.2 Physical Environment

The higher elevations in the lake basin are dominated by volcanic rocks, primarily basalt, while the lower elevations which include the ancient lake bed contain colluvial, fluvial, and lacustrine sediments along with thick, weathered red soils (Chacón-Torres 1993). The soil that comprises the highest margins of the basin are yellow-brown humic andosols that are the result of seasonally humid conditions under a fir-pine forest (West 1948). The slopes of the volcanic hills are comprised of *t'upuri* (Tarascan for "yellow earth"), humic andosols which are a major soil of the basin. The *t'upuri* soils are the most productive of the mountain soils, having an extremely fine texture and moisture-retention qualities. *Charanda* (Tarascan for "red earth") comprises the lower mountain slopes and floor of the basin. This is a red-brown clay soil which developed from the weathering of volcanic rock in a climate characterized by warm summers, mild winters, and broad leaf vegetation (Pollard 1993). The *charanda* clays serve as the raw material for the red pottery found in the region. The lacustrine soils (*tamacua*, “tierra fertile y humeda”; León 1888:94) are located in certain areas along the shore of Lake Pátzcuaro. They are the result of deposition from arroyos draining the hillslopes from a time when the lake level was higher. These soils contain a high degree of organic content and adequate nutrients to allow annual crops, making them the most highly valued in the region for agriculture (Pollard 1993). The *uirás* soil (Tarascan for “white earth”) is a highly localized soil of “fibery textured white clay” (West 1948:11) which is the product of compressed volcanic ash. This soil is entirely infertile and is used to manufacture the white-gray adobe bricks and as a source of white clay for pottery. The oldest rock outcroppings in the region are eroded andesitic-volcanic and basaltic-andesitic edifices underlying the semi-shield volcanoes prevalent in the region (Luhr and Simkin 1993). Basaltic rock is so prevalent in the Pátzcuaro region that it was used as the primary construction material for the Purépecha, both for construction of the *yacatas* at Tzintzuntzan and the building foundations and pyramids at Angamuco.

According to sediment cores that provide 48,000 years of limnologic history, Lake Pátzcuaro has never been dry through much of the mid- and late Wisconsin and throughout all of the Holocene (Platt Bradbury 2000). This makes it an invaluable resource in terms of understanding the climatic history of the region through the analysis of fossilized pollen and diatoms present in lacustrine sediments. Paleoenvironmental investigations have demonstrated significant environmental changes during the mid-Holocene (Fisher et al. 2003; Garduño-Monroy et al. 2011; Israde-Alcántara et al. 2005; Metcalfe et al. 2007; Ruter et al. 2004; Street-Perrott et al. 1989; Watts and Bradbury 1982). Cool and arid temperatures have been documented in lake cores until about 11,000-10,500 years BP, which is when summer precipitation began to increase.

The present climate in Central Mexico, including the LPB is characterized by mid- to late-summer rainfall resulting from the northern migration of the Inter-Tropical Convergence Zone (ITCZ) (Metcalfe 1987). Winter brings stable, dry conditions to the Pátzcuaro Basin as the ITCZ returns south towards the equator, however cold outbreaks of polar air can bring low temperatures and winter rainfall to the region (Metcalfe 1987). The mean annual precipitation for Pátzcuaro is about 950-1200 mm, with upwards of 80 percent accumulating during the months from May to September but can vary quite substantially from year to year. The lowest annual precipitation recorded for the region was 567 mm in 1957, while the highest value recorded was 1636 mm in 1935 (Platt Bradbury 2000). Pine, oak, and fir forests characterize most of the volcanic landscape from 2500-3300 M asl and agricultural crops, grasses and secondary vegetation <2500 M asl (Israde-Alcántara et al. 2005), however few forests remain in the modern lake basin. Deforestation for agricultural land, housing construction, railroads, and firewood are evident on the contemporary landscape of the LPB (Works and Hadley 2004).

2.3 Environmental Zones

Research in the LPB during the 1980s and 1990s led to the designation of six distinct environmental zones within the lake basin Pollard (1993) These environmental zones have been determined based on hydrologic boundaries, vegetation and soil distribution in addition to their utility in terms of resources for the inhabitants of the lake basin. In this sense, they are a product of prehistoric and historic land management strategies that Pollard (1980) argued directly influenced the centralization of power and the formation of the Tarascan State. The six environmental zones include open water, tule-reed marsh, lakeshore, lower slope Sierra, upper slope Sierra, and alpine (Figure 2.2). I will briefly discuss each of these zones and their relation resources for the inhabitants of the prehistoric lake basin.

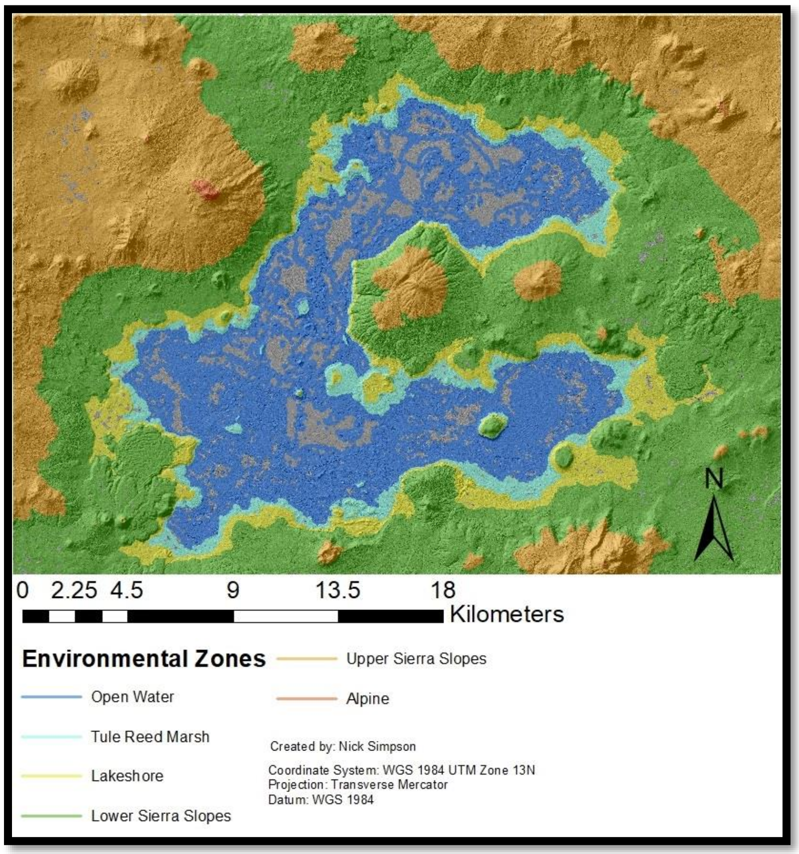

Figure 2.2: Enviornmental zones within the LPB (DEM generated by Steve Leisz and NASA)

The first zone is the open water zone, which includes the entirety of Lake Pátzcuaro all the way to the tule-reed marsh. At its highest levels, the open water zone is expected to have reached as high as 2,050 M asl and encompassed 14.6 percent of the basin. This zone includes at least seven species of fish, including the aforementioned *pescado blanco*, and waterfowl that feed primarily on the tule-reed marsh. The open water zone served as an important source of food during the prehispanic period, when the lake was a highly productive center for fishing. The tradition of butterfly net fishing is unique to the area and is continued today, although the productivity of the lake has declined to all-time lows.

The second zone is the tule-reed marsh, which exists along the shallow shoreline areas surrounding the lake, likely no more than 4 to 5 meters deep. This zone encompasses only 1.3 percent of the basin. The southern portion of the lake basin represents the largest proportion of these shallow zones. Because of the dynamic nature of fluctuations in the level of Lake Pátzcuaro it makes these zones highly sensitive to changes, extending and reducing the extent of the marsh. During the prehispanic period this fluctuating area may have occurred between 2,050 M asl and reaching as high as 2,070 M asl (Pollard 1993). The vegetation in this zone consists primarily of tule-reed but also cattails, reeds, water lilies, and includes fauna such as shrimp, frogs, and snakes. This makes the tule-reed marsh zone an area high in resources for food and textiles for the prehispanic inhabitants of the lake basin.

The third zone is the lakeshore zone, which has been calculated to exist between 2,050 and 2,100 M asl and occupies 12.2 percent of the basin. The topography of this zone is the semi-flat floor of the basin, which includes the lake islands, alluvial deltas, and plains. This zone has had almost all of the indigenous vegetation removed and is used primarily for agricultural purposes, making it the result of human-environmental interactions. During the prehispanic period, this zone likely extended up to the edge of the *malpais* Angamuco is located on. Oak and pine forests with some shrub, grasslands, and cacti dominate the area that have not been cleared for agriculture. Wildlife in these areas include foxes, squirrels, skunks, chipmunks, gophers, lizards, salamanders, leopard frogs, garter snakes, and rattle snakes (Pollard 1993; Fisher 2000).

The fourth zone, located between 2,100 and 2,300 M asl, is the lower slopes of the Sierra zone which contain deciduous stands of trees making up 31.9 percent of the basin. This area is not affected by lake level fluctuations or is only very minorly impacted. This topography includes low sloping volcanic hills and mountains, and lava flows (Pollard 1993). The lower elevations of the landscape are dominated by woodland forests, with a diversity of more than twelve species of oak, and several species of alder and basswood. Upper elevations of the landscape are dominated by a mix of pine and oak forests (Fisher 2000).

The fifth zone, located between 2,300 and 2,800 M asl, is the upper slope of the Sierra zone, which is found in the upper slopes of most of the mountains within the lake basin and makes up 36.1 percent of the basin. This landscape is dominated by conifer forests consisting of pine, but also contains a mix of pine/oak forests. The topography is mostly volcanic hills and mountains but include some small alluvial basins (Pollard 1993). At least seven species of pine exist in this zone as well as forest of fir occurring at elevations higher than 2,800 M asl. The fauna in this zone consist of white-tailed deer, peccaries, wolves, mountain lions, and wild turkeys, which would have made this zone an area of great importance for hunting game for the prehispanic inhabitants of the lake basin.

The sixth, and final zone is the alpine zone, located between 2,800 and 3,200 M asl and making up only 3.9 percent of the total basin. This zone is predominantly fir and some pine forests, although the flora doesn't particularly thrive at this altitude. Additionally, this zone makes up a fairly small portion of the total lake basin and is of very little concern regarding Angamuco.

While the six environmental zones identified in the LPB relate to the natural environment, three additional agricultural classes were also identified by Pollard 1993. These classes are based on agricultural yields as they were in 1993, land use, and general characteristics of the landscape supported by ethnohistoric data, which formed a model of the proto-historic productivity of the lake basin. A more robust description of modern land-use classes, which the protohistoric land-use classes are based on can be found in Gorenstein and Pollard (1980, 1983).

Class Ia is permanently watered land that is under constant irrigation by either canal or pot/ditch techniques. This land is found on either lacustrine or alluvial soils along the lakeshore. No fallowing of this land is necessary, and it is often under continuous production. Class Ib land is seasonally watered through floodwater techniques. Small portions are terraced, and most is on naturally fertile alluvium and lacustrine soils.

Class II land is in the flattish floor of the basin and corresponds with the lakeshore environmental zone and the alluvial basins of the upper slopes environmental zone. The agriculture in this land is watered by rainfall and is generally fallowed every other year. This land has deeper and more fertile soils than that of the Class III land. The soils here are described as *charanda* and *t'upuri*.

Class III land includes the remainder of the agricultural land in the lake basin. It is located on the lower and some of the upper slopes environmental zones containing *charanda*, *t'upuri*, and yellow-brown soils. These soils are the least fertile of the classes in the basin and must be fallowed every other year. Additionally, because of their higher altitude they experience longer frost seasons and greater potential for erosion due to the higher degree of sloped landscape.

2.4 Cultural Background

Little is known about the prehistory of the Pátzcuaro region prior to the formation of the Purépecha State in the 1350s. There is very limited evidence of human occupation in the region prior to the Preclassic period. Obsidian debitage, a projectile point, and a mano identified in Los Portales cave in the adjacent Zacapu Basin (CEMCA Project, Michelet et al. 1989) just north of Pátzcuaro, have been dated to the archaic period (2,500-2,200 B.C) and represent some of the earliest identified anthropogenic deposits in the region. The earliest evidence for occupation in the Pátzcuaro Basin is attributed to maize pollen recovered from sediment cores in the lake that date between 1690 and 940 BC (Platt Bradbury, 2000). The earliest known sedentary, or semi-sedentary occupational evidence is in the form of maize pollen in lacustrine cores dated to 1500 B.C., also from the Zacapu Basin (Fisher et al. 1999). Archaeological evidence from the Bajio and Cuitzeo Basins suggest that it's likely that these populations may have been culturally part of the Chupicuaro tradition (Darras 2006; Darras and Faugère 2005; Darras et al. 1999).

At the time of contact, the Purépecha Empire was the second largest empire in Mesoamerica (75,000 square kilometers) and the third largest in the Americas after the Aztecs and Inca. The development of the Purépecha Empire in the LPB has been summarized in several publications in the latter half of the twentieth century and early twenty-first century (Gorenstein and Pollard 1983; Pollard 1977, 1980, 1982, 2008; Pollard and Gorenstein 1980). The descriptions of political centralization are based on archaeological, ethnohistoric, and historic records from Purépecha settlements in the LPB. The collection of evidence available confirms the presence of a distinct Purépecha cultural tradition by the Late Preclassic period in the LPB and a politically centralized and socially stratified state in the Middle Postclassic period (Pollard

2008). The archaeological settlement patterns of the LPB have been separated into eight local phases spanning from the Middle Preclassic (>500-150 B.C.) to the Late Postclassic (A.D. 1350-1525) (Table 2.1). These local phases are traditionally characterized by the role of climatic variation and shifting resources in conjunction with political decision making (Gorenstein and Pollard 1983; Pollard 1977, 1980, 1982; Pollard and Gorenstein 1980). In the following section, I will briefly discuss the progression of occupational development in the LPB as it is understood today, beginning in the Late Preclassic.

Table 2.1: Local Cultural phases and corresponding lake levels (adapted from Pollard, 2008)

Period	Phase	Year	Lake Level (meters asl)
Late Preclassic to Early Classic	Loma Alta	100 BC-600 AD	2033-2035
Middle Classic to Epiclassic	Jaracuaro, Lupe/La Joya	600 AD-900 AD	2035
Early Postclassic	Early Urichu	900 AD-1100 AD	2028-2030
Middle Postclassic	Late Urichu	1100 AD-1350 AD	2030-2039
Late Postclassic	Tariacuri	1350 AD-1525 AD	2041-2043

The cultural period defined between 150 B.C. and A.D. 550 is known as the Loma Alta Phase. In many parts of central and northern Michoacán, the Loma Alta Phase provides evidence of a period of transition between the earlier Chupicuaro culture group of the Middle Preclassic and the later Classic and Postclassic societies from which the Purépecha State emerged (Pollard 2008). The type site for the Loma Alta Phase is the site of Loma Alta located in the Zacapu Basin (Arnauld et al. 1993; Michelet et all 1989). Excavations there revealed the presence of an architectural complex which included a sunken plaza with a central altar, worked stone walls, and stairways (Carot 2001, 2004). Loma Alta has been identified in the Pátzcuaro Basin, Zacapu Basin, Morelia, and Cuitzeo Basin. During this phase in the LPB, the level of the lake fluctuated between 2,033 and 2,035 m asl (Fisher et al. 2003). Evidence of the size and density of settlements in the area at this time suggested a basin population of between 5,000 and 8,000 people (Pollard 2008). Long distance exchange is documented at Erongaricuaro in the form of obsidian from Ucareo in northern Michoacán (Darras and Faugère 1998, 1999; Pollard 2005) and prismatic blades imported from central Mexico. Additionally, the sunken plaza and altar complex is associated with a burial tradition in which the wealth of the burials are directly related to their proximity to the platform centrality (Pereira 1996). This represents the best evidence for the timing of the emergence of social ranking among populations of central Michoacán.

The period between A.D. 600 and 1000 is known as the Lupe and Early Urichu Phases. During the Early Urichu phase (A.D. 900-1100) the level of Lake Pátzcuaro continued to fluctuate, but never reached very low levels. However, during the latter part of this phase the lake level began to drop, and lacustrine settlements moved closer to the reduced lakeshore. This is evidenced by an increased number of settlements of the margins of the lake, with the lowest settlement documented at 2,028 m asl (Pollard 2008). The population of the basin is estimated to have increased to between 6,000 and 7,000 inhabitants, which is attributed in part to the increased land available for settlement due to the lake's diminished shoreline. Evidence of wetland agriculture is demonstrated through the presence of deeply buried irrigation canals in these new settlement areas. Soil erosion was low around the settlements, which is attributed to higher inputs of labor for preserving agricultural land and reducing soil erosion (Fisher et al. 2003).

The following period, between A.D. 1000 and 1350 is the Late Urichu Phase which consists of the two centuries during which the state began to emerge as a centrally organized entity. During this period, the number of sites in the Pátzcuaro Basin again increased with settlements appearing on recently exposed islands and on the fertile lacustrine soils exposed by the lake's regression (Fisher et al. 2003). The population estimates for this period for the entire basin is up to 48,000 inhabitants, marking an explosion in population compared to the previous periods in the LPB. In the last several decades of this phase, the lake level rose to its Contact-period levels above 2,041 m asl, resulting in the abandonment of the recently occupied shoreline zones. Pollard (1980) argues that the elevated lake levels that occurred between 1000 and 1300 A.D. would have submerged 5 percent of the basin, reducing the amount of irrigable land by 60-70 percent. The combination of lost farmland and the displacement of many of the inhabitants from settlements at lower elevations necessitated the importation of food from margin communities. This importation was facilitated through one of two avenues: the market system, which was not a state-controlled entity, and the state-controlled tribute system. She contends that these environmental conditions spurred behavioral adaptations by elites in affected areas. Intermarriage between elite families served to reduce hostilities and allow the flow of goods through market networks (Pollard 1980). As alliances and intermarrying practices continued, the LPB became more unified and an expanding centralized state began to emerge.

The Tariacuri Phase (A.D. 1350- 1525) is the final period before the arrival of the Spaniards into Michoacán and is the high-water mark for the Purépecha empire. Tzintzuntzan was the regional primate center in the LPB with an estimated 90 to 95 settlements total within the basin (Pollard 2008). Goods and services were imported and exported through a fully developed complex market system as well as state institutions (Pollard 1993). The royal dynasty during this phase, controlled access to land, water, forests, and mineral resources. Changing mortuary practices display a shift in elite identity from that of highly ranked local chiefs into a more socially stratified elite class (Pollard 2008). Accompanying the shift in elite control was the shift in cosmological power to the Pátzcuaro Basin. This was accomplished by the establishment of a new ideology that encapsulated the cultural traditions that characterized many of the Postclassic inhabitants of Michoacán. The patron gods of the elites were elevated as celestial authorities, while the varying regional deities and ideologies were either co-opted or marginalized. The best example of this blending of ideologies into a reigning cosmology is the joining of the Chichimec (*uacusecha*) deity, Curicaveri with the Purépecha goddess Xaratanga. The two dieties were worshipped jointly at Ihuatzio and Tzintzuntzan and reinvented as husband and wife, or sun and moon (Pollard 2008). Additionally, the appearance of a specialized pyramid, known as a *yacata*, coincides with the emergence of the Tarascan state. This structure consists of a keyhole shape, with a circular or semicircular platform connected to a rectangular platform. There are three such structures that have been reconstructed at the modern city of Tzintzuntzan, as well as several documented *yacatas* at Angamuco. The *yacatas* were typically built as religious monuments, dedicated to the god Curicaveri.

According to the *Relación* the Aztec leader, Montezuma, sent ten messengers in 1521 from Mexico City to Taximaroa, now the modern city of Hidalgo in northeast Michoacán. They came with a message for the *Cazonci* (leader of the Purépecha Empire) about foreign invaders near Mexico City. At that time, the *Cazonci*, a man named Zuangua, received the Aztec messengers and was presented with gifts of blankets, jerky, feathers, and ten circular shields. Upon hearing of the invading Spaniards, Zuangua sent four messengers back to Mexico City to confirm the Aztecs' claims. Upon their return they reported that Mexico City had indeed been invaded and that Montezuma was pleading for Zuangua to dispatch warriors to Mexico City to help the Aztecs defeat the Spaniards. After consulting with several advisors, Zuangua chose not to send assistance to the Aztecs, hopeful that the Spaniards would defeat their long-held rivals.

In 1522, conquistador Cristobal de Olíd led an army of mostly indigenous soldiers into the state of Michoacán, towards Tzintzuntzan. He met little resistance as much of the reigning elite and upper nobility had been killed off by smallpox and measles the year previous. When the people of Tzintzuntzan learned of the approaching Spaniards they sacrificed eight hundred slaves, fearing that they would join the Spaniards and turn against the Purépecha. Upon arriving in Tzintzuntzan, Olíd and his men took residence in the temples and houses of the chief priests. The steps and entrances of the temples were still covered with blood from the sacrifices that had been made before their arrival. The Spaniards proceeded to roll the sacrificial stones down the temple stairs and topple the statue of the messenger god *Curitacaheri*. The reigning monarch, Tangaxoan, did not resist Olíd and was allowed to continue ruling over his kingdom for eight more years, before he was deposed in 1530. Michoacán was then incorporated into the Viceroyalty of New Spain and the boundary of the Purépecha Empire effectively became the modern boundary of the state of Michoacán (Warren 1985).

2.5 Angamuco

The site of Angamuco is geographically located in the southeastern portion of the LPB, approximately 5 km southeast from the imperial capital city of Tzintzuntzan and 12 km northeast from the modern town of Ihuatzio. Angamuco is situated on a volcanic landform known as a *malpais* ("badlands"), which is made up of multiple lava flows that form large ridges and swales that make much of the landscape rough and inhospitable for modern agricultural use. The site is situated on the boundary of the Lakeshore Zone (2070-2100 m asl) and the *malpais* itself consists entirely of Lower Slope Sierra Zone (2100-2300 m asl) vegetation. The highly rugged characteristic of this landscape is extremely fortunate for archaeologists interested in Angamuco because much of the site has remained undisturbed due to its unsuitability for agriculture, its rugged topography, and the dense vegetation covering the landscape.

Angamuco was first documented by Dr. Chris Fisher during the 2007 survey season, which was focused on identifying sites in the eastern portion of the LPB. About 1 km^2 of the site was surveyed using traditional methods and it was thought that the site encompassed a total of 6 km^2 (Fisher et al. 2009). Full coverage survey was performed in the following field season which documented architectural features covering an area of 12 km^2 (Fisher et al. 2010; Fisher and Leisz 2013). It was clear that the settlement covered the entirety of the *malpais* from east to west, while the northern extent of the site could not be located. Given the rugged nature of the topography and the density of archaeological features, it was determined that documenting the entire site using traditional methods would likely take well over a decade of intensive survey. In an attempt to expedite the survey of the entire landscape, two LiDAR flights were performed over the site in 2011 and 2013 encompassing an area of 35 km^2, which included the entire *malpais* and surrounding areas. The results of the LiDAR acquisitions documented over 20,000 architectural features and have been discussed in numerous academic publications (Fisher 2005; Fisher and Leisz 2013; Chase et al. 2012; and Fisher et al. 2017).

A portion of the southwestern site was excavated in the summer of 2013, confirming an extensive occupation spanning from the Early Urichu phase through the Tariacuri phase (AD 900-1520) (Fisher and Leisz 2013). Fisher and Leisz (2013) were also able to identify three phases with distinct architectural associations. The sequence begins in the Early Postclassic period (AD 900-1200) with a focus on sunken patio complexes similar to those from the Bajio region of Mexico (Cárdenas García 1999; Darras and Faugère 2005). The Middle Postclassic (AD 1200-1350) occupation at Angamuco is marked by episodes of major growth and expansion centered around several nodes with distinct rectilinear pyramid complexes similar to those documented in the adjacent Zacapu Basin (Arnauld and Faugère-Kalfon 1998; Michelet 1996, 2000, 2008). The final phase exhibits a phase of contraction of the settlement area during the Late Postclassic (AD 1350-1520), with a focus around at least two nodes with Imperial Purépecha style architecture known as *yacatas*, pyramids with circular and rectilinear elements (Fisher and Leisz 2013).

The LiDAR data for Angamuco has allowed for multiple analyses of the spatial complexity present at the site. One of the first goals was to identify natural and human-generated divisions in the landscape that may indicate hierarchical, ethnic, or familial organization by the ancient inhabitants of the site (Bush 2012; Fisher and Leisz 2013; Urquhart 2015). Fisher and Leisz (2013) proposed that Angamuco was comprised of spatial units known as *complejos*. These are spatial units that are larger than individual households but smaller than neighborhoods and likely only represent one or two functions. Urquhart (2015) suggests that the spatial data for Angamuco provide strong evidence for the presence of *complejos*, which he argues are organized in an informal manner, existing predominantly as clusters of architecture with no common public spaces uniting them (Urquhart 2015: 133), a notion which will be discussed later in this thesis. *Complejo* units are arranged into neighborhoods which are defined at Angamuco by the inclusion of many types of architecture, such as civic-ceremonial, storage, and boundary forms. In this sense, neighborhoods at Angamuco are multifunctional, serving a larger area rather than the individual household (Fisher and Leisz 2013). Many of these spatial units are demarcated by walls, roads, terraces, or natural boundaries. It is highly likely that reservoirs played a significant role in the movement of people across the landscape and the further demarcation of social spaces. This idea will be further expanded upon in the Results chapter.

CHAPTER 3 : WATER MANAGEMENT AND THE BUILT ENVIRONMENT

This chapter will serve to explain the form, function, and utility of prehistoric water management systems in several contexts and relate them to the system present at Angamuco. I will summarize several different types of water management systems that have been recorded globally and their constituent features that allow them to function. I will begin by reviewing several archaeological examples of water management systems and the varying forms they take, focusing specifically on Mesoamerican water management systems for which there is literature available. This chapter will conclude with an examination of water as power through centralized government and ritual. I will then focus on water as a community-based common property resource and evaluate the role of depressions in the landscape as water control features. The goal is to place the landscape at Angamuco into a larger framework of archaeological settlements that have incorporated extensive and complex water management systems into their settlements.

The role of water management in urban environments is one of great importance for the sustainability of large populations. Water is an essential resource for all life and access to water for drinking, hygiene, and crop irrigation rank among some of the most important requirements for complex societies. Because of its great importance for the survival of all human societies, there are a broad number of archaeological examples of water management systems spanning the entire globe (Figure 3.1). Variation in cultural and environmental conditions have resulted in a multiplicity of water management strategies over time. Water availability presents a limiting factor on the placement of permanent settlements. Places without perennial drainage sources such as rivers or streams that can be diverted must find alternative solutions for providing populations with access to water. In addition to water being a necessity for survival, it oftentimes carries great symbolic and ritual significance across many cultures. The ability to retain and control water may also have served symbolic functions in association with elite authority as has been suggested for the Maya region of the Yucatan and Guatemala (Scarborough, 1998; Scarborough and Gallopin, 1991; Lucero, 2006). Conversely, recent research into water management in urban contexts has suggested that access to water was not controlled by elites, rather that individual households constructed and maintained residential reservoirs cooperatively without elite interference (Chase, 2016). These concepts will be discussed further below.

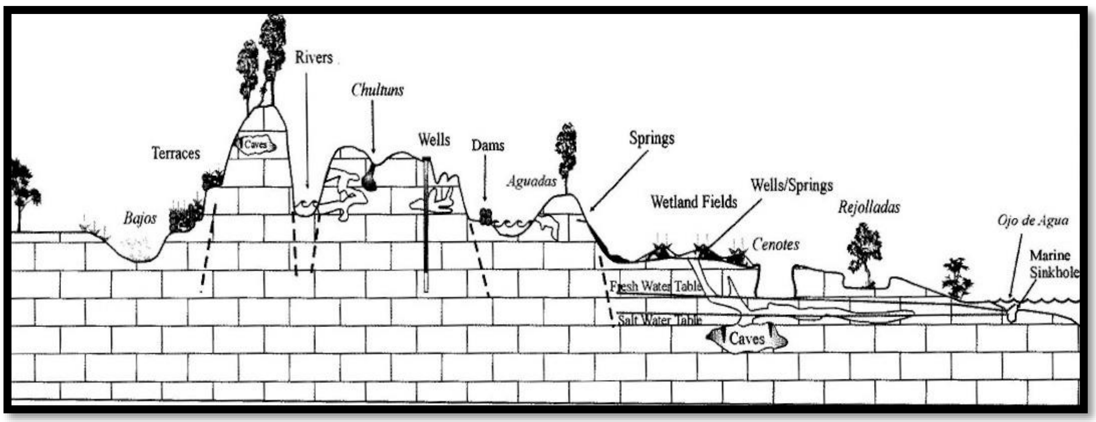

Figure 3.1: Common water management features found primrily in the Maya region (Luzzader-Beach et al., 2016)

3.1 Water Management: Forms and Functions

A broad diversity of geographic and cultural factors has led to the emergence of many different methods for redirecting, retaining and distributing water at urban settlements across the globe. This thesis is focused primarily on water management systems that are fed by seasonal rainfall and runoff, therefore I will largely omit those systems where water is redirected from perennial sources such as streams or rivers. Water retention features can be broken down into several different categorical types, each meant to retain water for sustenance through dry seasons, but who's forms may vary slightly from one context to another. I will briefly discuss the different types of water control features found at many archaeological sites around the world.

3.1.1 Chultuns

Chultuns are subterranean pit features from the Maya region of Mexico and Guatemala that are often associated with water storage. Their size and shapes can vary dramatically in terms of both their plan view and profile (see Calderon and Hermes, 2005) and they can have one chamber or multiple. Limestone lids covering the circular entrances have often been recorded (Hunter, 1995; Puleston, 1965) but wooden lids may also have been used (Pinto and Acevedo, 1993). Chultuns are commonly, although certainly not always, lined with stucco and may range from 2-3.5 meters in depth and 1-2.8 meters in width (Cagnato, 2017). These features are found commonly within Mayan settlements in the Yucatán and have been recorded in the southern Maya lowlands of Petén, Guatemala and Belize and were used from the Middle Preclassic into the late Classic periods (1000 B.C. – A.D. 850) (Calderon and Hermes, 2005; Dunning, 1992; Scarborough et al., 1995; Smyth et al., 1998). Similar subterranean chamber features, known as *botellones* have been recorded in the Maya highlands, El Salvador, and highland Mexico (Marroquin, 2006; Winter, 1976).

Chultuns are commonly accepted as water storage tanks for sustenance through the dry months of the year, especially in settlements located far away from a perennial source of fresh water. However, scholars have developed many different hypotheses to explain their function through time. Some of the proposed explanations for the function of chultuns include sweatbaths (Ricketson, 1925; Ricketson and Ricketson, 1937), refuse pits or latrines (Pollock, 1956; Haviland, 1963), and food storage- particularly for the nut of the ramon tree (*Brosimum* *alicastrum*) (Blom, 1936; Bullard, 1960; Ford, 1991; Freidel and Sabloff, 1984; Puleston, 1965). Chultuns have also been suggested to be artificial caves and used as ritual spaces (Vogt and Stuart, 2005), however there is little evidence to support this claim. A number of archaeological experiments concerning chultuns have been conducted to test their storage capacities, ability to retain water, and how well they can preserve food. Several of these experiments are summarized by Cagnato (2017) who goes on to explain that the results of the experiments suggest that chultuns may not have been well suited for food storage. While they may protect food from pests and scavengers, their relatively high levels of humidity breed molds and bacteria. Puleston (1965) re-plastered a chultun at Uxmal, which allowed drinking water for an archaeological crew working during a full field season. Several years later he poured water into an un-lined chultun only to find it empty eight hours later (Puleston, 1971). His experiments lend much credence to the notion that chultuns were used for water storage in cases where they are lined with stucco. Most archaeologists today, however, have resigned themselves to arguing that chultuns were multi-purpose features, even within the same site.

3.1.2 Aguadas

Aguadas are among some of the most abundant water resources known in the southern Maya Lowlands. They encompass a broad range of features, with descriptions ranging from "broad shallow depressions" (Flores-Nava, 1994; Monroe, 1970; Matheny, 1976); "sinkholes and shallow water deposits (Lundell, 1933; Cervantes-Martinez et al., 2002; Acuña, 2008); and "small ponds associated with topographic depressions" (Wahl et al., 2007). The size and origins of aguadas varies greatly both within and between regions between the Maya lowlands and highlands. Many of them clearly began as dolines or karst sinkholes that have partially filled with sediment. Other aguadas may have started as quarries that were later modified to retain water. However oftentimes the impacts of large amounts of human modification can obscure the origins of the aguada. These features are often found on the margins of *bajos*, or low-lying reservoirs or depressions, located on the periphery of settlements (Bullard, 1960; Siemens, 1978; Dahlin et al., 1980; Dunning and Beach, 1994; Wahl et al., 2007). Siemens (1978) argued that the early Mayan settlers to the area may have been attracted to these locations by the suitability of *bajo* margins for aguada formation or construction.

Arrendondo-Figueroa and Flores-Nava (1992) and Flores-Nava (1994) group aguadas into one of three categories based on their origins: permanent sinkhole aguadas; seasonal shallow basin aguadas; and quarry aguadas. Permanent sinkhole aguadas are formed through the dissolution of underlying carbonate rock which causes a collapse of the surface (Flores-Nava, 1994). These features are often referred to as cenotes when they are still attached to an underground aquifer that supply fresh water. When these features have been cut off from the underlying water table due to sedimentary or organic matter blockage over time they are considered aguadas. Oftentimes, these structures may also be referred to as *rejolladas*, and the term seems to be used interchangeably depending on the author (Luzzadder-Beach, 2000; Sheryl et al., 2016). Permanent sinkhole aguadas may have steep sided walls, reflecting their former origins as cenotes and are only fed by rainfall and runoff as a means for water accumulation (Flores-Nava, 1994; Cervantes-Martinez et al., 2002).

Seasonal shallow basin aguadas are the result of direct surface dissolution of karst rock which form depressions on the surface of the ground (Monroe, 1970). These features exhibit two distinct ecological phases of “dilution” and “concentration” (Flores-Nava, 1994). Nutrients such as phosphorous and nitrogen are released into the water during the early dilution phase when the wet season begins. This sets off high primary productivity and their successive links up the trophic ladder in these depressions. The concentration phase happens during the dry season when nutrients supplement the dry aguada sediments, leading to vegetation that retains the nutrients until the following wet season when they are released back into the water (Arrendondo-Figueroa and Flores-Nava, 1992; Flores-Nava, 1994).

Quarry aguadas are anthropogenic depressions in the limestone created by the Maya. These aguadas were likely the most labor intensive to create as they had to be manually excavated and lined with an impermeable layer of thick plaster, which have been recorded at the site of San Bartolo in northeast Petén (Garrison and Dunning, 2009). The combination of all three types of aguadas made this type of feature a robust resource for Mayan water management during the dry months of the year, allowing for year-round occupation of many settlements.

3.1.3 Cenotes

The expansive Maya region of the northern Yucatán Peninsula contains no natural above ground rivers and very few lakes for sources of freshwater for sustaining large populations. However, a vast system of underground rivers exists due to the karst geologic environment of the region. The only access to these underground sources of water are through the flooded caves and cenotes, or sinkholes, that pierce the region’s surface. Multiple scholars have attributed the location of early Mayan settlements to the ease of access to water through cenotes (Smith, A.L., 1962; Pope, K.O., 1996; Brown, C.T., 1999; Hare et al., 2014). The settlements of the Maya lowlands depended deeply on cenotes for passive water collection and storage due to the lack of other available sources of water. Cenotes have been documented near such monumental sites as Chichén Itzá, Chunchucmil, and Dzibalchaltun (Luzzadder-Beach, 2000; Sheryl et al., 2016). Cenotes that represent the only major access to water in a given region were highly revered among the Maya, and all cenotes and caves were considered sacred portals that connected to a watery underworld (Houston, 2010). Mesoamerican ideologies related to water will be further discussed later in this chapter. It should also be noted that cenotes are likely the least relevant form of water management to Angamuco because of their existence exclusively in karst environments, which are not present in the LPB.

3.1.4 Irrigation and Drainage

The category of irrigation and drainage features is quite broad, encompassing a number of landscape features used to direct the movement of water from existing sources towards agricultural areas lacking adequate moisture for cultivation (Whitmore and Turner, 2001). The most common forms of irrigation found in Mesoamerica are canals and raised field agriculture. Canals are used to transport and redistribute water across the landscape or through urban centers by force of gravity (Doolitle, 1995). These features are most common along the edges of rivers, lakes, on the peripheries of swamps, and within seasonal *bajos*. The primary purpose of canals is to increase production of agricultural crops and to make use of marginal landscapes (Turner and Denevan, 1985). Most canalized landscapes are wetland environments that often experience seasonal inundation from overflowing riverbanks or excessive runoff from rainfall. Riverine wetlands are characterized by "discernable surface water flow and display cyclical inundation patterns associated with the rise and fall of the river" (Turner and Denevan, 1985; p.12). Conversely, basin wetlands are "enclosed features, with perhaps small surface outlets to collect and retain runoff. Surface water typically has very little flow and can be permanent" (Turner and Denevan, 1985; p.12).

Oftentimes waterlogged soils that are excavated for the creation or maintenance of canal features are piled in a linear way to create raised fields. This agricultural practice has been observed widely in portions of Mesoamerica in the Mayan Highlands (Scarborough, 1983; Silverstein et al., 2009), the Basin of Mexico (Calnek, 1972; Robles et al., 2019), and in the Lake Pátzcuaro Basin (Fisher et al., 1999). The Basin of Mexico is particularly known for the distinctive role of *chinampa* agriculture which were developed over 3,000 years ago in several wetlands in Mexico (Robles et al., 2019). The word *chinampa* comes from the Nahuatl word *chinamitl*, meaning 'woven fence of canes' (Robles et al. 2019). *Chinampas* varied in shape and size, however they are most often represented as rectangular islets set 50 cm above the water, 5-10 m wide and could be up to over 100 m in length. They were surrounded by networks of small canals and broader canals that provided both navigation routes by canoe in addition to water supply through irrigation. These features were essential for the agricultural support of the Aztec capital of Tenochtitlán, which had an estimated population of 1 million inhabitants in and around the city in the sixteenth century (Robles et al. 2019). The *chinampa* system of agriculture was so successful and sustainable in the region that it was adopted by the Spaniards who colonized the Basin of Mexico. They altered the *chinampa*s by making them wider to accommodate the use of mules for tilling the soil for planting. In rural areas around Mexico City, this system of agriculture is still practiced to this day, which speaks to the efficacy of the Aztec agricultural practices.

In addition to raised field agriculture, the practice of terracing was a common method for distributing water more evenly across a landscape. Terraces have been commonly reported in the southeastern Maya Lowlands (Puleston, 1978; A. Chase and D. Chase, 1987, 1998; Murtha, 2002) as well as on the former island of Apupáto in the Lake Pátzcuaro Basin (Pezzutti, 2010). Recently, scholars have been able to use LiDAR data to analyze the effectiveness of terraces for distributing water across the landscape at Caracol (see Chase & Weinshampel, 2016).

3.1.5 Reservoirs

Likely one of the most common forms of water retention features are reservoirs. A reservoir is a natural or artificially constructed pond or lake that is used for the storage and later use of water. These features have been documented across much of Mesoamerica and portions of the Southwestern United States. Reservoirs may vary drastically in size, function, and importance both within an and between individual sites. Scarborough (1983, 1998) and Lucero (2006) have both discussed the importance of reservoirs as they relate to socioeconomic displays of power through elite control over access to water, but neither address residential reservoirs. The lack of focus on residential reservoirs leads to the false assumption that elites dominated their subjects' access to drinking water and that residents of these urban centers had no access to water on a local level. Recent research seems to be illustrating this narrative to be limiting in its capability to explain the large number of community and household reservoirs present at many Mayan urban centers. With a greater ability to document household reservoirs using LiDAR we are beginning to see that these features were more often built and maintained at the household and community level (Crandall, 2009; Chase, 2016; Chase and Cesaretti, 2018). This concept will be discussed further and expanded upon later in this thesis.

3.1.6 Wells

Wells are one of the most commonly used forms of water management found globally. They deep, often straight sided holes dug into the ground to exploit the subterranean water table, or the level within rock below which all pores are saturated with water (Price, 1985:6). Wells have been recorded for much of the Maya region, including at the sites of Dzibilchaltún and Chunchucmil (Johnston, 2004; Luzzader-Beach, 2000). The depths of wells are entirely dependent upon the depth of the water table, thus can vary greatly across different geographic contexts. Some wells recorded in the Maya region do not reach the permanent water table, but are rather used for retaining water which percolates through the soil and rock during the wet season. These types of wells often do not retain enough water for a dependable dry-season water supply (Johnston, 2004)

3.1.7 Bajos

The karst bedrock that constitutes most of the Maya region of the Yucatan and Péten in Guatemala exhibits interesting geologic formations as a result of dissolution of the bedrock by water. One of these features created by this process are *bajos*. The term *bajo* oftentimes refers to low lying swampy terrain, where a combination of the dissolution of bedrock and faulting has created naturally depressed areas which are seasonally inundated (Dunning et al. 2018; Perry et al. 2009). Many of the Preclassic Maya urban centers began developing around these *bajo* areas beginning around 800 BCE, with large urban centers containing *bajos* on their peripheries. One of the advantages offered by the margin *bajo* terrain was that oftentimes the sloping landscape and seasonal stream channels could be used to funnel runoff into nearby reservoirs which were necessary for the year-round settlement of urban centers, especially during the annual dry season (Dunning et al. 2018). Similar features to the Mayan *bajos* exist on the margins of the *malpais* at Angamuco. Although their geomorphological characteristics are quite different than the karst region of the Yucatan, the function of these features is very similar, and will be discussed in greater detail in the Results chapter.

3.2 The Built Environment

Anthropological queries into the built environment have been around since the first formalized theories concerning cultural evolution in the 19th century. The built environment is, in its broadest terms an aspect of culture expressed through the physical alteration of the natural environment, from hearths to cities (Lawrence and Low, 1990). The built environment has traditionally been interpreted in an architectural sense, referring primarily to dwellings and monumental architecture. However, according to Lawrence and Low (1990), the built environment has been expanded in recent years to include any constructed space that is defined and bounded but not necessarily enclosed. This allows for the analysis of such structures as streets, compounds, plazas, and specifically for this thesis, reservoirs.

Amos Rapoport (1969) postulated that the built environment expresses more than simply its passive functional purpose, rather features are constructed with complex sets of purposes and are greatly influenced by the cultural milieu to which they belong. One of the clearest examples of built forms which transcend functionality is that of the palace. They are spaces that exist as functional living spaces, symbolic representations of authority, as well as spaces of socioeconomic production (Webster, 1998:25; Fash 1998:260; Inomata, 2001). Rapoport (1969) further hypothesizes that:

> "…house form is not simply the result of physical forces or any single causal factor but is the consequence of a whole range of socio-cultural factors seen in their broadest terms. Form is in turn modified by climatic conditions (the physical environment which makes some things impossible and encourages others) and by methods of construction, materials available, and the technology (the tools for achieving the desired environment)."

To this end, the causal relationship between many socio-cultural factors and house form can be expanded to include all aspects of the built environment. Moore (1996) expands upon Rapoport's ideas concerning the anthropological approach to the built environment by suggesting that culturally constructed landscapes include utilitarian and non-adaptive, innovative and conservative elements. It is by examining these elements within their specific cultural contexts that we may gain insights into how people in the past understood and manipulated their environments.

3.3 Water as Power

Political

The role of water management in the formation of socially complex states has been something that has interested scholars for well over a century. Having access to water is one of the most critical requirements that all people share. Thus, controlling access to water has the potential to elevate the status of certain individuals or groups of individuals into an elite role. Water also has iconographic and symbolic importance across much of the prehistoric and modern world and is often central in different rituals and ceremonies (see Scarborough, 1998). While there is simply no extant data regarding the nature of social organization surrounding Purépecha water management, a topic this thesis hopes to help elucidate, it seems very likely that some level of symbolic and ritual significance was attached to water and may have been expressed through water management practices at Angamuco.

One of the earliest attempts at explaining the origins of the state was Wittfogel's Hydraulic Hypothesis (Wittfogel, 1957), an early nomothetic approach for addressing the formation of states as a worldwide phenomenon. Wittfogel suggested that the development of irrigation for agriculture and the sustenance of large sedentary populations necessitated a centralized form of bureaucracy to control and coordinate water allocation. He argued that the resulting centralized organization became the archaic state and that elites maintained "total control" over access to resources. This view is now mostly dismissed as highly deterministic and limited in its explanatory power, however it brought attention to several other of the "prime movers" of state formation (e.g. warfare, trade, population pressures, etc.) (Scarborough and Lucero, 2010). Most scholars today view the formation of archaic states as highly non-linear processes that cannot be pinned down to a single instance or characteristic (Scarborough, 2003; Scarborough and Burnside, 2010; Yoffee, 2005). However, Wittfogel's focus on populations of sedentary agriculturalists, geographic settings with limited rainfall, and heavily modified landscapes may have some explanatory merit and water management certainly can't be easily dismissed as a significant variable of complex societal development (Scarborough, 2003).

Several recent investigations into Classic Period (A.D. 300-900) Mayan water management adaptations bear resemblance to Wittfogel's Hydraulic Hypothesis (Scarborough, 1998; Lucero, 2006a, 2006b). These investigations tend to focus on the ubiquity of very large, centrally constructed reservoirs that are situated adjacent to monumental architecture located in the city centers. Lucero 2006b argues that at major non-river centers such as Tikal, Caracol, and Calakmul, ruler's maintenance of artificial reservoirs combined with their knowledge and performance of rituals associated with specific seasonal or celestial events facilitated dry-season nucleation at site centers, lessening the need for hinterland farmers to build their own reservoirs. She further argues a reduced level of elite control at secondary centers such as Lamanai, Piedras Negras, Dos Pilas, and Seibal due to their locations in hilly upland areas along rivers or other water sources (Lucero, 2006b). These settlements exhibit dispersed pockets of agricultural land and small-scale water systems including scattered dams, canals, and drainage ditches which were all built and maintained at the household and community level.

3.4 Water in Ritual

It is difficult to dispute that the large central reservoirs of Tikal and Caracol are associated with the power held by the elites, given their obviously important placement in central locations near monumental architecture as well as their large size and high volumetric capacities. Lucero (2008) suggests that the populations of large centers like Tikal may have dispersed into the hinterlands during the rainy season to perform agricultural activities and nucleated in the urban centers during the dry season when water became scarce. She cites the "onion-skin" construction phases of the monumental architecture at Tikal and other urban centers (see Culbert, 1991; Laporte and Fialko, 1990) as evidence of episodic dry season construction events that took place during periods of population nucleation when water availability in the hinterlands was diminished. These public works suggest that elites were able to not only legitimize the status quo among the commoners but also to integrate the masses for purposes of social cohesion at a time when people were together for the dry season (Lucero, 2008).

Scarborough (1993) demonstrates the connections made between water and sacred power through the examination of several case studies from around the world from modern cultures who exhibit similar levels of socioeconomic and sociopolitical complexity as the Maya. The examples he draws upon are those with rich ethnographic and ethnohistoric records, who occupy semitropical settings, and specifically those who use the role of ritual to attract and maintain a support population. The following statement by Homans (1941:172) summarizes the dominant line of anthropological thought that Scarborough draws from:

> "Ritual actions do not produce a practical result on the external world- that is one of the reasons why we call them ritual. But to make this statement is not to say that ritual has no

function. Its function is not related to the world external to the society but to the internal constitution of the society. It gives the members of society confidence, it dispels their anxieties, it disciplines their social organization."

Two of the relevant specific examples included in Scarborough's synopsis are those of the royal bath ritual of the Merina in Madagascar and the Balinese *subak* system. The case of Madagascar exhibits a reinforcement of the divine power held by the king over his subjects. The ritual bath performed during the grand royal ceremony is derived from a similar ritual performed widely at the household level. In every Merina household, water blessings are splashed from father to child at the beginning of the new year. The father acts as a spiritual liaison in delivering the blessings from their immediate ancestors to their children by visiting their ancestral tombs the day before the ceremony (Bloch, 1987). The ritual is echoed up the social hierarchy and is played out at the highest levels by the king. By elaborating and publicly articulating this household ceremony within the state palace, the annual royal bath of the king legitimized his ancestral right to rule over his kingdom and declared his fatherly domination over his subjects (Scarborough, 1993).

The case of the Balinese water management system is used in reference to the Classic Maya because it is a modern model of the "theater state" (Scarborough, 1998). Similar to the Maya and the Purépecha, water and its availability are of critical importance to the Balinese. Water is broken up and regulated by districts known as *subaks*. Lansing (1987, 1991) demonstrated a hierarchical and dendritic organization of *subaks* which are separated by bifurcations in streams and canals. Laborers from different villages and village districts work collectively within a *subak* district, which transcends village boundaries. A series of priests reside in water temples located at junctures in downward-flowing diversion channels and ultimate authority rests with the High Priest of the Temple of the Crater Lake. This High Priest resides at the apex of the island, which is viewed by the Balinese as the source of their irrigation waters (Scarborough, 1993). Farmers make regular devotional visits to the water temple priests to report on the conditions of their crops and the priests in turn regulate water allocation based upon the farmers' reports in conjunction with calendric cycles.

The pervasive role of Hindu-Balinese ideology means that the water management practices on the island are imbued with considerable ceremony and ritual for the success of the rice crop (Barth, 1993). Holy water is obtained from the Temple of the Crater Lake at the summit of the water system and carried down to the water temples with each new crop to bless the forthcoming harvest. Lansing (1987, 1991) emphasizes the role of purity in transporting water from the source to the water temples upon each new crop and the role of the High Priest and the subsequent hierarchy that controls water allocation among the Balinese.

At the time of this writing, it is unknown how the Purépecha regulated access to water and its distribution for household and agricultural consumption. The examples given above have been used in reference primarily to the Maya region, but may be applicable to the Tarascan Empire especially at Angamuco where it is almost certain that the residents of the city relied primarily on runoff from rainfall. Although the Purépecha conceptions of water and seasonal rainfall is unknown, indigenous veneration of the cosmological forces that bring the rains has been well documented across the globe (Brady and Ahsmore, 1999; Bray, 2013; Singh, 2006; Scarborough, 1998). While it is unclear exactly how the Purépecha cosmology was (if at all) expressed through their water management practices, the *Relación de Michoacán* makes mention of several deities associated with water and the rains.

The Tarascan creator goddess, Cuerauáperi controlled birth and death but she was also associated with the vapor from hot springs, which rise to form clouds that bring rain. More specifically, she sent the rains from the east and could withhold them and send famine. Offerings were made to Cuerauáperi during the feast of *sicuíndiro* (the feast of flaying) in which the hearts of sacrificial victims were placed in hot springs to encourage rain (Pollard, 1993). Additionally, Pollard mentions that at *sicuíndiro* a dance featured two nobles who represented four clouds-white (frost), yellow (dew), red (soft wind), and black (running water). Xarátanga, the daughter of Cuerauáperi, was the goddess of the moon and sea, thus naturally associated with water. The Xarátanga cult was associated with ball courts and thermal springs and she was known to have the power to conceal fish in lakes.

The *Relación de Michoacán* makes clear that the Purépecha had some semblance of cosmological associations tied to water and the rains that supplied them. What is unclear at this time is to what extent these cosmological ideologies played a role in the construction of water management resources or how access to this crucial resource was controlled, if at all. However, it seems highly likely that the gods were intertwined with perceptions of water control and management at Angamuco during the Late Postclassic.

3.5 Water as Community Infrastructure

The recent integration of LiDAR with traditional archaeological surveying techniques and the subsequent analysis of that data have led researchers more recently to several alternative conclusions regarding water management in the Maya region. Specifically, research conducted away from the urban centers at Caracol have demonstrated that the vast numbers of previously undocumented household reservoirs could not have been controlled by the Mayan elites (Chase A.S.Z., 2016). Further investigations in the role that small depressions might serve as water management features further reinforce this notion. Research by Weiss-Krejci and Sabbas, (2002) in the Petén region of northwestern Belize demonstrates that shallow depressions located in residential areas of sites could potentially have stored enough water to sustain a population throughout the dry season. They specifically cite at least one depression (the smallest that they hypothesized to have a water storage function) as capable of supporting 47 people year-round if every person consumed 4.8 liters per day (Weiss-Krejci and Sabbas, 2002:353).

Another study which has been highly influential to the work done in this thesis is the research into the residential reservoirs at Caracol conducted by A.S.Z. Chase (2016). In this study, Chase utilized LiDAR data for Caracol to remotely identify 1590 reservoirs within the monumental core of the site as well as the surrounding residential complexes. The results of this study ran counter to the narratives that suggested elite control over water management systems in the Maya region (Scarborough, 1998; Lucero, 2006a; Lucero 2006b). His results indicated that 95% of the 1590 reservoirs sampled were under 77 M^2 and were comprised of residential reservoirs, whose distance never exceeded 120 M from any household plazuela group. He argues that due to their highly dispersed nature across the site and proximity to residential complexes that it would have been very difficult or entirely impossible for elites to maintain control over these resources. Further, Chase observed that there was no apparent standardization of size or shape for these residential reservoirs. He argues that reservoirs constructed with elite regulation would likely have more standardized metrics and likely some semblance of control over access to water from these features. No such evidence was identified in any of the residential reservoirs, however the reservoirs located in the monumental core of the site did exhibit characteristics of elite control such as restricted access and a higher degree of standardization (Chase, 2016).

The fact that access to year-round water is such a crucial component for any complex society to be able to thrive, it has been the focus of a multitude of studies regarding human ecology. The advent of new technologies and greater access to large datasets that allow archaeologists to study landscapes in their totality is leading to many re-evaluations of urban models and social complexity. It is my hope with this thesis to contribute to the understanding of urban planning and water management as it relates to the Purépecha and the broader Mesoamerican tradition. Many of the concepts discussed in this chapter will be applied and further evaluated in relation to the landscape and water management system identified at Angamuco in the Results Chapter.

CHAPTER 4 : METHODS

4.1 Introduction

The construction of water control features and irrigation is well documented within Mesoamerica. In the Maya lowlands it is common to find reservoirs for capturing and retaining rainfall runoff, such as those found at Tikal or Caracol. In the Basin of Mexico, Tenochtitlan's canal system displays a complex network of hydrological engineering. However, very little is known about the water management practices of West-Central Mexico in the territory controlled by the Purépecha Empire. Angamuco's distance from the prehistoric boundary of Lake Pátzcuaro and the size of the urban settlement indicate that a system for managing access to water would have been imperative to the survival and resiliency of the city's population. Unfortunately, our understanding of Purépecha water management is extremely limited for several reasons. The area of Mesoamerica that encompasses the Purépecha territory, and more specifically, the core of the empire located in the Lake Pátzcuaro Basin is extremely understudied compared to their better-known Aztec counterparts in the Basin of Mexico. Within the Pátzcuaro Basin, the majority of well documented settlements spanning from the Late Preclassic through the Late Postclassic Periods (~ 500 BC-1520 AD) were located much closer to the lake than Angamuco, most existing within half a kilometer of the prehistoric lake shore. Today the lake shore exists at least 8 km away from Angamuco, depending where on the site's boundary one measures from. However, during the Late Postclassic when Lake Pátzcuaro was at its highest elevation (2046 m asl), it was as close as 2.5 km away from the site boundary (Cohen, 2016). The distance of such a large urban center from a consistent source of water for drinking and irrigating crops meant that the population would have likely been more reliant on water from two other sources: runoff from seasonal rainfall and groundwater seepage. Thus, a greater understanding of the hydrology of the landscape at Angamuco will help to elucidate the natural water input systems which the inhabitants of Angamuco relied on and manipulated to optimize water retention and storage, particularly in areas with dense settlements.

The objective of the hydrological modeling performed for this thesis is to address three primary lines of inquiry. The first is to identify the areas of high flow accumulation, where water is likely to naturally drain across the landscape as runoff moving from areas of higher elevation to those of lower elevation. The second is to identify the basins, which act as catchments where water will be retained on the landscape either as a result of the natural topography of the *malpais* or constructed water management features. The last line of inquiry seeks to understand how water control features are spatially distributed across the site within and between urban communities. These features include modified portions of the landscape which were already likely locations for water storage, formally constructed reservoirs, margin reservoirs, and sunken roadways which act as features to direct the flow of runoff. The overall end product, consisting of multiple different raster and vector output files generated in ArcGIS, display in great detail the location of reservoirs and the paths that rainwater takes which drain into the large margin reservoirs located along the peripheries of the site in the ancient lake basin, and ultimately into Lake Pátzcuaro itself. These datasets can be used further to address anthropological questions about the distribution of water resources at Angamuco as well as population thresholds for the water management system, which will be discussed further in Chapter 6.

Of the many different tools and techniques that archaeologists use to better understand site structure and composition, few have been as innovative and revolutionary as the application of light detection and ranging (LiDAR). Its unique ability to produce a 3-dimensional representation of vegetation, the ground surface, and innumerable other objects of interest make it an invaluable tool for surveying and analyzing landscapes. LiDAR is particularly useful in allowing researchers to observe and run operational analyses across landscapes at varying scales exponentially faster than would be possible through traditional survey methods alone. In many cases, LiDAR surveys have recorded entirely undocumented features in previously recorded sites as well as showing, in great detail, features that are not easily visible from the ground (Carter et al. 2016; Doneus and Briese, 2006). This technology has proven most useful for archaeological prospection in heavily forested areas that are difficult to access from the ground, specifically in the tropics of Southeast Asia (Evans et al., 2013; O'Reilly et al., 2017) and portions of Mesoamerica (Chase et al., 2012; Fernandez-Diaz, 2014; Fisher et al., 2017). The application of LiDAR is nothing short of a revolution for archaeologists in terms of our capability to map large landscapes and perform complex spatial analyses on a scale never before possible. Only through the use of LiDAR data for Angamuco is it even remotely possible to analyze the water control features on the scale that we are now able to.

The employment of LiDAR at Angamuco, over the course of two acquisition flights, has made it possible to map the entirety of the urban settlement in high resolution and with great accuracy in a matter of days (Fisher and Leisz, 2013). The combined scans total over 35 km^2 with a spatial resolution of 50 cm per cell. The specs for the first scan are fully described in Fisher and Leisz (2013), Fisher et al. (2012), and Fisher et al. (2011). The products derived from both scans provide essential geospatial data for the entire *malpais* which would have otherwise involved decades of survey using traditional "boots on the ground" techniques. The accuracy of such archaeological digital elevation models (DEMs) can be tested very simply by overlaying georeferenced plan maps of features of interest (Figure 4.1) to see how well they line up with the LiDAR data. Oftentimes, rectifying plan maps over a DEM has the added benefit of identifying features present in the LiDAR data that may not have been observed in the field or are difficult to see from the ground.

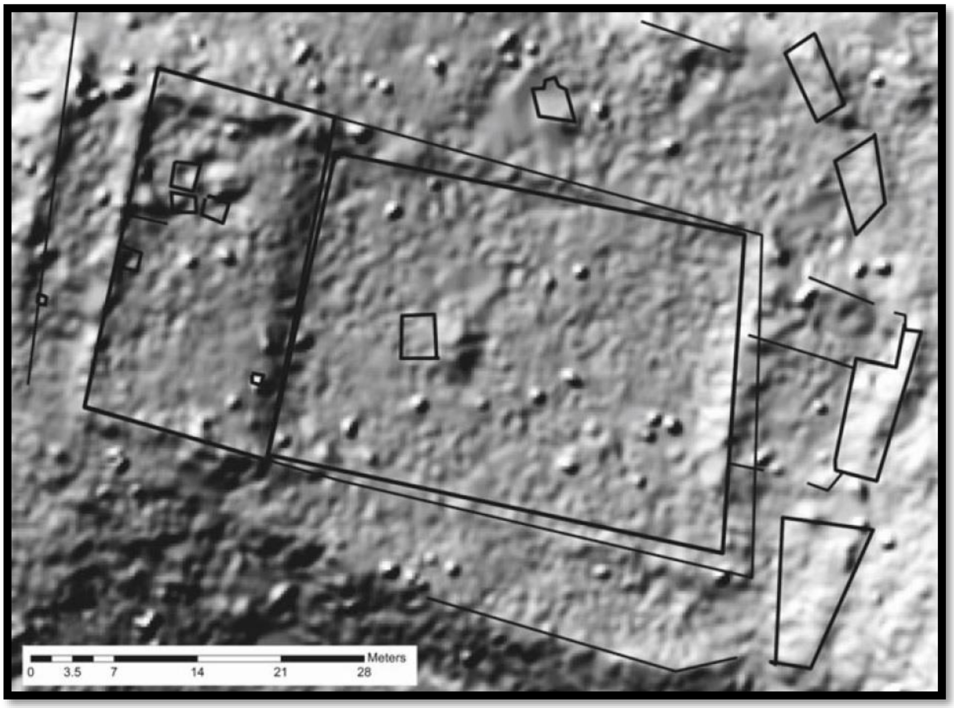

Figure 4.1: Georeferenced features mapped in the field laid over LiDAR data (Fisher and Leisz, 2013)

LiDAR is an active remote sensing technique that can be utilized in several different ways dependent upon the goals of the researcher. Active remote sensing technologies differ from passive systems in that they generate the source of light that they are recording. Conversely, passive systems rely on light produced by a separate source, oftentimes the sun. Passive remote sensing techniques include multispectral imaging and photographs taken from sensors which can be mounted to planes, helicopters or satellites. Passive systems are designed to capture light being emitted or reflected from a target object. As an active system, LiDAR functions by emitting pulses of light, both in the near infrared (NIR) and visible spectrums and receiving the light reflected from the target surface via an optical sensor. One of the most obvious differences between the two systems is that passive systems register spectral signatures, while LiDAR data registers elevations and intensity of reflected signals. Another key difference being that LiDAR data can be processed to remove the vegetation cover, while passively collected imagery cannot. LiDAR sensors are, at their most basic, composed of three separate subsystems: an optical transmitter, an optical receiver/detector, and ranging/timing electronic components. These three components work in conjunction to produce a point cloud, which represents the vertical and horizontal location in space of each return.

The most common method for employing LiDAR by archaeologists is called time of flight (TOF) and it's the simplest form of data acquisition. During TOF LiDAR reconnaissance, hundreds of thousands of pulses of light are emitted per second by the optical transmitter which are echoed back and recorded by the optical receiver. The time between light emission and return detection are recorded by the sensor, which stores each return with X (horizontal), Y (vertical), and Z (elevation) coordinates. The length of time for each return is divided by two, then multiplied by the known speed of light in order to derive the distance between the ground and the sensor. Aircrafts with LiDAR sensors on them also have onboard monitoring equipment to record the altitude, pitch, and yaw of the aircraft so that these factors can be accounted for in the processing phase of acquisition. Oftentimes aircrafts will also carry GPS equipment that is communicating with ground points, satellites, or both to ensure the highest level of accuracy regarding its geographical position.

The raw data gathered during LiDAR acquisition needs to be processed and calibrated with the onboard computing equipment to ensure the creation of an accurate product. The resulting dataset, known as a point cloud, is comprised of billions of points containing X, Y, and Z data for every pulse of light emitted by the onboard sensor. The point cloud data is processed through software, such as ArcGIS, MARS, or Global Mapper to classify each point based on its elevation and spatial location in reference to surrounding points, or an absolute value. Archaeologists are primarily concerned with objects on the ground surface, which can be the last or lowest returns received by the sensor but are not always. These ground return points are filtered out from the rest of the points, which are likely the result of overlying vegetation or tree canopies. Upon all the points being correctly classified, a Triangular Irregular Network (TIN) is used to interpolate the space between the ground points to create a triangulated representation of the surface. The resulting DEM can then be utilized in ArcGIS for various analytic purposes spanning a broad range.

This thesis is focused on hydrological analyses performed on the DEM that was generated for Angamuco, including the natural flow lines of surface runoff across the landscape as well as the places that runoff will be captured in natural or artificial basins for water storage. The DEM that was produced for Angamuco has a spatial resolution of 50cm, which is more than adequate to produce accurate hydrological models (Zhang and Montgomery 1995). This is done using the suite of tools in the Hydrology toolbox in ArcGIS 10.5 and utilizing a Topographic Index formula, similar to the index used for identifying the water retention capacity of terraces at Caracol (Chase and Weinshampel, 2016). The next section will outline the workflows for producing the data used in modeling the spatial distribution of reservoirs across the landscape at Angamuco.

4.2 Data Correction

The first and arguably most important step for hydrological modeling is to ensure that the DEM accurately reflects the landscape as much as possible. As previously mentioned, LiDAR data must be processed after it is collected to classify points into either ground or non-ground points which is done using proprietary algorithms or independently developed software tools. Although the algorithms classify the vast majority of points correctly, oftentimes points or entire groupings of points may be misclassified resulting in digital “artifacts” that do not accurately reflect the landscape. If the misclassified points are not corrected, they can result in spikes (points far above the ground) or deep troughs (points recorded far below the ground). These errors can be remedied easily in the point cloud by selecting the misclassified points and reassigning them to a non-ground class. For the sake of ease, all of the errors in the Angamuco point cloud were reclassified as “noise” and subsequently removed from the analysis dataset.

In addition to removing misclassified points from the point cloud, modern features on the landscape can likewise be removed so that the interpolated surface more closely resembles the prehistoric landscape. For example, Federal Highways 14D, a modern East-West trending road that runs south of Angamuco, extends through one of the margin reservoir features on the southeastern side of the site. In order to more accurately reflect the prehistoric landscape, the points representing the raised road in the point cloud data were also reclassified as “noise”. The data void was interpolated from the unmodified landscape, creating a flatter surface that more accurately reflects the prehistoric topography in the margin reservoir (Figure 4.2). Once the point cloud has been successfully corrected and all misclassified points and modern features have been removed, a DEM can be generated for performing hydrological analyses with a higher confidence of accuracy.

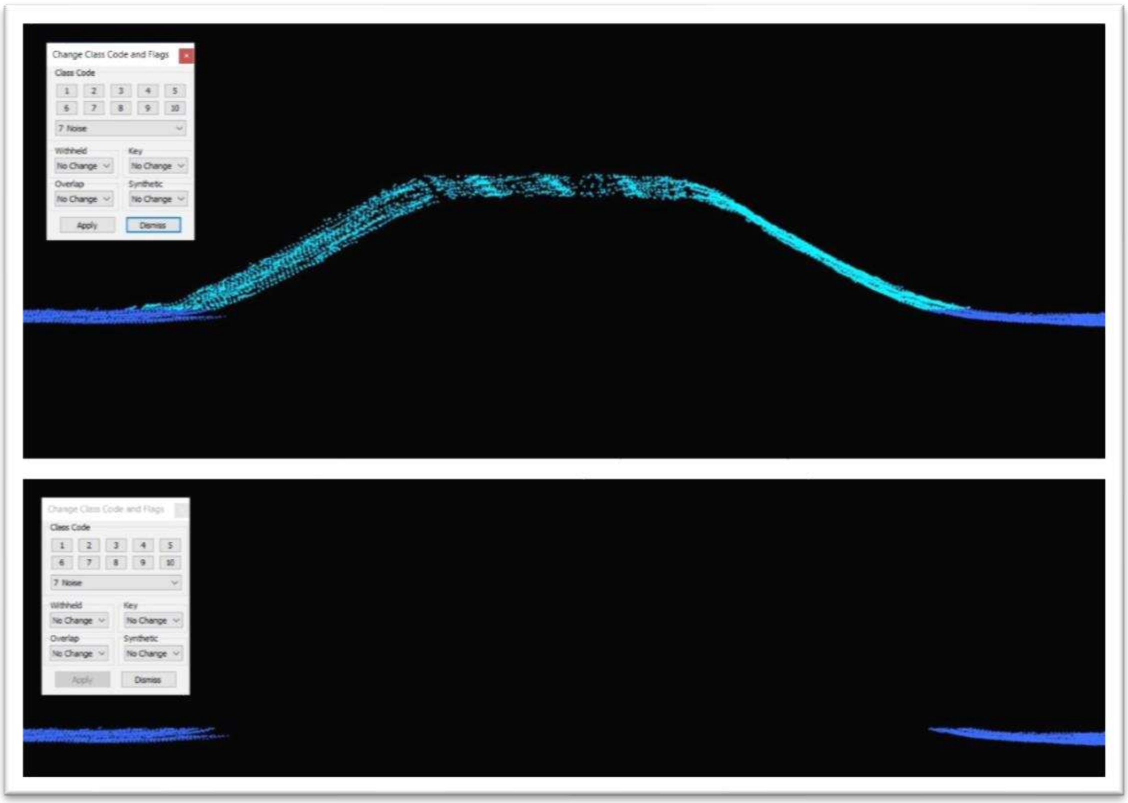

Figure 4.2: Road berm reclassified as noise. ArcMap automatically interpolates the gap to create a flat surface.

4.3 Hydrologic Modeling

The successful identification of reservoir features through semi-automatic extraction across Angamuco is a complex endeavor involving multiple steps and refinements. The hydrology toolkit in ArcGIS is designed for just such a task and is often utilized by engineers and environmental scientists to delineate watersheds. Since the recent advent of LiDAR data for archaeological feature prospection, multiple methods have been employed for identifying water storage features which include both visual inspections of the landscape using different visualization techniques (A.S.Z Chase, 2016) and semi-automated identification techniques (Hanus and Evans, 2016) similar to those used in this thesis. This thesis utilizes several of the tools in the Hydrology toolkit in ArcGIS to accomplish the goal of delineating the watersheds across the site and locating potential reservoir features through the Hydrology workflow. Grasping how the algorithms executed by the software iterate across the DEM is vital for understanding how the number and locations of reservoirs at Angamuco were estimated.

The workflow for automatically identifying potential reservoir locations includes a multi-step process that identifies basins, or "sinks" in the DEM, the direction of flow across the surface, the areas of accumulation, and the resulting watershed basins. The first step in this process is to smooth the original DEM raster for hydrological analysis. This involves the use of the Low Pass filter tool using the Spatial Analyst extension in ArcGIS. The Low Pass filter operates by evaluating and averaging the values for each cell in a 3x3 cell neighborhood. By running a Low Pass filter over the entire DEM, much of the noise is filtered out. Because each cell in the original raster represents a 50x50 cm area, the averages represent a 2.25 M^2 area. This allows for the elimination of extreme values in the local topography while still recognizing larger architectural features such as mounds, walls, and roads. After the original DEM has been processed with the Low Pass filter the resulting dataset can be run through several of the tools in the Hydrology toolbox using the Spatial Analyst extension of ArcGIS.

The Fill tool marks the first step in the hydrological modeling process and is the primary raster used for most of the subsequent analyses. This tool, located in the ArcGIS Hydrology toolbox, is a "Nearest Neighbor" algorithm designed to identify and eliminate "sinks" in a raster dataset. A “sink” is defined as a cell with an undefined drainage direction, meaning that no surrounding cells contain a lower elevation, or z-value. The Fill tool iterates upwards from the cell with the lowest z-value until it reaches the next lowest cell with a defined drainage direction, or “pour point”. The pour point represents the elevation at which water would spill out of the sink if it were full of water. By adjusting the Z-limit allowable by the Fill tool, basins can be filled according to their depth allowing for watersheds to be generated at varying scales, accounting for greater or lesser episodes of rainfall. The original DEM raster is then subtracted from the Fill DEM using the Raster Calculator tool. The resulting raster displays the difference in values between the original DEM and the filled DEM. Depressions identified by the Fill tool are highlighted across the site and can be used to determine high probability locations for reservoirs (Figure 4.3).

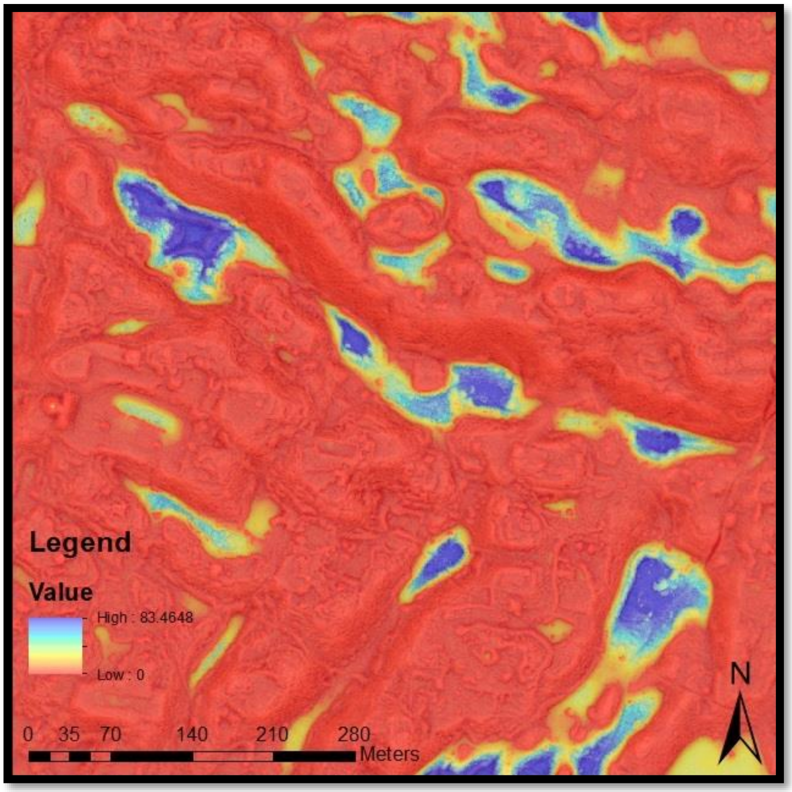

Figure 4.3: Raster created by subtracting the original DEM from the Fill DEM with no Z-limit. Areas highlighted in blue represent topographic basins which are high probability locations for reservoirs

The output Fill raster is subsequently fed into the Flow Direction tool. This is another nearest neighbor algorithm which calculates the direction water will flow out of one pixel into one of its eight neighboring cells. The calculation is determined by the greatest decrease in z-value between cells. The neighboring cell with the lowest z-value represents the path of steepest descent, or the path water will travel across the landscape. The Flow Direction output feeds into the Flow Accumulation tool, which calculates flow values as the accumulated weight of all cells flowing into each consecutive downhill cell. Areas with higher flow accumulations are areas where water flow is concentrated, allowing for the delineation of stream channels.

The Flow Accumulation raster and the Flow Direction raster are used together to determine stream order. The stream order is determined using a method for dendritic stream networks developed by Strahler (1957). This method for identifying stream networks operates by assigning increasing order values to streams at juncture points where two streams join together. A stream with no other contributing tributaries is designated as a first order stream. When two first order streams join together, they form a second order stream. When a second order stream joins another second order stream, it becomes a third order stream, and so on. However, before the Stream Order analysis could be run I had to first define a the quantity of accumulation I wanted to designate as a “stream”. Using the Raster Calculator, I defined a “stream” as any Flow Accumulation line that was fed by greater than or equal to 500 cells, which is equal to 125 M^2 in area. The stream orders may change by assigning a smaller threshold for stream designations, but for the purposes of this thesis there did not seem to be any value in evaluating a smaller area.

Finally, the Flow Direction output is used again to determine the extent of each watershed basin present across the site. Drainage basins are delineated by identifying ridge lines between basins. ArcMap locates the pour points, where water would pour out of the raster from a given drainage channel, then identifies the contributing area upslope from each pour point. These basins can be altered by changing the Z-limit of the Fill raster that was used to generate the Flow Direction raster, thereby altering drainage basins by connecting or separating flow networks dependent upon how many basins are filled to their pour points. When there is no Z-limit set for the Fill raster in the beginning of the process, the largest possible watershed basins for the site are generated. However, it is unlikely that these basins reflect the true micro-watersheds present across the site. As previously stated, this is one of the reasons these analyses were run on filled rasters with varying Z-limits, as watersheds increase in size when basins spill over their edges and feed water further downslope. Figure 4.4 shows the model I developed in ArcGIS to automate the hydrological modeling process I have described above. The process begins at the upper left corner with the Fill Tool and ends with the production of Watershed Basin Polygons, Stream Order Polygons. In the process the model generates a Filled raster with basins filled to varying depths and corresponding Flow Direction, Flow Accumulation, Stream Order, and DEM difference rasters. The yellow squares denote tools from the ArcGIS suite of Hydrological tools, the green ovals denote the generated products, and the blue ovals indicate the input datasets. Automating the workflow made running these analyses much less time intensive and reduced the likelihood that errors might be made when performing each step on its own.

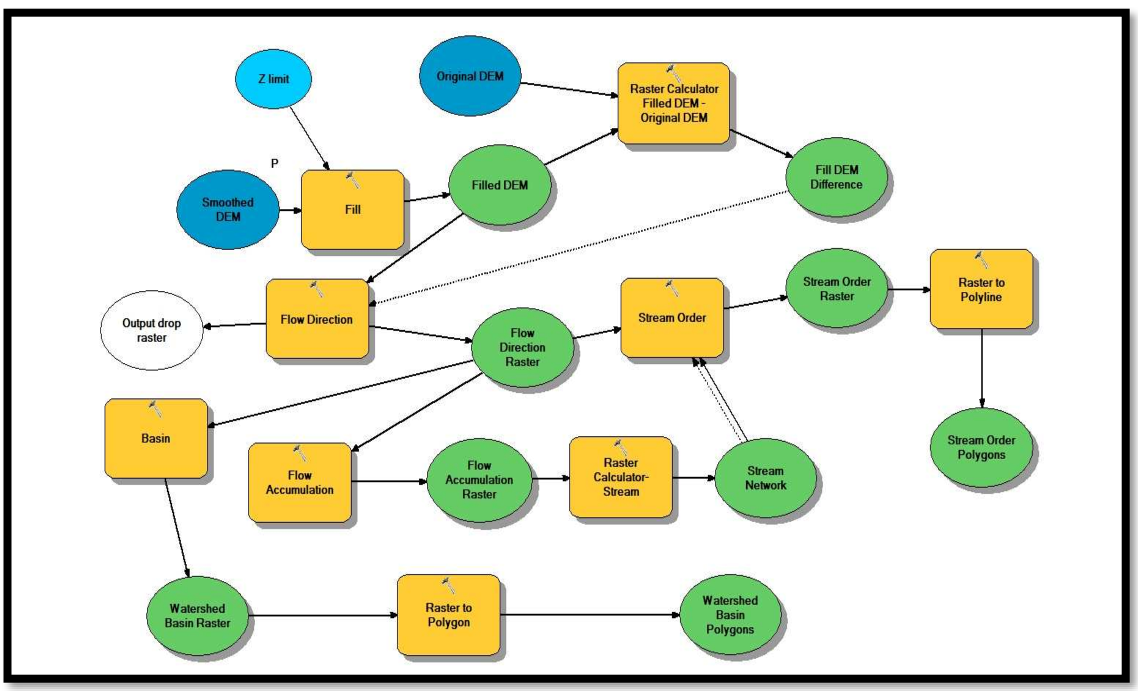

Figure 4.4: ArgGIS Model for Hydrology workflow (dotted lines represent preconditions)

4.4 Topographic Convergence and Sediment Transport Indices

The Topographic Convergence Index (TCI), also known as the Topographic Wetness Index (TWI) uses Map Algebra, and the Hydrology, Surface, and Topography toolboxes developed for ArcGIS to provide an estimate of soil saturation based on flow convergence. Calculating TCI is based on the following formula:

$$\text{TCI} = ln\frac{Upstream\ area}{\tan(Slope)}$$

In this equation, the Upstream area has already been calculated with the Flow Accumulation raster and Slope is expressed in radians rather than degrees (For a full description of this formula, see Beven and Kirkby [1979]). This model provides an estimate for soil saturation based on flow convergence and represents the amount of water retained in the soils (Chase and Weinshampel 2016). Cells of higher values will become saturated before cells of lower values, meaning that places where water pools or flows slowly, TCI values will be higher. This is useful for identifying low lying areas on the landscape and channels that water is likely to flow through. Figure 4.5 displays the southeastern portion of the site containing the southernmost *yacata* pyramid. Figure 4.6 displays the output raster generated from the above formula. The areas which grade from red to yellow indicate very low to zero accumulation of water and the blue stream lines display areas where water is likely to flow relative to the area of upslope contribution. While this model does have some utility, it was not any better for identifying water management features than the methods discussed earlier, thus was used only minimally in this analysis.

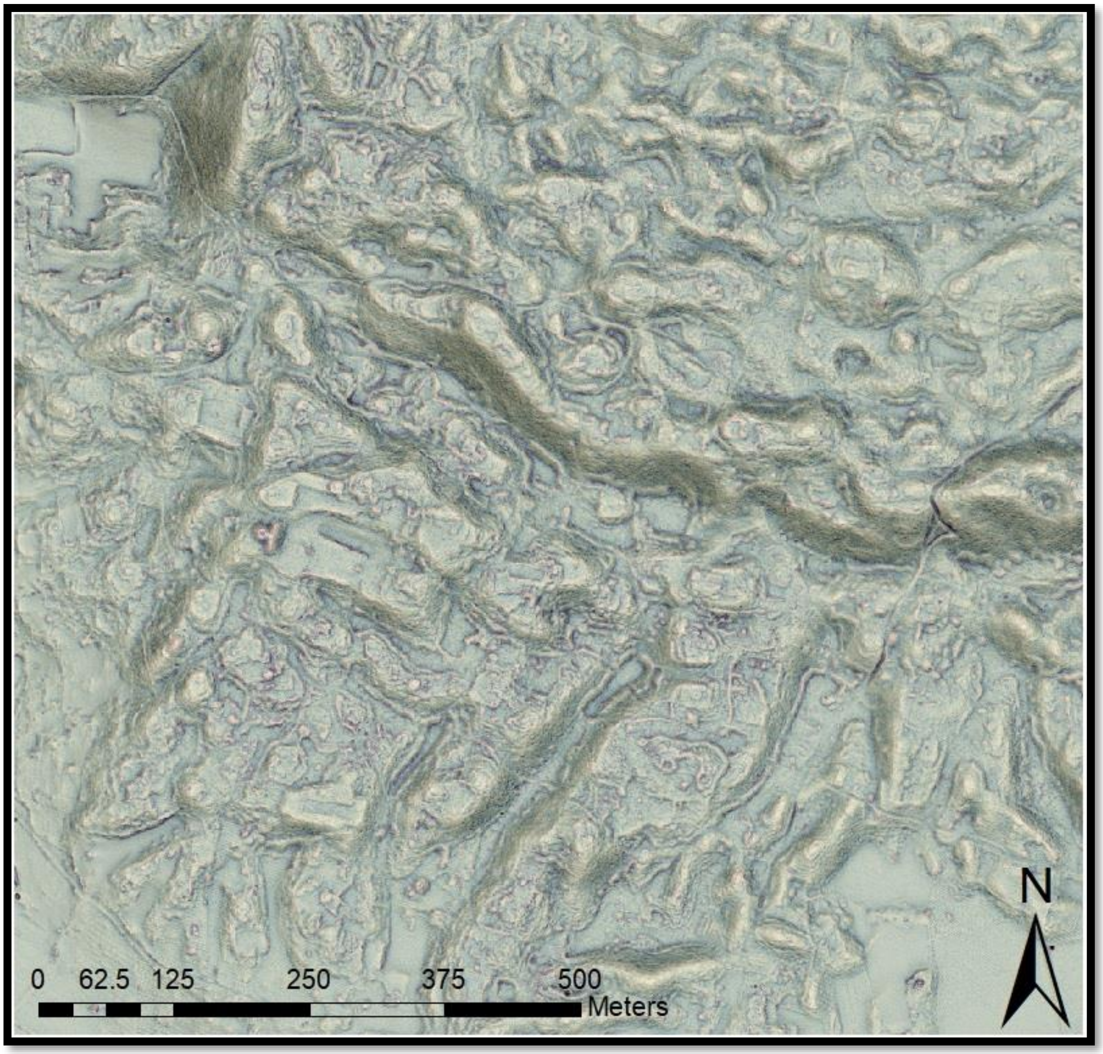

Figure 4.5: Southeastern portion of the site showing large southern yacata (Visualization includes overlain slope, local relief model, positive and negative oppenness, and the ridge valley index)

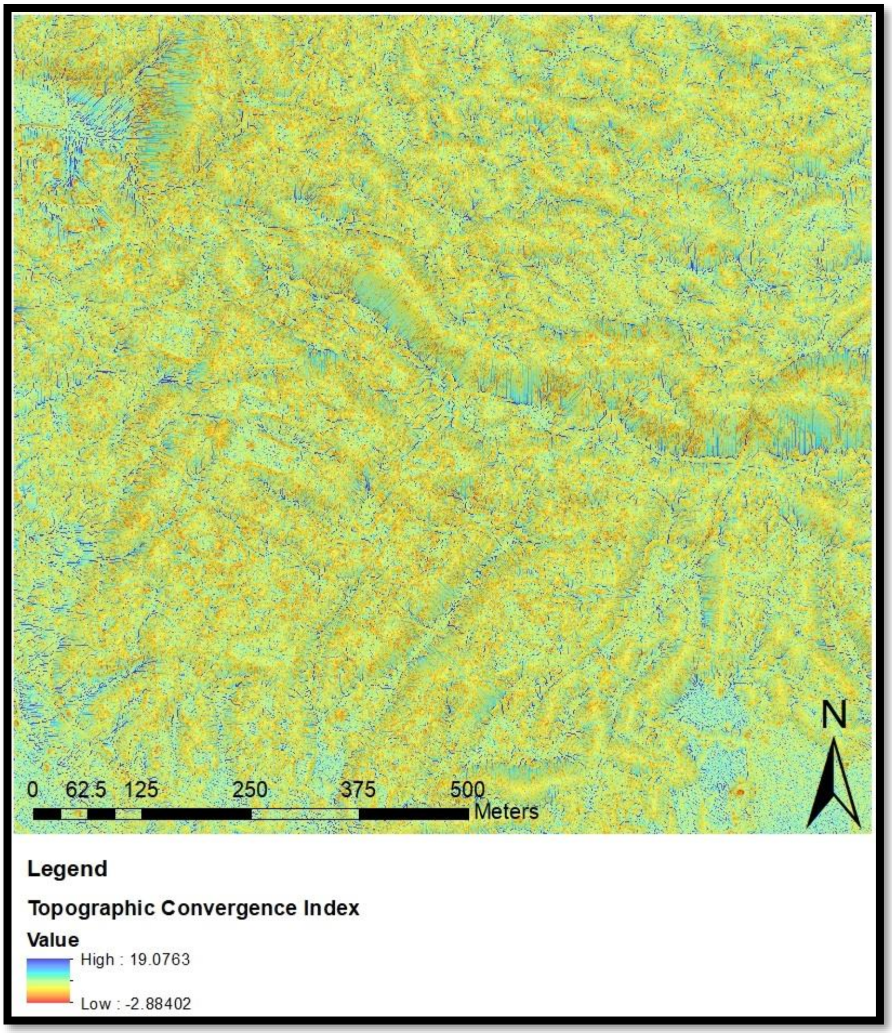

Figure 4.6: Shows the same location as Figure 4.5 with Topographic Convergence Index raster overlaid. The yellow to red areas indicate low levels of flow accumulations while the blue stream networks represent high levels of flow accumulation.

For visualization of the locations which are most highly susceptible to erosion at Angamuco, I utilized the sediment transport index (STI) (Burrough, 1998). This algorithm has also been applied successfully at the Classic Maya site of Caracol to assess soil preservation by terracing (Chase and Weinshampel, 2016). The index is based upon the speed and amount of water flowing across an area. The following formula is used to calculate STI:

$$STI = \left(\frac{Upstream\ Area}{22.13}\right)^{0.6} * \left(\frac{\sin(Slope)}{0.0896}\right)^{1.3}$$

Again, the Upstream Area in this formula is the Flow Accumulation raster generated earlier. This index has the capacity to better inform us of places at Angamuco which may exhibit higher levels of sediment transport during rainfall events, which may allow us to better understand the rates at which many of these features accumulate sediment over time both during the site's occupational period and following abandonment. Figure 4.7 shows the resulting STI raster for the same area shown in Figure 4.5.

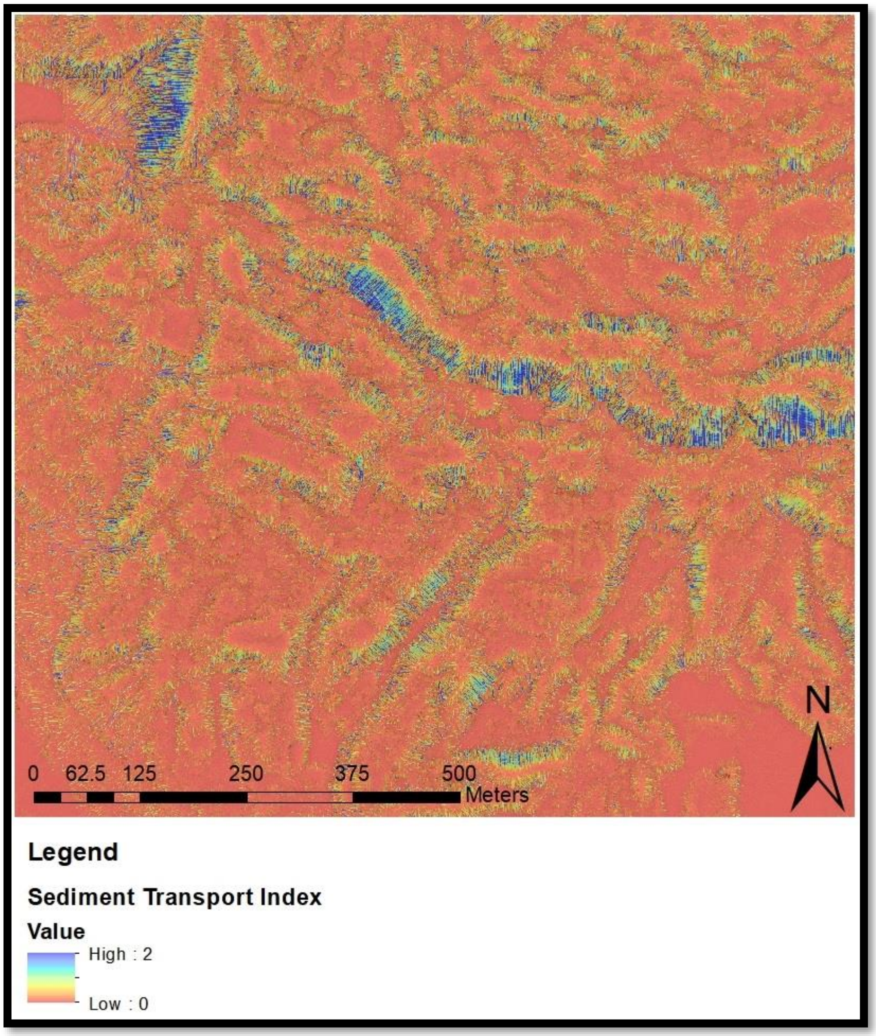

Figure 4.7: Sediment Transport Index showing locations most highly susceptible to soil erosion (blue and yellow) and areas not likely to experience high amounts of erosion (red).

4.5 Identification and Quantification of Water Management Features

As previously established, the Lake Pátzcuaro Basin relies solely upon rainfall and groundwater seepage for its sources of freshwater. The complex topography present at Angamuco provides a naturally southward downslope for water to run from the northern portions of the *malpais* to the lake basin on the southern and western edges. The landscape is also marked by many swales and depressions and it is many of these natural depressions with which we are concerned when looking for water management features. Once identified, reservoirs were given unique designations, extracted and converted into polygons, and assigned attributes for their estimated areas and volumetric capacities.

In order to maintain spatial organization of features, I analyzed the entire site in 500 m^2 blocks using a previously established grid which covers the entirety of the dataset (Figure 4.8). Each block has an alphanumeric designation wherein the letters progress from north to south, and the numeric values increase from west to east. For example, AA66 lies directly to the north of AB66 and directly to the west of AA67. Reservoirs that were identified within a grid were assigned that grid's designation followed by an underscore and a secondary number (e.g. AL67_01; AL67_02; AL67_03; and so on).

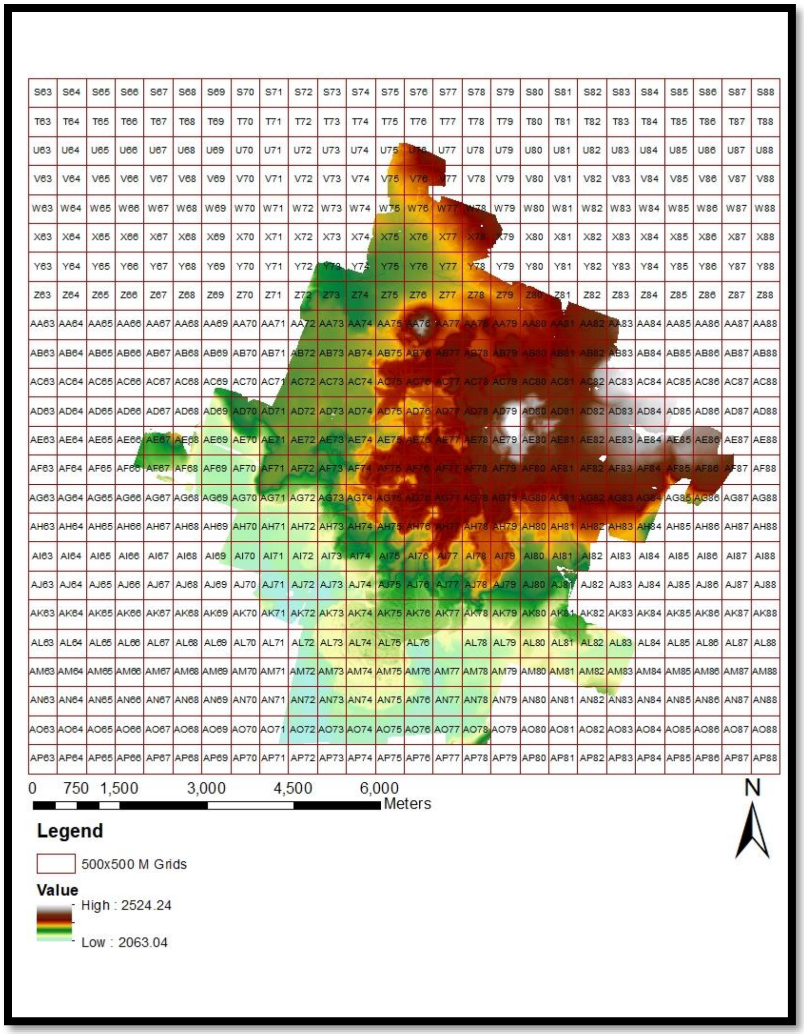

Figure 4.8: Labeled 500x500 M grid for Angamuco

An important point to make here is that an architectural typology has already been developed for architectural features at Angamuco (Cohen 2016; Fisher et al. forthcoming publication). This typology is based on over 7,000 architectural features which were field verified and mapped using sub-meter handheld GPS. The sample includes four categories of architectural features: Above Ground, Ground Level, Prepared Open Zone, and Landscape Feature. Reservoirs do not fit neatly into any of the current categories. The closest being Landscape Features, which consists of agricultural, habitational, and architectural terraces as well as sunken roads and raised roads (*huatziri*) (Fisher et al, 2019). It may be necessary to create a sunken feature class to include features such as sunken plazas, sunken roads, and reservoirs, however such a distinction is beyond the scope of this thesis.

The hydrological modeling described above was used to guide the identification of reservoirs across the landscape of Angamcuo by highlighting the areas of high potential for water retention. Once these areas were identified, contours were generated at 20cm, 50cm, and 1M intervals to help determine the highest elevation of the bounded basins. Once the highest closed contour for each depression feature was located it was selected and used as an upper limit for the potential reservoir. I turned to Model Builder in ArcGIS again to help automate the process of extracting and quantifying each depression feature (Figure 4.9). I first converted the bounded polyline into a polygon representing the maximum extent of the reservoir feature. The next step used the Extract by Mask tool in the Spatial Analyst extension using the polygon created from the highest contour as the mask, and the DEM as the input surface. Once the DEM was extracted, I used the Surface Volume tool in the 3D Analyst extension to calculate the metrics of the reservoir. This tool calculates the area and volume between an input surface and a manually designated reference plane. The reference plane is the elevation of the bounded contour that represents the highest elevation of the potential reservoir. The output is a table containing the 2D area, which is the area of the polygon that represents the reservoir, the 3D area, which is the surface area of the input surface, and the volume of the depression. There is presently no way to automate the extraction of every bounded basin present on the site, so each basin was extracted and measured individually. Once all of the features were extracted, the separate tables for each feature were joined together in Microsoft Excel to generate a master table containing all of the reservoir designations as well as their metric calculations. I exported the Excel table as a CSV (comma delimited) file and performed a Join function with the polygons that were created for all of the reservoirs across the site. The resulting dataset consisted of a single polygon shapefile containing every potential reservoir identified on the site with their calculated areal and volumetric capacities joined as attributes.

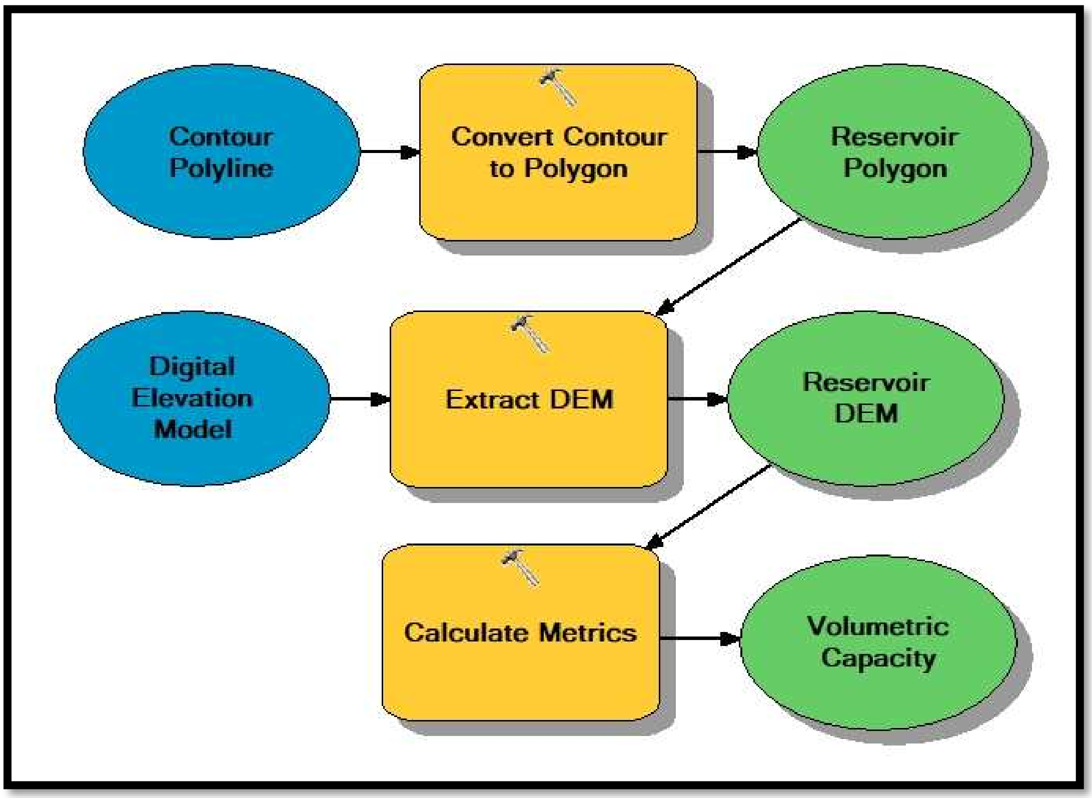

Figure 4.9: Model for generating reservoir polygons and calculating metrics

Each individual polygon can now be selected and the spatial data for the reservoir feature it represents is available. In addition, by converting the outputs for the watershed basins and flow accumulation values into polygons, it is possible to calculate metrics and other spatial data from these primary datasets. Through the evaluation of the spatial distribution of water management features and the quantification of potential reservoirs and hydrological features present at

Angamuco it is possible to speculate on the social and cultural influences that may have contributed to the constructed hydrologic landscape at the site.

In addition to spatial analysis of the volumetric capacities of the reservoirs, I also performed runoff analyses using the polygons generated for the individual watershed basins. This was done by selecting the basins generated with the original DEM and the filled DEM with a set 1M z-limit. I selected a study area on the southern portion of the *malpais* for all analyses. The study area consists of 2 km^2 of the site and consists of grids AM74, AM75, AN73, AN74, AN75, AO73, AO74, and AO75 (Figure 4.10). The runoff analysis is performed by calculating the area of all contributing runoff basins for an individual reservoir and multiplying it by the average rainfall for the region, then multiplying the resulting factor by the "runoff percentage", or the amount of water that runs across the surface rather than percolating into the soils. The results of these analyses will be explained further in the Results chapter.

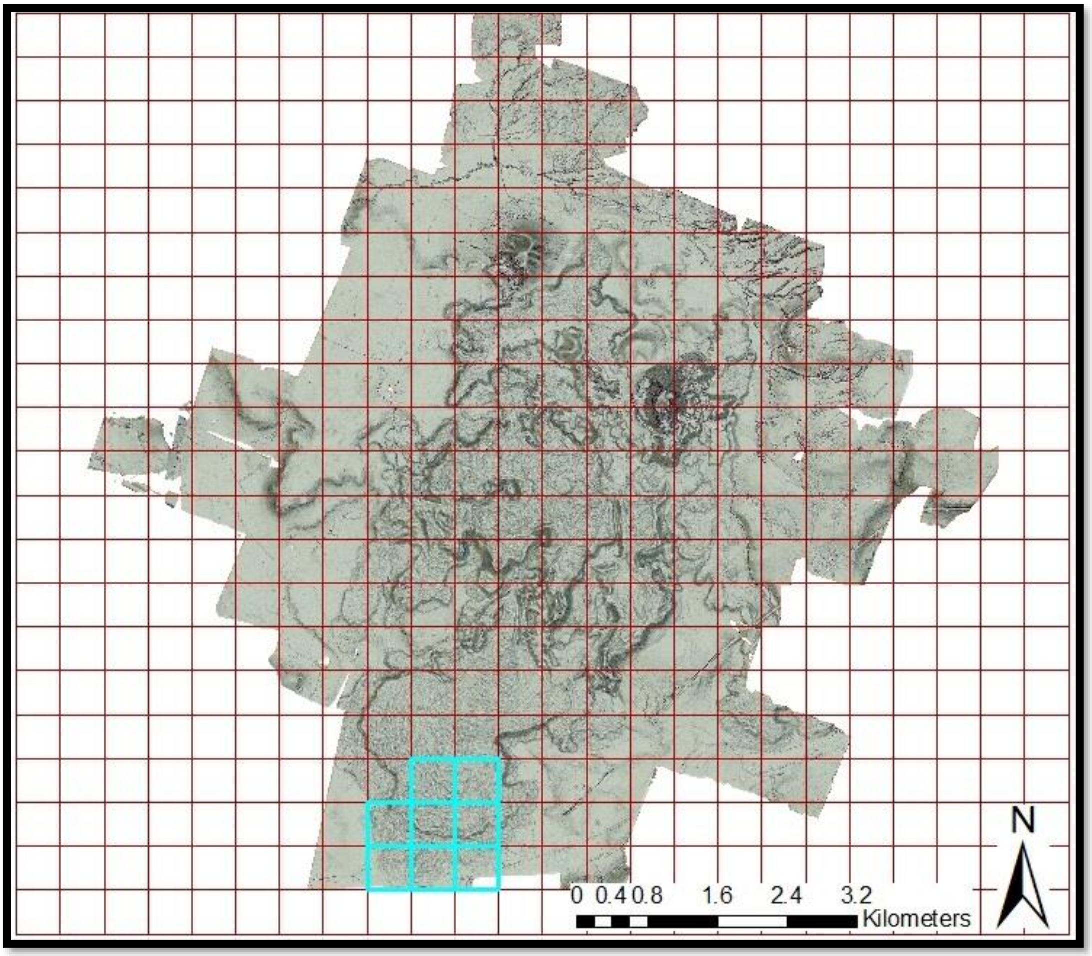

Figure 4.10: 500x500 M grids with study area highlighted Each Grid cell represents 0.25 km².

CHAPTER 5 : RESULTS

The sweeping landscape scale analysis of prehistoric water management systems in complex societies allows researchers to examine ancient civilizations from a multitude of perspectives including the hydrology, spatial distribution of water management features, and volumetric data for each individual feature. In the functional sense, the control and distribution of water across settlements is an essential infrastructural undertaking necessary for maintaining large populations. In addition to this fact, the way that the water management systems are constructed, maintained, and distributed across the landscape can tell us a great deal about the social organization of the complex societies which built them. As discussed in Chapter 3, water management is not simply a purely functional means for retaining water but is an expression of cultural identity that is heavily influenced by the cultural milieu from which it emerged including both utilitarian and non-adaptive elements (Rapoport 1969; Moore 1996). By analyzing water management in relation to other known systems around the prehistoric world, we may begin to gain preliminary insights into the ways that societies organized themselves in terms of infrastructure and resilience strategies. This analysis identified a total of 811 water management features spread across the *malpais*, including wells, residential reservoirs, and margin reservoirs (Figure 5.1). These were all identified manually with the utilization of the various rasters generated using the methods previously discussed in Chapter 4.

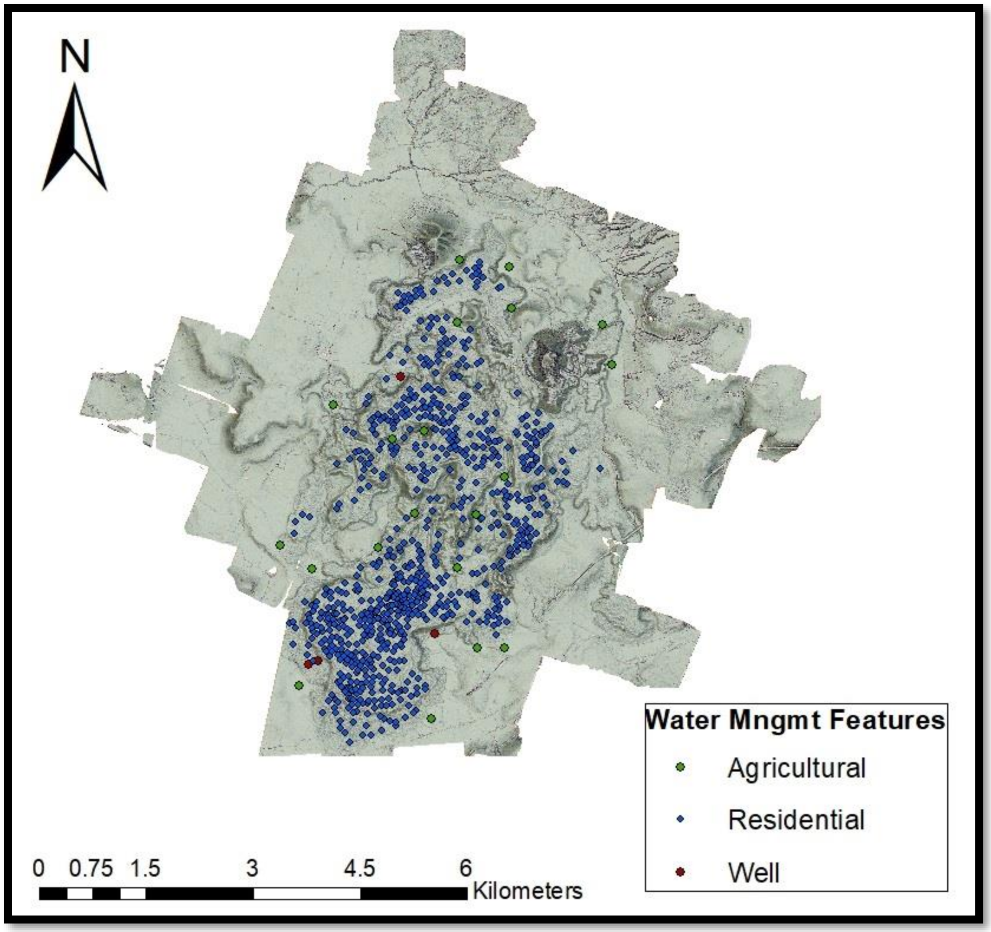

Figure 5.1: Map of Angamuco showing all identified water management features

In this chapter I will discuss the results of the hydrological modeling for the site of Angamuco and the ways that the models suggest water from rainfall runoff moves across the *malpais* landscape. The discussion will first address the different types of water management features identified at Angamuco, specifically their forms and perceived functions as well as their volumetric capacities. Then I will discuss the results of the hydrological modeling and the ways that the calculated stream order networks and watershed basins can be used in conjunction with the reservoir volumetric data to inform us about the functionality of the water management system as a whole at Angamuco. These results will be further synthesized in the following chapter.

5.1 Water Management Features at Angamuco

5.1.1 Wells

A total of four wells were identified through this analysis based on their locations near the edge of the *malpais* as well as their depths and dimensions (Figure 5.2). As defined in Chapter 3, wells are vertical shafts used to exploit the permanent water table or to retain water which percolates through the soil and rock (Johnston, 2004). Two of the wells (Well_01 and Well_02) identified in this analysis were ground verified during the 2010 field season at Angamuco (Fisher et al., 2011). Both are located in Grid AM73 near one of the yacata structures recorded on the edge of the site. Well_01 measures 7.5 x 8.5 meters in diameter and has a maximum depth of 3.5 meters. Volumetrically Well_01 is the largest of the four wells identified with a capacity of 45.9 M^3. Well_02 is located 145 meters northeast of Well_01 and measures 5 x 5.5 meters in diameter with a maximum depth of 2.5 meters. The volumetric capacity of Well_02 is 20.05 M^3, which makes it the third largest of the four identified wells on the site. It is important to note here that the volumetric capacities of the wells are likely not valuable indicators for the amount of water available in them because their function serves to access permanent ground water rather than necessarily retaining runoff.

Well_03 and Well_04 were identified during this analysis and have not been field verified, however given their similar structure and morphologies to Wells_01 and 02, they are likely candidates for well features. Well_03 is located on the eastern boundary of the *malpais* in Grid AL76. The well is situated on the lowest portion of the landform above the lake basin. There are no other reservoir features located on this portion of the *malpais*, meaning that this well may have been the primary source of drinking water for the residents of this portion of the site. However, the largest margin reservoir (discussed later) is located about 100 meters from this urban cluster and may have provided another source of water for the inhabitants of this area. Well_03 measures 3.8 x 5 meters in diameter and is 1.5 meters deep. This is the smallest of the recorded wells with a volumetric capacity measuring 7.08 M³, thus without a source of permanent groundwater to draw from, this feature is not large enough to act as a reliable source of water from its storage capacity alone. Well_04 is located in the northern portion of the site in Grid AE75, near the lake basin. It measures 7.8 x 6.2 meters in diameter with a maximum depth of 1.5 meters. The volumetric capacity of this well is 31.5 M³, making it the second largest well recorded volumetrically speaking. It is a minimum of 50 meters east from the nearest cluster of urban architecture.

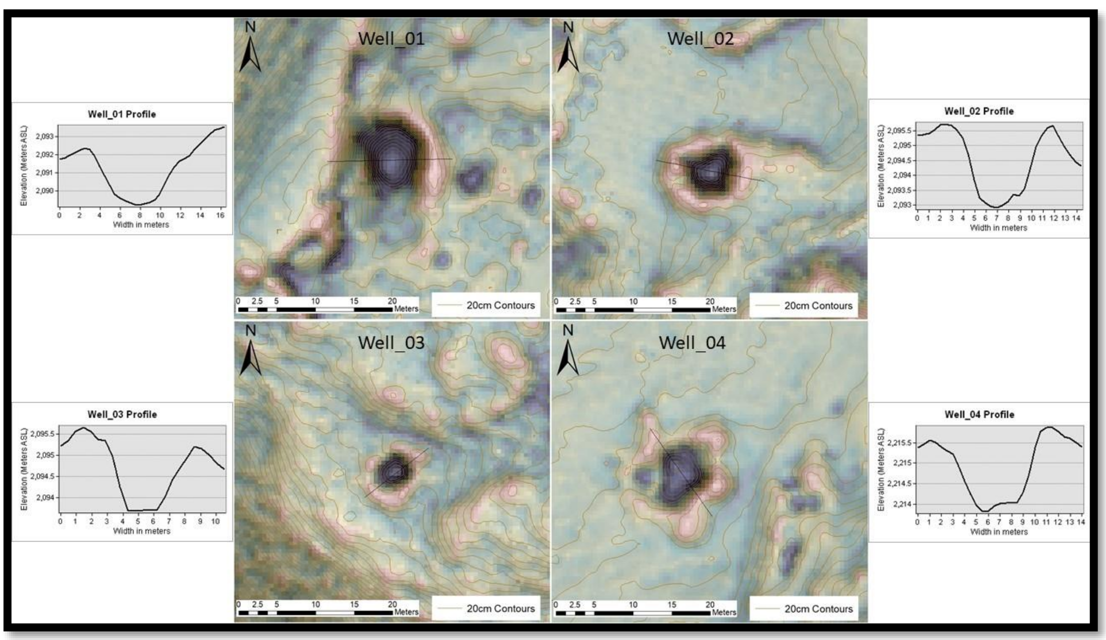

Figure 5.2: Wells and associated profiles identified at Angamuco

The identification of four wells across the site is likely a very conservative estimate, with other wells or modified springs likely present but less obvious on the edges of the *malpais*. However, it demonstrates that the methods used in this thesis can be used for identifying even small architectural structures and water management features. It is likely that these features are shallow and only present on the edges of the *malpais* because of the fairly shallow nature of the water table in the old lake basin itself. The water table in the lake basin is <1 M below the surface (Fisher 2017, personal communication), meaning wells don't need to be excavated very deep in order to reach the permanent source of groundwater. It is also possible that these well features may be partially collapsed which is not discernable from the LiDAR data and would require field verification. It is important to note as well that these likely represent a small sample of the wells at Angamuco. With further field investigations and surveys to locate extant and non-extant springs in addition to wells, the number of wells documented will almost certainly be higher than the numbers presented here.

5.1.2 Residential Reservoirs

This analysis identified a total of 794 residential and communal reservoirs located around the *malpais*. Residential reservoirs are designated as those located on the *malpais* within the dense urban settlement. This represents 97% of the total number of water management features identified for the site. Here I will be focusing only on the reservoirs within the study area described in Chapter 4 (n = 116). These features are highly variable in terms of their construction style, size, and proximity to residential structures. The residential reservoirs, meaning any reservoir not considered a margin reservoir, within the study area range from 1.90 to 968.75 M^2 in area and from 0.73 to 12,080.58 M^3 in volumetric capacity. The wide range of morphologies and capacities of the reservoirs spread across the landscape make it difficult to break them down into distinct categories, however there are several commonalities among all of the features which will be elaborated below.

The first commonality among the identified water management features at Angamuco is their location in naturally occurring valleys or swales on the *malpais*. These are areas which were targeted by the Fill tool that are morphologically prone to natural flooding and water retention. Many of these areas have been modified by the additional removal of soil to create deeper, flat basins to optimize their storage capabilities. Additionally, the placement within naturally low-lying areas of the site means that more upslope area is available for contributing runoff to these features. The placement of reservoirs in low-lying areas means that they are also located between the most densely occupied areas of the site, which exist on the ridges and hilltops, evidenced by the greater number of architectural remains present in these areas. This is likely due to the natural tendency of swales and valleys to flood, making them less desirable locations for settlement. Figures 5.3 through 5.5 shows the locations of several of these reservoirs and their highly variable construction styles and morphologies.

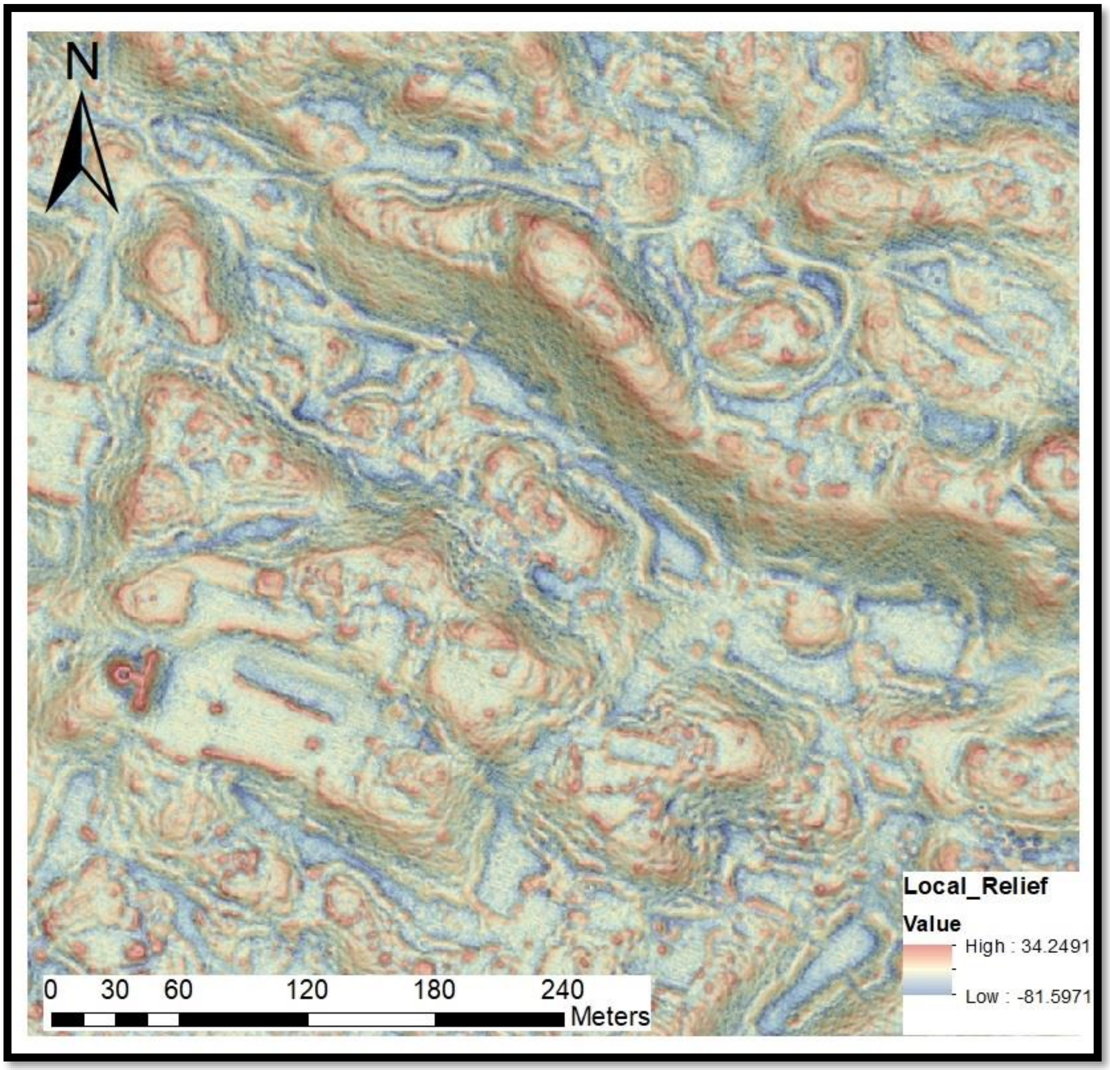

Figure 5.3: Local relief map showing low-lying depressions (blue) and hilltops (red)

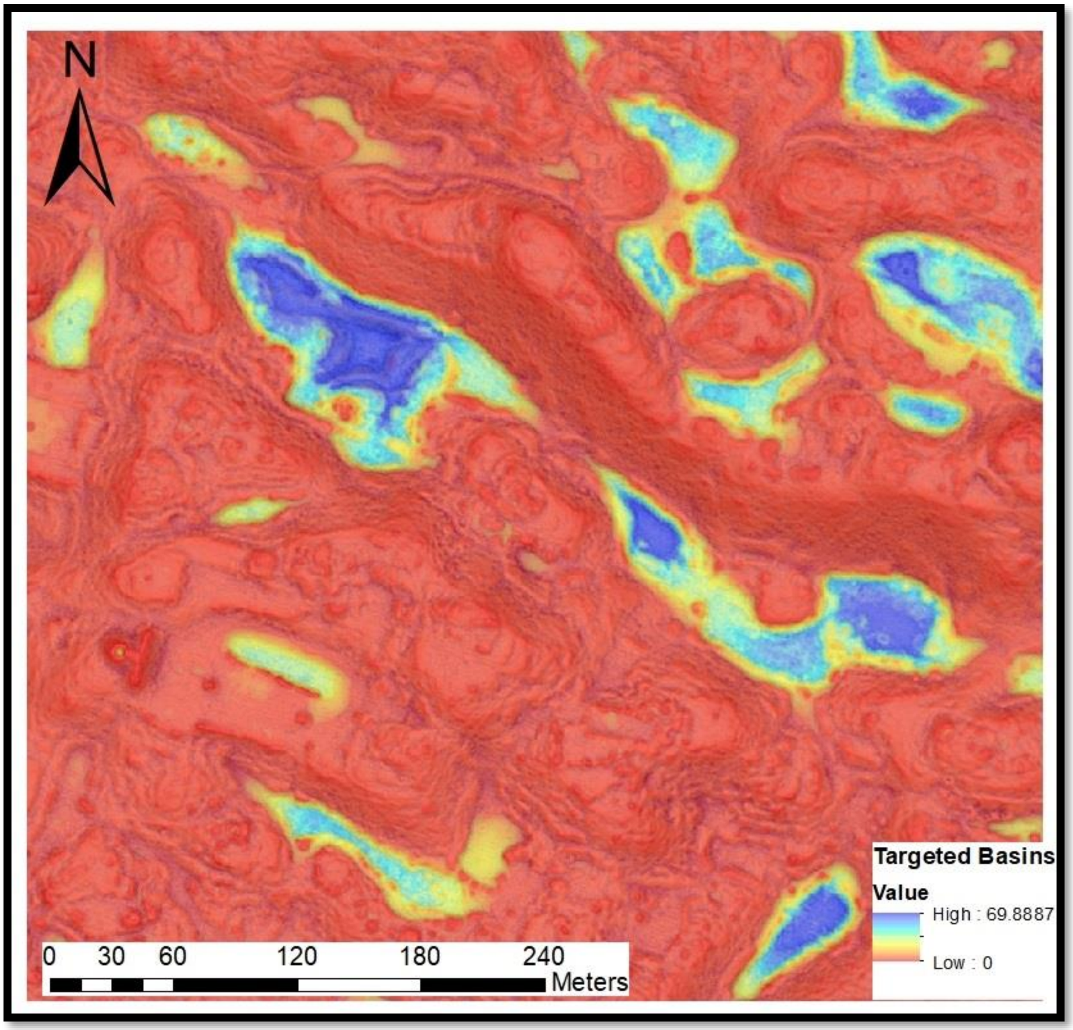

Figure 5.4: Raster displaying basins targeted by the Fill tool

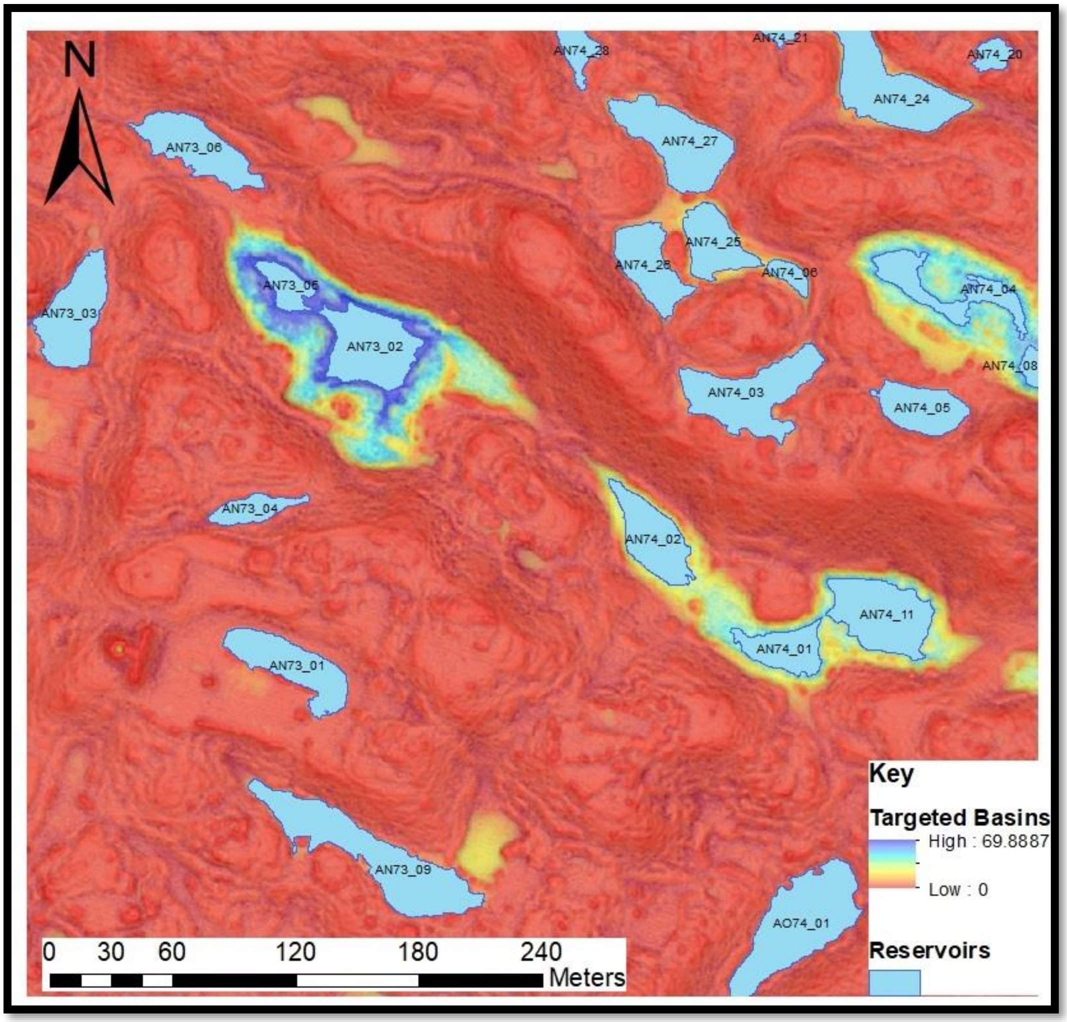

Figure 5.5: Reservoir polygons identified from targeted basins.

The location of reservoirs in low-lying areas between areas of higher urban density suggests also that these were shared communal resources accessed by multiple different groups. There is no evidence of restricted access to any of the documented reservoirs with one exception being reservoir AN73_01, which is located in association with the major southern *yacata* at the site (Figure 5.6). This part of the site was associated with Area C during the 2014 field excavations. Fisher et al., 2019 noted that access to the plaza where this reservoir is located was highly restricted by a set of stairs. The assemblage recovered from this plaza are dated to from the Middle to Late Postclassic periods (1200-1520 AD), thus are associated with the Empire and may reflect a higher degree of hierarchical organization, compared with reservoirs with no such restricted access associated with them. Additionally, the association of this reservoir with one of the largest *yacata* structures on the site and its proximity to elite residences and ceremonial complexes (Fisher and Leisz, 2013) may indicate that this reservoir was designated only for use for special ceremonies or by members of the elite class.

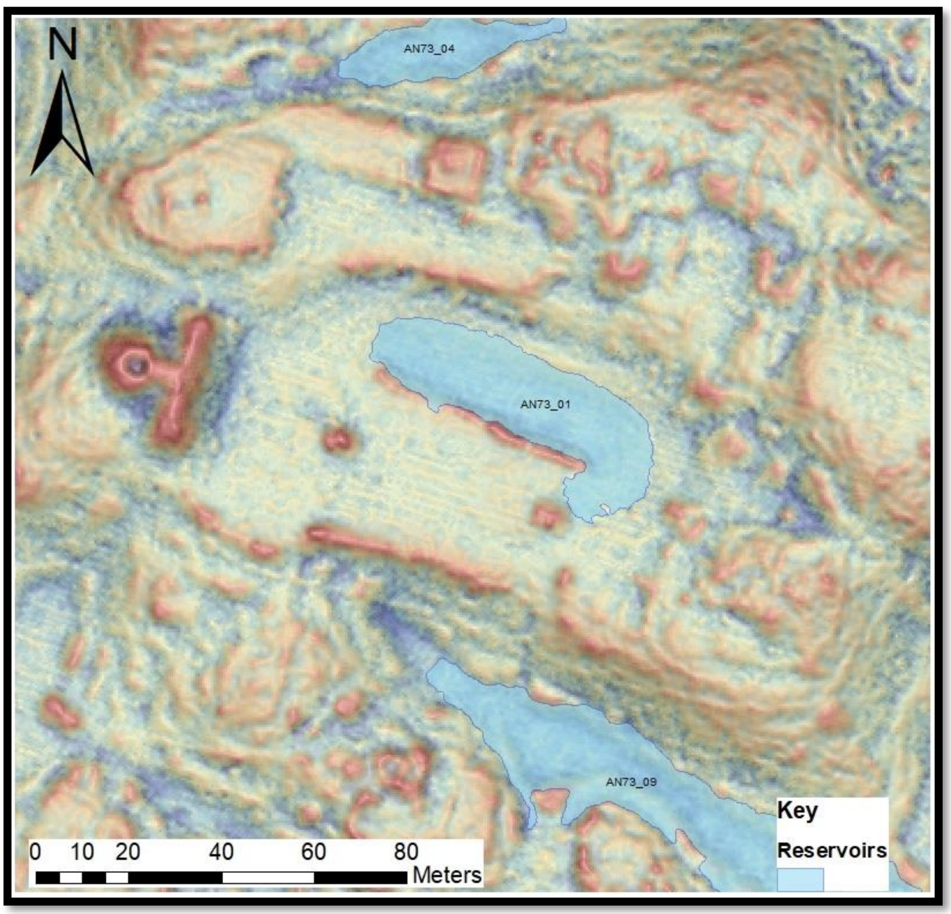

Figure 5.6: Reservoir AN73_01 and its association with the southern yacata and elite complexes. (DEM created by Nick Simpson from Merrick and NCALM point cloud data. Visualization includes Local Relief overlaid with Slope, Positive and Negative Oppenness, and Ridge/Valley Index)

With the exception of AN73_01, the vast majority of reservoirs identified at Angamuco are located in areas between settlement complexes. Urquhart (2015) examined the spatial units at

Angamuco and identified over 700 individual community groups known as *complejos*. *Complejos* defined here are small community units made up of architectural clusters (Urquhart, 2015: 67). These clusters of architectural features are likely made up of kin groups or family units. The spatial organization of the reservoirs may indicate that the social organization of the *complejos* at Angamuco is not as clear cut as it initially appears. Much like the *subaks* of the Balinese water management systems (see Scarborough, 1998), these features appear to cross the traditional boundaries of the *complejos*, possibly joining multiple kin groups or *complejo* units into a greater "water district" wherein access to and maintenance of reservoirs may be spread among multiple kin groups across the site. Additionally, these boundaries may become flexible in times of drought, when some reservoirs become dry before others. Using Thiessen polygons, we can visualize the extent of influence or resource acquisition measured from a central point within each *complejo* polygon. This illustration allows us to visualize the reservoirs most likely associated with the nearest *complejo* unit (Figure 5.7). As stated previously, as environmental conditions change, it is likely that these boundaries too would change in times of drought or resource scarcity.

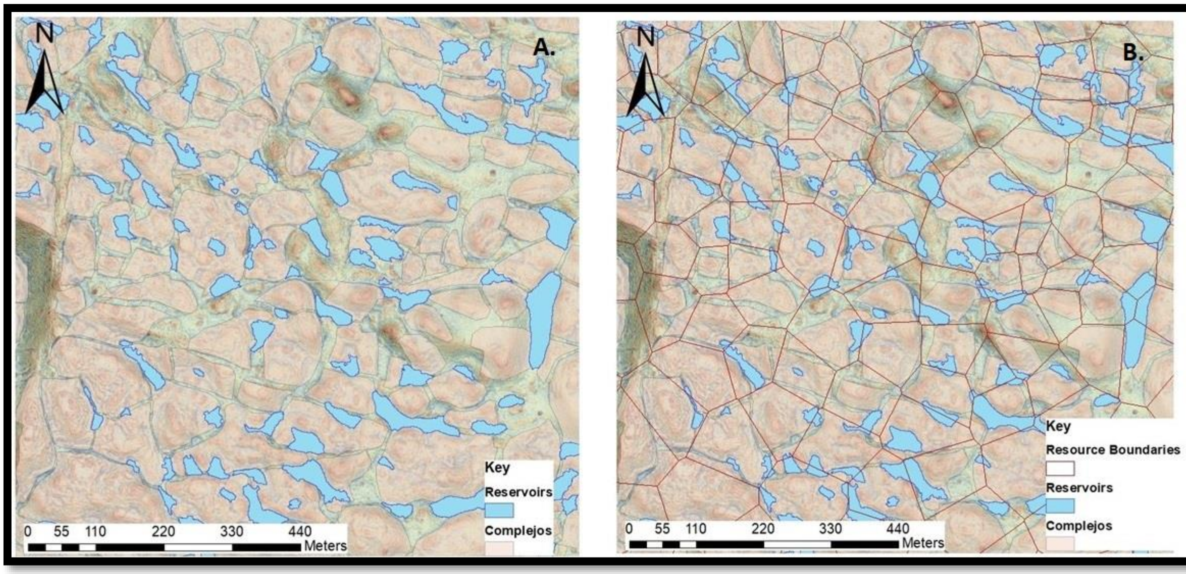

Figure 5.7: A: Location of reservoirs between complejo units. B: Reservoirs between complejo units with Thiessen Polygons generated for each complejo.

The construction morphologies of the proposed reservoirs at Angamuco vary widely, but there are several general characteristics which can be identified. Many of the features identified as potential reservoirs have also been identified as plazas and plazuelas in previous analyses of the site (Cohen, 2016; Bush, 2012). At Angamuco, plazas are distinguished as square or kidney-bean shaped open spaces with one to three stairs leading into them on all sides. Plazuelas refer to smaller plazas that occur as either sunken or partially open spaces in the narrow valleys located on the upper portions of the site (Bush,2012: 58). Many of the plazas and plazuelas are located at the base of sloping hills which were modified at the bottom. It is possible that these features were used as reservoirs during a portion of the dry season (November through April) and used as public spaces when water was absent from them.

Many of the proposed reservoirs are surrounded on one or more sides by raised roads, or walls which separate the retention tanks from sunken roads on the other sides (Figure 5.8). These features may be meant to allow access around reservoirs during periods when they are inundated with water and also act to create a larger storage capacity for the reservoirs themselves. At Angamuco these features are raised or prepared with flattened dirt or paving stones, and vary in width, some continuing for substantial distances. At the site of Ihuatzio, in the LPB basin, these raised roads are known as *uatziri* (Cárdenas Garcia, 2004:206-207) and they have been argued as formal pathways for the elite. Here it is suggested that many of these features served as bastions for retaining water in reservoir tanks as well as serving to transport people from one part of the site to others. More extensive research is needed to verify this claim, however from the visual inspection of the LiDAR data the ubiquitous presence of raised roads associated with sunken plazas and reservoirs is worth noting.

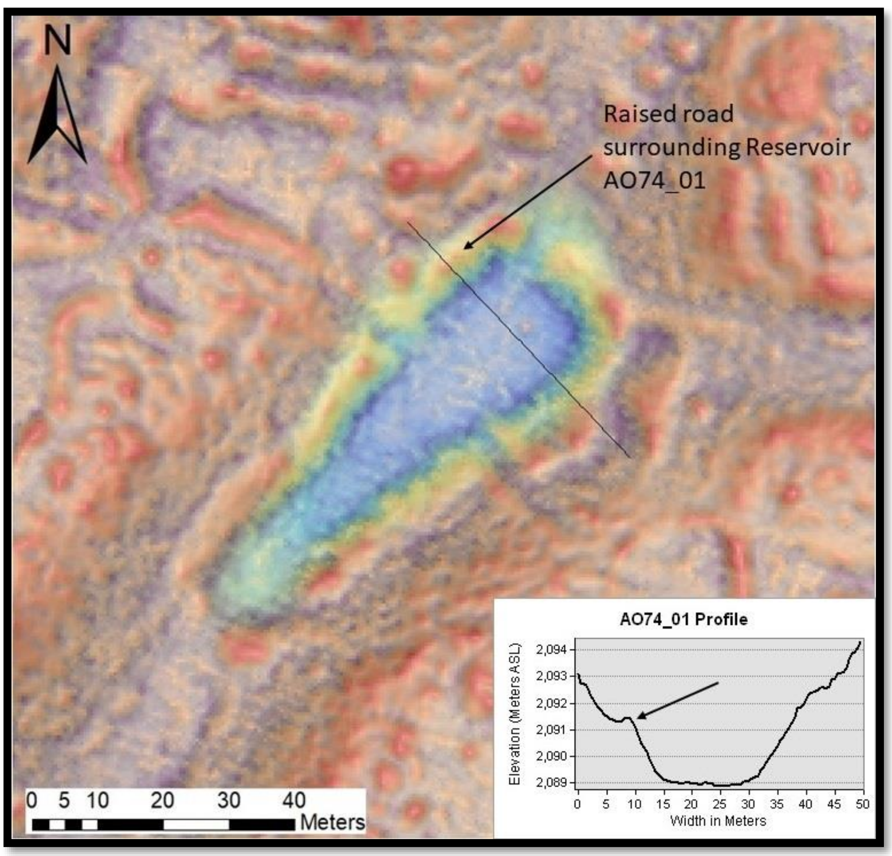

Figure 5.8: Reservoir AO74_01 showing raised road surrounding reservoir

5.1.3 Margin Reservoirs

The margin reservoirs are some of the largest water management features at Angamuco. They all occur just off the edges of the *malpais* in the ancient lake basin and are similar to the *bajo* reservoirs recorded for the Maya region (Davis-Salazar,2003; Dunning et al.,2002; Dunning et al., 2018; Lucero, 2008). In total there are thirteen identified margin reservoirs across the site, making up 1.6% of the total number of reservoirs, however their volumetric capacities combined make up a total of 62.6% (2,945,927.36 M^3) of the total volumetric capacities of all of the water management features combined at Angamuco. The margin reservoirs range in size from 5,746.5 to 472,436.14 M^2 in area and in some cases wrap around entire sides of the *malpais*. These features differ from the residential reservoirs in terms of their location on the peripheries of the site rather than within the urban settlement itself, but also in terms of their probably functionality. These features are likely associated with agricultural activities and irrigation, given their proximity to the hinterlands of the site and their great size. It is also possible that these were used as sources of drinking water in times of water scarcity on the *malpais* itself.

It is unclear how often these features were filled to their maximum storage capacities; however, it is likely that they don't rely solely on overland runoff. The water table within the ancient lake basin itself is extremely shallow- occurring only 5-10 cm below the surface (Fisher 2016, personal communication). Thus, the margin reservoirs are likely fed by a combination of overland surface runoff from the *malpais* as well as ground water seepage coming up from the shallow water table when the ground becomes inundated. Figure 5.9 shows several of the large margin reservoirs located on the southeastern and southwestern sides of the site. One of these features (Margin_01) can still be seen holding water in satellite imagery for the LPB.

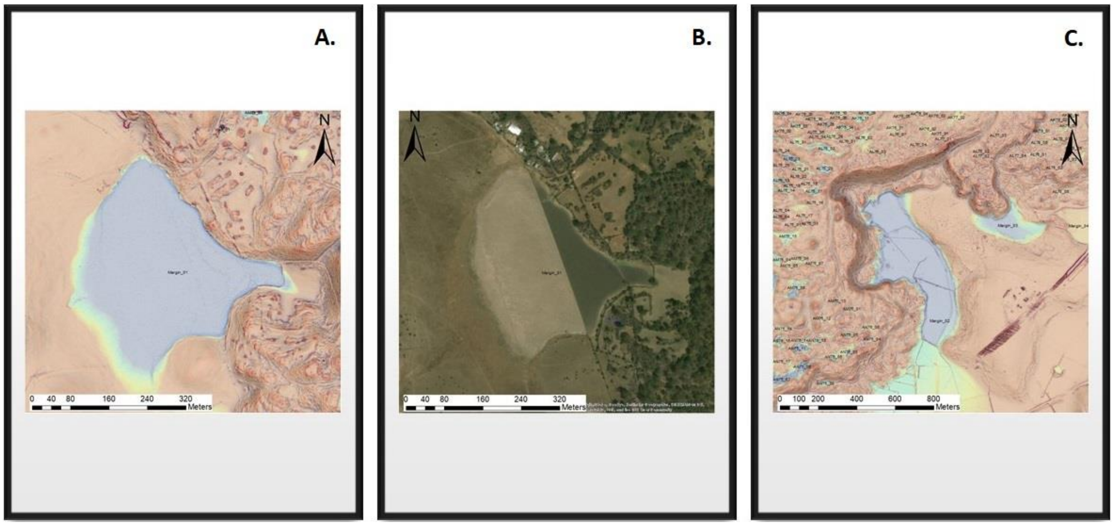

Figure 5.9: A: Margin_01 located on southwest side of malpais B: Margin_01 satellite imagery showing water in reservoir C: Margin_02 and Margin_03 reservoirs on the southwestern edge of the malpais

In terms of construction methods, these features are not nearly as modified as many of the reservoirs located on the *malpais* itself. The reservoirs appear to be part of the natural landscape, existing in naturally formed depressions around the lake basin. It is possible that these features were excavated to increase their storage capacities and make water more easily accessible within them by creating a surface that is closer to the permanent water table within the lake basin. It is possible that these features may be what attracted the first inhabitants to settle Angamuco because of their natural predispositions as perennial sources of ground water and their large sizes, capable of supporting growing populations.

5.2 Hydrological Analysis

5.2.1 Z-Limit Variations

All hydrological models were performed on Filled DEM rasters that were set at varied Z-limits in order to determine how the data outputs changed with increased inputs of water. As discussed in Chapter 4, in order to identify depressions on the landscape, the Fill tool was used to identify cells with no downslope neighbor (i.e. the lowest point in a basin) then fill them to the nearest outlet. When a Z-limit is defined for the tool, the Fill algorithm will not fill a depression greater than the value set. For the purposes of this analysis, I set Z-limits to 0M, 1M, 2M, 3M, 4M, 5M, 6M, and No Limit. Setting a 0M Z-limit is to effectively run the hydrological analysis on the original DEM with no basins filled, while setting no limit means that every basin would be filled regardless of depth. By varying the Z-limit allowable in the Fill algorithm and subtracting each of those outputs from the original raster, we can identify depressions of varying depths at varying scales. Small, shallow depressions are highlighted more strongly with a lower Z-value while larger depressions are either partially filled or omitted entirely. As the Z-limit value increases, larger basins become more evident, but some of the smaller basins become less evident as they are effectively washed out by the larger values of the deeper basins. Figures 5.10 through 5.13 illustrate how these iterations change with varying Z-limits from 1 to No Limit. The areas highlighted in red exhibit little to no deviation from the original DEM, while the areas which grade from yellow to blue indicate areas which deviate more from the original DEM, meaning they were targeted by the Fill algorithm and represent depressions on the landscape. The targeted depressions are places on the *malpais* where water is likely to gather whether because of the natural topography or because of human-altered or created structures. The creation of these DEMS helped to guide the identification of such features, which will be discussed further later in this chapter.

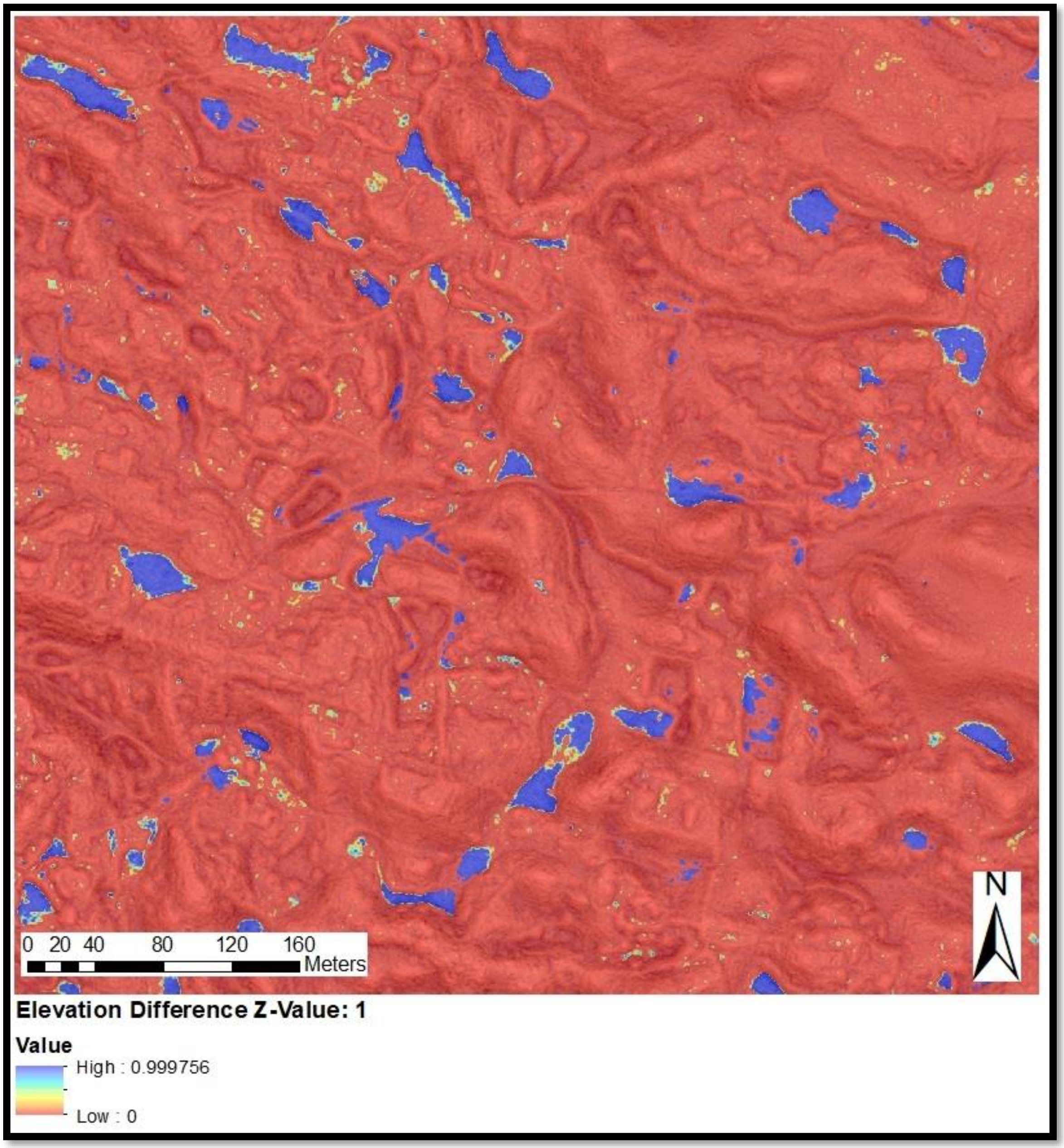

Figure 5.10: Identified basins using Filled raster with 1-meter Z-limit

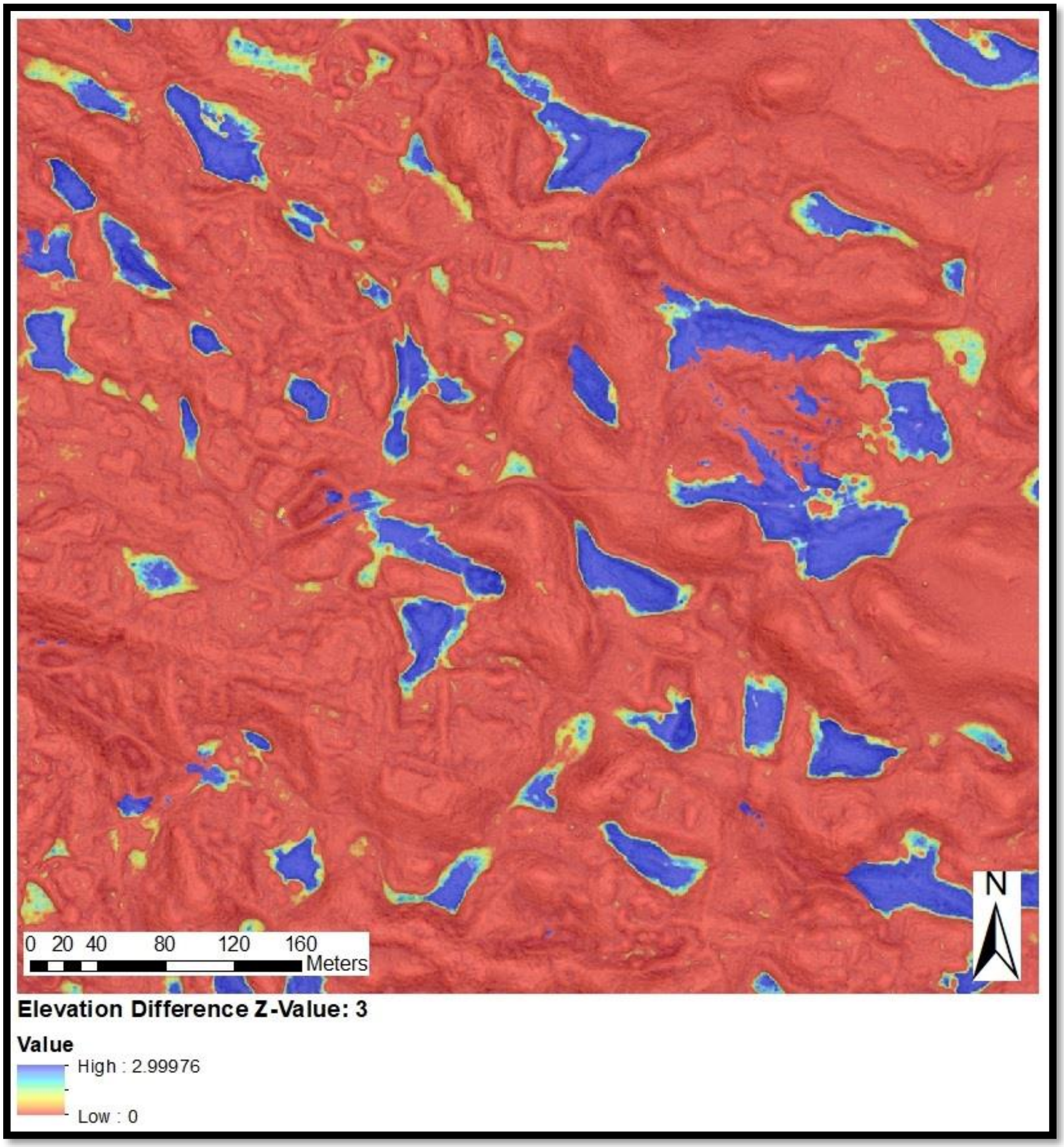

Figure 5.11: Identified basins using Filled raster with 3-meter Z-limit

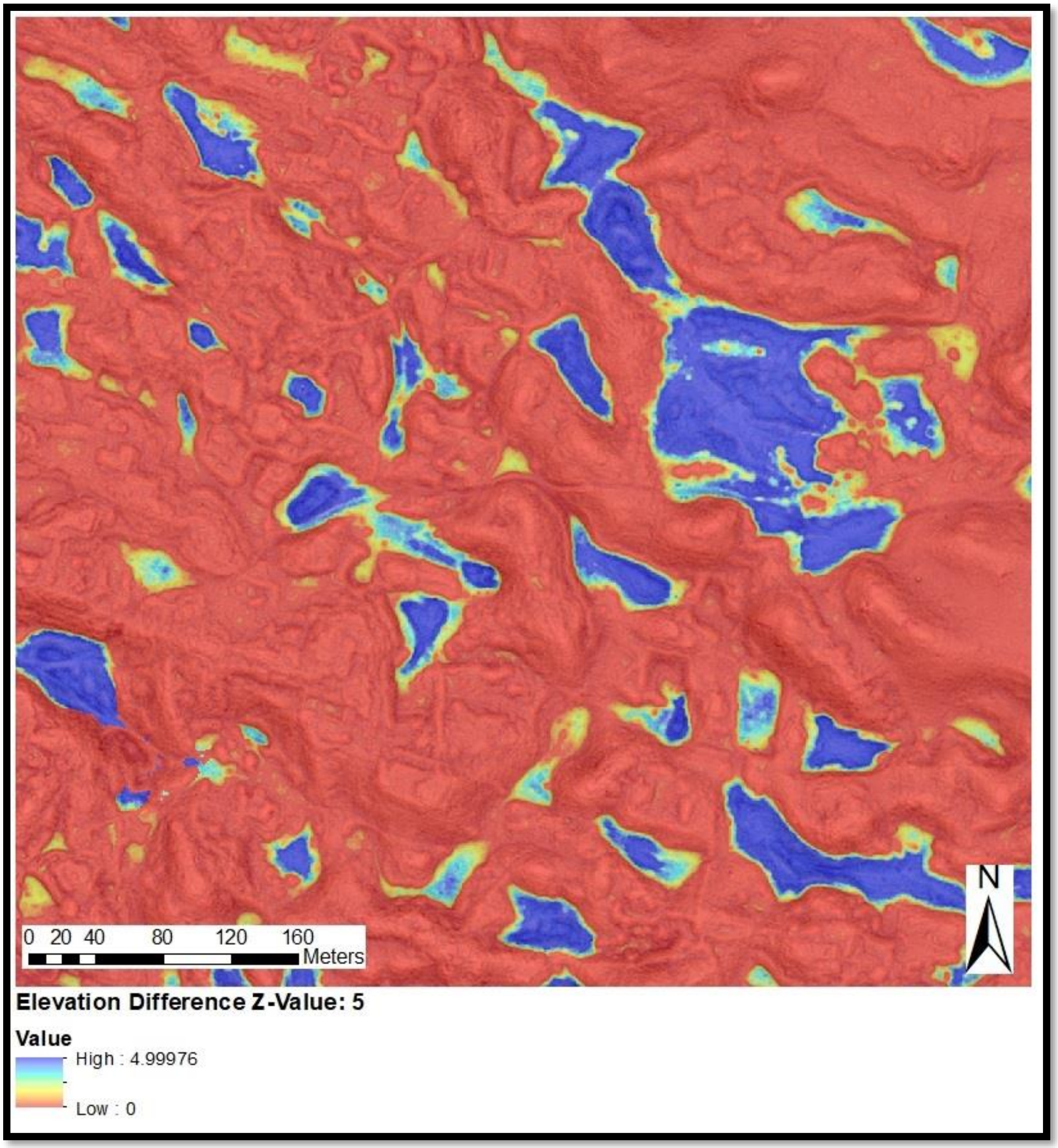

Figure 5.12: Identified basins using Filled raster with 5-meter Z-limit

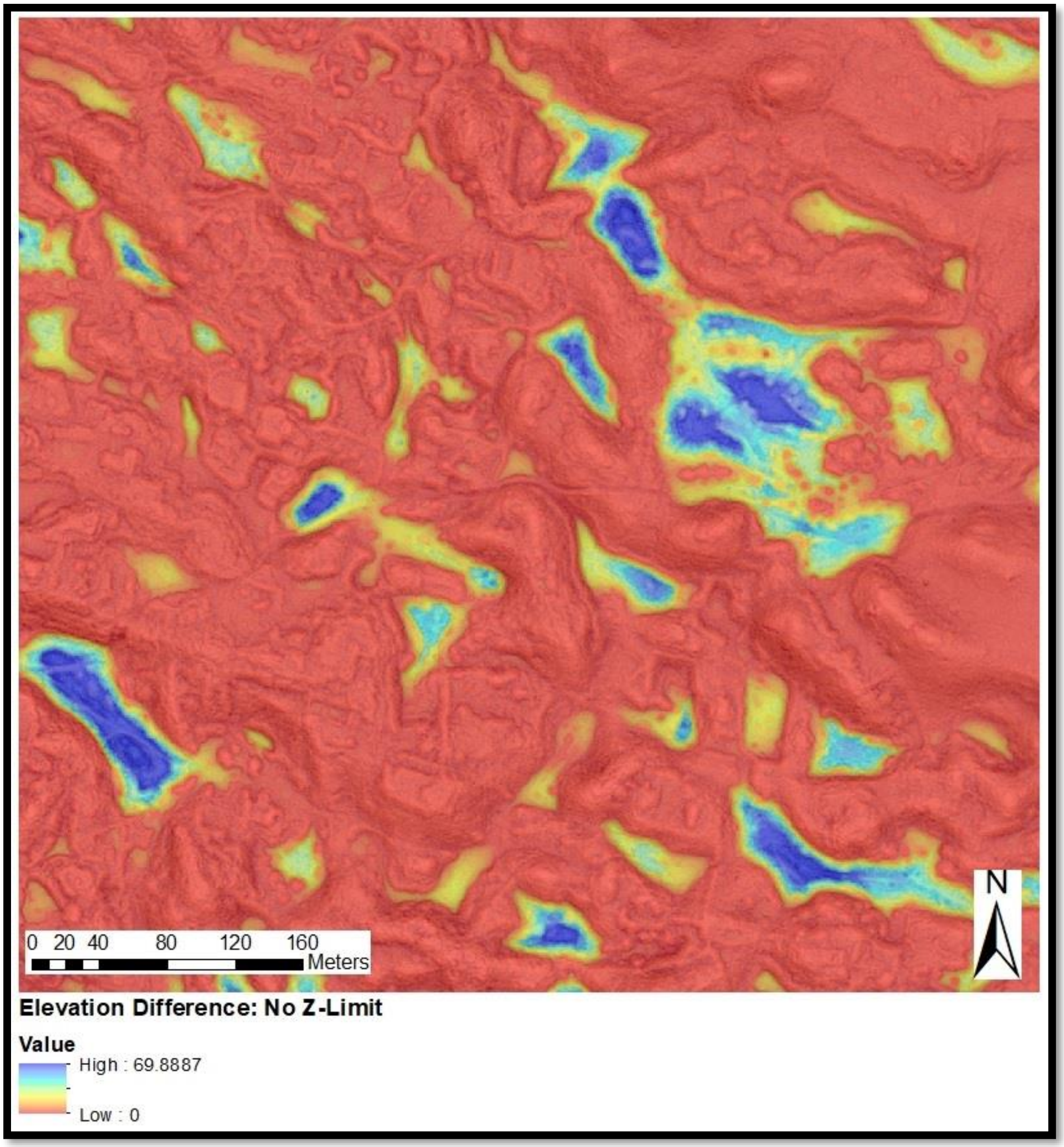

Figure 5.13: Identified basins using Filled raster with no Z-limit

5.2.2 Stream Network Analysis

As discussed in the methods chapter, the stream network analysis utilized the Stream Order tool in the ArcGIS Hydrology toolbox. This method follows the Strahler (1957) method of delineating stream networks by assigning numbers based on the number of tributaries feeding a particular stream. This analysis found that at the site, when a stream is defined as having a contribution area of at least 500 cells (125 M²), that the maximum number stream orders at all Z-limit evaluations never exceeds eight. In addition, the only places on the landscape where the stream orders reach the eighth order is when they have drained off of the *malpais* itself and are in the ancient lake basin. Of the stream orders which contribute directly to identified water management features (not including margin reservoirs), 70.0% are first order streams. This means that they do not converge with any other streams or tributaries before feeding directly into a reservoir. First order streams dominate the stream orders that feed directly into water management features, indicating that runoff is captured locally rather than being transported over greater distances. Second order streams make up 15.6% of the streams which feed directly into reservoirs, third order making up 7.4%, and fourth through seventh order making up the remaining 7% (Figure 5.14). These percentages were calculated using a simple count of all stream order polygons which intersected with reservoir features, which indicates that they flow directly into them.

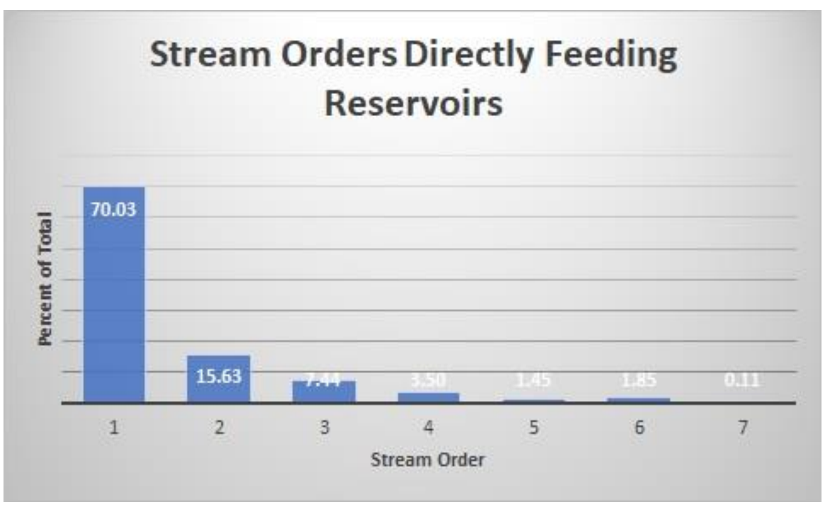

Figure 5.14: Stream orders that directly feed reservoirs

5.2.3 Watershed Basins

The watershed basins identified across the site indicates the area which contributes runoff to a single outflow point. As the Z-limit was adjusted to fill smaller to larger topographic depressions, the resulting output watershed basins map is likewise altered to include filled depressions into the larger network of basins which they are a part of. The watershed basins contributing to a single reservoir feature also contribute to all downslope watershed basins, once the reservoir is filled to its maximum capacity and begins to spill out of its pour point. The resulting basin output rasters were converted into polygons, allowing for their areal quantification. Having the area of all of the individual watershed basins on the site allows for rather quick calculation of the land surface area which contributes to individual reservoir features. The value of this data is that we can begin to computationally estimate the amount of rainfall required to generate sufficient runoff to fill any reservoir on the site to its maximum carrying capacity. For example, surface runoff can be calculated using the formula:

$$Surface\ Runoff = (Basin\ Area * Average\ Rainfall) * Surface\ Percentage$$

In this example, surface runoff is retained by the reservoir features identified across the site, while the average rainfall is taken from monthly climatic averages reported for the Lake Pátzcuaro region from multiple weather stations and compiled by climate-data.org, which reflects similar averages to those reported historically in the LPB (Chacón-Torres and Múzquiz-Iribe 1996; Platt Bradbury 2000). As mentioned in Chapter 2, the average annual rainfall in the Pátzcuaro region is between 900 and 1250 mm; but can vary drastically from year to year (Platt Bradbury 2000). Using the formula above, I calculated average runoff accumulations for all of the reservoirs identified in the study area (n= 116) for the months of May-October when over 80% of the annual rainfall occurs in the LPB (Pollard, 1993). The surface percentages were calculated in increments of ten from 10-90%, where 10% means that of the rain which fell, only 10% is retained as surface runoff while the other 90% is absorbed by the soil. This would be common in a very sandy environment, whereas 90% runoff would be common on hard surfaces such as paved or plastered surfaces. It is assumed that the true runoff percentage exists somewhere between these two values. This is an extremely simplified way to calculate the total runoff that might feed into a reservoir over the course of several months but is lacking in specific variables which would make it a more accurate way to estimate retained runoff. These will be discussed in the next chapter.

When the above formula is applied to the reservoirs in the study area (n=116). At 30% of rainfall retained as surface runoff, 61 (53%) of the reservoirs are capable of being entirely filled at some point during the rainy season. At 60% runoff retention, 91 (78%) of the 116 reservoirs in the study area would be filled to their maximum capacities. Finally, at 90% runoff retention, 102 (88%) of the reservoirs in the study area would be filled to their maximum storage capacities from the watershed basins in the surrounding vicinity only (Figure 5.15). The bedrock beneath the soils on the *malpais* are all basalt, given that they are volcanic in origin. Basalt is highly impermeable, therefore while much of the water may be absorbed by the soils on the *malpais*, it is likely that there is a 100% runoff rate where the soils meet the bedrock. This indicates that the water lost to ground seepage on higher portions of the landform are likely transported over the bedrock and retained in reservoirs at lower elevations on the site.

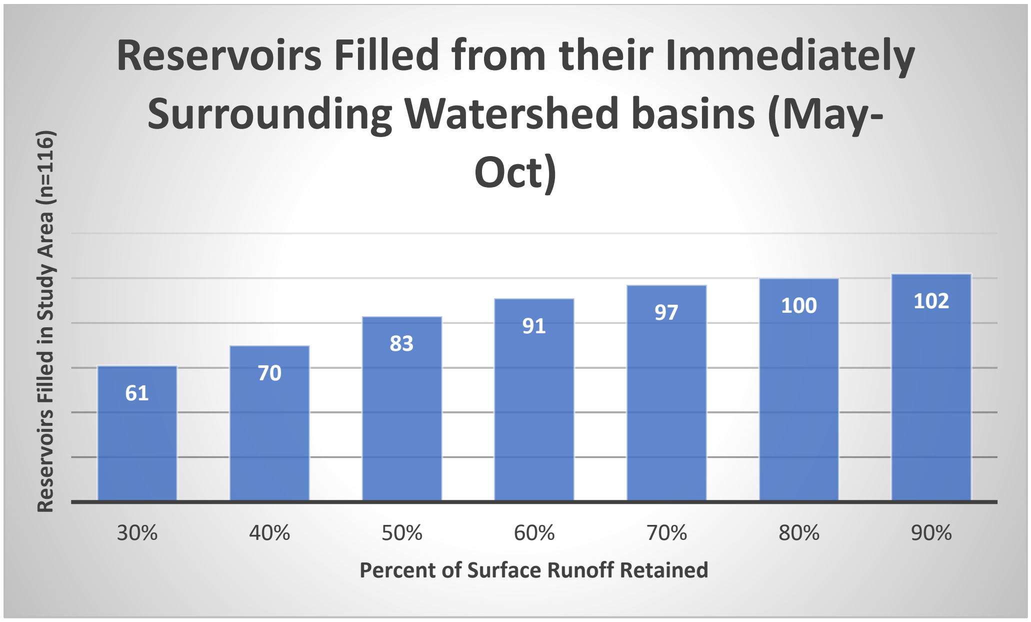

Figure 5.15: Monthly rainfall averages taken from LPB weather stations

This leaves only fourteen reservoirs which do not receive enough rainfall as runoff at any time to fill to their maximum volumetric capacities (Figure 5.16). However, eight of the fourteen reservoirs which do not receive enough runoff to be filled maximally are part of larger stream order networks than just their immediate surrounding area. Thus, these eight reservoirs will receive runoff from additional watershed basins that were not calculated in this thesis. Additionally, while these features may not receive enough direct runoff to fill entirely, it is possible that they do not need to fill entirely in order to serve their functions as permanent or semi-permanent sources of water for the large population present at Angamuco. While this may be useful tool for calculating rough estimates for the efficacy of the water management at Angamuco, there are multiple factors which have been ignored in these calculations which will be further examined in the next chapter.

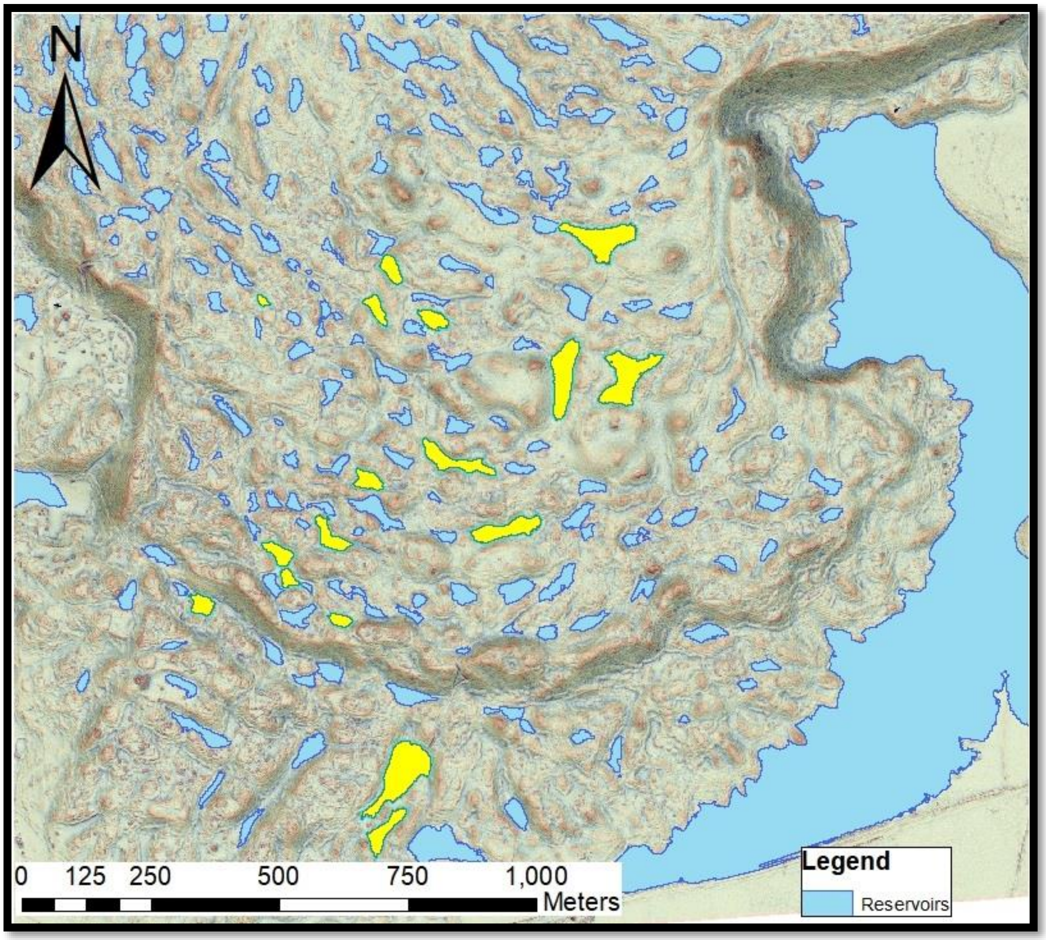

Figure 5.16: Study area showing reservoirs that do not fill from their immediately surrounding watershed basins (highlighted)

CHAPTER 6 : DISCUSSION

In comparison with other cultures in Mesoamerica, the Purépecha have received very little attention from scholars and archaeologists. Despite extensive investigations at sites in the LPB, much of the information regarding Purépecha lifeways remains a mystery. Angamuco has proven itself to be an extremely significant site both in terms of its size and complexity, however its role in the larger narrative of the Purépecha empire and the greater Mesoamerican tradition is still largely unknown. In this thesis I have attempted to elucidate the role of the complex water management system at Angamuco through various algorithmic methods and manual feature extraction and quantification. The results of these analyses allow us to examine Angamuco's water management system within the broader Mesoamerican tradition of rain fed water management. It also makes Angamuco stand out among other sites in the LPB as the only documented settlement with an extensive and complex system of reservoirs. This chapter will serve to discuss some of the applications and limitations of the dataset created for this thesis.

6.1 Social Organization

Many Mesoamerican scholars have examined social organization and stratification through the lens of water management (Scarborough and Gallopin, 1991; Scarborough and Lucero, 2010; Lucero, 2008; Chase, 2016). Scarborough and Gallopin (1991) identified three reservoir types that they associated with distinct status and functions. The first being central precinct reservoirs located in the sites' epicenter near much of the monumental architecture. The second, residential reservoirs are located within the densely populated zones of the site and appear to be primarily for domestic use. The third were *bajo* margin reservoirs, located on the peripheries of the site away from dense population aggregates, and are presumed to be used for agricultural purposes. Scarborough proposed that water was distributed from the central precinct reservoirs by elites who maintained control over access to water from these features. Conversely, the residential reservoirs at Tikal were maintained by local inhabitants and were not fed or controlled by elites. *Bajo* reservoirs are situated so that they are positioned to receive most of the runoff from the four major catchment areas at Tikal.

Table 6.1 displays how the reservoirs from the study area and the margin reservoirs compare with those from Tikal. Unlike Tikal, Angamuco possesses no large central reservoirs associated with monumental architecture. The only reservoir at Angamuco that may have had restricted access is AN73_01, which is located near the southern *yacata* and elite complexes. However, this reservoir has a storage capacity of 790 M^3, thus does not function to serve large populations like the central precinct reservoirs at Tikal. The residential reservoirs at Tikal are much larger than those at Angamuco, however given their locations are likely meant to serve larger populations than the residential reservoirs at Angamuco, which are dispersed across the landscape mostly between smaller settlement groups. The larger size of the residential reservoirs at Tikal suggests that they are less susceptible to water loss through evapotranspiration than are those at Angamuco. It is likely that due to their much smaller size, many of the reservoirs at Angamuco may run dry during the dry months of the year given their smaller size and shallowness. This may cause inhabitants to rely on larger, more widely dispersed reservoirs that are farther from their immediate communities. Finally, the margin reservoirs at Angamuco range in size from smaller to larger than the *bajo*-margin reservoirs found at Tikal and are more numerous. It is likely that the reservoirs at both sites serve the same functions given their positions away from the dense settlements, nearer to the hinterlands. Both types of reservoirs also share the commonality of being located at the terminus of the watershed basins for each site. It is likely that the water held in these reservoirs is of lower quality and may not have been suitable for drinking as they contained runoff that drained from the densely settled areas, where pollutants may wash downstream.

Table 6.1: Tikal reservoir metrics compared to Angamuco reservoir metrics from study area (Adapted from Scarborough, 1991)

TIKAL			ANGAMUCO		
Reservoir Type	**Number**	**Reservoir Capacity (m^3)**	**Reservoir Type**	**Number**	**Reservoir Capacity (m^3)**
Central Precinct	6	105,108 - 243,711	Central Precinct	0	N/A
Residential	3	42,647 - 133,921	Residential	116	3 - 12,080
Bajo-margin	4	48,956 - 172,149	Margin	13	1,495 – 926,400

Given the complete lack of central reservoirs at Angamuco, it seems unlikely that elites maintained any level of control over the water management system present at the site, such as that proposed by Scarborough and Lucero (see Scarborough, 1998 and Lucero, 2006). It seems more probable that given the large number of smaller, dispersed reservoirs at Angamuco that water management was maintained by local communities and kin groups, which may have crossed traditional neighborhood or *complejo* boundaries.

The results of this analysis compare favorably with other studies in Mesoamerica regarding the identification of water management features using remotely sensed data (e.g. A.S.Z. Chase, 2016). In the Maya region, Caracol is the most intensively studied site using

LiDAR for the identification of water management features. In 2016, 1,590 small reservoirs were identified through the use of remote sensing using various visualization methods for manual identification. Chase, 2016 noted that the distance between a household plazuela unit and the nearest reservoir never exceeded 120 m. Thus, the inference suggested by the close proximity of the reservoirs to plazuela groups was that absolute elite control over these features would have been difficult or impossible entirely. Likewise, at Angamuco 178 of the 184 *complejos* in the study area are located within 120 meters of the nearest reservoir (Figure 6.1). The greatest distance does not exceed 248.5 meters in distance, and all 6 of the *complejos* which are more than 120 meters from the nearest reservoir are located near the very edge of the *malpais* where access to the flooded lake floor was likely possible.

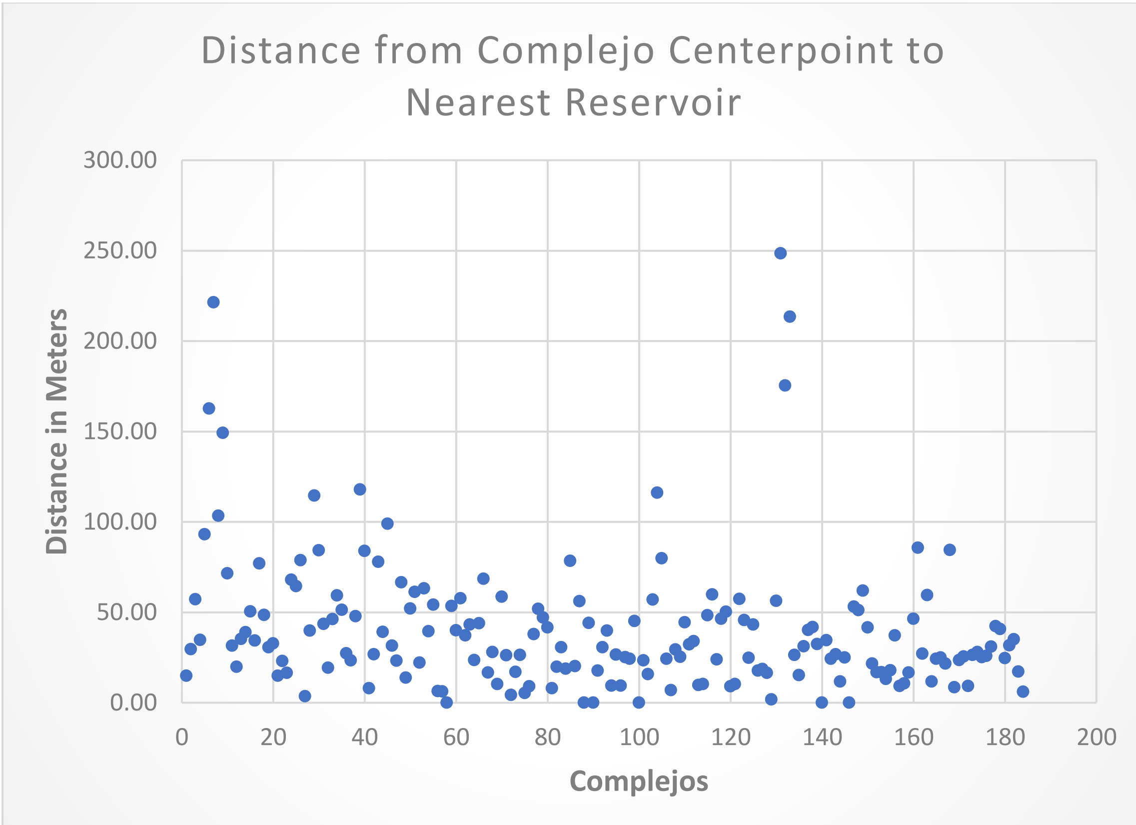

Figure 6.1: Distance from complejo center-point to nearest reservoir expressed in meters.

6.2 Population Estimates

As previously stated, access to potable water sources year-round acts as a limiting factor for growing and sustaining populations. The lack of perennial surface water means that the population of Angamuco was heavily reliant on a functioning water management system to provide drinking water throughout the dry season (October-May). Using water storage capacities for population estimates is a common practice among Mesoamerican archaeologists, particularly in the Maya region (Gallopin, 1990; McAnany, 1990; Weiss-Krejci and Sabbas, 2002). In the study area defined for this thesis, the total of 116 reservoirs have a maximum combined storage capacity of 121,498 M³ (121,497,794 L). Based on requirements provided by the World Health Organization (WHO) (Reed and Reed, 2011), between 7.5 to 15 liters per person per day are required for drinking, basic hygiene, and cooking needs. Using these metrics for survival, the maximum capacity of the reservoirs within the study area have the potential to support 22,191 individuals for one year. This calculation does not consider loss of water through ground seepage or evapotranspiration. It is also important to mention that the water requirements presented by the WHO are those needed for basic human survival and it is likely that in times of abundance more water would have been used daily for hygiene, ritual practice, or other non-essential purposes.

If the quantity of water consumed per day is doubled to 30 liters, the population supported by the reservoirs in the study area becomes 11,096 individuals for one year. As mentioned in the previous chapter, 78% of the reservoirs (n=91) in the study area are likely to fill to their maximum storage capacities with a runoff retention of only 60% of the total average rainfall. The study area encompasses areas A, B, C, and D from the 2013 excavation season at Angamuco and radiocarbon dates suggest that this area was occupied from the Preclassic through the Late Postclassic periods (145-1635 AD) (Fisher et al., 2013; Cohen, 2016). Although the occupations of these areas may not be continuous, it is likely that any water management features built in the earlier occupations would have been re-used during later occupations. The Middle and Late Postclassic periods in the LPB were marked by explosions in population size, with estimates of the lake basin containing 48,000 people during the Late Urichu phase (AD 1000-1350) and upwards of 80,000 during the Tariacuri phase (AD 1350-1525) (Pollard, 2008). Given the large size of the site and the ability of the water management system for just a portion of the site to sustain over 11,000 individuals means that the population of the LPB was likely much higher during the Middle to Late Postclassic periods than has been previously estimated. Much more research is needed to verify this claim, however the size and scale of the supporting water infrastructure at Angamuco lend credence to the notion that the LPB was home to many more inhabitants than previously estimated.

6.3 Limitations

While the LiDAR data collected for Angamuco offers an almost incomprehensibly large dataset from which to ask questions about settlement structure and patterning and multiple levels of spatial analysis, there are also limitations to the conclusions we can draw from the data itself. Using large reservoirs for the retention of rainwater is certainly not the only way to capture rainfall, and other methods may not be discernable through LiDAR data alone. Additionally, structures and architectural features may have once existed or still exist, such as drainage outlets which cannot be recorded by LiDAR data alone. Furthermore, without a more complete understanding of the soil types present at Angamuco, specifically the soils within the proposed reservoir features, need to be more intensely investigated to fully understand the nature of these features.

When assessing the water management system at Angamuco using LiDAR derived data, we are in essence examining the landscape and its modifications through the lens of spatial analyses. In this realm of research, there are no artifacts to examine or samples to analyze. While it is highly likely that the large reservoirs identified at Angamuco served a critical role in the storage of water for consumption and agricultural use, it is possible that more perishable objects were also used to collect rainwater during the rainy seasons. Ceramic vessels and gourds may serve to catch rainfall during storms to provide clean drinking and cooking water to individual households for short term periods during the wet season. Thick walled jar and bottle vessels have been recorded at Angamuco in urban areas (Fisher et al., 2013; Cohen, 2016) which may have been used to store water from an individual storm, rather than using water from reservoir features. Additionally, Pollard (1993) discusses market services described in the *Relación de Michoacán* (1956:114) in which individuals were hired as water carriers. Presumably water was transported in large ceramic vessels or gourds, which would serve equally as well to capture rainfall during the many thunderstorms the LPB receives during the rainy season. These vessels may have served as short-term resources for residents during the rainy seasons, allowing for the reservoirs to maintain higher levels for longer without people drawing from the daily. Such features cannot be recorded by LiDAR data thus their identification must come from supplemental artifact analysis.

Another key issue is that of drainage systems which may have been present and are not identifiable through LiDAR data. While drainage canals and sunken roads are present at the site and identifiable in the LiDAR data, drainage outlets from sunken plazas may not necessarily be readily apparent from the data. Although drainage conduits are not recorded for the LPB, it does not preclude them from existing, especially given the very poor understanding of water management at *malpais* settlements in the region. These features have been recorded however at Maya sites, such as Copan in Honduras (Davis-Salazar, 2006). At Copan, substructure conduits are stone-lined features that drain semi-enclosed courtyard areas by flushing water through pyramidal bases and out the back side of the structures. Figure 6.2 shows an example of what one of the drainage conduits looks like.

Figure 6.2: Drainage conduit recorded at Copan, Honduras. Adapted from (Davis-Salazar, 2006)

Given the drainage conduit's location at the base of the structure, it would not be possible to identify in LiDAR data, which is mostly taken from NADIR and rarely exceed angles of more than 20° on either side (Fernandez-Diaz et al., 2014).

Finally, without a clearer understanding of the soils present at Angamuco, particularly within sunken plaza and depression contexts, it is impossible to know how well these features would retain water in the long term. The *malpais* falls primarily within the Lower Sierra Slopes environmental zone described by Pollard (1993). According to her, in addition to yellow-brown andosols, these slopes primarily consist of *charanda* soils and *t'upuri*, as well as some *uirás* (see Chapter 2 for a full description of soils). The *charanda* soils are described as having poor water retention qualities and often crack at the end of the dry season, making them not ideal for the water retention features. *T'upuri* on the other hand is made up of humic and vitric andosols which have a high moisture-retentive quality. When the surface dries, it forms a fine powder which acts as an insulator, which prevents evaporation from the soils beneath (West 1948:9). At the end of the dry seasons, the insulated soils may be moist below 7 cm from the surface (Pollard, 1993: 68). This makes them ideal soils for reservoirs, as they have high retentive properties and remain at a high saturation rate through most of the dry season, reducing water loss through ground seepage. The *uirás* are highly localized soils formed from compressed volcanic ash and is often used to manufacture adobe bricks and pottery. The highly impermeable nature of these soils means that oftentimes they are overlain with lacustrine deposits. While there is currently no evidence for lined water management features or prepared reservoir surfaces at Angamuco, these soils might be ideal for such a purpose. The last chapter will offer a few closing remarks and suggestions for future research directions to build upon the data presented in this thesis.

CHAPTER 7 : CONCLUSION

Relative to other great city-states and empires in Mesoamerica, the Purépecha are significantly underrepresented as an important cultural force on the landscape. Angamuco rivals many of the better-known archaeological sites in Mesoamerica, such as Caracol and Calakmul, in terms of the spatial extent and complexity of its water management systems. Complex water management systems for the Tarascan region on *malpais* landscapes are virtually unknown and there is no precedent for which to compare the system found at Angamuco. In this thesis I have presented a method for identifying natural depressions, many of which have been modified to retain runoff from rainfall during the wet season (June-September) to sustain a large population through the dry season (October-May). From the resulting datasets I then identified 811 potential water storage features including wells, residential reservoirs, and margin reservoirs. I also identified delineated the hydrology of the *malpais* using tools in the Hydrology toolbox in ESRI ArcMap 10.6. The hydrological analyses included identifying stream orders from flow directions calculated for the entire site and identifying micro-watershed basins for the entire site at varying Z-limits.

Generally speaking, the reservoirs identified at Angamcuo are distributed across the entire *malpais* landscape and along the margins of the site in the ancient lake bed. All of the reservoirs identified exist in naturally low-lying areas, suggesting that the inhabitants of Angamuco advantageously used portions of the site which were already predisposed to water retention from runoff. Not a single proposed reservoir exists on a hilltop or ridge crest. This may be partially to do with the location of many architectural features and monumental structures already present at these locations. However, it is also very likely that the placement of reservoirs at the base of slopes and in the low-lying swales was a strategic move to maximize the amount of runoff captured by upslope contributing areas. This is in line with Amos Rapoport's assertion that methods of construction of the built environment are modified by climatic and environmental conditions which encourage some forms while making others impossible (Rapoport, 1969). The rugged landscape at Angamuco likely encouraged the inhabitants of the site to construct infrastructure advantageously while simultaneously maximizing their returns by placing reservoirs in low-lying areas.

Stylistically, there is very little to no uniformity in the shape or size the reservoirs at Angamuco were constructed with few exceptions. The first is the previously stated pattern of reservoir placement in topographically low points on the landscape. The second being the presence of raised roads surrounding many of the proposed reservoir features. This pattern is found in virtually all areas of the site, with no noticeable exceptions. While raised roads are not present around all reservoirs, they are present around a significant number. Their function may be two-fold here: 1. To allow access around reservoirs at times when they are inundated with water and 2. To shore up sides of reservoirs and increase their ultimate volumetric capacities. Aside from these two stylistic forms, there are no consistent shapes or dimensions which appear repetitiously across the site. This low degree of uniformity has been argued to imply a lack of centralized governance in the construction of such features at other sites in Mesoamerica (A.S.Z. Chase, 2016). The ubiquity of raised roads surrounding many of the reservoirs identified at Angamuco may be the result of organic diffusion of a stylistic mode of construction but may also be the product of multiple stylistic and adaptive factors including road construction, the discussion of which are outside of the scope of this thesis.

In addition to the value of being able to visually analyze the landscape in its entirety at Angamuco, the 811 proposed reservoirs were extracted and merged into a single polygon shapefile with associated attributes concerning the metrics of each individual reservoir and their location at the site. This might be the single greatest value offered by such spatial analyses using LiDAR derived products. The ability to quantify these features has allowed for the analysis of these features using the datasets generated in the hydrological analyses to estimate captured runoff potential and make predictions about population carrying capacities. For the 116 reservoirs in the 2 km² study area, 91 (78%) are likely to fill to their maximum capacity at 60% retention rate from their immediately surrounding watershed basins. Given the volumetric capacities of the entire 2 km² area, and their high likelihood of being filled to their maximum capacities means that this area could potentially support a population of over 11,000 individuals annually. Over the course of the 2009-2010 field seasons, 2 km² of the site was surveyed in conjunction with the LiDAR data. The survey ground verified and documented well over 2,500 architectural and landscape features (Fisher, 2011). The 2009-2010 field seasons surveyed a portion of the site nearby and similar in architectural density to the study area defined in this thesis. I believe that based on the volumetric measurements and average rainfall regimen of the LPB that the water management system at Angamuco was sufficiently adequate to support a large population over the course of the year. However, much more research is necessary to refine the population estimates, taking additional factor such as soil retention and seepage rates into account.

7.1 Future Work

The research presented in this thesis is one small part of a larger investigation effort needed to fully understand the nature of the water management system at Angamuco. This data would be vastly supplemented by field testing the proposed reservoirs identified in this thesis to look for hydrologic sediments. The presence of hydrologic sediments such as those found in the Palace and Temple reservoirs at Tikal (Scarborough et al., 2012; Tamberino, 2013) might help to indicate whether the features were in fact used as reservoirs. The identification of laminar sediments may prove to be extremely valuable in dating the age of the reservoir from initial construction and throughout its use life.

During the 2013 and 2014 field seasons at Angamuco, an excavation unit (E4N0E0) was placed in a sunken plaza that has been identified in this thesis as a potential reservoir (AM73_06). The LORE-LPB team chose to excavate here because of its proximity to room E3 (see Fisher et al., 2014 and Cohen, 2016) and because they wanted to test one of the sunken plazas on the upper *malpais*. They documented three distinct strata (Figure 7.1) and deep deposits for the site (1.5 M) with a relatively low artifact density, consisting primarily of fragmented monochrome sherds. The stratigraphy consisted of a 25-30 cm deep surface deposit of dark brown sediment (7.5 YR 3/4 dark brown) with few artifacts. Stratum II included 40 cm of increasingly yellow (7.5 YR 5/6 strong brown) silty loam with a few small rocks with a medium to low density of artifacts. Stratum III was a slightly clay-like yellow sandy silt sediment (7.5 YR 5/6 strong brown), with medium to large rocks and no few to no artifacts. The lack of rocks and deep soils may indicate that the plaza was altered by the inhabitants of the site to create the sunken plaza in a topographically low spot on the *malpais* and that the rocks may have been used for construction fill elsewhere. There is not distinct evidence of hydrologic soils in this unit, indicating that this feature may not have held water, however the unit was not excavated in the deepest portion of the plaza, where hydrologic soils may yet exist.

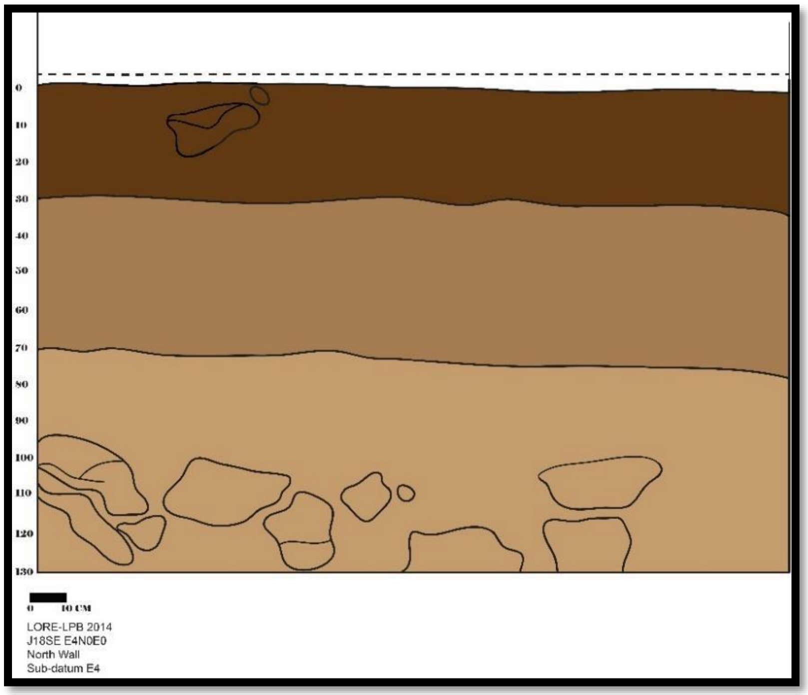

Figure 7.1: Excavation Unit E4N0E0 North Profile

In order to test the validity of the data generated in this thesis, additional soil profiles in other sunken plazas and reservoirs should be excavated to identify any potential hydrologic soils. Using the reservoir shapefiles generated in this thesis, a series of reservoirs from various portions of the site may be cored for sediments and small units excavated for sediment and pollen samples similar to those done in Tikal and Lake Pátzcuaro itself (Scarborough et al., 2012; Platt-Bradbury, 2000). The most cost-effective way to perform this task would likely be to select reservoirs which have the highest probability of water retention and are easiest to access given the rugged topography at the site.

At the current stage of research into the water management system at Angamuco, only preliminary statements can be made about the nature of the reservoirs at the site. As stated multiple times previously, water is an essential resource for any population to survive and thrive. The hydrology of Angamuco in conjunction with the complex modified topography appears to be ideal for an environment in which runoff from rainfall can be diverted, captured and retained over long periods of time. It also appears that enough catchments exist with capacities large enough to support a large sedentary population with potable drinking water and water for large scale agricultural undertakings. The spatial distribution of reservoirs across the *malpais* suggest that most communities had direct access to water sources. With supplementary field data and a greater understanding of the soils present in many of these features, it is my hope that in the future we will have a more holistic understanding of the incredibly complex and diverse water management system at Angamuco and the ways they tie into the broader Mesoamerican tradition of water management.

REFERENCES

Acuña, H.G.

2008 Rain Harvesting in the Rainforest: The Ancient Maya Agricultural Landscape of Calakmul, Campeche, Mexico. British Archaeological Reports (BAR) 1879. Oxford: Archaeopress.

Arnauld, Marie Charlotte, Patricia Carot, and Marie-France Fauvet-Berthelot

1993 *Arqueología de las Lomas en la cuenca lacustre de Zacapu, Michoacán, México.* Cuadernos de Estudios Michoacános 5. Centre d'Etudes Mexicaines et Centre-Ame´ricaines, Mexico City.

Arnauld, M. C., & Faugère-Kalfon, B.

1998 Evolución de la ocupación humana en el Centro- Norte de Michoacán (Proyecto Michoacán, CEMCA) y la emergencia del Estado Tarasco. In V. Darras (Ed.), *Génesis, culturas y espacios en Michoacán* (pp. 13–34). Mexico: Centre d'Etudes Mexicaines et Centraméricaines.

Arredondo-Figuero, J.L and Flores-Nava, A.

1992 Caractericas Limnologicas De Pequenos Embalses Epicontinentales, Su Uso Y Manejo En La Acuicultura. *Hidrobiologica* 3/4: 1-9

Barbour, C.D.,

1973 A biogeographical history of *Chirostoma* (Pices: Atherinidae): a species flock from the Mexican Plateau. Copeia 3, 533–556.

Beekman, Christopher S.

2010 Recent Research in Western Mexican Archaeology. *Journal of Archaeological Research* 18(1): 41-109

Beven, Keith J., and Michael J. Kirkby

1979 A physically based, variable contributing area model of basin hydrology/Un modèle à base physique de zone d'appel variable de l'hydrologie du bassin versant. *Hydrological Sciences Journal* 24(1):43–69.

Bloch, M.

1987 The Ritual of the Royal Bath in Madagascar: The Dissolution of Death, Birth and Fertility into Authority. In *Rituals of Royalty: Power and Ceremonialism in Traditional Societies*, edited by D. Cannadine and S. Price, pp. 271-297. Cambridge University Press, New York.

Blom, Frans R.

1936 The Conquest of Yucatan. Houghton-Mifflin, Boston.

Brown, C.T.

1999 Mayapán Society and Ancient Maya Social Organization. Ph.D. Dissertation, Tulane University, New Orleans, LA, USA

Bullard, William

1960 Maya Settlement Pattern in Northeastern Peten, Guatemala. American Antiquity 25: 355-372.

Burrough, Peter A.

1998 Chapter 9: Dynamic Modelling and Geocomputation. In *Geocomputation: A Primer,* edited by Paul Longley, Sue Brooks, Rachael McDonnell, Bill MacMillan, pp. 165–192. John Wiley & Sons, New York City, New York.

Bush, Jason W.

2012 Architectural patterning in the Purépecha heartland: An intrasite settlement study at the urban center of Sacapu Angamuco, Michoacán, México. Unpublished MA Thesis, Colorado State University. Fort Collins.

Cagnato, Clarissa

2017 Underground Pits (Chultunes) In the Southern Maya Lowlands: Excavation Results from Classic Maya Period Sites in Northwestern Petén. *Ancient* Mesoamerica 28(1):75-94.

Calderon, Zoila, and Bernard Hermes

2005 Chultunes en Los Alrededores de la Laguna Yaxha, Petén. In XVIII Simposio de Investigaciones Arqueológicas en Guatemala, 2004, edited by J.P. Laporte, B. Arroyo and H. Mejía, pp.111–130. Museo Nacional de Arqueología y Etnología, Guatemala.

Calnek, Edward E.

1972 Settlement Pattern and Chinampa Agriculture at Tenochtitlan. *American Antiquity* 37(1):104–115. DOI:10.2307/278892.

Cárdenas García, E.

1999 *El Bajío en el Clásico: Análisis Regional y Organización Política*. Zamora: El Colegio de Michoacán.

2004 Jiuatsio, "la casa del coyote." In *Tradiciones arqueológicas*, edited by Efraín Cárdenas García, pp. 195–215. El Colegio de Michoacán, Zamora, Michoacán.

Carot, Patricia

2001 *Le site de Loma Alta, Lac de Zacapu, Michoacán, Mexique*. Paris Monographs in American Archaeology 9, BAR International Series 920. British Archaeological Reports, Oxford.

2004 Arqueología de Michoacán: Nuevas aportaciones a la historia purhépecha. In *Introducción a la arqueología del occidente de México*, edited by Beatriz Braniff Cornejo, pp. 443–474. Universidad de Colima and Instituto Nacional de Antropología e Historia, Mexico City.

Carter, William E., Ramesh L. Shrestha, and Juan Carlos Fernandez-Diaz

2016 Archaeology from the air. *Am. Sci* 104:28–35.

Cervantes-Martinez, A., M., Elias-Gutierrez and E. Suarez-Morales.

2002 Limnological and morphometrical data of eight karstic systems cenotes of the Yucatan Peninsula, Mexico, during the dry season. *Hydrobiologia* 482: 167-177.

Chacón Torres, Arturo

1993 Lake Pátzcuaro, Mexico: Watershed and Water Quality Deterioration in a Tropical High-altitude Latin American Lake. *Lake and Reservoir Management* 8(1): 37–47.

Chacón-Torres, Arturo, and Elizabeth Múzquiz-Iribe

1997 Climatic trends, water balance and Lake Pátzcuaro, a tropical high altitude lake. *Quaternary International* 43:43–51.

Chase, Adrian S. Z.

2016 Beyond elite control: residential reservoirs at Caracol, Belize. *Wiley Interdisciplinary Reviews: Water* 3(6):885–897.

Chase, Adrian S. Z., and Rudolf Cesaretti

2018 Diversity in ancient Maya water management strategies and landscapes at Caracol, Belize, and Tikal, Guatemala. *Wiley Interdisciplinary Reviews: Water*: e1332.

Chase, Adrian S.Z., and John Weishampel

2016 Using LiDAR and GIS to investigate water and soil management in the agricultural terracing at Caracol, Belize. *Advances in Archaeological Practice* 4(3):357–370.

Chase, Arlen F. and Diane Z. Chase

1987 *Investigations at the Classic Maya City of Caracol, Belize, 1985-1987, P.A.R.I. Monograph No. 3*. San Francisco, Pre-Columbian Art Research Institute.

1998 Scale and Intensity in Classic Period Maya Agriculture: Terracing and Settlement at the "Garden City" of Caracol, Belize. *Culture and Agriculture; Bulletin of the Anthropological Study Group on Agrarian Systems* 20(2/3):60-77.

Chase, Arlen F., Diane Z. Chase, Christopher T. Fisher, Stephen J. Leisz, and John F. Weishampel

2012 Geospatial revolution and remote sensing LiDAR in Mesoamerican archaeology. *Proceedings of the National Academy of Sciences of the United States of America* 109(32):12916–12921.

Cohen, Anna Stephanie

2016 Creating an Empire: Local Political Change at Angamuco, Michoacán, Mexico. Unpublished PhD Thesis.

Crandall, James

2009 *Water and The Mountains: Maya Water Management at Caracol, Belize*. Master's Thesis, University of Central Florida, Orlando, FL.

Culbert, T P.

1991 Maya political history and elite interaction: a summery view. In *Classic Maya Political History: Hieroglyphic and Archaeological Evidence.* T. P. Culbert, ed. Pp. 311-346. Cambridge: Cambridge University Press.

Dahlin, B.H., J.E. Foss, M.E. Chambers.

1980. Project Acalches: Reconstructing the Natural and Cultural History of a Seasonal Swamp at El Mirador Guatemala; Preliminary Results. In *El Mirador, Peten Guatemala, Interim Results*, ed. R.T. Matheny, pp. 37-59. Papers of the New World Archaeological Foundation 45, Utah.

Darras, Véronique

2006 Las Relaciónes entre Chupícuaro y el centro de México durante el preclásico reciente. Una crítica de las interpretaciones arqueológicas. Journal de la Société des Américanistes 92:69–110.

Darras, Véronique, and Brigitte Faugère

1998 La obsidiana en la *Relación de Michoacán* y en la realidad arqueológica: Del símbolo al uso o del uso de un símbolo. In *Génesis, culturas y espacios en Michoacán*, edited by Véronique Darras, pp. 61–88. Centre Franc¸ais d'Etudes Mexicaines et Centre-Américaines, Mexico City.

1999 *Tecnologías prehispánicas de la obsidiana: Los centros de producción de la región de Zináparo-Prieto, Michoacán*. Cuadernos de Estudios Michoacános 9. Centre Francais d'Etudes Mexicaines et Centre-Américaines, Mexico City.

2005 Cronología de la cultura Chupícuaro. Estudio del sitio La Tronera, Puruagüita, Guanajuato. In *El antiguo occidente de México. Nuevas perspectivas sobre el pasado prehispánico*, edited by Eduardo Williams, Phil C. Weigand, Lorenza López Mestas, and David Grove, pp. 255–281. El Colegio de Michoacán, Instituto Nacional de Antropología e Historia, Guadalajara.

Darras, Véronique, Brigitte Faugère-Kalfon, Christophe Durlet, Catherine Liot, Javier Reveles, Rosalba Bérumen Omar Cervantés, Cédric Caillaud, and Cybèle David

1999 Nouvelles recherches sur la culture Chupicuaro (Guanajuato, Mexique). Journal de la Sociéte´ des Américanistes 85: 343–351.

Davis-Salazar, Karla L.

2003 Late Classic Maya Water Management and Community Organization at Copan, Honduras. *Latin American Antiquity* 14(3):275–299.

Doneus, M. and Christian Briese

2006 Full-waveform airborne laser scanning as a tool for archaeological reconnaissance. *BAR International Series* 1568:99.

Doolittle, William E.

1995 Indigenous Development of Mesoamerican Irrigation. *Geographical Review* 85(3):301–323.

Dunning, Nicholas P.

1992 Lords of the Hills: Ancient Maya Settlement in the Puuc Region, Yucatan, Mexico. Monographs in World Archaeology No. 15. Prehistory Press, Madison.

Dunning, N. P., and T. P. Beach

1994 Soil Erosion, Slope Management, and Ancient Terracing in the Maya Lowlands. *Latin American Antiquity* 5 (1): 51-69.

Dunning, Nicholas P., Armando Anaya Hernández, Timothy Beach, Christopher Carr, Robert Griffin, John G. Jones, David L. Lentz, Sheryl Luzzadder-Beach, Kathryn Reese-Taylor, and Ivan Šprajc

2018 Margin for error: Anthropogenic geomorphology of Bajo edges in the Maya Lowlands. *Geomorphology*.

Dunning, Nicholas P., Sheryl Luzzadder-Beach, Timothy Beach, John G. Jones, Vernon Scarborough, and T. Patrick Culbert

2002 Arising from the bajos: The evolution of a neotropical landscape and the rise of Maya civilization. *Annals of the Association of American Geographers* 92(2):267–283.

Espejel Carbajal, Claudia

2008 *La justicia y el fuego: dos claves para leer la Relación de Michoacán*. Colegio de Michoacán, Zamora, Michoacán.

Evans, D., Roland J. Fletcher, Christophe Pottier, Jean-Baptiste Chevance, Dominique Soutif, Boun Suy Tan, Sokrithy Im, Darith Ea, Tina Tin, and Samnang Kim

2013 Uncovering archaeological landscapes at Angkor using lidar. *Proceedings of the National Academy of Sciences* 110(31):12595–12600.

Fairley, Jerry P.

2003 Geologic Water Storage in Precolumbian Peru. *Latin American Antiquity* 14(2):193–206.

Fernandez-Diaz, Juan Carlos, William E. Carter, Ramesh L. Shrestha, and Craig L. Glennie

2014 Now You See It ... Now You Don't: Understanding Airborne Mapping LiDAR Collection and Data Product Generation for Archaeological Research in Mesoamerica. *Remote Sensing* 6(10):9951–10001.

Fisher, Christopher T.

2000 Landscapes of the Lake Pátzcuaro Basin. Thesis (Ph. D.) University of Wisconsin, Madison

2005 Demographic and landscape change in the Lake Pátzcuaro basin, Mexico: abandoning the garden. *American Anthropologist* 107(1):87–95.

2011 *Technico Parcial: Legados de la resiliencia: La Cuenca de Pátzcuaro Proyecto Arqueológico (Proyecto LORE LPB) 2011* (p. 110). Mexico: Instituto Nacional de Antropología y Historia.

Fisher, Christopher T., Anna S. Cohen, Juan Carlos Fernández-Diaz, and Stephen J. Leisz

2017 The application of airborne mapping LiDAR for the documentation of ancient cities and regions in tropical regions. *Quaternary International* 448:129–138.

Fisher, Christopher T., Anna S. Cohen, Rodrigo Solinis-Casparius, Florencia Pezzutti, Jason W. Bush, Marion Forest, and Andrea Torvinen

2019 A Typology of Ancient Purépecha (Tarascan) Architecture from Angamuco, Michoacán, Mexico. forthcoming publication.

Fisher, Christopher T., Florencia Pezzutti, Anna S. Cohen, and Rodrigo Solinis-Casparius

2012 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB). Proyecto Informe Técnico Parcial, Temporada 2011.* Instituto Nacional de Antropología e Historia, Mexico City.

Fisher, Christopher T., Jason W. Bush, Florencia Pezzutti, and Anna S. Cohen

2011 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB). Proyecto Informe Técnico Parcial, Temporada 2010.* Instituto Nacional de Antropología e Historia, Mexico.

Fisher, C., Pollard, H., & Frederick, C.

1999 Intensive agriculture and socio-political development in the Lake Pátzcuaro Basin, Michoacán, Mexico. *Antiquity, 73*(281), 642-649.

Fisher, Christopher T., Helen P. Pollard, Victor Hugo Garduño-Munroy, and Isabel Israde-Alcántara

2003 A Re-examination of Human-Induced Environmental Change within the Lake Pátzcuaro Basin, Michoacán, Mexico. *Proceedings of the National Academy of Sciences* 100(8): 4957–4962.

Fisher, Chris (with J. Bush, A. Cohen, and F. Pezzutti)

2009 Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (Proyecto LORE-LPB). Informe Técnico Parcial, Temporada de 2009. Report submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia.

Fisher, Christopher T., and Stephen J. Leisz

2013 New perspectives on Purépecha urbanism through the use of lidar at the site of Angamuco, Mexico. In *Mapping archaeological landscapes from space*, pp. 199–210. Springer.

Fletcher, Roland, Dan Penny, Damian Evans, Christophe Pottier, Mike Barbetti, Matti Kummu, and Terry Lustig

2008 The water management network of Angkor, Cambodia. *Antiquity* 82(317):658–670.

Flores-Nava, A.

1994 Some limnological data from five water bodies of Yucatan as a basis for agriculture development. *Anales del Instituto de Ciencias del Mar y Limnologia* 1–2 (21).

Ford, Anabel

1991 Problems with Evaluation of Population from Settlement Data: Examination of Ancient Maya Residential Patterns in the Tikal–Yaxha Intersite Area. Estudios de Cultura Maya 18:157–186.

Freidel, David A., and Jeremy A. Sabloff

1984 Cozumel, Late Maya Settlement Patterns. Academic Press, Orlando.

Gallopin, Gary G.

1990 Water storage technology at Tikal, Guatemala. Unpublished PhD Thesis, University of Cincinnati.

Garduño-Monroy, Victor Hugo, Diana Soria-Caballero, Isabel Israde-Alcántara, V.M. Hernández Madrigal, Víctor Manuel, Alejandro Rodríguez-Ramírez, Mikhail Ostroumov, Miguel Ángel Rodríguez-Pascua, Arturo Chacon-Torres, and Juan Carlos Mora-Chaparro

2011 Evidence of Tsunami Events in the Paleolimnological Record of Lake Pátzcuaro, Michoacán, Mexico. *Geofísica internacional* 50(2): 147–161.

Garrison, T.G., and N.P. Dunning

2009 Settlement, Environment, and Politics in the San Bartolo-Xultun Territory, El Petén, Guatemala. *Latin American Antiquity* 20:525-552.

Gorenstein, Shirley

1985 *Acambaro: Frontier Settlement on the Tarascan-Aztec Border*. Vanderbilt University Press, Nashville, Tennessee.

Gorenstein, Shirley, and Helen Perlstein Pollard

1980 "The Development of the Protohistoric Tarascan State." Report to the National Science Foundation and the National Endowment for the Humanities.

1983 *The Tarascan Civilization: A Late Prehispanic Cultural System*. Vanderbilt University Press, Nashville, Tennessee.

Hanus, Kasper, and Damian Evans

2016 Imaging the Waters of Angkor: A Method for Semi-Automated Pond Extraction from LiDAR Data. *Archaeological Prospection* 23(2):87–94.

Haskell, David L., and Christopher J. Stawski

2017 Re-Envisioning Tarascan Temporalities and Landscapes: Historical Being, Archaeological Representation, and Futurity in Past Social Processes. *Journal of Archaeological Method and Theory* 24(2):611–639.

Haviland, William A.

1963 Excavation of Small Structures in the Northeast Quadrant of Tikal, Guatemala. Ph.D. dissertation, Department of Anthropology, University of Pennsylvania, Philadelphia. University Microfilms, Ann Arbor.

Homans, G. C.

1941 Anxiety and Ritual: The Theories of Malinowski and Radcliffe-Brown. *American Anthropologist* 43:164-172

Houston, S.D.

2010 Living waters and wondrous beasts. D. Finamore & S.D. Houston (Eds.), In Fiery pool: The Maya and the mythic sea (pp. 66–79). New Haven: Yale University Press.

Hunter, Clarissa C.

1995 The Chultuns of Caracol, Belize. Master's thesis, Department of Anthropology, Ball State University, Muncie.

Israde-Alcántara, I., V. H. Garduño-Monroy, C. T. Fisher, H. P. Pollard, and M. A. Rodríguez-Pascua

2005 Lake level change, climate, and the impact of natural events: the role of seismic and volcanic events in the formation of the Lake Pátzcuaro Basin, Michoacán, Mexico. *Quaternary International* 135(1). Geochronology and Environmental Reconstruction: a Tribute to Glenn A. Goodfriend:35–46.

Johnston, Kevin J.

2004 Lowland Maya water management practices: The household exploitation of rural wells. *Geoarchaeology: An International Journal* 19(3):265–292.

Laporte, J. P., and V. Fialko C.

1990 New perspectives on old problems: dynasticreferences for the Early Classic at Tikal. In *Vision and Revision in Maya Studies.* F. S. Clancy and P. D. Harrison, eds. Pp. 33-66. Albuquerque: University of New Mexico Press.

Lawrence, Denise L., and Setha M. Low

1990 The Built Environment and Spatial Form. *Annual Review of Anthropology* 19(1):453–505. DOI:10.1146/annurev.an.19.100190.002321.

León, Nicolás

1888 *Anales del Museo-Michoacáno*. Vol. 1. “Calendario de los Tarascos,” pp.33-42; “Las yácatas de Tzintzuntzan,” pp.65-70. Morelia, Mexico

Lucero, Lisa J.

2006a *Water and Ritual: The Rise and Fall of Classic Maya Rulers*. Austin, TX: University of Texas Press.

2006b The Political and Sacred Power of Water in Classic Maya Society. In *Precolumbian Water Management*, University of Arizona Press, Tucson, AZ, pp. 116–128.

2008 Water Control and Maya Politics in the Southern Maya Lowlands. *Archeological Papers of the American Anthropological Association* 9(1):35–49.

Lundell, C.L.

1933 Archaeological Discoveries in the Maya Area. *Proceedings of the American Philosophical Society* 72 (3): 147-179.

Luhr, F. and T. Simkin

1993 Parı´cutin, the Volcano born in a Mexican Cornfield. Geoscience Press, Phoenix, Arizona 427pp.

Luzzadder-Beach, Sheryl

2000 Water Resources of the Chunchucmil Maya. *Geographical Review* 90(4):493–510. DOI:10.2307/3250781.

Luzzadder-Beach, Sheryl, Timothy Beach, Scott Hutson, and Samantha Krause

2016 Sky-earth, lake-sea: climate and water in Maya history and landscape. *Antiquity* 90(350):426–442.

Macías Goytia, Angelina

1990 *Huandacareo, lugar de juicios, tribunal*. Instituto Nacional de Antropología e Historia, México City.

Marroquín Franco, Luz M.

2006 Los Botellones en el Valle Central de Guatemala: Rasgos y Contextos. Licenciatura thesis, Escuela de Historia, Universidad de San Carlos, Guatemala City.

Matheny, R.T.

1976. Maya Lowland Hydraulic Systems. *Science* 193 (4254): 639-646.

1978 Northern Maya Lowland Water-Control Systems. In *Pre-Hispanic Maya Agriculture*, edited by Peter D. Harrison and B.L. Turner II, pp. 185-210. Albuquerque, University of New Mexico Press.

Matheny, Ray T., Deanne L. Gurr, Donald W. Forsyth, and F. Richard Hauck

1983 *Investigations at Edzna Campeche, Mexico. Volume 1, Part 1: The Hydraulic System.* Papers of the New World Archaeological Foundation, No. 46. Provo, Brigham Young University.

McAnany, Patricia A.

1990 Water Storage in the Puuc Region of the Northern Maya Lowlands: A Key to Population Estimates and Architectural Variability. In Precolumbian Population History in the Maya Lowlands, edited by T. Patrick Culbert and Don S. Rice, pp. 263-284. University of New Mexico Press, Albuquerque

Metcalfe, S. E.

1987 Historical Data and Climatic Change in Mexico: A Review. *The Geographical Journal* 153(2):211–222. DOI:10.2307/634873.

Metcalfe, Sarah E., Sarah J. Davies, John D. Braisby, Melanie J. Leng, Anthony J. Newton, Nicola L. Terrett, and Sarah L. O'Hara

2007 Long and Short-term Change in the Pátzcuaro Basin, central Mexico. *Palaeogeography, Palaeoclimatology, Palaeoecology* 247(3–4): 272–295.

Michelet, D.

1996 El origen del reino tarasco protohistórico. *Arqueología Mexicana, 19*, 24–27.

2000 Yacatas y otras estructuras ceremonials tarascas en el Malpaís de Zacapu, Michoacán. In J. Litvak & L. Mirambell (Eds.), Arqueologîa, historia y antropologîa. In memoriam José Luis Lorenzo Bautista (pp. 117–137). México: INAH (Colección -Cientf fi ca 4l5).

2008 Vivir Diferentement. Los sitios de la fase Milpillas (1250–1450 d.C.) en el malpaís de Zacapu (Michoacán). In A. G. Mastache, R. H. Cobean, A. Garcia Cook, & K. G. Hirth (Eds.), El Urbanismo en Mesoamérica/Urbanism in Mesoamerica vol. 2. Instituto Nacional de Antropología e Historia (pp. 447–499). University Park: Pennsylvania State University.

Michelet, Dominique, Marie Charlotte Arnauld, and Marie-France Fauvet-Berthelot

1989 El Proyecto del CEMCA en Michoacán. Etapa I: Un balance. *Trace* 16: 70–87.

Monroe, W. H.

1970 A Glossary of Karst Terminology. Geological Survey Water-Supply Paper 1899-K. USGS, Washington.

Murtha, Timothy

2002 Land and Labor: Classic Maya Terraced Agriculture at Caracol, Belize. Unpublished Ph.D. Dissertation, Department of Anthropology, Pennsylvania State University, State College, PA.

Nichols, Deborah L

1987 Infrared Aerial Photography and Pre hispanic Irrigation at Teotihuacan: The Tlajinga Canals:12.

O'Reilly, Dougald, Damian Evans, and Louise Shewan

2017 Airborne LiDAR prospection at Lovea, an Iron Age moated settlement in central Cambodia. *antiquity* 91(358):947–965.

Pereira, Gregory

1996 Nuevos hallazgos funerarios en Loma Alta, Zacapu, Michoacán. En *Las cuencas del occidente de México. Época prehispánica*, edited by Eduardo Williams and Phil C. Weigand, pp. 105–129. Centre Francais d'Études Mexicaines et Centre-Américaines, Instituto de Investigación Científica para el Desarrollo en Cooperación, El Colegio de Michoacán, Mexico.

Perry, E., Payton, A., Pederson, B., Velazquez-Oliman, B.,

2009 Groundwater geochemistry of the Yucatan Peninsula, Mexico, constraints on stratigraphy and hydrogeology. Journal of Hydrology. 367, 27–40.

Pezzutti, Florencia Lorena

2010 *The Steps of Kings: Terraced Landscapes in the Lake Pátzcuaro Basin, Michoacán, Mexico*. Master's thesis, Colorado State University, Fort Collins, Colorado.

Pinto, Alba Estella, and Renaldo Acevedo

1993 Chultunes en Uaxactún: Forma y Uso. In VI Simposio de Investigaciones Arqueológicas en Guatemala, 1992, edited by Juan Pedro Laporte, Hector Escobedo, and S. Villagran de Brady, pp. 202–230. Museo Nacional de Arqueología y Etnología, Guatemala City.

Platt Bradbury, J.

2000 Limnologic history of Lago de Pátzcuaro, Michoacán, Mexico for the past 48,000 years: impacts of climate and man. *Palaeogeography, Palaeoclimatology, Palaeoecology* 163(1):69–95.

Pollard, Helen Perlstein

1977 An Analysis of Urban Zoning and Planning in Prehispanic Tzintzuntzan. Proceedings of the American Philosophical Society 121:46–69.

1980 Central Places and Cities: A Consideration of the Protohistoric Tarascan State. American Antiquity 45:677–696.

1982 Water and Politics: Paleoecology and the Centralization of the Tarascan State. Paper presented for symposium on Paleoecology and Man in Central Mexico, 44th International Congress of Americanists, Manchester.

1993 *Taríacuri's Legacy: The Prehispanic Tarascan State*. University of Oklahoma Press, Norman, Oklahoma

1997 Recent Research in West Mexican Archaeology. *Journal of Archaeological Research*. 5(4): 345-384

2005 Michoacán en el mundo mesoamericano prehispánico: Erongaricuaro, Michoacán y los estados teotihuacano y tarasco. In *El antiguo occidente de México. Nuevas perspectivas sobre el pasado prehispánico*, edited by Eduardo Williams, Phil C. Weigand, Lorenza López Mestas, and David Grove, pp. 283–303. El Colegio de Michoacán, Instituto Nacional de Antropología e Historia, Guadalajara.

2008 A model of the emergence of the Tarascan state. *Ancient Mesoamerica* 19(2):217–230.

Pollard, Helen P., and Shirley Gorenstein

1980 Agrarian Potential, Population and the Tarascan State. Science 209:274–277.

Pollock, H. E. D.

1956 The Southern Terminus of the Principal Sacbe at Mayapan-Group Z-50. Carnegie Institution of Washington, Current Reports No. 37, pp. 529–549. Department of Archaeology, Carnegie Institution of Washington, Washington, DC.

Pope, K.O.; Ocampo A.C.; Kinsland, G.L.; Smith, R.

1996 Surface expression of the Chicxulub Crater. *Geology:* (24), 527–530.

Price, M.

1985. Introducing groundwater. London: George Allen & Unwin

Puleston, Dennis E.

1965 The Chultuns of Tikal. Expedition 7:24–29.

1971 An Experimental Approach to the Function of Classic Maya Chultuns. American Antiquity 36:322–335.

1978 Terracing, Raised Fields, and Tree Cropping in the Maya Lowlands: A New Perspective on the Geography of Power. In *Pre-Hispanic Maya Agriculture*, edited by Peter D. Harrison and B.L. Turner II, pp. 225-245 University of New Mexico Press, Albuquerque.

Rapoport, Amos

1969 *House form and Culture*. Prentice-Hall of India Private Ltd.: New Delhi, India.

Reed, Brian and Bob Reed

2011 Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies: How much water is needed in emergencies. Prepared for the World Health Organization (WHO) by Water, Engineering and Development Centre, Loughborough University, Leicestershire, UK

Ricketson, Oliver

1925 Burials in the Maya Area. American Anthropologist 27:381–401.

Ricketson, Oliver G., and Edith B. Ricketson

1937 Uaxactún, Guatemala, Group E, 1926–1931. Carnegie Institution of Washington, Publication No. 477. Carnegie Institution of Washington, Washington, DC.

Robles, Braulio, Jorge Flores, Jose Luis Martínez, and Patricia Herrera

2019 The Chinampa: An Ancient Mexican Sub-Irrigation System. *Irrigation and Drainage* 68(1):115–122.

Ruter, Anthony, Jennifer Arzt, Steven Vavrus, Reid A. Bryson, and John E. Kutzbach

2004 Climate and Environment of the Subtropical and Tropical Americas (NH) in the Mid-Holocene: Comparison of Observations with Climate Model Simulations. *Quaternary Science Reviews* 23(5–6): 663–679.

Scarborough, Vernon L.

1983 A Preclassic Maya Water System. *American Antiquity* 48(4):720–744.

1998 Ecology and Ritual: Water Management and the Maya. *Latin American Antiquity* 9(2):135–159.

2003 The flow of power: ancient water systems and landscapes. School of American Research Press, Santa Fe

2006 An Overview of Mesoamerican Water Systems. In *Precolumbian Water Management: Ideology, Ritual, and Power*, edited by Lisa J. Lucero and Barbara W. Fash, pp. 223-236. Tucson, University of Arizona Press.

Scarborough, Vernon L., and William R. Burnside

2010 Complexity and Sustainability: Perspectives from the Ancient Maya and the Modern Balinese. *American Antiquity* 75(2):327–363.

Scarborough, Vernon L., and Gary G. Gallopin

1991 A Water Storage Adaptation in the Maya Lowlands. *Science* 251(4994):658–662.

Scarborough, Vernon L., and Lisa J. Lucero

2010 The non-hierarchical development of complexity in the semitropics: water and cooperation. *Water History* 2(2):185–205.

Scarborough, Vernon L., Matthew E. Becher, Jeffrey L. Baker, Garry Harris, and Fred Valdez Jr.

1995 Water and Land at the Ancient Maya Community of La Milpa. Latin American Antiquity 6:98–119.

Scarborough, Vernon L., Nicholas P. Dunning, Kenneth B. Tankersley, Christopher Carr, Eric Weaver, Liwy Grazioso, Brian Lane, John G. Jones, Palma Buttles, Fred Valdez, and David L. Lentz

2012 Water and sustainable land use at the ancient tropical city of Tikal, Guatemala. *Proceedings of the National Academy of Sciences of the United States of America* 109(31):12408–12413.

Siemens, A.

1978. Karst and the Pre-Hispanic Maya in the Southern Lowlands. In *Pre-Hispanic Maya Agriculture,* edited by Peter D. Harrison and William L. Turner II, pp. 117-145. Albuquerque: University of Mexico Press.

Silverstein, Jay

2001 Aztec Imperialism at Oztuma, Guerrero. *Ancient Mesoamerica* 12(1): 31–48.

Silverstein, Jay E., David Webster, Horacio Martinez, and Alvaro Soto

2009 Rethinking the Great Earthwork of Tikal: A Hydraulic Hypothesis for the Classic Maya Polity. *Ancient Mesoamerica* 20(1):45–58.

Smith, A.L.

1962 Residential and associated structures at Mayapán. In *Mayapán Yucatan, Mexico*; Pollock, H.E.D., Roys, R.L., Proskouriakoff, T., Smith, A.L., Eds.; Carnegie Institution of Washington Publication: Washington, DC, USA, Vol. 619, pp. 165–320.

Smyth, Michael P., José Ligorred Perramon, David Ortegón Zapata, and Pat Farrell

1998 An Early Classic Center in the Puuc Region. Ancient Mesoamerica 9:233–257.

Strahler, Arthur N.

1957 Quantitative analysis of watershed geomorphology. *Transactions, American Geophysical Union* 38(6):913.

Street-Perrott, F. A., R. A. Perrott, and D. D. Harkness

1989 Anthropogenic Soil Erosion around Lake Pátzcuaro, Michoacán, Mexico, during the 323 Preclassic and Late Postclassic-Hispanic Periods. *American Antiquity* 54(4): 759–765.

Tamberino, Anthony T.

2013 Ancient Maya Reservoirs and their Role in the Abandonment of Tikal, Guatemala: A Multi-Proxy Investigation of Solid Sediment Cores. Unpublished M.A., University of Cincinnati, United States -- Ohio.

Turner BL II, Denevan WM.

1985 Prehistoric manipulation of wetlands in the Americas: a raised field perspective. In: Farrington IS, ed. *Prehistoric Intensive Agriculture in the Tropics Part I*. BAR International Series, vol. 232. Oxford, UK: B.A.R.;11–30.

Urquhart, Kyle Ryan

2015 The Ireta: A model of political and spatial organization of P'urépecha cities. Unpublished MA Thesis, Colorado State University. Fort Collins.

Valdez, Francisco, Catherine Liot, Eduardo Williams, Helen P. Pollard, Efraín Cárdenas García, Dan M. Healan, Marie-Charlotte Arnauld, M.F. Fauvet-Berthelot, and Dominique Michelet

1994 La cuenca de Sayula: yacimientos de sal en la frontera oeste del estado Tarasco. In *El Michoacán antiguo*, pp. 285–305. El Colegio de Michoacán, Zamora, Michoacán.

Vogt, Evon Z., and David Stuart

2005 Ritual Caves among the Ancient and Modern Maya. In Stone Houses and Earth Lords: Maya Religion in the Cave Context, edited by Keith M. Prufer and James E. Brady, pp. 155–185. University Press of Colorado, Boulder.

Wahl, D., T. Schreiner, R. Byrne and R. Hansen.

2007 A Paleoecological Record from a Late Classic Maya Reservoir in the North Peten. *Latin American Antiquity* 18 (2): 212-222.

Warren, J. Benedict

1985 *The Conquest of Michoacán: Spanish Domination of the Tarascan Kingdom 1521-1530*. University of Oklahoma Press, Norman.

Watts, W. A., and J. Platt Bradbury

1982 Paleoecological Studies at Lake Pátzcuaro on the West-Central Mexican Plateau and at Chalco in the Basin of Mexico. *Quaternary Research* 17(1): 56–70.

Weiss-Krejci, Estella, and Thomas Sabbas

2002 The Potential Role of Small Depressions as Water Storage Features in the Central Maya Lowlands. *Latin American Antiquity* 13(3):343–357.

West, Robert

1948 *Cultural Geography of the Modern Tarascan Area*. Institute of Social Anthropology 7. Smithsonian Institute, Washington, D.C.

Whitmore TM, Turner BL II.

2001. *Cultivated Landscapes of Middle America on the Eve of Conquest*. Oxford, UK: Oxford University Press.

Wienhold, Michelle L.

2013 Prehistoric land use and hydrology: a multi-scalar spatial analysis in central Arizona. *Journal of Archaeological Science* 40(2):850–859.

Winter, Marcus C.

1976 The Archaeological Household Cluster in the Valley of Oaxaca. In The Early Mesoamerican Village, edited by Kent V. Flannery, pp. 25–30. Academic Press, New York.

Wittfogel, Karl

1957 Oriental despotism: a comparative study of total power. Yale University Press, New Haven

Works, Martha A. and Keith S. Hadley

2004 The Cultural Context of Forest Degradation in Adjacent Purépechan Communities, Michoacán, Mexico. *The Geographical Journal* 170:22-38.

Yoffee, Norman

2005 Myths of the ancient state. Cambridge University Press, Cambridge

Zhang, Weihua, and David R. Montgomery

1994 Digital elevation model grid size, landscape representation, and hydrologic simulations. *Water Resources Research* 30(4):1019–1028.

APPENDIX A

Appendix A includes all of the metrics calculated for the reservoirs at Angamuco which were used in subsequent analyses. Table 1 includes all 811 reservoir features listed by their grid location, Reservoir ID, and includes their 2D Area, Volume expressed in both M^3 and Liters, and their proposed function. Table 2 includes the reservoirs in the study area (n=116) and are highlighted for the months and runoff percentages for which they would reach their maximum carrying capacities.

Table 1

Grid	Reservoir	Area_2D (M^2)	Volume_M^3	Volume_Liters	Function
AB75	AB75_01	737.75	545.39	545394.21	Residential
AB76	AB76_01	545.50	326.61	326608.83	Residential
AB76	AB76_02	867.75	739.04	739035.67	Residential
AB76	AB76_03	1206.50	634.25	634252.93	Residential
AB76	AB76_04	275.25	117.49	117490.60	Residential
AB76	AB76_05	361.50	257.12	257124.51	Residential
AB76	AB76_06	541.25	331.10	331104.32	Residential
AB76	AB76_07	1023.25	771.27	771265.39	Residential
AB77	AB77_01	490.50	89.70	89700.60	Residential
AB77	AB77_02	1267.00	848.46	848459.28	Residential
AB77	AB77_03	726.25	332.60	332604.14	Residential
AB77	AB77_04	3699.00	4290.25	4290251.92	Residential
AB77	AB77_05	165.75	35.45	35447.90	Residential
AB77	AB77_06	1356.25	988.85	988852.29	Residential
AB77	AB77_07	847.25	375.75	375750.69	Residential

AB77	AB77_08	1211.50	869.04	869035.58	Residential
AB77	AB77_09	1613.75	1833.65	1833650.82	Residential
AB77	AB77_10	669.25	434.62	434624.49	Residential
AB77	AB77_11	629.75	320.27	320272.83	Residential
AB77	AB77_12	118.25	38.99	38994.19	Residential
AB77	AB77_13	415.25	278.04	278035.52	Residential
AB78	AB78_01	1013.00	521.43	521432.16	Residential
AB78	AB78_02	131.50	49.27	49271.98	Residential
AC75	AC75_01	608.50	639.41	639407.36	Residential
AC75	AC75_02	47.00	12.09	12087.09	Residential
AC75	AC75_03	153.50	80.39	80387.99	Residential
AC75	AC75_04	1449.50	1100.75	1100750.10	Residential
AC75	AC75_05	716.25	461.60	461602.96	Residential
AC75	AC75_06	548.00	501.37	501365.31	Residential
AC75	AC75_07	2644.00	1993.18	1993175.37	Residential
AC75	AC75_08	922.00	288.71	288712.53	Residential
AC75	AC75_09	187.00	72.76	72758.98	Residential
AC76	AC76_01	1024.75	1346.19	1346191.24	Residential
AC76	AC76_02	462.00	544.53	544531.30	Residential
AC76	AC76_03	4509.75	9712.54	9712536.48	Residential
AC76	AC76_04	894.00	314.59	314590.66	Residential
AC76	AC76_05	10212.00	52163.89	52163890.61	Residential
AC76	AC76_06	705.25	388.67	388665.57	Residential
AC76	AC76_07	4653.25	15872.83	15872834.12	Residential
AC76	AC76_08	124.00	31.29	31288.34	Residential
AC81	AC81_01	7690.75	20822.66	20822663.93	Agricultural
AD75	AD75_01	2154.00	4368.72	4368723.98	Residential
AD75	AD75_02	6183.50	9230.93	9230925.56	Residential

AD75	AD75_03	1122.00	736.43	736432.87	Residential
AD76	AD76_01	313.50	124.20	124197.88	Residential
AD76	AD76_02	318.50	172.72	172723.74	Residential
AD76	AD76_03	326.00	338.77	338766.82	Residential
AD76	AD76_04	294.00	223.79	223785.48	Residential
AD76	AD76_05	110.75	35.56	35557.10	Residential
AD76	AD76_06	1322.75	2473.04	2473040.89	Residential
AD76	AD76_07	3541.75	8044.02	8044018.20	Residential
AD76	AD76_08	798.75	974.42	974424.76	Residential
AD76	AD76_09	1677.75	1620.76	1620761.92	Residential
AD76	AD76_10	272.50	128.37	128373.34	Residential
AD76	AD76_11	299.75	136.49	136492.50	Residential
AD76	AD76_12	1308.30	1014.58	1014580.59	Residential
AD76	AD76_13	43812.82	230826.03	230826034.00	Residential
AD77	AD77_01	194.00	65.30	65301.84	Residential
AD77	AD77_02	3432.50	3453.52	3453519.97	Residential
AD77	AD77_03	360.25	140.65	140650.48	Residential
AD77	AD77_04	181.25	64.09	64090.56	Residential
AD77	AD77_05	230.25	93.39	93388.44	Residential
AD77	AD77_06	799.00	237.85	237853.36	Residential
AD77	AD77_07	1305.75	3131.11	3131112.61	Residential
AD77	AD77_08	122.00	126.92	126919.67	Residential
AE74	AE74_01	490.75	516.85	516849.23	Residential
AE75	AE75_01	2156.50	3715.26	3715258.09	Residential
AE75	AE75_02	380.75	223.94	223938.71	Residential
AE75	AE75_03	1335.25	1617.52	1617516.05	Residential
AE75	AE75_04	316.50	135.82	135822.81	Residential
AE75	AE75_05	5285.75	7867.40	7867401.33	Residential

AE76	AE76_01	925.75	1933.16	1933163.95	Residential
AE76	AE76_02	824.25	786.99	786989.36	Residential
AE76	AE76_03	5147.25	21232.46	21232456.76	Residential
AE76	AE76_04	903.75	571.71	571707.17	Residential
AE76	AE76_05	606.00	312.82	312821.57	Residential
AE76	AE76_06	335.75	219.26	219261.34	Residential
AE76	AE76_07	536.00	387.83	387830.37	Residential
AE76	AE76_08	241.75	168.49	168488.77	Residential
AE76	AE76_09	334.00	168.88	168876.90	Residential
AE76	AE76_10	810.75	325.05	325050.13	Residential
AE76	AE76_11	625.00	303.85	303846.21	Residential
AE77	AE77_01	252.25	170.29	170287.82	Residential
AE77	AE77_02	5929.50	24220.86	24220855.25	Residential
AE77	AE77_03	4617.75	14978.42	14978421.81	Residential
AE77	AE77_04	1122.25	2021.16	2021161.68	Residential
AE77	AE77_05	729.50	909.81	909808.56	Residential
AE77	AE77_06	34435.00	274155.53	274155530.60	Residential
AE77	AE77_07	528.50	252.46	252462.83	Residential
AE77	AE77_08	1087.50	849.12	849123.83	Residential
AE77	AE77_09	7804.50	11487.32	11487315.88	Residential
AE78	AE78_01	1316.75	1504.77	1504769.24	Residential
AF74	AF74_01	468.75	168.03	168033.85	Residential
AF74	AF74_02	1424.25	1738.85	1738854.40	Residential
AF74	AF74_03	2879.50	5813.70	5813696.86	Residential
AF74	AF74_04	645.00	199.04	199038.60	Residential
AF74	AF74_05	863.00	1020.11	1020106.02	Residential
AF74	AF74_06	351.50	245.06	245055.11	Residential
AF74	AF74_07	754.50	629.78	629783.82	Residential

AF74	AF74_08	811.75	922.19	922187.22	Residential
AF75	AF75_01	576.50	507.78	507779.60	Residential
AF75	AF75_02	539.25	440.48	440475.28	Residential
AF75	AF75_03	547.75	377.42	377418.09	Residential
AF75	AF75_04	530.75	387.83	387831.62	Residential
AF75	AF75_05	852.75	664.57	664569.43	Residential
AF75	AF75_06	731.50	554.51	554506.70	Residential
AF75	AF75_07	1809.50	1632.31	1632312.78	Residential
AF75	AF75_08	1010.50	810.69	810694.26	Residential
AF75	AF75_09	565.50	362.67	362674.76	Residential
AF75	AF75_10	427.75	281.80	281798.61	Residential
AF75	AF75_11	551.25	141.36	141359.34	Residential
AF75	AF75_12	2152.61	1184.21	1184212.10	Residential
AF75	AF75_13	1395.84	557.06	557060.66	Residential
AF75	AF75_14	449.75	679.25	679250.29	Residential
AF75	AF75_15	2868.26	1761.75	1761751.30	Residential
AF75	AF75_16	919.25	735.51	735513.54	Residential
AF75	AF75_17	2137.75	2708.60	2708596.53	Residential
AF75	AF75_18	4.25	1.89	1885.52	Residential
AF75	AF75_19	3950.00	8930.21	8930213.09	Residential
AF76	AF76_01	1801.25	2334.00	2334001.60	Residential
AF76	AF76_02	730.50	402.69	402689.61	Residential
AF76	AF76_03	543.25	313.54	313535.18	Residential
AF76	AF76_04	893.75	794.78	794779.30	Residential
AF76	AF76_05	945.00	1108.25	1108249.32	Residential
AF76	AF76_06	1714.75	1379.39	1379392.28	Residential
AF76	AF76_07	653.75	479.93	479932.23	Residential
AF76	AF76_08	333.75	106.78	106776.20	Residential

AF76	AF76_09	447.75	332.07	332069.84	Residential
AF76	AF76_10	724.75	700.20	700202.01	Residential
AF76	AF76_11	237.50	123.68	123683.80	Residential
AF76	AF76_12	551.25	281.91	281907.67	Residential
AF76	AF76_13	913.75	615.13	615134.01	Residential
AF76	AF76_14	1697.25	1235.47	1235472.98	Residential
AF76	AF76_15	641.50	207.45	207453.78	Residential
AF76	AF76_16	720.00	612.17	612172.12	Residential
AF76	AF76_17	618.75	376.01	376012.71	Residential
AF76	AF76_18	505.50	670.06	670056.67	Residential
AF76	AF76_19	872.00	973.50	973500.21	Residential
AF76	AF76_20	1903.25	1755.72	1755722.42	Residential
AF76	AF76_21	86.75	21.99	21990.57	Residential
AF76	AF76_22	9741.00	30206.89	30206885.81	Agricultural
AF76	AF76_23	426.50	346.04	346040.95	Residential
AF76	AF76_24	9.75	3.98	3982.84	Residential
AF76	AF76_25	163.75	57.67	57669.78	Residential
AF77	AF77_01	2418.75	3997.32	3997318.48	Residential
AF77	AF77_02	5761.25	10402.91	10402907.47	Residential
AF77	AF77_03	1420.50	998.66	998664.95	Residential
AF77	AF77_04	4075.25	4043.87	4043868.50	Residential
AF77	AF77_05	1220.50	836.44	836444.53	Residential
AF77	AF77_06	1941.50	2912.28	2912284.30	Residential
AF77	AF77_07	2121.25	1192.18	1192176.18	Residential
AF77	AF77_08	7100.75	5456.43	5456425.37	Residential
AF77	AF77_09	2342.25	2974.98	2974979.31	Residential
AF77	AF77_10	3653.78	4226.54	4226544.08	Residential
AF77	AF77_11	852.00	400.75	400747.83	Residential

AF77	AF77_12	2079.50	2174.12	2174120.98	Residential
AF78	AF78_01	3237.00	4426.66	4426662.38	Residential
AF78	AF78_02	1617.75	1176.71	1176709.87	Residential
AF78	AF78_03	7136.44	11551.34	11551341.28	Residential
AF78	AF78_04	5612.00	4745.54	4745541.51	Residential
AF78	AF78_05	17.25	5.00	5001.51	Residential
AF79	AF79_01	2196.00	3532.39	3532394.53	Residential
AF79	AF79_02	1421.50	1041.61	1041609.59	Residential
AF79	AF79_03	5325.50	13967.77	13967774.17	Residential
AF79	AF79_04	400.25	150.91	150909.25	Residential
AF79	AF79_05	274.75	114.22	114217.81	Residential
AF79	AF79_06	381.00	293.79	293792.63	Residential
AF79	AF79_07	768.75	461.07	461066.81	Residential
AF79	AF79_08	442.75	200.83	200833.27	Residential
AF79	AF79_09	471.50	224.75	224753.29	Residential
AF79	AF79_10	1662.50	1796.73	1796727.08	Residential
AF79	AF79_10	1662.50	1796.73	1796727.08	Residential
AG73	AG73_01	4915.50	8617.84	8617844.80	Residential
AG74	AG74_01	1349.25	2015.48	2015482.82	Residential
AG74	AG74_02	232.50	101.06	101064.40	Residential
AG74	AG74_03	1109.25	1149.66	1149663.40	Residential
AG74	AG74_04	1550.25	3317.58	3317583.66	Residential
AG74	AG74_05	1088.50	1470.41	1470412.37	Residential
AG74	AG74_06	122.25	36.16	36157.54	Residential
AG74	AG74_07	150.00	39.72	39722.91	Residential
AG74	AG74_08	220.25	74.87	74874.94	Residential
AG74	AG74_09	1184.75	533.81	533813.01	Residential
AG74	AG74_10	1595.50	1922.39	1922393.49	Residential

AG74	AG74_10	1595.50	1922.39	1922393.49	Residential
AG75	AG75_01	227.50	69.38	69383.03	Residential
AG75	AG75_02	955.83	499.61	499605.96	Residential
AG75	AG75_03	1104.50	1748.65	1748649.46	Residential
AG75	AG75_04	866.25	767.70	767700.61	Residential
AG75	AG75_05	1000.75	381.76	381762.89	Residential
AG75	AG75_06	1838.75	2830.33	2830326.52	Residential
AG75	AG75_07	227.00	107.90	107896.04	Residential
AG75	AG75_08	7.25	2.66	2662.99	Residential
AG75	AG75_09	1059.50	1101.98	1101978.13	Residential
AG75	AG75_10	5895.50	30703.21	30703214.15	Agricultural
AG76	AG76_01	1049.00	854.08	854076.58	Residential
AG76	AG76_02	379.25	209.77	209771.87	Residential
AG76	AG76_03	423.75	244.20	244199.98	Residential
AG76	AG76_04	600.50	346.17	346169.95	Residential
AG76	AG76_05	2142.00	2702.91	2702912.30	Residential
AG76	AG76_06	734.00	653.26	653263.66	Residential
AG76	AG76_07	2868.25	3712.06	3712060.64	Residential
AG76	AG76_08	1513.50	1587.96	1587962.19	Residential
AG76	AG76_09	8335.50	14480.80	14480802.42	Residential
AG76	AG76_10	805.75	521.89	521888.74	Residential
AG76	AG76_11	249.75	112.68	112681.21	Residential
AG76	AG76_12	1508.50	2049.07	2049067.05	Residential
AG77	AG77_01	3367.50	6187.67	6187666.87	Residential
AG77	AG77_02	383.75	202.80	202801.25	Residential
AG77	AG77_03	405.50	201.53	201529.70	Residential
AG77	AG77_04	823.75	780.56	780559.27	Residential
AG77	AG77_05	1381.25	1579.92	1579919.37	Residential

AG77	AG77_06	628.75	530.57	530572.53	Residential
AG77	AG77_07	161.50	86.99	86986.66	Residential
AG77	AG77_08	189.00	68.48	68482.25	Residential
AG77	AG77_09	787.00	732.15	732148.19	Residential
AG77	AG77_10	416.50	155.98	155978.96	Residential
AG77	AG77_11	946.50	721.58	721581.58	Residential
AG77	AG77_12	770.50	1089.89	1089889.33	Residential
AG77	AG77_13	296.75	100.34	100335.71	Residential
AG77	AG77_14	4229.75	7773.34	7773343.98	Residential
AG77	AG77_15	247.25	61.48	61483.28	Residential
AG77	AG77_16	1195.00	1365.79	1365785.58	Residential
AG77	AG77_17	2381.69	1897.01	1897011.16	Residential
AG77	AG77_18	1494.25	2109.03	2109029.27	Residential
AG77	AG77_19	6223.75	11234.58	11234580.70	Residential
AG77	AG77_20	2445.25	1460.67	1460665.72	Residential
AG78	AG78_01	2561.25	2492.83	2492826.68	Residential
AG78	AG78_02	1171.50	607.07	607072.70	Residential
AG78	AG78_03	1481.50	730.04	730042.29	Residential
AG78	AG78_04	427.00	107.69	107688.22	Residential
AG78	AG78_05	4749.50	11347.48	11347482.74	Residential
AG78	AG78_06	1206.50	1561.09	1561092.29	Residential
AG78	AG78_07	1501.75	2139.16	2139156.27	Residential
AG78	AG78_08	407.75	156.65	156650.40	Residential
AG78	AG78_09	453.75	218.05	218045.74	Residential
AG78	AG78_10	26.00	7.35	7348.28	Residential
AG78	AG78_11	4062.50	3738.21	3738212.75	Residential
AG78	AG78_12	4724.00	4675.87	4675867.23	Residential
AG79	AG79_01	1015.50	1017.55	1017547.72	Residential

AG79	AG79_02	34.75	13.42	13415.56	Residential
AG79	AG79_03	826.50	352.08	352081.76	Residential
AG79	AG79_04	1263.75	1161.75	1161751.58	Residential
AG79	AG79_05	814.50	454.27	454269.33	Residential
AG79	AG79_06	685.00	309.62	309615.35	Residential
AG79	AG79_07	2255.00	3994.70	3994703.93	Residential
AG79	AG79_08	1440.50	1350.21	1350209.95	Residential
AG79	AG79_09	1570.98	924.93	924930.92	Residential
AG79	AG79_10	1882.25	2369.97	2369970.54	Residential
AG79	AG79_11	670.25	462.36	462364.78	Residential
AG79	AG79_12	1076.75	1451.46	1451460.10	Residential
AG79	AG79_13	961.75	1214.07	1214073.02	Residential
AG79	AG79_14	16.50	13.65	13652.64	Residential
AG79	AG79_15	1180.00	937.92	937916.99	Residential
AG79	AG79_16	17.50	4.74	4735.95	Residential
AG79	AG79_17	7085.25	30630.06	30630058.80	Residential
AG79	AG79_18	5124.50	18900.11	18900112.15	Residential
AG79	AG79_19	87.75	48.30	48304.58	Residential
AG80	AG80_01	656.25	284.14	284141.84	Residential
AG80	AG80_02	1002.00	404.50	404498.06	Residential
AG81	AG81_01	223.25	100.00	100003.99	Residential
AH73	AH73_01	2810.25	5153.34	5153342.99	Residential
AH74	AH74_01	1046.25	785.72	785723.31	Residential
AH74	AH74_02	1420.75	1391.77	1391770.22	Residential
AH74	AH74_03	338.50	248.11	248110.25	Residential
AH74	AH74_04	1976.50	2138.38	2138381.16	Residential
AH75	AH75_01	613.50	533.28	533276.56	Residential
AH75	AH75_02	127.00	46.75	46745.17	Residential

AH76	AH76_01	810.50	1313.14	1313141.91	Residential
AH76	AH76_02	1836.00	3012.06	3012059.16	Residential
AH76	AH76_03	1300.50	1264.53	1264532.75	Residential
AH76	AH76_04	395.75	207.11	207108.38	Residential
AH76	AH76_05	1634.75	979.03	979029.47	Residential
AH76	AH76_06	1572.50	1610.92	1610922.31	Residential
AH76	AH76_07	1319.75	2105.96	2105958.07	Residential
AH76	AH76_08	5779.75	11941.86	11941858.93	Residential
AH77	AH77_01	1850.00	1769.51	1769514.50	Residential
AH77	AH77_02	2150.25	1216.21	1216209.52	Residential
AH77	AH77_03	405.50	180.89	180885.67	Residential
AH77	AH77_04	3761.75	8317.77	8317771.75	Residential
AH77	AH77_05	953.00	772.07	772067.20	Residential
AH77	AH77_06	2764.50	6432.54	6432541.91	Residential
AH77	AH77_07	307.00	156.42	156421.05	Residential
AH78	AH78_01	291.75	131.70	131704.53	Residential
AH78	AH78_02	1141.50	2176.92	2176923.50	Residential
AH78	AH78_03	310.75	96.06	96060.69	Residential
AH78	AH78_04	1256.00	1076.15	1076146.64	Residential
AH78	AH78_05	179.50	81.98	81977.70	Residential
AH78	AH78_06	289.25	146.20	146202.66	Residential
AH78	AH78_08	452.50	345.99	345991.05	Residential
AH78	AH78_09	131.50	36.48	36482.27	Residential
AH78	AH78_10	5131.50	13791.05	13791051.50	Agricultural
AH78	AH78_11	2584.82	2774.37	2774371.83	Residential
AH79	AH79_01	823.00	412.74	412740.75	Residential
AH79	AH79_02	1661.75	1864.11	1864109.11	Residential
AH79	AH79_03	1224.00	774.94	774944.73	Residential

AH79	AH79_04	1054.25	1731.50	1731501.10	Residential
AH79	AH79_05	661.75	743.80	743800.98	Residential
AH79	AH79_06	334.25	132.68	132676.83	Residential
AH79	AH79_07	3236.25	6626.33	6626328.07	Residential
AH79	AH79_07	3236.25	6626.33	6626328.07	Residential
AH79	AH79_08	1231.50	1677.75	1677747.62	Residential
AH80	AH80_01	1285.00	659.47	659471.73	Residential
AH80	AH80_02	639.75	241.62	241624.26	Residential
AH80	AH80_03	899.75	542.69	542685.04	Residential
AH80	AH80_04	2398.75	2858.98	2858984.39	Residential
AI72	AI72_01	10305.84	6756.68	6756677.38	Residential
AI72	AI72_02	690.25	171.37	171371.64	Residential
AI72	AI72_03	600.00	101.13	101132.97	Residential
AI73	AI73_01	724.50	298.08	298083.66	Residential
AI73	AI73_02	1909.75	3806.03	3806029.84	Residential
AI75	AI75_01	1239.75	2077.21	2077205.27	Residential
AI75	AI75_02	612.75	220.62	220619.45	Residential
AI75	AI75_03	91.75	17.67	17667.84	Residential
AI75	AI75_04	371.25	203.29	203290.16	Residential
AI76	AI76_01	6078.25	15508.44	15508436.94	Agricultural
AI76	AI76_02	4772.75	5859.96	5859963.96	Residential
AI76	AI76_03	156.50	55.52	55520.72	Residential
AI76	AI76_04	1710.75	2944.88	2944882.90	Residential
AI76	AI76_05	1590.50	1106.27	1106268.27	Residential
AI77	AI77_01	3401.50	9235.45	9235445.70	Residential
AI77	AI77_02	50.75	13.74	13741.72	Residential
AI77	AI77_03	48.25	20.66	20656.57	Residential
AI77	AI77_04	376.00	102.80	102801.59	Residential

AI77	AI77_05	7549.25	15506.81	15506814.39	Agricultural
AI77	AI77_06	578.50	160.05	160049.25	Residential
AI78	AI78_01	414.00	292.77	292767.37	Residential
AI78	AI78_02	1155.50	576.89	576889.87	Residential
AI78	AI78_03	239.50	86.49	86487.02	Residential
AI78	AI78_04	1002.50	947.14	947138.81	Residential
AI78	AI78_05	467.75	174.02	174016.90	Residential
AI78	AI78_06	5372.50	4761.20	4761198.75	Residential
AI78	AI78_07	2527.50	2886.28	2886278.97	Residential
AI78	AI78_08	2327.75	2557.49	2557490.65	Residential
AI78	AI78_09	520.75	238.94	238942.11	Residential
AI78	AI78_10	4089.00	11365.23	11365228.32	Residential
AI78	AI78_11	101.25	28.46	28455.69	Residential
AI78	AI78_12	41.50	8.56	8556.68	Residential
AI78	AI78_13	315.50	119.17	119174.02	Residential
AI79	AI79_01	399.75	122.08	122079.95	Residential
AI79	AI79_02	316.75	97.67	97670.23	Residential
AI79	AI79_03	218.25	39.24	39239.81	Residential
AI79	AI79_04	234.50	116.41	116411.07	Residential
AI79	AI79_05	1457.50	1503.05	1503045.59	Residential
AI79	AI79_06	3630.75	6694.99	6694992.37	Residential
AI79	AI79_07	102.50	23.34	23338.49	Residential
AI79	AI79_08	31.25	9.96	9961.92	Residential
AI79	AI79_09	54.75	13.51	13508.72	Residential
AI79	AI79_10	5191.25	5969.69	5969692.63	Residential
AI79	AI79_11	597.25	564.35	564354.96	Residential
AI79	AI79_12	1443.25	2153.65	2153649.60	Residential
AJ74	AJ74_01	1604.50	1030.79	1030787.97	Residential

AJ74	AJ74_02	274.25	72.54	72537.24	Residential
AJ74	AJ74_03	1215.75	1211.43	1211425.47	Residential
AJ74	AJ74_04	6125.50	15857.96	15857958.17	Residential
AJ75	AJ75_01	226.00	68.60	68603.71	Residential
AJ75	AJ75_02	330.00	90.59	90587.92	Residential
AJ75	AJ75_03	439.00	159.49	159488.15	Residential
AJ75	AJ75_04	306.25	78.39	78394.01	Residential
AJ75	AJ75_05	527.75	262.12	262120.26	Residential
AJ75	AJ75_06	207.00	60.87	60867.49	Residential
AJ75	AJ75_07	76.00	38.39	38391.84	Residential
AJ75	AJ75_08	119.25	20.54	20540.66	Residential
AJ75	AJ75_09	435.25	171.96	171960.52	Residential
AJ75	AJ75_10	117.50	54.92	54922.79	Residential
AJ75	AJ75_11	929.75	1831.16	1831163.63	Residential
AJ75	AJ75_12	93.25	29.55	29550.97	Residential
AJ75	AJ75_13	101.75	23.46	23464.53	Residential
AJ75	AJ75_14	449.50	165.44	165435.56	Residential
AJ75	AJ75_15	523.75	182.73	182728.87	Residential
AJ75	AJ75_16	140.75	37.93	37932.91	Residential
AJ75	AJ75_17	242.25	57.38	57380.94	Residential
AJ75	AJ75_18	295.25	107.24	107241.43	Residential
AJ76	AJ76_01	1145.11	563.09	563092.52	Residential
AJ76	AJ76_02	493.26	306.96	306960.54	Residential
AJ76	AJ76_03	766.50	340.04	340037.56	Residential
AJ76	AJ76_04	122.00	48.51	48509.24	Residential
AJ76	AJ76_05	703.75	686.40	686396.62	Residential
AJ76	AJ76_06	201.75	61.52	61523.11	Residential
AJ76	AJ76_07	152.25	30.87	30870.51	Residential

AJ76	AJ76_08	10.00	3.95	3953.19	Residential
AJ76	AJ76_09	17.25	5.46	5459.46	Residential
AJ76	AJ76_10	220.50	61.58	61584.05	Residential
AJ76	AJ76_11	496.25	631.08	631080.57	Residential
AJ76	AJ76_12	1061.75	820.84	820842.73	Residential
AJ76	AJ76_13	5084.50	10976.86	10976855.44	Residential
AJ76	AJ76_14	1182.50	1175.91	1175913.15	Residential
AJ76	AJ76_15	1316.50	708.87	708874.28	Residential
AJ76	AJ76_16	370.00	97.63	97634.38	Residential
AJ76	AJ76_17	10.00	2.54	2539.58	Residential
AJ77	AJ77_01	628.50	670.01	670007.80	Residential
AJ77	AJ77_02	3672.75	2793.16	2793156.91	Residential
AJ77	AJ77_03	8524.75	19730.44	19730443.55	Agricultural
AJ77	AJ77_04	3131.50	8790.74	8790744.38	Residential
AJ77	AJ77_05	2246.50	2132.66	2132656.97	Residential
AJ77	AJ77_06	81.50	24.74	24735.54	Residential
AJ77	AJ77_07	233.25	59.10	59101.77	Residential
AJ78	AJ78_01	691.25	423.03	423033.24	Residential
AJ78	AJ78_02	1271.75	2828.24	2828238.98	Residential
AJ78	AJ78_03	523.75	550.76	550762.68	Residential
AJ78	AJ78_04	376.75	221.56	221557.01	Residential
AJ78	AJ78_05	265.50	101.10	101095.63	Residential
AJ78	AJ78_06	763.50	792.61	792614.96	Residential
AJ78	AJ78_07	162.75	37.95	37954.62	Residential
AJ78	AJ78_08	257.50	211.65	211652.42	Residential
AJ78	AJ78_09	181.25	48.99	48989.41	Residential
AJ78	AJ78_10	310.50	94.29	94287.65	Residential
AJ79	AJ79_01	397.00	331.49	331491.87	Residential

AJ79	AJ79_02	320.25	148.11	148112.35	Residential
AJ79	AJ79_03	641.50	298.26	298264.42	Residential
AK72	AK72_01	3393.75	3793.07	3793071.63	Residential
AK73	AK73_01	1010.25	541.99	541986.72	Residential
AK73	AK73_02	198.59	52.02	52021.22	Residential
AK73	AK73_03	275.50	103.82	103824.42	Residential
AK73	AK73_04	628.50	208.20	208201.44	Residential
AK73	AK73_05	2878.25	3073.59	3073585.50	Residential
AK73	AK73_06	2035.93	1102.32	1102323.06	Residential
AK73	AK73_07	1062.50	937.62	937618.45	Residential
AK73	AK73_08	890.25	605.94	605935.73	Residential
AK73	AK73_09	4584.50	3190.93	3190929.75	Residential
AK73	AK73_10	1142.25	620.31	620311.22	Residential
AK73	AK73_11	1261.00	676.82	676818.57	Residential
AK73	AK73_12	833.68	229.44	229440.77	Residential
AK73	AK73_13	443.00	144.45	144448.97	Residential
AK73	AK73_14	821.75	413.81	413806.08	Residential
AK73	AK73_15	3301.75	2262.52	2262515.66	Residential
AK74	AK74_01	1031.00	567.65	567649.99	Residential
AK74	AK74_02	482.25	100.72	100717.06	Residential
AK74	AK74_03	476.00	128.56	128558.07	Residential
AK74	AK74_04	2358.75	816.12	816120.85	Residential
AK74	AK74_05	629.75	248.06	248064.04	Residential
AK74	AK74_06	1106.00	465.97	465969.92	Residential
AK74	AK74_07	359.00	126.14	126138.05	Residential
AK74	AK74_08	212.50	74.43	74428.28	Residential
AK74	AK74_09	486.75	174.63	174633.04	Residential
AK74	AK74_10	331.00	96.54	96535.61	Residential

AK74	AK74_11	397.25	212.61	212608.93	Residential
AK74	AK74_12	125.00	37.87	37869.18	Residential
AK74	AK74_13	247.50	107.37	107372.31	Residential
AK74	AK74_14	701.25	447.91	447905.09	Residential
AK74	AK74_15	1229.50	654.53	654531.40	Residential
AK74	AK74_16	68.25	20.32	20320.53	Residential
AK74	AK74_17	1165.40	328.61	328614.31	Residential
AK75	AK75_01	668.50	366.40	366398.68	Residential
AK75	AK75_02	629.00	223.00	223003.62	Residential
AK75	AK75_03	1910.10	1543.82	1543822.43	Residential
AK75	AK75_04	386.25	385.20	385202.31	Residential
AK75	AK75_05	464.50	330.91	330912.11	Residential
AK75	AK75_06	145.25	50.13	50130.12	Residential
AK75	AK75_07	236.00	147.70	147704.45	Residential
AK75	AK75_08	425.25	145.54	145543.39	Residential
AK75	AK75_09	1165.00	986.75	986754.91	Residential
AK75	AK75_10	1472.75	550.68	550684.03	Residential
AK75	AK75_11	1166.00	715.55	715554.35	Residential
AK75	AK75_12	6.50	1.79	1785.32	Residential
AK75	AK75_13	5.25	1.29	1291.66	Residential
AK75	AK75_14	90.75	17.38	17381.26	Residential
AK75	AK75_15	572.25	363.48	363475.71	Residential
AK75	AK75_16	98.50	19.38	19381.55	Residential
AK75	AK75_17	336.00	166.84	166840.45	Residential
AK75	AK75_18	1271.25	1407.82	1407823.87	Residential
AK75	AK75_19	922.75	395.50	395495.05	Residential
AK75	AK75_20	8.00	2.19	2185.38	Residential
AK75	AK75_21	916.00	746.40	746402.94	Residential

AK75	AK75_22	1190.75	832.69	832692.29	Residential
AK75	AK75_23	35.25	7.81	7807.55	Residential
AK75	AK75_24	105.50	28.22	28224.71	Residential
AK75	AK75_25	407.70	127.42	127421.73	Residential
AK75	AK75_26	2951.48	1735.09	1735092.48	Residential
AK75	AK75_27	229.25	72.15	72150.68	Residential
AK75	AK75_28	228.25	140.04	140040.34	Residential
AK75	AK75_29	839.50	1008.72	1008723.86	Residential
AK75	AK75_30	823.76	455.57	455569.80	Residential
AK75	AK75_31	173.50	69.32	69324.21	Residential
AK75	AK75_32	31.25	6.07	6071.27	Residential
AK75	AK75_33	218.25	101.13	101130.72	Residential
AK75	AK75_34	2026.50	2306.60	2306603.47	Residential
AK75	AK75_35	893.50	466.43	466425.56	Residential
AK75	AK75_36	751.75	459.13	459134.91	Residential
AK75	AK75_37	234.25	113.93	113925.63	Residential
AK75	AK75_38	1207.50	843.37	843371.97	Residential
AK75	AK75_39	409.00	190.23	190227.94	Residential
AK75	AK75_40	145.92	21.52	21515.05	Residential
AK75	AK75_41	121.00	26.95	26952.86	Residential
AK75	AK75_42	150.25	26.24	26241.40	Residential
AK75	AK75_43	6192.95	5041.22	5041217.49	Residential
AK75	AK75_44	3985.25	8909.76	8909763.76	Residential
AK75	AK75_45	788.50	231.28	231283.37	Residential
AK76	AK76_01	2230.71	820.73	820727.15	Residential
AK76	AK76_02	2209.54	826.20	826196.96	Residential
AK76	AK76_03	249.25	135.36	135360.44	Residential
AK76	AK76_04	541.00	491.10	491095.09	Residential

AK76	AK76_05	773.06	247.41	247412.31	Residential
AK76	AK76_06	1162.92	388.59	388589.36	Residential
AK76	AK76_07	4949.95	3182.77	3182773.50	Residential
AK76	AK76_08	848.25	376.82	376820.40	Residential
AK76	AK76_09	5622.88	3688.59	3688587.98	Residential
AK76	AK76_10	3292.26	2063.38	2063378.62	Residential
AK76	AK76_11	2219.00	2444.73	2444733.46	Residential
AK76	AK76_12	787.00	675.22	675222.49	Residential
AK76	AK76_13	360.50	222.12	222119.22	Residential
AK76	AK76_14	295.00	139.45	139448.28	Residential
AK76	AK76_15	1499.00	1408.90	1408898.25	Residential
AK76	AK76_16	751.25	481.33	481330.50	Residential
AK76	AK76_17	399.75	258.31	258310.23	Residential
AK76	AK76_18	792.50	602.76	602761.08	Residential
AK76	AK76_19	125.00	37.06	37057.40	Residential
AK76	AK76_20	563.25	403.49	403487.69	Residential
AK76	AK76_21	189.50	44.69	44687.00	Residential
AK76	AK76_22	2230.00	3039.39	3039387.90	Residential
AK76	AK76_23	756.50	326.54	326538.06	Residential
AK76	AK76_24	541.00	294.94	294938.07	Residential
AK76	AK76_25	591.25	282.91	282906.76	Residential
AK76	AK76_26	583.50	339.38	339381.60	Residential
AK76	AK76_27	463.00	227.92	227922.29	Residential
AK76	AK76_28	264.75	121.26	121255.93	Residential
AK76	AK76_29	1356.75	898.96	898960.88	Residential
AK76	AK76_30	544.94	101.74	101735.72	Residential
AK76	AK76_31	1709.75	1633.64	1633640.95	Residential
AK77	AK77_01	191.00	96.95	96952.38	Residential

AK77	AK77_02	5032.29	2039.67	2039674.28	Residential
AK77	AK77_03	658.50	375.02	375017.62	Residential
AK77	AK77_04	1235.50	512.92	512921.00	Residential
AK77	AK77_05	518.50	289.94	289938.40	Residential
AK77	AK77_06	139.25	48.47	48472.90	Residential
AK77	AK77_07	142.00	40.24	40235.57	Residential
AK77	AK77_08	204.25	99.21	99213.54	Residential
AK77	AK77_09	108.50	33.88	33879.98	Residential
AK77	AK77_10	57.50	12.41	12409.67	Residential
AK77	AK77_11	3811.75	13513.40	13513403.75	Residential
AK78	AK78_01	1117.09	856.27	856265.69	Residential
AK78	AK78_02	1221.25	935.55	935552.25	Residential
AK78	AK78_03	1067.25	628.68	628679.11	Residential
AK78	AK78_04	254.50	56.73	56725.67	Residential
AK78	AK78_05	576.75	161.23	161230.65	Residential
AK78	AK78_06	3692.25	716.24	716237.13	Residential
AK78	AK78_07	379.19	136.53	136532.56	Residential
AK78	AK78_08	14.25	6.02	6018.35	Residential
AL72	AL72_01	563.25	541.31	541308.81	Residential
AL72	AL72_02	3490.25	2382.46	2382457.24	Residential
AL72	AL72_03	861.03	358.03	358031.67	Residential
AL72	AL72_04	603.50	196.00	195996.89	Residential
AL72	AL72_05	6509.03	5160.66	5160661.19	Residential
AL73	AL73_01	387.00	269.47	269471.65	Residential
AL73	AL73_02	1460.02	1975.58	1975581.86	Residential
AL73	AL73_03	1128.75	746.36	746364.50	Residential
AL73	AL73_04	367.50	195.93	195933.44	Residential
AL73	AL73_05	1787.67	1609.52	1609517.32	Residential

AL73	AL73_06	1606.50	2239.64	2239636.36	Residential
AL73	AL73_07	1041.00	876.29	876292.53	Residential
AL73	AL73_08	624.75	374.95	374946.00	Residential
AL73	AL73_09	921.25	413.78	413778.99	Residential
AL73	AL73_10	539.00	424.38	424384.76	Residential
AL73	AL73_11	1047.75	1050.07	1050071.95	Residential
AL73	AL73_12	210.00	54.77	54766.80	Residential
AL73	AL73_13	173.75	78.02	78016.46	Residential
AL73	AL73_14	2180.50	2858.41	2858412.21	Residential
AL73	AL73_15	2967.25	5854.37	5854373.20	Residential
AL73	AL73_16	938.25	483.95	483949.58	Residential
AL73	AL73_17	1092.00	1140.87	1140865.36	Residential
AL73	AL73_18	1435.50	1188.99	1188989.81	Residential
AL73	AL73_19	371.75	278.05	278050.26	Residential
AL73	AL73_20	885.75	762.89	762894.64	Residential
AL73	AL73_21	411.75	168.87	168868.07	Residential
AL73	AL73_22	924.25	592.70	592695.41	Residential
AL73	AL73_23	1254.50	968.59	968586.82	Residential
AL73	AL73_24	303.50	193.05	193051.78	Residential
AL73	AL73_25	490.75	282.19	282189.26	Residential
AL73	AL73_26	2531.50	3391.67	3391669.90	Residential
AL73	AL73_27	1166.25	1005.53	1005526.82	Residential
AL73	AL73_28	2591.93	2864.06	2864056.24	Residential
AL73	AL73_29	635.50	455.96	455964.39	Residential
AL73	AL73_30	446.10	144.45	144448.02	Residential
AL73	AL73_31	618.25	390.82	390821.37	Residential
AL73	AL73_32	1192.00	1285.00	1284998.11	Residential
AL73	AL73_33	1123.00	850.06	850061.38	Residential

AL73	AL73_34	2229.00	2723.31	2723305.51	Residential
AL74	AL74_01	997.00	682.18	682182.81	Residential
AL74	AL74_02	688.75	261.41	261414.15	Residential
AL74	AL74_03	709.50	468.49	468486.68	Residential
AL74	AL74_04	3332.00	3029.72	3029718.23	Residential
AL74	AL74_05	135.50	24.04	24038.33	Residential
AL74	AL74_06	554.00	281.76	281763.68	Residential
AL74	AL74_07	1153.50	1265.48	1265483.80	Residential
AL74	AL74_08	415.00	307.59	307585.10	Residential
AL74	AL74_09	1115.25	872.76	872759.54	Residential
AL74	AL74_10	211.25	57.84	57844.06	Residential
AL74	AL74_11	197.25	53.52	53523.50	Residential
AL74	AL74_12	874.25	408.67	408669.92	Residential
AL74	AL74_13	250.75	62.91	62914.40	Residential
AL74	AL74_14	1570.00	1281.80	1281796.04	Residential
AL74	AL74_15	349.75	195.68	195676.86	Residential
AL74	AL74_16	160.50	57.31	57313.00	Residential
AL74	AL74_17	190.25	45.97	45967.19	Residential
AL74	AL74_18	387.25	266.43	266432.47	Residential
AL74	AL74_19	136.75	40.38	40378.96	Residential
AL74	AL74_20	1007.75	410.49	410492.78	Residential
AL74	AL74_21	483.75	246.23	246234.60	Residential
AL74	AL74_22	541.25	261.31	261310.75	Residential
AL74	AL74_23	933.50	637.36	637360.32	Residential
AL74	AL74_24	543.25	227.19	227186.56	Residential
AL74	AL74_25	752.75	395.57	395573.96	Residential
AL74	AL74_26	117.50	42.33	42328.66	Residential
AL74	AL74_27	623.50	268.46	268464.44	Residential

AL74	AL74_28	194.00	84.84	84838.58	Residential
AL75	AL75_01	536.25	281.07	281073.94	Residential
AL75	AL75_02	4944.25	5160.20	5160201.90	Residential
AL75	AL75_03	104.75	43.09	43089.67	Residential
AL75	AL75_04	1118.00	682.29	682294.27	Residential
AL75	AL75_05	539.01	234.21	234212.35	Residential
AL75	AL75_06	2960.25	2476.02	2476018.36	Residential
AL75	AL75_07	269.50	153.43	153426.84	Residential
AL75	AL75_08	1124.50	803.21	803213.45	Residential
AL75	AL75_09	314.25	124.77	124765.77	Residential
AL75	AL75_10	5363.25	8791.02	8791022.88	Residential
AL75	AL75_11	554.25	354.16	354159.88	Residential
AL75	AL75_13	532.75	328.10	328096.78	Residential
AL75	AL75_14	862.00	726.75	726750.25	Residential
AL75	AL75_15	70.50	15.47	15474.67	Residential
AL75	AL75_16	589.25	199.17	199166.99	Residential
AL75	AL75_17	421.25	138.69	138691.87	Residential
AL75	AL75_18	560.00	230.16	230164.17	Residential
AL75	AL75_19	455.25	138.08	138077.04	Residential
AL75	AL75_20	2563.50	4438.21	4438211.46	Residential
AL75	AL75_21	696.25	326.34	326337.18	Residential
AL75	AL75_22	54.00	14.33	14327.65	Residential
AL75	AL75_23	2707.50	4132.53	4132525.88	Residential
AL75	AL75_24	166.25	51.48	51477.76	Residential
AL75	AL75_25	1066.75	773.69	773691.13	Residential
AL75	AL75_26	1124.75	910.72	910719.72	Residential
AL75	AL75_27	91.25	24.50	24503.16	Residential
AL75	AL75_28	847.00	430.99	430994.30	Residential

AL75	AL75_29	1382.14	1100.78	1100781.82	Residential
AL75	AL75_31	1711.25	1264.10	1264095.77	Residential
AL75	AL75_32	18.25	2.80	2797.39	Residential
AL75	AL75_33	462.75	218.34	218337.42	Residential
AL75	AL75_34	776.00	576.62	576623.30	Residential
AL75	AL75_35	300.50	123.81	123811.13	Residential
AL75	AL75_36	779.50	244.33	244329.52	Residential
AL75	AL75_37	1247.90	1286.22	1286217.10	Residential
AL76	AL76_01	608.25	388.86	388857.09	Residential
AL76	AL76_02	2257.75	1476.34	1476343.42	Residential
AL76	AL76_03	1030.00	463.52	463524.82	Residential
AL76	AL76_04	217.50	64.45	64453.21	Residential
AL76	AL76_05	44.00	11.02	11018.34	Residential
AL76	AL76_07	170.75	56.72	56716.87	Residential
AL77	AL77_01	160.25	67.07	67071.87	Residential
AL77	AL77_01	160.25	67.07	67071.87	Residential
AL77	AL77_02	545.75	273.11	273113.17	Residential
AL77	AL77_02	545.75	273.11	273113.17	Residential
AL77	AL77_03	94.00	24.25	24245.43	Residential
AL77	AL77_04	378.25	142.42	142417.87	Residential
AL78	AL78_01	476.25	140.57	140574.61	Residential
AL78	AL78_02	405.78	113.53	113534.18	Residential
AL78	AL78_03	183.50	48.63	48627.33	Residential
AL78	AL78_04	469.25	170.16	170162.67	Residential
AL78	AL78_05	338.75	116.41	116414.05	Residential
AL78	AL78_06	469.00	409.15	409147.28	Residential
AL78	AL78_07	1460.50	799.59	799586.04	Residential
AL78	AL78_08	941.25	339.10	339096.31	Residential

AM72	AM72_01	2795.75	2567.29	2567292.37	Residential
AM73	AM73_01	1181.50	992.39	992393.76	Residential
AM73	AM73_02	105.25	44.92	44917.24	Residential
AM73	AM73_03	91.75	20.67	20665.24	Residential
AM73	AM73_04	456.75	261.68	261678.63	Residential
AM73	AM73_05	2539.89	2054.92	2054924.05	Residential
AM73	AM73_06	553.00	562.25	562246.02	Residential
AM73	AM73_07	189.00	87.44	87436.22	Residential
AM73	AM73_08	318.50	145.74	145739.46	Residential
AM73	AM73_09	200.25	86.27	86271.35	Residential
AM73	AM73_10	514.25	480.31	480305.79	Residential
AM73	AM73_11	738.00	492.12	492120.35	Residential
AM74	AM74_01	540.75	379.01	379011.10	Residential
AM74	AM74_02	790.75	368.60	368603.02	Residential
AM74	AM74_03	968.75	630.74	630735.96	Residential
AM74	AM74_04	3189.75	4043.91	4043905.41	Residential
AM74	AM74_05	1069.25	1331.57	1331566.72	Residential
AM74	AM74_06	707.50	498.72	498721.81	Residential
AM74	AM74_07	103.75	51.69	51686.08	Residential
AM74	AM74_09	681.00	540.32	540324.30	Residential
AM74	AM74_10	287.00	241.59	241589.54	Residential
AM74	AM74_11	272.25	154.99	154994.87	Residential
AM74	AM74_12	689.25	242.30	242300.20	Residential
AM74	AM74_13	1165.25	867.34	867337.36	Residential
AM74	AM74_14	305.00	135.86	135863.24	Residential
AM74	AM74_16	46.50	10.22	10222.00	Residential
AM74	AM74_17	181.25	65.24	65236.36	Residential
AM74	AM74_18	446.25	379.46	379458.73	Residential

AM74	AM74_19	958.25	1028.62	1028620.45	Residential
AM74	AM74_20	237.25	105.98	105982.56	Residential
AM74	AM74_21	170.00	54.23	54228.51	Residential
AM74	AM74_22	488.50	255.83	255828.27	Residential
AM74	AM74_23	222.75	73.83	73827.34	Residential
AM74	AM74_24	228.50	163.05	163052.93	Residential
AM74	AM74_25	1035.75	1016.02	1016018.52	Residential
AM74	AM74_26	1233.00	1183.45	1183449.90	Residential
AM74	AM74_27	1207.25	1593.90	1593896.70	Residential
AM74	AM74_28	1091.25	946.52	946522.38	Residential
AM74	AM74_29	1390.50	2061.98	2061977.74	Residential
AM74	AM74_30	711.50	324.21	324211.40	Residential
AM74	AM74_31	1441.75	1087.64	1087644.39	Residential
AM74	AM74_32	697.63	366.59	366585.18	Residential
AM74	AM74_33	114.75	39.20	39199.28	Residential
AM74	AM74_34	1319.00	741.06	741057.48	Residential
AM74	AM74_35	423.00	122.42	122421.85	Residential
AM74	AM74_36	1007.25	581.47	581468.56	Residential
AM75	AM75_01	234.25	118.92	118918.82	Residential
AM75	AM75_02	561.25	314.31	314313.59	Residential
AM75	AM75_03	4869.00	7987.68	7987677.56	Residential
AM75	AM75_04	2136.50	2192.56	2192563.12	Residential
AM75	AM75_05	314.00	89.09	89092.07	Residential
AM75	AM75_06	652.00	258.66	258655.32	Residential
AM75	AM75_07	1088.50	620.84	620836.22	Residential
AM75	AM75_08	5827.50	8212.69	8212693.60	Residential
AM75	AM75_09	323.75	109.02	109024.08	Residential
AM75	AM75_10	520.75	326.60	326598.32	Residential

AM75	AM75_11	819.75	685.24	685242.73	Residential
AM75	AM75_12	797.50	480.85	480845.43	Residential
AM75	AM75_13	1012.00	757.33	757329.70	Residential
AM75	AM75_14	1099.50	842.08	842078.97	Residential
AM75	AM75_15	5364.50	5424.35	5424353.59	Residential
AM76	AM76_01	407.75	168.26	168255.45	Residential
AN73	AN73_01	1079.50	790.25	790245.50	Residential
AN73	AN73_02	1320.50	1925.27	1925274.03	Residential
AN73	AN73_03	1165.00	910.09	910093.15	Residential
AN73	AN73_04	383.00	292.90	292901.23	Residential
AN73	AN73_05	354.50	181.90	181901.43	Residential
AN73	AN73_06	1076.64	681.85	681853.58	Residential
AN73	AN73_07	561.25	297.44	297438.54	Residential
AN73	AN73_08	154.00	32.27	32273.08	Residential
AN73	AN73_09	2095.60	1757.37	1757366.50	Residential
AN74	AN74_01	648.25	276.87	276872.33	Residential
AN74	AN74_02	944.00	928.81	928810.30	Residential
AN74	AN74_03	1513.50	1253.88	1253881.75	Residential
AN74	AN74_04	825.00	373.51	373514.41	Residential
AN74	AN74_05	782.00	899.80	899804.60	Residential
AN74	AN74_06	172.50	126.36	126358.84	Residential
AN74	AN74_07	491.50	437.14	437138.45	Residential
AN74	AN74_08	515.75	296.27	296268.32	Residential
AN74	AN74_09	592.00	268.92	268923.33	Residential
AN74	AN74_10	1355.50	1334.62	1334621.50	Residential
AN74	AN74_11	1360.25	1051.25	1051248.88	Residential
AN74	AN74_12	1982.25	2567.07	2567067.83	Residential
AN74	AN74_13	193.50	87.05	87051.95	Residential

AN74	AN74_14	3439.82	3250.53	3250529.24	Residential
AN74	AN74_15	628.25	401.92	401920.92	Residential
AN74	AN74_16	2479.00	3429.22	3429217.21	Residential
AN74	AN74_17	203.75	80.97	80967.46	Residential
AN74	AN74_18	1485.25	2168.00	2167997.68	Residential
AN74	AN74_19	596.50	298.41	298412.67	Residential
AN74	AN74_20	200.25	104.26	104256.93	Residential
AN74	AN74_21	259.00	100.28	100282.25	Residential
AN74	AN74_22	651.00	524.90	524897.70	Residential
AN74	AN74_23	545.75	576.54	576541.24	Residential
AN74	AN74_24	1918.75	2107.56	2107564.66	Residential
AN74	AN74_25	766.00	727.14	727141.13	Residential
AN74	AN74_26	881.50	799.67	799674.06	Residential
AN74	AN74_27	1434.50	1532.72	1532721.43	Residential
AN74	AN74_28	399.00	280.24	280235.00	Residential
AN74	AN74_29	375.25	150.39	150389.67	Residential
AN75	AN75_01	638.25	384.16	384161.05	Residential
AN75	AN75_02	1037.00	790.87	790869.40	Residential
AN75	AN75_03	411.00	248.59	248589.95	Residential
AN75	AN75_04	163.75	43.49	43494.01	Residential
AN75	AN75_05	680.25	546.62	546622.49	Residential
AN75	AN75_06	939.50	733.55	733550.64	Residential
AN75	AN75_07	1254.00	1256.89	1256888.61	Residential
AN75	AN75_08	781.37	474.47	474474.33	Residential
AN75	AN75_09	270.50	95.86	95856.79	Residential
AN75	AN75_10	1985.00	1395.04	1395035.45	Residential
AN75	AN75_11	530.50	327.04	327036.02	Residential
AN75	AN75_12	194.25	70.31	70308.20	Residential

AN75	AN75_13	899.75	716.08	716075.56	Residential
AN75	AN75_14	461.25	268.48	268477.56	Residential
AN75	AN75_15	1330.75	1349.09	1349089.47	Residential
AN75	AN75_16	461.50	297.42	297422.69	Residential
AN75	AN75_17	1938.25	1227.70	1227704.17	Residential
AN75	AN75_18	933.25	486.54	486537.85	Residential
AN75	AN75_20	1620.00	1827.62	1827616.67	Residential
AN76	AN76_01	466.25	241.56	241559.49	Residential
AN76	AN76_02	807.00	421.03	421030.75	Residential
AN76	AN76_03	660.50	636.08	636077.10	Residential
AN76	AN76_04	691.00	228.68	228680.40	Residential
AN76	AN76_05	1186.25	1445.50	1445496.58	Residential
AN76	AN76_06	1326.49	488.23	488225.13	Residential
AO73	AO73_01	755.75	530.53	530526.79	Residential
AO74	AO74_01	1943.75	3066.32	3066319.29	Residential
AO74	AO74_02	930.75	448.51	448511.88	Residential
AO74	AO74_03	2224.00	3104.04	3104044.53	Residential
AO74	AO74_04	6696.88	4193.26	4193262.63	Residential
AO74	AO74_05	5.25	2.94	2938.02	Residential
AO74	AO74_06	7592.00	12080.58	12080575.05	Residential
AO75	AO75_01	1466.75	1344.34	1344343.29	Residential
AO75	AO75_02	1056.50	773.19	773190.68	Residential
AO75	AO75_03	6.75	2.84	2839.11	Residential
Margin	Margin_01	111679.00	93042.69	93042690.93	Agricultural
Margin	Margin_02	472436.14	905080.70	905080695.80	Agricultural
Margin	Margin_03	42472.00	77228.88	77228878.83	Agricultural
Margin	Margin_04	23407.50	13704.85	13704854.88	Agricultural
Margin	Margin_05	65047.21	96943.64	96943641.37	Agricultural

Margin	Margin_06	7989.00	4324.40	4324403.51	Agricultural
Margin	Margin_07	124679.50	718219.90	718219901.60	Agricultural
Margin	Margin_08	7335.75	6018.90	6018904.38	Agricultural
Margin	Margin_09	127132.25	926400.68	926400679.70	Agricultural
Margin	Margin_10	24385.56	12338.52	12338522.71	Agricultural
Margin	Margin_11	9946.25	9384.89	9384894.86	Agricultural
Margin	Margin_12	19891.50	81743.99	81743987.78	Agricultural
Margin	Margin_13	5746.50	1495.30	1495304.65	Agricultural
AM73	Well_01	55.06	45.91	45905.20	Well
AM73	Well_02	20.50	20.05	20052.08	Well
AL76	Well_03	10.47	7.09	7085.62	Well
AE75	Well_04	43.50	31.50	31496.55	Well

Table 2

AM73_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	26.10	52.21	78.31	104.42	130.52	156.63	182.73	208.84	234.94	992.39
June	105.63	211.27	316.90	422.53	528.16	633.80	739.43	845.06	950.70	992.39
July	144.49	288.97	433.46	577.95	722.43	866.92	1011.41	1155.89	1300.38	992.39
August	144.49	288.97	433.46	577.95	722.43	866.92	1011.41	1155.89	1300.38	992.39
September	115.35	230.69	346.04	461.39	576.73	692.08	807.42	922.77	1038.12	992.39
October	46.75	93.49	140.24	186.98	233.73	280.47	327.22	373.97	420.71	992.39

AM73_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	47.07	94.13	141.20	188.26	235.33	282.40	329.46	376.53	423.59	44.92
June	190.45	380.91	571.36	761.81	952.27	1142.72	1333.17	1523.63	1714.08	44.92
July	260.50	521.01	781.51	1042.02	1302.52	1563.03	1823.53	2084.04	2344.54	44.92
August	260.50	521.01	781.51	1042.02	1302.52	1563.03	1823.53	2084.04	2344.54	44.92
September	207.97	415.93	623.90	831.86	1039.83	1247.80	1455.76	1663.73	1871.69	44.92
October	84.28	168.56	252.84	337.12	421.40	505.69	589.97	674.25	758.53	44.92

AM73_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	26.96	94.13	141.20	188.26	235.33	282.40	329.46	376.53	423.59	261.68
June	109.11	380.91	571.36	761.81	952.27	1142.72	1333.17	1523.63	1714.08	261.68
July	149.25	521.01	781.51	1042.02	1302.52	1563.03	1823.53	2084.04	2344.54	261.68
August	149.25	521.01	781.51	1042.02	1302.52	1563.03	1823.53	2084.04	2344.54	261.68
September	119.15	415.93	623.90	831.86	1039.83	1247.80	1455.76	1663.73	1871.69	261.68
October	48.29	168.56	252.84	337.12	421.40	505.69	589.97	674.25	758.53	261.68

AM73_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	577.66	1155.32	1732.99	2310.65	2888.31	3465.97	4043.63	4621.29	5198.96	2054.92
June	2337.51	4675.03	7012.54	9350.06	11687.57	14025.09	16362.60	18700.12	21037.63	2054.92
July	3197.29	6394.58	9591.87	12789.16	15986.45	19183.74	22381.03	25578.32	28775.61	2054.92
August	3197.29	6394.58	9591.87	12789.16	15986.45	19183.74	22381.03	25578.32	28775.61	2054.92
September	2552.46	5104.92	7657.38	10209.83	12762.29	15314.75	17867.21	20419.67	22972.13	2054.92
October	1034.42	2068.83	3103.25	4137.67	5172.09	6206.50	7240.92	8275.34	9309.76	2054.92

AM73_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	25.33	50.65	75.98	101.30	126.63	151.95	177.28	202.61	227.93	562.25
June	102.48	204.96	307.44	409.92	512.41	614.89	717.37	819.85	922.33	562.25
July	140.18	280.35	420.53	560.70	700.88	841.05	981.23	1121.40	1261.58	562.25
August	140.18	280.35	420.53	560.70	700.88	841.05	981.23	1121.40	1261.58	562.25
Septembe r	111.90	223.81	335.71	447.62	559.52	671.43	783.33	895.24	1007.14	562.25
October	45.35	90.70	136.05	181.40	226.75	272.10	317.46	362.81	408.16	562.25

AM73_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	10.07	20.13	30.20	40.26	50.33	60.39	70.46	80.52	90.59	87.44
June	40.73	81.46	122.19	162.92	203.65	244.38	285.11	325.83	366.56	87.44
July	55.71	111.42	167.13	222.84	278.55	334.26	389.97	445.68	501.39	87.44
August	55.71	111.42	167.13	222.84	278.55	334.26	389.97	445.68	501.39	87.44
September	44.47	88.95	133.42	177.90	222.37	266.85	311.32	355.80	400.27	87.44
October	18.02	36.05	54.07	72.10	90.12	108.14	126.17	144.19	162.21	87.44

AM73_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	5.70	11.41	17.11	22.82	28.52	34.23	39.93	45.64	51.34	86.27
June	23.08	46.17	69.25	92.34	115.42	138.51	161.59	184.67	207.76	86.27
July	31.57	63.15	94.72	126.30	157.87	189.45	221.02	252.60	284.17	86.27
August	31.57	63.15	94.72	126.30	157.87	189.45	221.02	252.60	284.17	86.27
September	25.21	50.41	75.62	100.83	126.03	151.24	176.45	201.66	226.86	86.27
October	10.22	20.43	30.65	40.86	51.08	61.29	71.51	81.72	91.94	86.27

AM73_10

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	15.44	50.65	75.98	101.30	126.63	151.95	177.28	202.61	227.93	480.31
June	62.48	204.96	307.44	409.92	512.41	614.89	717.37	819.85	922.33	480.31
July	85.46	280.35	420.53	560.70	700.88	841.05	981.23	1121.40	1261.58	480.31
August	85.46	280.35	420.53	560.70	700.88	841.05	981.23	1121.40	1261.58	480.31
September	68.22	223.81	335.71	447.62	559.52	671.43	783.33	895.24	1007.14	480.31
October	27.65	90.70	136.05	181.40	226.75	272.10	317.46	362.81	408.16	480.31

AM73_11

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	44.10	88.20	132.30	176.40	220.50	264.60	308.70	352.80	396.90	492.12
June	178.45	356.90	535.35	713.80	892.25	1070.70	1249.15	1427.60	1606.05	492.12
July	244.09	488.17	732.26	976.35	1220.43	1464.52	1708.60	1952.69	2196.78	492.12
August	244.09	488.17	732.26	976.35	1220.43	1464.52	1708.60	1952.69	2196.78	492.12
September	194.86	389.72	584.58	779.44	974.29	1169.15	1364.01	1558.87	1753.73	492.12
October	78.97	157.94	236.91	315.88	394.85	473.81	552.78	631.75	710.72	492.12

AM74_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	34.78	69.57	104.35	139.13	173.92	208.70	243.49	278.27	313.05	379.01
June	140.75	281.50	422.26	563.01	703.76	844.51	985.27	1126.02	1266.77	379.01
July	192.52	385.05	577.57	770.09	962.62	1155.14	1347.66	1540.19	1732.71	379.01
August	192.52	385.05	577.57	770.09	962.62	1155.14	1347.66	1540.19	1732.71	379.01
September	153.69	307.39	461.08	614.78	768.47	922.17	1075.86	1229.56	1383.25	379.01
October	62.29	124.57	186.86	249.15	311.43	373.72	436.01	498.30	560.58	379.01

AM74_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	80.32	160.64	240.95	321.27	401.59	481.91	562.22	642.54	722.86	368.60
June	325.01	650.01	975.02	1300.03	1625.03	1950.04	2275.04	2600.05	2925.06	368.60
July	444.55	889.10	1333.65	1778.20	2222.74	2667.29	3111.84	3556.39	4000.94	368.60
August	444.55	889.10	1333.65	1778.20	2222.74	2667.29	3111.84	3556.39	4000.94	368.60
September	354.89	709.78	1064.68	1419.57	1774.46	2129.35	2484.24	2839.14	3194.03	368.60
October	143.82	287.65	431.47	575.30	719.12	862.95	1006.77	1150.60	1294.42	368.60

AM74_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	19.62	39.25	58.87	78.49	98.11	117.74	137.36	156.98	176.60	630.74
June	79.40	158.81	238.21	317.61	397.02	476.42	555.82	635.23	714.63	630.74
July	108.61	217.22	325.83	434.44	543.05	651.66	760.27	868.88	977.48	630.74
August	108.61	217.22	325.83	434.44	543.05	651.66	760.27	868.88	977.48	630.74
September	86.71	173.41	260.12	346.82	433.53	520.23	606.94	693.64	780.35	630.74
October	35.14	70.28	105.42	140.55	175.69	210.83	245.97	281.11	316.25	630.74

AM74_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	66.30	132.61	198.91	265.21	331.51	397.82	464.12	530.42	596.72	4043.91
June	268.29	536.59	804.88	1073.18	1341.47	1609.76	1878.06	2146.35	2414.65	4043.91
July	366.98	733.95	1100.93	1467.91	1834.88	2201.86	2568.84	2935.81	3302.79	4043.91
August	366.98	733.95	1100.93	1467.91	1834.88	2201.86	2568.84	2935.81	3302.79	4043.91
September	292.96	585.93	878.89	1171.86	1464.82	1757.79	2050.75	2343.72	2636.68	4043.91
October	118.73	237.46	356.18	474.91	593.64	712.37	831.09	949.82	1068.55	4043.91

AM74_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	54.95	109.90	164.84	219.79	274.74	329.69	384.64	439.59	494.53	1331.57
June	222.35	444.70	667.04	889.39	1111.74	1334.09	1556.44	1778.79	2001.13	1331.57
July	304.13	608.26	912.39	1216.53	1520.66	1824.79	2128.92	2433.05	2737.18	1331.57
August	304.13	608.26	912.39	1216.53	1520.66	1824.79	2128.92	2433.05	2737.18	1331.57
September	242.79	485.59	728.38	971.18	1213.97	1456.76	1699.56	1942.35	2185.15	1331.57
October	98.40	196.79	295.19	393.58	491.98	590.37	688.77	787.16	885.56	1331.57

AM74_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³

May	22.58	45.16	67.74	90.33	112.91	135.49	158.07	180.65	203.23	498.72
June	91.38	182.75	274.13	365.50	456.88	548.26	639.63	731.01	822.38	498.72
July	124.99	249.97	374.96	499.94	624.93	749.91	874.90	999.88	1124.87	498.72
August	124.99	249.97	374.96	499.94	624.93	749.91	874.90	999.88	1124.87	498.72
September	99.78	199.56	299.34	399.11	498.89	598.67	698.45	798.23	898.01	498.72
October	40.44	80.87	121.31	161.75	202.18	242.62	283.06	323.49	363.93	498.72

AM74_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	39.54	79.07	118.61	158.15	197.69	237.22	276.76	316.30	355.84	51.69
June	159.99	319.98	479.97	639.95	799.94	959.93	1119.92	1279.91	1439.90	51.69
July	218.83	437.67	656.50	875.34	1094.17	1313.01	1531.84	1750.68	1969.51	51.69
August	218.83	437.67	656.50	875.34	1094.17	1313.01	1531.84	1750.68	1969.51	51.69
September	174.70	349.40	524.10	698.80	873.50	1048.20	1222.90	1397.60	1572.30	51.69
October	70.80	141.60	212.40	283.20	354.00	424.80	495.60	566.40	637.20	51.69

AM74_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	28.51	57.01	85.52	114.02	142.53	171.03	199.54	228.05	256.55	540.32
June	115.35	230.70	346.05	461.40	576.74	692.09	807.44	922.79	1038.14	540.32
July	157.78	315.55	473.33	631.10	788.88	946.66	1104.43	1262.21	1419.99	540.32
August	157.78	315.55	473.33	631.10	788.88	946.66	1104.43	1262.21	1419.99	540.32
September	125.96	251.91	377.87	503.82	629.78	755.73	881.69	1007.65	1133.60	540.32
October	51.05	102.09	153.14	204.18	255.23	306.27	357.32	408.36	459.41	540.32

AM74_10

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	2.82	5.64	8.46	11.28	14.11	16.93	19.75	22.57	25.39	241.59

June	11.42	22.83	34.25	45.66	57.08	68.50	79.91	91.33	102.74	241.59
July	15.61	31.23	46.84	62.46	78.07	93.69	109.30	124.92	140.53	241.59
August	15.61	31.23	46.84	62.46	78.07	93.69	109.30	124.92	140.53	241.59
September	12.47	24.93	37.40	49.86	62.33	74.79	87.26	99.73	112.19	241.59
October	5.05	10.10	15.16	20.21	25.26	30.31	35.36	40.42	45.47	241.59

AM74_11

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	27.10	54.19	81.29	108.38	135.48	162.57	189.67	216.76	243.86	154.99
June	109.64	219.28	328.93	438.57	548.21	657.85	767.50	877.14	986.78	154.99
July	149.97	299.94	449.91	599.88	749.85	899.82	1049.79	1199.76	1349.73	154.99
August	149.97	299.94	449.91	599.88	749.85	899.82	1049.79	1199.76	1349.73	154.99
September	119.72	239.45	359.17	478.90	598.62	718.35	838.07	957.79	1077.52	154.99
October	48.52	97.04	145.56	194.08	242.60	291.12	339.64	388.16	436.68	154.99

AM74_12

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	22.08	44.17	66.25	88.34	110.42	132.51	154.59	176.68	198.76	242.30
June	89.37	178.73	268.10	357.47	446.83	536.20	625.57	714.93	804.30	242.30
July	122.24	244.47	366.71	488.95	611.19	733.42	855.66	977.90	1100.13	242.30
August	122.24	244.47	366.71	488.95	611.19	733.42	855.66	977.90	1100.13	242.30
September	97.58	195.17	292.75	390.34	487.92	585.51	683.09	780.67	878.26	242.30
October	39.55	79.09	118.64	158.19	197.74	237.28	276.83	316.38	355.93	242.30

AM74_13

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	49.05	98.10	147.14	196.19	245.24	294.29	343.33	392.38	441.43	867.34
June	198.47	396.94	595.42	793.89	992.36	1190.83	1389.30	1587.78	1786.25	867.34

July	271.47	542.95	814.42	1085.89	1357.37	1628.84	1900.31	2171.79	2443.26	867.34
August	271.47	542.95	814.42	1085.89	1357.37	1628.84	1900.31	2171.79	2443.26	867.34
September	216.72	433.44	650.17	866.89	1083.61	1300.33	1517.06	1733.78	1950.50	867.34
October	87.83	175.66	263.49	351.32	439.15	526.98	614.81	702.64	790.47	867.34

AM74_14

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	9.60	19.19	28.79	38.39	47.98	57.58	67.18	76.77	86.37	135.86
June	38.83	77.67	116.50	155.33	194.17	233.00	271.83	310.67	349.50	135.86
July	53.12	106.23	159.35	212.47	265.59	318.70	371.82	424.94	478.05	135.86
August	53.12	106.23	159.35	212.47	265.59	318.70	371.82	424.94	478.05	135.86
September	42.40	84.81	127.21	169.62	212.02	254.43	296.83	339.24	381.64	135.86
October	17.18	34.37	51.55	68.74	85.92	103.11	120.29	137.48	154.66	135.86

AM74_16

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	1.67	3.35	5.02	6.70	8.37	10.04	11.72	13.39	15.06	10.22
June	6.77	13.55	20.32	27.09	33.86	40.64	47.41	54.18	60.96	10.22
July	9.26	18.53	27.79	37.06	46.32	55.58	64.85	74.11	83.38	10.22
August	9.26	18.53	27.79	37.06	46.32	55.58	64.85	74.11	83.38	10.22
September	7.40	14.79	22.19	29.58	36.98	44.37	51.77	59.17	66.56	10.22
October	3.00	5.99	8.99	11.99	14.99	17.98	20.98	23.98	26.98	10.22

AM74_17

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	15.20	30.41	45.61	60.82	76.02	91.23	106.43	121.64	136.84	65.24
June	61.53	123.05	184.58	246.10	307.63	369.15	430.68	492.20	553.73	65.24
July	84.15	168.31	252.46	336.62	420.77	504.93	589.08	673.24	757.39	65.24
August	84.15	168.31	252.46	336.62	420.77	504.93	589.08	673.24	757.39	65.24

September	67.18	134.37	201.55	268.73	335.91	403.10	470.28	537.46	604.64	65.24
October	27.23	54.45	81.68	108.91	136.13	163.36	190.59	217.81	245.04	65.24

AM74_18

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	15.01	30.03	45.04	60.05	75.06	90.08	105.09	120.10	135.12	379.46
June	60.75	121.50	182.25	243.00	303.75	364.50	425.25	486.00	546.75	379.46
July	83.10	166.19	249.29	332.38	415.48	498.57	581.67	664.76	747.86	379.46
August	83.10	166.19	249.29	332.38	415.48	498.57	581.67	664.76	747.86	379.46
September	66.34	132.67	199.01	265.35	331.68	398.02	464.35	530.69	597.03	379.46
October	26.88	53.77	80.65	107.53	134.42	161.30	188.19	215.07	241.95	379.46

AM74_19

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	38.38	76.75	115.13	153.50	191.88	230.26	268.63	307.01	345.38	1028.62
June	155.29	310.58	465.87	621.15	776.44	931.73	1087.02	1242.31	1397.60	1028.62
July	212.41	424.81	637.22	849.62	1062.03	1274.44	1486.84	1699.25	1911.66	1028.62
August	212.41	424.81	637.22	849.62	1062.03	1274.44	1486.84	1699.25	1911.66	1028.62
September	169.57	339.14	508.70	678.27	847.84	1017.41	1186.98	1356.54	1526.11	1028.62
October	68.72	137.44	206.16	274.88	343.60	412.32	481.04	549.76	618.48	1028.62

AM74_20

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	12.20	24.39	36.59	48.79	60.98	73.18	85.38	97.57	109.77	105.98
June	49.35	98.71	148.06	197.41	246.77	296.12	345.47	394.83	444.18	105.98
July	67.51	135.01	202.52	270.03	337.53	405.04	472.55	540.05	607.56	105.98
August	67.51	135.01	202.52	270.03	337.53	405.04	472.55	540.05	607.56	105.98
September	53.89	107.78	161.68	215.57	269.46	323.35	377.24	431.13	485.03	105.98

October	21.84	43.68	65.52	87.36	109.20	131.04	152.88	174.72	196.56	105.98

AM74_21

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	13.84	27.69	41.53	55.38	69.22	83.07	96.91	110.76	124.60	54.23
June	56.02	112.04	168.07	224.09	280.11	336.13	392.16	448.18	504.20	54.23
July	76.63	153.26	229.89	306.51	383.14	459.77	536.40	613.03	689.66	54.23
August	76.63	153.26	229.89	306.51	383.14	459.77	536.40	613.03	689.66	54.23
September	61.17	122.35	183.52	244.70	305.87	367.04	428.22	489.39	550.57	54.23
October	24.79	49.58	74.37	99.17	123.96	148.75	173.54	198.33	223.12	54.23

AM74_22

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max Vol. M^3
May	131.15	262.31	393.46	524.61	655.77	786.92	918.08	1049.23	1180.38	255.83
June	530.71	1061.43	1592.14	2122.86	2653.57	3184.29	3715.00	4245.72	4776.43	255.83
July	725.92	1451.84	2177.76	2903.68	3629.60	4355.52	5081.44	5807.36	6533.28	255.83
August	725.92	1451.84	2177.76	2903.68	3629.60	4355.52	5081.44	5807.36	6533.28	255.83
September	579.52	1159.03	1738.55	2318.06	2897.58	3477.10	4056.61	4636.13	5215.64	255.83
October	234.86	469.71	704.57	939.43	1174.28	1409.14	1644.00	1878.85	2113.71	255.83

AM74_23

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	42.61	85.21	127.82	170.43	213.04	255.64	298.25	340.86	383.46	73.83
June	172.41	344.82	517.23	689.64	862.05	1034.46	1206.87	1379.28	1551.69	73.83
July	235.83	471.65	707.48	943.30	1179.13	1414.96	1650.78	1886.61	2122.43	73.83
August	235.83	471.65	707.48	943.30	1179.13	1414.96	1650.78	1886.61	2122.43	73.83
September	188.26	376.53	564.79	753.06	941.32	1129.59	1317.85	1506.11	1694.38	73.83
October	76.30	152.59	228.89	305.19	381.48	457.78	534.08	610.37	686.67	73.83

AM74_24

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	11.99	23.99	35.98	47.98	59.97	71.97	83.96	95.95	107.95	163.05
June	48.53	97.07	145.60	194.14	242.67	291.21	339.74	388.28	436.81	163.05
July	66.39	132.77	199.16	265.55	331.93	398.32	464.70	531.09	597.48	163.05
August	66.39	132.77	199.16	265.55	331.93	398.32	464.70	531.09	597.48	163.05
September	53.00	106.00	158.99	211.99	264.99	317.99	370.98	423.98	476.98	163.05
October	21.48	42.96	64.43	85.91	107.39	128.87	150.35	171.82	193.30	163.05

AM74_25

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	27.91	55.82	83.72	111.63	139.54	167.45	195.35	223.26	251.17	1016.02
June	112.93	225.86	338.79	451.72	564.64	677.57	790.50	903.43	1016.36	1016.02
July	154.47	308.93	463.40	617.86	772.33	926.79	1081.26	1235.73	1390.19	1016.02
August	154.47	308.93	463.40	617.86	772.33	926.79	1081.26	1235.73	1390.19	1016.02
September	123.31	246.63	369.94	493.25	616.57	739.88	863.19	986.50	1109.82	1016.02
October	49.97	99.95	149.92	199.90	249.87	299.85	349.82	399.79	449.77	1016.02

AM74_26

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	28.64	57.29	85.93	114.58	143.22	171.86	200.51	229.15	257.79	1183.45
June	115.91	231.82	347.72	463.63	579.54	695.45	811.35	927.26	1043.17	1183.45
July	158.54	317.08	475.62	634.16	792.70	951.24	1109.78	1268.32	1426.86	1183.45
August	158.54	317.08	475.62	634.16	792.70	951.24	1109.78	1268.32	1426.86	1183.45
September	126.57	253.13	379.70	506.26	632.83	759.40	885.96	1012.53	1139.09	1183.45
October	51.29	102.59	153.88	205.17	256.46	307.76	359.05	410.34	461.63	1183.45

AM74_27

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	23.51	47.02	70.53	94.04	117.55	141.06	164.56	188.07	211.58	1593.90
June	95.13	190.26	285.39	380.52	475.65	570.78	665.91	761.04	856.17	1593.90
July	130.12	260.24	390.36	520.48	650.60	780.72	910.84	1040.97	1171.09	1593.90
August	130.12	260.24	390.36	520.48	650.60	780.72	910.84	1040.97	1171.09	1593.90
September	103.88	207.76	311.63	415.51	519.39	623.27	727.14	831.02	934.90	1593.90
October	42.10	84.20	126.29	168.39	210.49	252.59	294.68	336.78	378.88	1593.90

AM74_28

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	152.21	304.42	456.63	608.84	761.04	913.25	1065.46	1217.67	1369.88	946.52
June	615.91	1231.83	1847.74	2463.66	3079.57	3695.49	4311.40	4927.32	5543.23	946.52
July	842.46	1684.92	2527.37	3369.83	4212.29	5054.75	5897.21	6739.66	7582.12	946.52
August	842.46	1684.92	2527.37	3369.83	4212.29	5054.75	5897.21	6739.66	7582.12	946.52
September	672.55	1345.10	2017.65	2690.20	3362.75	4035.30	4707.85	5380.40	6052.95	946.52
October	272.56	545.12	817.68	1090.24	1362.80	1635.36	1907.92	2180.48	2453.04	946.52

AM74_29

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	31.87	63.74	95.61	127.47	159.34	191.21	223.08	254.95	286.82	2061.98
June	128.96	257.91	386.87	515.83	644.78	773.74	902.70	1031.65	1160.61	2061.98
July	176.39	352.78	529.17	705.56	881.94	1058.33	1234.72	1411.11	1587.50	2061.98
August	176.39	352.78	529.17	705.56	881.94	1058.33	1234.72	1411.11	1587.50	2061.98
September	140.81	281.63	422.44	563.26	704.07	844.89	985.70	1126.52	1267.33	2061.98
October	57.07	114.13	171.20	228.27	285.33	342.40	399.47	456.54	513.60	2061.98

AM74_30

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3

May	17.06	34.11	51.17	68.22	85.28	102.33	119.39	136.45	153.50	324.21
June	69.02	138.03	207.05	276.06	345.08	414.10	483.11	552.13	621.14	324.21
July	94.40	188.80	283.20	377.61	472.01	566.41	660.81	755.21	849.61	324.21
August	94.40	188.80	283.20	377.61	472.01	566.41	660.81	755.21	849.61	324.21
September	75.36	150.72	226.09	301.45	376.81	452.17	527.54	602.90	678.26	324.21
October	30.54	61.08	91.62	122.17	152.71	183.25	213.79	244.33	274.87	324.21

AM74_31

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	12.78	25.57	38.35	51.13	63.92	76.70	89.48	102.27	115.05	1087.64
June	51.73	103.46	155.18	206.91	258.64	310.37	362.10	413.83	465.55	1087.64
July	70.75	141.51	212.26	283.02	353.77	424.53	495.28	566.04	636.79	1087.64
August	70.75	141.51	212.26	283.02	353.77	424.53	495.28	566.04	636.79	1087.64
September	56.48	112.97	169.45	225.94	282.42	338.91	395.39	451.88	508.36	1087.64
October	22.89	45.78	68.67	91.56	114.46	137.35	160.24	183.13	206.02	1087.64

AM74_32

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	16.52	33.04	49.56	66.09	82.61	99.13	115.65	132.17	148.69	366.59
June	66.85	133.71	200.56	267.42	334.27	401.12	467.98	534.83	601.69	366.59
July	91.44	182.89	274.33	365.78	457.22	548.66	640.11	731.55	822.99	366.59
August	91.44	182.89	274.33	365.78	457.22	548.66	640.11	731.55	822.99	366.59
September	73.00	146.00	219.00	292.01	365.01	438.01	511.01	584.01	657.01	366.59
October	29.58	59.17	88.75	118.34	147.92	177.51	207.09	236.68	266.26	366.59

AM74_33

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	1.56	3.12	4.68	6.24	7.80	9.36	10.92	12.47	14.03	39.20

June	6.31	12.62	18.93	25.24	31.55	37.86	44.17	50.48	56.79	39.20
July	8.63	17.26	25.89	34.52	43.15	51.79	60.42	69.05	77.68	39.20
August	8.63	17.26	25.89	34.52	43.15	51.79	60.42	69.05	77.68	39.20
September	6.89	13.78	20.67	27.56	34.45	41.34	48.23	55.12	62.01	39.20
October	2.79	5.58	8.38	11.17	13.96	16.75	19.55	22.34	25.13	39.20

AM74_34

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	51.05	102.09	153.14	204.18	255.23	306.27	357.32	408.37	459.41	741.06
June	206.56	413.12	619.67	826.23	1032.79	1239.35	1445.90	1652.46	1859.02	741.06
July	282.53	565.07	847.60	1130.13	1412.66	1695.20	1977.73	2260.26	2542.79	741.06
August	282.53	565.07	847.60	1130.13	1412.66	1695.20	1977.73	2260.26	2542.79	741.06
September	225.55	451.10	676.65	902.21	1127.76	1353.31	1578.86	1804.41	2029.96	741.06
October	91.41	182.82	274.22	365.63	457.04	548.45	639.85	731.26	822.67	741.06

AM74_35

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	44.88	89.76	134.64	179.52	224.40	269.27	314.15	359.03	403.91	122.42
June	181.60	363.21	544.81	726.41	908.02	1089.62	1271.23	1452.83	1634.43	122.42
July	248.40	496.80	745.20	993.60	1242.00	1490.40	1738.80	1987.20	2235.60	122.42
August	248.40	496.80	745.20	993.60	1242.00	1490.40	1738.80	1987.20	2235.60	122.42
September	198.30	396.61	594.91	793.21	991.51	1189.82	1388.12	1586.42	1784.73	122.42
October	80.36	160.73	241.09	321.46	401.82	482.19	562.55	642.92	723.28	122.42

AM74_36

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	51.56	103.13	154.69	206.25	257.82	309.38	360.94	412.51	464.07	581.47
June	208.65	417.30	625.96	834.61	1043.26	1251.91	1460.56	1669.22	1877.87	581.47

July	285.40	570.80	856.19	1141.59	1426.99	1712.39	1997.78	2283.18	2568.58	581.47
August	285.40	570.80	856.19	1141.59	1426.99	1712.39	1997.78	2283.18	2568.58	581.47
September	227.84	455.68	683.52	911.35	1139.19	1367.03	1594.87	1822.71	2050.55	581.47
October	92.33	184.67	277.00	369.34	461.67	554.01	646.34	738.68	831.01	581.47

AM75_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	31.89	63.78	95.67	127.56	159.45	191.34	223.23	255.12	287.01	118.92
June	129.05	258.09	387.14	516.18	645.23	774.27	903.32	1032.36	1161.41	118.92
July	176.51	353.02	529.53	706.04	882.55	1059.06	1235.57	1412.08	1588.59	118.92
August	176.51	353.02	529.53	706.04	882.55	1059.06	1235.57	1412.08	1588.59	118.92
September	140.91	281.82	422.73	563.65	704.56	845.47	986.38	1127.29	1268.20	118.92
October	57.11	114.21	171.32	228.42	285.53	342.64	399.74	456.85	513.96	118.92

AM75_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	66.80	133.60	200.39	267.19	333.99	400.79	467.59	534.38	601.18	314.31
June	270.30	540.60	810.90	1081.19	1351.49	1621.79	1892.09	2162.39	2432.69	314.31
July	369.72	739.44	1109.16	1478.87	1848.59	2218.31	2588.03	2957.75	3327.47	314.31
August	369.72	739.44	1109.16	1478.87	1848.59	2218.31	2588.03	2957.75	3327.47	314.31
September	295.15	590.31	885.46	1180.61	1475.77	1770.92	2066.07	2361.23	2656.38	314.31
October	119.61	239.23	358.84	478.46	598.07	717.69	837.30	956.92	1076.53	314.31

AM75_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	87.36	174.72	262.08	349.44	436.80	524.15	611.51	698.87	786.23	7987.68
June	353.50	707.00	1060.50	1414.00	1767.50	2121.00	2474.50	2828.00	3181.50	7987.68
July	483.52	967.05	1450.57	1934.09	2417.61	2901.14	3384.66	3868.18	4351.70	7987.68

August	483.52	967.05	1450.57	1934.09	2417.61	2901.14	3384.66	3868.18	4351.70	7987.68
September	386.01	772.01	1158.02	1544.02	1930.03	2316.03	2702.04	3088.04	3474.05	7987.68
October	156.43	312.87	469.30	625.74	782.17	938.60	1095.04	1251.47	1407.90	7987.68

AM75_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	51.71	103.43	155.14	206.85	258.56	310.28	361.99	413.70	465.41	2192.56
June	209.26	418.51	627.77	837.03	1046.28	1255.54	1464.79	1674.05	1883.31	2192.56
July	286.22	572.45	858.67	1144.90	1431.12	1717.34	2003.57	2289.79	2576.02	2192.56
August	286.22	572.45	858.67	1144.90	1431.12	1717.34	2003.57	2289.79	2576.02	2192.56
September	228.50	457.00	685.49	913.99	1142.49	1370.99	1599.49	1827.99	2056.48	2192.56
October	92.60	185.20	277.81	370.41	463.01	555.61	648.21	740.82	833.42	2192.56

AM75_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	21.79	43.57	65.36	87.14	108.93	130.71	152.50	174.28	196.07	89.09
June	88.15	176.31	264.46	352.62	440.77	528.93	617.08	705.24	793.39	89.09
July	120.58	241.16	361.74	482.32	602.90	723.48	844.06	964.64	1085.22	89.09
August	120.58	241.16	361.74	482.32	602.90	723.48	844.06	964.64	1085.22	89.09
September	96.26	192.52	288.78	385.04	481.31	577.57	673.83	770.09	866.35	89.09
October	39.01	78.02	117.03	156.04	195.06	234.07	273.08	312.09	351.10	89.09

AM75_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	50.88	101.75	152.63	203.50	254.38	305.25	356.13	407.00	457.88	258.66
June	205.87	411.74	617.60	823.47	1029.34	1235.21	1441.07	1646.94	1852.81	258.66
July	281.59	563.18	844.77	1126.36	1407.95	1689.54	1971.12	2252.71	2534.30	258.66
August	281.59	563.18	844.77	1126.36	1407.95	1689.54	1971.12	2252.71	2534.30	258.66

September	224.80	449.60	674.39	899.19	1123.99	1348.79	1573.59	1798.39	2023.18	258.66
October	91.10	182.20	273.31	364.41	455.51	546.61	637.72	728.82	819.92	258.66

AM75_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	40.95	81.89	122.84	163.78	204.73	245.67	286.62	327.56	368.51	620.84
June	165.69	331.37	497.06	662.74	828.43	994.11	1159.80	1325.49	1491.17	620.84
July	226.63	453.26	679.88	906.51	1133.14	1359.77	1586.39	1813.02	2039.65	620.84
August	226.63	453.26	679.88	906.51	1133.14	1359.77	1586.39	1813.02	2039.65	620.84
September	180.92	361.84	542.76	723.68	904.61	1085.53	1266.45	1447.37	1628.29	620.84
October	73.32	146.64	219.96	293.28	366.60	439.92	513.24	586.57	659.89	620.84

AM75_08

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	115.38	230.77	346.15	461.54	576.92	692.31	807.69	923.08	1038.46	8212.69
June	466.91	933.81	1400.72	1867.62	2334.53	2801.44	3268.34	3735.25	4202.15	8212.69
July	638.64	1277.28	1915.92	2554.57	3193.21	3831.85	4470.49	5109.13	5747.77	8212.69
August	638.64	1277.28	1915.92	2554.57	3193.21	3831.85	4470.49	5109.13	5747.77	8212.69
September	509.84	1019.68	1529.52	2039.36	2549.20	3059.04	3568.88	4078.72	4588.56	8212.69
October	206.62	413.24	619.86	826.48	1033.10	1239.72	1446.34	1652.95	1859.57	8212.69

AM75_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	18.44	36.88	55.32	73.76	92.20	110.64	129.08	147.52	165.96	109.02
June	74.62	149.24	223.86	298.48	373.09	447.71	522.33	596.95	671.57	109.02
July	102.07	204.13	306.20	408.26	510.33	612.39	714.46	816.52	918.59	109.02
August	102.07	204.13	306.20	408.26	510.33	612.39	714.46	816.52	918.59	109.02
September	81.48	162.96	244.44	325.92	407.40	488.88	570.36	651.84	733.32	109.02

October	33.02	66.04	99.06	132.08	165.11	198.13	231.15	264.17	297.19	109.02

AM75_10

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	25.00	49.99	74.99	99.98	124.98	149.97	174.97	199.96	224.96	326.60
June	101.14	202.29	303.43	404.58	505.72	606.86	708.01	809.15	910.30	326.60
July	138.35	276.69	415.04	553.39	691.73	830.08	968.42	1106.77	1245.12	326.60
August	138.35	276.69	415.04	553.39	691.73	830.08	968.42	1106.77	1245.12	326.60
September	110.44	220.89	331.33	441.78	552.22	662.67	773.11	883.56	994.00	326.60
October	44.76	89.52	134.28	179.04	223.80	268.55	313.31	358.07	402.83	326.60

AM75_11

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	22.87	45.73	68.60	91.47	114.33	137.20	160.07	182.93	205.80	685.24
June	92.53	185.06	277.59	370.12	462.65	555.18	647.71	740.24	832.77	685.24
July	126.56	253.13	379.69	506.25	632.82	759.38	885.94	1012.51	1139.07	685.24
August	126.56	253.13	379.69	506.25	632.82	759.38	885.94	1012.51	1139.07	685.24
September	101.04	202.08	303.11	404.15	505.19	606.23	707.27	808.30	909.34	685.24
October	40.95	81.89	122.84	163.79	204.73	245.68	286.63	327.58	368.52	685.24

AM75_12

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	77.15	154.30	231.44	308.59	385.74	462.89	540.03	617.18	694.33	480.85
June	312.18	624.36	936.54	1248.72	1560.90	1873.08	2185.26	2497.44	2809.62	480.85
July	427.00	854.01	1281.01	1708.02	2135.02	2562.02	2989.03	3416.03	3843.04	480.85
August	427.00	854.01	1281.01	1708.02	2135.02	2562.02	2989.03	3416.03	3843.04	480.85
September	340.89	681.77	1022.66	1363.54	1704.43	2045.31	2386.20	2727.09	3067.97	480.85
October	138.15	276.30	414.45	552.59	690.74	828.89	967.04	1105.19	1243.34	480.85

AM75_13

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	24.57	49.14	73.71	98.28	122.85	147.42	171.99	196.56	221.13	757.33
June	99.42	198.84	298.26	397.69	497.11	596.53	695.95	795.37	894.79	757.33
July	135.99	271.98	407.97	543.96	679.95	815.94	951.93	1087.92	1223.91	757.33
August	135.99	271.98	407.97	543.96	679.95	815.94	951.93	1087.92	1223.91	757.33
September	108.56	217.13	325.69	434.25	542.82	651.38	759.94	868.51	977.07	757.33
October	44.00	87.99	131.99	175.99	219.98	263.98	307.98	351.97	395.97	757.33

AM75_14

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	20.06	40.13	60.19	80.26	100.32	120.38	140.45	160.51	180.57	842.08
June	81.19	162.38	243.57	324.75	405.94	487.13	568.32	649.51	730.70	842.08
July	111.05	222.10	333.15	444.20	555.25	666.31	777.36	888.41	999.46	842.08
August	111.05	222.10	333.15	444.20	555.25	666.31	777.36	888.41	999.46	842.08
September	88.65	177.31	265.96	354.62	443.27	531.92	620.58	709.23	797.89	842.08
October	35.93	71.86	107.78	143.71	179.64	215.57	251.50	287.43	323.35	842.08

AM75_15

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	68.97	137.94	206.92	275.89	344.86	413.83	482.80	551.78	620.75	5424.35
June	279.10	558.19	837.29	1116.38	1395.48	1674.57	1953.67	2232.77	2511.86	5424.35
July	381.75	763.50	1145.25	1527.01	1908.76	2290.51	2672.26	3054.01	3435.76	5424.35
August	381.75	763.50	1145.25	1527.01	1908.76	2290.51	2672.26	3054.01	3435.76	5424.35
September	304.76	609.52	914.28	1219.04	1523.80	1828.56	2133.32	2438.08	2742.84	5424.35
October	123.51	247.02	370.52	494.03	617.54	741.05	864.55	988.06	1111.57	5424.35

AN73_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	51.46	102.91	154.37	205.83	257.28	308.74	360.19	411.65	463.11	790.25
June	208.22	416.44	624.66	832.87	1041.09	1249.31	1457.53	1665.75	1873.97	790.25
July	284.80	569.61	854.41	1139.22	1424.02	1708.83	1993.63	2278.44	2563.24	790.25
August	284.80	569.61	854.41	1139.22	1424.02	1708.83	1993.63	2278.44	2563.24	790.25
September	227.36	454.73	682.09	909.46	1136.82	1364.19	1591.55	1818.92	2046.28	790.25
October	92.14	184.29	276.43	368.57	460.71	552.86	645.00	737.14	829.28	790.25

AN73_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	30.04	60.08	90.12	120.16	150.20	180.24	210.28	240.32	270.36	1925.27
June	121.56	243.11	364.67	486.23	607.79	729.34	850.90	972.46	1094.01	1925.27
July	166.27	332.54	498.80	665.07	831.34	997.61	1163.87	1330.14	1496.41	1925.27
August	166.27	332.54	498.80	665.07	831.34	997.61	1163.87	1330.14	1496.41	1925.27
September	132.73	265.47	398.20	530.94	663.67	796.41	929.14	1061.88	1194.61	1925.27
October	53.79	107.59	161.38	215.17	268.96	322.76	376.55	430.34	484.13	1925.27

AN73_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	34.66	69.32	103.98	138.64	173.29	207.95	242.61	277.27	311.93	910.09
June	140.25	280.49	420.74	560.99	701.24	841.48	981.73	1121.98	1262.22	910.09
July	191.83	383.66	575.50	767.33	959.16	1150.99	1342.83	1534.66	1726.49	910.09
August	191.83	383.66	575.50	767.33	959.16	1150.99	1342.83	1534.66	1726.49	910.09
September	153.14	306.29	459.43	612.57	765.72	918.86	1072.00	1225.15	1378.29	910.09
October	62.06	124.13	186.19	248.25	310.32	372.38	434.44	496.51	558.57	910.09

AN73_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³

May	20.62	41.24	61.86	82.48	103.11	123.73	144.35	164.97	185.59	292.90
June	83.44	166.89	250.33	333.78	417.22	500.66	584.11	667.55	751.00	292.90
July	114.14	228.27	342.41	456.54	570.68	684.82	798.95	913.09	1027.23	292.90
August	114.14	228.27	342.41	456.54	570.68	684.82	798.95	913.09	1027.23	292.90
September	91.12	182.23	273.35	364.47	455.59	546.70	637.82	728.94	820.05	292.90
October	36.93	73.85	110.78	147.71	184.63	221.56	258.48	295.41	332.34	292.90

AN73_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	29.22	58.43	87.65	116.87	146.08	175.30	204.52	233.73	262.95	181.90
June	118.23	236.45	354.68	472.91	591.13	709.36	827.58	945.81	1064.04	181.90
July	161.71	323.42	485.14	646.85	808.56	970.27	1131.98	1293.69	1455.41	181.90
August	161.71	323.42	485.14	646.85	808.56	970.27	1131.98	1293.69	1455.41	181.90
September	129.10	258.20	387.29	516.39	645.49	774.59	903.68	1032.78	1161.88	181.90
October	52.32	104.64	156.96	209.27	261.59	313.91	366.23	418.55	470.87	181.90

AN73_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Totl Vol.
May	86.82	173.64	260.47	347.29	434.11	520.93	607.76	694.58	781.40	681.85
June	351.33	702.65	1053.98	1405.31	1756.64	2107.96	2459.29	2810.62	3161.95	681.85
July	480.55	961.10	1441.65	1922.20	2402.76	2883.31	3363.86	3844.41	4324.96	681.85
August	480.55	961.10	1441.65	1922.20	2402.76	2883.31	3363.86	3844.41	4324.96	681.85
September	383.63	767.27	1150.90	1534.53	1918.17	2301.80	2685.43	3069.07	3452.70	681.85
October	155.47	310.94	466.42	621.89	777.36	932.83	1088.31	1243.78	1399.25	681.85

AN73_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	67.63	135.26	202.89	270.52	338.15	405.78	473.41	541.05	608.68	297.44
June	273.67	547.34	821.01	1094.67	1368.34	1642.01	1915.68	2189.35	2463.02	297.44

July	374.33	748.66	1122.98	1497.31	1871.64	2245.97	2620.30	2994.62	3368.95	297.44
August	374.33	748.66	1122.98	1497.31	1871.64	2245.97	2620.30	2994.62	3368.95	297.44
September	298.83	597.67	896.50	1195.33	1494.17	1793.00	2091.83	2390.67	2689.50	297.44
October	121.11	242.21	363.32	484.42	605.53	726.64	847.74	968.85	1089.96	297.44

AN73_08

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	11.06	22.12	33.18	44.24	55.30	66.36	77.42	88.48	99.54	32.27
June	44.76	89.51	134.27	179.02	223.78	268.53	313.29	358.04	402.80	32.27
July	61.22	122.43	183.65	244.87	306.08	367.30	428.52	489.74	550.95	32.27
August	61.22	122.43	183.65	244.87	306.08	367.30	428.52	489.74	550.95	32.27
September	48.87	97.74	146.61	195.48	244.35	293.22	342.09	390.97	439.84	32.27
October	19.81	39.61	59.42	79.22	99.03	118.83	138.64	158.44	178.25	32.27

AN73_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	80.29	160.58	240.88	321.17	401.46	481.75	562.05	642.34	722.63	1757.37
June	324.90	649.81	974.71	1299.62	1624.52	1949.42	2274.33	2599.23	2924.14	1757.37
July	444.41	888.82	1333.23	1777.64	2222.05	2666.45	3110.86	3555.27	3999.68	1757.37
August	444.41	888.82	1333.23	1777.64	2222.05	2666.45	3110.86	3555.27	3999.68	1757.37
September	354.78	709.56	1064.34	1419.12	1773.90	2128.68	2483.46	2838.24	3193.02	1757.37
October	143.78	287.56	431.34	575.12	718.90	862.68	1006.46	1150.24	1294.01	1757.37

AN74_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	25.70	51.40	77.10	102.80	128.50	154.20	179.90	205.60	231.31	276.87
June	104.00	208.00	311.99	415.99	519.99	623.99	727.98	831.98	935.98	276.87
July	142.25	284.50	426.75	569.00	711.25	853.50	995.75	1138.00	1280.25	276.87

August	142.25	284.50	426.75	569.00	711.25	853.50	995.75	1138.00	1280.25	276.87
September	113.56	227.12	340.68	454.24	567.80	681.37	794.93	908.49	1022.05	276.87
October	46.02	92.04	138.07	184.09	230.11	276.13	322.15	368.18	414.20	276.87

AN74_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	69.93	139.86	209.79	279.72	349.65	419.58	489.51	559.44	629.38	928.81
June	282.98	565.95	848.93	1131.90	1414.88	1697.85	1980.83	2263.80	2546.78	928.81
July	387.06	774.12	1161.17	1548.23	1935.29	2322.35	2709.40	3096.46	3483.52	928.81
August	387.06	774.12	1161.17	1548.23	1935.29	2322.35	2709.40	3096.46	3483.52	928.81
September	309.00	617.99	926.99	1235.98	1544.98	1853.97	2162.97	2471.97	2780.96	928.81
October	125.22	250.45	375.67	500.90	626.12	751.35	876.57	1001.80	1127.02	928.81

AN74_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	30.46	60.91	91.37	121.82	152.28	182.73	213.19	243.64	274.10	1253.88
June	123.24	246.48	369.72	492.95	616.19	739.43	862.67	985.91	1109.15	1253.88
July	168.57	337.14	505.70	674.27	842.84	1011.41	1179.97	1348.54	1517.11	1253.88
August	168.57	337.14	505.70	674.27	842.84	1011.41	1179.97	1348.54	1517.11	1253.88
September	134.57	269.14	403.71	538.28	672.85	807.42	942.00	1076.57	1211.14	1253.88
October	54.54	109.07	163.61	218.15	272.68	327.22	381.76	436.29	490.83	1253.88

AN74_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	58.79	117.58	176.37	235.16	293.95	352.74	411.53	470.32	529.11	373.51
June	237.90	475.79	713.69	951.59	1189.48	1427.38	1665.28	1903.17	2141.07	373.51
July	325.40	650.80	976.20	1301.59	1626.99	1952.39	2277.79	2603.19	2928.59	373.51
August	325.40	650.80	976.20	1301.59	1626.99	1952.39	2277.79	2603.19	2928.59	373.51

September	259.77	519.54	779.32	1039.09	1298.86	1558.63	1818.40	2078.18	2337.95	373.51
October	105.28	210.55	315.83	421.10	526.38	631.66	736.93	842.21	947.48	373.51

AN74_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	11.46	22.92	34.38	45.83	57.29	68.75	80.21	91.67	103.13	899.80
June	46.37	92.73	139.10	185.47	231.83	278.20	324.57	370.93	417.30	899.80
July	63.42	126.84	190.26	253.68	317.11	380.53	443.95	507.37	570.79	899.80
August	63.42	126.84	190.26	253.68	317.11	380.53	443.95	507.37	570.79	899.80
September	50.63	101.26	151.89	202.52	253.15	303.78	354.41	405.04	455.67	899.80
October	20.52	41.04	61.56	82.07	102.59	123.11	143.63	164.15	184.67	899.80

AN74_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	8.67	17.33	26.00	34.66	43.33	51.99	60.66	69.32	77.99	126.36
June	35.06	70.13	105.19	140.26	175.32	210.39	245.45	280.52	315.58	126.36
July	47.96	95.92	143.89	191.85	239.81	287.77	335.73	383.70	431.66	126.36
August	47.96	95.92	143.89	191.85	239.81	287.77	335.73	383.70	431.66	126.36
September	38.29	76.58	114.87	153.16	191.44	229.73	268.02	306.31	344.60	126.36
October	15.52	31.03	46.55	62.07	77.59	93.10	108.62	124.14	139.65	126.36

AN74_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	32.48	64.97	97.45	129.93	162.42	194.90	227.38	259.86	292.35	437.14
June	131.44	262.89	394.33	525.77	657.22	788.66	920.10	1051.55	1182.99	437.14
July	179.79	359.58	539.37	719.16	898.95	1078.74	1258.53	1438.32	1618.11	437.14
August	179.79	359.58	539.37	719.16	898.95	1078.74	1258.53	1438.32	1618.11	437.14
September	143.53	287.06	430.59	574.12	717.65	861.18	1004.71	1148.24	1291.77	437.14

October	58.17	116.33	174.50	232.67	290.84	349.00	407.17	465.34	523.51	437.14

AN74_08

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	23.39	46.78	70.18	93.57	116.96	140.35	163.75	187.14	210.53	296.27
June	94.66	189.31	283.97	378.63	473.29	567.94	662.60	757.26	851.92	296.27
July	129.47	258.95	388.42	517.90	647.37	776.84	906.32	1035.79	1165.26	296.27
August	129.47	258.95	388.42	517.90	647.37	776.84	906.32	1035.79	1165.26	296.27
September	103.36	206.72	310.08	413.45	516.81	620.17	723.53	826.89	930.25	296.27
October	41.89	83.78	125.67	167.55	209.44	251.33	293.22	335.11	377.00	296.27

AN74_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	18.48	36.97	55.45	73.94	92.42	110.90	129.39	147.87	166.36	268.92
June	74.80	149.59	224.39	299.18	373.98	448.78	523.57	598.37	673.17	268.92
July	102.31	204.61	306.92	409.23	511.54	613.84	716.15	818.46	920.77	268.92
August	102.31	204.61	306.92	409.23	511.54	613.84	716.15	818.46	920.77	268.92
September	81.67	163.35	245.02	326.70	408.37	490.04	571.72	653.39	735.07	268.92
October	33.10	66.20	99.30	132.40	165.50	198.60	231.70	264.80	297.90	268.92

AN74_10

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	36.57	73.14	109.71	146.28	182.85	219.42	255.99	292.56	329.13	1334.62
June	147.98	295.96	443.94	591.92	739.90	887.89	1035.87	1183.85	1331.83	1334.62
July	202.41	404.82	607.23	809.64	1012.05	1214.46	1416.87	1619.28	1821.70	1334.62
August	202.41	404.82	607.23	809.64	1012.05	1214.46	1416.87	1619.28	1821.70	1334.62
September	161.59	323.18	484.76	646.35	807.94	969.53	1131.12	1292.71	1454.29	1334.62
October	65.49	130.97	196.46	261.94	327.43	392.91	458.40	523.89	589.37	1334.62

AN74_11

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	69.74	139.49	209.23	278.98	348.72	418.46	488.21	557.95	627.70	1051.25
June	282.22	564.44	846.66	1128.88	1411.10	1693.32	1975.54	2257.76	2539.98	1051.25
July	386.02	772.05	1158.07	1544.10	1930.12	2316.15	2702.17	3088.20	3474.22	1051.25
August	386.02	772.05	1158.07	1544.10	1930.12	2316.15	2702.17	3088.20	3474.22	1051.25
September	308.17	616.34	924.51	1232.68	1540.85	1849.02	2157.20	2465.37	2773.54	1051.25
October	124.89	249.78	374.67	499.56	624.45	749.34	874.23	999.12	1124.01	1051.25

AN74_12

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	92.35	184.70	277.05	369.39	461.74	554.09	646.44	738.79	831.14	2567.07
June	373.69	747.38	1121.07	1494.76	1868.45	2242.14	2615.83	2989.52	3363.21	2567.07
July	511.14	1022.28	1533.42	2044.56	2555.69	3066.83	3577.97	4089.11	4600.25	2567.07
August	511.14	1022.28	1533.42	2044.56	2555.69	3066.83	3577.97	4089.11	4600.25	2567.07
September	408.05	816.10	1224.16	1632.21	2040.26	2448.31	2856.36	3264.42	3672.47	2567.07
October	165.37	330.74	496.11	661.47	826.84	992.21	1157.58	1322.95	1488.32	2567.07

AN74_13

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	10.46	20.92	31.38	41.85	52.31	62.77	73.23	83.69	94.15	87.05
June	42.33	84.67	127.00	169.33	211.66	254.00	296.33	338.66	380.99	87.05
July	57.90	115.81	173.71	231.61	289.52	347.42	405.32	463.22	521.13	87.05
August	57.90	115.81	173.71	231.61	289.52	347.42	405.32	463.22	521.13	87.05
September	46.23	92.45	138.68	184.90	231.13	277.35	323.58	369.80	416.03	87.05
October	18.73	37.47	56.20	74.93	93.67	112.40	131.13	149.87	168.60	87.05

AN74_14

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	64.54	129.08	193.61	258.15	322.69	387.23	451.77	516.31	580.84	3250.53
June	261.16	522.31	783.47	1044.62	1305.78	1566.93	1828.09	2089.24	2350.40	3250.53
July	357.21	714.42	1071.64	1428.85	1786.06	2143.27	2500.48	2857.70	3214.91	3250.53
August	357.21	714.42	1071.64	1428.85	1786.06	2143.27	2500.48	2857.70	3214.91	3250.53
September	285.17	570.34	855.51	1140.68	1425.85	1711.02	1996.18	2281.35	2566.52	3250.53
October	115.57	231.14	346.71	462.27	577.84	693.41	808.98	924.55	1040.12	3250.53

AN74_15

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	20.19	40.38	60.57	80.76	100.95	121.14	141.33	161.51	181.70	401.92
June	81.70	163.39	245.09	326.78	408.48	490.18	571.87	653.57	735.27	401.92
July	111.75	223.49	335.24	446.98	558.73	670.47	782.22	893.96	1005.71	401.92
August	111.75	223.49	335.24	446.98	558.73	670.47	782.22	893.96	1005.71	401.92
September	89.21	178.42	267.63	356.83	446.04	535.25	624.46	713.67	802.88	401.92
October	36.15	72.31	108.46	144.61	180.76	216.92	253.07	289.22	325.38	401.92

AN74_16

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	88.56	177.13	265.69	354.25	442.82	531.38	619.94	708.51	797.07	3429.22
June	358.37	716.74	1075.12	1433.49	1791.86	2150.23	2508.60	2866.98	3225.35	3429.22
July	490.19	980.37	1470.56	1960.75	2450.94	2941.12	3431.31	3921.50	4411.68	3429.22
August	490.19	980.37	1470.56	1960.75	2450.94	2941.12	3431.31	3921.50	4411.68	3429.22
September	391.33	782.65	1173.98	1565.30	1956.63	2347.96	2739.28	3130.61	3521.93	3429.22
October	158.59	317.18	475.77	634.36	792.95	951.54	1110.13	1268.72	1427.31	3429.22

AN74_17

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3

May	15.88	31.76	47.63	63.51	79.39	95.27	111.15	127.03	142.90	80.97
June	64.25	128.50	192.76	257.01	321.26	385.51	449.76	514.01	578.27	80.97
July	87.88	175.77	263.65	351.54	439.42	527.31	615.19	703.08	790.96	80.97
August	87.88	175.77	263.65	351.54	439.42	527.31	615.19	703.08	790.96	80.97
September	70.16	140.32	210.48	280.64	350.80	420.96	491.12	561.28	631.44	80.97
October	28.43	56.87	85.30	113.73	142.17	170.60	199.03	227.47	255.90	80.97

AN74_18

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	29.42	58.84	88.25	117.67	147.09	176.51	205.92	235.34	264.76	2168.00
June	119.04	238.08	357.12	476.16	595.19	714.23	833.27	952.31	1071.35	2168.00
July	162.82	325.65	488.47	651.29	814.12	976.94	1139.76	1302.59	1465.41	2168.00
August	162.82	325.65	488.47	651.29	814.12	976.94	1139.76	1302.59	1465.41	2168.00
September	129.99	259.97	389.96	519.94	649.93	779.91	909.90	1039.88	1169.87	2168.00
October	52.68	105.36	158.03	210.71	263.39	316.07	368.75	421.43	474.10	2168.00

AN74_19

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	27.47	54.94	82.41	109.87	137.34	164.81	192.28	219.75	247.22	298.41
June	111.15	222.30	333.45	444.61	555.76	666.91	778.06	889.21	1000.36	298.41
July	152.03	304.07	456.10	608.14	760.17	912.21	1064.24	1216.28	1368.31	298.41
August	152.03	304.07	456.10	608.14	760.17	912.21	1064.24	1216.28	1368.31	298.41
September	121.37	242.74	364.12	485.49	606.86	728.23	849.61	970.98	1092.35	298.41
October	49.19	98.38	147.56	196.75	245.94	295.13	344.31	393.50	442.69	298.41

AN74_20

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	6.43	12.86	19.28	25.71	32.14	38.57	44.99	51.42	57.85	104.26

June	26.01	52.02	78.03	104.04	130.05	156.06	182.07	208.08	234.09	104.26
July	35.58	71.15	106.73	142.31	177.88	213.46	249.04	284.62	320.19	104.26
August	35.58	71.15	106.73	142.31	177.88	213.46	249.04	284.62	320.19	104.26
September	28.40	56.80	85.21	113.61	142.01	170.41	198.81	227.21	255.62	104.26
October	11.51	23.02	34.53	46.04	57.55	69.06	80.57	92.08	103.59	104.26

AN74_21

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	10.81	21.63	32.44	43.25	54.06	64.88	75.69	86.50	97.32	100.28
June	43.75	87.51	131.26	175.02	218.77	262.53	306.28	350.04	393.79	100.28
July	59.85	119.70	179.55	239.39	299.24	359.09	418.94	478.79	538.64	100.28
August	59.85	119.70	179.55	239.39	299.24	359.09	418.94	478.79	538.64	100.28
September	47.78	95.56	143.34	191.11	238.89	286.67	334.45	382.23	430.01	100.28
October	19.36	38.73	58.09	77.45	96.81	116.18	135.54	154.90	174.27	100.28

AN74_22

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	16.15	32.31	48.46	64.62	80.77	96.92	113.08	129.23	145.38	524.90
June	65.37	130.73	196.10	261.47	326.83	392.20	457.57	522.93	588.30	524.90
July	89.41	178.82	268.23	357.64	447.05	536.46	625.87	715.27	804.68	524.90
August	89.41	178.82	268.23	357.64	447.05	536.46	625.87	715.27	804.68	524.90
September	71.38	142.75	214.13	285.51	356.89	428.26	499.64	571.02	642.39	524.90
October	28.93	57.85	86.78	115.71	144.63	173.56	202.49	231.41	260.34	524.90

AN74_23

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	17.87	35.74	53.62	71.49	89.36	107.23	125.10	142.98	160.85	576.54
June	72.32	144.64	216.96	289.28	361.59	433.91	506.23	578.55	650.87	576.54

July	98.92	197.84	296.76	395.68	494.59	593.51	692.43	791.35	890.27	576.54
August	98.92	197.84	296.76	395.68	494.59	593.51	692.43	791.35	890.27	576.54
September	78.97	157.94	236.91	315.88	394.84	473.81	552.78	631.75	710.72	576.54
October	32.00	64.01	96.01	128.01	160.02	192.02	224.02	256.03	288.03	576.54

AN74_24

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	36.71	73.42	110.13	146.83	183.54	220.25	256.96	293.67	330.38	2107.56
June	148.54	297.08	445.62	594.17	742.71	891.25	1039.79	1188.33	1336.87	2107.56
July	203.18	406.36	609.53	812.71	1015.89	1219.07	1422.24	1625.42	1828.60	2107.56
August	203.18	406.36	609.53	812.71	1015.89	1219.07	1422.24	1625.42	1828.60	2107.56
September	162.20	324.40	486.60	648.80	811.00	973.20	1135.40	1297.60	1459.81	2107.56
October	65.73	131.47	197.20	262.94	328.67	394.40	460.14	525.87	591.61	2107.56

AN74_25

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	11.39	22.79	34.18	45.58	56.97	68.36	79.76	91.15	102.55	727.14
June	46.11	92.21	138.32	184.43	230.53	276.64	322.74	368.85	414.96	727.14
July	63.07	126.13	189.20	252.26	315.33	378.39	441.46	504.52	567.59	727.14
August	63.07	126.13	189.20	252.26	315.33	378.39	441.46	504.52	567.59	727.14
September	50.35	100.69	151.04	201.38	251.73	302.08	352.42	402.77	453.11	727.14
October	20.40	40.81	61.21	81.61	102.02	122.42	142.82	163.23	183.63	727.14

AN74_26

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	16.07	32.14	48.20	64.27	80.34	96.41	112.47	128.54	144.61	799.67
June	65.02	130.04	195.05	260.07	325.09	390.11	455.12	520.14	585.16	799.67
July	88.93	177.86	266.80	355.73	444.66	533.59	622.53	711.46	800.39	799.67

August	88.93	177.86	266.80	355.73	444.66	533.59	622.53	711.46	800.39	799.67
September	71.00	141.99	212.99	283.99	354.98	425.98	496.97	567.97	638.97	799.67
October	28.77	57.54	86.32	115.09	143.86	172.63	201.41	230.18	258.95	799.67

AN74_27

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	27.47	54.95	82.42	109.90	137.37	164.85	192.32	219.79	247.27	1532.72
June	111.18	222.35	333.53	444.70	555.88	667.05	778.23	889.40	1000.58	1532.72
July	152.07	304.13	456.20	608.27	760.34	912.40	1064.47	1216.54	1368.60	1532.72
August	152.07	304.13	456.20	608.27	760.34	912.40	1064.47	1216.54	1368.60	1532.72
September	121.40	242.80	364.19	485.59	606.99	728.39	849.79	971.18	1092.58	1532.72
October	49.20	98.40	147.59	196.79	245.99	295.19	344.39	393.59	442.78	1532.72

AN74_28

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	46.93	93.86	140.79	187.72	234.64	281.57	328.50	375.43	422.36	280.24
June	189.90	379.80	569.70	759.59	949.49	1139.39	1329.29	1519.19	1709.09	280.24
July	259.75	519.49	779.24	1038.99	1298.73	1558.48	1818.22	2077.97	2337.72	280.24
August	259.75	519.49	779.24	1038.99	1298.73	1558.48	1818.22	2077.97	2337.72	280.24
September	207.36	414.72	622.08	829.44	1036.80	1244.16	1451.52	1658.88	1866.24	280.24
October	84.04	168.07	252.11	336.14	420.18	504.21	588.25	672.28	756.32	280.24

AN75_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	15.49	30.98	46.47	61.96	77.45	92.94	108.43	123.92	139.41	384.16
June	62.68	125.36	188.04	250.72	313.40	376.08	438.75	501.43	564.11	384.16
July	85.73	171.47	257.20	342.93	428.67	514.40	600.14	685.87	771.60	384.16
August	85.73	171.47	257.20	342.93	428.67	514.40	600.14	685.87	771.60	384.16

September	68.44	136.89	205.33	273.77	342.21	410.66	479.10	547.54	615.99	384.16
October	27.74	55.47	83.21	110.95	138.69	166.42	194.16	221.90	249.64	384.16

AN75_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	47.72	95.44	143.16	190.88	238.60	286.32	334.04	381.76	429.48	790.87
June	193.10	386.20	579.30	772.39	965.49	1158.59	1351.69	1544.79	1737.89	790.87
July	264.12	528.25	792.37	1056.49	1320.62	1584.74	1848.86	2112.99	2377.11	790.87
August	264.12	528.25	792.37	1056.49	1320.62	1584.74	1848.86	2112.99	2377.11	790.87
September	210.85	421.71	632.56	843.42	1054.27	1265.13	1475.98	1686.84	1897.69	790.87
October	85.45	170.90	256.35	341.81	427.26	512.71	598.16	683.61	769.06	790.87

AN75_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	17.59	35.19	52.78	70.38	87.97	105.57	123.16	140.76	158.35	248.59
June	71.20	142.40	213.59	284.79	355.99	427.19	498.38	569.58	640.78	248.59
July	97.39	194.77	292.16	389.54	486.93	584.31	681.70	779.08	876.47	248.59
August	97.39	194.77	292.16	389.54	486.93	584.31	681.70	779.08	876.47	248.59
September	77.74	155.49	233.23	310.98	388.72	466.47	544.21	621.96	699.70	248.59
October	31.51	63.01	94.52	126.03	157.53	189.04	220.55	252.06	283.56	248.59

AN75_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	20.79	41.57	62.36	83.14	103.93	124.71	145.50	166.28	187.07	43.49
June	84.11	168.21	252.32	336.43	420.53	504.64	588.75	672.86	756.96	43.49
July	115.04	230.09	345.13	460.17	575.21	690.26	805.30	920.34	1035.39	43.49
August	115.04	230.09	345.13	460.17	575.21	690.26	805.30	920.34	1035.39	43.49
September	91.84	183.68	275.52	367.36	459.20	551.05	642.89	734.73	826.57	43.49

October	37.22	74.44	111.66	148.88	186.10	223.32	260.54	297.76	334.98	43.49

AN75_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	55.95	111.91	167.86	223.82	279.77	335.73	391.68	447.63	503.59	546.62
June	226.42	452.84	679.26	905.68	1132.10	1358.52	1584.94	1811.36	2037.78	546.62
July	309.70	619.40	929.10	1238.80	1548.50	1858.20	2167.90	2477.60	2787.30	546.62
August	309.70	619.40	929.10	1238.80	1548.50	1858.20	2167.90	2477.60	2787.30	546.62
September	247.24	494.48	741.72	988.96	1236.20	1483.44	1730.68	1977.92	2225.16	546.62
October	100.20	200.39	300.59	400.79	500.99	601.18	701.38	801.58	901.77	546.62

AN75_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	28.61	57.21	85.82	114.42	143.03	171.63	200.24	228.84	257.45	733.55
June	115.75	231.50	347.25	463.00	578.75	694.50	810.25	926.00	1041.76	733.55
July	158.33	316.65	474.98	633.30	791.63	949.95	1108.28	1266.60	1424.93	733.55
August	158.33	316.65	474.98	633.30	791.63	949.95	1108.28	1266.60	1424.93	733.55
September	126.39	252.79	379.18	505.58	631.97	758.37	884.76	1011.15	1137.55	733.55
October	51.22	102.45	153.67	204.89	256.11	307.34	358.56	409.78	461.01	733.55

AN75_07

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	26.15	52.30	78.44	104.59	130.74	156.89	183.04	209.18	235.33	1256.89
June	105.81	211.62	317.43	423.23	529.04	634.85	740.66	846.47	952.28	1256.89
July	144.73	289.45	434.18	578.91	723.63	868.36	1013.08	1157.81	1302.54	1256.89
August	144.73	289.45	434.18	578.91	723.63	868.36	1013.08	1157.81	1302.54	1256.89
September	115.54	231.08	346.61	462.15	577.69	693.23	808.77	924.30	1039.84	1256.89
October	46.82	93.65	140.47	187.29	234.12	280.94	327.76	374.59	421.41	1256.89

AN75_08

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	26.32	52.64	78.96	105.28	131.60	157.91	184.23	210.55	236.87	474.47
June	106.50	213.00	319.50	426.00	532.50	639.00	745.50	852.01	958.51	474.47
July	145.67	291.35	437.02	582.69	728.37	874.04	1019.71	1165.39	1311.06	474.47
August	145.67	291.35	437.02	582.69	728.37	874.04	1019.71	1165.39	1311.06	474.47
September	116.29	232.59	348.88	465.18	581.47	697.76	814.06	930.35	1046.64	474.47
October	47.13	94.26	141.39	188.52	235.65	282.78	329.91	377.04	424.17	474.47

AN75_09

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	21.23	42.46	63.69	84.92	106.15	127.38	148.61	169.83	191.06	95.86
June	85.90	171.81	257.71	343.62	429.52	515.43	601.33	687.24	773.14	95.86
July	117.50	235.00	352.51	470.01	587.51	705.01	822.51	940.01	1057.52	95.86
August	117.50	235.00	352.51	470.01	587.51	705.01	822.51	940.01	1057.52	95.86
September	93.80	187.61	281.41	375.22	469.02	562.82	656.63	750.43	844.24	95.86
October	38.02	76.03	114.05	152.06	190.08	228.09	266.11	304.12	342.14	95.86

AN75_10

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	39.47	78.95	118.42	157.90	197.37	236.85	276.32	315.80	355.27	1395.04
June	159.74	319.47	479.21	638.94	798.68	958.41	1118.15	1277.88	1437.62	1395.04
July	218.49	436.98	655.47	873.95	1092.44	1310.93	1529.42	1747.91	1966.40	1395.04
August	218.49	436.98	655.47	873.95	1092.44	1310.93	1529.42	1747.91	1966.40	1395.04
September	174.42	348.85	523.27	697.69	872.12	1046.54	1220.97	1395.39	1569.81	1395.04
October	70.69	141.37	212.06	282.75	353.44	424.12	494.81	565.50	636.19	1395.04

AN75_11

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	11.82	23.64	35.46	47.28	59.10	70.92	82.74	94.56	106.38	327.04
June	47.83	95.66	143.48	191.31	239.14	286.97	334.79	382.62	430.45	327.04
July	65.42	130.84	196.26	261.68	327.10	392.52	457.94	523.36	588.78	327.04
August	65.42	130.84	196.26	261.68	327.10	392.52	457.94	523.36	588.78	327.04
September	52.23	104.45	156.68	208.90	261.13	313.35	365.58	417.81	470.03	327.04
October	21.17	42.33	63.50	84.66	105.83	126.99	148.16	169.32	190.49	327.04

AN75_12

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	3.12	6.24	9.36	12.49	15.61	18.73	21.85	24.97	28.09	70.31
June	12.63	25.26	37.89	50.52	63.16	75.79	88.42	101.05	113.68	70.31
July	17.28	34.55	51.83	69.11	86.38	103.66	120.94	138.22	155.49	70.31
August	17.28	34.55	51.83	69.11	86.38	103.66	120.94	138.22	155.49	70.31
September	13.79	27.59	41.38	55.17	68.96	82.76	96.55	110.34	124.13	70.31
October	5.59	11.18	16.77	22.36	27.95	33.54	39.13	44.72	50.31	70.31

AN75_13

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	41.75	83.51	125.26	167.02	208.77	250.52	292.28	334.03	375.79	716.08
June	168.96	337.92	506.87	675.83	844.79	1013.75	1182.71	1351.67	1520.62	716.08
July	231.10	462.21	693.31	924.41	1155.52	1386.62	1617.73	1848.83	2079.93	716.08
August	231.10	462.21	693.31	924.41	1155.52	1386.62	1617.73	1848.83	2079.93	716.08
September	184.49	368.99	553.48	737.98	922.47	1106.97	1291.46	1475.96	1660.45	716.08
October	74.77	149.54	224.31	299.08	373.84	448.61	523.38	598.15	672.92	716.08

AN75_14

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³

May	144.40	288.79	433.19	577.59	721.98	866.38	1010.78	1155.17	1299.57	268.48
June	584.30	1168.61	1752.91	2337.21	2921.52	3505.82	4090.12	4674.43	5258.73	268.48
July	799.22	1598.44	2397.66	3196.88	3996.10	4795.32	5594.54	6393.76	7192.97	268.48
August	799.22	1598.44	2397.66	3196.88	3996.10	4795.32	5594.54	6393.76	7192.97	268.48
September	638.03	1276.06	1914.10	2552.13	3190.16	3828.19	4466.23	5104.26	5742.29	268.48
October	258.57	517.14	775.71	1034.28	1292.85	1551.43	1810.00	2068.57	2327.14	268.48

AN75_15

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	51.12	102.24	153.36	204.47	255.59	306.71	357.83	408.95	460.07	1349.09
June	206.85	413.70	620.55	827.41	1034.26	1241.11	1447.96	1654.81	1861.66	1349.09
July	282.93	565.87	848.80	1131.74	1414.67	1697.61	1980.54	2263.48	2546.41	1349.09
August	282.93	565.87	848.80	1131.74	1414.67	1697.61	1980.54	2263.48	2546.41	1349.09
September	225.87	451.74	677.62	903.49	1129.36	1355.23	1581.11	1806.98	2032.85	1349.09
October	91.54	183.08	274.61	366.15	457.69	549.23	640.76	732.30	823.84	1349.09

AN75_16

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	20.81	41.61	62.42	83.23	104.04	124.84	145.65	166.46	187.27	297.42
June	84.20	168.39	252.59	336.79	420.98	505.18	589.38	673.58	757.77	297.42
July	115.17	230.33	345.50	460.66	575.83	691.00	806.16	921.33	1036.49	297.42
August	115.17	230.33	345.50	460.66	575.83	691.00	806.16	921.33	1036.49	297.42
September	91.94	183.88	275.82	367.76	459.70	551.63	643.57	735.51	827.45	297.42
October	37.26	74.52	111.78	149.04	186.30	223.56	260.82	298.08	335.34	297.42

AN75_17

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	37.77	75.53	113.30	151.06	188.83	226.59	264.36	302.13	339.89	1227.70

June	152.82	305.64	458.46	611.28	764.10	916.92	1069.74	1222.55	1375.37	1227.70
July	209.03	418.06	627.09	836.11	1045.14	1254.17	1463.20	1672.23	1881.26	1227.70
August	209.03	418.06	627.09	836.11	1045.14	1254.17	1463.20	1672.23	1881.26	1227.70
September	166.87	333.74	500.61	667.49	834.36	1001.23	1168.10	1334.97	1501.84	1227.70
October	67.63	135.25	202.88	270.51	338.13	405.76	473.39	541.02	608.64	1227.70

AN75_18

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	76.05	152.10	228.14	304.19	380.24	456.29	532.34	608.39	684.43	486.54
June	307.73	615.46	923.19	1230.92	1538.65	1846.38	2154.11	2461.84	2769.57	486.54
July	420.92	841.84	1262.75	1683.67	2104.59	2525.51	2946.43	3367.34	3788.26	486.54
August	420.92	841.84	1262.75	1683.67	2104.59	2525.51	2946.43	3367.34	3788.26	486.54
September	336.03	672.05	1008.08	1344.11	1680.14	2016.16	2352.19	2688.22	3024.24	486.54
October	136.18	272.36	408.54	544.72	680.90	817.08	953.26	1089.44	1225.61	486.54

AN75_20

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	67.50	135.01	202.51	270.02	337.52	405.02	472.53	540.03	607.54	1827.62
June	273.16	546.31	819.47	1092.62	1365.78	1638.94	1912.09	2185.25	2458.40	1827.62
July	373.63	747.25	1120.88	1494.51	1868.14	2241.76	2615.39	2989.02	3362.64	1827.62
August	373.63	747.25	1120.88	1494.51	1868.14	2241.76	2615.39	2989.02	3362.64	1827.62
September	298.27	596.55	894.82	1193.09	1491.37	1789.64	2087.92	2386.19	2684.46	1827.62
October	120.88	241.76	362.64	483.52	604.40	725.28	846.16	967.03	1087.91	1827.62

AN76_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	11.56	23.12	34.68	46.24	57.80	69.36	80.92	92.48	104.04	241.56
June	46.78	93.55	140.33	187.11	233.88	280.66	327.43	374.21	420.99	241.56
July	63.98	127.96	191.94	255.93	319.91	383.89	447.87	511.85	575.83	241.56

August	63.98	127.96	191.94	255.93	319.91	383.89	447.87	511.85	575.83	241.56
September	51.08	102.16	153.23	204.31	255.39	306.47	357.54	408.62	459.70	241.56
October	20.70	41.40	62.10	82.80	103.50	124.20	144.90	165.60	186.30	241.56

AN76_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	64.02	128.03	192.05	256.07	320.08	384.10	448.12	512.13	576.15	421.03
June	259.04	518.09	777.13	1036.18	1295.22	1554.27	1813.31	2072.36	2331.40	421.03
July	354.33	708.65	1062.98	1417.30	1771.63	2125.95	2480.28	2834.60	3188.93	421.03
August	354.33	708.65	1062.98	1417.30	1771.63	2125.95	2480.28	2834.60	3188.93	421.03
September	282.86	565.73	848.59	1131.46	1414.32	1697.19	1980.05	2262.92	2545.78	421.03
October	114.63	229.27	343.90	458.54	573.17	687.81	802.44	917.08	1031.71	421.03

AN76_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	39.38	78.76	118.14	157.52	196.90	236.28	275.66	315.04	354.41	636.08
June	159.35	318.70	478.05	637.40	796.75	956.09	1115.44	1274.79	1434.14	636.08
July	217.96	435.92	653.88	871.84	1089.80	1307.76	1525.72	1743.68	1961.64	636.08
August	217.96	435.92	653.88	871.84	1089.80	1307.76	1525.72	1743.68	1961.64	636.08
September	174.00	348.00	522.01	696.01	870.01	1044.01	1218.01	1392.02	1566.02	636.08
October	70.52	141.03	211.55	282.07	352.58	423.10	493.62	564.13	634.65	636.08

AN76_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	29.99	59.97	89.96	119.95	149.93	179.92	209.91	239.89	269.88	228.68
June	121.34	242.68	364.02	485.37	606.71	728.05	849.39	970.73	1092.07	228.68
July	165.97	331.95	497.92	663.89	829.86	995.84	1161.81	1327.78	1493.76	228.68
August	165.97	331.95	497.92	663.89	829.86	995.84	1161.81	1327.78	1493.76	228.68

September	132.50	265.00	397.50	530.00	662.50	795.00	927.50	1059.99	1192.49	228.68
October	53.70	107.39	161.09	214.79	268.49	322.18	375.88	429.58	483.27	228.68

AN76_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	55.32	110.64	165.97	221.29	276.61	331.93	387.25	442.58	497.90	1445.50
June	223.86	447.72	671.58	895.44	1119.30	1343.16	1567.02	1790.88	2014.75	1445.50
July	306.20	612.40	918.60	1224.80	1531.00	1837.20	2143.40	2449.60	2755.80	1445.50
August	306.20	612.40	918.60	1224.80	1531.00	1837.20	2143.40	2449.60	2755.80	1445.50
September	244.45	488.89	733.34	977.78	1222.23	1466.67	1711.12	1955.56	2200.01	1445.50
October	99.06	198.13	297.19	396.26	495.32	594.39	693.45	792.52	891.58	1445.50

AO73_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	94.81	189.63	284.44	379.26	474.07	568.89	663.70	758.52	853.33	530.53
June	383.67	767.34	1151.00	1534.67	1918.34	2302.01	2685.68	3069.35	3453.01	530.53
July	524.79	1049.58	1574.36	2099.15	2623.94	3148.73	3673.51	4198.30	4723.09	530.53
August	524.79	1049.58	1574.36	2099.15	2623.94	3148.73	3673.51	4198.30	4723.09	530.53
September	418.95	837.90	1256.84	1675.79	2094.74	2513.69	2932.64	3351.59	3770.53	530.53
October	169.78	339.57	509.35	679.14	848.92	1018.71	1188.49	1358.27	1528.06	530.53

AO74_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	100.72	201.44	302.16	402.88	503.60	604.32	705.04	805.76	906.48	3066.32
June	407.57	815.13	1222.70	1630.27	2037.83	2445.40	2852.97	3260.53	3668.10	3066.32
July	557.48	1114.95	1672.43	2229.90	2787.38	3344.86	3902.33	4459.81	5017.29	3066.32
August	557.48	1114.95	1672.43	2229.90	2787.38	3344.86	3902.33	4459.81	5017.29	3066.32
September	445.04	890.09	1335.13	1780.18	2225.22	2670.26	3115.31	3560.35	4005.40	3066.32

October	180.36	360.72	541.08	721.44	901.80	1082.16	1262.52	1442.88	1623.24	3066.32

AO74_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	70.78	141.55	212.33	283.10	353.88	424.66	495.43	566.21	636.98	448.51
June	286.40	572.79	859.19	1145.58	1431.98	1718.37	2004.77	2291.17	2577.56	448.51
July	391.74	783.47	1175.21	1566.95	1958.68	2350.42	2742.16	3133.89	3525.63	448.51
August	391.74	783.47	1175.21	1566.95	1958.68	2350.42	2742.16	3133.89	3525.63	448.51
September	312.73	625.46	938.19	1250.92	1563.66	1876.39	2189.12	2501.85	2814.58	448.51
October	126.74	253.48	380.22	506.95	633.69	760.43	887.17	1013.91	1140.65	448.51

AO74_03

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	29.84	59.67	89.51	119.35	149.18	179.02	208.86	238.70	268.53	3104.04
June	120.74	241.47	362.21	482.94	603.68	724.41	845.15	965.89	1086.62	3104.04
July	165.14	330.29	495.43	660.58	825.72	990.87	1156.01	1321.15	1486.30	3104.04
August	165.14	330.29	495.43	660.58	825.72	990.87	1156.01	1321.15	1486.30	3104.04
September	131.84	263.68	395.51	527.35	659.19	791.03	922.86	1054.70	1186.54	3104.04
October	53.43	106.86	160.29	213.72	267.15	320.57	374.00	427.43	480.86	3104.04

AO74_04

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	109.41	218.82	328.23	437.64	547.05	656.46	765.87	875.28	984.70	4193.26
June	442.73	885.46	1328.19	1770.93	2213.66	2656.39	3099.12	3541.85	3984.58	4193.26
July	605.58	1211.15	1816.73	2422.30	3027.88	3633.45	4239.03	4844.60	5450.18	4193.26
August	605.58	1211.15	1816.73	2422.30	3027.88	3633.45	4239.03	4844.60	5450.18	4193.26
September	483.44	966.88	1450.33	1933.77	2417.21	2900.65	3384.10	3867.54	4350.98	4193.26
October	195.92	391.84	587.76	783.69	979.61	1175.53	1371.45	1567.37	1763.29	4193.26

AO74_05

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	3.79	7.58	11.38	15.17	18.96	22.75	26.54	30.34	34.13	2.94
June	15.34	30.69	46.03	61.38	76.72	92.07	107.41	122.76	138.10	2.94
July	20.99	41.98	62.97	83.96	104.95	125.93	146.92	167.91	188.90	2.94
August	20.99	41.98	62.97	83.96	104.95	125.93	146.92	167.91	188.90	2.94
September	16.76	33.51	50.27	67.02	83.78	100.54	117.29	134.05	150.80	2.94
October	6.79	13.58	20.37	27.16	33.95	40.74	47.53	54.32	61.12	2.94

AO74_06

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	174.50	349.00	523.50	698.00	872.50	1047.00	1221.50	1396.00	1570.50	12080.58
June	706.12	1412.23	2118.35	2824.46	3530.58	4236.70	4942.81	5648.93	6355.04	12080.58
July	965.84	1931.67	2897.51	3863.35	4829.18	5795.02	6760.86	7726.69	8692.53	12080.58
August	965.84	1931.67	2897.51	3863.35	4829.18	5795.02	6760.86	7726.69	8692.53	12080.58
September	771.05	1542.09	2313.14	3084.18	3855.23	4626.28	5397.32	6168.37	6939.42	12080.58
October	312.48	624.95	937.43	1249.91	1562.38	1874.86	2187.34	2499.81	2812.29	12080.58

AO75_01

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M³
May	142.02	284.03	426.05	568.07	710.08	852.10	994.12	1136.13	1278.15	1344.34
June	574.67	1149.35	1724.02	2298.69	2873.36	3448.04	4022.71	4597.38	5172.05	1344.34
July	786.05	1572.09	2358.14	3144.19	3930.23	4716.28	5502.33	6288.37	7074.42	1344.34
August	786.05	1572.09	2358.14	3144.19	3930.23	4716.28	5502.33	6288.37	7074.42	1344.34
September	627.52	1255.03	1882.55	2510.06	3137.58	3765.10	4392.61	5020.13	5647.65	1344.34
October	254.31	508.62	762.93	1017.24	1271.55	1525.86	1780.16	2034.47	2288.78	1344.34

AO75_02

Month	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Max Vol. M^3
May	214.92	429.83	644.75	859.67	1074.59	1289.50	1504.42	1719.34	1934.26	773.19
June	869.67	1739.33	2609.00	3478.66	4348.33	5217.99	6087.66	6957.32	7826.99	773.19
July	1189.54	2379.09	3568.63	4758.17	5947.71	7137.26	8326.80	9516.34	10705.88	773.19
August	1189.54	2379.09	3568.63	4758.17	5947.71	7137.26	8326.80	9516.34	10705.88	773.19
September	949.63	1899.27	2848.90	3798.54	4748.17	5697.81	6647.44	7597.08	8546.71	773.19
October	384.85	769.70	1154.56	1539.41	1924.26	2309.11	2693.96	3078.82	3463.67	773.19