2018

Revisiting the Postclassic Burials at Lamanai, Belize: A Second Look at the Unique Ventrally Placed, Legs Flexed Burials.

Victoria Izzo
University of Central Florida

REVISITING THE POSTCLASSIC BURIALS AT LAMANAI, BELIZE: A SECOND LOOK AT THE UNIQUE VENTRALLY PLACED, LEGS FLEXED BURIALS

by

VICTORIA STUART ROSE IZZO
B.A., Northern Arizona University, 2016

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the Department of Anthropology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Summer Term
2018

ABSTRACT

Analysis of unique mortuary patterns is often used to evaluate the social lives of the deceased and also those of the living who placed them there. The Ventrally Placed, Legs Flexed (VPLF) burials at the site of Lamanai in Belize, dating to the Postclassic period (1000 - 1544), have been recorded as a Maya mortuary pattern since the late 1970's. While many researchers have analyzed these skeletal remains, comprehensive and cumulative individual analysis of the VPLF individuals from Lamanai has not been conducted. In this study, I will argue that the VPLF individuals in this study were local to Lamanai, or the surrounding region. To do this, the characteristics of 20 VPLF burials are defined and discussed in context with previously published bone and tooth stable oxygen isotope values. All data was collected from field notes and previously published resources, and then compiled in both a narrative and quantitative fashion. Specifically, the variables of arm position, leg position, head position, body orientation, presence of cranial modification, presence of dental modification, and associated artifacts were statistically tested using a chi-square test of association for correlations.

While the correlation results were not statistically significant, the descriptive data did yield the identification of leg and arm positions that are characteristic of VPLF burials. This thesis specifically contributes to the future identification of VPLF burial burials by outlining commonly encountered characteristics operationalization of this unique mortuary practice. More broadly, however, this thesis highlights a general lack of consistency in bioarchaeological and mortuary data recording. Thus, this study is the first to compile VPLF mortuary information into one format, and therefore contributes to the study of bioarchaeology and anthropology by providing a foundation for comparison of future burials.

ACKNOWLEDGMENTS

Whew. What a whirlwind the last two year have been. I would like to thank my co-advisors, Dr. Tosha Dupras and Dr. Lana Williams. Dr. Dupras, thank you for always making sure that I felt heard and supported throughout my time in this program. Thank you for always having time to talk, and for always having such good advice. To Dr. Williams, thank you for sharing your excitement of Maya bioarchaeology, and thank you for always lending a listening ear to a lot of my crazy ideas. Thank you to my committee members, Dr. Michael Callaghan and Dr. Sandra Wheeler – both of your comments and input to this project was always greatly appreciated, and I am a better student because of your suggestions. Thank you all for putting in so much time and effort throughout this process – it is greatly appreciated. Thanks to Dr. John Starbuck for being a great statistics professor – your notes and lectures have helped me so much! Thanks to Dr. Beatriz Reyes-Foster for always having time to talk and for creating a safe place for graduate students. Thanks also to Lisa Haas and Jennifer Branson in the Anthropology Office for always being available to help with everything from enrolling to classes to financial aid. Thanks, too, to my cohort members who experienced the last two years with me.

I want to thank my archaeology family at BVAR, specifically Dr. Jaime Awe, Dr. Julie Hoggarth, Dr. Claire Ebert, Dr. Kirsten Green, Tia Watkins, and John Walden – you all were an email away anytime I encountered any issues or had any questions regarding to all things Maya. My experience with BVAR is part of the reason I pursued graduate education, so many thanks to you. A super special thanks to Dr. Chrissina Burke – you were my advisor, then mentor, now friend, and I wouldn't have been able to write this, or finish these two years without you. I hope to be half the professor and mentor you are one day.

I want to thank my family for being so supportive and always trying to learn more about my research. To my Dad, thank you for teaching me to be tough and that there is no shame in failure. To my Mom, thanks for instilling in me a positive outlook on life, and for always reminding me that "you get more bees with honey." And to you both, thanks for instilling in me honesty and human kindness.

Lastly, I want to thank my husband, Luke. You deserve this degree as much as I do. You never disagreed to listening to me read papers aloud repeatedly or relentlessly practicing presentations, all of which were met with nothing but kind and supportive words for me through this entire process. You kept me fed, focused, and caffeine fueled, while holding down our fort. And you never disagreed to driving me to and from the library late at night. I couldn't feel luckier to be your person. I love you and thank you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

Beginning with the pioneering works of Edward Thompson (1896) and Oliver Ricketson (1925), mortuary studies in Maya archaeology have utilized individual burials and the associated grave goods as a means to understand the lives of the dead themselves, but also the lives of the living who placed them in the mortuary landscape. Analysis of burial placement, burial type and grave goods, however, directs the focus of research towards the moments of interment. In the Maya region, death and burial is not perceived as the complete extinction of an individual; rather, it is the start of a process and relationship between the living and the dead (Fitzsimmons and Shimada, 2011; Gillespie, 2001). Because burial practices are so intimately tied to the social context of the living, studies focusing on the lifetime of the dead are important research avenues to understand the possible reasoning behind variations in burial position preference and prevalence of deviation from the social norm (Fitzsimmons and Shimada, 2011).

The archaeological site of Lamanai, located in the southern Maya lowlands of Belize, acted as a prominent ceremonial and administrative center for the ancient Maya. Archaeological and ethnohistorical evidence indicate that Lamanai was uniquely resilient to the Classic period collapse that occurred to many Maya sites within the Lowlands (Donis, 2013 Pendergast, 1981). While Lamanai sustained occupation throughout the Classic Period (AD 250 – 1000) they entered the Postclassic (AD 1000 – 1544) in a period of florescence which was characterized by increased trade and communication to areas to the north (Donis, 2013; Pendergast, 1981; Wrobel and Graham, 2015; Wrobel, 2004). This continuous occupation at Lamanai offers an important opportunity to investigate the temporal and spatial relationships of a set of unique individual

burials at Lamanai and the possible relationships between the living community who interred them.

The focus of this thesis is the remains of individuals discovered within Structure N 10 – 2 or N 10 – 4 in the southern sector of the site, which was dated to the Postclassic period (Pendergast, 1981). Additionally, all individuals selected in this study were reported to have been buried in a ventrally placed, legs flexed (VPLF) position (Donis, 2013), with the hands tightly flexed at the sides, and the feet positioned toward the pelvis. The individuals buried in the VPLF position are unique compared to other burials at Lamanai, and within Structures N 10 – 2 and N 10 – 4 due to the unique and fairly consistent positioning. Specifically, a majority of burials in the southern sector of the site are placed in an extended supine position. Head and facial orientation is variable for the individuals placed in this position, as they are in the VPLF burials. Additionally, some individuals are placed in what is recorded as "semi-flexed," but little description was provided for this position (Pendergast, 1981).

Research Questions

Bioarchaeological investigations of the Terminal Classic to Postclassic (AD 900 – 1100) transition are important because they provide context to the evaluation of larger questions concerning social change in the Maya world, which may have had a direct effect on human mobility and burial patterns within the region, and more specifically at Lamanai. This research builds upon previous investigations by Donis (2013), Lang (1990), White (1986), and Wrobel and Graham (2015). By combining the multiple lines of evidence and methods, the primary aim

of this research is to examine the VPLF burial position, the individuals interred in this position, and their relationship to the site of Lamanai with a new lens.

Therefore, three questions guide this research:

1) What are the defining characteristics of the VPLF burials that make them unique at Lamanai and in the surrounding regions?
2) Were these individuals local or non-local to Lamanai in their lifetime residence patterns?
3) What social or individual distinctions may have influenced the prevalence of this burial position within Structure N10-2 and N10-4 at Lamanai?

I hypothesize (H_A) that there will be a statistical correlation between the burial variables and the estimated age and sex of the individuals selected for this study. Therefore, the null hypothesis (H_0) that there will be no statistical correlation between the VPLF burials and the estimated age and sex. To accept the H_A I expect there to be no statistically significant correlation.

To attempt to answer these questions, I utilize multiple lines of evidence. First, I will incorporate mortuary descriptions initially recorded by Pendergast (1981) and contributed to by Graham and Wrobel (2015), and Donis (2013). These descriptions will include the position and orientation of the body, grave location, and the quantity and quality of associated grave goods. I will also incorporate $\delta^{18}O$ values for the included individuals published by Donis (2012) and Howie and colleagues (2010). In addition to these primary lines of evidence, I will also incorporate any associated artifact evidence and/or cultural modification (i.e. cranial and dental modification) to investigate the geographic origins of the deceased.

Following this introduction, Chapter 2 provides an overview of the site of Lamanai, Belize, the mortuary placement of the VPLF burials found at the site, and a brief introduction and overview of stable oxygen isotopes as a background to the isotopic data used in this thesis. Chapter 3 presents the materials and methodologies used in this study. Chapter 4 provides the results of further defining the VPLF burial characteristics and their residential mobility status during life. Chapter 5 discusses the results in relation to the context of social and mortuary changes experienced during the Terminal Classic to Postclassic transition at Lamanai and the surrounding regions. Chapter 6 provides a brief conclusion and suggestions for further research regarding this unique burial population.

CHAPTER TWO: REVIEW OF RELEVANT LITERATURE

Lamanai excavation history

Lamanai is an archaeological site within the Lamanai Archaeological Reserve, a 950-acre park located in the Orange Walk District of northern Belize, within the Southern Maya Lowlands (Fig. 1). The site is located along the northwest banks of the New River Lagoon, adjacent to the modern village of Indian Church (Fig. 2)

Lamanai is situated within a heterogenous environment with good soils, which include a pine ridge, broad leaf forest, and a lagoon connected to the New River. The location of Lamanai along the New River Lagoon (Fig. 2), situated the ancient inhabitants in an advantageous location, which facilitated coastal trade and communication, as the New River connects to the Chetumal Bay in the Caribbean Sea, approximately 80 km to the north. Pendergast (1981:32) indicates that this settlement pattern may have served as the foundation for such a uniquely long period of continuous occupation.

The survey and excavations at Lamanai have yielded over 718 mapped structures constructed during an extensive and rich occupation history that spanned over 2000 years (Table 1), within a 4.5 sq. km strip along the Lagoon (Fig. 2). Given the extensive excavation history of Lamanai, ceramic seriation was developed, and most structures or construction phases are dated using the diagnostic ceramics (Table 2). A summary of ceramic sequences organized in a chronological fashion can be found in Table 2.

Figure 1 Map of Belize, with a gold star indicating the location of Lamanai (Adapted from Metcalfe et al., 2009)

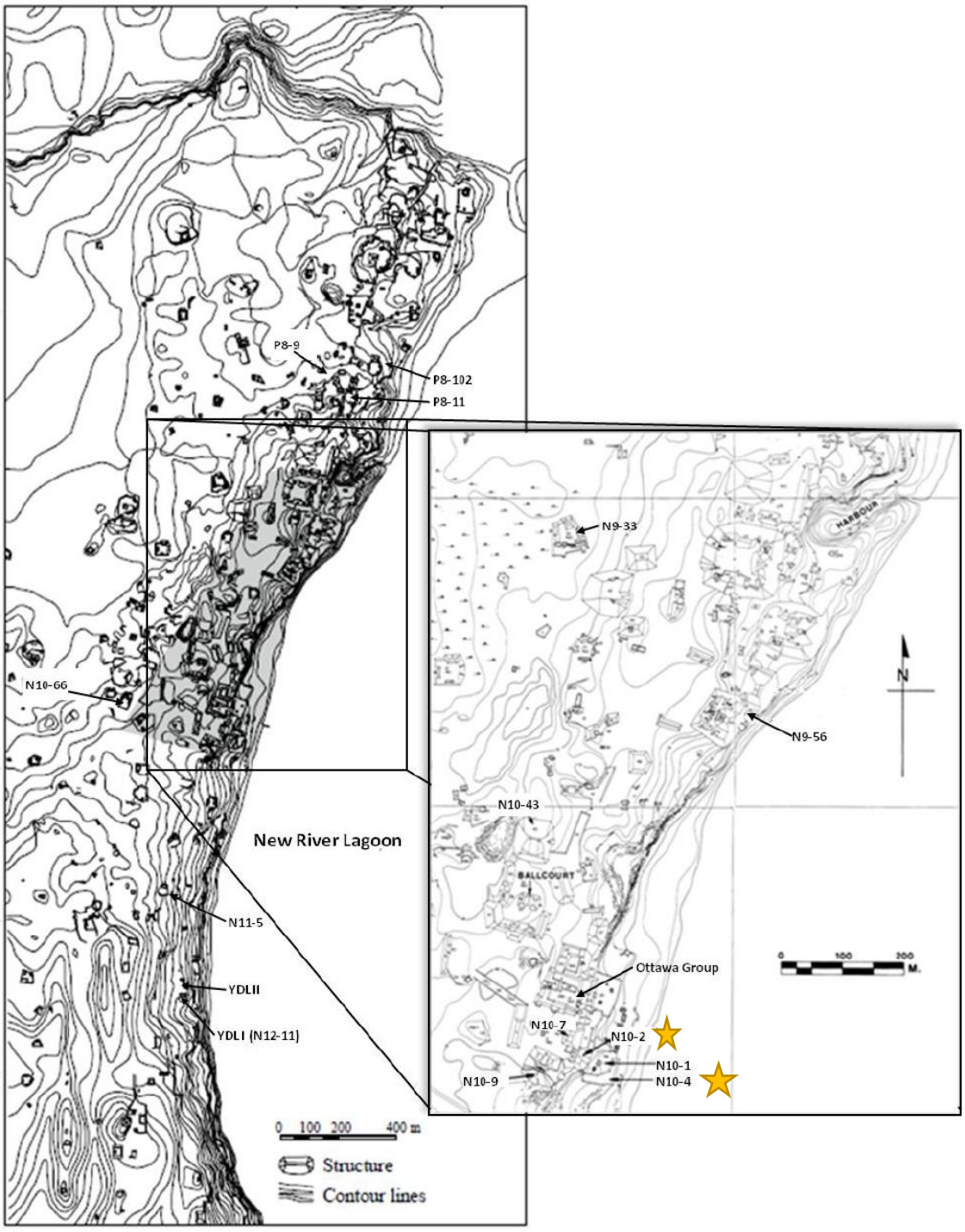


Figure 2 Map of Lamanai (Adapted from Donis, 2013)

Table 1 Lamanai temporal periods and corresponding dates (Donis, 2013)

Time Period	Dates
Preclassic	
Early	2500 – 1250 BC
Middle	1250 – 400 BC
Late	400 BC – AD 250
Classic	
Early	AD 250 – 400
Middle	AD 400 – 650
Late	AD 650 – 900
Terminal	AD 900 – 1000
Postclassic	
Early	AD 1000 – 1100
Middle	AD 1100 – 1400
Late	AD 1400 – 1544
Historical	AD 1544 - 1670

During the Terminal Classic, a transitional period between the Classic to the Early Postclassic, many northern sites experienced instability and conflict, which resulted in increased migration. The collapse of power institutions in the Central Petén and the surrounding areas caused disruption of exchange, communication, and political networks, which resulted in the emergence of new trade networks. During this period at Lamanai, the population regularly engaged in ceremonial construction projects, which is similar to the site of Chau Hiix (Pendergast, 1986). As Pendergast outlines, these construction projects generally took the form of refurbishing older buildings and the construction of smaller ball courts. The difference in construction goals between the elite sponsored Classic period constructions and the smaller Terminal Classic public projects are that the latter indicates a greater community effort and incorporation than the former (Donis, 2013; Pendergast, 1981).

Table 2 A summary table of Lamanai's ceramic chronology (Modified from Donis, 2013; Howie, 2012; Powis, 2002)

Time	Ceramic Complex
1500 – 1400 (BC)	Yglesias
1400 – 1200 (BC)	Cib
1200 – 1000 (BC)	Buk
1000 – 800 (BC)	Terclerp
800 – 625 (BC)	Tzunun
625 – 500 (BC)	Shel
500 – 300 (BC)	Sac
300 (BC) – 100 (AD)	Zotz
100 – 400 (AD)	Lag
400 – 900 (AD)	Mesh

The Postclassic period at Lamanai

The Postclassic population at Lamanai was a vibrant community that maintained its stability from the Classic period, which was demonstrated by the expansion of structure construction to the south (Howie 2006, 2012; Pendergast, 1981). The continuous resiliency at Lamanai throughout the Postclassic is commonly attributed to the sites unique location alongside the New River Lagoon, which afforded opportunity for economic trade and also aided in the maintenance of a stable population via the acquisition of dietary resources during times of stress (Pendergast, 1975; 1981; 1986). Multiple studies, however, have argued that personal attributes

of the leaders at Lamanai may also have contributed to the sites resiliency (Graham, 2006; Howie, 2006; Pendergast, 1992).

Regional isotopic studies focusing on dietary reconstructions of individuals from Lamanai indicate that dietary diversity was present between nearby sites within the Maya lowlands (Coyston et al., 1999; White et al., 1993). Further, studies by Emery (1999) indicate that during the Postclassic period, the population at Lamanai maintained its stability by shifting dietary focus from terrestrial fauna such as deer, to aquatic resources. It is important to highlight here that these dietary differentiations when compared to other nearby sites are possibly indicative of successful adaptive behavior not present at sites abandoned at the end of the Classic period, such as Pacbitun (Wrobel, 2004). Isotopic and dental analysis of individuals from Lamanai completed by White (1997) indicate the site's population was in good health during this transitional period. Specifically, White (1997) explains these individuals consumed a mixed diet that became increasingly dominated by maize in the Postclassic.

Pendergast (1981) notes many architectural similarities between the Postclassic period structures at Lamanai, and sites in the Yucatan, specifically identified in Structures N10 - 1 , N10 – 2, N10 – 4, and N10 – 7 (Fig. 2). The focus of this study are Structures N10 – 2 and N10 – 4. These two structures, specifically, have yielded a significant number of burials, Howie and colleagues (2010) findings are consistent with Pendergast's (1981) observations that these two structures, in combination with other structures, are positioned in a pattern consistent with the "typical Maya residential grouping," which some have described as a "domestic compound that would have housed an extended family of relations over multiple generations" (Howie et al., 2010:375).

Analysis of the ceramic sequences at Lamanai dating to the Postclassic yielded evidence that indicates significant interaction between the Lamanai population and the rest of the Maya world (Graham and Pendergast, 1989). One important association was identified between Lamanai and the site of Marco Gonzalez. Marco Gonzalez is located on the southern tip of Ambergris Caye, which is approximately 182 km from Lamanai. Graham and Pendergast (1989) note that the material culture recovered from Marco Gonzalez is strikingly similar to the Early Postclassic artifacts, which they argue is indicative of a cultural link.

Structure N 10 – 2

Structure N 10 – 2 is a small, ceremonial structure, located within the southern sector of the site, which has yielded a total of fifty human burials and ceramics dated to the early and late Postclassic (Fig. 2) (Lang, 1990; Pendergast, 1981). This structure was originally selected for excavation due to its relative proximity and a shared western plaza border wall with structure N 10 – 1, which has also yielded evidence consistent with a Postclassic date. A total of ten individuals from this structure are included in this study.

This structure is situated just east of the N10-9 plaza group and yields the earliest date (Preclassic) of the Ottawa Group and the surrounding structure (Howie et al., 2010). Structure N10 -2 was one of the largest structures of the southern sector and Ottawa group. This structure experienced multiple reconstruction phases until cessation in the Early to Middle Postclassic. Analysis of the architecture features indicate that N10 -2 was likely used as a ceremonial center (Howie et al., 2010).

Structure N 10 – 4

Structure N 10 – 4 was an elite residential or administrative building, located within the southern sector of the site, which has yielded 47 human burials (Fig. 2) (Lang, 1990; Pendergast, 1981). Structure N 10 – 4 was one of the largest structures within the Ottawa Group and the peripheral structures. This structure, in addition to N 10 -2, experienced multiple phases of reconstruction, which ceased in the Early to Middle Postclassic. Analysis of the architectural features of this structure indicate that it was most likely used as an elite residential or administrative center (Howie et al., 2010; Pendergast, 1975, 1981).

This structure was selected for excavation as part of the continuation of the investigation of the N 10 – 1 Plaza group, in which N 10 – 4 forms the eastern border. Pendergast notes that the structure appears to have been constructed on an area of sloping ground, so that an extended platform would be created, with greater height on the east side than on the western, plaza, side. The total length of the top of the platform, which was measured prior to excavation, was 42 meters (Donis, 2013; Pendergast, 1981).

Throughout the course of excavation in this structure, Burial N 10 – 4/1 was initially discovered. Pendergast (1981, field notes) indicates that at the time of excavation, the first burial was seemingly straightforward, but was confounded during the subsequent discovery of other burials in the same area, which made distinctions between interments and their associated artifacts less clear. Previous researchers (Lang, 1990; White, 1986) have described that this building most likely acted as a graveyard during the Postclassic period. Analyses of the associated grave goods for these burials indicate an apparent corresponding date to the late 15th or early 16th century (Lang, 1990; Pendergast, 1981). A total of 10 individuals from this structure are included in this study.

Mortuary studies of the Maya

Mortuary practices are defined as the culturally defined protocols regarding the disposal of deceased individuals within a community, such as the place, time, and manner of burial (Buikstra and Beck, 2006; Rakita et al., 2005). The study of mortuary practices offers insight into religious, social, and political structures of a community, and possibly the broader population (Buikstra and Beck, 2006; Green, 2016). Studies of mortuary treatment of individuals buried at ancient Maya sites have long been used to understand both the lives of the deceased and also of the living people who placed them there.

No comprehensive analysis of ancient Maya burial practices exits, though some earlier and still useful regional attempts do exist (e.g. Welsh, 1988). Welsh (1988), who created an early analysis of Maya Lowlands burials, identified single interments as the norm, but more recent findings have identified clear exceptions at specific sites (Chase and Chase, 1996; Healy et al., 1998). Burials were also identified to typically be located within structures and features, or beneath floors. The burials of deceased elite individuals commonly located in ceremonial structures or household shrines. Additionally, these individuals are commonly associated with many valuable grave goods (Donis, 2013; Welsh, 1988). While Welsh (1988) identified that certain valuable grave items are specifically associated with elite individuals, he also identified that more general or utilitarian grave goods cross-cut both age and sex groups.

Welsh (1988) also identified a series of burial practices occurring throughout the Maya Lowlands, calling them the "Pan Lowland Maya Burial Practices," which include the placement of a ceramic bowl or dish on the cranium, the placement of jade beads in the mouth, and the skeletons in their study oriented to one particular direction.

Burial patterns at Lamanai

The burial patterns and practices observed at Lamanai throughout its occupation history, are characterized by variation, which is consistent with the rest of the Maya world. The variation in burial practices and patterns is apparent in the differences of type and quantity of grave goods, body position, and grave type. The observed variation in burial practice at Lamanai cross-cuts both sex and age categories. Additionally, at Lamanai, primary burials are predominate, with only a few examples of secondary burials recovered at the site.

Earlier in Lamanai's occupation history, Pendergast (1981) did discover multiple important burial patterns, such as the "Lamanai tomb form." During the later periods of Lamanai's occupation history, Howie (2006, 2012) indicates that the burial placement of individuals within the structure core and foundation became a regular practice. Additionally, Howie (2006; 2012; Howie et al., 2010) indicates that this predominant practice may indicate an expansion of certain ceremonial structures, as they began to function as burial repositories (Donis, 2013).

Pre-inhumation breakage of ceramics is the intentional smashing and breakage of ceramics that are then placed alongside or on top of an interred individual. This practice began to characterize burials starting in the Terminal Classic and was standard in by the Postclassic period at Lamanai. Investigations by Howie (2006) and Howie and colleagues (2010) to restore the vessels broken in the pre-inhumation process, indicate that in every instance there is a fragment of the vessel missing, and they argue that these missing pieces may have been retained as mementos. Additionally, the authors (Howie, 2006; Howie et al., 2010) argue the initiation of this practice may be indicative of not only a shift in mortuary ritual, but also a shift in the notion of appropriate treatment and functionality of ceramics in a burial context (Donis, 2013). The

pattern of pre-inhumation breakage in the Terminal Classic and Postclassic burials at Lamanai is also observed at other Maya sites in the region, such as Postclassic Santa Rita Corozal, Belize (Chase, 1985). Additionally, Pendergast (1986) notes the presence of metal artifacts burials dated to the Postclassic at Lamanai.

VPLF burials

In this thesis, all sampled individuals were buried in a unique position, called Ventrally Placed, Legs Flexed. These were selected with the goal of understanding more about these individuals and the possible reasoning behind the emergence of this unique mortuary placement. The individuals who are buried in this position are identified based on the commonality of significant leg flexion, which results in the feet resting on the posterior surface of the pelvis. Additionally, arms are typically at the sides or in some variant of being placed on the anterior aspect of the body. The individuals are all in a prone position or laying face-down. Apart from consistency in tight leg flexion, it has been recorded (Graham et al., 2013), that there is no other type of standardization in body position or artifact association. Additionally, no special orientation within the structure or a cardinal direction has been identified with this mortuary practice. Individuals buried in the VPLF position have also been identified at other nearby sites, such as Chau Hiix, Marco Gonzalez, and San Pedro (Graham, 2004; Graham et al., 2013; Wrobel, 2007).

Figure 3 Example photo of VPLF individual (not included in this study), (adapted from Graham et al., 2013)

As mentioned, previous studies of VPLF burials have identified significant variability in hand placement (i.e. arms at sides or tightly flexed in the front of the individual), but this variability does not seem to correlate directly with any variables such as structure, age, sex,

associated grave goods, or time period. While there is no apparent standardization in body placement or mortuary treatment, apart from the feet being placed on the pelvis, some researchers have posited that the feet were most likely bound prior to burial (Graham et al., 2013; Pendergast, 1981).

All individuals belonging to the VPLF burial group were dated using stratigraphy and ceramics, indicating that while a majority of the VPLF individuals are dated to the Early Postclassic (950 – 1250 BC), some VPLF burials were also found to be associated with the Middle (1200 – 1350 BC) and Late Postclassic (1350 – 1492) (Howie, 2006; Pendergast, 1981). The temporal continuity of this burial practice is also matched with the prevalence at the site, as researchers (e.g., Graham et al., 2013), have indicated that over one-third of all Postclassic burials were positioned in the VPLF position. Importantly, this burial practice transcends all sex and age groups, with no consistent pattern easily observable.

VPLF individuals were discovered in structures within the southern sector of the site: the Ottawa group, Structure N 10 – 2, and Structure N 10 – 4 (Fig. 2). While Structure N 10 -4 and others within the Ottawa group have been understood to have been residences of the sites elite, and the Ottawa group being identified more specifically as the home of Lamanai's highest level elite individuals. Wrobel (2007) has also identified VPLF burials at the nearby site of Chau Hiix, Belize and in the coastal site of Marco Gonzalez and San Pedro (Fig. 1) (Graham, 2004:235; Graham et al., 2013; Wrobel and Graham, 2015).

A study by Wrobel and Graham (2015) found that the Buk phase VPLF individuals at Lamanai, dated to the Postclassic, are associated with Zakpah ceramics from Marco Gonzalez, Belize. Wrobel and Graham (2015 also observed that this burial group exhibited ubiquitously exhibited unusual patterns of dental and cranial cultural modification. Specifically, Wrobel and

Graham (2015) used dental morphology to determine whether genetic relatedness of the Buk Phase VPLF individuals at Lamanai differed when compared to earlier populations. A significant difference in dental morphology would indicate that Buk phase elites were descended from a non-local origin, while a lack of significant variation in dental morphology would indicate Buk phase elites came from local populations who most likely used non-local ceramic types.

The initial results of Wrobel and Graham (2015) were inconclusive due to small sample sizes and an unavoidable sample bias, which are common issues encountered in Maya bioarchaeological research. Considering these issues, the authors compared the metric (*t*-tests) and non-metric (x^2) traits of elite individuals dating to the Early Postclassic to the Late to Terminal Classic. The results yielded substantial variation, indicating that some of the elite VPLF individuals did not recently originate from Lamanai (Wrobel and Graham, 2015).

The results of Wrobel and Graham (2015) are consistent with the findings of Howie et al. (2010), which posits that Zakpah ceramics are typically found in association with populations that are connected to northern Yucatan trade routes. Additionally, these ceramics were made out of local materials and exhibit both local and non-local characteristics. Pendergast (1981) had noted earlier that the presence of Zakpah ceramics in association with Postclassic burials may be a distinguishing characteristic of the VPLF burial pattern. These data may indicate that the Postclassic VPLF burials may have a connection to the coast or northern Yucatan.

Stable isotope analysis

Isotopes of a specific element are those that have the same number of protons, but differ in their number of neutrons. Stable isotopes are those isotopes that do not undergo radioactive decay over time. As atomic mass is determined by the number of protons and neutrons, isotopes

of an element differ in their atomic masses. This difference in mass affects the physical and chemical characteristics, consequently causing the heavier isotopes to react more slowly. This slower reaction time results in difference in isotopic ratios, called fractionation. Fractionation can occur during both states of equilibrium and metabolic change (Faure and Mensing, 2005).

The isotopic composition refers to the ratio of lighter to heavier isotopes, relative to the ratios of those same isotopes in an internationally standard reference material. The resulting isotopic values are reported using the delta (δ) notation, and are expressed in per mil (‰). The Δ-value is defined as:

$$\delta = [(R_{sample} - R_{standard}) \div R_{standard}]$$

Where R is the ratio of heavy to light isotopes.

Isotopic measures of mobility

Prior to the use of isotopic analyses, researchers who wished to study human mobility in the past would assess the distribution of goods as proxies to indicate human movement. However, in more recent years, the isotopic analysis of biogeneic tissues to elucidate the movement of people, goods, and animals has been an increasingly major focus of recent archaeological research (e.g., Balasse et al., 2002; Bentley, 2007; Britton et al., 2009; Dupras and Schwarcz, 2001, Hedges et al., 2005; Meiggs, 2007; Price et al., 2006). The reconstruction of the movement of people and goods is an important research avenue because it allows researchers to understand resource acquisition strategies, social relationships, and political boundaries (Barrett et al., 2008; Guiry et al., 2012; Meiggs, 2007). Specifically, in this study we will be using stable isotopes to assess the foreign or local identity of a specific burial group.

Makarewicz and Sealy (2015) suggest that while the abundance of isotope-based ancient mobility studies are increasing, most studies are constrained by limiting interpretations to the local or non-local designation of sampled individuals. They highlight that these coarse scales of analysis do not allow for the reflection of complexities and subtleties of human mobility. They argue that an accurate definition of movement mechanisms in the past is dependent on the understanding and application of appropriate isotopic systems for a given environment.

To effectively characterize different isotopic systems within spatially circumscribed environments, foundational studies attempting to track human and animal movement are necessary. When attempting to assess human mobility more specifically, the isotopic analysis of contemporaneous faunal remains, primarily the recovered bones and teeth of herbivores is also necessary, to develop a comparable isotopic baseline. Herbivores are preferentially selected because typically, their isotopic values are reflective of the environmentally local isotopic values of the natural vegetation and hydrological systems. The isotopic values of the local herbivores, therefore provide a point of comparison against which sampled human individuals can be compared.

The isotopic values from contemporaneous herbivores and omnivores are often referred to as a comparative 'isotopic baseline' (Makarewicz and Sealy, 2015). Unfortunately, many baseline data violate sampling requirements by relying on few isotopic values to understand and interpret the isotopic compositions of local environments and food webs. These poorly supported baseline data result in restricted ranges of isotopic diversity, which may potentially cause inaccurate local or non-local designations of sampled human individuals (Makarewicz and Sealy, 2015).

Human bones and teeth are those biological remains which are most often preserved for archaeological and bioarchaeological analysis. Human bone remodels throughout an individual's life, by incorporating new atoms from imbibed water and consumed food (Table 3). The rate of human bone turnover is influenced by factors such as bone type, sex and age of the individual, and any stress of pathology (Sealy et al., 1995; Hedges et al., 2007; Martin, 2000). Bone is also a porous matrix, which allows exogenous substances to also be incorporated into the system during burial. In contrast, dense and non-porous dental enamel does not remodel throughout life, therefore preserving isotopic signals that were recorded during tooth mineralization throughout an individual's childhood. Additionally, dental enamel is the preferable tissues for isotopic studies of mobility due to enamel matrix being much more resistant to diagenetic change during burial (Budd et al., 2004). The use of bone for mobility studies necessitates caution due to bones decreased resiliency to diagenetic alteration. Thus, the combination of stable oxygen values from both bones and teeth provide a method of assessing within lifetime movement.

Table 3 Bone and tooth turnover rates (Donis, 2013:7)

Tissue	Element	Rate of Turnover
Tooth	Adult first molar	Birth – 2.5 years
Tooth	Adult second molar	3.8 – 6 years
Tooth	Adult third molar	9.5 – 12 years
Bone	Bone collagen	Last ten years of life

Oxygen isotopes

Oxygen is naturally abundant in two stable isotopes, ^{18}O and ^{16}O, where the ratio between the two is recorded as $\delta^{18}O$. The $\delta^{18}O$ value is calculated in relation to the international standard(s), either the Vienna Standard Mean Ocean Water (VSMOW) or PeeDee Belemnite

(VPDB), which are used for $\delta^{18}O$ ratios measured from bioapatite phosphate (PO_4) or carbonate (CO_3), respectively (Donis, 2013). The $\delta^{18}O$ values of global rainwater is systematically variable, with the highest values near the equator and in coastal regions, and the lowest values at higher elevations and in rain shadows (Donis, 2013).

Rain water in the Maya region is predominated by precipitation transported via Caribbean trade winds, with increased rainfall across the Isthmus and a minimal contribution of Pacific Ocean moisture to the west of the continental divide. Lachniet and Patterson (2009), have shown that the $\delta^{18}O$ of surface water patterns in Guatemala are determined by the rainfall of ^{18}O as precipitation moves over the Maya lowlands, coupled with temperature-dependent equilibrium fractionation at altitude. Therefore, $\delta^{18}O$ values from coastal Belize will be the highest, and will gradually decline as weather and precipitation system move inland across the Petén. Additionally, a significant drop in oxygen values will occur when weather moves into the Highlands and will rise again near the Pacific Ocean piedmont and coast. A summary of oxygen isotope values for archaeological sites throughout the Maya region can be seen in Table 4.

Seasonal rainfall characterizes the Maya area, with sparse rainfall throughout the months from December to April. Wright (2012) indicates that although the effects of seasonality on $\delta^{18}O$ values has not been explicitly studied in the Maya area, river water $\delta^{18}O$ values should not vary drastically because it should be biased to reflect the predominant wet season precipitation. The lakes in the Petén region reflect significant enrichment caused by evaporation, resulting in higher $\delta^{18}O$ values than elsewhere (Lachniet and Patterson, 2009). Wright (2012) indicates that at Tikal, Guatemala, the $\delta^{18}O$ values of the ancient drinking water may also have been affected by the evaporative enrichment effect within artificial water reservoirs.

Table 4 Selected published stable oxygen isotope values for the Mesoamerican region.

Site	Mean $\delta^{18}O$ / ‰	Std. Deviation	*n*	Range	Region	Reference
Lamanai	17.7	0.8	58	16.9 – 18.5	Lowland Belize	Donis, 2013
Altun Ha	18.9	0.8	18	17.7 – 20.0	Lowland Belize, Coast	Metcalfe, 2005
Chau Hiix	18.8	0.8	11	17.2 – 19.6	Lowland Belize	Olsen, 2006
Ixchimché	15.7	0.4	2	15.4 – 16.0	Guatemalan Highlands	White et al., 1998
Kaminaljuyú	16.7	0.7	30	15.6 – 17.7	Guatemalan Highlands	White et al., 1998
Rio Azul and Rio Bravo	19.9	0.7	7	18.3 – 20.4	Northeastern Guatemala	White et al., 2004
Guanajuato and Lake Zacapu sites	14.3	n/a	n/a	13.5 – 15.0	West Mexico, Michoacan	White et al., 2009
Lake Patzquaro sties	12.8	n/a	n/a	12.1 – 13.7	West Mexico, Michoacan	White et al., 2009
Monte Alban	13.0	0.6	16	12.1 – 13.9	Mexico, Valley of Oaxaca	White, et al. 2009
Teotihuacan	14.8	0.3	11	14.3 – 15.2	Basin of Mexico	White et al., 1998

Oxygen isotopes have been shown to be useful in the study of residential history of individuals because they represent a reflection of imbibed water sources (Kohn, 1996; Longinelli, 1984). Schwarcz and colleagues (1991) were the first to apply oxygen isotope analysis to the study of human mobility, in their study of the geographical origins of the War of 1812 soldiers. Since that initial study, oxygen isotope analysis has received significant attention for its use in paleomobility studies, especially in the Maya area. Using these foundational methods and findings regarding human mobility, I will be using stable oxygen isotope analysis to

determine the geographical origin or within lifetime movement for the individuals buried in the VPLF position.

While the application of stable oxygen isotope analysis to studies of human mobility have been widely used, the oxygen isotope composition of the imbibed water can be altered by numerous climactic and environmental aspects within the hydrological cycle. These influential factors such as temperature, latitude, elevation, and humidity introduce variability to individual body water systems, which is then incorporated into the bones and teeth. Those bones and teeth, after stable isotope analysis, will therefore yield signals that are either typical or atypical of the archaeologically defined "local" population (White et al., 2002:221). To further define geographical origins, stable oxygen values can be compared to the values for surrounding areas by identifying outliers (e.g. Table 4) (Donis, 2013; White et al., 2002). Within Mesoamerica, the established and expected intrapopulational variability is ~2‰ (White et al., 1998).

Breastfeeding has been identified as a cause of ^{18}O enrichment, and therefore needs to be considered when utilizing human teeth formed during weaning periods from sampled individuals. Previously published research conducted in Mesoamerica have indicated that samples of bone from individuals under three years of age, deciduous second molars, and permanent first molars should be adjusted downward 0.7‰. Additionally, canines and premolars should be decreased by 0.35‰ (White et al., 2007). Since isotopically depleted water vapor is lost via respiration, bodily fluids such as blood, sweat, and urine, are more enriched in O^{18}. Therefore, infants consuming a homogenous diet of breast milk are imbibing previously enriched water (Wright and Schwarcz, 1999).

When specifically using oxygen isotope values for studies of human mobility, climactic and environmental factors can be influential to the values yielded from samples human bones

and teeth. Fluctuations in climate throughout time impact and alter the isotopic compositions of precipitation, and imbibed water. Therefore, Budd et al., (2004) suggests using contemporaneous burial populations and/or multiple types of evidence. In this study, we use oxygen isotopic signatures from both bones and teeth, as well as other type of archaeological evidence.

Due to the preferential release of the lighter ^{16}O, oxygen isotope values from the coast will typically be more enriched, and will gradually become increasingly depleted as one moves inland. Oxygen isotope studies in Belize and Guatemala have shown regional variation patterns that are reflected in human populations (Friewald, 2011). A study by Lachinet and Patterson (2009) indicate that approximately 84% of oxygen isotope variation is due to the distance from the coast and altitude. More specifically, in their study, Lachniet and Patterson (2009) sampled 186 water source, and were able to identify that was an approximately 1.24‰ variation in $\delta^{18}O$ values for each 100 millimeters of precipitation.

CHAPTER THREE: MATERIALS AND METHODS

Materials

The remains used in this thesis are the result of large scale excavations at the site of Lamanai, directed by Dr. David Pendergast and Dr. Elizabeth Graham at the Royal Ontario Museum. The approximately 420 individuals excavated from 1974 – 1985 were initially analyzed by Dr. Hermann Helmuth while curated at Trent University. In 1998 the remains were moved from Trent University to the University of Western Ontario, as Dr. Christine White directed osteological research for the site from 2003-2016. The remains were housed at the University of Western Ontario until 2016, when they were transferred to Dr. Lana Williams and Dr. Sandra Wheeler at the University of Central Florida, where they are currently curated for research purposes. Donis (2013) provides the extraction methods and techniques used in dental enamel and dentin isotopic analysis. All burial information was obtained from field notes and appendices of field reports (Pendergast, 1981, 1975).

The data used in this study was obtained from previously published studies regarding within-lifetime mobility of individuals dating from the Postclassic at Lamanai, Belize. Of the 52 individuals placed in a VPLF position during burial (Graham et al., 2013) at Lamanai, a sample of 20 individuals (Table 5) were selected for this study due to three key criteria. First, all individuals were recorded as purposefully positioned in a VPLF position during burial. Second, all individuals were recovered from Structures N10 – 2 and N10 – 4, both dating to the Postclassic. Finally, these individuals were associated with previously published oxygen isotope data. The following is a narrative description of those burials, which have not been

comprehensively reported elsewhere. All information was gathered from field notes and Donis (2013).

Table 5 Individuals included in this study, with estimated sex and age

Individual ID	Estimated Sex	Age (year)	Age Category
N10-2/4a	F	14 - 18	YA
N10-2/14	F	AD	MA
N10-2/16	M	20-40	MA
N10-2/20b	M	40-50	MA
N10-2/21	U	12 - 14	AD
N10-2/22	M	30+	MA
N10-2/23	M	60+	OA
N10-2/40	F	45-50	MA
N10-2/44	U	n/a	n/a
N10-4/10	M	15-20	AD
N10-4/11	F	30+	MA
N10-4/16	M	50+	OA
N10-4/22	F	MA	MA
N10-4/26	M	30+	MA
N10-4/27	U	AD	AD
N10-4/28	M	OA	OA
N10-4/31	U	18-21	YA
N10-4/33	F	30-40	MA
N10-4/44	M	MA	MA
N10-4/45	M	30+	MA

U = Unknown sex, F = Female, M = Male
AD = Adult; YA = Young Adult, MA = Middle Adult, OA = Older Adult

Burial descriptions of study group

N 10 – 2/4a

Burial N 10 – 2/4a, discovered in structure N 10 – 2, was a female individual, estimated to be approximately 14 – 18 years old. This individual was found in a prone position, with the

hands positioned underneath the chest. The legs of this individual were bent backwards tightly, so that the feet rested on the posterior side of the pelvis. Information regarding the head position, body orientation, presence of cranial modification, and presence of dental modification for this individual was not provided. Numerus artifacts were discovered in association with this burial: a red, incised jar located to the northwest of the cranium, with a portion near the right arm, a round, convex ovoid stone was also discovered at the right side of the pelvis, a hammerstone was found between the knees, Oliva shell and stones on top of the left proximal ulna and radius, and an obsidian blade fragment. No association with ceramic sequence was provided for this individual. No notes or information regarding architecture or features was provided for this individual. This individual is the primary skeleton in a two-individual burial. The secondary skeleton was highly fragmentary.

N 10 – 2/14

Burial N 10 – 2/14, discovered in the core of structure N 10 – 2, was of unknown sex, and estimated to be an adult individual. This individual was observed to be in a prone position with the arms of this individual at their sides. The right leg loosely resting on the left leg, which Pendergast (1981) noted may have been indicative of a failure in binding of the body. The cranium was reported to be in a downward position, and slightly turned to the right. Information regarding the body orientation, presence of cranial modification, presence of dental modification, associated artifacts, ceramic phase association, special architecture or feature notes, and the presence of another individual was not provided for this individual.

N 10 – 2/16

Burial N 10 – 2/16, discovered in structure N 10 – 2, was estimated to be an adult female individual. Apart from the burial position being generally described as "frogged," no information regarding the arm, leg, or head position was provided for this individual. The body was recorded to be oriented 91 degrees to the east. No information regarding the presence of cranial modification or dental modification was provided for this individual. Multiple artifact types were recovered in association with this individual: ceramics, needles, pins or awls, Oliva shell beads, an obsidian blade fragment, and a bronze ring. This individual was recorded as associated with the Gom phase. The burial was cut into an area at the western edge of the Tok phase floor and was capped with a Gom phase floor. There was no grave lining observed, but large stones were present on the north end of the burial, which rose above the penultimate level. The burial appeared to be capped with unshaped stones. Information regarding whether this individual was associated with another individual was not provided.

N 10 – 2/20b

Burial N 10 – 20b, discovered in structure N 10 – 2, was a male individual, estimated to be of adult age. The hands of this individual were recorded as bent at the elbows with the hands resting on the posterior aspect of the lower back. The legs of this individual were apparently displaced by another intrusive burial, and were therefore unable to be observed. This body orientation of this individual was eight degrees to the north. Information regarding the presence of cranial modification or dental modification for this individual was not provided. A large jar was found in association with this burial, placed slightly west of the cranium. Pendergast (1981) estimates approximately 15 complete vessels were broken during the pre-inhumation process.

This burial was associated with the Tok phase. The burial was located within core soil, with no observable lining or cap. There were, however, some larger stones at the north and western borders of the grave. This individual was accompanied by a female individual of approximately the same age, which Pendergast (1981) claims could be indicative of a couple.

N 10 – 2/21

Burial N 10 – 2/21, discovered in structure N 10 – 2, was of unknown sex, estimated to be 12 – 14 years old. Information regarding specific hand position and leg position was not included. The post-cranial skeleton of this individual was positioned 213 degrees to the west, and with the face 265 degrees to the west. No information regarding the presence of cranial modification, presence of dental modification, and associated artifacts is not provided for this individual. This burial is estimated to be from the Postclassic period due to the burials location within Structure N 10 – 2, but no ceramic association is provided for this burial. The burial was located within core soil, with no observable grave lining or cap. Information regarding the association of this burial with another individual was not provided.

N 10 – 2/22

Burial N 10 – 2/22, discovered in structure N 10 – 2, was a male individual, estimated to be over 30 years old. The arm position of this individual was described as the right arm being tightly flexed with the left arm located under the chest. The left hand was also tightly flexed downward so to point towards the pelvis. The leg position of this individual was described as being found tightly flexed so that the feet rested on the posterior aspect of the pelvis. The head position of this individual was described as being in a downward position. This individual

exhibited fronto-occipital cultural cranial modification. No information regarding the presence of dental modification was provided for this individual. Excavators noted the presence of a bead and stone near the anterior surface of the face, which may have originally been placed in the mouth. This burial was recorded as associated with the Tok phase. The burial was located within core soil, with no observable lining or cap. However, excavators did note the presence of a large stone at the southeast side of the grave. Information regarding the association of this burial with another was not provided.

N 10 – 2/23

Burial N 10 – 2/23, discovered in structure N 10 – 2, contained a male individual, estimated to be 60 years of age or older. The individual was discovered in a "dorsal" position that was partially extended, with the arms slightly resting at their sides. The legs were tightly flexed so that the feet rested on the posterior surface of the pelvis. Information regarding the head position, body orientation, and presence of cranial modification was no provided for this individual. Dental modification was present on the upper left and right central incisors with notching on both the labial and buccal sides. There were numerous artifact types associated with this burial. A group of perforated shells were discovered at the west end of the grave, almost opposite of the left elbow. An awl tool made out of a deer ulna was discovered underneath the individual. Two hand drums were found in this burial, one slightly larger than the other. Fragmentary ceramic sherds were discovered to the side of the interred individual. Information regarding ceramic phase association for this burial was not provided. Two flat stones were discovered on the sides of the cranium and over the chest area. Information regarding the association of this burial with another was not provided.

N 10 – 2/40

Burial N 10 – 2/40, discovered in structure N 10 – 2, contained a male individual, estimated to be approximately 45 – 55 years old. The position of this individual was described as "frogged," with the arms at their sides, and the feet resting on the posterior aspect of the pelvis. No information regarding the head position, body orientation, or presence of dental modification was provided. This individual exhibited cultural cranial modification (fronto-occipital), and also exhibited a high prevalence of dental caries. Excavators recorded that there appeared to be a group of vessels found smashed over this individual's back. Information regarding a ceramic phase association, special architecture or feature notes, and presence of an additional individual was not provided.

N 10 – 2/44

Burial N 10 – 2/44, discovered in structure N 10 – 2, contained an individual of unknown age and sex in the VPLF burial position. The arms were bent with the left hand located on the abdomen and the right hand located under the left side of the chest. The feet were observed to be located on the posterior surface of the pelvis, possibly indicating tight flexion of the legs. The exact position, however, was not discernable due to preservation conditions of this individual. Information regarding the head position and boy orientation was not provided. This individual exhibited cultural cranial modification (fronto-occipital). Information regarding the presence of dental modification was not provided. A jade pendant was discovered above the burial and appeared to be reworked from a larger original stone. A shell pendent and a flaring-side vessel was found scattered and fragmentary over the burial. Information regarding the association with

ceramic phases, special architecture or features, and the presence/association with an additional individual was not provided.

N 10 – 4/10

Burial N 10 – 4/10, discovered in structure N 10 – 4, contained an individual of unknown sex, estimated to be approximately 15 – 20 years old. The individual was recorded to have been placed in the VPLF burial position with their arms placed on the anterior aspect of the pelvis. Information regarding the leg position, head position, body orientation, and presence of cranial modification was not provided for this individual. This individual exhibited dental modification of the upper right lateral incisor, which was notched on the labial corner. The upper right and left central incisors and the upper left lateral incisor were described to have possibly exhibited dental modification, but no other explanation was provided. A Tulum-related dish was involved in pre-inhumation breakage. Marginella beads and an obsidian blade fragment was also found in association with this burial. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided.

N 10 – 4/11

Burial N 10 – 4/11, discovered in structure N 10 – 4, contained a probable female individual, estimated to be over 30 years old. The remains were found to be in the VPLF position, with the arms bent inward. The remains were described to have been disturbed by the stone bedding which resulted in a slight irregular curvature of the body causing the legs to be much lower than the head. Information regarding the specific leg position, head position, body orientation, presence of cranial modification, and the presence of dental modification was not

provided for this individual. A chert blade was located above the burial and was assumed to be associated. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/16

Burial N 10 – 4/16, discovered in structure N 10 – 4, was a male individual, estimated to be over the age of 50 years old. This individual was noted to have been buried in the VPLF position with their arms at the sides and the legs tightly flexed so that the feet rested on the posterior aspect of the pelvis. The cranium was positioned with the anterior surface downward. Information regarding body orientation, presence of cranial modification, presence of dental modification, and associated artifacts was provided for this individual. This burial was assumed to be associated with the Tuk phase, and was lined with small, unshaped stones. There was no cap observed for this grave. No information regarding the association or presence on an additional individual was provided for this burial.

N 10 – 4/22

Burial N 10 – 4/22, discovered in structure N 10 – 4, was a female individual, estimated to be of mature adult age. The remains were observed to be in the VPLF position with the arms at the sides, and the right hand placed on the anterior surface of the pelvis and the left hand placed near the left hip. Information regarding the leg position was not provided. The head of this individual was noted to be facing east. Information regarding the body position and presence of cranial modification was not provided. This individual exhibited dental modification of the upper left and right central and lateral incisors, which were notched on the lingual and buccal

aspects and filed to a pointed apex. An out-curving side-dish with a tripod base was discovered inverted over the left shoulder. Additionally, excavators noted evidence of pre-inhumation breakage. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/26

Burial N 10 – 4/26, discovered in structure N 10 – 4, was a male individual, estimated to be over the age of 30 years. The cranium was position downward and to the northeast. The individual was recorded as being placed in the VPLF burial position with the arms at their sides and the right hand placed at the hip, and the left arm bent so to position the left hand on the anterior aspect of the pelvis. Information regarding the leg position was not provided for this individual. The cranium was position downward and to the northeast. Information regarding the body orientation, presence of cranial modification, and presence of dental modification was not provided for this individual. Incised ceramics, Marginella shells, and freshwater mussel shell fragments were found in association with this burial. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/27

Burial N 10 – 4/27, discovered in structure N 10 – 4, was of unknown sex, and estimated to be an adult individual. This individual was placed in the VPLF burial position. While it is clearly noted that this burial was severely disturbed both by other burials and bioturbation, the remaining lower left arm and hand did appear to be tightly flexed and placed on the lower back

of this individual. Excavators noted that there were many bones missing from this burial, such as the head removed by one burial, and the legs cut by another burial. Information regarding the leg position, head position, body orientation, presence of cranial modification, presence of dental modification, associated artifacts, association with ceramic phases, special architecture or features, and the presence or association with an additional individual was not provided for this individual.

N 10 – 4/28

Burial N 10 – 4/28, discovered in structure N 10 – 4, was of unknown sex, and was estimated to a mature adult. This individual was buried in the VPLF position with their arms tightly flexed with the hands placed on the anterior aspect of the shoulders. Information regarding leg position, head position, body orientation, and presence of cranial modification was not provided. This individual exhibited dental modification, but the type and a description were not provided. Incised ceramics with pre-inhumation breakage was present. Other artifacts found in association with this burial include: an animal jaw, mirror, shell and jade disc beads, copper button-shaped (Monte Alban form) ornaments, human tooth beads, and carved bone representations of human phalanges. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/31

Burial N 10 – 4/31, discovered in structure N 10 – 4, was an individual of unknown sex, estimated to be between 18 – 21 years old. The excavators recorded that the individual was in

the VPLF position with the arms most likely placed at the sides, though due to preservation the exact position is indiscernible. Information regarding leg position, head position, body orientation, and presence of cranial modification was not provided for this individual. This individual exhibited dental modification to the upper left and right central and lateral incisor. The modifications were notched on the labial and buccal aspects, to produce a flat to pointed apex. The artifacts found in association with this burial included an out-curved dish with Tulum-style tripod feet that was placed inverted over the left elbow. Excavators noted the possible presence of incomplete pre-inhumation breakage. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/33

Burial N 10 – 4/33, discovered in structure N 10 – 4, was a female individual, estimated to be approximately 30 – 40 years old. individual was discovered to be in the VPLF position with the arms approximately at the sides and the feet most likely placed on the posterior aspect of the pelvis. The exact burial position of this individual was challenging to determine due to the degree of preservation. Information regarding head position, body orientation, presence of cranial modification, and presence of dental modification was not provided for this individual. A mass of ceramic sherds, possibly a whole vessel, was found to the west of the left leg, approximately 10cm above the anterior surface of the leg. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

N 10 – 4/44

Burial N 10 – 4/44, discovered in structure N 10 – 4, a male individual, estimated to be a mature adult. This individual was placed prone, with the right hand placed anteriorly under the pelvis, and the left hand placed to the left of the femur. The legs were uniquely flexed and positioned with the knees to the left side. This individual remains consistent in regard to foot positioning on the posterior aspect of the pelvis. Information regarding head position, body orientation, presence of cranial modification, presence of dental modification, association with ceramic phases, special architecture or features, and the presence or association with an additional individual was not provided.

N 10 – 4/45

Burial N 10 – 4/45, discovered in structure N 10 – 4, was a male individual, estimated to be approximately 30 years or older. This individual was found in the VPLF position, with their arms at the sides and slightly bent at the elbows, with the hands positioned on the anterior aspect of the pelvis. Information regarding the position of the legs was not provided. The position of the head was 16 degrees north. Information regarding body orientation was not provided. This individual was recorded as exhibiting cranial modification, but the type and other descriptions were not provided or recorded. Information regarding the presence of dental modification was not provided. A complete jar was discovered on top of the cranium, as well as evidence for pre-inhumation breakage. Other artifacts found in association with this burial include shell ornaments and a lamina of pyrite above the thoracic vertebrae. Information regarding association with ceramic phases, special architecture or features, and the association of an additional individual was not provided for this burial.

Methods

All of the original individual burial information was organized into one master spreadsheet using Microsoft Excel 2016 (Appendix). Within the one file, multiple tabs were used to aid in the categorical organization of the data. These included sex estimations, age estimations, structure, arm position, leg position, head position, body orientation, presence of cranial modification, presence of dental modification, presence of elite associated artifacts, oxygen isotope values (not corrected for breast feeding), oxygen isotope values (corrected for breast feeding), and any other contextual information regarding the structure, architecture, and special features of the burials.

This type of categorization allows for greater ease during comparison and analysis of the data. The demographics and tissues sampled by Donis (2013) for the sample selected in this study are summarized in Table 3. Due to the difference in turnover rates of skeletal tissues, the isotopic value for each tissues type is representative of a difference point in an individual's lifespan (see Table 3 for an example of different tissue turnover rates). Stable oxygen isotope values for bones and teeth sampled from individuals assessed in this study are presented in Table 6.

Table 6 List of tissues analyzed for each individual, and their respective δ ^{18}O values (data from Donis, 2013)

Individual	Sex	Age (years)	Bone	M1	M2	PM	δ ^{18}O Bone	δ ^{18}O Tooth
N 10 – 2/4a	F	14 – 18	X		X		n/a	20.0
N 10 – 2/14	F	AD	X	X			18.0	20.3
N 10 – 2/16	M	20 – 40	X	X	X		19.7	19.6
N 10 – 2/20b	M	40 – 50	X			X	17.5	19.4
N 10 – 2/21	U	12 – 14	X	X	X		17.5	19.3
N 10 – 2/22	M	30+	X	X			18.6	n/a
N 10 – 2/23	M	60+	X				17.5	19.9
N 10 – 2/40	F	45 – 50	X	X			17.5	19.6
N 10 – 2/44	U	n/a	X		X		17.8	19.6
N 10 – 4/10	M	15 – 20	X	X			17.8	17.4
N 10 – 4/11	F	30 +	X	X			18.6	20.6
N 10 – 4/16	M	50+		X			n/a	20.4
N 10 – 4/22	F	MA	X			X	18.3	20.0
N 10 – 4/26	M	30 +	X		X		19.7	19.8
N 10 – 4/27	U	AD	X				17.4	n/a
N 10 – 4/28	M	OA	X				17.9	n/a
N 10 – 4/31	U	18 – 21	X			X	19.5	19.0
N 10 – 4/33	F	30 – 40	X	X			18.7	17.9
N 10 – 4/44	M	MA	X				16.7	n/a
N 10 – 4/45	M	30+	X	X			19.4	19.8

CHAPTER FOUR: RESULTS & INTERPRETATIONS OF ISOTOPE ANALYSES

This burial group included a total of 20 individuals including ten males, six females, and four individuals of unknown sex (Table 3). Five individuals were of unknown age, four were estimated to be under 20 years old, six individuals were estimated to be between 20 – 40 years of age, and five individuals were estimated to be over 40 years of age (Table 6).

Arm placement of the VPLF individuals is described below. Of the 20 individuals, only one had unknown or unobservable arm position. Four individuals had their arms placed on the anterior aspect of their chest. Six individuals had their arms placed straight at their sides. Three individuals had their elbows bent, causing the hands to be placed on the posterior aspect of the back. One individual had their arms position tightly flexed at their sides. Two individuals had arm placement at the anterior aspect of the pelvis. Three individuals had their arms placed to their sides, with one hand on the lateral femur and the other placed on the anterior aspect of the pelvis. The frequency of arm placement variation is outlined below in Table 8.

Table 7 Summary of arm placement frequencies

Arm position	Count	Frequency
Unknown/Unobservable	1	5%
Anterior chest	4	20%
Straight at sides	6	30%
Elbows bent, hands on back	3	15%
Tightly flexed at sides	1	5%
Straight at sides, hands placed anteriorly	3	15%

Of the 20 individuals included in this research, two individuals had unknown leg placement, and one individual was found with their legs resting on one another. Seventeen individuals, however, had their legs positioned tightly backward in the prone position, so that the feet rested on the posterior aspect of the pelvis (Table 9). Eighteen individuals had unknown burial orientation, one was oriented to the east, and one individual was oriented to the north (Table 10). Within this burial group, four individuals exhibited cultural cranial modification, and five exhibited cultural dental modification (Table 11). Five individuals did not have information available regarding associated burial artifacts, but 13 individuals had elite artifacts, and two had non-elite artifacts.

Table 8 Summary of leg placement frequencies

Leg position	Count	Frequency
Unknown/Unobservable	2	10%
Legs resting on top of each other	1	5%
Tightly bent posteriorly so that the feet rest on back	17	85%

Table 9 Summary of burial orientation frequencies

Burial orientation	Count	Frequency
Unknown/Unobservable	18	90%
East	1	5%
North	1	5%

Table 10 Summary of cranial and dental modification frequencies

Type of modification	Modification presence count	Frequency
Cranial modification	4	20%
Dental modification	5	25%

Correlation between sex and arm position

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and arm position of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the arm position (Table 12). This is subsequently statistically supported by the chi-square test (χ = 11.694, df = 12, p = .471). Thus, the null hypothesis that there is no association between estimated sex and arm position was accepted at the .01 level of significance

Table 11 Results of a chi-square test of association between estimated sex and arm position

			Sex			
			Unknown	Male	Female	Total
Arm Position	Unknown	Count	1	0	0	1
		Expected Count	.2	.5	.3	1.0
	Anterior chest	Count	1	2	1	4
		Expected Count	.8	2.0	1.2	4.0
	At sides	Count	1	2	3	6
		Expected Count	1.2	3.0	1.8	6.0
	Elbows bent, hands on posterior pelvis	Count	1	2	0	3
		Expected Count	.6	1.5	.9	3.0
	Tightly flexed	Count	0	0	1	1
		Expected Count	.2	.5	.3	1.0
	Anterior pelvis	Count	0	2	0	2
		Expected Count	.4	1.0	.6	2.0
	At sides with one hand on lateral femur and other on anterior pelvis	Count	0	2	1	3
		Expected Count	.6	1.5	.9	3.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and leg position

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and leg position of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the leg position (Table 13). This is subsequently statistically supported by the chi-square test (χ = 11.694, df = 12, p = .471). Thus, the null hypothesis that there is no association between estimated sex and leg position was accepted at the .01 level of significance.

Table 12 Results of a chi-square test of association between estimated sex and leg position

			Sex			
			Unknown	Male	Female	Total
Leg Position	Unknown	Count	1	1	0	2
		Expected Count	.4	1.0	.6	2.0
	Tightly bent backward so that the feet rest on the posterior pelvis	Count	3	9	5	17
		Expected Count	3.4	8.5	5.1	17.0
	One leg resting on the other, extended.	Count	0	0	1	1
		Expected Count	.2	.5	.3	1.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and head position

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and head position of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the

two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the head position (Table 14). This is subsequently statistically supported by the chi-square test (χ = 8.139, df = 6, p = .228). Thus, the null hypothesis that there is no association between estimated sex and head position was accepted at the .01 level of significance.

Table 13 Results of a chi-square test of association between estimated sex and head position.

			Sex		
			Unknown	Male	Female	Total
Head Position	Unknown	Count	3	6	3	12
		Expected Count	2.4	6.0	3.6	12.0
	Downward	Count	0	4	2	6
		Expected Count	1.2	3.0	1.8	6.0
	East	Count	0	0	1	1
		Expected Count	.2	.5	.3	1.0
	West	Count	1	0	0	1
		Expected Count	.2	.5	.3	1.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and body orientation

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and body orientation of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the body orientation (Table 15). This is subsequently statistically supported by the chi-square test (χ = 2.222, df = 4, p

= .695). Thus, the null hypothesis that there is no association between estimated sex and body orientation was accepted at the .01 level of significance.

Table 14 **Results of a chi-square test of association between estimated sex and body orientation**

			Sex			
			Unknown	Male	Female	Total
Body Orientation	Unknown	Count	4	8	6	18
		Expected Count	3.6	9.0	5.4	18.0
	East	Count	0	1	0	1
		Expected Count	.2	.5	.3	1.0
	North	Count	0	1	0	1
		Expected Count	.2	.5	.3	1.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and cranial modification

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and the presence of cranial modification for individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the presence of cranial modification (Table 16). This is subsequently statistically supported by the chi-square test (χ = .104, df = 2, p = .949). Thus, the null hypothesis that there is no association between estimated sex and presence of cranial modification was accepted at the .01 level of significance.

Table 15 **Results of a chi-square test of association between sex and cranial modification**

			Sex			
			Unknown	Male	Female	Total
Cranial Mod	Unknown	Count	3	8	5	16
		Expected Count	3.2	8.0	4.8	16.0
	Present	Count	1	2	1	4
		Expected Count	.8	2.0	1.2	4.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and dental modification

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and the presence of dental modification for individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the presence of dental modification (Table 17). This is subsequently statistically supported by the chi-square test (χ = .356, df = 2, p = .837). Thus, the null hypothesis that there is no association between estimated sex and presence of dental modification was accepted at the .01 level of significance.

Table 16 Results of a chi-square test of association for estimated sex and presence of dental modification

			Sex		
			Unknown	Male	Female	Total
Dental Mod	Unknown	Count	3	7	5	15
		Expected Count	3.0	7.5	4.5	15.0
	Present	Count	1	3	1	5
		Expected Count	1.0	2.5	1.5	5.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and burial artifacts

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and the presence of elite burial artifacts for individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and the presence of elite burial artifacts (Table 18). This is subsequently statistically supported by the chi-square test (χ = 3.426, df = 4, p = 4.89). Thus, the null hypothesis that there is no association between estimated sex and presence of elite burial artifacts was accepted at the .01 level of significance.

Table 17 Results of a chi-square test of association for estimated sex and presence of elite burial artifacts

			Unknown	Male	Female	
Associated Artifacts	Unknown	Count	2	1	2	5
		Expected Count	1.0	2.5	1.5	5.0
	Elite	Count	2	8	3	13
		Expected Count	2.6	6.5	3.9	13.0
	Non-elite	Count	0	1	1	2
		Expected Count	.4	1.0	.6	2.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and stable oxygen isotope values from bone

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and the oxygen isotope values from bone for individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated sex and bone stable oxygen isotope values (Table 19). This is subsequently statistically supported by the chi-square test (χ = 1.804, df = 4, p = .772). Thus, the null hypothesis that there is no association between estimated sex and oxygen isotope values from bone was accepted at the .01 level of significance.

Table 18 **Results of a chi-square test of association for estimated sex and stable oxygen isotope values from bone**

Crosstab

			Sex			
			Unknown	Male	Female	Total
BoneValues	Unknown	Count	0	1	1	2
		Expected Count	.4	1.0	.6	2.0
	Within Lamanai Range	Count	4	8	5	17
		Expected Count	3.4	8.5	5.1	17.0
	Not within Lamanai Range	Count	0	1	0	1
		Expected Count	.2	.5	.3	1.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between sex and stable oxygen isotope values from teeth

A chi-square test of association was conducted to determine if there was a relationship between estimated sex and the oxygen isotope values from teeth for individuals within this burial group. The test was conducted using an alpha of .01. The assumption of independence was not

met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error. It was hypothesized that there was an association between the two variables.

There appears to be no relationship between estimated sex and tooth oxygen isotope values (Table 20). This is subsequently statistically supported by the chi-square test (χ = 6.708, df = 4, p = .152). Thus, the null hypothesis that there is no association between estimated sex and oxygen isotope values from teeth was accepted at the .01 level of significance.

Table 19 Results of a chi-square test of association between estimated sex and oxygen isotope values from teeth

			Sex			
			Unknown	Male	Female	Total
TeethValues	Unknown	Count	1	3	0	4
		Expected Count	.8	2.0	1.2	4.0
	Within Lamanai Range	Count	3	2	2	7
		Expected Count	1.4	3.5	2.1	7.0
	Not within Lamanai Range	Count	0	5	4	9
		Expected Count	1.8	4.5	2.7	9.0
Total		Count	4	10	6	20
		Expected Count	4.0	10.0	6.0	20.0

Correlation between age and arm position

A chi-square test of association was conducted to determine if there was a relationship between estimated age and arm position of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and arm position (Table 21). This is subsequently statistically supported by the chi-square test (χ = 14.861, df = 18, p = .671). Thus, the null hypothesis that there is no association between estimated age and arm position was accepted at the .01 level of significance.

Table 20 Results of a chi-square test of association between age and arm position

	Age		Less than 20 years old	20 -40 years old	Over 40 years old		
Arm Position	Unknown	Count	0	1	0	0	1
		Expected Count	.3	.2	.3	.3	1.0
	Anterior chest	Count	1	1	1	1	4
		Expected Count	1.0	.8	1.2	1.0	4.0
	At sides	Count	1	1	1	3	6
		Expected Count	1.5	1.2	1.8	1.5	6.0
	Elbows bent, hands on posterior pelvis	Count	1	0	1	1	3
		Expected Count	.8	.6	.9	.8	3.0
	Tightly flexed	Count	0	0	1	0	1
		Expected Count	.3	.2	.3	.3	1.0
	Anterior pelvis	Count	0	1	1	0	2
		Expected Count	.5	.4	.6	.5	2.0
	At sides with one hand on lateral femur and other on anterior pelvis	Count	2	0	1	0	3
		Expected Count	.8	.6	.9	.8	3.0

Correlation between age and leg position

A chi-square test of association was conducted to determine if there was a relationship between estimated age and leg position of individuals within this burial group. The test was

conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and leg position (Table 22). This is subsequently statistically supported by the chi-square test (χ = 5.735, df = 6, p = .453). Thus, the null hypothesis that there is no association between estimated age and leg placement was accepted at the .01 level of significance.

Table 21 Results of a chi-square test of association between age and leg position

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
Leg Position	Unknown	Count	0	1	0	1	2
		Expected Count	.5	.4	.6	.5	2.0
	Tightly bent backward so that the feet rest on the posterior pelvis	Count	4	3	6	4	17
		Expected Count	4.3	3.4	5.1	4.3	17.0
	One leg resting on the other, extended.	Count	1	0	0	0	1
		Expected Count	.3	.2	.3	.3	1.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and head position

A chi-square test of association was conducted to determine if there was a relationship between estimated age and head position of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and head position (Table 23). This is subsequently statistically supported from the chi-square test (χ = 5.735, df = 6, p = .453). Thus, the null hypothesis that there is no association between estimated age and head position was accepted at the .01 level of significance.

Table 22 Results of a chi-square test of association between age and head position

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
Head Position	Unknown	Count	3	2	3	4	12
		Expected Count	3.0	2.4	3.6	3.0	12.0
	Downward	Count	1	1	3	1	6
		Expected Count	1.5	1.2	1.8	1.5	6.0
	East	Count	1	0	0	0	1
		Expected Count	.3	.2	.3	.3	1.0
	West	Count	0	1	0	0	1
		Expected Count	.3	.2	.3	.3	1.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and body orientation

A chi-square test of association was conducted to determine if there was a relationship between estimated age and body orientation of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and body orientation (Table 24). This is subsequently statistically supported by the chi-square test (χ = 5.519, df = 6, p = .479). Thus, the null hypothesis that there is no association between estimated age and body orientation was accepted at the .01 level of significance.

Table 23 Results of a chi-square test of association between age and body orientation

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
Body Orientation	Unknown	Count	5	4	5	4	18
		Expected Count	4.5	3.6	5.4	4.5	18.0
	East	Count	0	0	1	0	1
		Expected Count	.3	.2	.3	.3	1.0
	North	Count	0	0	0	1	1
		Expected Count	.3	.2	.3	.3	1.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and cranial modification

A chi-square test of association was conducted to determine if there was a relationship between estimated age the presence of cranial modification of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and the presence of cranial modification (Table 25). This is subsequently statistically supported by the chi-square test (χ =

1.667, df = 3, p = .644). Thus, the null hypothesis that there is no association between estimated age and presence of cranial modification was accepted at the .01 level of significance.

Table 24 Results of a chi-square test of association between age and the presence of cranial modification

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
Cranial Mod	Unknown	Count	4	4	4	4	16
		Expected Count	4.0	3.2	4.8	4.0	16.0
	Present	Count	1	0	2	1	4
		Expected Count	1.0	.8	1.2	1.0	4.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and dental modification

A chi-square test of association was conducted to determine if there was a relationship between estimated age and presence of dental modification of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and the presence of dental modification (Table 26). This is subsequently statistically supported by the chi-square test (χ = 4.000, df = 3, p = .261). Thus, the null hypothesis that there is no association between estimated age and presence of dental modification was accepted at the .01 level of significance.

Table 25 **Results of a chi-square test of association between age and the presence of dental modification**

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
Dental Mod	Unknown	Count	4	2	6	3	15
		Expected Count	3.8	3.0	4.5	3.8	15.0
	Present	Count	1	2	0	2	5
		Expected Count	1.3	1.0	1.5	1.3	5.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and burial artifacts

A chi-square test of association was conducted to determine if there was a relationship between estimated age and presence of elite burial artifacts of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and presence of elite burial artifacts (Table 27). This is subsequently statistically supported by the chi-square test (χ = 8.969, df = 6, p = .175). Thus, the null hypothesis that there is no association between estimated age and presence of elite burial artifacts was accepted at the .01 level of significance.

Table 26 **Results of a chi-square test of association between age and associated burial artifacts**

			Age				Total
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	
Associated Artifacts	Unknown	Count	3	2	0	0	5
		Expected Count	1.3	1.0	1.5	1.3	5.0
	Elite	Count	2	2	5	4	13
		Expected Count	3.3	2.6	3.9	3.3	13.0
	Non-elite	Count	0	0	1	1	2
		Expected Count	.5	.4	.6	.5	2.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and stable oxygen isotope values for bone

A chi-square test of association was conducted to determine if there was a relationship between estimated age and bone stable oxygen isotope values of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and bone stable oxygen isotope values (Table 28). This is subsequently statistically supported by the chi-square test (χ = 5.735, df = 6, p = .453). Thus, the null hypothesis that there is no association between estimated age and bone stable oxygen isotope values was accepted at the .01 level of significance.

Table 27 **Results of a chi-square test of association between age and stable oxygen isotope values from bone**

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
BoneValues	Unknown	Count	0	1	0	1	2
		Expected Count	.5	.4	.6	.5	2.0
	Within Lamanai Range	Count	4	3	6	4	17
		Expected Count	4.3	3.4	5.1	4.3	17.0
	Not within Lamanai Range	Count	1	0	0	0	1
		Expected Count	.3	.2	.3	.3	1.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

Correlation between age and stable oxygen isotope values for teeth

A chi-square test of association was conducted to determine if there was a relationship between estimated age and tooth stable oxygen isotope values of individuals within this burial group. The test was conducted using an alpha of .01. It was hypothesized that there was an association between the two variables. The assumption of independence was not met since the respondents were not randomly selected, thus, there is an increased probability of a Type I error.

There appears to be no relationship between estimated age and dental oxygen isotope values (Table 29). This is subsequently statistically supported by the chi-square test (χ = 2.563, df = 6, p = .861). Thus, the null hypothesis that there is no association between estimated age and dental stable oxygen isotope values was accepted at the .01 level of significance.

Table 28 **Results of a chi-square test of association between age and stable oxygen isotope values from bone**

Crosstab

			Age				
			Unknown	Less than 20 years old	20 - 40 years old	Over 40 years old	Total
TeethValues	Unknown	Count	2	0	1	1	4
		Expected Count	1.0	.8	1.2	1.0	4.0
	Within Lamanai Range	Count	1	2	2	2	7
		Expected Count	1.8	1.4	2.1	1.8	7.0
	Not within Lamanai Range	Count	2	2	3	2	9
		Expected Count	2.3	1.8	2.7	2.3	9.0
Total		Count	5	4	6	5	20
		Expected Count	5.0	4.0	6.0	5.0	20.0

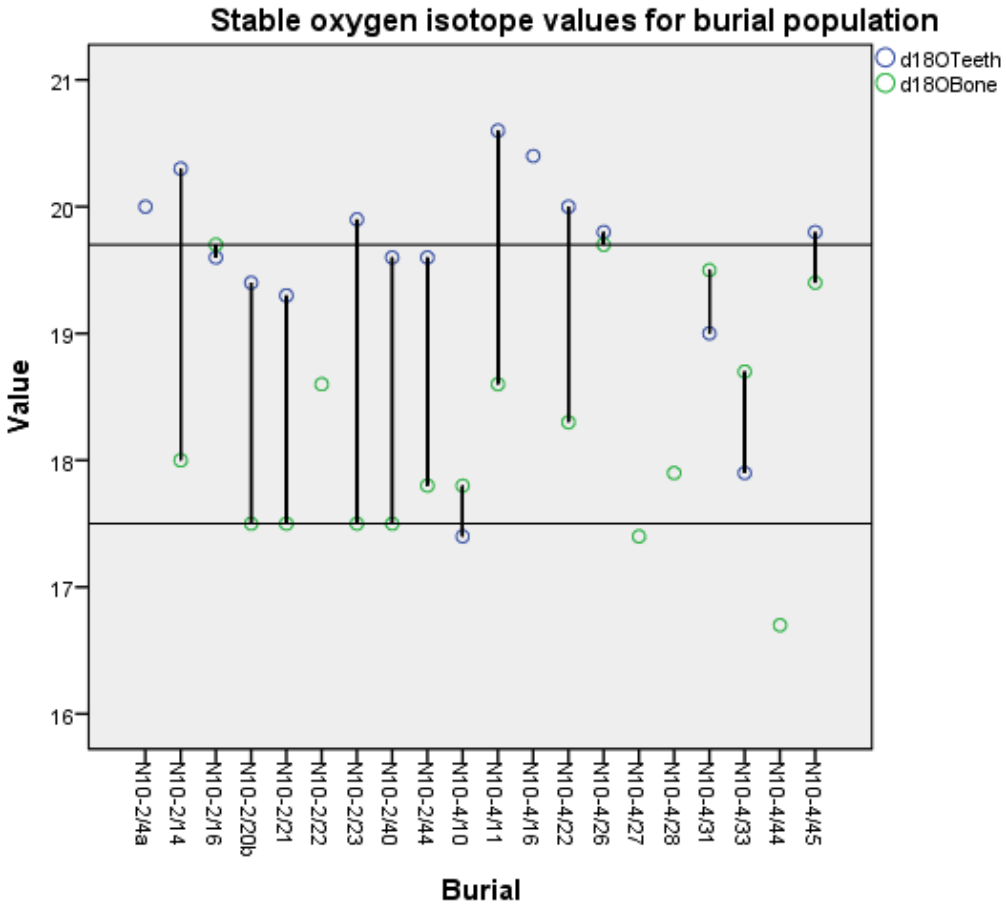
All variables were tested for correlation by using a chi-square test of association because the data was nominally organized. No statistical correlations between the variables observed for the VPLF individuals was identified through these statistical tests. The variables that were tested against the two independent variables, sex and age were arm placement, leg placement, head placement, body orientation, cranial modification, dental modification, artifacts, and stable oxygen isotope values from bones and teeth. While there were not statistical correlations between these variables, the descriptive statistics and frequency data do highlight that there was a prevalence towards arms being placed at the sides with the feet flexed tightly so that the feet rest on the back.

Stable Isotope Results

The stable oxygen isotope values of the individuals selected in the study are presented in Table 30 and Table 31. The values of both oxygen values from bone and teeth are presented, in comparison with the Lamanai baseline that was established by Howie et al. (2010) in both tables. The tables also indicates that the most variation was present in sampled teeth. Table 30 includes

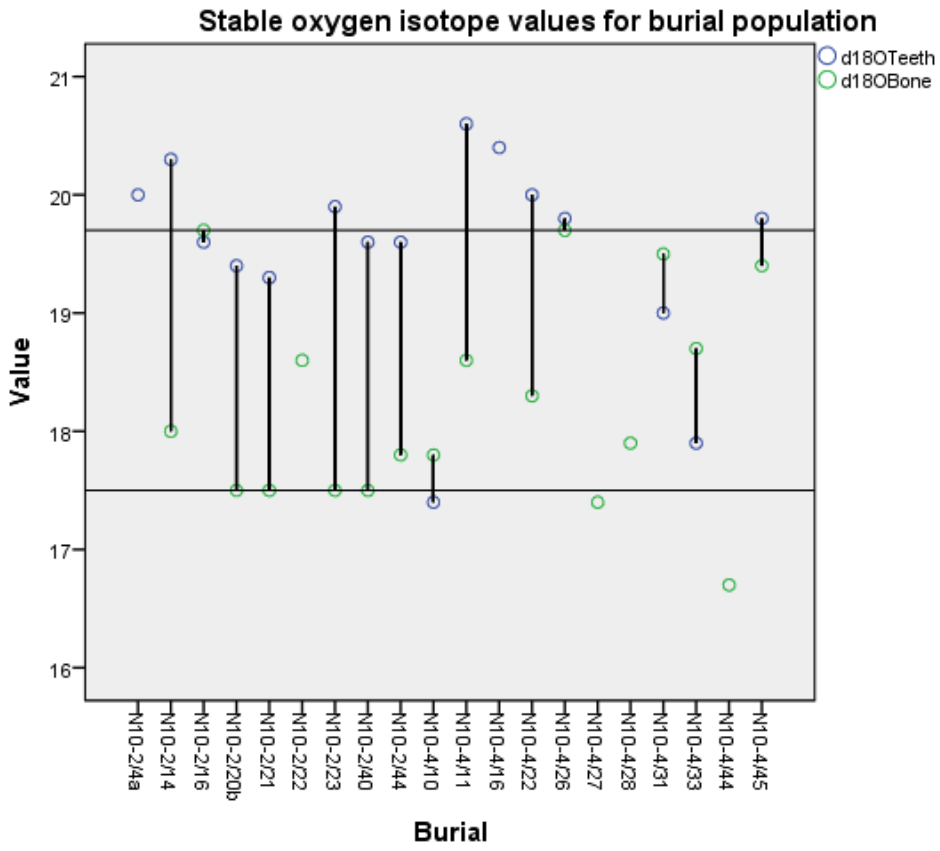
values prior to correcting them for breast feeding, and Table 31 includes values after applying the correction for breast feeding. Because there were not any individuals in this study under the age of three years old, bone values were not corrected. Permanent first and second molars were corrected for breast-feeding by decreasing 0.7‰, and values from sampled permanent premolars were corrected for breast-feeding by decreasing 0.35‰ (Wright and Schwarcz, 1998).

Table 29 **Stable oxygen isotope values from bone and teeth samples (not corrected for breast feeding) for this burial population (Isotope data from Donis, 2013). The horizontal lines indicate the Lamanai δ ^{18}O range (Howie et al., 2010)**



All values indicate δ^{18}O sampled teeth and bones.

Table 30 **Stable oxygen isotope values from bone and teeth samples (corrected for breast feeding) for this burial population (Isotope data from Donis, 2013). The horizontal lines indicate the Lamanai δ ^{18}O range (Howie et al., 2010)**



CHAPTER FIVE: DISCUSSION

Given the unique VPLF burial position, and its apparent temporal circumscription at Lamanai, it is normal to investigate whether or not these individuals were originally from Lamanai. Explicit investigations into the geographical origins of the VPLF individuals have not been widely completed, but Wrobel and Graham (2015) did complete dental morphological analysis on individuals associated with Buk phase ceramics, a majority of whom were buried in the VPLF position. Here, the authors used dental morphometrics to investigate the possibility of a foreign origin of the Buk phase burials. The results indicate that the Buk phase burials at Lamanai are genetically distinct from those individuals dating to the Late to Terminal classic periods. The authors assert that this distinct genetic group was the result of recent non-local origins or non-local elites marrying into the Postclassic population (Wrobel and Graham, 2015).

The research of White et al. (2009) and Howie et al., (2010) yielded stable oxygen isotope results for bone and teeth sampled from individuals buried in the VPLF position. Donis (2013) incorporated the data of these data in to the stable oxygen isotope results from bones and teeth in her dissertation to provide increased statistical validity. Donis's (2013) isotope data incorporated White and colleague's (2009) data, and was subsequently compared against the stable oxygen isotope baseline that was determined by Howie and colleagues (2010) (17.5 – 19.7‰).

The present study, while incorporating information gathered by previously published sources, uses and presents the data in a new way. By presenting the data regarding VPLF individuals in a descriptive or narrative manner, while also organizing variables in an ordinal fashion, it allows for ease in future comparison and operationalization of the VPLF burial pattern. More specifically, it allows for increased ease in interpretation of intra and inter-

individual variation of VPLF burials. Ordinally organizing the burial data with the use of labels, allows for statistical comparability and quantitative analysis.

The statistical results of this study did not yield any significant correlations between burial variables, which is consistent with previous work on this burial population (i.e. Graham et al., 2013; Wrobel and Graham, 2015). While statistical significance may increase with sample size, the results of this study do yield some interesting patterns that contribute to the further definition and operationalization of this unique mortuary practice, and the deceased individuals themselves.

The most prevalent pattern found in this burial group was that the feet were placed in a tightly flexed position, so that the feet ultimately rested on the posterior aspect of the pelvis. This leg position was observed for seventeen of the twenty individuals included in this study. This is the most definitive feature of the VPLF burial pattern, and appears to be the most readily recognizable characteristic (Pendergast, 1981; Wrobel and Graham, 2015). As is apparent in the previous chapter, the prevalence of posteriorly flexed feet cross-cut both sex and age groups, and are not associated with other burial variables. One individual was observed by Pendergast (1981) to have had their legs loosely placed on each other, which he posits may be indicative of a failed attempt to bind the legs.

The second most prevalent pattern in this burial group was the arm placement. While a majority of previous publications (i.e. Graham et al., 2013) identified arm positioning as the most variable characteristic of VPLF individuals, this study possibly indicates otherwise. While the results of this study were not statistically significant, there do remain to be two main arm position types: tightly flexed so that the hands rest on the small of the back, and arms at the sides (with variation in hand placement). It is important to note here that varying degrees of

preservation may have affected the accurate observation and recording of VPLF arm placement. As Welsh (1988) has indicated, intra- and interpopulational variation in burial practices, specifically bodily orientation, may be indicative of an ideological change.

This study addressed the three research questions in the following ways. To address the first research question, "what are the defining characteristics of the VPLF burials that make them unique at Lamanai and in the surrounding regions?" by combining all burial data for each individual. This information was presented in both narrative and ordinal form. By presenting the cumulative burial data, which spanned multiple decades, in a narrative form, a more detailed representation of each individual was able to be achieved. The narrative form also allowed for easier identification of VPLF-specific characteristics. Those characteristics were then transferred into statistical software which allowed for correlation analysis.

To address the second research question, "were these individuals local or non-local in their lifetime residence patterns?" I used previously published oxygen isotope data to assess within lifetime mobility. More specifically, both bone and dental tissues were utilized in order to address both childhood and near death periods of life. And to address the third research question, "What social or individual distinctions may have influenced the prevalence of this burial position within Structure N 10 -2 and N 10 – 4?" I addressed specific variables, such as elite burial accoutrements.

Through the analysis of the variation of stable oxygen isotope values from both the bone and tooth samples, it is apparent that a majority of the individuals in the burial group do express variation between their bone and tooth oxygen values. The stable oxygen values from teeth, prior to correcting for breast feeding, for this burial group generally fell outside the isotopic baseline range for Lamanai (Table 30), indicating that the sampled individuals most likely experienced

childhood outside Lamanai, but most likely in an isotopically similar region (Howie et al., 2010). It is important to note that only one individual, N10 – 2/16, had tooth values that were beyond 1‰ of the Lamanai range, which is a significant indicator of movement outside of Lamanai and the surrounding area. The stable oxygen values from teeth, after correcting for breast feeding, for this burial group show significantly less outliers (that is, those outside the Lamanai baseline) when compared to those values *not* corrected.

A majority of the oxygen values from bone, expressed less variation, and generally fell into the isotopic baseline range previously defined by Howie and colleagues (2010). Thus, it is likely that a majority of these individuals spent most of their adult lives at Lamanai, or at sites within a similar environment within the region.

CHAPTER SIX: CONCLUSION

The Postclassic florescence at Lamanai is described as a time of increased interregional and international trade, which definitely could have had impact on the mobility of people within the region. As outlined, the studies of dental morphology indicate that the variation present the individuals from Lamanai suggests that there was evidence of Lamanai accepting immigrants (Jacobi, 2000; Lang, 1990). Though in both the Postclassic and Historic periods, the isotopic studies indicate that individuals most likely moved between areas that were isotopically similar to the water signatures at Lamanai. The stable oxygen isotope values for individuals dated to the Historic period exhibited much more variation in dental oxygen values which indicate increased childhood migration outside of the area that has a homogenous stable oxygen isotope signature.

No significant outliers (<1‰) for oxygen stable isotopes were identified, which makes it difficult to accurately identify foreign individuals, even though N10 – 2/16 did fall over 1‰ outside of the previously defined Lamanai baseline range. Variation decreased after applying a correction for breast feeding to the oxygen values from teeth. The difference in both the climate and physiography of the regions makes it possible to differentiate between the two regions of Northern Belize and other areas within Mesoamerica. This is an important distinction to make, especially since much of the region surrounding the site of Lamanai is a homogenous environment, especially considering stable oxygen isotope values. Regardless, there are obviously individuals included in this study who experienced within lifetime variability of stable isotope oxygen values which is indicated by their < 23‰ oxygen values, the range for intra-populational variability within Mesoamerica (White et al., 1998; White et al., 2002; White et al., 2004). In conclusion, based off of the published data used in this thesis, most individuals at

Lamanai may have experienced movement within the region surrounding Lamanai, which provided mostly local oxygen signatures.

This study addressed the three research questions in the following ways. To address the first research question, "what are the defining characteristics of the VPLF burials that make them unique at Lamanai and in the surrounding regions?" by combining all burial data for each individual. This information was presented in both narrative and ordinal form. By presenting the cumulative burial data, which spanned multiple decades, in a narrative form, a more detailed representation of each individual was able to be achieved. The narrative form also allowed for easier identification of VPLF-specific characteristics. Those characteristics were then transferred into statistical software which allowed for correlation analysis.

To address the second research question, "were these individuals local or non-local in their lifetime residence patterns?" I used previously published oxygen isotope data to assess within lifetime mobility. More specifically, both bone and dental tissues were utilized in order to address both childhood and near-death periods of life. And to address the third research question, "What social or individual distinctions may have influenced the prevalence of this burial position within Structure N 10 -2 and N 10 – 4?" I addressed specific variables, such as elite burial accoutrements.

This study focused on the broad geographical identity of a selected few individuals buried at Lamanai, and dating to the Postclassic period. The oxygen data, which was provided by Donis (2013), indicates that there was some evidence of relocation specifically after childhood, while the majority of the burial population are likely local to Lamanai, and the surrounding region.

The results of this study significantly highlight the degree of variability present within these VPLF burials, which may have contributed to the confusion with operationalizing the term VPLF. The variability present for the VPLF individuals is not only expressed in the body positionality, but also in the arm placement, age, sex, even though the results of this study did not yield any statistically significant results. It is important to note that the presence of this burial practice may be indicative of an ideological shift, and further studies may contribute to this data. More specifically, the influence ideology would have on this mortuary practice would be important because it transcends multiple variable such as age, sex, and social status.

Future Directions

The results of this study, although not statistically significant, do highlight the unique characteristics of individuals found in the VPLF burial position. Additionally, though devoid of statistical significance, this study highlights a chasm of lost data that is the result of inconsistent recording techniques. It is apparent that, throughout the over forty years of excavation and analysis of these remains, standardized methods of recording and observation were not present.

In future studies, further definition of VPLF individuals and burial characteristics should be addressed, such as assessing the frequencies and cultural significance of the presence and specific type of cranial and dental modification. Additionally, by increasing sample size, specific patterns of burial characteristics may be identifiable. Also, incorporating isotopic data with trace element analysis would provide a temporally succinct microsample of the dentition, coupled with the bulk sample provided by the isotope data.

APPENDIX: VPLF VARIABLES AND ISOTOPE VALUES

		Demography		Burial Position				Skeletal		Associated Artifacts	$\delta^{18}O$ (‰)	
	Individual ID	**Sex**	**Age**	**Arms**	**Legs**	**Head**	**Orientation**	**Cranial Modification**	**Dental Modification**		**Bone**	**Tooth**
1	N10-2/4a	2	1	1	1	1	0	0	0	0	n/a	20
2	N10-2/14	2	0	2	2	1	0	0	0	0	18	20.3
3	N10-2/16	1	2	3	1	0	1	0	0	1	19.7	19.6
4	N10-2/20b	1	3	3	0	0	2	0	0	1	17.5	19.4
5	N10-2/21	0	1	0	0	3	0	0	0	0	17.5	19.3
6	N10-2/22	1	2	1	1	1	0	1	0	1	18.6	n/a
7	N10-2/23	1	3	2	1	0	0	0	1	1	17.5	19.9
8	N10-2/40	2	3	2	1	0	0	1	0	1	17.5	19.6
9	N10-2/44	0	0	1	1	0	0	1	0	1	17.8	19.6
10	N10-4/10	1	1	5	1	0	0	0	1	1	17.8	17.4
11	N10-4/11	2	2	4	1	0	0	0	0	2	18.6	20.6
12	N10-4/16	1	3	2	1	1	0	0	0	2	n/a	20.4
13	N10-4/22	2	0	6	1	2	0	0	1	1	18.3	20
14	N10-4/26	1	2	6	1	1	0	0	0	1	19.7	19.8
15	N10-4/27	0	0	3	1	0	0	0	0	0	17.4	n/a
16	N10-4/28	1	3	1	1	0	0	0	1	1	17.9	n/a
17	N10-4/31	0	1	2	1	0	0	0	1	1	19.5	19
18	N10-4/33	2	2	2	1	0	0	0	0	1	18.7	17.9
19	N10-4/44	1	0	6	1	0	0	0	0	0	16.7	n/a
20	N10-4/45	1	2	5	1	1	0	1	0	1	19.4	19.8

REFERENCES

Ashmore, W. (1981). Construction and cosmology: Politics and ideology in lowland Maya settlement patterns. In, Hanks, W.F., and D.S. Rice (Eds.), *Word image in Maya culture: Exploration in language, writing, and representation.* Salt Lake City: University of Utah Press, 272-286.

Balasse, M., Ambrose, S.H., Smith, A.B., & Price, T.D. (2002). The seasonal mobility model of prehistoric herders in the south-western cape of South Africa assessed my isotopic analysis in sheep tooth enamel. *Journal of archaeological science, 29,* 917 – 932.

Barrett, J., Johnstone, C., Harland, J., Van Neer, W., Ervynck, A., Makowiecki, D., Heinrich, D., Hufthammer, A.K., Enghoff, I.B., Amundsen, C., Christiansen, J.S., Jones, A.K.G., Locker, A., Hamilton-Dyer, S., Lõugas, L., Roberts, C., & Richards, M. (2008). Detecting medieval cod trade: a new method and first results. *Journal of archaeological science, 35,* 850 – 861.

Bentley, R.A. (2007). Mobility, specialisation and community diversity in the Linearbandkeramik: Isotopic evidence from the skeletons. *Proceedings of the British Academy, 144,* 117 – 140.

Britton, K., Grimes, V., Dau, J., & Richards, M.P. (2009). Reconstructing faunal migration using intra-tooth sampling and strontium and oxygen isotope analyses: A case study of modern caribou (*Rangifer tarandus granti*). *Journal of archaeological science, 36,* 1163 – 1172.

Budd, P., Millard, A., Chenery, A., Lucy, S., & Roberts, C. (2004). Investigating population movement by stable isotope analysis: A report from Britain. *Antiquity, 78,* 127 – 141.

Buikstra, J.E. & Beck, LA. (2006). Bioarchaeology: The contextual analysis of human remains. Waltham: Academic Press.

Chase, D.Z. 1985. Ganned but not forgotten: Late postclassic archaeology and ritual at Santa Rita Corozal, Belize. In Chase, A.F. & Rice, P.M. (Eds.). *The lowland Maya Postclassic.* Austin: University of Texas Press.

Chase, D.Z. & Chase, A.F. (1996). Maya multiples: Individuals, entries and tombs in Structure A34 at Caracol, Belize. In Chase, A.F. & Rice, P.M. (Eds.). *The lowland Maya Postclassic.* Austin: University of Texas Press.

Coyston, S., White, C.D., Schwarcz, H.P. (1999). Dietary carbonate analysis of bone and enamel for two sites in Belize. In White, C.D. (Ed.). *Reconstructing ancient Maya diet.* Salt Lake City: University of Utah Press, 221 – 244.

Dupras, T.S. & Schwarcz, H.P. (2001). Strangers in a strange land: Stable isotope evidence for human migration in the Dakhleh Oasis, Egypt. *Journal of archaeological science, 28,* 1199 – 1208.

Donis, A. (2013). Exploring the movement of people in the Postclassic and Historic period Lamanai using stable isotopes. MA Thesis, University of Western Ontario.

Emery, K. F. (1999). Continuity and variability in Postclassic and Colonial animal use at Lamanai, Belize. In White, C.D. (Ed.). *Reconstruction ancient Maya diet.* Salt Lake City: University of Utah Press, 61 – 82.

Faure, G. & Mensing, T.M. (2005). Isotopes: Principles and applications. Hoboken: John Wiley and Sons, Inc.

Fitzsimmons, J.L. & Shimada, I. (2011). Introduction. In Fitzsimmons, J.L. & Shimada, I. (Eds.). *Living with the dead: Mortuary ritual in Mesoamerica*. Tucson: University of Arizona Press, 1 – 16.

Friewald, C. (2011). Maya migration networks: Reconstructing population movement in the Belize River valley during the Late and Terminal Classic. Ph.D Dissertation, University of Wisconsin.

Gillespie, S.D. (2001). Personhood, agency, and mortuary ritual: A case study from the ancient Maya. *Journal of anthropological archaeology, 20*: 73 – 112.

Graham, E. (2004). Lamanai reloaded: Alive and well in the Early Postclassic. In Awe, J.J., Morris, J., & Jones, S. (Eds.). *Archaeological investigations in the eastern Maya Lowlands – Papers of the 2003 Belize Archaeology Symposium.* Belmopan, Belize: The Institute of Archaeology, 223 – 241.

Graham, E. (2006). An ethnicity to know. In Sachse, F. (Ed.). *Maya ethnicity: The construction of ethnic identity from Preclassic to Modern times.* Germany: Verlag Anton Saurwein, 109 – 124.

Graham, E. & Pendergast, D.M. (1989). Excavations at the Marco Gonzalez site, Ambergris Cay, Belize, 1986. *Journal of Field Archaeology, 16,* 1 – 16.

Graham, E., Simmons, S.E., & White, C.D. (2013). The Spanish Conquest and the Maya collapse: How 'religious' is change? *World Archaeology, 45,* 161 – 185.

Green, K.A. (2016). The use of stable isotope analysis on burials at Cahal Pech, Belize in order to identify trends in mortuary practices over time and space. Unpublished PhD Dissertation. Missoula: University of Montana.

Guiry, E.J., Noel, S., Tourigny, E., & Grimes, V. (2012). A stable isotope method for identifying transatlantic origin of pig (*Sus scrofa*) remains at French and English fishing stations in Newfoundland. *Journal of archaeological science, 39,* 2012 – 2022.

Healy, P.F., Awe, J.J, & Helmuth, H. (1998). An ancient Maya multiple burial at Caledonia, Cayo District, Belize. *Journal of Field Archaeology, 25,* 261 – 274.

Hedges, R., Thompson, J.M., & Hull, B.D. (2005). Stable isotope variation in wool as a means to establish Turkish carpet provenance. *Rapid communications in mass spectrometry, 19,* 3187 – 3191.

Hedges, R.E.M., Clement, J.G., Thomas, D.L., & O'Connell, T.C. (2007). Collagen turnover in the adult femoral mid-shaft: Modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology, 133,* 808 – 816.

Helmuth, H. (2003). The human remains from the ancient Maya site of Lamanai (YDL-85). Unpublished Report, Department of Anthropology, Trent University, Peterborough, ON.

Helmuth, H. (2005). The human remains from the ancient Maya site of Lamanai. Unpublished Report, Department of Anthropology, Trent University, Peterborough, ON.

Howie., L. (2006). Ceramic production and consumption in the Maya lowlands during the terminal classic to early Postclassic transition: A technological study of ceramics at Lamanai, Belize. PhD. Dissertation, University of Sheffield.

Howie, L. (2012). Ceramic change and the Maya collapse: A study of pottery technology, manufacture and consumption at Lamanai, Belize. Oxford: Archaeopress.

Howie. L., White, C.D., & Longstaffe, F.J. (2010). Potographies and biographies: The role of food in ritual and identity as seen through life histories and selected Maya pots and people. In, Staller J.E. and Carrasco, M.D (Eds.). *Pre-Columbian foodways: Interdisciplinary approaches to food, culture, and markets in ancient Mesoamerica.* New York: Springer Science + Business Media, 369 – 398.

Jacobi, K.P. (2000). Last rites for the Tipu Maya: Genetic structuring in a colonial cemetery. Tuscaloosa: University of Alabama Press.

Kohn, M.J. (1996). Predicting animal $\delta^{18}O$: Accounting for diet and physiological adaptation. *Geochimica et cosmochimica acta, 60 (23),* 4811 – 4829.

Lachniet, M.S. & Patterson, W.P. (2009). Oxygen isotope values of precipitation and surface waters in northern Central America (Belize and Guatemala) are dominated by temperature and amount effects. *Earth and planetary science letters, 284,* 435 – 446.

Lang, C.A. (1990). The dental morphology of the ancient Maya from Lamanai and Tipu, Belize: A study of population movement. PhD. Dissertation, Trent Anthropology.

Longinelli, A. (1984). Oxygen isotopes in mammal bone phosphate: A new tool for paleohydrological and paleoclimatological research? *Geochimica et cosmochimica acta, 48,* 343 – 354.

Makarewicz, C.A. & Sealy, J. (2015). Dietary reconstruction, mobility, and the analysis of ancient skeletal tissues: Expanding prospects of stable isotope research in archaeology. *Journal of archaeological science, 56,* 146 – 158

Martin, R.G. (2000). Toward a unifying theory of bone remodeling. *Bone, 26,* 1 – 6.

Meiggs, D.C. (2007). Visualizing the seasonal round: A theoretical experiment with strontium isotope profiles in ovicaprine teeth. *Anthropozoologica, 42,* 107 – 127.

Metcalfe, J.Z. (2005). Diet and migration at Chau Hiix, Belize: A study of stable carbon, nitrogen, and oxygen isotopes. MA Thesis, University of Western Ontario.

Metcalfe, J.Z., White, C.D., Longstaffe, F.J., Cook, D.C., & Pyburn, A.K. (2009). Isotopic evidence for diet at Chau Hiix, Belize: Testing regional models of hierarchy and heterarchy. *Latin American Antiquity,* 15 – 36.

Makarewicz, C.A. & Sealy, J. (2015). Dietary reconstruction, mobility, and the analysis of ancient skeletal tissues: Expanding prospects of stable isotope research in archaeology. *Journal of archaeological science, 56,* 146 – 158.

Olsen, K.C. (2006). Dedication and sacrifice: An oxygen-isotope study of human remains from Altun Ha, Belize and Iximché, Guatemala. MA Thesis, University of Western Ontario.

Pendergast, D.M. (1975). Lamanai 1975: The goods are oft interr'd with their bones. *ROM: Archaeological Newsletter, 122.*

Pendergast, D.M. (1981). Lamanai, Belize: Summary of excavation results, 1974 – 1980. *Journal of Field Archaeology, 8,* 29-53.

Pendergast, D.M. (1986). Stability through change: Lamanai, Belize, from the ninth to the seventeenth century. In, Sabloff, J.A. and Andrews, E.W. (eds.). *Late lowland Maya civilization: Classic to Postclassic.* School for Advanced Research Press, 223-249.

Pendergast, D.M. (1992). Noblesse oblige: The elites of Altun Ha and Lamanai, Belize. In Chase, D.Z. & Chase, A.F. (Eds.), *Mesoamerican elites: An archaeological assessment* (pp 61-79). Norman: University of Oklahoma Press.

Powis, T.G. (2002). An integrative approach to the analysis of Late Preclassic ceramics at Lamanai, Belize. PhD. Thesis, The University of Texas at Austin.

Price, T.D., Wahl, J., & Bentley, R.A. (2006). Isotopic evidence for mobility and group organization among Neolithic farmers at Telheim, Germany, 5000 BC. Eur. *Journal of archaeology, 9,* 259 – 284.

Rakita, G.F., Buikstra, J.E., Beck, L.A., Williams, S.R. (2005). Interacting with the dead: Perspectives on mortuary archaeology for the new millennium. University Press of Florida.

Ricketson, O. (1925). Burials in the Maya area. *American anthropologist, 27* (3): 381 – 401.

Schwarcz, H.P., Gibbs, L., & Knyf, M. (1991). Oxygen isotope analysis as an indicator ofplace of origin. In Pfeiffer, S. & Williamson, R.F. (Eds.), *An investigation of a military cemetery from the War of 1812,* (pp 263 – 268). Toronto: Dundurn Press.

Sealy, J.C., Armstrong, R., & Schrire, C. (1995). Beyond lifetime averages: Tracing life histories through isotopic analysis of difference calcified tissues from archaeological human skeletons. *Antiquity, 69,* 290 – 300.

Simmons, S.E., Pendergast, D.M., & Graham, E. (2009). The context and significance of copper artifacts in Postclassic and Early Historic Lamanai, Belize. *Journal of Field Archaeology, 34,* 57 – 75.

Thompson, E. (1896). Ancient tombs of Palanque. *American antiquarian society,* Worcester: Wentworth Publishing, 418 – 421.

Welsh, B. (1988). An analysis of Classic Lowland Maya burials. Oxford: BAR International Series.

White, C.D. (1986). Paleodiet and nutrition of the ancient Maya at Lamanai, Belize: A study of trace elements, stable isotopes, nutritional and dental pathologies. Unpublished MA Thesis, Department of Anthropology, Trent University, Peterborough, ON.

White, C.D. (1997). Ancient diet at Lamanai and Pacbitun: Implications for the ecological model of collapse. In Whittington, S.L. & Reed, D.M. (Eds.), *Bones of the Maya: Studies of ancient skeletons*. Tuscaloosa: University of Alabama Press, 171 - 180

White, C.D., Healy, P.F., Schwarcz, H.P. (1993). Intensive agriculture, social status, and Maya diet at Pacbitun, Belize. *Journal of Anthropological Research,* 347 – 375.

White, C.D., Spence, M.W., Stuart-Williams, H., & Schwarcz, H.P. (1998). Oxygen isotopes and the identification of geographical origins: The valley of Oaxaca versus the Valley of Mexico. *Journal of Archaeological Science, 25,* 642 – 655.

White, C.D., Spence, M.W., Longstaffe, F.J., Stuart-Williams, H., & Law, K. (2002). Geographic identities of the sacrificial victims from the feathered serpent pyramid, Teotihuacan: Implications for the nature of state power. *Latin American Antiquity, 13(2),* 217 – 236.

White, C.D., Storey, R., Longstaffe, F.J., & Spence, M.W. (2004). Immigration, assimilation, and status in the ancient city of Teotihuacan: Stable isotopic evidence from Tlajinga 33. *Latin American Antiquity, 15 (2),* 176 – 198.

White, C.D., Price, D., & Longstaffe, F.J. (2007). Residential histories of the human sacrifices at the Mood Pyramid, Teotihuacan: Evidence from oxygen and strontium isotopes. *Ancient Mesoamerica, 18,* 159 – 172.

White, C.D., Longstaffe, F.J., Pendergast, D.M., & Maxwell, J. (2009). Cultural embodiment and the enigmatic identity of the lovers from Lamanai. In Knudson, K.J. & Stojanowski, C.M. (Eds.). *Bioarchaeology and identity in the Americas.* Gainesville, FL: University Press of Florida, 155 – 176.

Wright, L.E. (2012). Immigration to Tikal, Guatemala: Evidence from stable strontium and oxygen isotopes. *Journal of Anthropological Archaeology, 31(3),* 334 – 352.

Wright, L.E. & Schwarcz, H.P. (1998). Stable carbon and oxygen isotopes in human tooth enamel: Identifying breastfeeding and weaning in prehistory. *American Journal of Physical Anthropology, 106,* 1 – 18.

Wright, L.E. & Schwarcz, H.P. (1999). Correspondence between stable carbon, oxygen, and nitrogen isotopes in human tooth enamel and dentine: Infant diets at Kaminaljuyú. *Journal of Archaeological Science, 26(9),* 1159 – 1170.

Wrobel, G. (2004). Metric and nonmetric dental variation among the ancient Maya of northern Belize. PhD. Dissertation, Indiana University.

Wrobel, G. (2007). Issues related to determining burial chronology by fluoride analysis of bone from the Maya archaeological site of Chau Hiix, Belize. *Archaeometry, 49(4),* 699 – 711.

Wrobel and Graham (2015). The Buk phase burials of Belize: Testing genetic relatedness among early Postclassic groups in Northern Belize using dental morphology. In Cucina, A. (Ed.). *Archaeology and bioarchaeology of population movement among the Prehispanic Maya,* 85 – 95.