THE WATER SYSTEM AT THE UPPER CITY OF HASANKEYF AND ITS IMPACT ON URBAN SETTLEMENT

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Approval of the Graduate School of Social Sciences

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ABSTRACT

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Hasankeyf, located in Upper Mesopotamia, southeastern Turkey with its environs at the floodplains of Tigris, welcomed many cultures in different periods. It has a very unique status with its difficult topography and distinctive outlook where spatial urbanization in almost every period must have been extraordinary, as well. The aim of this thesis is to study the water distribution system, specifically its relation to natural and man-made environment, at the Upper city of Hasankeyf, in order to identify the impact of utilization of water on the urban structure, with a new perspective.

The thesis tries to explain the designation of urban patterns and understand possible late settlement strategies in the light of cistern-incentive and available canal data collected at the Upper city. The identification of 185 cisterns and their various characteristics helps to make different analyses to establish links between the water system and settlement areas at macro and micro levels, which go hand in hand with mapping studies. Notwithstanding the abovementioned objectives, this study endeavors to find some common denominators with Roman water practices, which are considered to be comparable to those of Hasankeyf, thus unveil some clues for Hasankeyf water features.

It now appears that water and urban settlement are two sides of a coin where water can not be treated as the sole determinant on the development of settlement patterns in which case the urban settlement also has impact on the water distribution at the Upper city.

Keywords: Water Distribution System, Upper City of Hasankeyf, Urban Settlement

ÖZ

HASANKEYF YUKARI ŞEHİRDE SU SİSTEMİ
VE KENTSEL YERLEŞİM ÜZERİNE ETKİSİ

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Yukarı Mezopotamya'da, Türkiye'nin güneydoğusundaki Dicle havzasında yer alan Hasankeyf ve çevresi, farklı dönemlerde birçok kültüre ev sahipliği yapmıştır. Hemen her dönemde mekansal kentleşmenin de sıradışı gerçekleşmiş olması gereken Hasankeyf, zor topoğrafyası ve ayırt edici görünümü ile eşsiz bir konuma sahiptir. Bu tezin amacı, yeni bir bakış açısı ile, su kullanımının kentsel yapı üzerindeki etkisini belirleyebilmek için Hasankeyf Yukarı şehirdeki su sistemini ve özellikle doğal ve insan yapımı çevre ile ilişkisini incelemektir.

Bu tez kentsel dokuların tasarımını ve olası geç yerleşim stratejilerini, Yukarı şehirde toplanan sarnıç yoğun ve mevcut kanal verilerinin ışığında açıklamaya ve anlamaya çalışmaktadır. 185 adet sarnıcın ve bunların çeşitli özelliklerinin teşhisi, mikro ve makro düzeylerde su sistemi ve yerleşim alanları arasındaki bağlantıları kurabilmek için, haritalama çalışmaları ile birlikte farklı analizlerin yapılmasına yardımcı olmaktadır. Yukarıda bahsedilen amaçların yanında, bu çalışma, Hasankeyf'tekiler ile karşılaştırılabilir olduğu düşünülen Roma su uygulamaları ile ortak paydalar bulmaya ve böylece Hasankeyf su yapıları için kimi ipuçlarını ortaya çıkarmaya çalışmaktadır.

Görünen odur ki su ve kentsel yerleşim, Yukarı şehirde suyun tek başına yerleşim dokularının gelişimi üzerinde belirleyici olarak değerlendirilemeyeceği ve fakat kentsel yerleşimin de su sistemi üzerinde etkili olduğu bir durumun ayrılmaz iki parçasıdır.

Anahtar Kelimeler: Su Dağıtım Sistemi, Hasankeyf Yukarı Şehir, Kentsel Yerleşim

To Ahide, Refik and Ozan

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I would like to express my deep appreciation and sincere thanks to Prof. Dr. Vedat TOPRAK for his invaluable guidance and continuous support throughout the whole study and during the exhausting field work at the Upper city of Hasankeyf. This study owes much to his precious suggestions on such an exciting research topic. I also offer my deep respect for his sheer contributions in realizing the valuable outputs derived from a vast amount of data during each phase of the study. What is more, without his preeminent foresight, guidance and patience, the thesis would fall behind the spirit of a real scientific research.

I would like to offer thanks to TAÇDAM Project Office for providing the base map of the settlement pattern of the Upper city. I also offer thanks to Asst.Prof. Dr.Veronica KALAS for her contributions to the correction process of the thesis.

Also, I thank to the honorable people of Hasankeyf who have expressed their hospitality and kind approach for the purposes of this research. Special thanks go to the local dweller of the Upper city, Yakup AYHAN, for his invaluable contributions during the exhausting field work. It is so much worth offering thanks for accelerating the study with an incredible number of cisterns under such a time constraint and limited supply of water under the burning sun.

To my friends, Ebru Anıl YAYLA and Sema ŞIK, I would like to thank for their never ending encouragement during my sleepless days. Their willingness is gratefully acknowledged for enduring me during the last phases of the research.

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CHAPTER 1

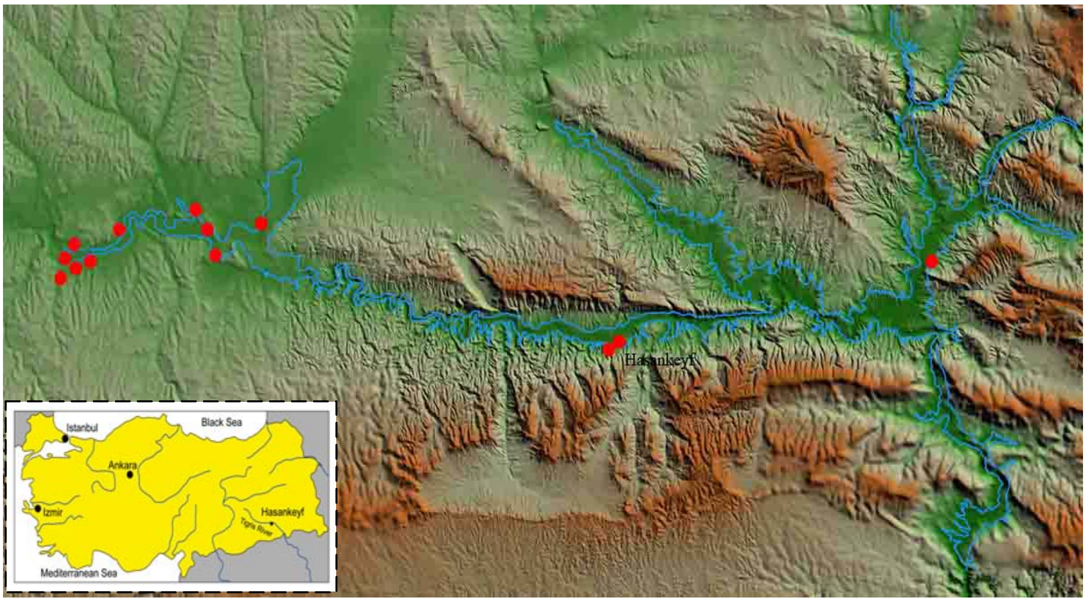
INTRODUCTION

1.1 Purpose and Scope

The purpose of this thesis is to understand the water system in an area limited with the Upper city of Hasankeyf which is surrounded by a natural scarp of about 2.5 km. With the help of present and easily tracked architectural elements and water features on the surface, the thesis focuses on cistern and canal remains. The study is confined to the settlement area (excluding the public spaces), the main canal remains, the siphon and the collecting tank (hereinafter referred to as the "Pool" and/or the "pool" including those mentioned in the cover pages), all of which lie at the southernmost end of the city. However, although data and analyses regarding the main canal, the siphon and the Pool are out of the scope of this research, visual samples with regards to their current condition are exhibited in order to assess the integrity of the water distribution pattern with all the related items of the Upper city. The thesis further tries to explain the relationship between the water distribution features and the patterns of urban settlement.

1.2 Location

Ancient Hasankeyf lies at the center of today's modern Hasankeyf district, which is within the borders of Batman province in southeastern Turkey. The town is located 36 km southeast of the modern province Batman, 26 km north of the sub-province Gercüş, 140 km southeast of modern province Diyarbakır and 65 km from Iraqi and Syrian borders toward the north. It is located at the floodplains of the Tigris River. Therefore, it is at the crossroads of the Near Eastern and Anatolian cultures in Upper Mesopotamia, on the banks of Tigris River (Figure 1.1). As a unique town where cultures of Mesopotamia, the West, Iran and Central Asia meet, it is one of many well preserved medieval towns in Anatolia.



(Source:TAÇDAM-Centre for Research and Assessment of the Historic Environment, 1998-2003)
Figure 1.1 Location of Hasankeyf and its environs

The importance of the site is also due to the position near Ilısu dam, located at the Tigris river, -an irrigation hydropower project as part of the Southeast Anatolia Project (GAP). Despite salvage projects, the modern town and the lower city are currently under the risk of being inundated by the said dam.

1.3 Previous Works

Gertrude Bell, a modern traveler, is known to have photographed Hasankeyf in the beginning of 20th century. Beyond of the scope of this study, French Albrecht Gabriel contributed to the detail study of El Rızk Mosque, which is one of the most fascinating buildings of Hasankeyf. Archaeological excavations and salvage projects that were launched from 1986s onwards in Hasankeyf have produced information for medieval periods. Important reports come from the projects initiated by Prof. Dr. Oluş Arık in between 1989 and 1991. Research carried out by Arık and his teams reveals that Christian and Islamic periods had a great impact on the city. However, Urartian and Assyrian architectural features are also observed despite the lack of written sources (Arık, 2001). Architectural studies are still limited as far as rock-cut houses and subsidiary features are concerned. Only the El Rızk Mosque at which research was carried out by the German Institute of Archaeology has received considerable attention. The point is that many researches do not take into account the periods before the middle ages.

TAÇDAM (Centre for Research and Assessment of the Historic Environment- (Tarihsel Çevre Değerlerini Araştırma Merkezi) conducted a survey at the Upper city and produced a city map in 2002, including all the residential areas. Information sheets were prepared in accordance with the survey carried out in each settlement unit detected at the Upper city. Such sheets recorded information about the remaining and visible characteristics of the area including architectural properties of the settlement. This thesis also endeavors to refer to the most recent data provided by the excavations carried out by Prof. Dr. Oluş Arık and his team and; TAÇDAM under the direction of Prof. Dr. Numan Tuna.

In addition, current literature on Roman water system design is deemed to contribute to the assessment of Hasankeyf's water system. The reason why Roman water is linked to this study is that, apart from historical periods dating back to reign of many civilizations after the Roman world, Roman water features are comparable to those of Hasankeyf which was once under the Roman rule. Views of Frontinus which he wrote in 97 A.D, and thoughts of Vitruvius about water supply and engineering techniques that he recorded in 24 B.C are lightened as far as Roman water systems are concerned (Morgan, 1960). They are discussed in order to give additional insight about the subject.

1.4 Methods of Study

This study utilizes 187 records of the field work carried out at the Upper city in June 2005. Data is recorded in accordance with the architectural features, mainly the cisterns, canals and research units (hereinafter referred to as "house/housing units" for the purposes of this research). Specific manual drawings or sketches which refer to the current state of such features are also made so to provide information on some of their distinctive properties. A database which includes, at the minimum extent, the measurements and descriptions of those identified features is created for data and analysis.

The recent 1/1000 scale map of the Upper city produced by TAÇDAM Project Office is the substantial material for mapping studies. It is used to exhibit a general view of the Upper city and the location of certain structures. It is also reproduced to establish the links between water features and housing units within the macro settlement level, to attain further perspectives about the development of settlement according to the water system. In consideration of the variables such as topography, cistern proximity, density and distribution analyses, water structures are analyzed with the help of quantitative techniques. In this respect, quantitative approach is one of those methods for seeking the relationship between water structures and the settlement pattern and the relationship between cisterns themselves within the research design.

In addition, water distribution systems of the ancient and medieval sites, most particularly those of ancient Anatolian cities are reviewed at the end. Water networking practices especially during the Roman period are given as reference points which may act as analogies to help the discussion of Hasankeyf data. Therefore, relevant conclusions are drawn through understanding of such water systems.

1.5 Limitations

Best efforts were made to collect the most yielding data for this research. However, some cistern data is estimated where evidence is weak. The absence of satisfactory measurement is valid for the canal remains, too. Meanwhile, the coordinates of the cisterns which are given in Appendix E are not completely correct. A scientific global positioning (GPS) method could not be applied during field work due to ± 6 m error in the readings. Furthermore, canals all lack coordinates. Another limitation of this research is that coordinates of the cisterns are not absolutely correct. After being plotted manually on the Settlement Pattern Analysis Map at the field, cistern coordinates are determined by exporting data from Figure 3.2. The cisterns recorded in the very northeastern part perhaps best approach the real coordinate values. It is because of very initial attempts to take GPS values before malfunctioning of the related device.

On the other hand, the locations of cisterns in relationship to their present condition may slightly change because of associated housing units which are assigned as the base locations for cisterns that are subject to conversion. Conversion activities which are related with secondary use of cisterns may retain plenty of undiscovered clues that may have been skipped. Some shapes of cisterns can also be rethought because it was sometimes very difficult to determine whether a cistern took the form of one of those three shapes (all explained in Chapter 3) during the field work. In any case, some secondary usage cisterns are especially processed for shape identification.

1.6 Layout of Thesis

Chapter 2 focuses on the description of the Upper city, considering the natural and man-made environments. Historical information is presented to further detail the significance of typical city elements and emphasize private and public spaces. The last part of this chapter outlines water features which are the keys for understanding their origins within the borders of the Upper city.

Chapter 3 is the bulk of this study. It mainly discusses the cisterns of the Upper city, their numbers and types. Cisterns are the primary features of the water system within the housing units. Their characteristics are explained on the basis of actual and estimated data. Their physical forms are described visually and their current conditions are attempted to be categorized. The evidence for canal remains, no less important than cisterns, is discussed as the complementary side of the study.

Chapter 4 provides analysis pertaining to data given in Chapter 3. The formulation of sub-parts in this chapter is determined by analytical procedures to support the hypotheses that are put forward under the scope of this research. Three main scientific analyses are made to understand what the data may yield for the upcoming discussions. Therefore, relationships between cisterns, topographical conditions and the urban settlement are assessed according to the results of different analyses provided throughout Chapter 4.

In Chapter 5, analyses previously made for water features and settlement areas are questioned taking into account the pitfalls of this research. In addition, evaluations about the distribution of converted cisterns are tried to be made in order to understand the settlement behaviors of the Upper city. Predictions for possibly missed evidence are attempted to trigger new and extended research topics not covered by this study. Finally, the impact of the water system on the ancient and post-period urban settlement pattern(s) of the Upper city is elaborated to attain a set of ideas.

A brief introduction about the ancient and medieval use of water and a background for some well-known water distribution systems most of which are dated to Classical periods are given in Chapter 6. Some general aspects of the engineering works and use of water at the social level are provided before samples of water conduct systems from the cities many of which were Roman in Asia Minor are presented. In the mean time, ancient water distribution systems in cities of the Near East where remarkable evidence comes are explained due to their proximity to the sub-regions of Upper Mesopotamia. Some other samples are especially emphasized with a view to address the medieval times which was shared by Hasankeyf within the same time range.

Chapter 7 accomplishes the purposes of this thesis most closely. This part shows that many functions can be assigned to water features individually while it is also suggested that the water system should be considered as a whole throughout the area. Finally all the relevant collected data is presented in the Appendices to show that analyses are made depending on the quantity and quality of such data to come up with useful conclusions.

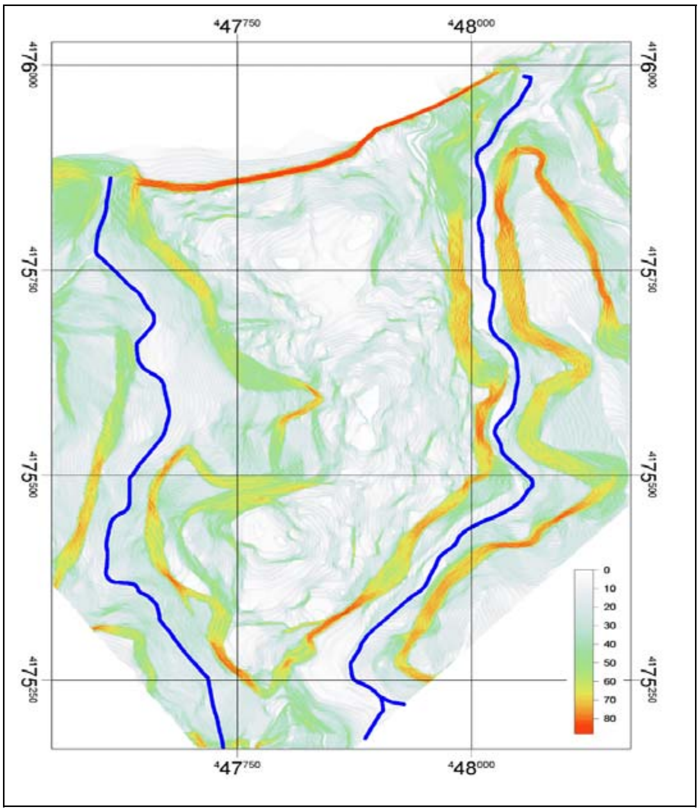
CHAPTER 2

BACKGROUND ON HASANKEYF SETTLEMENT

2.1. Topography and Rock Type

The natural boundary of Hasankeyf district is the Raman Mountain range in the north and Midyat Mountains and Tigris River arc lying in the south. It has a unique geographical setting which was possibly more or less the same in the ancient times. Tigris rises earlier than Euphrates and carries 2.5 times more water in the right season. The river bed of Tigris is high above the terrains, that is; it cuts deeper into the plains. Hence, it is no chance that the Upper city of Hasankeyf is a natural result of the formation process of such a harsh topography. The reason for extensive cutting activity of Tigris from geological point of view is out of the scope of this research but the need to supply water at such a difficult and risky area must have compelled the inhabitants to adopt perennial irrigation and water storage (Forbes, I, 1993). The criteria for continuous water supply should only be the effect of topographic conditions. Therefore, to the contrary of Forbes's considerations, risings in the levels of rivers in the wrong season did not force the inhabitants to adopt regular water distribution (pp. 18-19).

The public and private areas of the settlement are carved into the rock; the rock has a natural scarp around the settlement. As Toprak and Süzen (2004) note, the natural scarp, which is 2400 m long, has a mean slope of 70 degrees (Figure 2.1). The elevation difference measures 75 m to 30 m respectively in the south and northern parts which are embraced with two hung valleys near the Tigris River. Some of the sections are leveled artificially to produce the morphology of the city. The rock type is best expressed in architectural features. About 29.4% of the area is made up of non-karstic caves and buildings with a mean slope between 5 and 28 degrees where the mean value is 14-15. Caves and buildings are in a state of integration and they are mostly made up of limestone with the highest percentage (99%) and of basalt with a very little percentage (1%).



(Source: Toprak and Süzen, 2004)
Figure 2.1 Slope map of the Upper city of Hasankeyf

Although not archaeological, the property of rocks is a good criterion in analyzing certain architectural elements. Shale, sandstone and limestone are the main rock units of the surrounding area. Furthermore, for example, thin bedded soft and resistant rocks are found together. The dip amount of those rocks (5-7 degrees) that also controls the slope in the area, constitute a suitable environment for carving of all caves and other types of buildings from geoarchaeological point of view.

Rocky bottoms are preferable topographies to construct water systems and work well provided that they have the right angle. Forbes (1993) well textures citing to Strabon that, Alexander the Great selected rocky bottoms to change the bed of a river by opening a new mouth, in soft nature soil yielding terrains of Arabia in tackling canals. The rational way of manipulating over the land also brings the idea of rational utilization of water works, just like Trajan and Hadrian did for canal construction (pp.24-25). Hence, canal building was a traditional way of water transportation and distribution in ancient Mesopotamia, assuming all special conditions of cities constant.

2.2. Climate

On average, a warm climatic zone is effective in Hasankeyf and its environs. Warm climatic conditions, especially in winter are also observed due to mitigation effect of Tigris. On the other hand, because it is very vulnerable to arid currents coming from the very south, dry summer conditions which may easily rise up to 43-45 degrees are typical in Hasankeyf.

Due to continental climate and hydrological conditions of Upper Mesopotamia, cities and irrigation lands were often below the level of river beds and canals. However, Hasankeyf is distinctive with its somehow comparatively advantageous position within this region of Upper Mesopotamia high above the Tigris River, to avoid fighting with water and perennial inundations at the Upper city. On the other hand, if conditions were much like today which means that the climate was arid (and it does not seem that impossible), the city must have fought with supplying and preserving adequate water.

Meanwhile, climate can not be a sole determinant on water collection. Reservoirs conducting water from a main canal to the smaller ones must have been opened and closed again. Strabon's way of thinking for the upkeep of canals due to rising of rivers as in the case of Tigris excludes Hasankeyf from such debate in a sense. If Hasankeyf is to be included in the debate, then the idea could have emerged from easy flow of water down and across the harsh topography in reverse to preventing soft types of soil being swept out by streams as a result of overflowing. In the light of Forbes's (1993) hypotheses, the maintenance of water distribution must have been so vital that the social fabric of the city was perhaps based on water control just similar to that impression all over Mesopotamia, regardless of natural factors (pp.19-21).

Water conservation and drainage are two major concerns if the climate is arid. Aqueduct building comes therewith. Hasankeyf can be a sample for sophisticated engineering because archaeological evidence reveals the existence of Roman hydraulic works in aqueduct construction and storage of water in huge cisterns, ponds and canals in Mesopotamia (pp.43-45). Moreover, drainage plans, whatever the climate was, were achieved by water tunnels, often with subterraneous tunnels of the qanat type with air shafts at regular intervals (p.47). There is again no reason why Hasankeyf did not maintain such a system despite its topography. However, archaeological evidence is absent for qanat type structures up to now.

2.3. Historical Background

Although the identity of first settlers of Hasankeyf is still unknown, it is certain that several cultures settled here throughout history. It is located in the Fertile Crescent and was inhabited by Assyrians, Romans, Byzantines, Sassanids, Abbasids, Artukids, Ayyubids, Seljuks and Ottomans.

Plüss and Arık (2001) describe the city as very unique. The name of the town "Castrum Kepa" (the castle of rock) comes from the Assyrian language, which was also used by the Romans, Umayyads and Abbasids. Byzantine, Ottoman and Seljuk texts provide information on the medieval status of Hasankeyf in terms of its geographical and strategic importance. However, there is no adequate information or written source from the pre-Byzantine periods. In the late Roman period, Sassanids passed Hasankeyf to Byzantines and the occupation continued until 7th century. The fortress which was constructed in 4th century by the Byzantines formed the basis for further conquests. The importance of the city comes from the settlement of a very ancient Christian community and establishment of an independent religious institution in the beginning of early medieval ages. Muslims conquered the town only after 7th century. The town reached its peak during the reign of the Artukids, which was a principality of the Seljuk Empire between 1100 and1234 A.D.

The main reason why Hasankeyf has been regarded as a suitable land for settlement is that topography facilitated defense war especially on the hilltop. Thousands of cave dwellings maintained their strategic importance. The medieval city pattern began with the Seljuk period. Many ruins are not unearthed yet (p. 96).

Because the water system is discussed in this thesis, the focus is on the water features. The literature on water works at Hasankeyf starts with the Artukids. Plüss and Arık (2001) discovered that convergent tubes and a siphon system are two remarkable features of the Upper city dating to the reign of Sultan Karaaslan. In this period, the castle was reconstructed on the rocky plateau and vineyards and gardens were formed on the banks of Tigris. There is evidence that fresh water was brought to the city from high plateaus via canals which were cut into rocks. It was circulated from a cliff to the castle. The ruins of the canals and the depot where water reached the castle are still visible today. Cisterns constitute an important part of the innumerable rock-cut dwellings where large or small rooms, workplaces and storage areas are contained, as well. Caves were used as natural dwelling areas. Water was transported to these caves from mountains in the southeast through canals and funneled down from the tops of cliffs to the valley as mentioned before. It was simply pressured up to the cave-dwellers' residences and the surrounding area throughout the Upper city. Such evidence has the potential to support the overall water system in many respects (p.98). This is discussed in the coming parts in detail.

Arık (2003) provides further details about the canals bringing water to the castle. Almost everywhere, canals in the form of big window shape clay pipes are observed to have been carved into the rock inside which smaller canals made of clay pipes transported water. Remains of the water depot where canals reached the castle and the remains of a "maksem[1]" similar to that in Taksim-İstanbul, also prove that water was first brought to the Grand Palace and then distributed to the districts and quarters of the Upper city via a secondary network (p.136). He adds that there is still doubt whether water was transported to private areas of the Upper city. He also refers to medieval travelers who note that the system served district fountains. Cisterns were a kind of preventive mechanism which collected water not only from rainfalls for the dry season but also from fountains and Tigris via zigzag stairways that were carved

[1] Water tower which acts to increase the level of water, thus the pressure and distributes it to the city and/or its surrounding.

into the northern scarp (p.122). Such structures are dated to periods much before than Artukids. Water which was brought via a siphon system or a “maksem” served for drinking or cleaning purposes at the Upper city as well as for irrigation of the surrounding lands. Additionally, evidence tells that water which was brought from Tur Abdin[2] was actively used for the irrigation of wheat and barley fields and other green areas (p.136).

2.4 Housing (Public/ Private)

The housing pattern of the Upper city exploits the advantages of a defensible topography. It is very likely that houses had to stand very close to each other because of environmental conditions. This is probably facilitated by the rock-cut building practice. As Peker (2004) confirms, houses are located in parallel with the landscape whereas monumental structures and buildings which served for the public areas are placed on the highest levels on relatively flat grounds toward the northern part of the Upper city (TAÇDAM web site). Figure 2.2 gives a quick view about how the settlement areas are designed in accordance with the topography.

Slope degrees of the landscape are observed to be moderate in most parts of the public areas which are below 45 degrees while they can reach 45 degrees in private areas and the road network (Toprak and Süzen, 2004). Maximum degrees are measured along the natural scarp surrounding the whole city in all directions (pp.804-811).

TAÇDAM (1998-2003) records that it is only possible to reach the castle through open and secret gateways. Apart from two zigzag stairs near the Tigris and the main entrance from the east, an entrance which extends to the Sır Gate from the western valley is also possible. The public area lies in the northern part of the Upper city. Settlement areas, including the rock-cut houses are all around this main public area. Domestic quarters partly border the Pool in the southern part of the city just before the scarp. Figure 2.3 shows the main settlement features of the Upper city. For the

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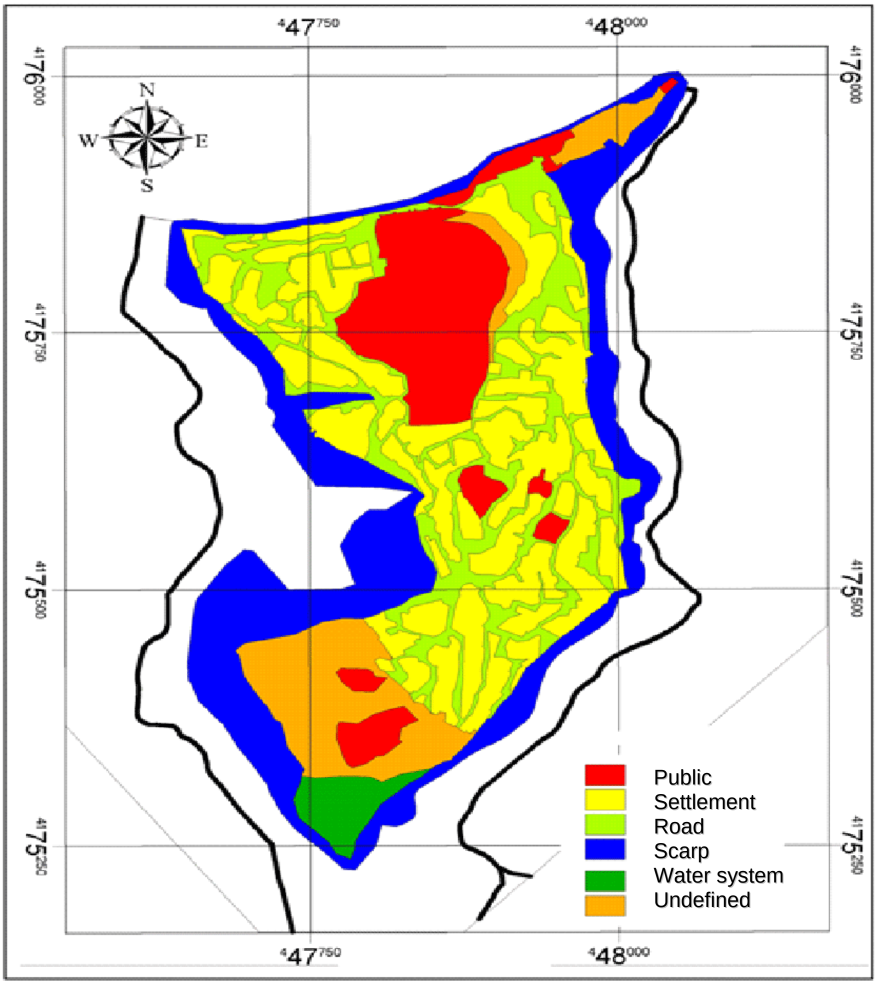
[2] Modern Midyat (sub-province of Mardin) and its surrounding.

purposes of this study, it is worth noting domical baths and cisterns above the ground level. Some are reached by stairs and are among the most common features encountered at the courtyards. Moreover, baths which are adjoined to the housing units are closed spaces with niches and basins on the floor inside which there are benches for sitting (Peker, 2004). The Great Mosque (hereinafter referred to as Ulu Mosque) complex which is spread over a wide area and made up of ordinary walls and a doorway in the southeast side reveals evidence for well-preserved cisterns. Cisterns have capacity to store hundred tons of water within the courtyard of this complex.

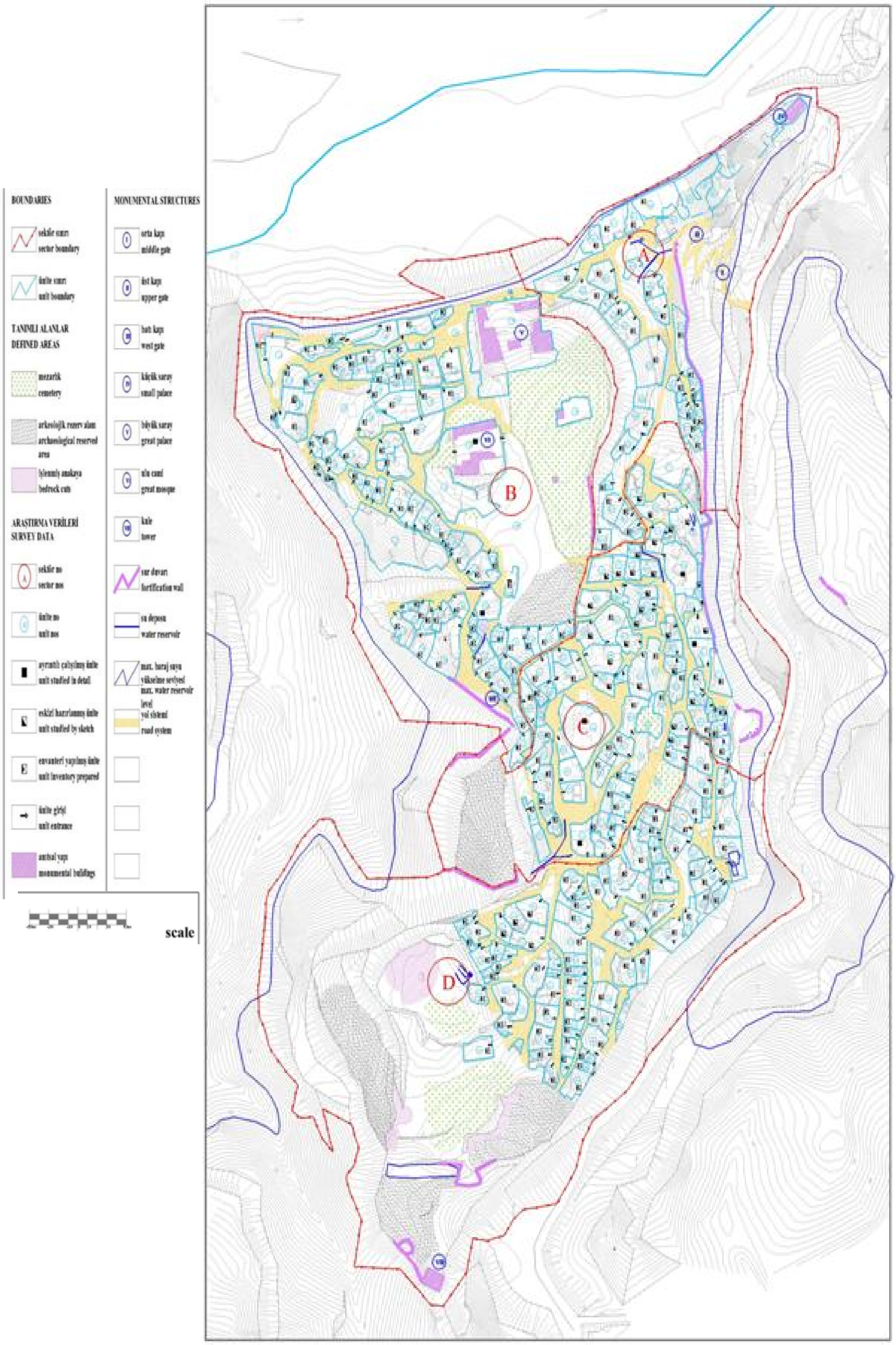
Figure 2.2 A view from the settlement areas at the Upper city, compatible with topography

Houses are sometimes located at the centre of courtyards while closed entrances can lead the way to houses which stand at the very back of a courtyard or to houses scattered around a common courtyard 2 m at most. Houses served with a road network are the first domestic features in order to analyze the relationship between the water features and settlement areas (TAÇDAM web site).



(Source: Toprak and Süzen, 2004)
Figure 2.3 Classification of the archaeological features at the Upper city

The housing units with all other relevant structures of the Upper city are shown on the Settlement Pattern Analysis Map, in Figure 2.4. Figure 2.5 is the same as Figure 2.4 which exhibits a larger view without a legend. In total, 264 housing units, excluding research units assigned to public areas are shown on the Settlement Pattern Analysis Map. No records are made for C18, B60, B33 and D17 units because they are now covered up with earth or are so badly damaged that boundaries are not clear. Taking the individual housing borders into account, a sampling area of 112 housing units within a total number of 129 locations, out 264 housing units provide evidence. However, the special locations which are out of the borders of housing units like roads or scarp areas in partial are included as separate locations in the research and recorded within 129 locations. In sum, no evidence is recorded for the remaining 152 houses at the Upper city.



(Source: TAÇDAM, 1998-2003)

Figure 2.4 The Settlement Pattern Analysis Map of the Upper city

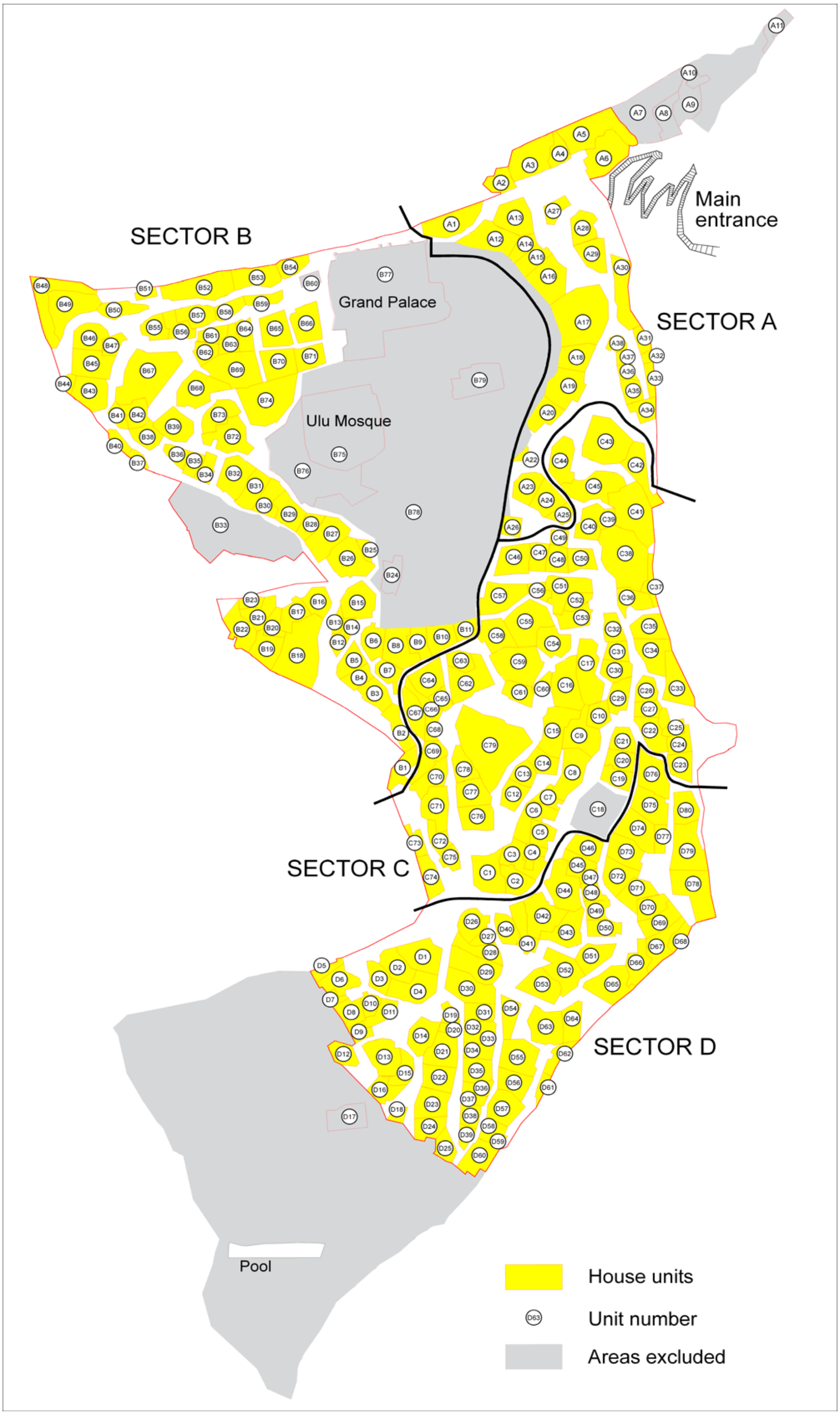


Figure 2.5 A simplified version of the Settlement Pattern Analysis Map of the Upper city with house unit numbers

2.5 Water Structures

When considered in general with all the elements of the Upper city, five main components of the water network are visible today. These are:

a. The main canal coming from the source,

b. The siphon system

c. The Pool

d. Distribution canals

e. Cisterns.

Figure 2.6 shows the direction towards which three features (a through c) of the water system, that lie outside the borders of the settlement areas at the Upper city can be reached. Simply, Figure 2.6 addresses the location of the main canal coming from the main water source; the siphon system and the Pool. They are reached via the modern road which follows the route along and right below the eastern scarp.

Figure 2.6 The location of the main canal, the siphon and the Pool

Figure 2.7 shows that the main canal brings water to the southwestern part of the Upper city carved into a single block of a main rock. The canal then splits into two short extensions which merge again below the recent elevation of the canal making their way towards the siphon system.

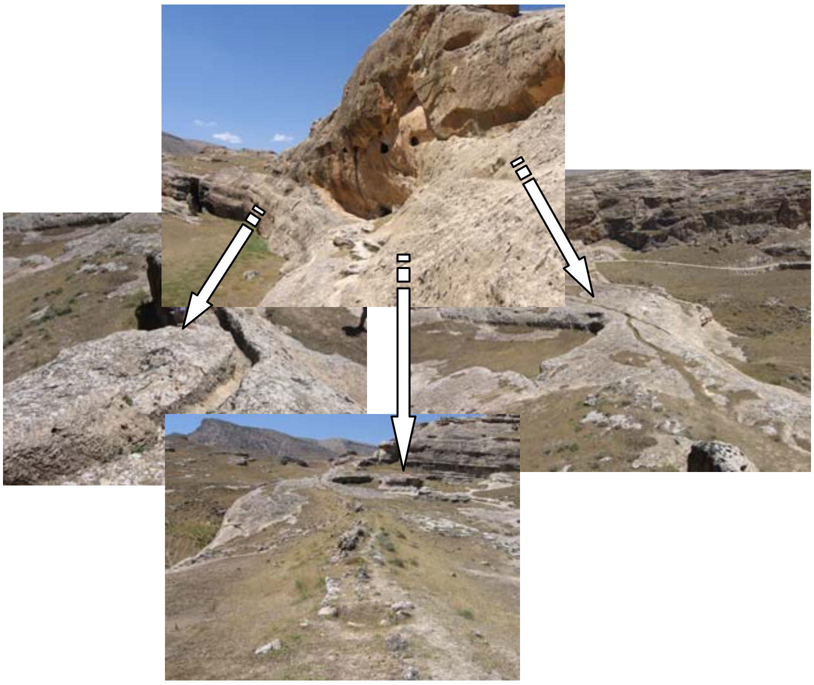


Figure 2.7 The main canal arriving at the siphon system

Another canal extension at the right hand directly flows downwards making its way towards the cisterns near the main canal. This extension which is much below the recent elevation can only be tracked for a while and then disappears (Figure 2.8).

Figure 2.8 The canal extension stretching towards the cisterns at a very low elevation near the main canal

Figure 2.9 shows the canal extensions directly originating from the main canal, joining again and following the route towards the siphon system. Evidence for terra-cotta pipes is shown below.

Figure 2.9 The canal extension and terra-cotta pipe remains stretching towards the siphon system

The siphon system is the south of the Pool. A canal network is supposed to have originated from this point stretching toward the north and across the housing units. In Figures 2.10 and 2.11, two blocks of the siphon system are standing face-to-face below the elevation where the main canal sends water to this location. The water falls from the first block (Figure 2.10) at a higher elevation, reaches the ground level and is pressured into the second block with a certain acceleration rate (Figure 2.11).

Figure 2.10 The first block of the siphon system

Figure 2.11 The second block of the siphon system

The Pool is located up at the end of the second block toward the north at a higher elevation in the southern part of the Upper city. It is welcome by the southern borders of the Upper city. At this point, water is distributed to the Upper city (Figure 2.12).

Figure 2.13 shows that the Pool was adjoined with distribution canals in the south to provide the housing areas with water. Figure 2.14 shows the short extension which originates from the western side of the Pool.

Figure 2.12 The Pool located between the Upper city and the second block of the siphon system

Figure 2.13 The view from the Pool and canal tracks extending from the east side of the Pool towards the settlement areas

Figure 2.14 shows the short extension which originates from the western side of the Pool.

Generally, the eastern part of the Upper city has more canals and cisterns than the western part.

Figure 2.14 The view from canal tracks extending from the west side of the Pool towards the settlement areas

Forbes (1993) underlines that, ancient texts of Mesopotamia mention about a tail at the end of a canal system. Such tail is no different than a reservoir system. Also, lateral canals are ascribed to have been closed by “mouths”, probably spill-ways that were generally used for irrigation purposes. Archaeological evidence attests that, long before the Roman times, huge canals were present bringing water from the mountains down to plains in east of Tigris to supply towns with water and its environs in Assyria. There is reason to assume that the same system was inherited from very ancient times for the Romans (I, p.22).

The bulk of water seems to have been transported from the south to the Upper city by main canals and the siphon system. In the light of historical structures, it is understood that there are three methods of water distribution. The first one is achieved with the help of a main Pool which is carved in the southern part, although this part of the city falls outside the borders of the settlement area as defined above. The second one is canal usage which is observable inside and outside the borders of settlement area. The last category goes to small water depots and cisterns encountered throughout the settlement area. Cistern usage is a very good point to comprehend the design of the settlement due to their abundance in number.

CHAPTER 3

CISTERN AND CANAL DATA

This chapter describes the data collected at the Upper city of Hasankeyf during the field studies. Two major water features studied in detail are the cisterns and canal remains that are explained below, under separate sections.

3.1 Cistern Data

The field work carried out at the Upper city is focused on cisterns. The Settlement Pattern Analysis Map prepared by TAÇDAM (See Figure 2.4) was used as the base map during the research. The distribution of 185 cisterns recorded throughout the Upper city is shown in Figure 3.1 by using the same template. The cisterns recorded in this study are named under housing units, thus only confined to them. Other parts of the city are excluded. However, they are touched upon when necessary to understand how water features were integrated within the urban context. These parts are either public areas (such as the Grand Palace, Ulu Mosque, cemeteries) or are not visible. They lie under archaeological deposits. Some are so heavily destroyed that the cisterns can not be identified. Accordingly, the recorded cisterns are shown with their locations in Figure 3.2 which is a merged version of Figures 2.5 and 3.1. There are two major steps during the collection of cistern data which are: 1) Identification of cisterns and, 2) Measurement of the cistern.

1) Identification of cisterns: Only a couple of cisterns have been reported from previous works. Most of the cisterns are identified for the first time, in this study. In the beginning of the field studies, it was recognized that the total number of cisterns was much more than the estimated/expected. Therefore, assistance was provided by the local people of the Upper city to some extent, in order to accelerate the cistern identification process.

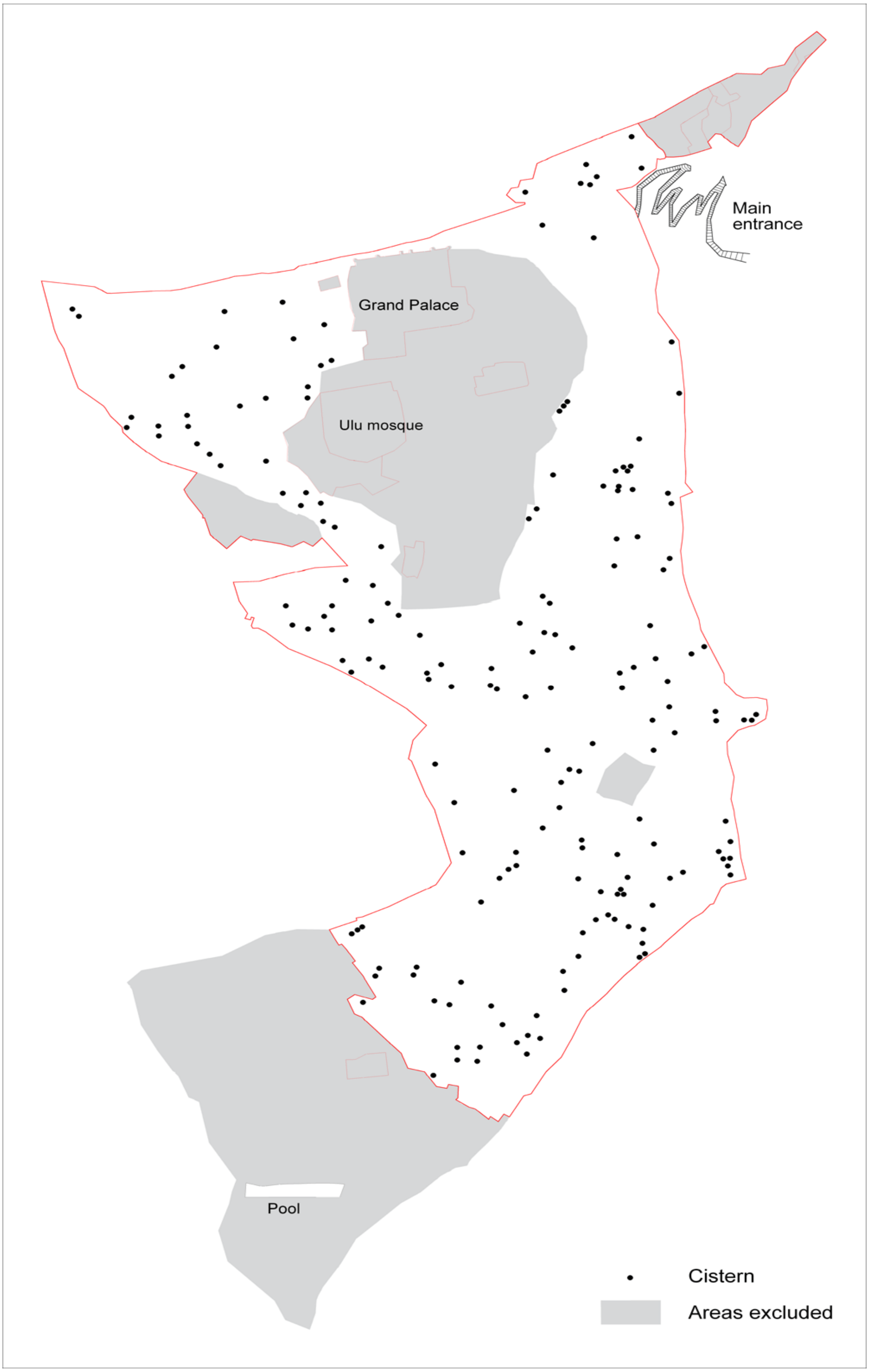


Figure 3.1 Cistern distribution map at the Upper city of Hasankeyf

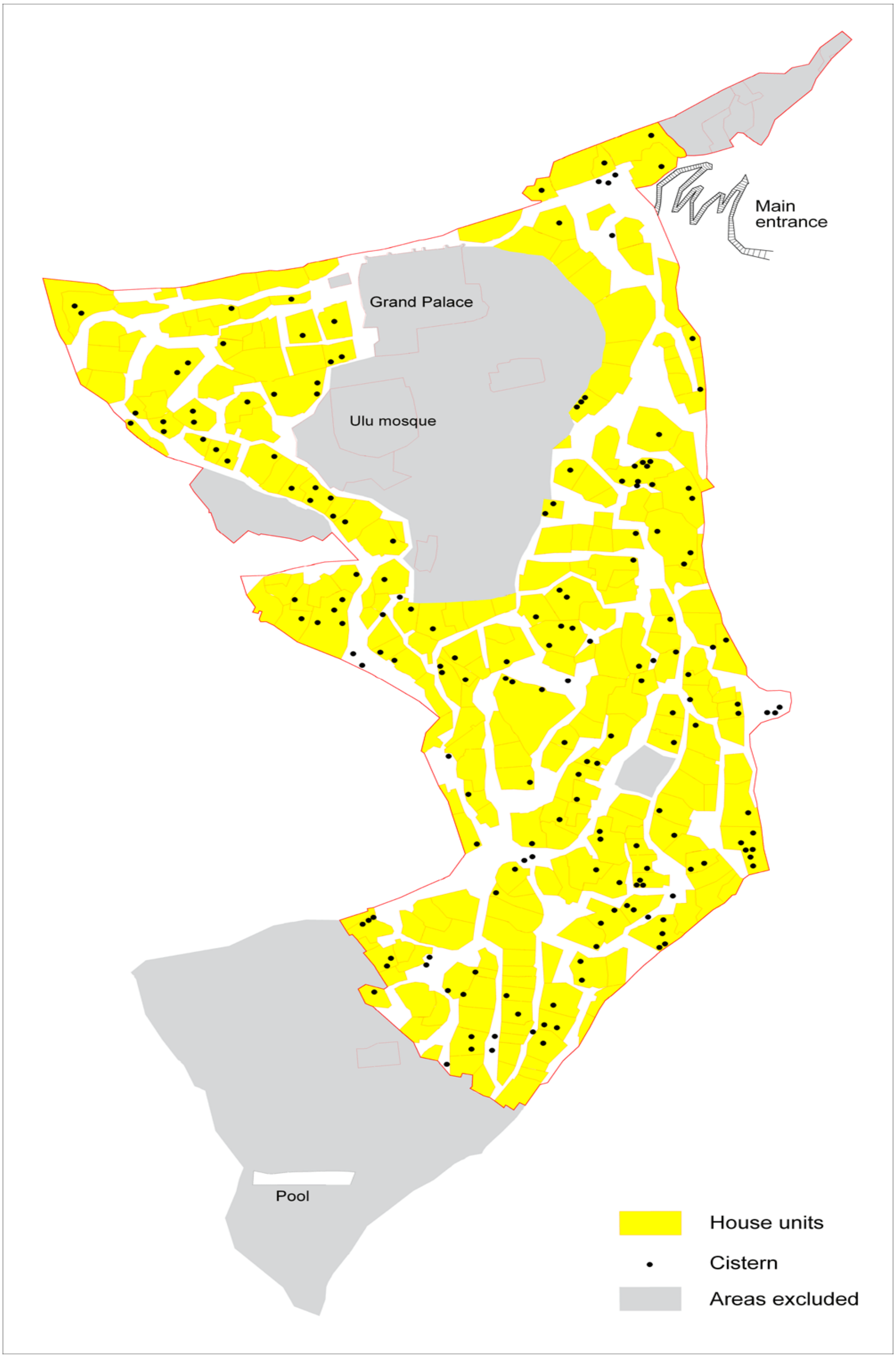


Figure 3.2 Cistern distribution map with locations at the Upper city of Hasankeyf

2) Measurement of the cistern data: Maximum attention was paid to be as accurate as possible during the data collection process. For this reason, it was usually intended to enter the cisterns most of which were accessible through passages built later or through the rock-cut houses.

Examples of cisterns under various conditions are illustrated in Figure 3.3. Some cisterns are well-preserved and located within the courtyard of a housing unit (D78) whereas some are on a main road (B71-2). Some others are closed (A5) from their top but might be accessed from a house or totally filled (A6), thus can not be measured. Some cisterns are partly destroyed due to rock fall (D26) or badly destroyed arising from late modifications in the caves (D44).

3.1.1 Cistern measurements

A total of 185 cisterns, excluding one small pool and a special public cistern, were identified during the field work (The small pool and the special cistern are included in Appendices A, B, C and E). For each cistern, a field record sheet was filled with information concerning height, diameter, shape, current condition, basic descriptions and remarks. A database was generated from these sheets, which is given in Appendix A for the measurements and in Appendix B for the descriptions. Appendix A exhibits the exact measurements of cisterns taken at the field. It also helps to show the estimated volume and sizes for those given mainly in the last two columns of the table. The methodology of the estimations is discussed below.

The heights of the cisterns were recorded in two ways; one way was to record from top (opening) to base and the other from neck to base. The former is valid for cylindrical and conical forms while the latter was used for pear-shape cisterns. The heights of the cylindrical and conical forms measure between 90 cm (min.) and 710 cm (max.). The neck-to-base measurements range between 150 cm (min.) and 600 cm (max.).

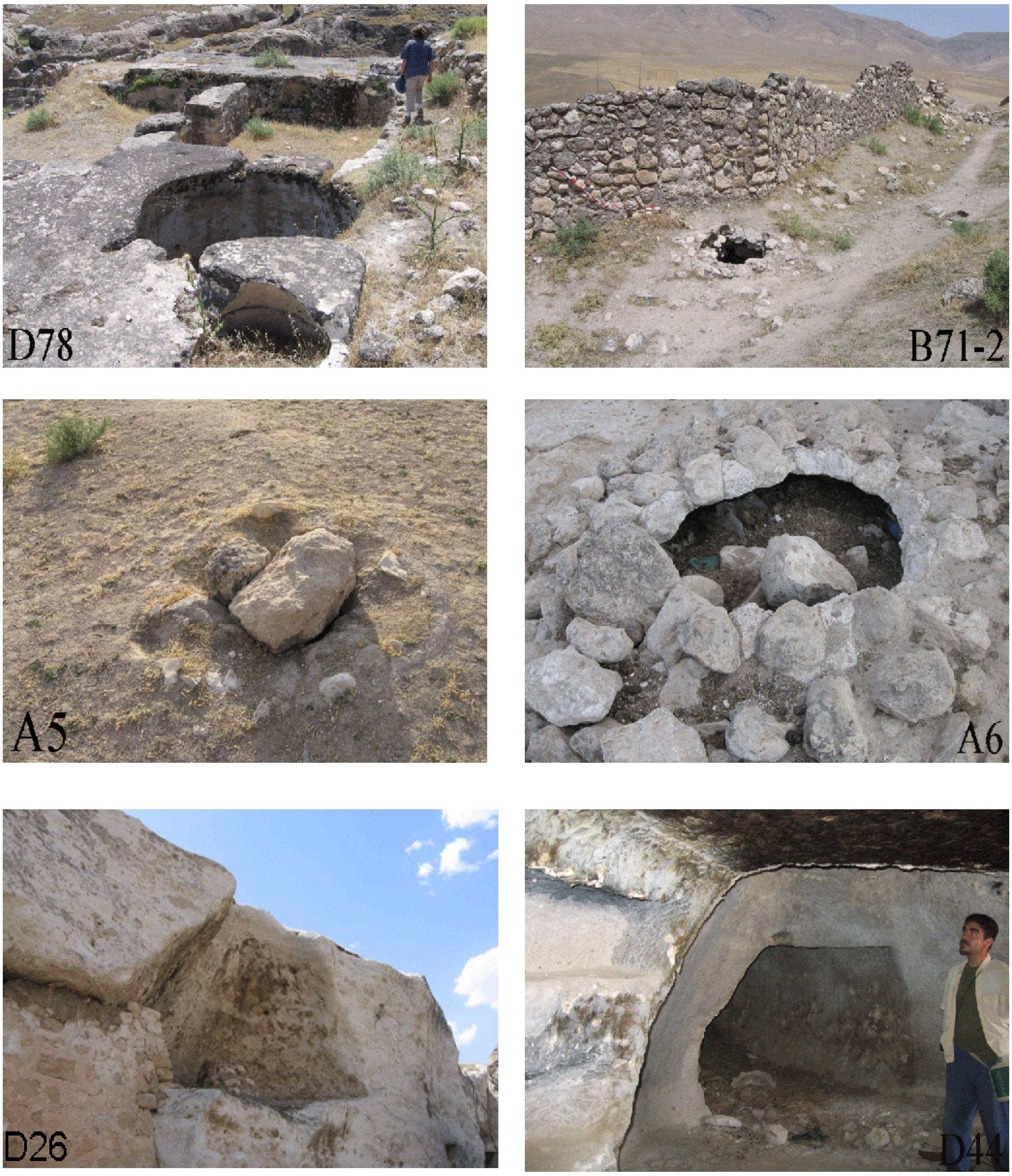


Figure 3.3 Cistern samples from the Upper City which are observed to be well-preserved in a courtyard (D78), located on a main road (B71-2), closed (A5), filled (A6), partly destroyed (D26) or badly destroyed (D44).

The diameters of the openings and of the bases are the other measurements taken. Firstly, diameters of openings were measured on their north-south (N-S) and east-west (E-W) axes, respectively. The same method was applied to record the base diameters. Some data is missing for the axis based measurements because not all the cisterns are accessible and/or they are so badly destroyed that it is impossible to reflect satisfactory measurements. However, since estimations with respect to relevant measurements are already given in Appendix A, the direction of axes does not count for any measurement consideration. In brief, it is determined that the smallest diameter recorded for an opening is 35/35 (N-S/ E-W) cm and the largest is 330/200 (N-S/ E-W) cm (excluding the small pool which is measured 400/400 cm as the largest in the database). On the other hand, the smallest base diameter is recorded as 60/80 (N-S/ E-W) cm and the largest one(s) as 740/660 (N-S/ E-W) and 710/690 ((N-S/ E-W) cm.

3.1.2 Cistern Characteristics

Cisterns measured at the Upper city can be identified in terms of their shape; volume and size; and pattern. Their current conditions are not considered within the cistern characteristics context. However, determination of their current condition is central to this research in order to comment whether any conversion activity is more deliberate for certain cisterns when compared to the others. Moreover, since absolute dating studies fall out of the scope of this thesis, it is impossible to date all the water features. Rather, condition recording is thought to make some contribution for understanding the idea behind the secondary usage of cisterns.

3.1.2.1 Shape: Mainly three shapes of cisterns, excluding the small square pool, are recorded as cylindrical, conical and pear-shape at the end of the field study. Apart from those which are filled or can never be reached, it is determined that 4 cisterns are cylindrical, 132 cisterns are conical and 21 cisterns are pear-shape. Diagrams and samples for each type of cistern are provided below with Figures through 3.4-3.7.

Shapes of 28 cisterns are undefined either because they are filled, broken, destroyed or can not be reached at all. Although measurements of C6 are complete, its top and base values are so close that no shape is assigned to this cistern (Appendix A). The shape of the cistern (no:88) in D65 unit is also undefined because the base can not be reached due to the well ring-like lid, thus it has to be estimated. There are cisterns whose bases can not be reached but they can be detected with the eye. These are included in shape classification.

The majority of the cisterns have conic forms. The ones which are mostly subject to conversion belong to the same type, as well.

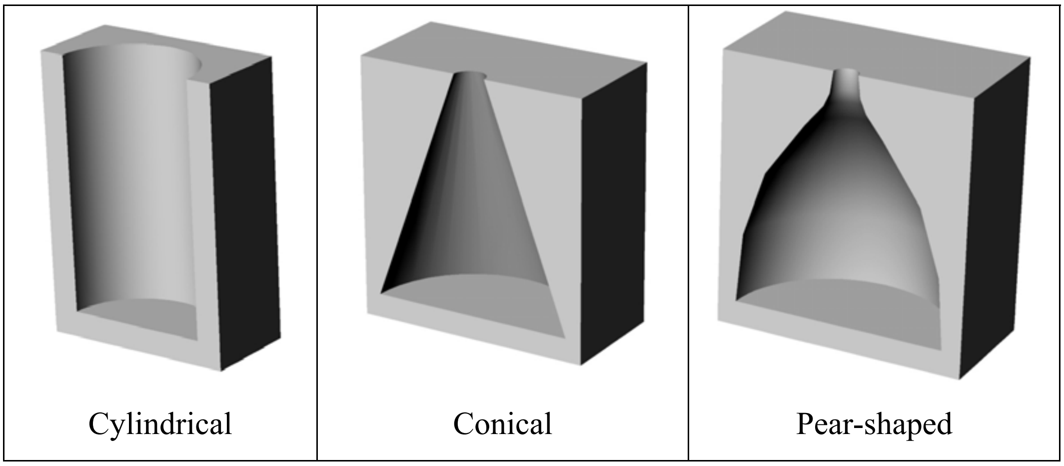


Figure 3.4 Block diagrams of three types of cistern shapes

Figure 3.5 Sample for the cylindrical cistern

Figure 3.6 Samples for conical cisterns

Figure 3.7 Samples for pear-shape cisterns

3.1.2.2 Volume and size: It is observed that cisterns have various sizes, independent of their proximity to each other. However, sizes are usually dependent on where they are located. This is further analyzed in Chapter 4. Sizes of 43 cisterns are estimations, leaving the special one found within the courtyard of the Ulu Mosque out of scope (Appendix B). It is given additionally, as 1 representative of 6 samples detected in different parts of the Ulu Mosque, just to show that they are equally important parts of the Upper city.

There are mainly three reasons for the estimations. First, it was sometimes impossible to access certain cisterns because they are either closed by reason of human activity or filled due to natural factors. Second, although some provide partial or subsidiary data, such data can not help to come up with precise calculations for their volume. Therefore, it is impossible to identify them in terms of volume and size. Third, although a cistern definitely satisfies one of those vital parameters to calculate its size, another parameter has to be estimated using the most approaching number and/or a median, based on the closest reference(s). Meanwhile, vital data stressed above to calculate a size is based on the base diameter and the height of a cistern. The criterion for measuring the height for pear-shape cisterns is based on the vertical distance between the base and the neck.

Estimations are made by applying two simple methods. One is that the missing data is tried to be derived by checking the closest values which means that some cisterns exhibit similar recurring or approximate measurements in the relevant column(s) given in Appendix A. By this way, the possible maximum measurement(s) are tried to be fit to the missing column(s), either by putting the recurring value or calculating a median. An estimation example can be given for the settlement unit B72 where cistern no: 26 is recorded. Three conical cisterns (98, 101 and 144 attributable to units as D63, D56 and B3) are addressed as reference points whose heights are 350, 310 and 250; top diameter values are measured as 110 in the north-south direction; and base diameter values range between 305 and 400. Since the only data for B72 is the exact diameter of its opening (top diameter), and thus cisterns no: 98, 101 and 144 satisfy this value, all three are resumed as the most approximating cisterns. The standing points for estimating the height and base diameter of B72 are the median values of the heights and base diameters of those three cisterns stated above. As a result, the estimated height value of B72 is calculated as 2.75 m and the base diameter as 3.50 m.

The other methodology is based on the measurements of neighboring cisterns. For example if two cisterns show identical measurements for each and every column or at least for some common columns, then the missing data for a cistern which is also adjacent to the subject cisterns is automatically inserted. However, this does not mean that other references are not used to make comparisons. Thus, already estimated values that are dependent on the adjacent cistern measurements are also tried to be compared with those which have close measurements regardless of physical proximity. For example, the adjacent cisterns which are numbered as 73, 74 and 75 in the database (Appendix A) reveal almost similar characteristics in size. Although, cistern no: 75 is somehow distinctive with its height and top diameter value, the base diameters for all three cisterns have to be valued somewhere between 100-110/150 cm where 110 goes to cistern no: 75. Such an attribution is based on taking precise base diameter values of cisterns no: 60 and 79 as the reference ones in the same manner stated before.

Histogram showing the variation of the identified cisterns is given in Figure 3.8. Two cisterns in the database (the pool and the special one; no: 83 and 187, respectively) are excluded in this computation. The cisterns are grouped under six categories as very small, small, medium, large, very large and extremely large.

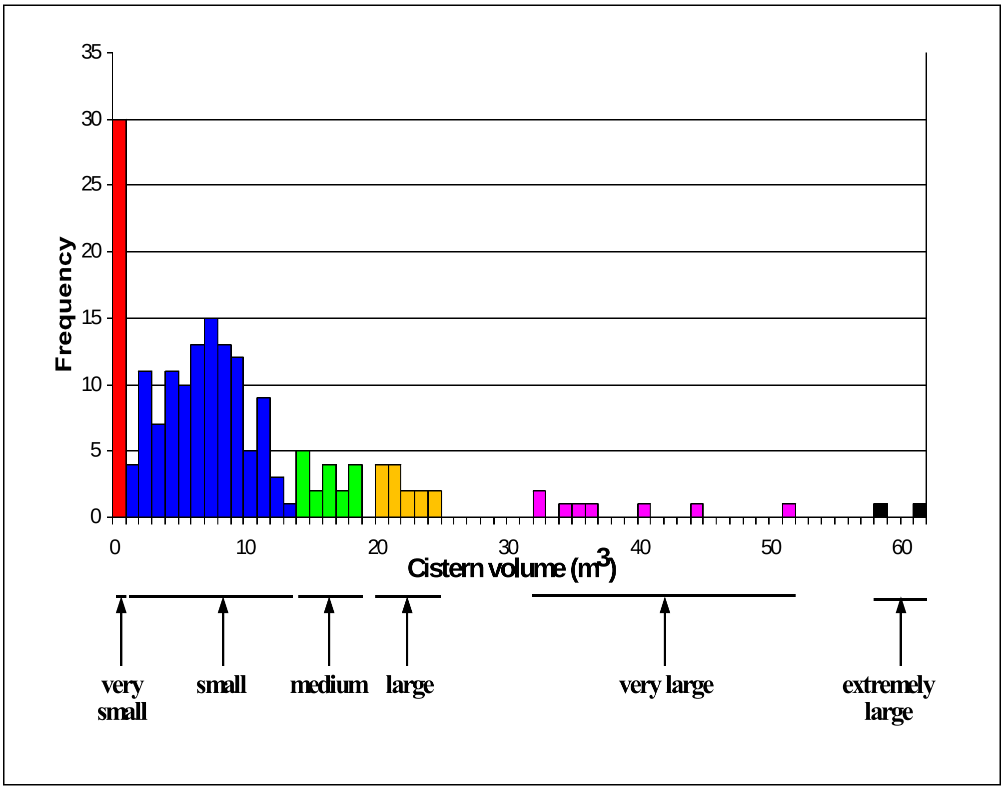


Figure 3.8 Histogram of cistern size categories

Categorization is made according to the range of volume measurements, each of which is calculated for three cistern types. The smallest cistern has a capacity to collect 0.19 m^3 of water and the largest has a capacity to collect 61.47 m^3 of water. Accordingly,

- the first size category as "very small" denotes a volume range value between 0 and 1 m^3
- the second size category as "small" denotes a volume range value between 1 and 14 m^3
- the third size category as "medium" denotes a volume range value between 14 and19 m^3
- the fourth size category as "large" denotes a volume range value between 20 and 25 m^3
- the fifth size category as "very large" denotes a volume range value between 32 and 45 m^3
- the sixth size category as "extremely large" denotes a volume range value over 52 m^3.

It is also determined that cisterns may have great gaps in size. For example a cistern can rate as "very small" while its adjacent can fall under the "large" category (Appendix A). Totally,

30 cisterns are ranked as "very small";
114 cisterns are ranked as "small";
17 cisterns are ranked as "medium";
14 cisterns are ranked as "large";
8 cisterns are ranked as "very large"
2 cisterns are ranked as "extremely large" (Figure 3.9-A).

Capacity of each category is shown in Figure 3.9-B. A total of 1821.4 m^3 of water is held by all the cisterns recorded at the Upper city. "Small" category cisterns hold about 43.3 % of the whole storage alone. "Medium", "large" and "very large" categories hold 15.3, 16.9 and 16.9 %, respectively. Two "extremely large" cisterns hold 6.6 % whereas 30 "very small" cisterns hold only about 1 % of the total water.

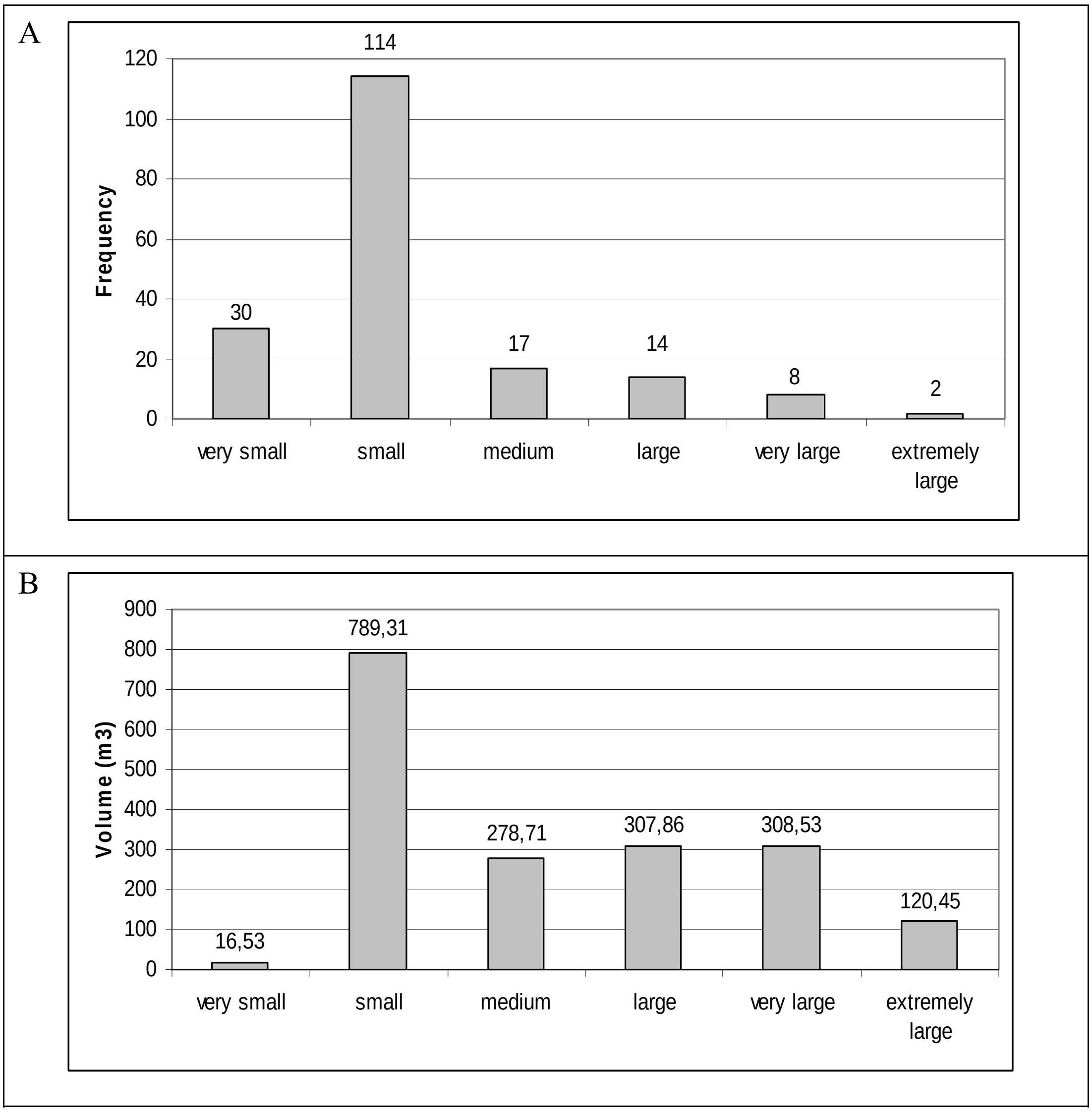


Figure 3.9 Frequency (A) and capacity (B) of cisterns satisfying size categories

3.1.2.3 Pattern: The parameters previously mentioned as shape and size, are characteristics of the cisterns if they are considered as individual structures. The third parameter (pattern), on the other hand, refers to the spatial relationship of a cistern with the surrounding cisterns. Although most of the cisterns stand alone and are isolated from other cisterns, some are very close to each other. The distance for such cisterns may be as close as 5 cm at the base, particularly where the cisterns are damaged or converted for secondary usage.

The cisterns which are very close to each other are either referred to as "twin" or "triple" in the study. A commonly observed feature of these neighboring cisterns is the elevation difference at the base level. Such cisterns are called "hung" cisterns. One distinctive feature for some is that they are accessible from two openings. These cisterns are named as "two-chimney" cisterns. Therefore, the following pattern categories are assigned to Hasankeyf cisterns at the Upper city:

1. Individual
2. Twin
3. Triple
4. Hung
   4.1 Single-hung
   4.2 Twin-hung
   4.3 Triple- hung
5. Two-chimney

Block diagrams of cistern patterns are shown in Figure 3.10. The frequency of these patterns is given in Table 3.1. Individual cistern category is not provided in the figures since it is deemed very common, by definition and nature. An important thing to stress is that some of the cisterns fall under the multi-pattern category which shall not be touched upon in this sub-part to create further categories. Rather, Appendix C facilitates the quick evaluation to make a cross-check for more patterns in the specified locations.

The reason for not assigning a multi-pattern category to cisterns is that as long as cisterns satisfy the requirements of one or more pattern category(ies), all of their characteristics with regards to each pattern are implicitly embedded in those categories. That is, if a cistern inside a house exhibits the characteristics of a triple category but only two cisterns are hung out of three, then this complex exports data to two categories. So, there is no need to elongate the list of cistern pattern category such as adding a new category as "two-hung in a triple". Note that calculations to attain total numbers for each pattern are based on recurring patterns. In addition to the remarks given above, number of cisterns calculated for 5 main pattern categories, ignoring the units to which they belong, are given in Table 3.1 in the light of Appendix C.

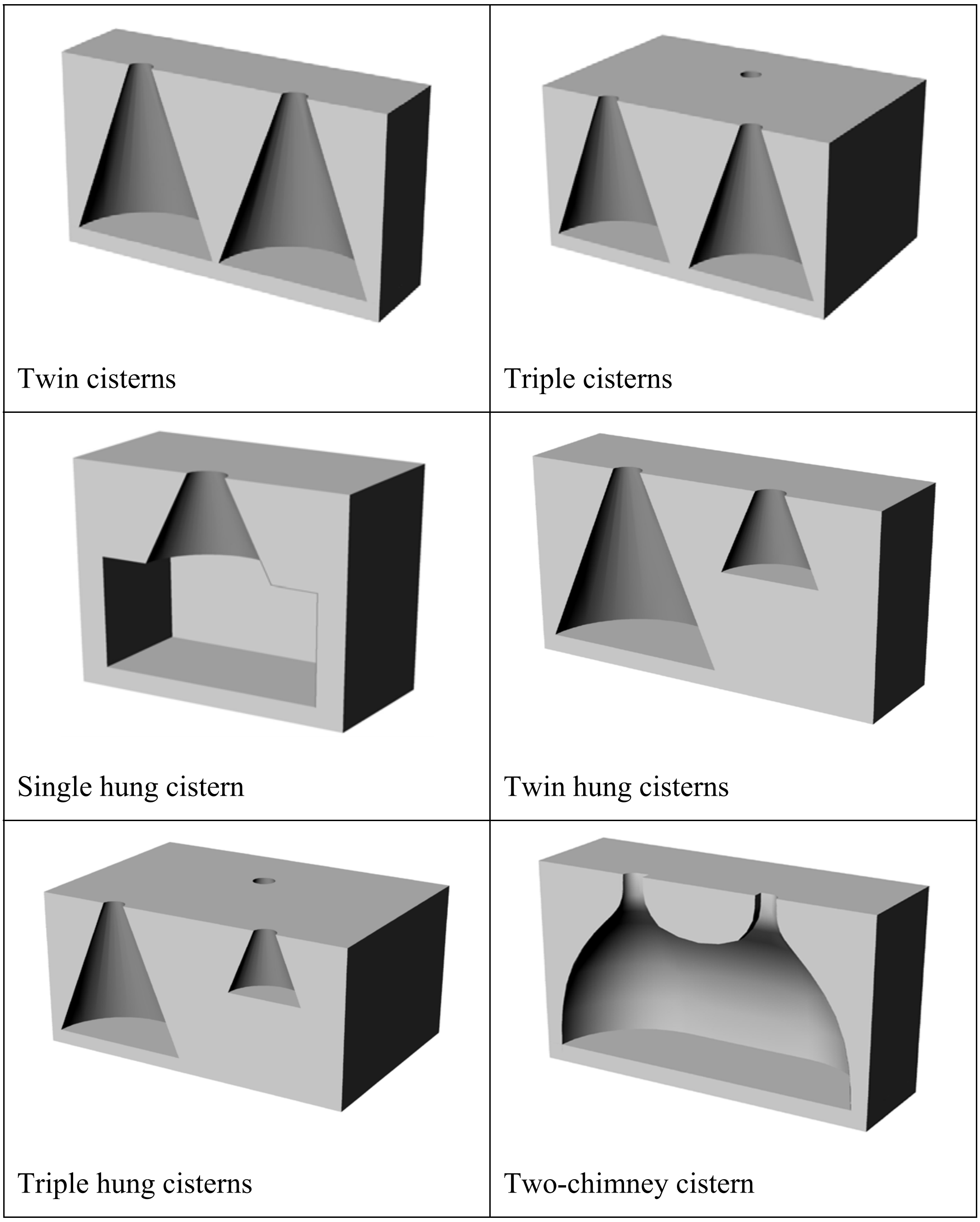


Figure 3.10 Block diagrams illustrating cistern patterns

The total number of cisterns classified as individual at the Upper city is 157. Among these, only 36 cisterns are identified to be single-hung. A single-hung cistern is recognized if the base part is modified during secondary use. One thing to note is that when a rectangular room is observed to be carved or enlarged toward a cistern, the cistern is easily confused with a dome-like structure at the roof of a rock-cut house (Figure 3.11).

Table 3.1 Total number of cisterns satisfying cistern patterns

PATTERN	TOTAL NUMBER
Individual	157
Twin	6
Triple	4
Hung	39
Single-hung	36
Twin-hung	2
Triple-hung	1
Two-chimney	2

Six twin cisterns are identified at the Upper city. These are located in B71, B74, D65, D51, C55 and C79 units according to the order given in Appendix C. Major characteristics of these cisterns (type, size, hanging status and their distances between centers) are given in Table 3.2. Locations of two twin cisterns (B74 and C79 units) are shown on the partial map in Figure 3.12 and their photographs are given in Figure 3.13.

Accordingly, the following observations are made on the twin cisterns:

- All twin cisterns belong to the conical type.
- Most of the cisterns are classified within the "very small" to "small" size category except the twin cisterns in house unit C55.
- Two cisterns in two twins (no:21 in B71 and no:23 in B74, Appendix B) are hung indicating that their bases are not at the same level with the other cisterns found in the said units. In units D51 and C55, on the other hand, both cisterns are hung indicating that their original bases are at the same level and such hanging position is due to secondary usage (Figure 3.14).
- The distances between the centers of twin centers range from 1.70 to 5.90 m with an average value of 3.8 m suggesting relatively short distances between the cisterns.

Figure 3.11 Samples for single-hung cisterns

Table 3.2 Major characteristics of twin cisterns

No	House unit	Shape of cisterns	Size of cisterns	Hung	Distance between centers (m)
20	B71	Both conical	medium		2.82
21			small	Yes	
22	B74	Both conical	small		5.90
23			small	Yes	
89	D65	Both conical	very small		1.92
90			very small		
96	D51	Both conical	very small	Yes	3.82
97			very small	Yes	
115	C55	Both conical	very large	Yes	4.42
116			large	Yes	
172	C79	Both conical	very small		1.70
173			very small		

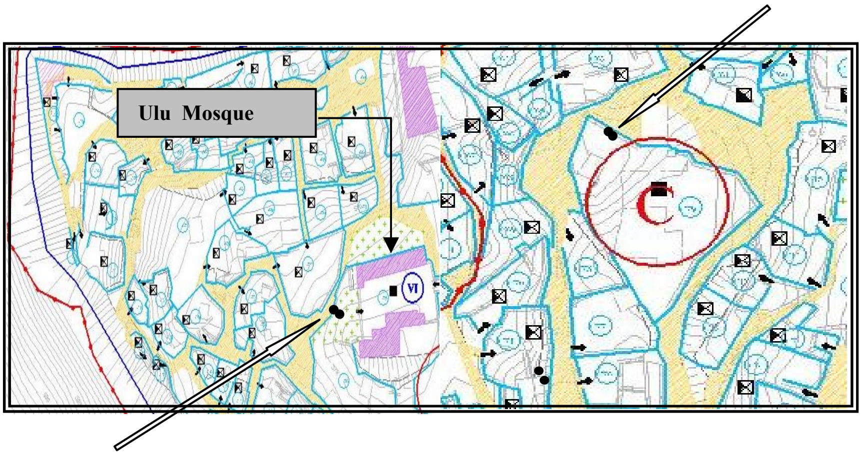


Figure 3.12 Location map of the samples for twin cisterns in B74 (left arrow) and C79 (right arrow).

Figure 3.13 Samples for twin cisterns

Figure 3.14 A sample for twin-hung cisterns

Triple cisterns are observed at four locations of the Upper city. A summary of these cisterns is given in Table 3.3. Also, the location maps of triple cisterns in C45 unit and the east of units C23 and C24 are given in Figures 3.15 and 3.16, respectively. Photographs of them are also shown in Figure 3.17. Based on the characteristics of the cisterns shown in Table 3.3, the following conclusions can be derived for the triple cisterns:

- With the exception of one pear-shape cistern in unit C45, all the identified ones fall into the conical category.
- Except the pear-shape cistern in C45, all the cisterns are classified within the "very small" to "small" size category.
- All three cisterns in C45 unit are hung indicating that these cisterns are exposed to secondary usage and might all have the same base levels. The hanging position of the cistern in D50 unit (no:136), on the other hand, suggests that the base of this cistern is now at a higher level than the bases of the other two.
- The distances between the centers range between 1.60 to 6.50 m with an average of 4.05 m which is closer to the average value of twin cisterns.

Table 3.3 Major characteristics of triple cisterns

No	House unit	Shape of cisterns	Size of cisterns	Hung	Distance between centers (m)
7	A20	Conical	small		7 to 8: 3.0 7 to 9: 6.5 8 to 9: 3.5
8		Conical	small		
9		Conical	small		
55	C45	Pear	large	Yes	55 to 56: 2.8 55 to 57: 3.7 56 to 57: 3.9
56		Conical	small	Yes	
57		Conical	small	Yes	
73	East of C23-C24	Undefined	very small		73 to 74: 3.10 73 to 75: 5.19 74 to 75: 2.83
74		Undefined	very small		
75		Undefined	very small		
135	D50	Conical	small		135 to 136: 1.60 135 to 137: 2.48 136 to 137: 2.00
136		Conical	very small	Yes	
137		Conical	small		

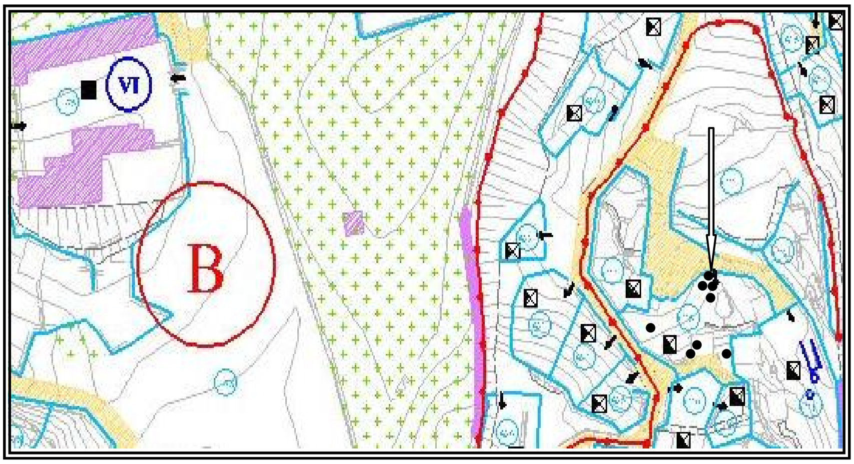


Figure 3.15 Location of a sample for triple-hung cisterns in C45

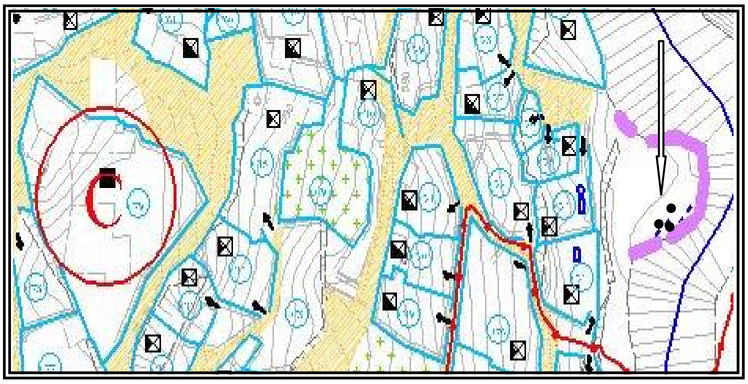


Figure 3.16 Location of a sample for triple cisterns in east of C23 and C24

Figure 3.17 Samples of triple cisterns. A partial view of cisterns in C45 and external view of cisterns located in the east of C23-24 units.

One distinguishing pattern as observed in two cisterns (no:19 in B36 unit and no:22 in B74 unit) is that the cistern is accessed by two openings from the top. The photograph of the cistern in B36 is shown in Figure 3.18. Both cisterns are classified as conical although the true shape is a modification of the conical shape. As far as the size is concerned, the one in B36 unit is classified as extremely large and the other as small. For both cisterns, there is no field evidence suggesting that these cisterns were initially twin and later modified. Considering the location of the chimneys in relation to the structure of the cisterns, it is believed that the designs of two-chimneys are original.

Figure 3.18 Sample for two-chimney cistern. External view (top) shows the location of the chimneys (black arrows). The lower view shows the interior part of the cistern.

3.1.3 Secondary use of cisterns

Secondary use is very much associated with the current condition of the cisterns. It is observed that some cisterns are located in the courtyards of the housing areas while some rest inside the houses as private platforms. The ones found inside the rock-cut houses are called as “in-house” cisterns while the ones within the courtyard are called as “external” cisterns. However, such expressions are not used for describing them in the database (Appendix B), not to cause any overloading throughout the text. An important exception is observed. A remarkable percentage of external and in-house cisterns belong to the neighboring houses due to secondary use purposes. To make it more clear; a cistern whether constructed in the courtyard or inside a housing area (See Figure 3.2) is sometimes discovered to have been used by the adjacent dwelling unit(s), most probably because it was used by that unit as a living platform in a converted condition in late periods.

There are also cisterns which are constructed on the main roads, near a wall or near a scarp. However, as this research disregards the condition of the main roads and the originality of roads and walls as to which period they belong, the associated cisterns are only recorded according to their current positioning. As mentioned in Chapter 2, special locations are assigned to cisterns considering their physical proximity to a scarp, positioning on a road or housing borders.

An undeniable fact is that cisterns are converted to living spaces like kitchens, rooms, stalls, etc. It is another observation that cisterns are very rarely converted to small baths. The rest is either very badly destroyed or kept in their original forms, most probably for water collection purposes, even in later periods. For those which are filled, it is impossible to evaluate their current conditions. Table 3.4 shows the classification and quantification of converted cisterns. 31 cisterns can not be assigned to any of the categories either because they are very badly destroyed, filled, half-filled or their halves are absent or shapes are undefined. Their functions are not clear so they are recorded as “Not applicable” (See Appendix H). Also, the small pool and the special cistern are not included in the classification and quantification of the converted cisterns.

Table 3.4 Classification and quantification of conversion categories

	Quantity	**(%) based on converted and unconverted population**
Conversion category		
Room	31	20.1
Stall	17	11
Kitchen	7	4.6
Bath	1	0.7
Weaving Platform	4	2.6
Other Purpose	40	26
Total # of conversions	100	65
Unconverted cisterns	54	35
Total # of converted and unconverted cisterns	154	100
Not applicable	31	

Cisterns which are converted to living spaces usually have rectangular niches carved on the inner walls. These features are rather large and numerous when compared to evidence for their usage as stalls. C74 (149. cistern) is a distinctive sample which is reached through two rooms from the entrance of the house (Appendix B).

Not all the converted cisterns are necessarily reached through multi-rooms. Plenty of them can be reached soon after the entrance of houses and usually via stairs while numerous cisterns are also reached through the first room of the related housing unit (Figure 3.19). A specific cistern (no:144) found in B3 unit lying at the edge of the scarp now exhibits an inner entrance from the cistern stretching towards the scarp (Figure 3.20). The function of this secondary entrance on the western side of the inner part of the cistern can not be defined (Appendix B). Such a conversion activity can be due to discharging of some wastes but it is still a question of debate.

Figure 3.19 Stairways reaching a cistern

Figure 3.20 A cistern near the edge of a scarp (B3 unit)

Living spaces with late walls which are entered via cisterns are another category for conversion work. For instance the cistern (no:71) standing at the entrance of C34 unit and the cistern (no:13) in the courtyard of B52 unit (Figure 3.21) prove two fine examples of splitting the plan by constructing a small wall in the middle of the base platform (Appendix B).

Figure 3.21 Late concrete wall built in a cistern (B52 unit)

There are nice examples for secondary usage as far as hung cisterns are concerned, too. Some cisterns are seen to have been cut from the base probably when two houses were adjoined, most likely for enlargement. Moreover, late interior walls are observed to have been added to segment the space, thus produce new housing forms (Figure 3.22) as in the case of C45. Another example is observed for column construction as part of the conversion activity. Two columns on which twin-hung cisterns (no:115. and no:116, Appendix B) are standing, are observed in C55 unit (Figure 3.23). However, it is sometimes doubtful whether a cistern subject to conversion with its hung position, kept its original type. Because bases do not always clearly reveal whether they were cut or they became hung when an adjacent room of a house was enlarged from a lower elevation.

Some cistern bases, on the contrary leave no doubt that they are clear. For example, looking at the virtual extension of the remainder inner surface of the cistern (no:146 in C67 unit) which fit the late base, the initial estimated value is recorded depending on such observation at the field work. Then it is discovered that the initial value recorded as ~300 cm more or less matches the original height and base measurements of other samples which are not hung (Appendix A).

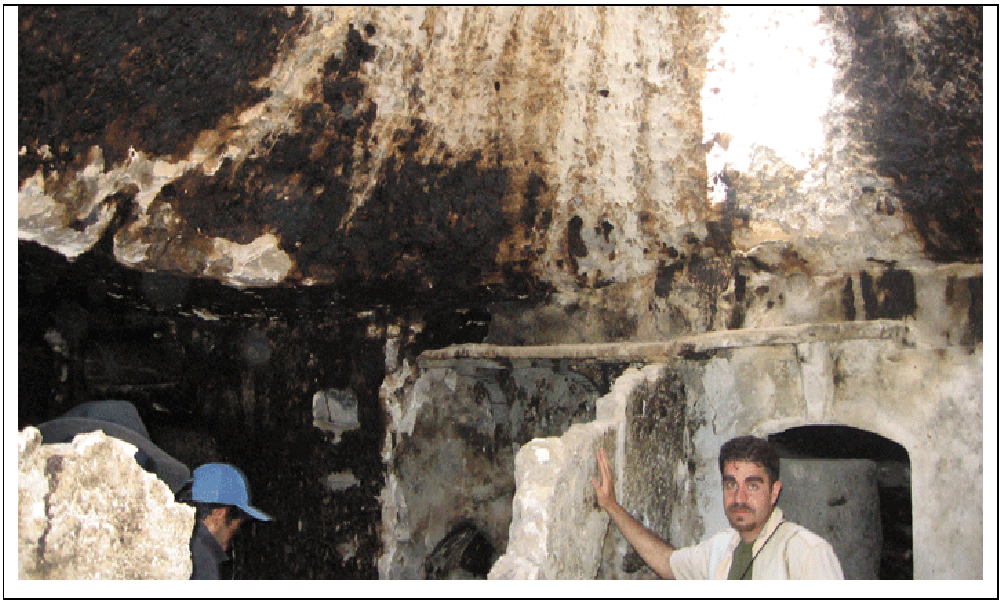


Figure 3.22 Late walls segregating living spaces (C45 unit)

Figure 3.23 Column usages as part of conversion activity (left: C55, right: east of D11)

Although B16 is an exception for such analogy, it proves to be a good visual sample as given in Figure 3.24. Therefore, it is inferred that relatively late bases are sometimes perfect circles that they seem to be original.

Figure 3.24 An observed clear base (B16 unit)

The best evidence to understand that a cistern was converted to a kitchen is the burn signs. Many cisterns which are now strongly believed to have been used as kitchens retain furnaces and chimneys that are usually seen in the middle of an inner surface and at the top as openings. Deep burn signs in Figure 3.25 confirm this identity. The ones which are badly destroyed were probably used for the same intention. On the other hand, cisterns that they were most probably used as stalls are clearly identifiable. Niches which seem very suitable for animal feeding platforms must have been created later (See Figure 3.26). They also have signs for tethering purposes, on the inner walls of the cisterns (Figure 3.27).

A cistern observed in B18 unit and a part of which must have been used for bathing purposes has basin-like platforms that are located right near a cooking platform with a chimney. A cistern in C51 unit was converted to a room whose opening seems to have been used like an air-venter (See Figure 3.11).

Figure 3.25 Conversion of a cistern to a kitchen (B36 unit)

Figure 3.26 Conversion of a cistern to a stall (B39 unit)

Figure 3.27 Niche (left, B74 unit) and animal tethering places (right, B39 unit) in converted cisterns

Meanwhile, some cisterns were converted to weaving platforms while some retain multi-weaving features. These usually take the form of rectangular spaces in which traces on the inner surfaces enable loom weight conjunctions (Figure 3.28).

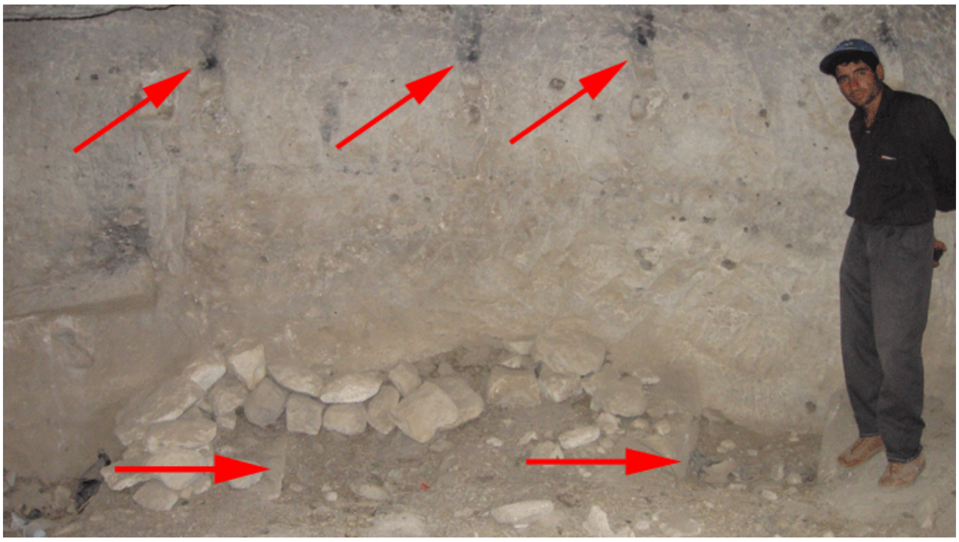


Figure 3.28 Conversion of a cistern to a weaving platform (C45 unit)

Some cisterns were plastered but it is not certain at which period(s) such processes were applied. Examples for cisterns whose openings are plastered and examples for complete plastering signs exist in different parts of the city. Some cisterns have openings on and along which bond techniques are applied. Such a technique could have been applied in late periods to strengthen the original construction of the opening as a restoration method. Apart from restorations, other indications for secondary usage are the late decorations and inscriptions. The cistern (no:130) in D76 unit is one of the samples whose ceiling is made of ceramic dating back to late periods, probably a work in the Roman style. The cistern (no:31) in B62 is also a fine sample for this category (Appendix B). Other indication for secondary usage is the cistern (no:92) in D65 unit which was used as an entrance to a house in most probably later periods (Appendix B).

Some cisterns are now located on the main road. Examples of these cisterns are illustrated in Figure 3.29. The cistern which is reached from the courtyard of B74 unit is now on the main road. Two samples belong to cisterns (no:104, no:105) found in the east of D37 and D38 units. One was detected near B18 unit near the scarp.

Figure 3.29 Samples of cisterns on a main road (from top to bottom: west of Ulu Mosque, near B18, east of D38, east of D37)

Although cisterns are the main focus, any other water features that might exist in the Upper city directly receive the attention of this research. One of these features is the water well mentioned in TAÇDAM (1998-2003) studies and assessed to a certain extent. In the light of data produced by TAÇDAM at the Upper city, it is understood that wells were part of the houses. Some units were recorded to retain wells and well-like structures including well-rings at their openings. These were encountered outside the well locations. So, the field work carried out for this thesis also questioned the existence of wells. Mainly two housing units were checked in detail in which well-like structures were observed. The first one is in A2 unit where such a structure (named as a cistern; no:5) was recorded. A well-ring and a small hole nearby were recorded as "associated objects" with the cistern (Figure 3.30). The structure was recorded as a well simply because tracks for rope usage are very visible in the courtyard of the said unit.

Figure 3.30 Well-rings observed over the cisterns (top A2, bottom A6)

Although most of the cisterns lack lids or special covers today, it is supposed that some cisterns could have had lids for hygienic purposes or for any other. Regarding lid usage and irrespective of the scope of well discussion, good evidence was observed in the converted cistern recorded in D8 unit (found at the base of the cistern due to late destruction) and the well-preserved cistern in unit D65 (Figure 3.31).

Figure 3.31 Lids observed inside a cistern or in a courtyard (top D8, bottom D65).

3.2 Canal Data

The canal system of the Upper city is one of the components of the water distribution network. Indeed, it is the main extension system starting from the Pool in the south and reaching the cisterns in certain parts of the Upper city.

This section concentrates on canal tracks which are recorded during the field study, regardless of their relative importance to each other within and/or around housing locations. Detailed information about the visible canal residues in association with the cisterns are given in Appendix B. Apart from relatively small scale but clear examples, it should be underlined that five remarkable canal extensions are recorded which are deemed as the backbones of the canal system. Therefore, they are tracked (Figure 3.32);

1. in the very south of D60, outside the borders of housing units.
2. in the southwestern corner of the Pool
3. at the opposite side of D2 and D3 units near the southwestern scarp;
4. in B22 unit near the western scarp;
5. between A18 and A36, A37 units on the main road towards the northwestern side of the Upper city.

Canal-1: Canal extensions observed in the southern part of the area, outside the housing unit borders in sector D, are very visible today. This is the area where such extensions are most extensively tracked (Figure 3.33). The visible length of the canal is approximately 60 m. Entirely carved into the rock, it forms a tunnel in some steep sections of the scarp. It is continuously traced from the Pool to the south of D60 unit.

This canal starts over the southern wall of the Pool (Figure 3.33-A) and turns sharply to the northeast direction, stretching about 15 m from the east of the Pool (Figure 3.33-B). It then runs for about 40 m parallel to the scarp where the tunnels are observed (Figure 3.33-C). In this section the canal is located almost at the middle of the scarp. Soon after the tunneled section towards the northeast, it reaches the top of the scarp and continues further for about 10 m where it disappears beneath the archeological deposits.

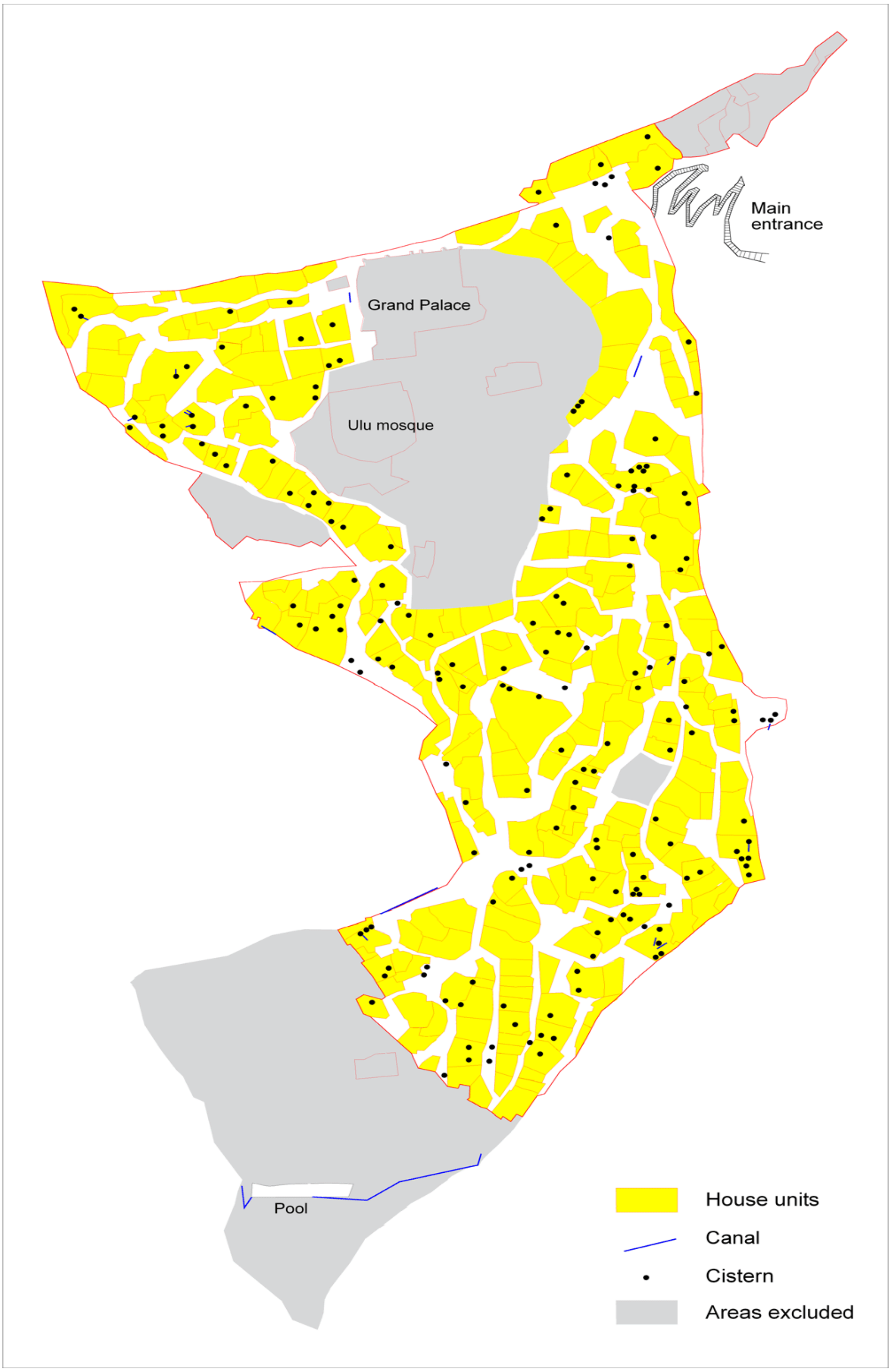


Figure 3.32 Distribution of canals at the Upper city of Hasankeyf

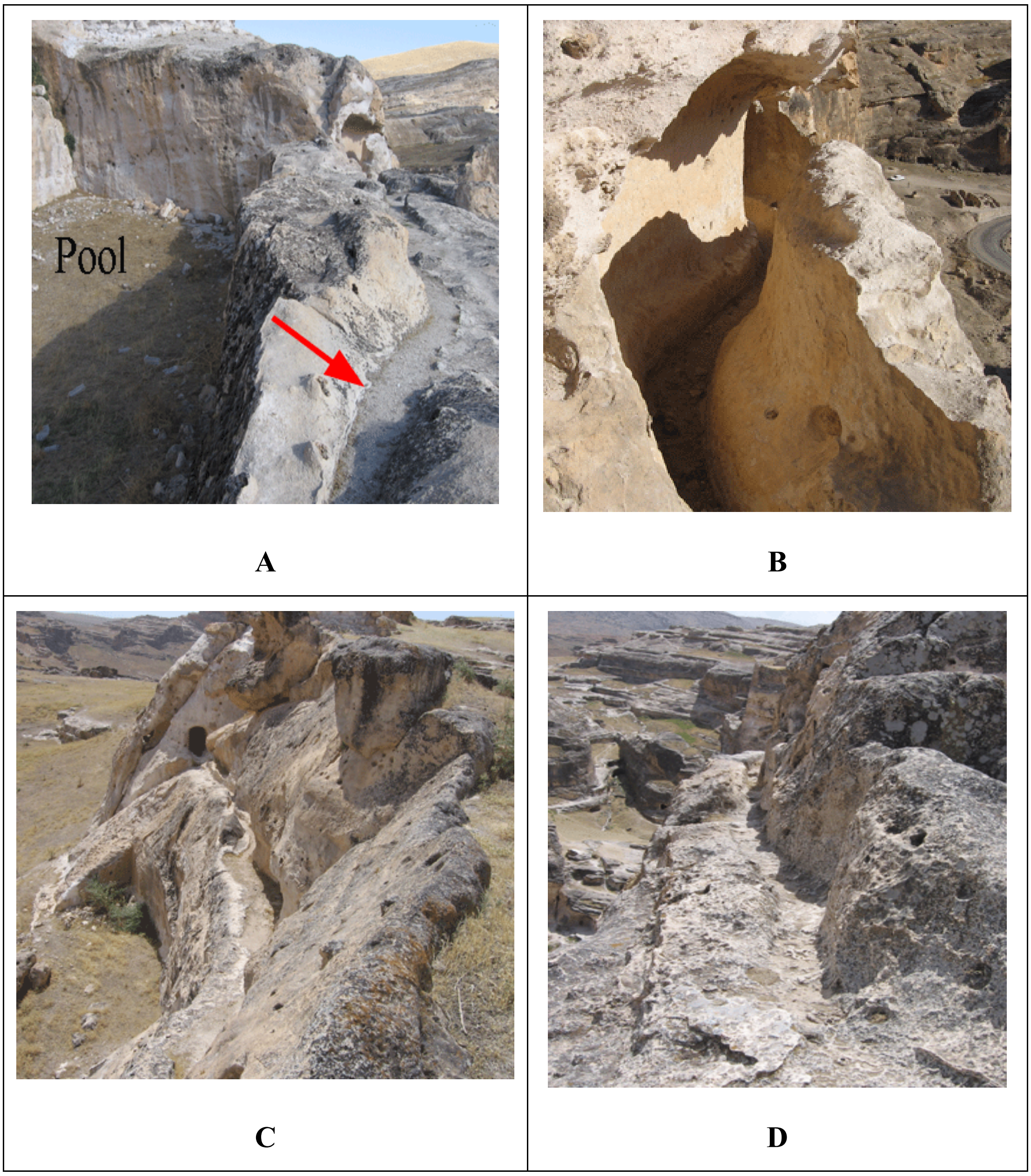


Figure 3.33 Canal extensions coming from the east of the Pool (Canal-1)

Canal-2: The second canal observed only for a few meters is located in the western margin of the Pool (Figure 3.34). It is believed, however, to be a remnant of the main canal (similar to Canal-1) which transports the water from the Pool to the Upper city along the western scarp. The bulk of the canal is destroyed today or not visible maybe because it forms a tunnel. A small opening shown by the black arrow from further distance might be an indication for a tunnel which is located along the course of the canal.

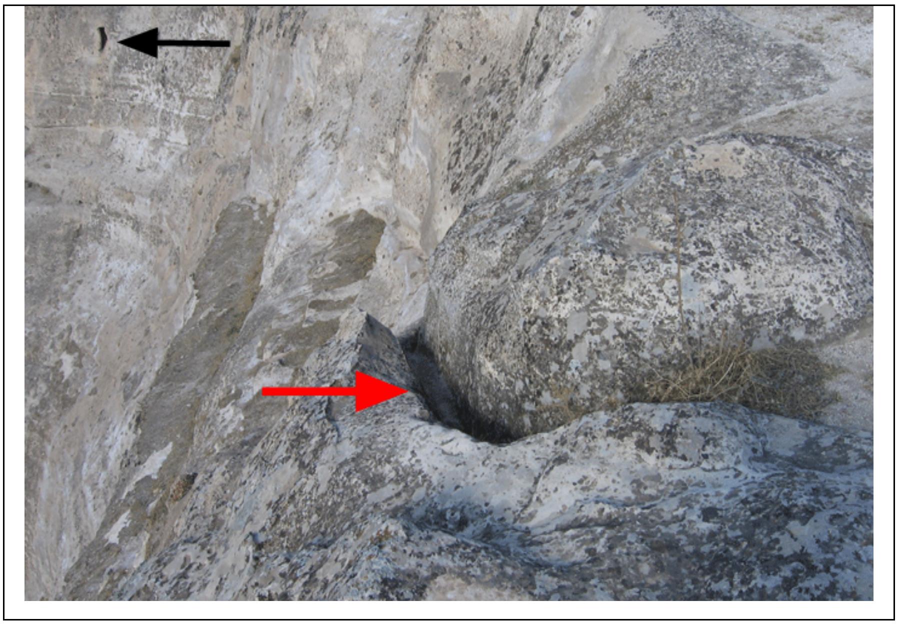


Figure 3.34 Canal extension coming from the west of the Pool (Canal-2)

Canal-3: This canal is the longest segment observed at the Upper city. It is located in the southwestern part of the city at the opposite side of D2 and D3 units. It is closer to the western scarp and runs parallel to it. It can be traced continuously for about 40 m in NEE-SWW direction. The western extension of the canal is carved into a natural rock-wall elevated from the ground (Figure 3.35-A). This segment is connected to a man-made wall which runs in the same direction (3.35-B).

There are several other minor canals in the vicinity of cisterns, particularly in D6 unit (Figure 3.36), which are most probably connected to Canal-3. This part of the city is relatively poor in quantity of cisterns when compared to the southern and southeastern parts. However, canal remains seen in D6 and the extension observed in its northern side are at relatively higher elevations than other canal locations in certain parts of the city. Details of these minor canals are explained in Appendix B.

Canal-4: This canal remain is observed in the southern margin of B22 unit (Figure 3.37). It is oriented in NW-SE direction and is parallel to the scarp. The width is 20 cm and visible length is about 3 m. The northwestern extension is destroyed and can not be traced further. The southeastern extension is now buried under a late building (rectangular structure in the lower-left corner of Figure 3.37).

Figure 3.35 Canal and wall extension at the opposite of D2 and D3 units (Canal-3)

Figure 3.36 Minor canal remains within D6 unit associated with Canal-3

Figure 3.37 Canal remain (red arrow) observed in B22 unit (Canal-4)

Canal-5: This canal extension is tracked between A18 and A36-37 units in the eastern part of the city. Canal-5 is the only example among other segments which does not run parallel to the scarp that surrounds the city. This canal is located next to the main road (Figure 3.38) leading to the main entrance of the Upper city. Similar to previous two canals, it is carved into a natural rock-wall and elevated from the ground.

Other than these major canal segments, there are several other small scale canal remains mostly making their way towards the cisterns in the associated housing units. Such remains are mentioned in the following paragraphs.

The sub-unit recorded as B49-1 near the rock stairs reaching down the Tigris River in the very northwest is a possible location for canal construction as given in Figure 3.39. Following only five settlement units, B41 which falls just the south of B49-1 but is still in the northwestern part of the Upper city, is another canal location (Figure 3.40). Tracks are detected in the eastern side of a main road running towards the

Figure 3.38 A view from Canal-5 (Main entrance to the city is seen at the background)

Figure 3.39 Canal tracks in B49-1 unit near the northern scarp

opening of this small size cistern. Unit B39, located in the east of B41 nearby welcomes two cisterns one of whose size is very large. A canal reaching this converted cistern has a width of 10 cm. Two possible canal tracks (Figure 3.41) inside the other cistern which is a small one leave no doubt to the existence of a relationship with the former one. Tracks are very clear since the cistern is closed from the opening, probably by reason of conversion. It is somehow well-preserved.

Figure 3.40 Canal track reaching B41 unit

Figure 3.41 Canal extensions observed from the interior facade of B39 unit

Two cisterns are recorded within the borders of B67 unit. B67 where one entrance to a large cistern (no:30 in Appendix A) is achieved from the scarp may also provide a specific location for a possible canal hole although no visual evidence is given below. The cistern is three units away from B39 which reveals canal evidence as stated above. The canal hole in B67 makes its way to the northern direction where the distance to the scarp is 10 m.

An interesting finding is in the interior eastern part of the city which is a stone cut gutter-like remain. It makes its course along the border of a housing unit, near the wall of its courtyard which is next to a location with stairs (Figure 3.42). The section of the gutter-like remain is given in Figure 3.43.

Figure: 3.42 Gutter-like remain in line with a road

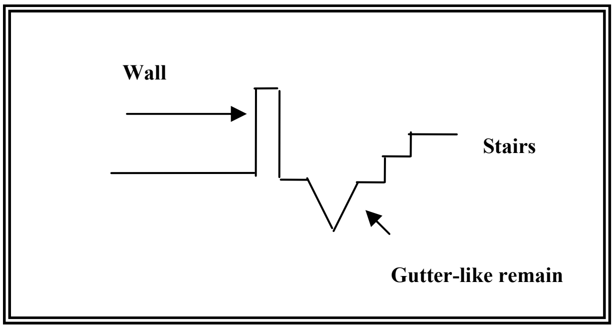


Figure 3.43 Section of the gutter-like remain shown in Figure 3.42

The other sample for a gutter-like remain is observed in the southwestern part, at the opposite of C1 unit on the main road. This stone-cut trace passes by the cistern (no:112, Appendix B) on the surface (Figures 3.44 and 3.45).

Figure 3.44 Gutter-like remain on a main road

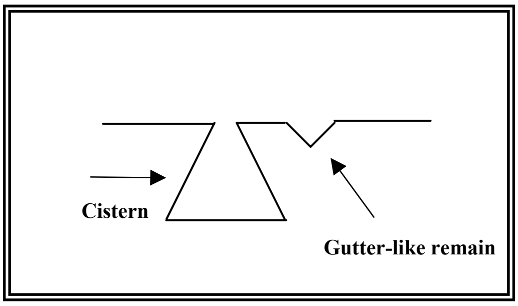


Figure 3.45 Section of the gutter-like remain shown in Figure 3.44

Triple cisterns detected in the eastern part of C24 unit right at the edge of the scarp welcome a canal trace directly arriving at the cistern in the middle (Figure 3.46). The middle cistern is recorded as no:74 (Appendix A). It is very clear that there is a connection between three cisterns from the surface. Likewise, Figure 3.47 shows that a canal arrives at D78 unit directly making its way to the courtyard where the cistern is placed, in the southeastern part of the Upper city. Figure 3.48 shows the location of small canals and cisterns found in D78 unit. For further information, a small canal remain is found in C29 unit which is near the main road but no visual evidence is available (no:122, Appendix B).

Figure 3.46 Canal signs traced from the surface in east of C23-C24 unit

Figure 3.47 A canal remain directly arriving at D78 unit

Two other tracks are also visible in D65 which fall in the southeastern part of the Upper city (Figure 3.49). It may be that these canal ways which first reach a cistern (besides other four cisterns) in the very middle of a courtyard, could have served the public. This is perhaps why other cisterns that are observed within the same unit are in a position to be directly linked with the canal ways.

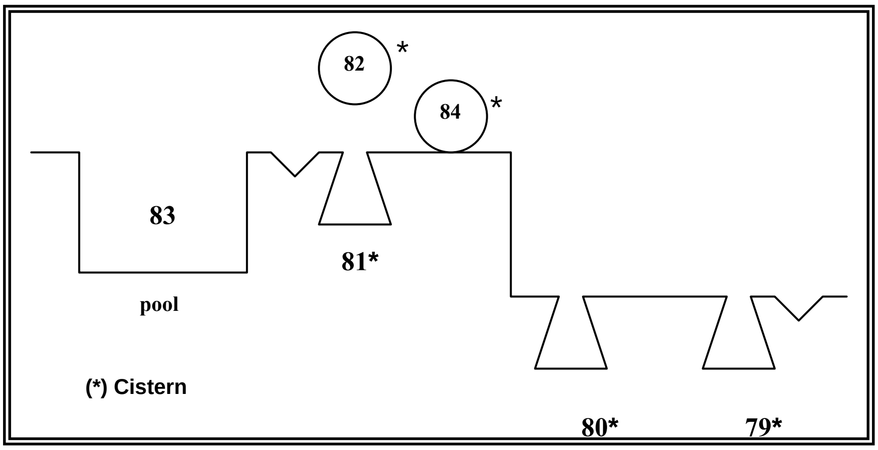


Figure 3.48 Section of cisterns and canal remains in D78 Unit

Figure 3.49 Two canal ways reaching D65 unit from both sides

Lastly, an interesting but not less important evidence comes from terra-cotta remains which are observed in the west of the Grand Palace, between B60 and B66 units (Figure 3.50). These are clay pipes which were brought to light during the archaeological excavations carried out at the site.

Figure 3.50 Terra-cotta remains in the west of Grand Palace (between B60 and B66 units)

CHAPTER 4

ANALYSIS

4.1 Distance Analysis of Cisterns

A distance analysis is realized to gain some insight about the optimum proximity between cisterns. A computer program is written in BASIC language to find the distances between cisterns. It is discovered that the shortest distance is 1.5 m (no:134 and 135, Appendix G), and the longest distance is 27.6 m between the cisterns (no:53 and 6, Appendix G). A histogram of the distances at 1 m interval is shown in Figure 4.1. The distance is 1-2 m at most for those which fall into 11.5% group. The highest percentages are seen in an area where the distance between two cisterns is 2 to 7 m maximum. The first sharp increase for distance measurements after this interval is observed for 2.5% of all cisterns as 8 m which is followed by a 1.5% of the sum where the distance increases to 12 m. On the other hand, the distance between the location where the first sharp increase occurs and the cistern at the maximum distance to the said location is 20 m which is still a remarkably large value. It is understood that the place of cisterns which are designed to keep their proximity at the minimum extent is set up by the majority of the cistern population.

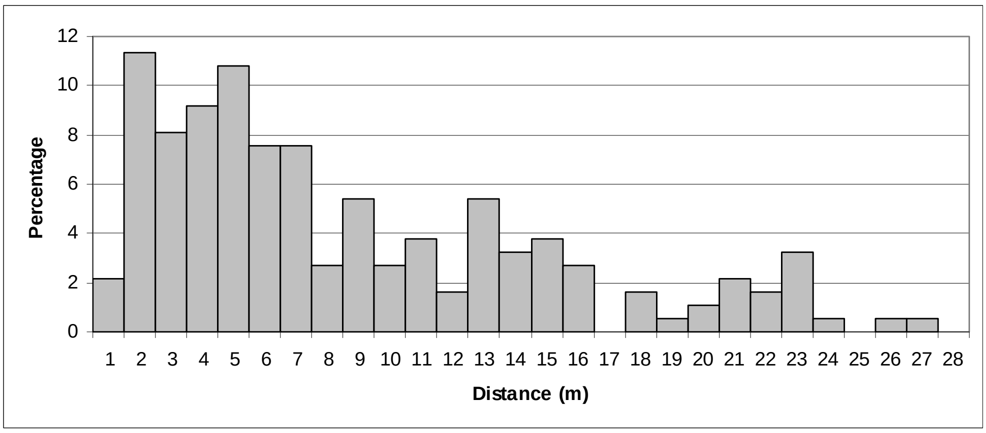


Figure 4.1 Distance distribution analysis of cisterns at the Upper city

4.2 Density Analysis of Cisterns

The purpose of the density analysis is to inquire about the concentration of cisterns over the settlement area. The procedure of the analysis is illustrated in Figure 4.2. Computations are made for a circle that moves both column-wise and row-wise over a regular grid system. The grid spacing is selected as 10 m. Accordingly there are 2016 grid points for 36 columns and 56 rows for the Upper city. The search radius which is usually two fold of the grid spacing is therefore appointed as 20 m in this study. Consequently, the area covered for each grid cell is 1256 m2.

A BASIC program is written to move the circle from left to right for all columns and top to bottom for all rows and to count the values for each grid. The program is executed twice; once for the frequency of the cisterns and once for the volume of water held by the cisterns. Results of each process are given below under two headings.

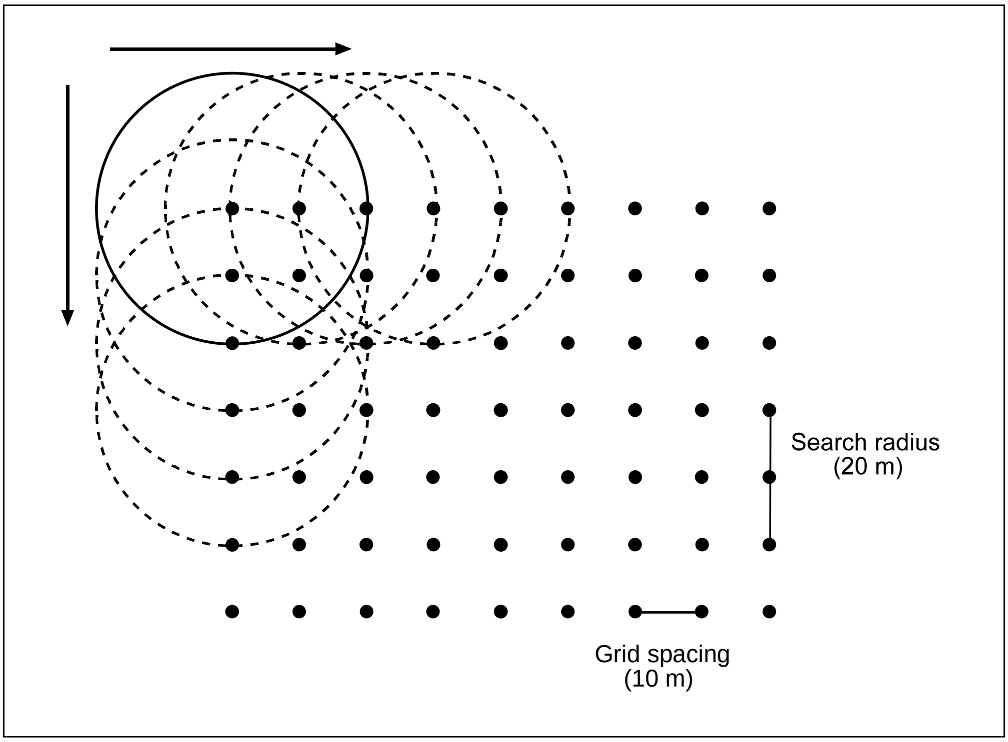


Figure 4.2 The procedure of the density analysis made for cisterns

4.2.1 Density distribution of cisterns in relation to frequency

Figure 4.3 shows the density of cisterns at the Upper city, based on their frequency. Gray areas are those masked regions (public areas, etc.) where cisterns were not measured. Density is illustrated by colors ranging from lowest (blue) to highest (red) concentrations. The areas that have no cisterns in each grid cell are highlighted with white color.

The following observations can be made in light of Figure 4.3:

- Density of the cisterns gradually decreases from south to north.
- Six areas are characterized by the lack of cisterns. These areas are circled with numbers in the Figure. The housing units where no cistern was identified during the field work are:

1) A1, A12, A14, A15, A16, A17, A18, A19, A29, A30, A35, A36, A37, A38
2) B43, B44, B45, B46, B47, B50, B51, B52, B55, B56
3) C46, C47, C48, C49, C52, C53, C54, C56, C57
4) B1, B2, C68, C69, C70, C71, C77, C78
5) D74, D75, D77, D80 and; C18 (as masked unit)
6) D1, D2, D3, D4, D19, D20, D29, D30, D31, D32, D33

- Relatively higher concentrations are observed at several areas. Such areas are pointed out by circular to elliptical shapes in red color. The highest three areas of concentration are indicated by arrows on the map.
    - The highest density is determined as 12 % which is observed in the southeastern part of the city. D50, D51, D52, D53 and D65 are examples of houses in this part.
    - The second highest density is observed in the east of the city. Most of the cisterns here belong to C45 unit.
    - The third area with a density of 9 % falls the south of the city. This concentration is due to the cisterns in D23, D34, D35, D55, D56, D57 and some others on the main road.
- The concentration is usually less than 6 in the close vicinity of the scarp all around the city. Most of the lowest concentrations (less than 1) are very close to the scarp. Higher concentrations, on the other hand, are confined to the interior parts of the city.

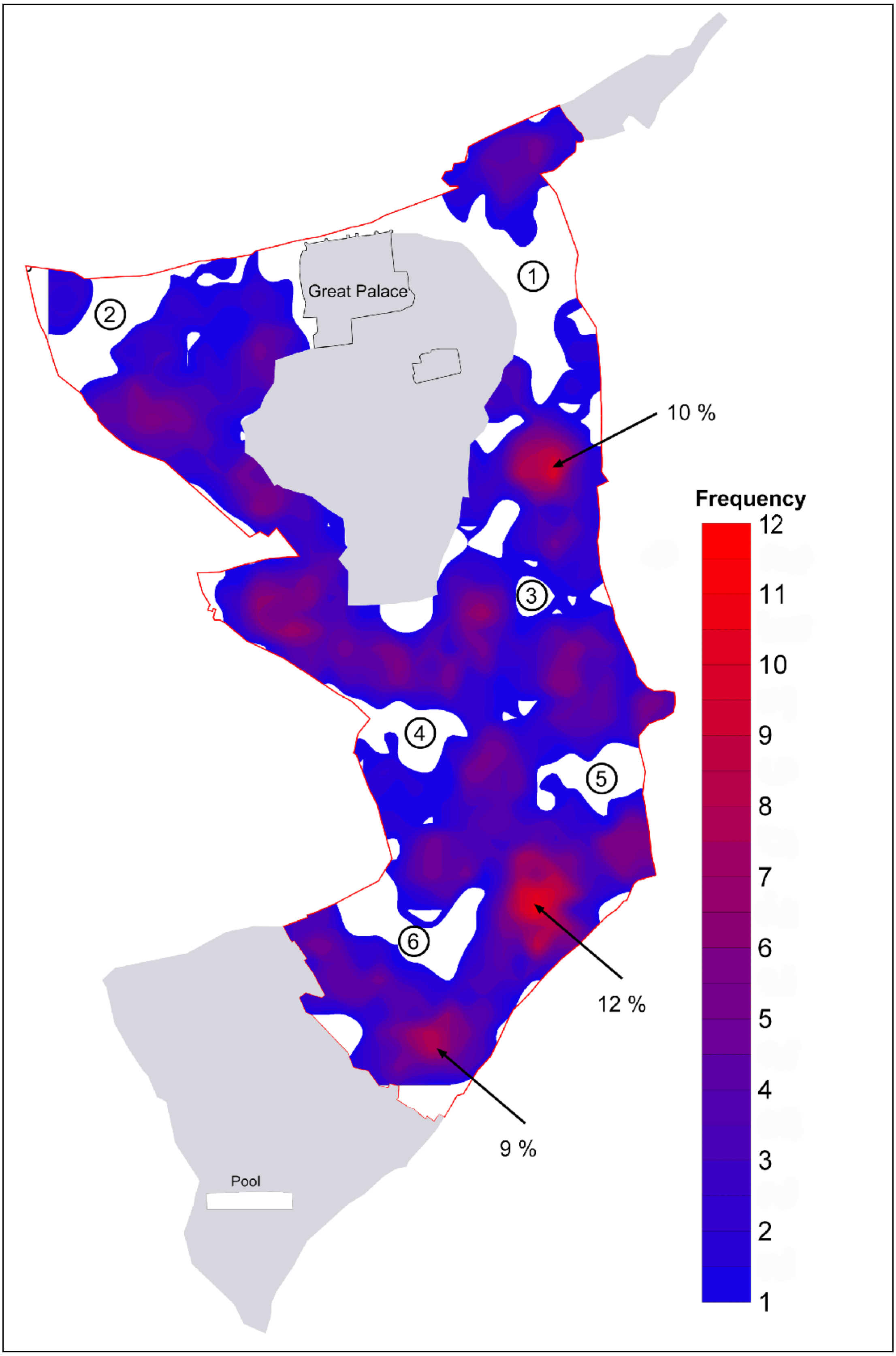


Figure 4.3 Distribution analysis of cisterns based on frequency at the Upper city

4.2.2 Density distribution of cisterns in relation to volume

Density analysis of cistern volume is performed in the same way as the frequency analysis. In this analysis, however, cistern volumes are taken into account instead of the number of the cisterns. Therefore it is intended to find out the distribution of the available amount of water at the city.

A density map is produced and given in Figure 4.4. The color scheme is the same as the previous analysis (blue for the lowest, red for the highest). The areas that have less than 10 m^3 of water per unit area are left blank (white). The following observations are made according to this map:

- Six areas determined in the frequency analysis are also identified for the volume analysis. Additionally, one more region in the western part of the city (no:4 in the Figure) is detected to hold less amount of water.
- There is almost a uniform distribution of the water volume throughout the city as indicated by the dominant blue color that corresponds to an average of 30 m^3. Compared with the frequency map (Figure 4.3), the smoothness of volume in Figure 4.4 suggests that cisterns have smaller volumes in high frequency areas whereas they have larger volumes in low frequency areas.
- Two areas with maximum concentrations are observed in the western part of the city (Figure 4.4). These areas are ranked as medium in frequency analysis (Figure 4.3). Such high concentrations are due to the existence of larger cisterns in those areas.
    - Examples of large cisterns for the highest concentration area are no:45 in B18 (very large), no:140 next to B12 on the main road (extremely large) and no:141 in B15 (very large).
    - Examples of the large cisterns in the second highest concentration are no:19 in B36 (extremely large), no:27 in B39 (very large) and no:41 in B35 (very large).
- The main roads can not be traced in both maps (Figures 4.3 and 4.4) where some of the cisterns are positioned on the said locations.

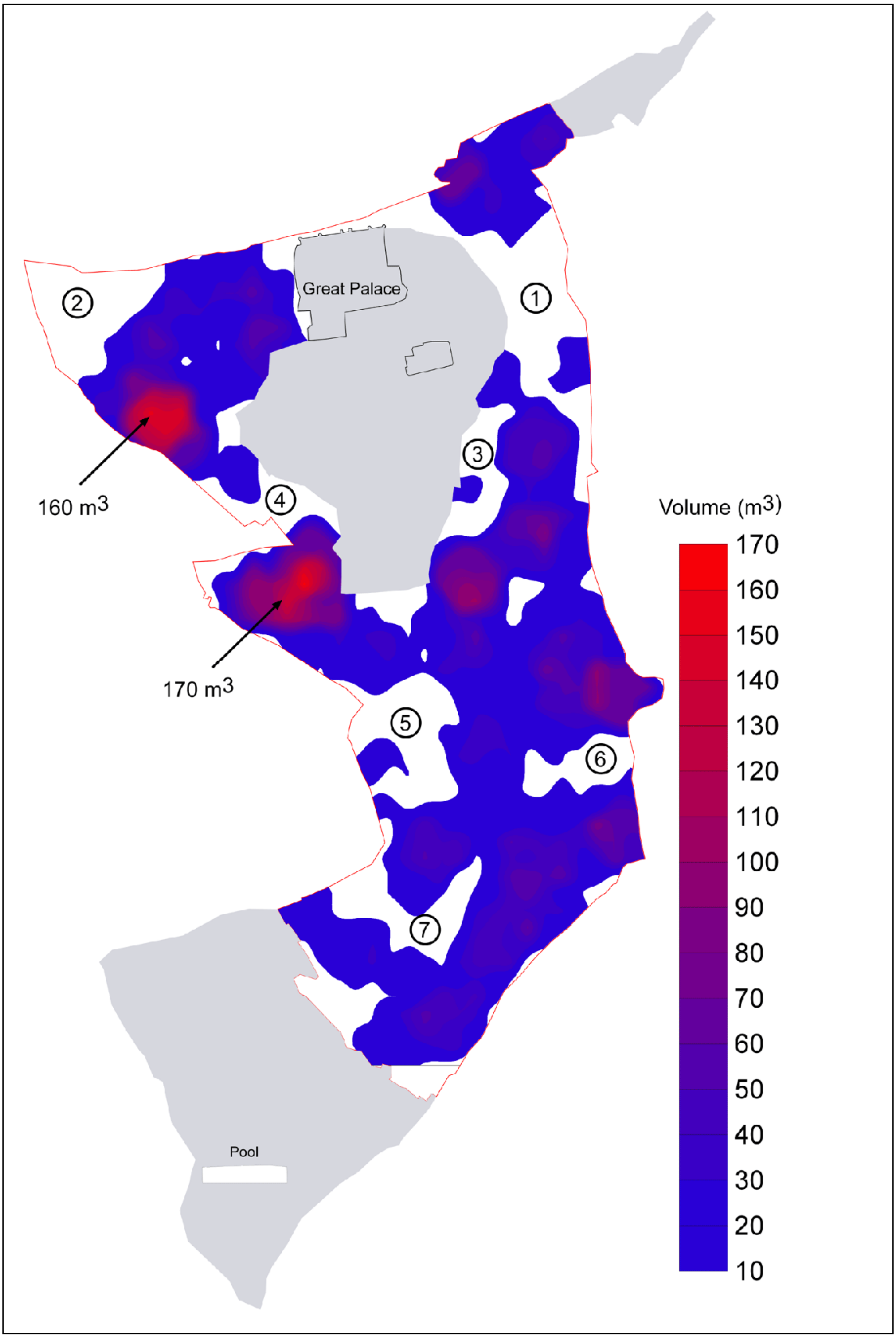


Figure 4.4 Distribution analysis of cisterns according to size at the Upper City

4.3. Distribution of Cisterns in Relation to Housing Units

It is pointed out in Chapter 3 and provided in Appendix A that cisterns do differ greatly in size. Neighboring cisterns, cisterns which have proximity to a canal extension or a canal remain, or those carved based on certain locations (seen together in Figure 3.32) do not always indicate a systematic range. This means that most of the values are likely to be random for almost each case.

The numbers of cisterns according to size categories attributable to each location are shown in Appendix D. Size categories calculated for each group do not have to give the total number of cisterns which is 185, since a cistern may satisfy more than one location category. Also, numbers of cisterns in a size group are implicitly reflected, when necessary, as the total sum of more than one location. Size groups based on such cases are shown with different patterns. D65 unit is one case where "1" cistern out of "5" cisterns which is on the main road is small and "2" of the remaining "4" cisterns are small. The other case goes to C29 location where "2" cisterns one of which is within the housing unit and the other below the main road are two very small cisterns, falling under the same category. Total number of cisterns above 591 m (the elevation of the canal extension in the southeastern part of the Upper city where water has to be distributed by natural gravity flow) which are attributable to each size category are not given, so as not to cause any mismatching among all values and patterns therein. They are shown in Table 4.1, instead. Categories are created from the standpoint of some specific areas which are resumed as critical determinants on cistern construction both from city planning and practicality of water transportation perspective, if any. Thus, it is determined that there are;

- 163 cisterns within the borders of a housing unit;
- 23 cisterns on a main road;
- 17 cisterns near a scarp area;
- 2 cisterns on a main road and a scarp area at the same time;
- 29 cisterns above the elevation of the main Pool.

As a result, the number of cisterns satisfying six different sizes for each location category is summarized below:

Table 4.1 Total number of cisterns satisfying size categories according to locations

		SIZE CATEGORIES Total # of cisterns					
Total # of cisterns	**LOCATION CATEGORIES**	very small	small	medium	large	very large	extremely large
163	Housing units	**20**	**93**	**16**	**12**	**8**	**1**
23	On road	**4**	**13**	**-**	**1**	**-**	**1**
17	Near scarp	**7**	**9**	**1**	**1**	**-**	**-**
2	Near road and scarp	**1**	**1**	**-**	**-**	**-**	**-**
29	Above 591 m	**6**	**20**	**2**	**1**	**-**	**-**

Meanwhile, to prevent further mismatching, it should be noted that predetermined locations (housing units such as “A4”, “B28”, “D6”, etc.; or expressions such as “On the main road”, Junction of A33-A34-A35”, “East of D11”, etc.) at the field study are given as single references of location, different than the procedure applied throughout Appendices A, B, C and E. The focus is on the satisfaction of a set of numbers pertaining to all the relevant locations. To prevent misleading, it should be noted that the number of cisterns determined within a housing unit can be the same with the numbers marked for a main road which is also assigned to the related unit (of course, the case is not the same for all since independent main road locations exist) as in the case of B71 (See Appendix B). There are only two cisterns assigned to B71 unit whose openings are found on a main road but they are now inside B71 as part of the said unit. On the other hand, for instance, the total number of cisterns assigned to D78 unit is 5, 2 of which are now placed near the scarp. D65 is a location where 4 cisterns are observed within the housing unit and 1 is on the main road which makes 5 totally, but 2 of these 5 cisterns are near the scarp. However, only “4” is put aside to be taken into account for the calculation of number of cisterns within a housing unit category whereas “5” is the exact value for the case of D78 and “2” for B71. Therefore, numbers marked in the aforementioned categories for a specific location do not always necessarily lead to a total sum. They are attained by being filtered through the cistern distribution map with locations (See Figure 3.2), for the purposes of this sub-part.

Figure 4.5, reproduced from the Cistern Distribution Matrix in Appendix D, summarizes the status of cistern size categories from a similar perspective with one exception. The number of each size category is shown side by side with the number of location categories. The chart shows how many all single location categories welcome cisterns that are identified according to their size. It is understood that 88 single locations (out of 129) retain 114 small cisterns. More than half of total locations (68%) recorded at the Upper city are allocated to the widely used cistern size which is "small".

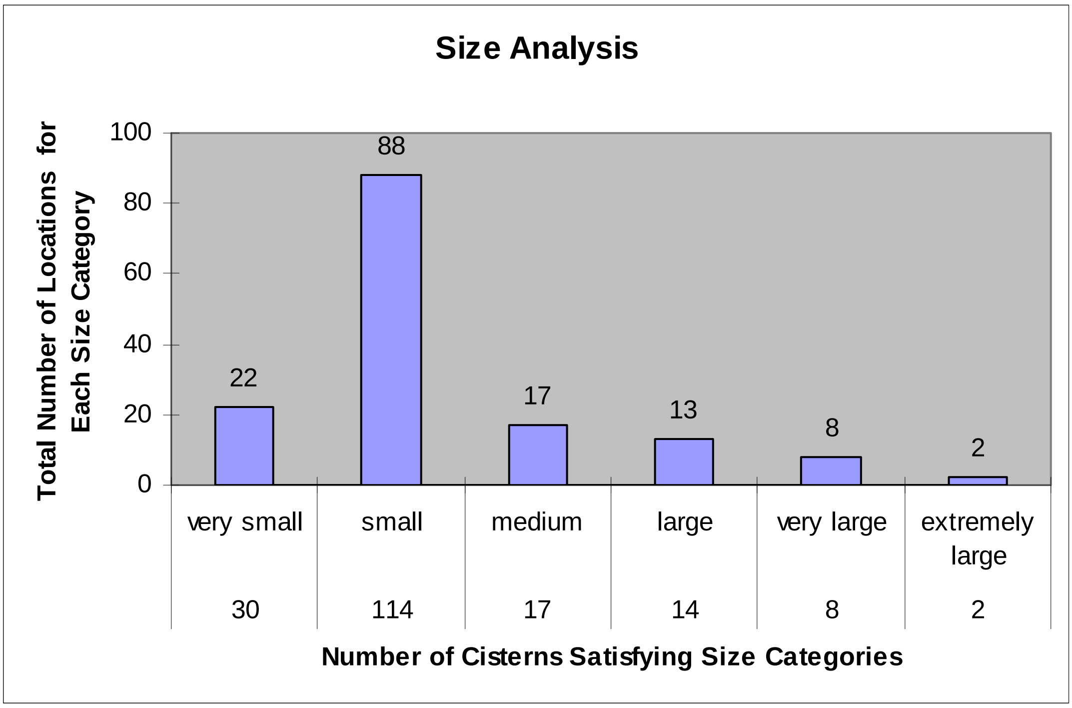


Figure 4.5 Distribution of number of cistern size categories according to the number of locations

Consequently, when the positions of the cisterns all over the city are considered and data pertaining to Table 4.1 and Figure 4.5 are simplified; distribution of cisterns is categorized on "housing unit", "road" and "scarp" basis. Therefore, a histogram for understanding the volume of water for each category throughout the Upper city is provided in Figure 4.6. It is understood that 88,15% of water is determined to have been consumed by housing units, 11,76% by main roads and 0,09% by scarp areas at the city.

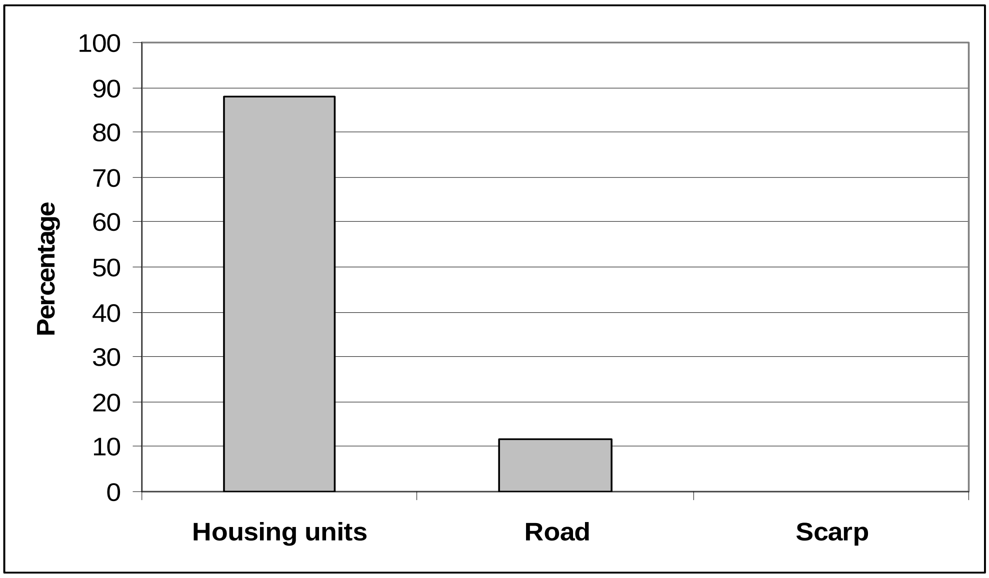


Figure 4.6 Distribution of volume of water according to location categories

As a next step, the scatter plot in Figure 4.7 is prepared to comprehend the relationship between the volume of water within the housing units and the housing areas.

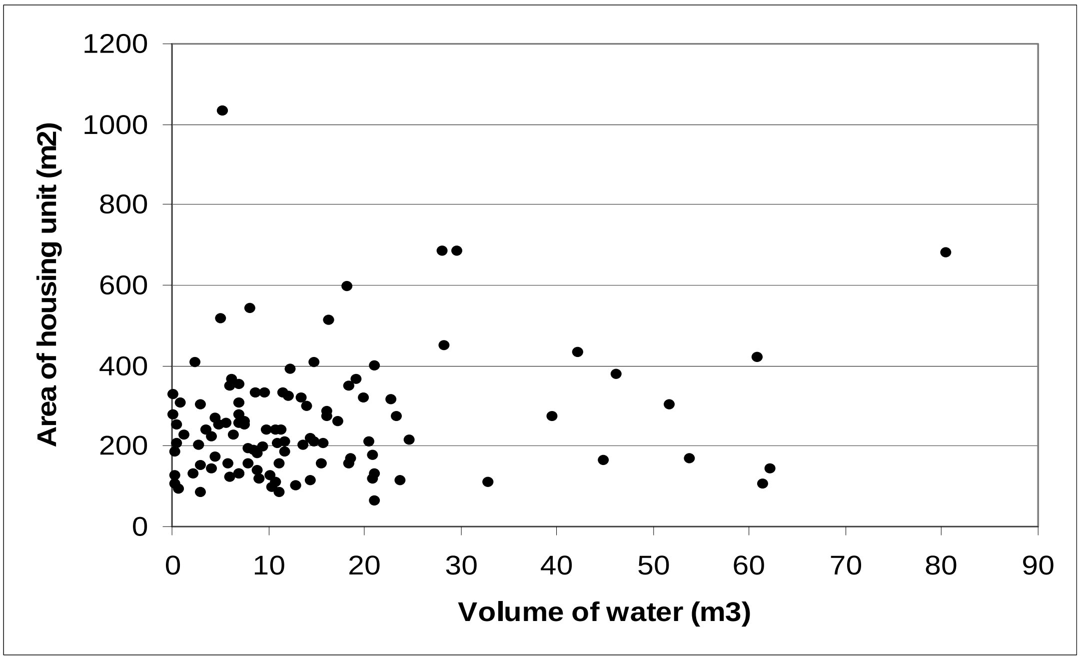


Figure 4.7 Scatter plot showing the relationship between volume of water and area of housing units (R^2=0.0357)

In doing so, the Settlement Pattern Analysis Map of TAÇDAM is used to determine the areas of housing units and; volumes of cisterns in a housing unit within which more than one cistern exist are all added to each other. At the end, it is determined that the correlation co-efficient (R^2) is equal to 0.0357 which means that no linear relationship can be proven. In other words, there is no definite relationship between the area of houses and volume of water. For example, the amount of water for C79 unit having the largest housing area (1032,61 m^2) is determined as 5.42 m^3. On the contrary, C24 (62,18 m3) and B36 (61,47 m3) units which possess water the most, are ranked among those second and third housing units having smaller areas (Appendix F).

4.4 Distribution of Cisterns in Relation to Topography

The distribution of cisterns is not straightforward for all parts of the Upper city. It is understood that certain sections of all four sectors are more suitable for topographical conditions. The relative abundance of cisterns in the B sector and part of the C sector may have reasons behind such positioning. However, one standing point is the topographic condition of relevant cisterns below 591 m. The elevation of the Pool (593m) eases the situation to send water with the help of distribution canals to the housing units. Normally, elevation of all the cisterns to get the maximum equal benefit from a possible canal network should be below 593 m. In consideration of the worst case for which the Pool can serve, the said value is limited to and below 591 m. Fewer cisterns are found in the southern interior parts of the city which are usually located on undulated grounds and designed according to terrace formations. The elevation of most of these cisterns approximate 591 m with some exclusions. On the contrary, cisterns encountered below 591 m are usually constructed in accordance with plain courtyards. The elevation of the cisterns in the vicinity of Ulu Mosque is 575 m while the elevation of the Grand Palace is 560 m. The positioning of cisterns according to topography is discussed in Chapter 5, accordingly.

For this part, the frequency and volume of water are analyzed with the help of Figures 4.8 and 4.9. It is concluded that the percentages for the volume and frequency of cisterns above 591 m are, in each case, less than those observed below

591 m. However, when assessed separately for the category above 591m, the frequency is definitely higher than the volume of cisterns in the said location category. Figure 4.10 shows that the elevations above 591 m make up 13.2% of the Upper city. The zone of the related housing units matching elevations above 591 m are trapped with a topographic contour embraced with black lines.

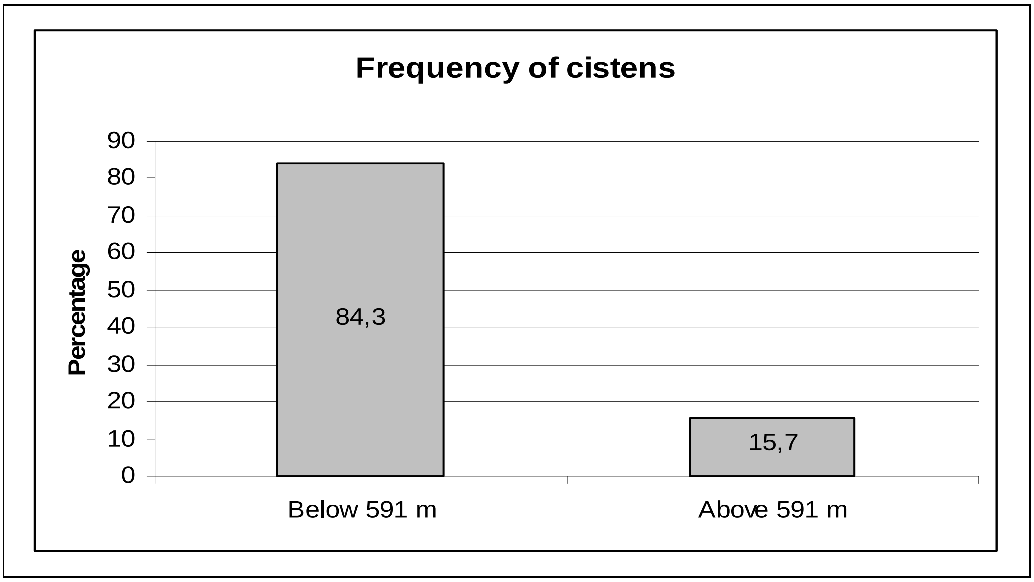


Figure 4.8 Distribution of frequency of cisterns in relation to elevations below and above 591 m

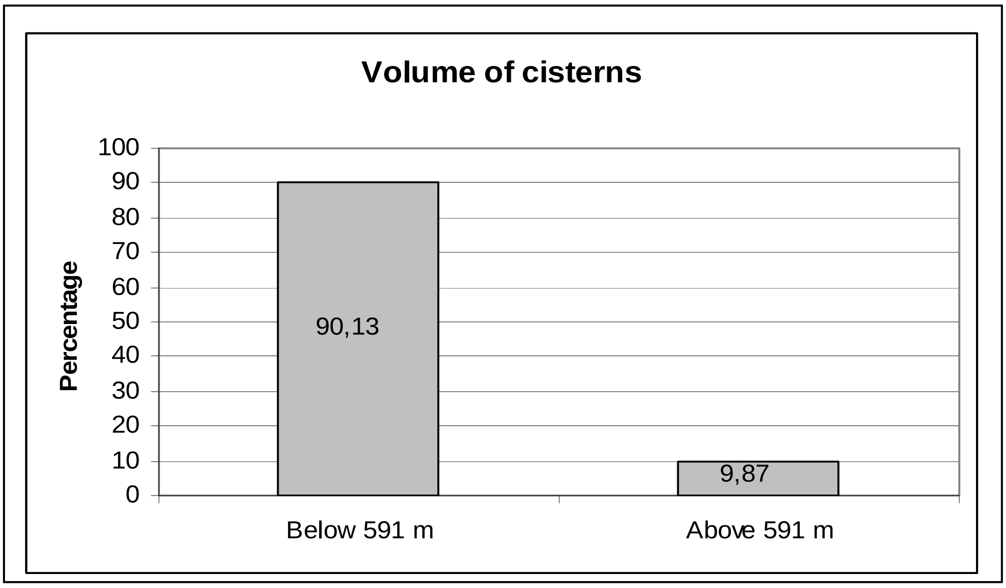


Figure 4.9 Distribution of volume of cisterns in relation to elevations below and above 591 m

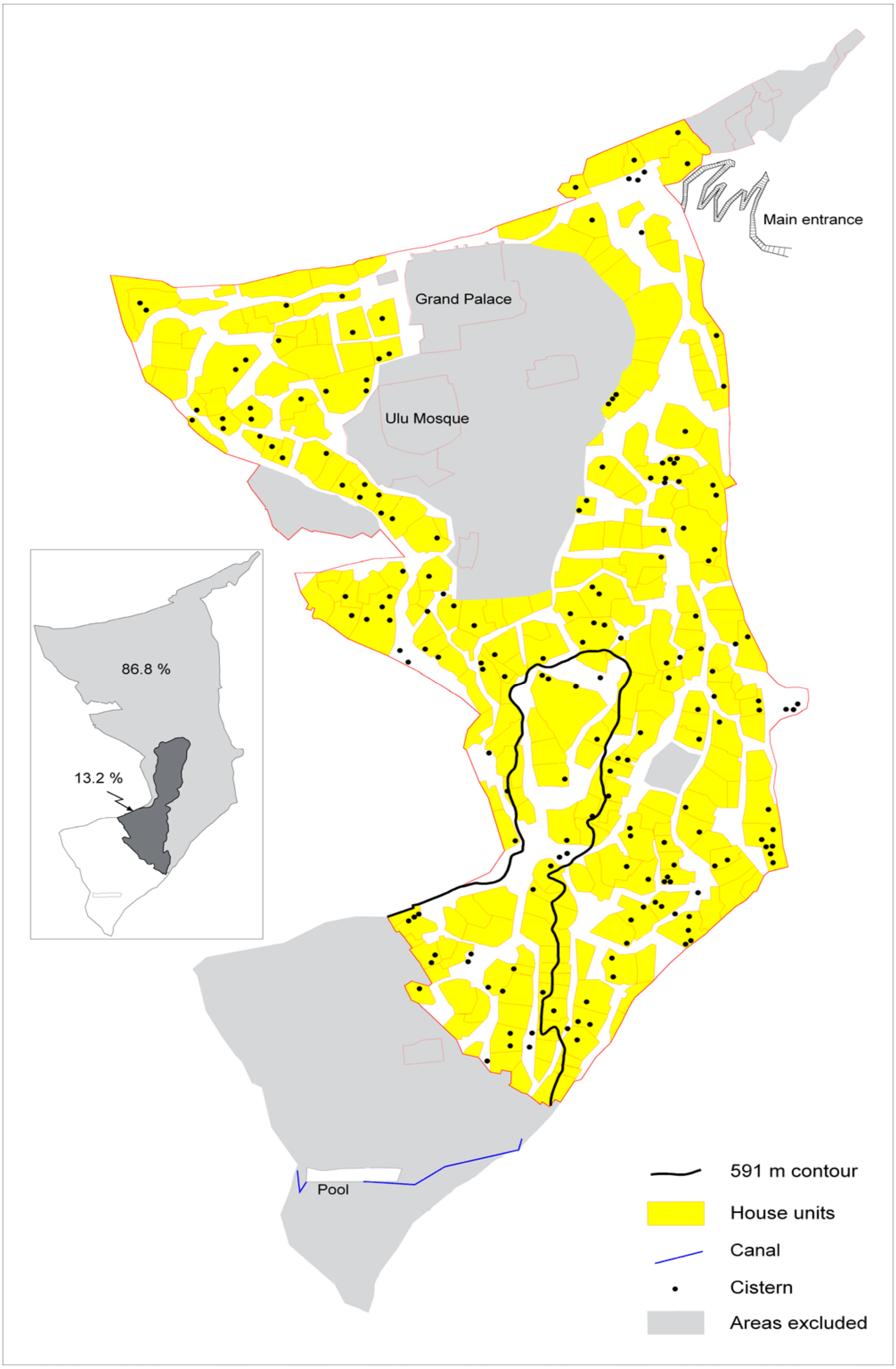


Figure 4.10 Distribution of cisterns and house units above 591m

CHAPTER 5

DISCUSSION

5.1 Distribution of Cisterns in Relation to Topography

Should the order of precedence for water service begin with public areas, then such areas must have been designed according to the elevation of the Pool. As mentioned in Chapter 2, Arık (2003) defines the primary and secondary networks of water. However, the very important thing to pay attention to the crux of discussion is that Ulu Mosque and Grand Palace are late designs. If the housing pattern of the Upper city and thus the cisterns belong to ancient periods, then it is irrelevant to constitute some relationships from topographical point of view. The same is valid for all assumptions and discussions of this research. However, it is assumed that the most recent public areas (the vicinity of Grand Palace and Ulu Mosque) were left special deliberately. In other words, public areas whether they retain late structures, must have also served the same purpose in much earlier times. Because it is a general habit of reserving readily designed platforms to certain segments of the city.

If the cisterns of the Upper city were initially intended to have been constructed according to topographical conditions, then it may be a possibility that the majority of the city population could have relied more on easy flow of water regardless of cistern sizes. Then, cistern frequencies can be normally accepted to be concentrated in the vicinity of lower elevation areas for most of the periods.

5.2 Distribution of Cisterns in Relation to Canal Residues

Direct relationships between canal remains and cisterns are visible in certain parts of the Upper city while indirect relations are also likely. One canal extension out of aforementioned five extensions is recorded to serve directly a housing unit, which now lies on the southern wall of B22 unit, in the western part of the city. Its width (20 cm) is remarkable so to be nominated as an important part of the water supply line. It probably had to flow along the border of B22 which lies just near the scarp, to make its way near the non-settlement area, B33 in the east (See Figures 2.5 and 3.32). Irrespective of the period, although baths are among those first hand users of water from aqueducts in the Roman period as explained in Chapter 6, one housing unit deserves attention in analyzing the proximity of canals to some possible special settlement areas. The position of the cistern (no:141, Appendix B), first recorded as a bath by TAÇDAM, in B15 unit can have a strong relationship with B22 unit. B15 unit is located four units away from B22 unit in the eastern direction (See Figures 2.5 and 3.32). If this cistern which is "extremely large" is a bath, then a branch of a canal line (the so-called "canal extension" throughout this research) on the border of B22 unit near the scarp may also have visited B15 unit. Moreover, the cistern (no:140) found on the main road and two units south of B15 (Appendix B) is a remarkable water structure taking its size into account (Appendix A). It may be a bath, as well. However, since many baths are special structures for they usually serve the public, it may be that branches of the said canal extension could have been built in later periods before the conversion of the baths to weaving platforms. B18 unit has perhaps a more advantageous position with important evidence pointing to the placement of baths near a canal extension. B18 is located just two units away from B22. Bath basins are very clearly observed in a cistern (no:44, Appendix B) within the said unit. This is also recorded as a large water structure through which water was channeled.

In addition to the analyses made for the western locations around B sector, gutter-like remains found in the eastern interior part and on a main road in the southwestern part show that the city at least has a possible discharge system although there are two examples. The gutter-like remains could have acted as discharging elements as part of a canal extension coming from B22 unit and that coming from the opposite of D2 and D3 units.

The canal extension at the opposite side of D2 and D3 units may also lead to questions about water distribution at higher elevations. The southwestern part of the city is less rich in cistern availability than the other parts of the Upper city. It may be that the slope of the land here facilitates water distribution without abundant cistern usage. However, it is still questionable whether water was conducted to such higher elevations via other means, for instance through a subterranean canal, etc.

The arrival from N63W of the canal remain at the cistern (most probably leaving the canal extension at the opposite of D2 and D3) in D6 unit may point to the system of canals serving the "nearest" water structure. The cistern (no:152, Appendix A) as the nearest water structure can be a supplementary element within a small zone where water supply is not deemed so urgent due to the advantages of topography (See Figure 3.2). Therefore, nearest cisterns could have fallen ahead in water collection practices although the sample (no:152) is a "small" size cistern. Otherwise, there is no reason why the cistern (no:151) which has a medium size would collect water at first hand, in D6 unit. Also, the other cistern (no:150) could have been constructed later, on demand.

The canal extension lying in the south and continuing until the Pool is the best evidence for water transport along the scarp. Indeed, no discreteness of the canal is observed although it can not be reached completely following its route on the same line. These traces form the backbone of the water distribution system to reach the southern part of the city. This is the original canal extension in addition to another branch of the same kind in the western side of the Pool. Because evidence is poor for this western extension and it is not longer than the one which leaves the eastern side of the Pool, it can questioned if this western line meets the possible discreet extension found at the opposite of D2 and D3 units. However, the elevations of the cisterns found in the vicinity of this part of D sector are mostly higher than the elevation of the canal extension which is in the western side of the Pool. There comes again the question whether a subterranean canal leaves the Pool to distribute water to the upper parts of the city. If the canal extension had to go along the scarp to arrive at the city in this southwestern part, then the assumption of a subterranean canal system extending from the Pool can be proposed.

The main road on which the fourth canal extension is encountered between A18 and A36, A37 units follows the topography with a decreasing slope. This is the eastern part of the Upper city (See Figure 2.5). It is no chance that the canal extension conforms to topography as in the case of the canal extension found at the opposite of D2 and D3. Moreover, the canal in the vicinity of A17, A18, A19, A37 and A38 seems to have provided water to these units directly since they are very poor in cistern availability (See Figure 3.2). It is more or less the same situation in the vicinity of the canal extension at the opposite of D2 and D3. Estimation can also be made for C43 and C44 units where almost no cisterns are recorded. Because only C43 retains a cistern, the question to be asked for this part of the city is if the canal extension found there has another absent extension which passes by C43 and C44 units. The analogy is again made according to the case seen in D6 unit. That is, a cistern (no:54) as the nearest water structure could have used water to act as a secondary water distribution element to the surrounding cisterns to collect water (Appendix A).

The canal remain arriving at B49-1 unit from the southeastern direction is likely to be the end point of the distribution network of the Upper city in the north, near the cliff over the Tigris (See Figures 2.5 and 3.32). If the canal extension observed on the southern wall of B22 continued to follow the route along the western scarp, then it is likely that the said canal extension would reach the scarp in the very north or turn towards the east and stopped elsewhere near B41 (which is a “small” size cistern) and split into secondary branches to supply water to the cisterns all over B sector. The crux in the light of such evidence is that all those five canal extensions detected at different parts of the Upper city should originally belong to the same period. This means that they could have been designed in the same fashion and period, for similar purposes.

Parallel to the assumption that the interior parts of the city are relatively disadvantageous when compared to the settlement areas near the scarp over which the canal extensions preferred to make their way, B39 (no:27) as a “very large” cistern is among those which must have been constructed according to its location (See Figures 2.5 and 3.32). That the central or interior areas must have possessed larger cisterns then comes from the need to collect water for longer periods due to transportation concerns. However, two possible canal remains inside the “small” size cistern (no:28) in B39 unit should not necessarily distort the logic of the assumptions made above because it can be alleged that it could have been constructed on the basis of spatial concerns. This means that despite the necessity of water for daily life, each unit must not have reserved more space to build additional larger cisterns. Cisterns could have served to meet the optimum amounts of water, instead. If larger cistern construction is dependent on water transportation, B67 whose size (medium) is very close to the limits assigned to the “large” category (no:30, Appendix A) confirms the assumption of locating larger cisterns much near a water line. The canal hole observed in B67 is only 10 m away from the scarp. Such case may further be an indicator for those absent lines of possible canal extensions in this part of the city.

It is difficult to make assumptions for the cisterns found just near the scarp in the east of C24 unit as well as the one found in C29. Since all of them are “very small” cisterns, they can be candidates for collecting water from a canal extension in the eastern part of the city if there was any. The quasi-canal ruin which is connected to the cistern (no:79) in the courtyard of D78 unit is a small indicator of a canal remain because the said cistern as a “very small” one seems to have been used for collection of other liquids different than water (See Figure 3.47). However, it is also possible that it could have been constructed in a later period as a cistern having a lid on its top for other reasons. Two canal remains embracing the cistern marked as no:88 in D65 as the most visible one in the southeastern part of the city which also has a well-ring like lid on its top, reveal that water was collected in the said cistern to be distributed to the surrounding cisterns (See Figure 3.49). Just like the cistern (no:79), these canal ways can be the means for transporting water from a canal extension to the other cistern (no:88, again a “small” cistern). Therefore, such a possible lacking canal extension as a continuation of the aforementioned canal extension near the Pool in D sector could have passed by this part of the city. The assumption that all the canal extensions passed by the regions very near the scarp in every direction of the city, excluding the very northern edges, is tried to be supported with the samples explained all above.

On the other hand, no analysis can be made as to whether there is relationship between canal extensions and/or remains and cisterns, in terms of cistern size and canal width. There is no evidence since canal “extensions” either do not directly arrive at certain cisterns or measurements taken for canal remains are not satisfactory. However, 10 cm wide canal remain which is connected with B39 unit, although it is the only evidence in value, in a way justifies the existence of a branch system splitting from all five and other possible canal extensions at the Upper city. It can also be that small branches are inherited from those Roman samples which let rain water run-off.

Despite poor evidence, terra-cotta remains found in the western part of the Grand Palace between B60 and B66 units and between the main canal and the siphon system in the very southern part, to a certain extent reveal that pipes possibly remedied the problems of water distribution. Canal extensions are directed towards parts of the city which are below the elevation of the Pool and towards public areas. Since evidence pertains to a location which is near the Grand Palace, order of precedence for the construction of a possible piping system is taken into account such that some parts of the city could have enjoyed the advantage of being located near pipe lines. However, this, of course, does not necessarily mean that such lines are designed just to let water directly flow toward privileged areas as separate closed lines. But there is no other evidence to suggest that a system as an extension of the most usual Roman type in the form of three separate pipe lines serving different segments of the city (public areas, baths; fountains and private houses as further explained in Chapter 6) is one possibility. Therefore, late piping systems could be an interpretation in the light of current medieval characteristics of the Upper city. In any case, it would be unrealistic to rehearse on exact resemblances with Roman systems at this point of the discussion.

Terra-cotta lines found between the main canal and the siphon can be crucial for further discussion. Evidence shows that a subterranean construction in the form of a closed pipe-line is embedded in earth (See Figure 2.9). The pipe is constructed between two discreet canal extensions of the same kind where the elevation difference is remedied by the earth-fill in which the terra-cotta pipe rests today (See Figure 5.1).

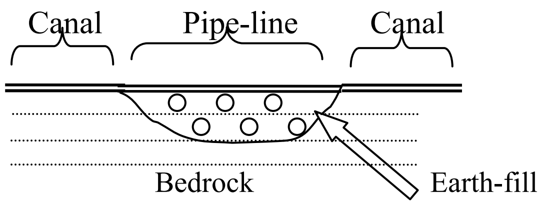


Figure 5.1 Sketch of the pipe-line construction between the main canal and siphon

The canal extension coming from the south of C1 unit with a wall to reach the opposite of D2 and D3 units also lead to the idea that a pipe-line could have been placed on top of this wall to raise the elevation of water to be carried easily (See Figure 3.35). The last two samples also appear to be medieval designs but one should also keep in mind that if the topography was more or less the same in ancient times then there should have been a system to send water from lower to higher elevations. If they are late features then an original mechanism which is presumably attributable to an aqueduct design could have been renewed as an extension of the similar fashion.

5.3 Distribution of Cisterns in Relation to Secondary Use

There is more conversion activity when a neighboring house unit is positioned above or below another unit which was an original user of a cistern. A sketch for the case which explains the use of cisterns as living spaces for their adjacent housing units is shown in Figure 5.2. The assumption is that there was one original topography (the first condition is shown as A in Figure 5.2) upon which the housing units were built. Later, the topography became a multi-layered sector (condition B) and secondary quarters were placed on each layer (condition C). The transformation process to the multi-layered condition C made it available for the dwellers to construct cisterns usually within the courtyards. An example can be given for the cistern found in B26 which probably belongs to another housing unit located above B26.

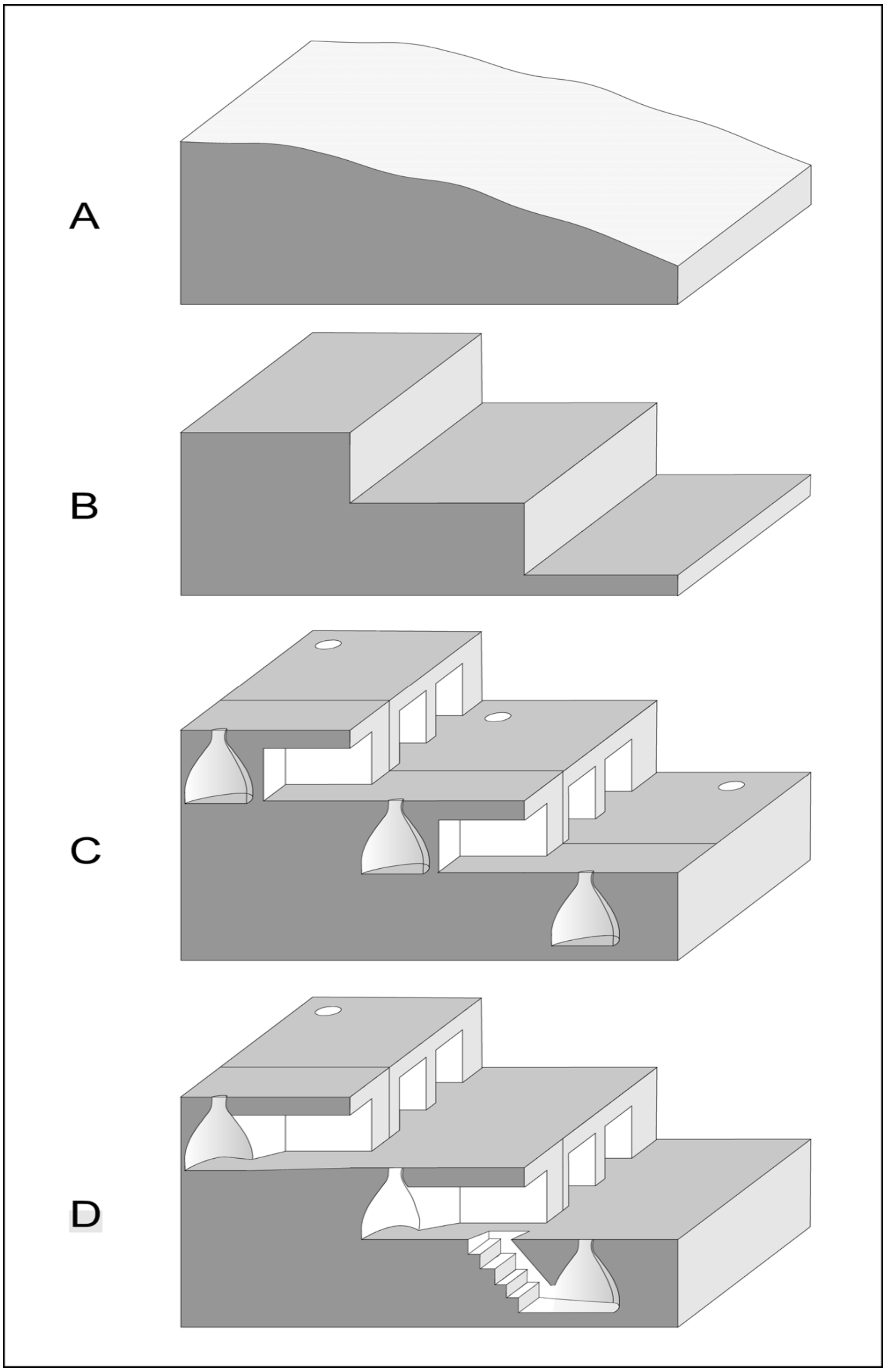


Figure 5.2 The process for cistern construction

The conversion activity (D) is not related with the current condition of a cistern all the time because a cistern which is recorded have been converted to a living space is sometimes observed to have preserved its original shape. They are sometimes seen to be have been cut to enlarge the interior space as part of a housing unit and sometimes to connect the original spaces of the cistern with original living rooms. Therefore, a cistern at the entrance of the Upper city in the northwest direction now belongs to a current household. The cistern is clearly observed to have been converted to a stall. It is still in use for self-sustaining purposes.

Since no dating technique was applied during the research at the Upper city, all the recording efforts were based on the current appearance of the cisterns. Meanwhile, it is inferred that more than half of the cisterns (65%) are subject to conversion (based on the total number of converted and unconverted cisterns given in Table 3.4) which may also have taken place until the abandonment of Hasankeyf by the last dwellers, in 1960s. The abovementioned percentage falls 11% (100/185=54%) when the analysis is based on 185 cisterns. The important thing is that conversion is observed to be more than half for each case.

The conversion activity must be due to the fact that, any change on the settlement pattern of a district could have shifted the original uses of the cisterns. Illustrative examples come from the cistern in B52 unit which is closed from the opening. It is inside B52 and probably belongs to the courtyard of B57. Although B52 is the exact location, the cistern is shown within the borders of B57 unit (See Figure 3.2). B73 is another location where the cistern found in B74 is reached from the courtyard of B73, so it probably belongs to B73 unit. The one found in B73 seems to be an original cistern which means that one of those two possible original cisterns of B73 was imported by the inhabitants of B74 in later periods to be used as additional living spaces. The cistern lying in the west of D37 is reached from this unit but is under the road now. It probably belongs to the courtyard of D23 originally. A shift in the road network of this part of the city is thought to have affected the original position of the cistern.

On the other hand, cisterns which are found in hung positions can also lead to the idea that they could have been abandoned or became out of use at a certain time. The reason for such a case can be due to a problem with the siphon system. If there were problems associated with the Pool, cisterns would be expected to have been cancelled all of a sudden. Another can be the idea of mass conversion in a certain period due to a decrease in the efficiency of cisterns for any reason. Conversions could have been realized when a settlement area was completely left to new settlers. Or more space could have been required by overpopulation. Furthermore, if there were any water shortages, such problems could have been eliminated by stable water by a dense population. It is still problematic why nearly half of the cistern population is subject to conversion.

Cisterns which are very badly destroyed are probably converted examples even though there are no niches or platforms for living. For the ones that are nearly half preserved today and that have become parts of living spaces in burned conditions point to extensive conversion activity for many purposes. Of course, such an assumption is not that valid for all similar samples. Because, for instance, it is very visible that a cistern found on a main road, in the south of B4 and whose base is on the edge of the scarp is very badly destroyed and half is fallen down due to rock fall. Figure 5.3 which shows a view from a destroyed pear-shape hung cistern near the courtyard of D26 unit brings to mind that destructions are not necessarily attributable to human action but it may also be that natural factors trigger shifts in cistern usage.

Figure 5.3 A destroyed cistern whose half is absent in D26

There are few cisterns whose bases are broken and they are cut at the middle of the base in the form of shallow pits such that the carved niche-like base platform could have been used for an unknown purpose. This may be another evidence for secondary usage. It is one possibility and a sole exemption that pits are very badly destroyed due to looters' activity. The cistern in the middle of the courtyard of A23 unit is one sample for such case which is not that high.

Filled cisterns which can not be reached fall out of the scope of this sub-part so no discussion is made for them.

The evidence for wells can be seen in D65 unit where 5 cisterns are placed. Although it is recorded as a cistern, the well-like structure (no:88, Appendix B) which almost rests near the scarp but stands in the middle of the courtyard has a ring on its top (See Figure 3.31). Its height is measured as 7,00 m, taking the well-ring like lid into account. As it is mentioned before, two canal ways run into this element. It can be that the water feature was used for public purpose. The ring which today seems as one of the indicators of a well could also have been used as a lid for this possible public cistern, to prevent pollution due to collective usage. No matter how and why they were used, shapes which resemble well rings could have belonged to cisterns. Still, wells may have been present at the Upper city of Hasankeyf. The lower parts of the city can be checked because the inhabitants could have used wells for easy access to underground waters at lower levels. They could have been triggered by the practicality of well construction at such elevations.

Cistern patterns so far help the assumption that most of the cisterns at the Upper city are original in shape although many are converted ones. Extensive use of small cisterns is strengthened by the dominance of individual cisterns in quantity where the number is 157. Approximating numbers of twin and triple cisterns are assessed to bring to discussion the possibility of some privileged private houses or villas at the city. For instance, 2 twin cisterns which are found very near the Grand Palace (B71-1 and B74-1 units, see Figures 2.5 and 3.2) and 1 twin which is recorded in the southeast of the public area borders (C55, Appendix B) reveal that multi-cisterns could have belonged to higher status domiciles originally, if not otherwise used by work places. It is one offering that heavy conversion activity is realized for the single-hung cisterns which are resumed to be wide-spread for many parts of the city apart from D sector. Such is construed to the late settlement preference which means that very early dwellers could have chosen to be clustered in the interior areas of the city for defense purposes or any other reason. If it is the case, the city is then assumed to have changed its settlement pattern scattering towards scarp areas for easy access to water means soon after a well-established water system was launched along the natural scarp to benefit from topographical conditions.

On the other hand, further discussion can be made separately taking into account the total number of converted and unconverted cisterns at the Upper city. Figure 5.4 shows the distribution of converted cisterns including their proximity to canals extensions and remains.

It seems that conversion of cisterns was realized for cisterns which are located near canal extensions and remains. It can also be inferred that since the majority of canal extensions are placed near and along the scarp, converted cisterns were preferably kept towards the borders of the Upper city. Although some density is observed in the central interior areas, the frequency of cisterns decreases in houses whose elevations are above 591 m (See Figure 4.10). Southern and western parts of the city are relatively the most preferred areas. It is interesting to see that the two areas where converted cisterns are concentrated are those with higher densities of cisterns in relation to frequency and volume (See Figures 4.3, 4.4 and 5.4). This commonality can also be interpreted in terms of a certain degree of preference for the selection of house locations. The concentration of converted cisterns in the said areas can also point to late settlement strategies. If these areas initially belonged to ancient periods then they could also have been chosen as the target areas by the late comers. There is also a dilemma here from the point of water use. Why were these areas recurrently preferred when conversion can imply shortages in the siphon system or overpopulation, etc., at the same time? Even though such problems could also have caused changes in the function of houses thus cisterns, then there comes the question of criteria assigning in favor of a settlement preference in the same two areas. Topographical factors may have played important roles in the selection of two main areas due to easier flow of water along the scarp.

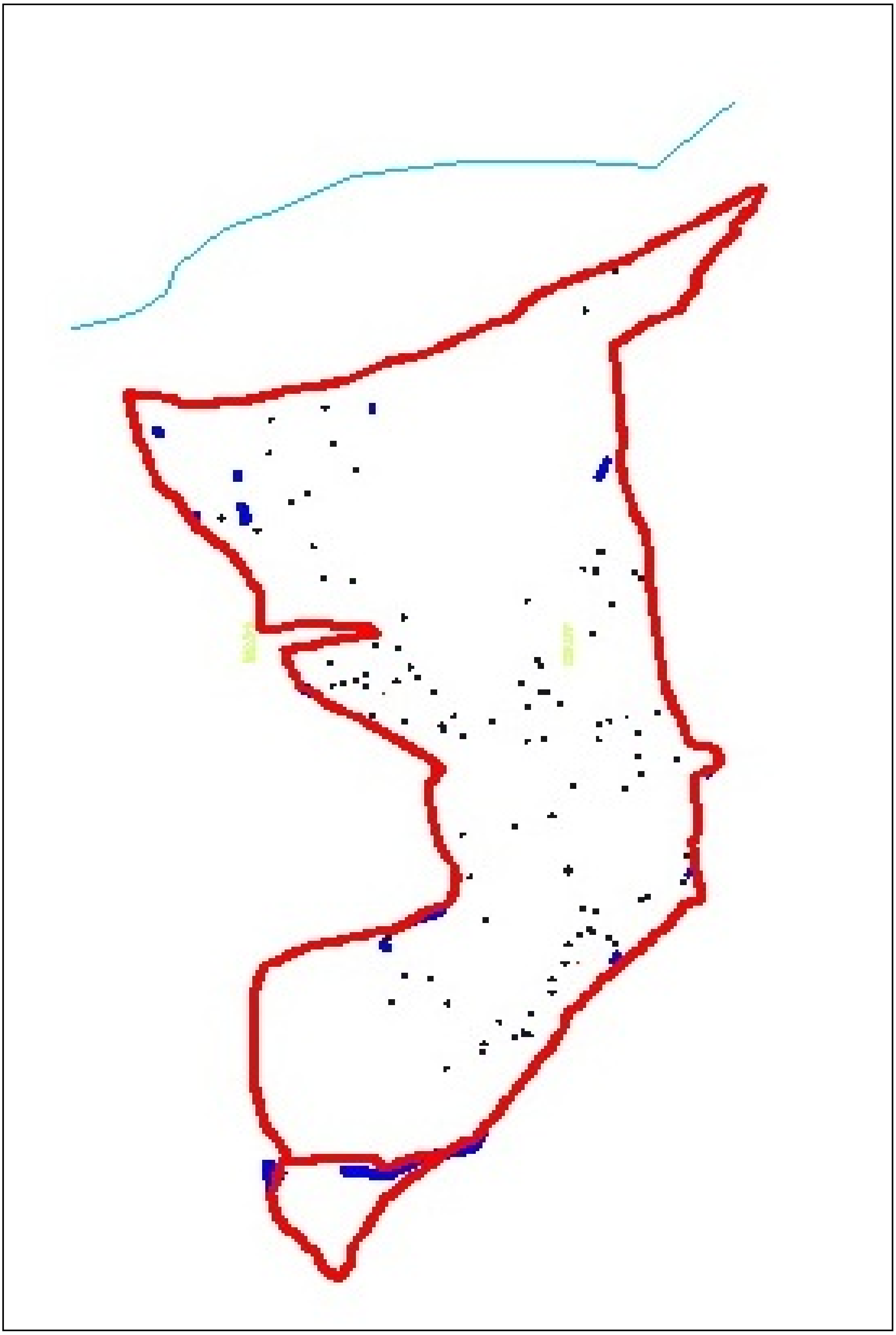


Figure 5.4 Distribution of converted cisterns at the Upper city of Hasankeyf

5.4 Impact of Water Features on Urban Settlement

It was mentioned that five canal extensions served the Upper city as first degree distribution means of water, besides other very possible lacking and unearthed ones which must have been destroyed due to abrasion or human activity. On the other hand, if a line crossing from the middle of the Grand Palace and extending to the eastern and western edges of the scarp is drawn, it is understood that no remarkable canal residues are observed in the north. So, the northern part of the city lacks direct water supply.

That the water features are determinant on the housing pattern of the Upper city is not a one-way flow when the positioning of the housing units which are scattered across a difficult terrain is one matter of fact. The same is valid visa versa. Water features especially the canal extensions seem to be depended on the environmental factors, mainly the topography. The chain effect shows itself on some portion of the settlement pattern at the Upper city. In other words, houses which are relatively near to canal extensions turn out to be natural exploiters of water sources. Such case may be accrued to the advantageous position of those housing units. However, when considered separately from canal extensions, it is an independent fact that houses are attached as integrated series of complexes and designed parallel with topography to utilize the ground at the maximum extent. Another expression is that certain houses are located in areas where canal extensions pass by, deliberately. If the standing point for deliberate settlement attempt in the relevant houses is due to a movement from the original clusters towards more flexible areas near the scarp, then it can be assumed that they were built in relatively late periods. Therefore, easy access to ready waters near the scarp areas can be a determinant on the urban settlement which may greatly depend on period.

It is very difficult to pose an assumption in every respect neglecting the periods. Then the discussion is limited with certain parameters which are mainly the conversion and size of 185 cisterns, their distribution throughout the housing units, elevation of the housing units and direction of the canal extensions.

The possible reasons for conversion are stated in sub-part 5.3. A change in the function of spaces within the housing platforms may be a result of water shortage in any period, perhaps following the Roman era. Hence, new ways of water supply could have had its impact on space usage. Whatever the reasons are, re-zoning houses used to be a common behavior of the early Byzantine settlements (Alston, 2001). A shift from clear house borders to enlargements by intervening public spaces such as roads or streets turns out to be a change process for the designation of water features. The case is observed for the cisterns of the Upper city. In line with the size of cisterns, as all debated from different perspectives in Chapter 4, it is inferred that there is the general tendency to construct relatively bigger cisterns in housing units near scarp areas. Generally, more space for cisterns near scarp areas is allocated to the associated housing units. These housing units can also be attributable to public usage spaces including baths, fountains or common work places. Some housing units retain plenty of cisterns where one sample encompassing a space suitable for 8 cisterns is discovered. The abundance or the poverty of housing units in cistern can also be discussed from another perspective that the distribution of cisterns tend to be random across the Upper city. Housing units which are rich in number of available cisterns can be thought in terms of public usage again. Or, cisterns could have been constructed to serve working places. Twin usage may fall into the same category while some privileged houses can be the other address. A vital question on the condition of cistern patterns comes from Vitruvian way of determination about cistern designs in the Roman period. Multi-segment cisterns which should be designed to filter water in one segment and then pass it to other segments may be the rationale behind constructing twin, triple or two-chimney cisterns at the Upper city (Morgan (1960) and Şevki Vanlı Mimarlık Vakfı (1998)).

A vast amount of conversion observed near the scarp and water extensive areas demonstrates shifts in the function of cisterns over time. Conversions can imply a certain level of impact of houses on the water features. Cisterns could have been changed or renewed according to house layouts that were occupied for new requirements, probably in periods following original constructions. Therefore, newly introduced houses also built in parallel with the topography could have been central to the enlargement of space within the city texture. Presumably, orientation seems to have been realized from compact settlements in the interior districts towards more scarp areas, particularly in the western part, with the introduction of conversion. Ultimately, almost equal division of residential areas may have been achieved in periods when conversions have become essential or were launched. Hence, the recurring use of cisterns could have become a general strategy as the city expanded. Shifts in road networks or service lines could have been inevitable subsequent or prior to such activity. However, it is difficult to interpret the order of precedence within the time context.

Housing units which are below certain elevations presumably abandoned new cistern utilization in case water shortages emerged or span of houses began to enlarge towards the scarp areas. Comparatively, the terracing of houses below 591 m is no longer observed near the scarp with some exclusion. The direction of canal extensions match more lavishly designed houses in every direction of the city, excluding the very northern part which lacks direct canal evidence. Larger cisterns are no chance to suggest that Tigris could have supplied the houses in this part of the city with water, eventually leading to larger borders. The reverse is valid such that larger spaces left for zoning the houses could have triggered the construction of larger cisterns.

Public places which reserve very large spaces for cistern usage, are supposed to exploit a greater portion of the water supply. Borders are luxuriously designed, stretching across the housing areas near two canal extensions. The denser accumulation of houses in the vicinity of the public space can be accrued to the maximization of water usage during the course of first instance water flow when the priority goes to public places.

Discussion is necessary to be further made for cistern size categories in certain locations. It should be noted that cisterns whose sizes are undefined are not recruited for such analysis (Appendix B). The overweighing size category is consumed by small cisterns which can justify the flexibility of water distribution to housing units as in the case of Near East samples (White, 1984). It is questionable whether water was manually carried from a public source or; a segment of a piping system assigned for private areas prevented extravagant use. The number of small size cisterns within housing units can be raised if a link is established with cisterns on roads which get the abundant numbers for small size. However, cisterns near scarp areas are out of this debate. As “very small” size category is the priority for such cisterns, it is assessed that they either serve as supplementary water structures to housing areas where more than one cistern is found or housing units near a scarp directly benefit from possible canal extensions due to readiness of flowing water. Similar assumption is valid for size categories of cisterns on a road and near scarp although numbers are not remarkable (See Appendix D). Cisterns above 591 m are overwhelmingly small with a view to assess them as poor beneficiaries of a possible discriminatory water distribution network.

Generally, the layout of the Upper city shows that houses were rigidly positioned but they also allowed themselves certain flexibility in using water. Cisterns which are placed in the courtyards seem to have left enough space for daily house activities. Meanwhile, attempts to place cisterns in the middle of courtyards also remind the Greek way of house designing (Crouch, 1993). Courtyards ensured that a cistern could be easily filled, accessed, cleaned and maintained. It was also common to place a second cistern around the courtyard with the intention of keeping enough water in long, hot and dry summers. Average-sized houses had such properties in Morgantina, Sicily. The main reason was that courtyards were the most logical places for laundry, dish washing, cooking and even bathing as part of daily activity. Houses with cisterns also had the advantage to survive in the event of a siege (pp.246-248). The inherited practice of building houses which were dependent on courtyards could have indirectly influenced the layout of the Upper city. However, courtyard planning was not always made in accordance with rigid placement of cisterns where they interrupted private zones at the Upper city texture. Houses which had more proximity to canal extensions are observed to have been designed in line with canal orientations. Plenty of them are found to have been built to make extensive use of terracing where necessary, with a series of large residential insulae in the layout of the Upper city. If there was the general habit of dividing water to certain segments of the city or otherwise it was enforced under certain regulations, canal extensions mainly flowing along and near the borders of the city could have formed the basis for the division of districts leading to public, administrative or private zones. That the role of canals could have affected new road patterns can be another factor for the formation of districts in late periods if there was a shift in house building towards scarp areas. It can be one possibility that damps of houses which shared common boundaries were swept away through adjacent gutter-like remains near the roads.

Gutter-like remains help to refresh minds about the role of sewage systems on the urban layout. Two evidences embedded in earth on relatively plain grounds may have served as part of a main artery which has now eroded due to rock type. These features may have been the backbone relievers of the excess waters of the city which is full of steep slopes. Because the discharge of water is easily achieved in its natural course when it flows from higher elevations, the existence of gutter-like remains on plain grounds is normally expected. Houses which are built on such terrain must have benefited from those discharge features. Accordingly, problems of flooding must have been overcome.

5.5 Prediction of Undetected Cisterns

Based on the Cistern Distribution Matrix in Appendix D and as stated in Chapter 2, there are 129 locations where cisterns are recorded. 112 housing units, 3 junctions of housing borders and 14 special locations of roads and scarp areas out of these 129 locations provide evidence for cisterns separately. To a certain extent, it is possible to come up with discussions for location categories. From the very recent private settlement pattern point of view, the relationship between cisterns and private dwellings under the sampling area of 112 housing units should be based on the average cistern usage for each housing unit. Based on the total number of cisterns (185) recorded at the Upper city and the total number of locations (129) where cisterns are found, each location must possess at least 1 cistern which is rounded for the accurate number 1.43 within the sampling area. The average cistern for all the settlement area (264) is 0.7 which can be approximated to 1 as the best case. If, common usage with junctions of housing borders, roads and scarp areas are excluded and only 112 housing units are taken into consideration, 1.7 cisterns is the average number for each housing unit.

In the light of such computation, 1.43 is taken as the optimum average cistern quantity for the coming discussions. So, 264 housing units could have possessed a total rounded number of 378 (*264x1.43*) cisterns at the Upper city at the minimum possibility. As stated in Chapter 2, there is no evidence for cisterns for the remaining 152 houses. Then a round value of 217 (*152x1,43*) additional cisterns can still be absent or it is the ideal value based on cistern usage per capita house (Of course, the remaining houses where no cistern is recorded should not necessarily retain this whole sum).

Another explanation can be that spaces enabling the construction of 185 possible cisterns are not preferred due to water distribution problems across the city. The location for the non-constructed or missing cisterns can be in the northern part and those locations above 591 m which are mainly observed in C and D sectors if no canal extensions or other means of common distribution are available. Furthermore, if part of 185 cisterns is somewhere above the elevations of 591m, the majority can be placed in sector D because there are only 10 cisterns above 591 m in C sector while the number is 19, almost two-fold in sector D. East of D sector is advantageous in terms of topography for easy flow of water (taking into account the possibility of a subterranean canal system, as stated in Chapter 4). The other side of the coin is that it may be full of disadvantages in terms of cistern availability. A remarkable percentage of 185 cisterns can be in D sector if the habit of using cisterns to collect rain water was (as there would be no other choice in the absence of a subterranean system) inherited from Roman or pre-Roman periods.

Also, the bulk of 185 cisterns can be small size cisterns if the majority of this number is somewhere around D sector. Such assessment is derived from the assumption which supports the idea of initial settlement strategies. Such strategies are associated with late settlement preferences as mentioned in sub-part 5.4. As the settlement pattern may have shifted to areas near the scarp or its skirts, original cisterns which are usually known to be “small” during pre-Roman and Roman periods could have been constructed as small size cisterns of Hasankeyf. The dilemma at this point is the scale with which the term “small” is defined. However, it is not a serious problem whether preferably, very small or medium size cisterns are associated with small cisterns of Romans'. Because still, a great percentage of evidence with respect to base measurements of Hasankeyf cisterns more or less fits the value range stated for small size and rock-cut bottle shape cisterns of the Near East (Nydahl, 2002) (See Appendix A for diameters of "small" cisterns).

The total volume of 185 cisterns is calculated as 1821 m^3 of water (not shown in Appendix A). The city population being constant and all the cisterns completely filled with water, a rough derivation for the average value for water distribution per cistern is 9,8 m^3. To go one step further and based on the recent number of houses which is 264 (regardless of house building activity in late periods, probably after Roman reign); a rounded value of 3704 (*9.8x378*) m^3 of water could have been distributed to the city. 3704 m^3 of water is not so irrelevant when 3000 m^3 of water was distributed to the Roman Imperial city of Psidia Antiochia in the first half of the 1st century (www.en.wikipedia.org, 2004). In this case, the unknown difference as 1883 m^3 of water (*3704-1821*) which is allocable to 192 cisterns for the undiscovered parts of the city emerges. The difference for (*217-192*) 25 additional cisterns can be a compensating value for some other unknown public cisterns. It should be noted that public cisterns are not used for the calculations made above. Theories about the population of the Upper city can be established from the ideal city population perspective. Although, such debate is out of scope, a very rough estimation per capita water usage can be calculated in the light of daily Roman consumption of water (Hansen, 2005). An average number of 60 m^3 of water is delivered to major points such as small pools or fountains. Based on unequal distribution of water and other factors being constant, approximately 900 individuals made use of this volume which computes to 0.7 m^3 per capita water consumption (p.11). Now, a very speculative number of approximately 14 [(9*.8/0.7*] people seem to be the target mass which could have used approximately 14 m^3 (9.8x1.43) of water in each housing unit. It is a very unrealistic number considering the daily requirements.

5.6 The Capacity of the Pool

For the Pool to send the maximum capacity of water to all cisterns, it is supposed to be full of water to ensure a day round supply continuously. A subterranean canal construction does not sound weird when water is not usually managed on demand in Roman times. Hansen (2005) reviews water management from demand aspect (p.1). If it is the general case for all the Roman cities and the Pool conducted water to high elevations of the city via a subterranean canal continuously, there comes the question of the volume of the Pool. It is measured as 1216 m^3 (405.4524 m^2 x 3m height). The area of the Pool is computed from the digital version of the Settlement Pattern Analysis Map prepared by TAÇDAM. The measurable dept of the Pool is recorded as 3 m where this number is supposed to be a little more because it is partly filled with earth (Toprak and Süzen, 2004). Presumably, the volume can go up to match the default requirement of 1821 m^3 of water where the difference is 605 m^3. There emerges the 1.5 m difference which can be the rest of an original dept of 4.5-5 m. However, the depth of the Pool should not be fixed even to a round value considering that it does not necessarily have to meet the volume equivalent to the total volume of cisterns if there was continuous flow of water.

Ready information comes from large public cisterns of the Constantinople (Bono, Crow and Bayliss, 2001) and the Near East. The city of Humeima in Jordan during the Roman period is known to retain two public cisterns which can store with 445 and 486 m^3 of water (Nydahl, 2002). In the light of another readily available information (Arık, 2003) that cisterns within the courtyard of Ulu Mosque retain hundreds of tons of water (although Ulu Mosque is dated to late periods of the medieval ages but the assumption is based on the probability of “ready” cistern inheritance from pre-medieval periods), a slight analogy can be established between the public cisterns of the Near East and those of the Upper city. It is undeniable that evidence for public cisterns of the Near East is not satisfactory in terms of quantity in this study. However, if the capacity of public cisterns is expressed with hundreds of tons of water, then it would not be weird to base the assumptions on Roman experiences of the Near East.

CHAPTER 6

WATER DISTRIBUTION SYSTEMS IN THE ANCIENT AND MEDIEVAL WORLD

6.1 Background

Water, as Kang (2004) well explains, was used in many different ways in ancient times. Drinking, washing, irrigation, industrial or craft process, storage, cleaning, livestock purposes are some of those that triggered the supply of water from various sources. Springs, sometimes in the form of spring houses sometimes as ritual fountains, were famous during the Roman times and designed in a way to be protected from the sun and pollution. Fortified centers also made use of such springs outside their walls in a way to access the source by closing the entrances or with the help of canals in the event of a siege. Wells are another type which provided the best quality water for drinking purposes.

Wood, brick or stone were the most commonly used construction components in almost all periods. Although cisterns and reservoirs were supplementary water features- usually for storage and catchments purposes during rainfall, they were sometimes used as urgent drinking sources or for irrigation. However, they were not all the time preferable since bad smell, taste and hygiene were important factors for non-usage. Examples exploiting efficient cistern usage go to Roman baths and famous pools of Solomon that were connected to an aqueduct system. Baths were very important public structures with multiple pools each of which had different water temperatures like cold water pools (frigidarium). Aqueducts, qanats and conduits were the most advanced types of Roman water systems which were generally made of lead and stone pipes beginning from the earlier times of the Imperial Rome. However, the requirement for high quality materials and time were two important constraints for the construction of such architectural features. In fact, qanats or quasi water-tunnels of the Persian style during Achaemenian kings' reign are noted as exceptions from water features peculiar to the Roman times. Qanats were constructed in the form of sloping tunnels along which water ran off via sinking access shaft every 30-50 m. Similar structures are encountered in Damascus, Palmyra, Palestine and in some other ancient Near Eastern cities, from Bronze Ages onwards (pp. 2-5). Therefore, qanats which are characterized as underground systems for tapping water are known to have been widely constructed in the ancient cities located in arid environments. Such environments were usually adjacent to a mountain water reservoir to create a large oasis (www.waterhistory.org, 2004).

According to Forbes (1993), the case was no doubt difficult in the ancient cities of Palestine and Syria where water tunnels (*sinnor*) were built on rocky hill-tops to supply water from springs (p.155). Water tunnels of the classical world are assessed as quasi-qanats by reason of similar construction techniques with air (inspection) shafts (p.158). It is already known that water was brought to certain cisterns via a qanat system and then carried through different pipes to separate places in Arabia as early as Herodotus (Figure 6.1). In the Roman world, tunneling technology as a very important part of water systems was very similar to qanat technology. A qanat way of tunneling with vertical shafts dug over the hill-tops with connected bottoms was made to prevent detours when hills could not be skirted. Qanats were not only used in the Roman and subsequent eras, particularly in Syria and Jordan which are mentioned in the forthcoming parts, but they are also used in the contemporary world, today (www.waterhistory.org, 2004).

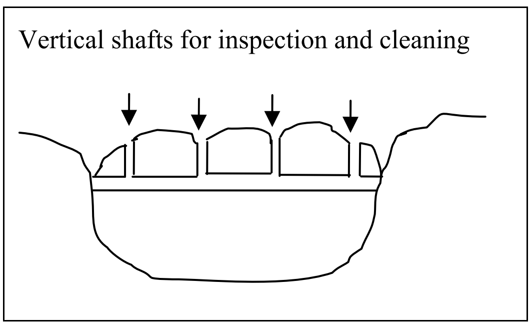


Figure 6.1 Tunneling in a qanat system during classical ages

The 14 km long, 7 m high and 6 m wide Titus Tunnel in Çevlik Village within the borders of modern Antakya province can be categorized within this type of water system which is dated to the Roman Seleucid period. It is known to be the first tunnel of the ancient world designed as a rock-cut water discharge system. The reason for the construction of such an impressive Roman engineering work during the reign of Vespasianus was to protect the Almina city against floods. This rock-cut huge canal was begun to be constructed in the northern direction to act as a barrier against the stream silting the harbor around 300 B.C. Hydraulic features of the tunnel reveal that it has two sectors and a very complex modulation against the silting maneuvers (Alkan and Öziş, 1991).

It is widely known that according to the great philosopher Thales, "the essence of every day things is water". Vitruvius, the Roman architect-engineer is also one of those who grasped the importance of water in human life. In his book, "The Ten Books of Architecture", he devotes the eighth part solely to water. Şevki Vanlı Mimarlık Vakfı (1998) translates what Vitruvius explains how to find water, what the properties of different water types are and how they are to be tested. In addition, detailing of Vitruvius about aqueducts, wells and cisterns are provided. According to Vitruvius, open sources of water ease the situation. He means that when open sources are absent around a settlement area, underground sources should be sought carefully. He also writes that rainwater is the best and healthier because it is drawn from the lightest parts of springs, mostly from where is nearby or up on the mountains during dawn times. It is filtered through air and turns back to the world (pp.227-230, pp.169-1719, respectively).

Landels (1996) explains that the most available water source is a spring formed at the foot of a hill or a mountain where water finds its natural outlet and flows continuously. Springs facilitate the transportation of water due to gravity. They form pits which are piled up by permeable rock types such as limestone with the help of underground waters that are usually seen in Greece such as Parnassos, Attike, Peloponnesus and Boiotia; and in Italy such as the Apennine mountains.

Landels continues with the Vitruvian view and focuses on the performance of water features in ancient times. Two types of waterlines with which water was conducted via gravity were open and closed lines. Romans extensively used the former one and called it as “substructio” which was generally made of stone containing plaster or cement inside while the latter took the form of a circular water-resistant pipe, generally made of metal or baked clay. Provided that the level where water enters the pipe was not exceeded, the required slope of the closed waterline could be beveled upwards or downwards. A disadvantage of an open waterline is the absolute necessity to keep the slope of the canal constant when the area is undulated (pp.36-39). However, methods of ancient engineering works to overcome the disadvantages of canal types shall not be mentioned in this study.

Morgan (1960) and Şevki Vanlı Mimarlık Vakfı (1998) mention Vitruvius’ stress on the contemporary methods of water transportation to urban areas. The very important aspect is that should considerable water fall be significant, then it is relatively easier to transport it to where anyone wishes. On the other hand, one should also depend on infrastructures in case pit holes or concave forms exist. As far as infrastructures are concerned, three ways of water transportation are pointed out which are supplied via canals through masonry conduits, lead pipes and pipes of baked clay. If water is to be conducted via earthenware conduits then the stone-cut features should be arched over to prevent it from sunlight. A water tank construction is a remedy through which the conduits reach the city and a distribution tank should be built with three compartments that are connected to the main tank. Three pipes for each connecting compartments are also necessary to link it to the main tank so that the water can run into the centre when it runs over the tanks on each side. Consequently, by constructing pipes, water can be smoothly transported to fountains, basins, baths and houses. Unless conditions let, further opinions of Vitruvius are cited as:

> If, however, there are hills between the city and the source of supply, subterranean channels must be dug, and brought to a level at the gradient[3] mentioned above. If the bed is of tufa or other stone let the channel be cut in it; but if it is of earth or sand, there must be vaulted masonry walls for the channel, and the water should thus be conducted, with shafts built at every two hundred and forty feet (p.244; p.179).

[3] If in conduits, let the masonry be as solid as possible, and let the bed of the channel have a gradient of not less than a quarter of an inch for every hundred feet, and let the masonry structure be arched over, so that the sun may not strike the water at all (p.244; p.179).

On the other hand, perhaps one of the most remarkable notes which serve the purposes of this research is conveyed such that every feature should collect water from those different pipes so that contribution to economic activity is achieved. It is meant that when houses can use water only from one of those three pipes, tax dependent contractors can be maintained or public baths can be visited frequently to yield annual incomes to the administration (pp.242-243; pp.178-179).

Stambaugh (1988) underlines that the first Roman aqueduct system was built in 312 B.C (p.130). The improvement of the system is confirmed by Landels (1996) noting the excellence of Roman water systems. Romans enabled the public to use the most strategic features such as the pools- “laus” and fountains- “salient”. Apart from baths supplying water from a second pipeline, houses are known to have had their own collectively used water network for which each resident paid a water tax (vectigal) (p.50). Rich and Wallace (1994) make additional remarks to exercise on baths that aqueducts were very central to the designation of bath locations in Roman cities. First, water had to be supplied to these vital features of the urban decoration. It was preliminary that they were to be provided with water since piping expenses of aqueducts were remarkable, in other words, luxury to serve everywhere in a city (p.222).

Parallel to this matter, however, as Landels (1996) continues, no exact derivation can be made concerning taps used in private dwellings. Non-emphasis by Vitruvius and Frontinus can somehow implicitly denote the existence of taps because if they were not used, then people would not arrange systems to enable water be discharged from gutter-pipes to basins and be sent to sewage systems (p.54). Stambaugh (1988) confirms the usage of tap water adding that it was dependent on the well-being of the inhabitants beginning from the 2nd century BC onwards. Evidence tells that they tapped their houses to public fountains by paying a certain amount while the less rich could also supply water by hiring contractors for private delivery (p.131). Likewise, as Alston (2001) mentions, financial contributions which were both made by higher officials and the rich in return for using water within their dwellings, must have attributed significant roles to major fountains. He strengthens the subject matter by giving samples from Romano-Egyptian cities that water collection by the citizens was usually potable, eventually being a critical determinant for district formulation in Roman cities. It means that districts were firstly created by zoning the shared spaces according to water supply. The author also writes about the usage of shared courtyards and narrow alleys which usually makes it difficult to separate public and private spaces. (pp.175-176). He argues that, the people of Alexandria districts shared facilities in the 1st century A.D under the Roman rule (p.165). It is only during very early Byzantine settlements in the Roman Empire that individual units were enlarged by intervening public spaces, most usually the streets, in which case such attitude is more peculiar to Egyptian cities. Evidence however tells that cities in the Near East had more clear gated neighborhoods with comparatively precise outlooks. Then significant neighboring as the author stresses for late Roman cities is also likely to be attributable to cities of the Near East (pp.175-177).

In the light of abovementioned information, utilization, discharge and recycling of water can be considered within the criteria which are to be set forth for the settlement strategies, as well. It must have been an important technical and economic burden to tackle ancient water management both in the public and private context. There is no reason why both did not apply the same methods.

To continue with the Roman aqueduct systems, Vitruvian thoughts help to understand more about piping systems. Morgan (1960) and Şevki Vanlı Mimarlık Vakfı (1998) mention the distinction made by Vitruvius with regard to lead pipes. A main tank is to be built at the supply source for this type of piping. Pipes, whose diameters are designed proportional to the amount of water to be carried, should be furnished from this tank to another tank built inside the city walls. If the slope between the city and the water source is regular, without any intervening hills, necessary substructures must be built, too. The same procedure can be applied even if there are still pit holes or cracks on the ground. However, water can be transported round circuitously when holes, cracks or pits are not that wide. When they are great enough and valleys are really wide, the water course should be directed down their slopes. As soon as the water reaches the bottom, a lower structure, the so-called “venter” can act to decelerate the rising water (aiming to reach the opposite side of the hill) due to length. It is known that venters rest in continuous and gentle slopes and are usually raised high above valleys and plains as in the case of Pergamon.

Pipes made of baked clay provide advantageous solutions for repair in case any damage, breakdown or fault occurs. It is also a healthier means of water conduct. When aqueducts can not be constructed or do not meet water requirements all the time, wells can be dug. Cisterns can be designed if the ground is too hard and veins lie very deep. They are activated by collecting water from roofs or higher platforms. Instructions are given such that the best and the clearest sand is searched for, lava is broken up into small pieces, lime and sand is mixed up in a mortar with 2/5 proportion. Walls are hammered and evened off until a reasonable level of resistant plate is reached. Such type of water collectors should be constructed in two or three segments because filtering from one segment to the other is critical for providing clean water, also because water shall be clear in a reservoir where the mud can settle (pp.244-248; pp.180-182).

In the ancient Near East, rainwater is known to have been collected for bathing, flushing drains and the like. Forbes (1993, v2) underlines the usage of masonry cisterns of considerable size including royal ones, during Assyrian times. They are fresh water suppliers which are sometimes found to have been sunk into rocky platforms to prevent pollution and designed like bottle shapes. Romans inherited similar designs which could be reached by stairs in some Mesopotamian cities. It is obvious that cistern construction practices come from ancient times (p.152).

Plommer (1973) refers to Palladius. His discussions about cisterns focus on availability regarding the landscape. He suggests that houses should be built on high lands in order to have access to quality water and not be placed in valleys where water is polluted. Elongated, covered and concrete-walled cisterns should be constructed in the absence of a water source like a spring or a well because rainwater is the healthiest of all. The main role of settling tanks and pipes which carry river water should be for washing and irrigation (pp.20-21). He emphasizes, also from the Vitruvian point of view, the vitality of clay pipe constructions in that an economical aqueduct of the Pergamon type is recommended. However, linked with views of

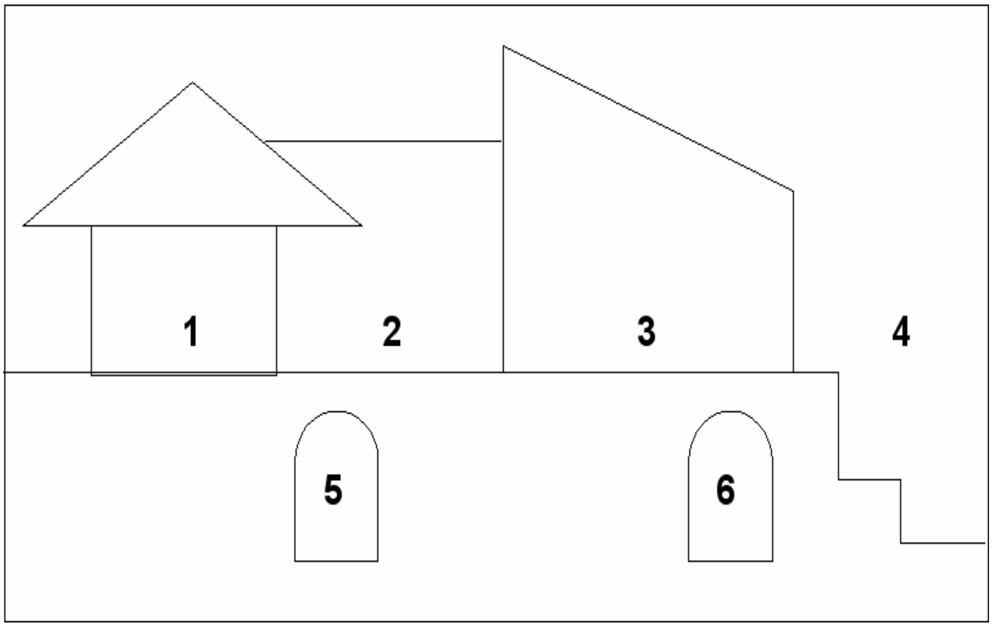
Faventinus, earthenware pipes should be more rustic without tongues but growing narrower from one end than those recommended by Vitruvius. Reservoirs can be placed along a passage, as well. The reason is that aqueducts can sometimes be interrupted to slow down water flow as springs may also dry up, so reservoirs can substitute the spring course (pp.29-30).

The Romans knew well the importance of water in a city. In Rome, all the aqueducts were diverted to the city at different elevations. According to Evans (1997), much older lines were constructed at lower elevations either because burying aqueducts underground was an easy practice against enemies or "fine points of leveling art" was not yet ascertained. The point is that whenever water came from higher elevations, lines usually ran together after they reached the city and fell into a pool within a short distance. When water came from lower elevations under less pressure for a longer distance, its delivery decreased due to the slowness of its passage. Its delivery must have been either decreased or supplemented within the city (pp.21-26). Therefore, secondary branch lines must have been added to low-lying parts of the aqueducts in later periods (p.71).

On the other hand, placement of water features particularly cisterns within the houses in the Roman period is strongly emphasized by Stambaugh (1988). According to him, cisterns were usually available in a Roman house. Houses were more or less in the standard Etrucsan style in south Italy, the so-called "Atrium" forms before 3rd century A.D. The "impluviate[4]" type of Atrium is known to have been suitable to let in sunlight and rain water some of which could be collected in shallow basins while the rest went to a basement cistern during overflow (p.162). Evidence for houses especially comes from the Republic period after 510 B.C. During this time, the lower class people lived in one or two chambered houses. These houses, usually attached in groups like rows and each opened to streets were used as work places, as well. Another house type is the construction on a narrow and long building plot which was reached through a corridor having two rooms on both sides. Soon after this corridor

[4] All the facades of roofs are inwardly sloped toward a "compluvium" which is a rectangular opening at the centre. The second type of atriums known as "displuviate" have outwardly sloped roofs to carry the rain water away.

and an inner courtyard, a transverse room under which a drainage pit lay, was adjoined to a garden via stairs at the rear (Figure 6.2). This transverse room was used as a kitchen, toilet, bath and a storage-room.



(Source: Stambaugh, 1988, p:167)
Figure 6.2 The simple Atrium form house in the Roman period (**1.** The two-three chambered house **2.** Courtyard, **3.** Transverse room **4.** Garden **5.** Cistern **6.** Drainage pit)

The courtyard between this transverse room and the main house with a corridor usually retained a cistern underneath in order to collect rain water which was conducted by pipes and spouts (pp.166-167). On the other hand, it is observed that housing forms gradually begin to change subsequent to degradation in the republican traditions. Housing, in late 2nd B.C during the Principate evolves from the atrium style to the widespread Mediterranean tradition of the open courtyard style. The completion of the adaptation to the Mediterranean style goes back to the 3rd and 4th centuries B.C (p.171). It was more fashionable for the upper class individuals while the lower class generally continued with one or two chambered houses. However, it is known that typical strip houses of the medieval and early cities of Italy were built, as well. Herculaneum represents this style best that houses had three courtyards in order to make use of sun light and provide space for cisterns (p.174).

6.2 Examples of Water Distribution Systems

It is deemed necessary, under the scope of this thesis, to try to understand the relationship between water systems and the urbanization process of a city whether the city as a whole or in part with its relevant features reached ultimate patterns. Since Roman periods provide the most sophisticated samples for water features, Parkins (1997) constitutes the links between urbanization and water, by putting water features together with others, as remarkable outcomes, into the urbanization process. He writes that the city is a vehicle for urbanization which is the acculturation and unification. He addresses the end of 1st century A.D when two views dominated to define the concept of a city. One is defined as a result of noticeable changes by the Roman period that the city is not only a symbol but also it is a definition of civilization. Including Vitruvius' works on defining the essences of a city by enumerating the necessary buildings, he rather refers to descriptions made by Panopeus that cities, by definition, are made up of agoras, fountain houses, proper water supplies and other various amenities such as theatres, baths, forums and civic buildings. They together give the vision of a city with strong walls and fortifications in urbanized areas (pp.22-23).

The importance of city elements inherited from Greeks and culminated during Roman times, continued in post-Roman times within somehow different scopes. Forbes (1993, II) notes that people became more dependent on wells, springs and rivers in many late cities compared to the Roman times when pure water was obtained far beyond the boundaries (p.179). Therefore, developments about water works in Roman cities are typical for the story of many medieval towns because some could keep the old Roman aqueducts more or less in repair while others sometimes built primitive kinds of aqueducts, the so-called "leats" that transported water from springs or rivers via open canals (p.181). Mundy and Riesenberg (1958) refer to a very crucial medieval advance which is the development of transportation by roads and rivers in continental areas excluding some important regions such as the Tigris, Euphrates and the Nile where very ancient societies already used similar methods. River canals were established where cultivation was made in valleys around the medieval towns. Such towns only and perhaps mostly experienced canal network building for drainage and irrigation. Resembling to those of the Romans, canal construction habits continued apart from less-river oriented coastal areas which were already opened by the nature (p 35). At the micro scale, the authors add that people of the medieval ages were also fond of developing their common spaces by building bridges and public baths. Very similar to Roman periods, penalties were imposed for neglect of roads and bridges, tolls were collected for their maintenance and for the construction of some other buildings, in return. Garbage disposition and open sewage regulation was subject to laws (pp.40-41). Such information closely finds its links with social aspects, anyway. These are all emphasized to clarify the common attitudes between the Roman and medieval cities which may lead to the idea that water systems of the medieval times in general, inherited the readily supplied water structures and imported technical knowledge from the Romans. The general practice of using pre-designed water features is a good standing point for the usage of older water features in Asia Minor cities. Because there is evidence for the inheritance of old aqueducts constructed by Greeks in cities like Sardis, Nysa, Ephesus, Pergamon, Smyrna and Miletus (Forbes, 1993, II). Although the example of aqueduct construction does not thoroughly fit to Hasankeyf considering its present condition, further discussions can be raised, as well. For example, construction of additional water features, especially in Upper Mesopotamian cities could have been eased by very ancient means of water transportation.

Considering the post periods, views of Frontinus are addressed for the occasional usage of siphons crossing sharp valleys. Siphons are transporters with the help of an aqueduct on tiers of arches bringing water to its own level. One satisfactory sample is the siphon system of Pergamon built during the reign of Eumenes II (p.168-171). At the very micro level, Uğurlu (2004) addresses the importance of the nymphae within the urban areas during the Roman Empire. These “passage architectures” are public fountains that served for the public amenity. Armatures facilitated the perception and visibility of the nymphaea and the urban landscape while the nymphaea helped the compartmentalization of land into meaningful wholes (pp.29-30).

Now that water is a crucial determinant in defining a city, samples from famous Roman cities in Anatolia are provided below as contributory texts with which

Hasankeyf data can be compared and ultimately discussed in seeking some estimations and conclusions. Contributory samples from medieval or Ottoman periods to demonstrate the continuation of water Roman systems in some special regions are also discussed at the end of this part.

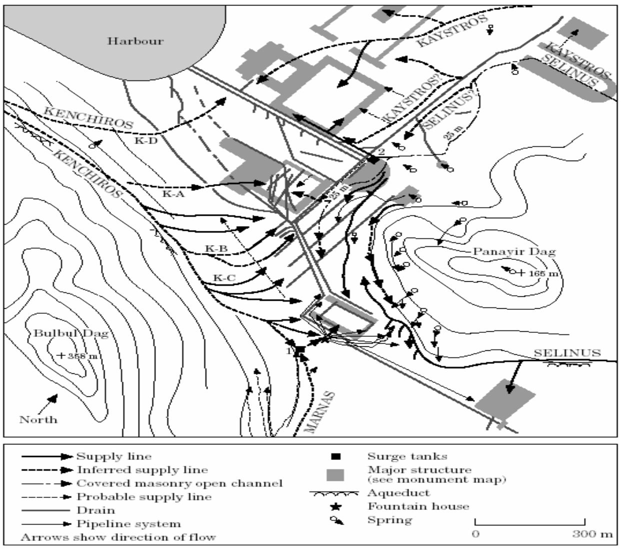
6.2.1 Ephesus

The ancient Roman Imperial city of Ephesus is located on the western shoreline of modern Turkey. Evidence is abundant for the ancient water distribution pattern of this city. Natural springs and wells supplied water starting from Mycenaean and Ionian times. Silting from Meander (Kystros) and Marnas (Klareas) Rivers led to several shifts on the overall settlement pattern beginning from the 2nd millennium B.C. Later, as the city developed and reached its Roman city pattern, a highly efficient water distribution, supply, storage and drainage system developed. Pipelines coming to the city from at least four major aqueducts (Kenchiros, Kaystros, Selinus, Marnas) were installed. Apart from those four aqueducts, the intercity distribution is not known thoroughly. It is certain that the system was based on terra-cotta piping with other supplementary stone and lead pipes (Figure 6.3). The city is established in a way that an obvious relationship between the natural setting and the urban growth in the Roman world is still visible today.

An urban water system analysis has already been made by Ortloff and Crouch (2001) with respect to the distribution of water to many public and private buildings. The analysis concentrates on baths, fountains, cisterns, single and multiple domestic units besides temples, agoras, stadiums, etc. (p.843). A note comes from Forbes (1993, II) that Roman engineers used lead pipes for the construction of pressure lines such as siphons while wooden or earthenware pipes were used to supply private dwellings with water. Similar materials are known to have been used during the middle ages, too. Earthenware pipes of Mesopotamia as in the case of Mari, still work perfectly today (pp. 153-154). The water system of Ephesus reflects outstanding Roman engineering techniques of the early centuries A.D. It is evidenced that a common reservoir house enabled various hydraulic head pools to activate water pressure and different flow rates through individual pipe lines at the city (www.homepage.univie.ac.at, 2004).

(Source: Ortloff and Crouch, 2001, p:849)
Figure 6.3 Pipeline segments with top air holes in Ephesus

Reconsidering Vitruvian notes about different purposes of each individual pipe-line in the multi-segment collecting tank (castellum) and their drainage, Ephesus possesses the distinctive features of the Roman water systems. As mentioned before, one set of pipelines supplied water to baths and public buildings while another did the same for residential areas in Roman cities. A third one was designed for fountains and public water basins. Ephesus water system is a distinctive design which very much resembles to that of Pompeii. Ortloff and Crouch (2001) repeat that the ancient water system features were long distance water pipes or open canal aqueducts which transported water from distant springs to collection basins. Other features were the castellum and distribution lines to fountains, dwelling areas, gutters and sewers for site drainage (See Figure 6.4). An important category was on-site wells and cisterns (p.845). Full flow rates were maintained via mildly sloped constructions and submerged outlets, particularly for shorter pipelines and castellums as far as destination and source were subject to hydraulic designation. Flow rates were supported with relatively steeper slopes for longer pipes. The castellum, designed according to the pipe slopes, enabled high and low head tanks to achieve tailored flow rates to other structures. Flow rates could be kept constant with the help of top air holes on pipes (p.849).



(Source: Ortloff and Crouch, 2001, p:853)

Figure 6.4 Water distribution pipeline and drainage system of Ephesus in the Roman Imperial period

According to Ortloff and Crouch, on the other hand, the drainage system could have retained large masonry open canal flow systems for the discharge of spring and aqueduct supplied water as well as for rain runoff. However, problems due to steep sloped position of Panayırdağ which fed the surrounding springs were overcome by constructing brick vaults underneath some hillside streets on the mountainous sides of the city. Drainage problems of some very specific features where large volumes of water were used as in the case of baths, were eliminated by optimization of flow rates in the pipes (pp.854-857).

6.2.2 Pergamon

It has now become more apparent that open canals were preferably constructed during the Roman period. Landels (1996) notes about the signs proving the existence of an impressive closed piping system in Pergamon. The system dates back to the reign of King II. Eumenes in the first half of the 2nd century B.C. However, uninstallement of the previous system and hence a shift to an open canal system constructed between two valleys supported with aqueducts and with a tunnel passing through the hill in between these two valleys during the Roman period is no chance (pp. 48-50). A siphon system was formulated in Pergamon in order to pipe water from a source of 375 m. above the sea level to distribute it to the city. White (1984) emphasizes that siphons were not very common features. The original siphon system was probably taken over from Greeks. It was later modified by fixing the point of delivery very below a summit and the upper parts of the city was supplied with water by being pumped up from a reservoir at the point of delivery (p.162).

Presumably, cisterns were vital features, designed and scattered around the city to store water in large quantities, especially under courtyards or adjoined spaces in housing areas of Pergamon. Crouch (1993) underlines the contributory role of cisterns of Pergamon to its defensive strength. Supplied with long distance aqueducts and a siphon system, cisterns suggest a complementary side of the overall water distribution system (p.113). Radt (2001) sets forth that collection of water must have been a strong requirement in cisterns since excavations proved no water source at the upper city and the fortress. Rain pipes within which water was collected from ceramic roof gutters were used. Hellenistic cisterns, generally carved into rocks having pear-like sections and plastered were constructed with very fine isolation techniques as the most famous types. Most frequently reused private ones can be dated to the Roman period while very few go back to the Byzantine times. In addition, those which served for the public in the form of fountains are very scarcely encountered. It is another probability that deep wells, as stated in the Astynomia inscription, were present in rural areas at lower elevations of the city. Similar to those regulations of Rome, water is evidenced to have been subject to laws. It was obligatory to clean up canals or protect and maintain them in original conditions not to cause any leakages (pp.145-147).

Since there was no water up on the hills in very ancient times, fountains discovered over the roads served as another source after water canals had been activated. It is supposed that a water way, formerly fed by the Selinos Plain in the western part of Kale Mountain (part of Madra Mountain line), carried much in quantity to the city fountain which is a real huge and impressive rectangular gallery on the main street. Pipes and tiles on which they retained seals and the technique of construction, most likely prove that the abovementioned water way, the so-called Attalos line, was designed in the I. Attalos period. In the light of excavations, another water way, differently sealed from that of Attalos line, is deemed to have been equipped with two pressure pipe sections which provided water for Hellenistic baths. Although both water ways seem as experimental remains, the second water way goes far beyond the first one in certain technical respects (pp.148-149). Technical details are not given for the purposes of this study.

It is now known that, as the water requirement increased in the Roman Period (most probably during 2nd and 3rd centuries A.D), new water ways had to be created. Radt puts forward that pipes and unusual water tunnels of the late Roman period which transported water from Geyikli Mountain and stood right in the western part of Pergamon, were particularly important for the Asklepion Sacred Area and its environs. Huge Roman aqueduct networks transported water to districts at the foot of Geyikli Mountain. On the other hand, three lines of water network which are dated to the Ottoman period do not match similar periods. Water could have been brought via less sophisticated techniques from more proximity areas of the Geyikli Mountain and Selinos Plain (pp.152-155). Plommer adds (1973) that the well-known stone aqueducts which were laid down on the ground in the Hellenistic period were replaced by a Roman arched structure across the lower part of the valley in its final condition. The structure resembles a venter which was described by Vitruvius (p.29). The point is that with the introduction of new water ways, any distant transportation network eventually resulting with cisterns provided less advantageous conditions both for public and private areas because evidence tells that not every dwelling site retained satisfactory water reservoirs with the end of the ancient period, in particular.

6.2.3 Side, Aspendos and Perge

The canal system and the bridges assisting canal extensions are worth emphasizing for Side. Multi-tiered bridges including single-storied ones are part of those Roman aqueduct systems which were used to cross lower areas (www.waterhistory.org). Mansel (1978) writes that Side was rich in water sources because Manavgat Stream (Melas), fed by the spring waters of the Taurus Mountains, was an important determinant in providing the necessary volume to Side and its surrounding area. In the Roman period, water was transported to the city from approximately 30 km. It was brought via an open canal of 2,70 km long and a closed structure of 1,30 m width, entering galleries and tunnels engraved on the slopes of hill ranges. Galleries were constructed in a way that they lay just parallel to Melas so that water could easily penetrate in them which were engraved in hard calcareous layers in herringbone patterns or in half ring forms on the right and left hand sides. With the help of galleries, water followed a rough topography and finally reached Side.

The water distribution system also retains some secondary canal remains near the main canal which were probably used for the irrigation of plain lands. On the other hand, 24 water bridges of various size most of which are single-storied were constructed on uneven lands. Bridges on rough lands were constructed with hard materials such as sandstone and conglomerate in bond techniques to prevent flooding and heavy rains whereas no remarkable fussiness as to stone work and construction material is observed pertaining to those built on plain lands (Figure 6.5).

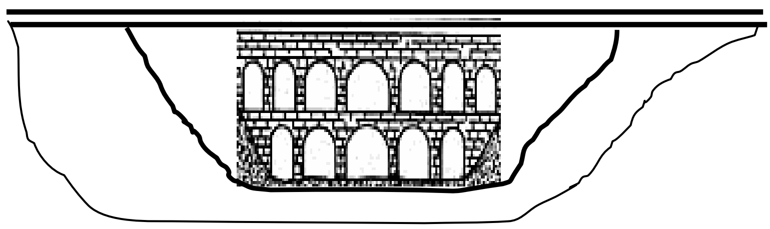


Figure 6.5 Multi-tiered bridges as part of the Roman aqueduct system in Side

When it comes to internal water systems, canals crossed over shallow hills, flew over a bridge near city walls towards the western direction and arrived at a rampart with an ultimate bridge. A thick steal or terra-cotta pipe departing from the main canal stretched out in the eastern direction to feed the monumental fountain (nymphaeum) standing out of the city gate. The nymphaeum wall retaining a pond in the front facade is one of the representative structures of the Roman period. Besides its monumental effect, main function was to provide water to inhabitants whom had no water at their dwellings. Canals made of sandstone departing from the rampart and passing over a bridge and then massive walls or arches finally reached cisterns which lay in the southern direction and in parallel with the coastal area. Since the width of the main street of Side is in between 9-11 m, it was probably a requirement to place an open canal on both sides of the street to discharge excess water collected in the nymphaeum. On the contrary, for instance, the water canal in Perge passes across the middle of the main street which has a width of 20 m.

Plenty of wells within the settlement area and street porticos were discovered in Side. These wells could have substituted malfunctioning water canals in later periods or they could have served in case water was cut off. Open and closed cisterns were also of great importance, particularly in late periods. The great cistern in Bishop's Palace can be a nice indicator for this reason. Two cisterns with some additional ones at the main columned street- the narrowest part of the peninsula- which served as large ponds to collect water from bridges and then discharge it via underwater canals and terra-cotta clay pipes, probably go back to the Roman Period (pp.79-108). Moreover, small and medium sized nymphaea can easily be seen especially in front of the facades of the cisterns. Cisterns must have served as significant architectural features in this city which was really rich in water.

Initially founded as a Hellenistic colony, the 3rd century B.C Roman city of Aspendos in ancient Pamphylia is located about 50 km east of Antalya and 12 km north of the Mediterranean (Ortloff and Kassinos, 2003). The importance of Aspendos can be attributed to its position on the Mediterranean commerce routes (since Strabon[5] well emphasizes) as well as on the Eurymedon River where the Mediterranean access was easier.

Aspendos is one of the most famous examples of Roman water systems. The water practice is best expressed by a siphon system which is 1.67 km long consisting of mainly a header tank, two separate elevated tower basins and a receiving tank (Figure 6.6). This is an interconnected system of 30 cm wide stone pipes which, in line with Vitruvian view, was used both for impulsive and slow-filling water supply from a distant spring. Roman engineers constructed three inverted back-to-back siphons in Aspendos which employed two water towers. It is very important to record that siphons were generally constructed when there were steep valleys over which water had to flow. The water distribution system was designed in a way that

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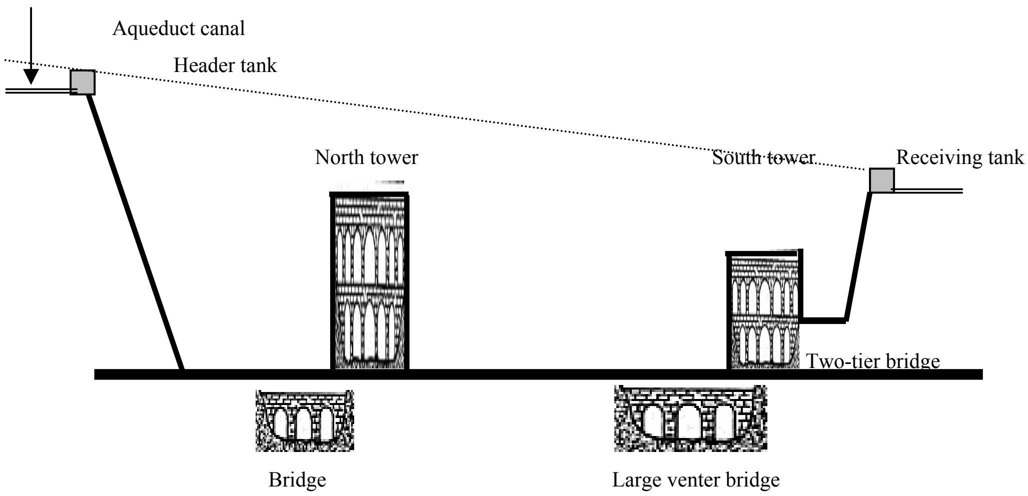
[5] Başgelen, Nezih. "Strabon-Antik Anadolu Coğrafyası". (Book: XII-XIII-XIV). *Arkeoloji ve Sanat Yayınları*. Antik Kaynaklar Dizisi:1(2000): 249. Kanaat Basımevi, İstanbul. (Strabon XIV.4).

approximately 3200 cored blocks whose end points were cut to form socket attachments, comprised the total pipeline. Water arrived with an aqueduct canal and reached the shallow header basin standing on a 14.5 m higher platform than the receiving tank. Then, single or multiple tier arched structures supporting horizontal siphon pipeline venters and two elevated tower basins facilitated the transfer of water with regard to oscillatory behaviors. During hydraulic analyses, it was understood that 3 cm holes which were opened on the stone pipes (the possible so-called "*colliquiaria*") permitted the occurrence of air and water leakages. Thus, turbulences inside the system were prevented. Vitruvius is also known to have recorded the same techniques (pp.417-421).

Although the hydraulic mechanics of Aspendos siphon system is quite complex, a simple visual explanation is provided in Figure 6.6 in order to give some insight about how the water was pressured to a higher elevation.



(Source: Ortloff and Kassinos, 2003, p:419)
Figure 6.6 The Aspendos siphon system with successive towers and bridges

The success of the Roman Empire in water distribution system of Aspendos is very obvious and instructive that the system functioned effectively for several years so that fountains, baths and housing areas could be provided with water continuously.

Perge which is one of those big ancient cities of Pamphylia such as Side and Aspendos, lies within the borders of Aksu, Antalya (Büyükyıldırım, 1994). Water was first brought to districts from short distance sources or underground waters and then it was collected to be discharged with the help of ancient canals. Pools, cisterns, wells and other collection elements acted as the basic features for water distribution. Cisterns were generally placed on the acropolis which has an elevation of approximately 60-70 m. Therefore, water could not be distributed to this part of the city. Rain water was used instead. As a result of increase in the requirement for water and change in the natural factors over time, distant sources were searched for and canals were constructed during Roman times. Canals were also used in the Byzantine period and post-periods. Traces of canals provide clues for the in-site distribution of water (pp.123-124).

The placement of canals within the city shows that the nymphaeum in the northern part of the city was the first hand user of water because the starting point of open in-city canals can be seen in front of this feature. Water flew from higher elevations at the maximum extent in accordance with the topography in open canals throughout the city. The reason was the climatic conditions to provide the inhabitants with refreshing feelings. Water which ran through the northern nympheum towards the main street reached the agora at the end. The canal bringing these waters was placed in the middle of the main street. Another canal which was perpendicular to the canal in the middle of the main street ran along a wide street in the east. Water was supplied to workplaces on the main streets through inferior pipes and via canals placed at the bottom or sideways of canals. There were also underground canals lying just beneath the surface canals. They acted as the sewage system of the city which collected waste water from underground pipes extending from the surrounding houses, work places and baths (pp.148-151).

6.2.4 Antioch Psidia

Antioch Psidia, an ancient province of the Kingdom of Cappadocia which was an ally of Rome, is within the borders of modern Yalvaç, Isparta. It is close to the Mediterranean in the northern shore of Lake Eğirdir which falls the south central part of Anatolia. The city was supplied with veterans in the first half of the 1st century and reorganized in the Roman fashion.

Sultan Mountains were the main source to provide the Psidian cities with water. A large u-shaped building transferred water to the fountains via aqueducts with lead and stone pipes. Rounded stone arches transported water from Suçıkan source at the foot of Sultan Mountains which now also provides water to modern Yalvaç. An average slope of 2.6% due to 287 m difference of altitude between the source and the nymphaea must have created a great pressure on the overall aqueduct system. Therefore, the volume of flow was lowered by phases and controlled by siphon aqueducts at the end of the system (www.en.wikipedia.org).

The ornamental fountain and sections of water pipes shows that water was delivered up to the level of Platea Tiberia (Owens, 1997). Stone pipes running across a roadway to the west of the agora and individual stone and lead sections in various parts of the city were part of a pressurized water network. The T-junction formation of several stone pipes reveals that water was distributed in two directions at the city. The section of the pressurized water system found in situ in the Platea Tiberia explains that one section of the stone pipeline ran in the north-south axis across the top of the platea which is near the Temple of Augustus while the other line stretched from the first line towards the west. Smaller pipes were split from the western oriented line and supplied water to small shops and offices near the platea. On the other hand, there is evidence for underground distribution of water. Water was transported upwards with smaller holes which pierced the upper surfaces of two stone pressure pipes in the platea and the western water line (pp.317-318).

Uğurlu (2004) explains that cardo and decumanus maximus formed the backbone of the city armature within which three main fountains were built. One of them was placed in the west, the second at the junction of main streets and the other at the end of cardo maximus. All fountains were designed to stand at the most important nodes of the city (p.37). Therefore, main features of the water supply system of Antioch Psidia were complemented with three nymphaea.

The semi-circular fountain on the western gate provided a psychologically refreshing view, an aesthetic appearance and a first-hand supply for the visitors while the one in the southeast end served as a traditional architectural element for the citizens. The nymphaeum placed at one of the highest points of the city at the end of decumanus maximus served to visual functioning of the city against the undesirable appearance of the aqueduct (p.40).

The bath of the city which resembles the one discovered in Sagalassos of Psidia is in the northwestern direction. Although its plan is yet unclear, it presents a plan of the arched colossal complex. However, the complex leaves doubt when the entrances lie in the west and northwestern directions because a general tendency is well accepted that entrances are built in the south and east due to wind and sun factors in Anatolia. On the other hand, the possibility of the existence of a water supply and a heating system is low due to weak traces. Moreover, the slope of the platform on which the building stands gives the impression that the complex was a foundation for another type of building as if it was at the lowest elevation above the arches of the possible main building. The complex is accepted as a bath anyway, also because a reasonable distance between the nymphaeum and the bath can be observed easily (www.en.wikipedia.org).

Among other Psidian cities, for example, Termessos has a very perfect location in a valley of 1050 m up in the Taurus Mountains. As Uysal and Buyruk (1986) explain, water was collected via triangular spaces in a tank wall from the surrounding springs on top of the steep hills where a high level of civilization was achieved in such a difficult city plan. Plenty of cisterns almost everywhere in the city constitute an important portion of the water collection system although they are considered as subsidiary features. This was due to inadequate number of springs to provide the city with water. Therefore, cisterns acted as substitutive features for rain water collection (p.38).

6.2.5 Syria , Jordan and Iran

Qanats, the so-called Roman canals, perhaps constitute the bulk of water utilization systems in ancient periods of the Near East. They are especially encountered in Damascus, Selemiya, Palmyra, Qadeym, and Taibe. Qanats vary in shape, size and method of architecture and there are plenty of them all over the Syrian lands. Most of them were constructed beginning from the 2nd century B.C. Still, Roman ones are alleged to have belonged to the Persian period. Persian styles leave no argument that they were also imported by the Greeks (Lightfoot, 2005).

Rainfall and evaporation are two important criteria to comment on water management systems in this part of the world. Semi-arid regions where 100-300 mm annual rainfall is observed on average were always preferred to construct qanats. As water easily evaporates in such climates on the surface, areas with high tendency for evaporation were more dependent on subterranean water systems. It appears that all qanats were constructed at or below 500 mm isohyets. Therefore, wetter areas were disregarded for qanat construction in ancient Syria. Consequently, since rainfall diminishes in many parts of Syria, underground piping becomes very vital for a remarkable number of regions.

When it comes to topographical determinants, wells are more frequently observed on flatter terrain whereas qanats are found on alluvial fans and synclinal bedrocks at the foot of mountains, hills or along valleys. Plenty of qanats were built in calcareous deposits such as calcium carbonate and silica formations. They were tunneled through solid beds of chalk and limestone. Rock type is similar to the case of Hasankeyf from this perspective. Moreover, as stressed by Lightfoot (2005), qanats were central to life in many settlements. Numerous laws were created to regulate the construction and maintenance of water systems during Roman times. Cities, thus qanats were abandoned when a water table dried up (www.waterhistory.org).

For some further remarks, Jordan, with its geographical proximity to Hasankeyf in Mesopotamian lands can be evaluated within the regional context because it provides striking evidence on the uniqueness of ancient water systems (Lenzen, 1996). Capitolias (modern Beit Ras) is one of those special ancient settlements which gradually changed beginning from Roman times. The city, at the minimum planned in a similar fashion like Hasankeyf, was constructed on a bedrock outcrop. Water features such as rain run-off canals and cisterns were originally cut like pockets in the bedrock, enlarged by chiseling and plastered. They are perfect indicators for human adaptation to the environment. The city enjoyed one of its golden periods during early Ottoman reign when plastered and randomly sized stone walls were used to subdivide cisterns. However, pipes and a sewage system were exceptions that they were not used. Also, since no housing areas were excavated it is really difficult to draw some conclusions for water utilization practices. It would perhaps not be wrong to assume, in the light of pottery pieces for water jars, that relevant household activity was based on the transportation of water from a central reservoir. Traces of a lower aqueduct which was constructed in the 4th century B.C give the impression that the aqueduct must have assisted the transfer of water to the cisterns and the reservoir (pp.13-15).

Nydahl (2002) focuses on Humeima and Nakhl desert sites where studies on the water systems of the Nabatean civilization in Jordan around 5th century B.C have revealed some evidence. Humeima where the average rainfall is approximately 80 mm per year has an outstanding aqueduct (Ain al-Quanah) which is about 19 km away from a spring to the settlement area. After being carried by Ain al-Quanah, water was collected in two reservoirs one of which belonged to the Roman period and sent to conduits. It was then distributed to 11 cisterns within the settlement area and 51 cisterns outside the settlements' catchments areas. Only 19 cisterns out of those 51 are original while the rest are either rock-cut or roofed and unroofed. The settlement area, with 2 sets of conduits or drains fed 2 main cisterns which had almost equal sizes at the centre of the city. Nydahl infers that these public cisterns (with a volume of 445 m^3 and 486 m^3 individually, as mentioned before) were built at the same time. On the contrary, almost all of 9 cisterns which have the capacity to collect less than 200 m^3 of water have circular shapes which indicate private usage when compared to 2 large cisterns (pp.19-24).

Nakhl, is a nice example for dam usage in the Roman and Byzantine periods. Water which was brought from Wadi Nakhl to low level dams was channeled to cisterns by surface run-off (p.25-26). Cisterns played important roles on these dry lands since early bronze ages. Over time, Nabataeans developed the Edomits' typical rock-cut and bottle shape cisterns whose diameters were 3-4 m wide at most, with very narrow necks. It is one interesting thing to note that Edomite types of cisterns were generally cut into bedrocks with canals so that water could be taken inside with a draw hole or intake (p.33). However, 1st and 2nd century B.C are resumed to be development eras for the emergence of new techniques until Byzantine periods. As the population grew and catchments areas of a city became larger, it was more difficult to tackle excess flow of water into cisterns. Containment walls or canals cut at the edges of bedrock slopes which were most commonly used by the Nabataeans had to be enhanced by piling stones in many slopes that were filled with gravel. Such stone piling technologies gradually developed around 1st century B.C and A.D in catchments areas where bedrocks were not dominant on the topography and could not form natural run-off areas. Among all, the most central aspect for this research, however, is the practice of small canal construction to direct water to cisterns during Nabataeans' reign. (pp.34-36) Bedrock-cut canals functioned to take in small amounts of water run-off whereas those made of sandstone blocks were used to collect water from roofs or pavements. Sandstone blocks were widely used from 1st century B.C through the Byzantine periods, to bring water from springs. What was different from the canals of Romans and Byzantines is that the Nabatean canals were designed on ground levels which were associated with the amount of available water flow. Construction of small canals has also been associated with the flexibility of water distribution that such conduits could make sharp turns when necessary, in reverse to Roman types. Moreover, strict water usage from public cisterns has strengthened the idea that open cisterns were either used to water animals or they were filled by the people manually. Roofed bedrock style cisterns began to change from the beginning of 2nd century B.C and took the form of waterproof ones. They were built of stone-cut transverse arches which had intake canals with settling tanks that probably let debris settle in the said tanks (pp.35-39).

The ancient Nabataean city of Petra in southwestern Jordan is very famous with its water features especially those cisterns and continuous flow pipeline systems. The origin of the city is dated to 300 B.C. It was later occupied by the Romans starting from 160 A.D. It was besieged by the Byzantines in the 7th century completing its history. The city possessed sequential settling basins to purify potable water, open canals for pressurized water to meet the maximum carrying capacity and cisterns some of which were subterranean. The system, according to Ortloff (2005) maintained constant water supply during wet and dry seasons. As the elevation of roads dropped, water pipes dropped slowly to keep water pressure at the optimum degree (Figures 6.7 and 6.8).

Figure 6.7 Views from open stone canals and pipes of Petra

Large numbers of cisterns were not constructed before the Iron Age. It was only after the invention of watertight plastered cisterns that people began to settle in mountainous settlement areas. The intensive use of cisterns was introduced in Mesopotamia and especially in Jordan lands in the Greco-Roman millennium between 332. BC and 640 A.D. The following intensive cistern building is dated to the Crusader and Mamluk periods between 1100-1516 A.D. Capitolias is a typical site for this era. However, there is little information to comment on the development of styles and types of cisterns in this region (Sabour and Vikor, 1995).

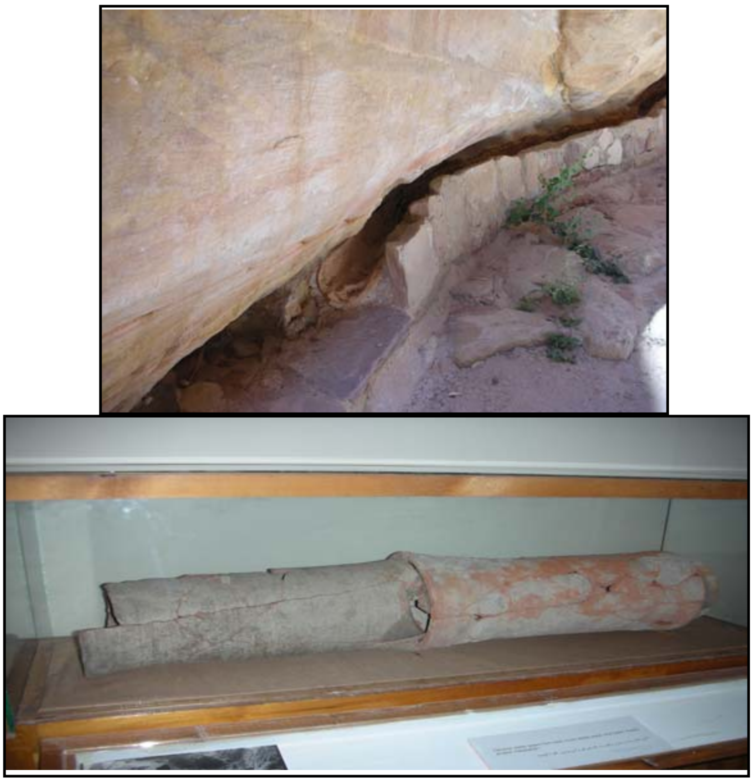


Figure 6.8 Views from terra-cotta pipes of Petra

English (1998) explains that the Iranian plateau was one core area for the construction of large numbers of water features. Information about the large numbers of qanats which are dated to the Sassanid civilization comes from pre-Islamic periods. Sassanids inherited the highest achievements of the Persian civilization including water systems in Iran between 3rd and 7th centuries A.D. Shushtar, Yazd, Tehran, Hamadan and Nishapur were some of those cities which tackled water distribution with the help of qanats. The qanats played important roles in defining the location of settlements and street patterns within such large cities. Water flew beneath domestic quarters and staircases usually reached down to waters via a surface (*payab*) at a public cistern. Public cisterns were generally placed along major streets which in turn affected the physical layout of a city. There were also private cisterns for domestic usage. Wealthier houses had special rooms beside underground water tunnels. Seepage, water loss by evaporation and domestic usage sometimes reduced the amount of available water to the lower parts of a city. Therefore, a public cistern was often located at the highest elevations. Water was then directed to baths where maximization of communal use was encouraged. Water was divided within a city and there were rotation periods to distribute it to different parts. Consequently, topography, water availability and quality were important determinants on the construction of water networks in Iran (pp. 198-200).

6.2.6 Zeugma and Rumkale

Satellite remote sensing applications carried out under the direction of the Institue de Geographie et de l'Amenagement de l'Universite de Nantes (IGARUN) have revealed significant clues for the existence of aqueducts in the city of Zeugma on the eastern bank of the Euphrates (Comfort, 1997). It has been observed that ancient large pipelines which probably belonged to the 1st century Roman period followed the contours to bring water from a spring source in the northern part of Zeugma. It was one finding that double inferior pipes were embedded in concrete. A second water source was also diverted to Bahçedere with the help of an ancient underground reservoir and stone pipes which are associated with a spring. The overweighing assumption is that water could have been brought to the city firstly by being raised with an aqueduct or with the help of a siphon and then through pipes which initially served the city and the baths in the east (pp.10-11). Rumkale which welcomes the northern bank of the Merzumen tributary and has the famous medieval castle keeps an aqueduct, as well. The aqueduct, partly seen open and partly observed in tunnels was probably fed by the spring waters of a mountain in the north. It has been reported that ancient bridges contributed to water transportation in this part of the Near Eastern lands (p.13). It can now be further questioned whether other ancient cities applied similar techniques in the vicinity of this region of Asia Minor.

6.2.7 Constantinople

The water supply in early medieval ages was very much dependent on Roman water systems, particularly in big ancient cities. Bono, Crow and Bayliss (2001) divert the attention to the importance of the water system of Constantinople. Today, it is known to be the best example for the longest water supply line of the ancient world. Citing to the results of the Anastasian Wall Project[6], water which started to travel more than 250 km from the springs of Istranja Mountains in the western part of modern Vize, was supplied by 30 water bridges made of stone and underground tunnels to the centre of the city. Grand baths and monumental nymphaea met the requirements of a big population. The archaeological investigations on the 6th century A.D enormous aqueducts and subterranean canals within the Thracian hinterland have revealed that bridges found around the contours of the hillsides were cut and roofed with stone vaults. Also, tunnels were made of limestone blocks.

It has been another discovery that parallel aqueducts formed the backbone of the water system. A striking point is the existence of a narrower second canal near Kurşunlugerme with high-level and low-level aqueduct systems. However, it is still questioned whether this second line which is dated to early 5th century A.D. was adjoined to the main line. Furthermore, it is unknown whether the 5th century high-level aqueduct system replaced the main canal line. One clear thing is that the high-level system of the second aqueduct was used as part of the low-level system in 4th century A.D. The abundance of springs makes the overall situation difficult to come up with conclusions for a possible relationship between the main and second canal (pp.1325-1329). Instead of sharp assertions, the authors denote the improvement of Roman water features in the Byzantine period, by replacing certain features with the older ones. It has been reported that the success of the city was due to natural factors in any period. The availability of karstic properties of the region turned out to be an advantage for Constantinople to distribute water to the inner parts. However, because of great differences in the discharge of springs between summer and winter times, karstic springs near Vize were the target area to supply the main canal with continuous water. The discharge of perennial tributaries in dry times were compensated by those karstic springs of the Istranja Mountains or linear springs in plains which utilized ground water seepage reaching river beds. The so-called Yerebatan cistern which was constructed in 6th century mainly served to collect water in dry seasons (pp.1330-1331). Numerous water storage features are yet unknown in

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[6] The Anastasian Wall Project investigaiton was carried out by Professor Kazım Çeçen. The research aimed at studying the long distance water system of ancient Constantinopolis. The relevant publications on the subject matter were made in 1996.

Constantinople but cisterns are likely to have served the public with the help of hydraulic control. Consequently, the “filling” activity was deemed to be the basis for cistern usage. Therefore, cisterns must have been refilled at night times in consideration of the extravagant usage of water in daylight activities. Constantinople was a city where water was supplied from plenty of resources most of which are still unknown. Evidence for distribution within the city is additionally poor (p.1332).

6.3 Comparison of the Water Distribution System at the Upper City of Hasankeyf with Roman and Medieval Samples

The canal system of the Upper City in Hasankeyf can roughly be dated to periods very much later than the second half of the 4th century B.C. if it was introduced under the Roman rule. It is an archaeological fact that Romans arrived at Asia Minor in 191 B.C. The establishment and culmination of Roman cities on these lands are dated to 1st and 2nd centuries B.C. The reasonable period in which the Romans could have launched a water system should be much after than the 1st century based on the assumption that it is not a sudden movement to reach the very eastern borders of Asia Minor, passing over the fertile lands of the resistant western populations. Roman cities are equipped with very well established water features. Should the basis of the water system of the Upper city go back to periods earlier than the Romans, then the following discussions are made for those periods.

Differences between the water features of Hasankeyf and Roman cities are not assessed in this study. Rather, similarities of water features with those of Roman samples are reviewed in order to base the Upper city specific discussions on already evidenced cases.

Canal extensions of the Upper city are dependent on the gravity flow across the scarp, similar to the placement of canals in Ephesus. Likewise, the practice of using hydraulic pools (Forbes, 1993) to pressure water to the city seems to be associated with the probability of raising water to the Upper city. The pressuring could have been achieved at different rates through individual pipe lines or via canal extensions. Or, flow rates could have been regulated if segmentation of pipe-lines was a general strategy of water distribution. White (1984) writes that 40 percent of water was allocated to public buildings, fountains and baths and 38.6 percent was consumed for domestic or industrial usage in Roman times (p.168). Leaving aside questioning the remaining 21.4 percent and accepting 38.6 percent for private usage in Hasankeyf for a while, there could have been a periodic water supply within a day or a week throughout the city if there was any strict water management to sustain even a moderate population.

It seems that the siphon system was constructed in the same manner with the one in Aspendos. Now that evidence tells, siphons were constructed on steep valleys (Ortloff and Kassinos, 2003), the siphon system of Hasankeyf imports more or less a similar design of those outstanding systems of the Roman style. Pergamon aqueducts were constructed between a main water source and a pool with open canals (Landels, 1996). Terra-cotta remains tracked on earth-fills between the main open canals which are out of the borders of the Upper city and the Pool bear a striking resemblance to the logic behind constructing aqueducts for easy conduct of water. Addition of supplementary branch lines to increase the passage of water by aqueducts on low elevation grounds in Roman times (Evans, 1997) may help to question the reasons behind the construction of discrete walls running towards the southwestern canal extension at the Upper city. Although it is highly possible that the wall is late, the idea could have dominated in many periods. Walls could have been the latest expressions of water raising techniques. Also, cisterns placed under the courtyards or in adjoined spaces in the residential areas can refer to the common fashion observed at the Upper city (Crouch, 1993). Being located at the hilltop with no water source (Radt, 2001), the upper city of Pergamon could have been the initial place for water features such as the cisterns. The houses built on higher elevations could have been the first districts for cistern use before the city developed outwards. Similar case may be attributable to the Upper city of Hasankeyf. Hellenistic plastered, rock-cut and pear shape cisterns of Pergamon (Radt, 2001) can be a standing point to understand the logic behind the construction of Hasankeyf Upper city cisterns in the same fashion. However, the extent of such analogy should be limited with shape since cisterns of Pergamon were inherited by the Romans. Moreover, Forbes' (1993) stress on the importation of Assyrian cisterns which were embedded in rocky platforms and reached with the help of stairs by the Romans in Mesopotamia can enlighten the cistern specific side of this study to some extent. On the contrary, deep wells of Pergamon (Radt, 2001) which were placed at lower elevations of the city can remind the poor number of well-like features at the Upper city while main discussions are based on the placement of wells at the lower city of Hasankeyf due to easy access of underground water levels.

Small pools to collect and discharge water found in Side (Mansel, 1978) bring to mind a reason for the construction of a small pool in D78 unit although it is the only evidence. However, keeping in mind that very little number of cisterns is one fact in Side when compared to Hasankeyf, non-construction of more pools may seem reasonable. Likewise, the placement of cisterns at the acropolis in Perge (Büyükyıldırım, 1994) suggests that potable water could have been used in houses at higher elevations where water could not have been distributed easily in early periods. Increases in the requirement for water could have led to alternative water transportation via canals if there were any. Open in-city canals of Perge (Büyükyıldırım, 1994) which distributed water from higher elevations provide some clues for similar type canals of the Upper city.

The presence of inferior pipes (Comfort, 1997) embedded in concrete in the famous Roman city of Zeugma can be another reference to establish a link for small canal remains of the Upper city. Despite weak evidence, Rumkale which is established in Upper Mesopotamia can be one of those potential areas of research to be further studied in terms of water distribution systems because it has geographical proximity to Hasankeyf.

As an extension to the points made, the fact that evolution from the Atrium form house to the Mediterranean style beginning from 3rd century B.C in the Roman period did not affect the lower class peoples' houses in the form of one or two chambered rooms reminds of the current condition of Hasankeyf rock-cut houses. One change is known to be the new open courtyard style. It may be that no remarkable change occurred in the position of cisterns when the closed courtyard of the Atrium style transformed itself to an open air silhouette (Stambaugh, 1988).

Optimum space allocation for cisterns, most reasonably the courtyards, could be regarded as a requirement in settlement areas where houses are ranged in very close positions.

Although two lines of stone piping of Antioch Psidia were designed in the opposite directions, the separation of smaller pipes to feed the small work places near Platea Tiberia point to the importance of water supply to strategically important districts (Owens, 1997). Regardless of elevation, those districts could have been the ones in the vicinity of Ulu Mosque with houses having converted cisterns at the Upper city of Hasankeyf, probably in late periods. However, no assumption can be made in relation to an aesthetic entity at the city. Many cisterns which have different shapes are all stone-cut without fine decorations. Generally, cisterns could have been used extensively in high elevation cities like Termessos. Extensive cistern usage could have been inevitable means in cities which have higher elevations up in the mountains or that were reached hardly (Uysal and Buyruk, 1986), like Hasankeyf.

The cities of the Near East were usually supplied with water from the surrounding waters of the Mesopotamian rivers or wells (White, 1984). On the other hand, cities of Jordan, Syria and Asia Minor which were set on hills or inner regions generally supplied their water from springs in valleys. By this way, sources were protected with the help of water tunnels which were accessed from defensive perimeters in war times. More mountainous regions like Iran or highlands of Upper Mesopotamia used more sophisticated means of water transport in the form of long distance subterranean water tunnels in the name of qanat and distributed water to densely populated habitations as a general practice (p.158). Meanwhile, the widespread use of cisterns in any region can be attributable to increases in population whether water was obtained from springs, wells or very near resources. Whatever the sources were, they had to be kept from contamination (p.168). Cisterns, in any case, were practical collectors of water especially in arid climates or cities in which division of water was an attempt to provide dwellers with water at the minimum extent. The adaptation of original cisterns to the environment by being cut in bedrock and then plastered in Capitolias, Jordan (Lenzen, 1996); the abundance of smaller volume cisterns in the residential areas of Jordan deserts and small canal extensions to transport water to cisterns (Nydahl, 2002); and open and continuous flowing canals accompanying different elevations in the ancient Nabataean city of Petra (Ortloff, 2005) may be some common denominators that correspond to the functions of Hasankeyf water features. Mesopotamian cities perhaps best reveal extensive cistern use beginning from the Greco-Roman era until medieval times. The Upper city of Hasankeyf could have been part of a Roman line within the geographical context. Medieval Hasankeyf, on the other hand, has reasons to be compared with its contemporary water systems, including those in the Iranian plateau when one intends to emphasize the renewal and replacement of an older water distribution system with the post works.

CHAPTER 7

CONCLUSION

The Upper city of Hasankeyf is one of those special sites where clear evidence for the existence of a sophisticated water system is observed. It is a general theory in archaeological thought that public areas reveal the bulk of the history of settlement areas since they mirror the common behavior of ancient societies. On the other hand, today, the archaeological world is in a trend to divert the attention to private settlements. Focus is on settlement patterns that underline the emergence and development of cities within the political, economic and social contexts that are attributable to different periods. The strive for understating the water distribution system and its impact on the urban settlement at the Upper city much benefits from apparent architectural elements which are deemed as inseparable from those rock-cut houses. Although water features can not be traced thoroughly in every part of the city, partial and complete evidence are considered to act as significant indicators to come up with a set of ideas, leaving the assignment of a precise date out of debate, with regards to the establishment and maintenance of a water distribution system which is, no doubt, supposed to have strong links with the urban design. However, assumptions on the resemblance of the current pattern to that of the Roman fashion in certain respects inevitably push the gravity center of ideas toward a preliminary Roman design. Moreover, since Hasankeyf is a well-preserved medieval town, re-designation of the water system by late comers and habits of importation of such features in the light of archaeological knowledge, is highly possible. Therefore;

1. There are three types of water structures at the Upper City which are mainly categorized as canal extensions, small canal remains and cisterns. The Pool is the key to the functioning of these structures. It displays the role of storage or distribution tanks of the ancient Roman cities some of which are explained under the scope of this research. Likewise, canal extensions act as pipe-lines while cisterns, although no fountains found, may indicate a substitution for such features. The abundance of

cisterns, although nearly half is converted to spaces for different purposes, shows the effective use of water. The arid climatic conditions of the region and topographical factors are not the same throughout the city. Including but not limited to these two factors, the placement of cisterns is denser in certain segments of the city.

2. The settlement pattern of the Upper city is determined by the topography and water features. There are many factors behind the formulation of water features at such a distinctive topography. The elimination of the barriers in order to create practicalities of a water network exhibits the engineering skills. In such a way were the disadvantages of topography overcome to distribute water to the city.

3. The designation of canal extensions is based on topography. They are built according to easy flow of water over and along the edges of the natural scarp. However, the placement of certain cisterns also exhibit that there may have been strong links with other possible canal extensions that are now eroded.

4. It appears that smaller canals as first-tier water conducts within the settlement levels near the scarp bring water from the canal extensions and distribute it to the houses. Meanwhile, some cisterns whose sizes are remarkably large are assumed to have been direct users of water as storage locations. Thus, they could have been used as secondary distribution features for water conduct. However, it is also assumed that interior areas compatible enough with the topography to permit easy flow of water possess cisterns, as well. They satisfy the availability of secondary distribution features. The eastern part of the city reveals evidence for such a case. Returning to the first remark, secondary features are generally positioned within or sometimes out of the borders of settlement units near the scarp. They may exhibit the function of third level features- namely the final collectors, to store steady water depending on daily needs or seasonal changes. However, the evidence is still poor to allege that the total amount of third level water features can be dated to similar or approximating periods.

5. A pipe-line system or an extension is supposed to have played role on water distribution in certain portions of the city, reminding the Roman practice. When

public areas are subject to discussion, the “period” dilemma emerges between public and settlement areas, including the water features in the vicinity public areas. When the general tendency for the maintenance of public areas is given the priority, a possible pipe-line system, if it served the late public area, can also be a late design accordingly. However, it is uncertain, due to discreteness of canal extensions, if a piping system undertook water distribution on the same strict lines to arrive at public places in the first instance.

6. No matter what the exact dates for the emergence, development or disuse of the water system are and despite non-satisfaction of quantifiable evidence for gutter-like remains, the Upper city reveals the existence of a discharge system at the small scale, mainly designed parallel to topographical conditions next to road systems. Although unexcavated, it is highly possible that the city had a drainage system at least to cope with problems of water run-off and send the contaminated waters away from the urban areas, carried with canal extensions.

7. Canal extensions originating from the Pool follow the route at the same elevation which is 593 m. Since they have to make their course gradually from higher to lower elevations, housing units which have elevations above the optimum value ($\geq$ 591 m) are not thought to have directly benefited from canal extensions unless there was a subterranean canal extension. Housing units whose elevations are above 591 m are scattered throughout the central and southern interior parts of the city. The existence of relatively less number of cisterns for the said parts points to the possibility of now absent canal extensions which reached undefined parts of the city. These may have traveled alone at strategic locations based on most suitable topographies or most usually with the assisting canal remains. They may have served at the minimum possibility and made their course from scarp areas.

8. The Pool is not surrounded by houses in order to keep the water clean. It is clear that water was channeled along the scarp. Therefore, the Pool is far beyond the borders of the housing areas. Evidence for a subterranean canal to conduct first clean waters to the canal extensions should further be sought from the point of technical and historical respects.

9. Districts which may be named as sub-sectors were designed considering the easy access to water areas. Therefore, cisterns were built in accordance with the locations of the housing units within a sub-sector. The placement of certain cisterns seems to be dependent on the nearest canal extensions. That the direction of the canal tracks on the openings of cisterns is towards the nearest canal extensions and mostly towards the entrances of housing unit reveal that cisterns which are inside or outside the courtyards were located to attain the maximum shortcut to water utilization in terms of space usage. Because the land is divided into meaningful insulae to maximize the use of a difficult terrain, the functional division of arterial roads comes accordingly. The unity between the districts and water features located within the city prove a clear relationship to each other although it seems very possible that additions were made over time. Therefore, the effective use of the terrain exhibits a full integrity of the city elements in any period. Roads display the facilitation of access to water resources, complementing the urban silhouette. The role of roads is best observed in districts which are nearer to the scarp.

10. Based on their frequency, the concentration of cisterns also shows that the southern and eastern parts of the city were preferable in terms of easy utilization of water from the canal extensions. Houses near those canal extensions were designed to possess more cisterns. On the other hand, houses which have larger volume cisterns in the western part of the city could have been built with the intention of maximizing water sources, thus supplying water to proximity areas from eastern canal extensions with stable means. Districts of this part of the city could have been the target place towards which late movements could have occurred. Even if they were occupied with inhabitants in the same period when houses were also absent in districts where the frequency of cisterns was higher, the abundance of large number of cisterns may be accrued to the difficulties of water transportation with canal extensions in the southeastern and eastern parts of the city.

11. Three shapes of cisterns which are conical, cylindrical and pear-shaped are identified at the Upper city. All the cisterns are classified under six size categories ranging from “very small” to “extremely large”. It is understood that five main

patterns based on their current condition as “individual”, “twin”, “triple”, “hung” and “two-chimney” tell more about their formulation. There is the greater percentage of conical, small and individual cisterns throughout the Upper city.

12. Many cisterns are located within the courtyards of houses to leave more space for daily activities. The general habit of locating cisterns as much as within the private borders shows the making of the most efficient use of terrain. Such attempts may point to security concerns arising from scarce supply of water in semi-arid climatic conditions. On the other hand, the majority of converted cisterns which were found inside the houses are assumed to belong to neighboring units due to shifts in the usage of houses in later periods. Such cisterns could have been used earlier in neighboring units.

13. Cisterns which are regarded as third level features of the water system are assumed to be collectors of water by man-driven carriage from the nearest cistern(s), on flatter courtyards. However, some are still assumed as candidates to be second level features, regardless of their size and proximity to a scarp area. One special area of the interior city in sector A enjoys an advantageous position with respect to its proximity to a canal extension. No matter, the abundance of cisterns expresses the extensive usage of steady water in the bulk of the city. In the light of Roman and medieval practices, small canals can be indicators of means for water runoff, in order to fill in open cisterns to be used for the animals. They may otherwise be identified as rain water collectors.

14. More than half of the cisterns were converted at the Upper city. Generally, conversions took place in areas that are near the scarp. Conversion of cisterns to form different purpose spaces demonstrates that their original functions were abandoned in certain respects. Hence, houses which have proximity to scarp areas could have been re-designed in accordance with the new functions of cisterns. Re-designing cisterns may be a result of changes in the water management strategies of other civilizations that have settled at Hasankeyf such as Byzantines, Sassanids, Artukids, etc.; may come from the necessity to adapt to changes brought by natural factors or; can be due to permanent habits of newcomers whether this be assigned to post-Roman periods

or very recent dwellings until 1960s. Evidence pertaining to cisterns of some cities in the Near East contributes to one hypothesis that the original cisterns of the Upper city are likely to have been superseded by late cisterns which are now large in size and mainly found in the interior parts of the city. Since available information comes from a very limited chronological span and area in the city, further dating studies need to be carried out to eliminate such problems.

15. Theories which are intensely formulated by methods of hydraulic data generation and geological analysis on water supply networks usually assume that water features are designed to facilitate the utilization of water supply and its distribution. What is also less acknowledged is that evidence for water features can sometimes retain specific character or inherited functions even though a settlement is completely attributable to a certain period. Although the Upper city of Hasankeyf is known as a medieval city, it yields some common characteristics with water supply practices of Roman cities. Therefore, it is presumed that the analogies driven through Roman water supply patterns could be realistic to interpret the water distribution patterns due to those resemblances provided in the previous Chapter. However, very sharp inferences and assignment of strict chronological orders should be avoided to understand the settlement strategies of the Upper city when layouts of settlements are also vulnerable to change which is related with political, economic and cultural factors. Despite absence of evidence demonstrating such factors, shifts in the settlement pattern is possible.

16. It is envisaged that the full identification of the water network is not that easy. However there are clear remains of a well-functioning siphon system closely located near a Pool which is regarded as the backbone of the city texture so to meet the water requirements. One big problem is the lack of absolute dating studies in the residential areas of the Upper city. Despite limitations, impacts of water features are apparently or implicitly observed for the reasons mentioned throughout this thesis. Usually, settlements tend to be positioned around water features at the initial stages. For the Upper city of Hasankeyf, water features seem to have been determinant on urban settlement pattern in ancient periods while this role could have been undertaken by houses due to shifts in the function of water features in later periods. Mainly, the

apparent data which comes along with the current conditions of the Upper city takes this research to more positive elaborations about the roles of many water features encountered in-situ. They have been helpful means to question the urban settlement pattern, as well. It is expected that further research to bring the never known sides of the overall water distribution system into light and complete the rest of the puzzle should be one of the requirements that should be owed to the Upper city.

REFERENCES

Alkan, Ahmet., and Ünal Öziş. "Su Mühendisliği Tarihi Açısından Çevlik Kanal ve Tünelleri". Teknik Dergi 2, 1 (1991). www.imo.org.tr (2004).

Alston, Richard. "The City in Roman and Byzantine Egypt". Routledge, London. (2001).

Arık, Oluş. "Hasankeyf Kazı ve Kurtarma Projesi- Hasankeyf Excavation and Salvage Project". Ilısu ve Karkamış Baraj Gölleri Altında Kalacak Arkeolojik ve Kültür Varlıklarını Kurtarma Projesi 1999 Yılı Çalışmaları- Salvage Project of the Archaeological Heritage of the Ilısu and Carchemish Dam Reservoirs Activities in 1999. (Edited by Numan Tuna., Jean Öztürk, and Jale Velibeyoğlu). TAÇDAM, ODTÜ, Ankara. (2001): 777-794.

Arık, Oluş. "Hasankeyf: Üç Dünyanın Buluştuğu Kent". Kültür Yayınları Ltd.Şti., Ankara. (2003).

Başgelen, Nezih. "Hasankeyf Sorguluyor!". *Arkeoloji ve Sanat* III (3 December 1999).

Bono, Paolo., James Crow, and Richard Bayliss. "The Water Supply of Constantinople: Archaeology and Hydrogeology of an Early Medieval City". *Environmental Geology* 40 (2001): 1325-1333.

Buyruk, Azmi, and Mustafa Uysal. "Termessos: A Psidian Mountain Town of Antiquity". Fırat Yayın Tanıtım, Antalya. May (1986).

Büyükyıldırım, Galip. "Antalya Bölgesi Tarihi Su Yapıları". Devlet Su İşleri Genel Müdürlüğü, Ankara. (1994).

Comfort, Anthony. "Satellite Remote Sensing and Archaeological Survey on the Euphrates". 1197 Report (Revised version). Luxembourg, 10 December 1997. www.ist.lu/htm/projects/de/zeugma/ftp/report1997.doc. (2002).

Crouch, Dora P. "Water Management in Ancient Greek Cities". Oxford University Press, New York. (1993).

English, Paul Ward. "Qanats and Life Worlds in Iranian Plateau Villages". Transformation of Middle Eastern Natural Environments: Legacies and Lessons.

Bulletin Series, Yale School of Forestry and Environmental Studies, no:103, Yale University Press, New Haven. (1998).

Evans, Harry B. "Water Distribution in Ancient Rome- The Evidence of Frontinus". The University of Michigan Press, U.S. (1997).

Forbes, Robert James. "Studies in Ancient Technology". (I-II), Interprint Ltd., Netherlands. (1993).

Hansen, Roger D. "Water and Wastewater Systems in Imperial Rome". (2005). www.waterhistory.org

Kang, John E. "The Old Testament and the Ancient Near East Water Systems". Western Evangelical Seminary, BST 550.
www.seminary.georgefox.edu/courses/bst550/reports/JKang/water.html (2004).

Landels, John G. "Eski Yunan ve Roma'da Mühendislik-Engineering in the Ancient World". (Çev. Barış. Bıçakçı). TÜBİTAK, Ankara. (1996).

Lenzen, Cherie J. "Water and Antiquity". United States Agency for International Development, USAID Development Experience Clearinghouse Document Number PN-ACG-029, The GreenCOM Project, December 1996.

Lightfoot, Dale. "Syrian Qanat Romani". www.waterhistory.org (2005).

Mansel, Arif Müfid. "Side: 1947-1966 Yılları Kazıları ve Araştırmalarının Sonuçları-Excavation Reports and Related Researches", Türk Tarih Kurumu Yayınları, Türk Tarih Kurumu Basımevi, V. Seri- Sa.33, Ankara. (1978).

Morgan, Morris Hicky. "Vitruvius, The Ten Books on Architecture- Translation". Dover Publications, Inc., New York. (1960).

Mundy, John Hine and, Peter Riesenberg. "The Medieval Town". D.Van Nostrand Reinhold Company, Princeton. (1958).

Nydahl, Hanna. "Archaeology and Water Management in Jordan". Department of Archaeology and Ancient History. Uppsala University, Uppsala. (2002).

Ortloff, Charles R., and Adonis Kassinos. "Computational Fluid Dynamics Investigation of the Hydraulic Behavior of the Roman Inverted Siphon System at Aspendos, Turkey". *Journal of Archaeological Science* 30 (2003): 417-428.

Ortloff, Charles R., and Dora P. Crouch. “The Urban Water Supply and Distribution System of the Ionian City of Ephesos in the Roman Imperial Period”. *Journal of Archaeological Science* 28 (2001): 843-860. (Revised manuscript, 8 May 2002).
Parkins, Helen M. “Roman Urbanism: Beyond the Consumer City”. Routledge, New York. (1997).

Ortloff, Charles R. “The Water Supply and Distribution System of the Nabataean City of Petra (Jordan), 300 BC-AD”. *Cambridge Archaeological Journal* 15:1 (2005): 93-109.

Owens, E. J. “The Water Supply of Antioch”. First International Congress on Antioch in Psidia. Yalvaç, Isparta, 2-4 July 1997. Kocaeli Gazetecilik ve Yayın A.Ş, Izmit. (2000).

Peker, Ali Uzay. “Hasankeyf Yukarı Şehir Çalışmaları- Hasankeyf Upper City Survey (2002)”. www.metu.edu.tr/home/wwwmuze/tacdam.html (TAÇDAM web site) (2004).

Plommer, William Hugh. “Vitruvius and Later Roman Building Manuals”. Cambridge University Press, London. (1973).

Plüss, Marco., and Oluş Arık. “Hasankeyf”. Tarih Vakfı- The Economic and Social History Foundation of Turkey , İstanbul. (2001).

Radt, Wolfgang. “Pergamon: Antik Bir Kentin Tarihi ve Yapıları- Pergamon: Geschichte und Bauten Einer Antiken Metropole (Darmstadt 1999)”. Yapı Kredi Yayınları, İstanbul. (2001).

Rich, John., and Andrew Wallace-Hadrill. T.J Press Ltd., Cornwall. (1994).

Sabour, M’hammed., and Knut S.Vikor. “Paper from the Third Nordic Conference on the Middle Eastern Studies”, Joensuu, June 1995. C.Hurst & Co Ltd., London. (1997). (www.hf-fak.uib.no).

Stambaugh, John E. “The Ancient Roman City”. The Johns Hopkins University Press, London. (1988).

Şevki Vanlı Mimarlık Vakfı. “Mimarlık Üzerine On Kitap- (Vitruvius The Ten Books of Architecture, translated by Morris Hicky Morgan, 68 Illustrations)”. YEM Yayın, İstanbul. (1998).

Uğurlu, Nur Banu. “The Roman Nypmhaea in the Cities of Asia Minor: Function in Context”. Graduate School of Social Sciences, Middle East Technical University, Ankara. (2004).

TAÇDAM (Orta Doğu Teknik Üniversitesi, Tarihsel Çevre Değerlerini Araştırma Merkezi -Middle East Technical University, Centre for Research and Assessment of the Historic Environment). "Ilısu Baraj Gölü ve Çevresinde Arkeolojik Kazı ve Araştırmaları (1998-2003)- Archaeological Excavations and Researches at Ilısu Dam and Its Environs (1998-2003)", Ankara.

Toprak, Vedat, and M.Lütfi Süzen. "Geological And Morphological Control On the Texture of Hasankeyf Upper City, Turkey". 5th International Symposium on Eastern Mediterranean Geology, II. Thessaloniki, Greece, 14-20 April 2004.

White, Kenneth, D. "Greek and Roman Technology". Cornell University Press, Ithaca, New York. (1984).

APPENDICES

APPENDIX A

THE MEASUREMENT TABLE

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
1	A5	390	310	155/145	438/458	3,10	2,24	16,28	medium
2	A6	~400		~80/90	~440/460	4,00	2,25	21,20*	large
3	A6 (west)	347			390	3,47	1,95	13,81	small
4	A4	215		130	275	2,15	1,38	4,25	small
5	A2	480	350	95/95	740/660	3,50	3,50	44,88	very large
6	A13	~350		137/115	~500	3,50	2,50	22,90*	large
7	A20-1	330		110/100	300	3,30	1,50	7,77	small
8	A20-2	330		90/70	205	3,30	1,03	3,66	small
9	A20-3	250		90/90	190	2,50	0,95	2,36	small
10	B65	300		90/90	460/450	3,00	2,27	16,18	medium
11	B66	~300		90/90	460/450	3,00	2,27	16,18*	medium
12	B59	430		125/100	450/470	4,30	2,30	23,81	large
13	B52	325	300	90/90	400/350	3,00	1,88	11,04	small
14	B49-1	200		110/100	165/170	2,00	0,84	1,48	small
15	B49-2	250		110/100	130/125	2,50	0,64	1,07	small
16	B41	250		130/170	400/400	2,50	2,00	10,47	small
17	B38-1	380	370	90/90	375/400	3,70	1,94	14,58	medium
18	B38-2	215		75/75	265/275	2,15	1,35	4,10	small
19	B36	375/350		80/80 85/60	550/1060	3,63	4,03	61,47	extremely large
20	B71-1	450		~200/130	350/430	4,50	1,95	17,91	medium
21	B71-2	350		undefined	300/280	3,50	1,45	7,70	small
22	B74-1A/B	360/360		80	270/400	3,60	1,68	10,57	small
23	B74-2	230		80	180/180	2,30	0,90	1,95	small
24	B73	310	200	130/135	345/360	2,00	1,76	6,48	small
25	B74	290		100	310/330	2,90	1,60	7,77	small
26	B72	~250-300		110/135	~300-400	2,75	1,75	8,81*	small
27	B39	460		80/70	500/540	4,60	2,60	32,55	very large
28	B39	260		100	320	2,60	1,60	6,97	small
29	B67	400		40/40	350/300	4,00	1,63	11,06	small

(*) Volume estimation is made according to estimated height and base value. Estimations of some top values are occasionally provided. All estimations are those shaded cells.

The Measurement Table (continued)

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
30	B67	350		70/60	450/450	3,50	2,25	18,55	medium
31	B62	400			450	4,00	2,25	21,20	large
32	B26	400			260	4,00	1,30	7,08	small
33	B27	140		60/80	60/80	1,40	0,35	0,18	very small
34	B28	~100-150		~40-40	100/100	1,25	0,50	0,33*	very small
35	B29	230		70/70	160/150	2,30	0,77	1,43	small
36	B29	200		105/95	105/95	2,00	0,50	0,52	very small
37	B29	~100-300		60/60	~110-300	2,00	1,02	2,18*	small
38	B30	210		90/105	400/385	2,10	1,97	8,49	small
39	B32	120		40/40	180/170	1,20	0,88	0,96	very small
40	B34	390-400		240/240	~350-550	3,95	2,25	20,93*	large
41	B35	~410-420		250/250	~500-600	4,15	2,75	32,85*	very large
42	B40	190		100/100	250/250	1,90	1,25	3,11	small
43	B16	180		300/250	440/430	1,80	2,18	8,91	small
44	B18	380			450	3,80	2,25	20,14	large
45	B18	420		240/240	520/600	4,20	2,80	34,46	very large
46	B19	350		80/90	330	3,50	1,65	9,97	small
47	B18	280			280	2,80	1,40	5,74	small
48	B18	560	460	50/50	440/380	4,60	2,05	20,23	large
49	Main road	710	600	80/80	200	6,00	1,00	6,28	small
50	B20	300		90	280/280	3,00	1,40	6,15	small
51	Junction of A33-A34-A35	450	370	80/80	~340	3,70	1,70	11,19	small
52	A31	320	280	40/40	80/135	2,80	0,54	0,85	very small
53	A28	430		120	400/350	4,30	1,88	15,82	medium
54	C43	250	~150	60/70	~350-370	1,50	1,80	5,09*	small
55	C45	460	380	70/70	450/480	3,80	2,33	21,50	large
56	C45	325		105	340/325	3,25	1,66	9,37	small
57	C45	315		80	250/250	3,15	1,25	5,15	small
58	C45	~100		100/80	~150	1,00	0,75	0,59*	very small
59	C45	~150-200		70/50	~80-160	1,75	0,60	0,66*	very small
60	A23	110		60/60	110/110	1,10	0,55	0,35	very small
61	A26	300		80/70	300	3,00	1,50	7,07	small
62	A26	~120-430		40	~80-380	2,75	1,15	3,81*	small

The Measurement Table (continued)

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
63	C45	300	200	50/50	~280	2,00	1,40	4,10*	small
64	C45	290	200	80/80	~300-350	2,00	1,62	5,49*	small
65	C41	260		85	280/280	2,60	1,40	5,33	small
66	C41	210		80/70	230/230	2,10	1,15	2,91	small
67	C45	~120-450		35/40	110	2,85	0,55	0,90*	very small
68	C38	266			300	2,66	1,50	6,26	small
69	C38	350		110/75	410/450	3,50	2,15	16,93	medium
70	C38	250		70	300/250	2,50	1,38	4,95	small
71	C34	470		100/90	390/360	4,70	1,88	17,29	medium
72	C33	225		90/80	250/200	2,25	1,13	2,98	small
73	East of C23-C24	~100		60/60	~110-150	1,00	0,65	0,44*	very small
74	East of C23-C24	~100		60/60	~110-150	1,00	0,65	0,44*	very small
75	East of C23-C24	~80		50/50	~110-150	0,80	0,65	0,35*	very small
76	C24	450		100	570/600	4,50	2,92	40,16	very large
77	C24	425		100	460/430	4,25	2,23	22,02	large
78	D79	375		80	390/390	3,75	1,95	14,92	medium
79	D78	150		70	120/120	1,50	0,60	0,57	very small
80	D78	270	180		300/320	1,80	1,55	4,53	small
81	D78	420		80	450/510	4,20	2,15	20,32	large
82	D78	350	210		390/390	2,10	1,95	8,36	small
83	(pool) D78	100		400/400	400/400	1,00	2,00	4,19	small
84	D78	210		95/105	400/385	2,10	1,97	8,53*	small
85	D70	480		100	380/380	4,80	1,90	18,14	medium
86	D70	330		80	~180	3,30	0,90	2,80	small
87	East of D51; on the main road	330		100	~250-300	3,30	1,38	6,58*	small
88	D65	700		110/110	~250	7,00	1,25	11,45*	small
89	D65	120		80/80	130/130	1,20	0,65	0,53	very small
90	D65	120		70/50	140/130	1,20	0,68	0,57	very small
91	D65	350		90	250	3,50	1,25	5,72	small
92	D65	250		170/180	300/300	2,50	1,50	5,89	small
93	D53	380		80	500/470	3,80	2,43	23,39	large
94	D52	380		100	300	3,80	1,50	8,95	small

The Measurement Table (continued)

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
95	D52	280		85	250	2,80	1,25	4,58	small
96	D51-1	130		70	150	1,30	0,75	0,77	very small
97	D51-2	150		60	120	1,50	0,60	0,57	very small
98	D63	350		110	305	3,50	1,53	8,52	small
99	D63	380		90	330/350	3,80	1,70	11,49	small
100	D55	340		70	330	3,40	1,65	9,69	small
101	D56	310		110	400	3,10	2,00	12,98	small
102	D56	235		40	350	2,35	1,75	7,53	small
103	D57	230		80	~250-300	2,30	1,38	4,58*	small
104	D38	250		260	350	2,50	1,75	8,01	small
105	D37	230		140	280	2,30	1,40	4,72	small
106	D35	250		80	210/200	2,50	1,05	2,88	small
107	D36	300	260	70/90	300	2,60	1,50	6,12	small
108	D34	250			330	2,50	1,65	7,12	small
109	D28	430	310	40/40	380/380	3,10	1,90	11,71	small
110	D26	430	310	40/40	380/380	3,10	1,90	11,71*	small
111	Opposite of C1;on the road	260		70	370/380	2,60	1,88	9,57	small
112	Opposite of C1;on the road	310		75/75	280/280	3,10	1,40	6,36	small
113	C51	460		150/150	490/550	4,60	2,70	35,10	very large
114	C50	400		70/70	~400-450	4,00	2,12	18,82*	medium
115	C55	410		250	570/600	4,10	2,93	36,72	very large
116	C55	330		130/120	530	3,30	2,65	24,26	large
117	C59	260		110	380/370	2,60	1,88	9,57	small
118	C59	350		70	310/330	3,50	1,60	9,38	small
119	C59	400		110	300	4,00	1,50	9,42	small
120	Road between C59-C60	200		120/120	300	2,00	1,50	4,71	small
121	C31	350		250/210	360/310	3,50	1,68	10,28	small
122	C29	200		50/50	80	2,00	0,40	0,33*	very small

The Measurement Table (continued)

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
123	Below the main road; C29	140		60	150	1,40	0,75	0,82	very small
124	C17	375	295	120	400	2,95	2,00	12,35	small
125	C10	390		110	390	3,90	1,95	15,52	medium
126	C21	400		150/120	275	4,00	1,38	7,92	small
127	C19	420		90/80	320	4,20	1,60	11,25	small
128	C27	330			~410	3,30	2,05	14,52*	medium
129	C22	330			410	3,30	2,05	14,52	medium
130	D76	320		100	410	3,20	2,05	14,08	medium
131	D72	460		80/60	300	4,60	1,50	10,83	small
132	D73	320		80	300/280	3,20	1,45	7,04	small
133	D48	90		80/110	130	0,90	0,65	0,40	very small
134	D49	320		80	330	3,20	1,65	9,12	Small
135	D50	330		230	320	3,30	1,60	8,84	Small
136	D50	150		70	150	1,50	0,75	0,88	very small
137	D50	310		80	230	3,10	1,65	8,83	small
138	B8	280		130	310	2,80	1,55	7,04	small
139	On the main road	120		80/90	270/350	1,20	1,55	3,02	small
140	On the main road	460		300	710/690	4,60	3,50	58,98	extremely large
141	B15	550		260	600/600	5,50	3,00	51,81	very large
142	On the main road	190		60/80	~100	1,90	0,50	0,50*	very small
143	B4	~250		85/80	~190	2,50	0,95	2,36*	small
144	B3	250		110/140	400/360	2,50	1,90	9,45	small
145	C67	290		60/60	~300	2,90	1,50	6,83*	small
146	C67	290		90/80	~300-350	2,90	1,62	7,97*	small
147	C70	400		90/120	300	4,00	1,50	9,42	small
148	C72	300		80	300	3,00	1,50	7,07*	small
149	C74	300		130	320	3,00	1,60	8,04	small
150	D6	130		80/80	150/150	1,30	0,75	0,77	very small
151	D6	300			490/480	3,00	2,43	18,47	medium
152	D6	350		145/190	210/280	3,50	1,23	5,50	small
153	D8	220		180	200	2,20	1,00	2,30	small

The Measurement Table (continued)

NO.	LOCATION	CISTERN MEASUREMENTS							SIZE
		Height (cm.)		Diameter (cm.)					
		(Top)	(Neck)	Top NS/EW	Base NS/EW	HEIGHT	RADIUS	(m^3) VOLUME	
154	D8	~220		150/100	~200	2,20	1,00	2,30*	small
155	D12	270		150/180	~180-230	2,70	1,03	3,00*	small
156	D23	~100		100/100	~150	1,00	0,75	0,59*	very small
157	D23	~300		60/60	~300	3,00	1,50	7,07*	small
158	D24	290		55/80	220	2,90	1,10	3,67	small
159	D14-D21 border	90		70/90	90	0,90	0,45	0,19	very small
160	D14	205		95	195	2,05	0,98	2,04	small
161	D14-D20 border	350		70	~310-330	3,50	1,60	9,38*	small
162	East of D11	300	150	90/130	480	1,50	2,40	9,04	small
163	East of D11	270		170/150	230/180	2,70	1,03	2,97	small
164	C1	450	350	35/35	~350-380	3,50	1,83	12,27*	small
165	C3	100		90/100	~150	1,00	0,75	0,59*	very small
166	C5	~250		170/180	~300	2,50	1,50	5,89	small
167	C6	350		200	250	3,50	1,25	5,72	small
168	C7	~290		60/60	~300	2,90	1,50	6,83*	small
169	C7	~300		50/50	~280	3,00	1,40	6,15*	small
170	C13	250		110	370	2,50	1,85	8,96	small
171	C76	300		80/80	~200-230	3,00	1,08	3,66*	small
172	C79	200		80	100	2,00	0,50	0,52	very small
173	C79	200		100	120	2,00	0,60	0,75	very small
174	C79	300		90	230	3,00	1,15	4,15	small
175	On the main road	350		330/200	520	3,50	2,60	24,76	large
176	C8	430		130	310/330	4,30	1,60	11,52	small
177	D44	370		150	300	3,70	1,50	8,71	small
178	D44	350		220	340	3,50	1,70	10,59	small
179	D43	300		60/60	~300	3,00	1,50	7,07*	small
180	D42	~300		50/50	~280	3,00	1,40	6,15*	small
181	C66	400		80	450	4,00	2,25	21,20	large
182	C62	360		110	260	3,60	1,30	6,37	small
183	C64	200		110/110	310/300	2,00	1,53	4,87	small
184	C58	~250-400		150	300	3,25	1,50	7,65	small
185	On the road	200		60/50	80	2,00	0,40	0,33	very small
186	On the main road	~170		50/60	80	1,70	0,40	0,28	very small
187	Special	500		~1150	600/550	5,00	2,88	43,41	very large

APPENDIX B

DESCRIPTION AND REMARKS TABLE

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
1	A5	pear	complete	in the middle of a flat courtyard; extended and converted to a stall; N05W of the small building
2	A6	undefined	filled	in the middle of a flat courtyard
3	A6 (west)	conical	complete	in the middle of a main road; distance to wall:5 m.(N70W); converted to a room in the east
4	A4	conical	complete	reached by stairs; in the middle of courtyard
5	A2	pear	complete	near the main road, east of a small mosque; plastered; tracks for rope usage; a well ring and small hole nearby
6	A13	undefined	filled	near the main road; distance to entrance: 415 cm.
7	A20-1	conical	complete	connected with A20-2 and A20-3; distance between A20-1/A20-2:300cm. & distance between A20-2/A20-3: 350cm.; distance between A20-3 and southwestern wall: 17m.
8	A20-2	conical	complete	connected with A20-1 and A20-3
9	A20-3	conical	complete	connected with A20-1 and A20-2
10	B65	conical	complete	in the middle of courtyard; reached by stairs; converted to a room; plastered at the top
11	B66	undefined	filled	west of courtyard and Grand Palace; a main road in the east and a wall in the south
12	B59	conical	complete	near wall; plastered; conversion to a stall; north of B59 and south of main road; entrance from B53; burn signs
13	B52	pear	filled on top	inside B52; probably belongs to the courtyard of B57; intense burn signs; conversion to a kitchen, additional late wall in the middle; distance to scarp: 5m; near Tigris
14	B49-1	conical	half-filled	near scarp; probably courtyard; near the stairs reaching Tigris; canal signs but not very satisfactory
15	B49-2	conical	complete	near scarp
16	B41	conical	complete	corner of courtyard; canal signs tracked in the east edge of the main road and towards the opening of the cistern
17	B38-1	pear	complete	corner of courtyard; 1/4 converted to a room in the west; next room belongs to 38-2; reached by stairs

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
18	B38-2	conical	complete	corner of the courtyard
19	B36	conical	complete	converted to a room or kitchen; sample for two-chimney cisterns; distance to main road: 620 cm.; first opening is near the main road
20	B71-1	conical	complete, half burnt	openings on the main road and filled; connected with B71-2 with a window later (thinnest part: 5 cm.); conversion to a room
21	B71-2	conical	hung	connected with B71-1; function undefined
22	B74-1A/B	conical	complete	near the Grand Palace; in the courtyard; distance between openings of B74-1/B74-2: 590 cm; distance between two double openings of B74-1as B74-1A/B74-1B: 175cm.; openings restorated with bond technique
23	B74-2	conical	complete	130/135 cm. above B74-1; connected with B741A/B (connection wall thickness: 30 cm.) and enlarged in the southeast; opening is on the main road
24	B73	pear	complete	in the courtyard; conversion to a stall or room which is opened towards south; probably original use
25	B74	conical	partly burnt	reached from the courtyard of B73 through a room; back corner of B74; opening closed; conversion to a stall or room
26	B72	undefined	filled	in a flat courtyard; indications to have been linked with a second one but no definite opening and filled; can not be measured all
27	B39	conical	half complete	near a wall; conversion to a room; extended in the north, probably used as a kitchen, later used as a stall; canal width:10 cm.
28	B39	conical	destroyed	conversion to a room and extended; two possible canal tracks inside; closed from top but somehow preserved
29	B67	conical	complete	entered approximately 15 m. away from the scarp; opens to a rectangular corridor; opening is very small compared to its size; bond technique applied on the opening; possible holes for amphora usage
30	B67	conical	complete	entrance from scarp; a possible canal hole in the northern direction; distance to scarp in the north: 10m.
31	B62	conical	partly destroyed	near road and wall; conversion to a room; west side is partly burnt; opening closed; clear inscriptions
32	B26	conical	hung, half complete	base can not be defined; opening closed; perhaps belongs to another house above B26; converted to a room
33	B27	cylindrical	half complete	in the courtyard; almost equal sizes of opening and base
34	B28	undefined	filled	in the courtyard; just at the right hand of entrance

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
35	B29	conical	destroyed	half present in vertical position; converted to a room
36	B29	cylindrical	complete	rather small when compared to other cisterns in B29
37	B29	undefined	filled	in the courtyard; can not be reached
38	B30	conical	hung, half complete	in the middle of courtyard; base is above 1,5 m.; obvious tracks for leveling; conversion to a room or stall and enlarged (traces for places where animals are fed); probably plastered originally; can be part of a complex; signs for original construction and late restoration are different
39	B32	conical	hung, half complete	inside the house; converted to a room; opening is restorated; hung (undefined whether rest is the base) since very smooth leveling is observed
40	B34	undefined	filled	in the courtyard; right of the entrance; can not be identified
41	B35	undefined	filled	at the right of the entrance
42	B40	conical	complete	edge of courtyard; near scarp
43	B16	conical	hung	opposite of the Bath; height taken from the opening to the cut base; converted to a room
44	B18	conical	hung	south east of B18; conversion to a kitchen with a chimney; maybe extended for bath-kitchen usage later (clear evidence for basins of bath); original base is obvious
45	B18	pear	complete	converted to a living space; height from neck to base can not be measured
46	B19	conical	half-complete	converted
47	B18	conical	destroyed	converted
48	B18	pear	destroyed	converted; burnt
49	Main road	conical	hung	between B18 and B4; bond technique applied for the opening; converted to a big room; near scarp
50	B20	conical	hung	in the courtyard; closed from the opening; converted; base leveled; canal traces (20cm.wide) on the southern wall of B22, they are tracked for a while and then they disappear
51	Junction of A33-A34-A35	pear	complete	original; edge of the western scarp; base can not be reached; a platform in the courtyard like a drinking basin
52	A31	pear	complete	in the courtyard; near scarp
53	A28	conical	half complete	outside the courtyard; closed from top
54	C43	pear	complete	in the courtyard; closed from top

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
55	C45	pear	complete	in the courtyard; at the right of the entrance; square opening
56	C45	conical	hung	connected with 55. cistern; thickness between 55. and 56. cistern: 5 cm.; converted; base of 56.cistern is 180 cm. above 55.cistern ; distance between 55. cistern and 56. cistern:280 cm.
57	C45	conical	hung	used as weaving platform; 55., 56., 57. cisterns are recorded as triple cisterns in C45; base of 57.cistern is 40 cm. above 56. cistern; distance between 56. cistern and 57. cistern: 390cm.; distance between 55.cistern and 57. cistern: 370 cm.
58	C45	undefined	filled	near the wall, outside; plastered
59	C45	undefined	filled	southwestern edge of C45
60	A23	conical	complete	in the middle of courtyard; shallow hole in the middle of the base
61	A26	conical	complete	in the courtyard; base can not be reached
62	A26	conical	destroyed	slightly outside of A26 in the southern direction; only opening is seen; converted to a rectangular platform
63	C45	pear	destroyed	converted to a room
64	C45	pear	destroyed	converted to a rectangular room; distance between 63. and 64. cisterns: 345 cm.; as two independent cisterns, 63.and 64.cisterns used to be in the courtyard and are now converted to living spaces in late periods; rectangular niches carved into interior walls of the cistern; a good sample that it used to be in the courtyard but is now on the main road
65	C41	conical	destroyed	converted; bond technique applied for the opening; half facade is absent
66	C41	conical	complete	converted; reached by stairs
67	C45	conical	hung, badly destroyed	SE of C45; badly destroyed;
68	C38	conical	hung	late bond technique on the opening; converted to a stall
69	C38	conical	complete	south of C38; original; C38 should be split into two in the plan (plan is problematic)
70	C38	conical	destroyed	square entrance; opening can not be seen from the courtyard
71	C34	conical	half complete	converted; entrance of C34; a wall constructed at the middle of the base
72	C33	conical	complete	in the courtyard
73	East of C23-C24	undefined	filled	edge of scarp, base can not be reached; a canal trace reaches the cistern

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
74	East of C23-C24	undefined	filled	edge of scarp, base can not be reached; a canal trace reaches the cistern
75	East of C23-C24	undefined	filled, broken	edge of scarp, base can not be reached; a canal trace reaches the cistern from 74. cistern; connection between 74., 75. and 76. cisterns via this canal from the surface
76	C24	conical	half burnt	in the courtyard
77	C24	conical	half burnt	near scarp; original courtyard; converted to a stall
78	D79	conical	hung	near scarp; base is visible; converted to a room; base is perfect circle
79	D78	conical	complete	near the scarp and pool; canal traces; lid trace on the opening (may be for wine, olive oil, etc.)
80	D78	pear	complete	far from 79. cistern in D78; near the scarp, the small pool and the house
81	D78	conical	complete	near the pool; near the scarp; converted; partly used for weaving; a late hole at the base (could have been opened by looters); reached by stairs; above the elevations of 79. and 80. cisterns
82	D78	pear	opening destroyed	near the pool; near the scarp; connected with 81. cistern later; reached by stairs; above the elevations of 79. and 80. cisterns
83	(pool) D78	square	complete	connected to 81.and 82. cisterns from the top; reached by stairs; above the elevations of 79. and 80. cisterns
84	D78	undefined	filled	near the scarp; reached by stairs; above the elevations of 79. and 80. cisterns
85	D70	conical	hung, half complete	converted to a room; reached through the second room
86	D70	conical	hung, destroyed	converted to a rectangular room; reached through the second room
87	East of D51; on the main road	conical	undefined	located between D66 and D51; base can not be reached
88	D65	undefined	complete	in the middle of courtyard; near scarp; lid on top; two canal ways observed; cistern height is 650 cm. without taking the well ring into account; could have been used for public purpose
89	D65	conical	complete	below 88. cistern; near scarp
90	D65	conical	complete	below 88. cistern; near scarp
91	D65	conical	badly destroyed	entrance from D65; originally on the main road; converted to a room or kitchen
92	D65	conical	destroyed	in the courtyard; converted to an entrance; north of 88. cistern
93	D53	conical	complete	converted to a stall

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
94	D52	conical	hung, destroyed	height between base and late leveled base: 200 cm; converted to a room
95	D52	conical	hung, badly destroyed	height between base and late leveled base: 220 cm; converted to a room or kitchen; burnt
96	D51-1	conical	hung, destroyed	two hung cisterns as D51-1 and D51-2; base of D51-1 is not clear; almost all burnt; converted to a room
97	D51-2	conical	hung, destroyed	almost all burnt; base of D51-2 is clear; converted to a room
98	D63	conical	half complete	converted to a room; restored and plastered later (very recent); half is absent on vertical axis
99	D63	conical	half complete	converted to a room; half is absent
100	D55	conical	hung, destroyed	all black (burnt); converted; original base probably extends to late base
101	D56	conical	hung; half complete	south of D56; near the scarp; converted; half absent (visible from outside); is now outside due to slope and rock fall
102	D56	conical	hung; destroyed	next to 101. cistern in the west; used as an entrance between two rooms
103	D57	conical	complete	in the courtyard; near scarp
104	D38	conical	complete	entrance from D38; cistern is under the courtyard of D23; reached through a late hole inside the house; opening is closed and destroyed; converted to a room
105	D37	conical	destroyed	entrance from D37 under the road; courtyard of D23 or road; half is absent; converted
106	D35	conical	destroyed	in the middle of courtyard; converted to a stall
107	D36	pear	destroyed	in the middle of road; conversion to room with a door
108	D34	conical	hung, destroyed	carved on the facade; below the main road
109	D28	pear	destroyed	converted; half of the base is a room
110	D26	pear	hung, destroyed	half is present
111	Opposite of C1;on road	conical	destroyed	half is absent; on the main road; two holes opened from both sides
112	Opposite of C1;on road	conical	complete	on the main road, a stone-cut gutter-like trace passes by the cistern

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
113	C51	conical	hung	converted to a room; opening seems to have been used as an air venter; less burnt
114	C50	conical	complete	corner of courtyard; main road is in the east; distance to southern wall of the courtyard:150 cm.; distance to northern wall of the courtyard: 60 cm.
115	C55	conical	hung, complete	entrance from C57; converted; bond technique applied on top but can not be measured from top; standing on a column; height measured until the leveled base
116	C55	conical	hung, complete	entrance from C57; converted; bond technique applied on top but can not be measured form top; standing on a column; height measured until the leveled base
117	C59	conical	complete	in the courtyard; converted to a hall
118	C59	conical	half complete	in the courtyard; converted to a room (inside the first room)
119	C59	conical	burnt	converted to a room
120	Road between C59-C60	conical	destroyed	on the main road; converted to a room or stall
121	C31	conical	destroyed	next to main road; in the courtyard; seems slight cylindrical at first sight; opening is destroyed
122	C29	undefined	filled	in the courtyard; can not be reached from base; width of canal at the point where it reaches the cistern: 4 cm; width of canal at the point where it starts to leave the cistern and disappears due to abrasion: 6 cm.
123	Below the main road;C29	conical	hung, complete	entrance from C29; converted to a room
124	C17	pear	hung	converted
125	C10	conical	half complete	converted to a stall; reached from the first room; burnt
126	C21	conical	complete	in the courtyard; can not be reached; plastered
127	C19	conical	complete	converted to a stall; placed at the entrance; should not be such in the ancient plan, a possible canal remain
128	C27	undefined	destroyed	converted; 1/4 is preserved
129	C22	conical	destroyed	converted
130	D76	conical	destroyed	ceiling made of ceramic; burnt

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
131	D72	conical	complete	in the courtyard
132	D73	conical	complete	south corner of D72; reached from a room
133	D48	conical	complete	in the middle of courtyard; opening is destroyed; slight cylindrical
134	D49	conical	complete	half of opening is closed with stone
135	D50	conical	destroyed	1/4 is preserved; the biggest cistern in D50
136	D50	conical	hung	above 135. cistern
137	D50	conical	complete	southwestern corner; 135., 136. and 137. cisterns are on a linear position; can not be understood whether 137. cistern is hung or not
138	B8	conical	destroyed	broken at the entrance; converted
139	On the main road	conical	complete	south of B15; on the main road; converted; complete but sides are destroyed
140	On the main road	conical	complete	next to B12; converted to a room and a weaving platform; opening is on the road and broken; water extensive region starts here
141	B15	conical	destroyed	converted to a weaving platform; recorded as a bath by TAÇDAM
142	On the main road	cylindrical	destroyed	south of B4; base is destroyed on the edge of the scarp; half of the cistern is missing due to rock fall; slight conical
143	B4	undefined	filled	in the courtyard; near the entrance
144	B3	conical	destroyed	in the courtyard; converted; entrance is in the west, inside the cistern; stretches to the scarp; near Sır Gate
145	C67	conical	hung, destroyed	near road; converted to a stall; entrance is closed
146	C67	conical	hung, destroyed	in the courtyard; converted to a stall
147	C70	conical	complete	out of C70, towards the southwestern direction
148	C72	conical	destroyed	corner of C72; next to the main road; late bond technique applied on the opening; converted to a stall
149	C74	conical	complete	converted; reached through two rooms; late bond technique applied on the opening
150	D6	conical	destroyed	in the courtyard; entrance of D6; converted; canal tracks at the opposite of D2-D3 in the northern direction

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
151	D6	conical	complete	converted; no opening
152	D6	conical	complete	in the courtyard; a canal remain is very clear reaching from N30E; break point of the canal extension makes towards N63W; distance between the break point and the cistern: 540 cm.
153	D8	conical	badly destroyed	below D8; converted to a room; leveled; reached through the first room; lid fallen down and lies on base now
154	D8	undefined	filled	base can not be reached
155	D12	conical	destroyed	converted to a kitchen
156	D23	undefined	filled	in the courtyard
157	D23	undefined	filled	in the courtyard
158	D24	conical	destroyed	out of D24, on the road; converted
159	D14-D21 border	cylindrical	complete	junction of D14 and D21 in the southern direction
160	D14	conical	destroyed	out of D14; half facade is absent; converted to a kitchen; reached through the first room
161	D14-D20 border	conical	undefined	base can not be reached
162	East of D11	pear	half complete	converted; out of the courtyard
163	East of D11	conical	badly destroyed	out of the courtyard
164	C1	pear	complete	in the courtyard of a mosque at the entrance; no entrance to cistern
165	C3	undefined	undefined	in the courtyard
166	C5	undefined	filled	in the southern border
167	C6	undefined	complete	converted; reached by stairs
168	C7	undefined	filled	in the courtyard
169	C7	undefined	filled	in the courtyard

Description and Remarks Table (continued)

NO.	LOCATION	SHAPE	CURRENT CONDITION	DESCRIPTION AND REMARKS
170	C13	conical	complete	in the courtyard; reached by stairs
171	C76	conical	undefined	converted
172	C79	conical	complete	in the courtyard; connected with 173. cistern
173	C79	conical	complete	in the courtyard; distance between 172. and 173. cistern: 170 cm.
174	C79	conical	hung	road is in the north; reached through a room
175	On the main road	conical	destroyed	between C61 and C79; converted to a room
176	C8	conical	hung	in the courtyard; converted to a kitchen; burn signs; opening is closed; height from top to leveled base: 170 cm.
177	D44	conical	destroyed	converted; opening is destroyed
178	D44	conical	destroyed	converted; opening is destroyed
179	D43	undefined	destroyed	in the courtyard; near the road; converted
180	D42	undefined	filled	in the courtyard; bond technique applied on opening
181	C66	conical	complete	converted
182	C62	conical	hung, destroyed	half facade is absent; converted
183	C64	conical	complete	at the edge of courtyard; converted; opening is destroyed
184	C58	conical	hung, destroyed	converted
185	On the road	conical	complete	opposite of A3-A4 border
186	On the main road	conical	complete	opposite of A3-A4 border; distance between 185.and 186. cistern: 130 cm.
187	Special	conical	complete	at the eastern entrance of Ulu Mosque; reached by stairs; enlarged; five additional cisterns are located in the courtyard of Ulu Mosque

APPENDIX C

PATTERN MATRIX TABLE

NO.	LOCATION	SHAPE	PATTERN						
			Individual	Twin	Triple	Hung			Two-chimney
						Single-hung	Twin-hung	Triple-hung	
1	A5	pear	x						
2	A6	undefined	x						
3	A6 (west)	conical	x						
4	A4	conical	x						
5	A2	pear	x						
6	A13	undefined							
7	A20-1	conical	x						
8	A20-2	conical	x		x				
9	A20-3	conical	x						
10	B65	conical	x						
11	B66	undefined							
12	B59	conical	x						
13	B52	pear	x						
14	B49-1	conical	x						
15	B49-2	conical	x						
16	B41	conical	x						
17	B38-1	pear	x						
18	B38-2	conical	x						
19	B36	conical							x
20	B71-1	conical	x	x					
21	B71-2	conical	x			x			
22	B74-1A/B	conical		x					x
23	B74-2	conical	x			x			
24	B73	pear	x						
25	B74	conical	x						
26	B72	undefined							
27	B39	conical	x						

Pattern Matrix Table (continued)

NO.	LOCATION	SHAPE	PATTERN						
			Individual	Twin	Triple	Hung			Two-chimney
						Single-hung	Twin-hung	Triple-hung	
28	B39	conical	x						
29	B67	conical	x						
30	B67	conical	x						
31	B62	conical	x						
32	B26	conical	x			x			
33	B27	cylindrical	x						
34	B28	undefined							
35	B29	conical	x						
36	B29	cylindrical	x						
37	B29	undefined							
38	B30	conical	x			x			
39	B32	conical	x			x			
40	B34	undefined							
41	B35	undefined							
42	B40	conical	x						
43	B16	conical	x			x			
44	B18	conical	x			x			
45	B18	pear	x						
46	B19	conical	x						
47	B18	conical	x						
48	B18	pear	x						
49	Main road	conical	x			x			
50	B20	conical	x			x			
51	Junction of A33-A34-A35	pear	x						
52	A31	pear	x						
53	A28	conical	x						
54	C43	pear	x						
55	C45	pear	x						
56	C45	conical	x		x	x		x	
57	C45	conical	x			x			

Pattern Matrix Table (continued)

NO.	LOCATION	SHAPE	PATTERN						
			Individual	Twin	Triple	Hung			Two-chimney
						Single-hung	Twin-hung	Triple-hung	
58	C45	undefined							
59	C45	undefined							
60	A23	conical	x						
61	A26	conical	x						
62	A26	conical	x						
63	C45	pear	x						
64	C45	pear	x						
65	C41	conical	x						
66	C41	conical	x						
67	C45	conical	x			x			
68	C38	conical	x			x			
69	C38	conical	x						
70	C38	conical	x						
71	C34	conical	x						
72	C33	conical	x						
73	East of C23-C24	undefined							
74	East of C23-C24	undefined			x				
75	East of C23-C24	undefined							
76	C24	conical	x						
77	C24	conical	x						
78	D79	conical	x			x			
79	D78	conical	x						
80	D78	pear	x						
81	D78	conical	x						
82	D78	pear	x						
83	(pool) D78	square							
84	D78	undefined							
85	D70	conical	x			x			
86	D70	conical	x			x			

Pattern Matrix Table (continued)

<table>
<tr><th>NO.</th><th>LOCATION</th><th>SHAPE</th><th colspan="7">PATTERN</th></tr>
<tr><th></th><th></th><th></th><th>Individual</th><th>Twin</th><th>Triple</th><th colspan="3">Hung</th><th>Two-chimney</th></tr>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th>Single-hung</th><th>Twin-hung</th><th>Triple-hung</th><th></th></tr>
<tr><td>87</td><td>East of D51; on the main road</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>88</td><td>D65</td><td>undefined</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>89</td><td>D65</td><td>conical</td><td>x</td><td rowspan="2">x</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>90</td><td>D65</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>91</td><td>D65</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>92</td><td>D65</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>93</td><td>D53</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>94</td><td>D52</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>95</td><td>D52</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>96</td><td>D51-1</td><td>conical</td><td>x</td><td rowspan="2">x</td><td></td><td>x</td><td rowspan="2">x</td><td></td><td></td></tr>
<tr><td>97</td><td>D51-2</td><td>conical</td><td>x</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>98</td><td>D63</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>99</td><td>D63</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>100</td><td>D55</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>101</td><td>D56</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>102</td><td>D56</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>103</td><td>D57</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>104</td><td>D38</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>105</td><td>D37</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>106</td><td>D35</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>107</td><td>D36</td><td>pear</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>108</td><td>D34</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>109</td><td>D28</td><td>pear</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>110</td><td>D26</td><td>pear</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>111</td><td>Opposite of C1;on road</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>112</td><td>Opposite of C1;on road</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>113</td><td>C51</td><td>conical</td><td>x</td><td></td><td></td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>114</td><td>C50</td><td>conical</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>115</td><td>C55</td><td>conical</td><td>x</td><td rowspan="2">x</td><td></td><td>x</td><td rowspan="2">x</td><td></td><td></td></tr>
<tr><td>116</td><td>C55</td><td>conical</td><td>x</td><td></td><td>x</td><td></td><td></td></tr>
</table>

Pattern Matrix Table (continued)

NO.	LOCATION	SHAPE	PATTERN						
			Individual	Twin	Triple	Hung			Two-chimney
						Single-hung	Twin-hung	Triple-hung	
117	C59	conical	x						
118	C59	conical	x						
119	C59	conical	x						
120	Road between C59-C60	conical	x						
121	C31	conical	x						
122	C29	undefined							
123	Below the main road;C29	conical	x			x			
124	C17	pear	x			x			
125	C10	conical	x						
126	C21	conical	x						
127	C19	conical	x						
128	C27	undefined							
129	C22	conical	x						
130	D76	conical	x						
131	D72	conical	x						
132	D73	conical	x						
133	D48	conical	x						
134	D49	conical	x						
135	D50	conical	x						
136	D50	conical	x		x	x			
137	D50	conical	x						
138	B8	conical	x						
139	On the main road	conical	x						
140	On the main road	conical	x						
141	B15	conical	x						
142	On the main road	cylindrical	x						
143	B4	undefined							
144	B3	conical	x						
145	C67	conical	x			x			
146	C67	conical	x			x			
147	C70	conical	x						
148	C72	conical	x						
149	C74	conical	x						

Pattern Matrix Table (continued)

NO.	LOCATION	SHAPE	PATTERN						
			Individual	Twin	Triple	Hung			Two-chimney
						Single-hung	Twin-hung	Triple-hung	
150	D6	conical	**x**						
151	D6	conical	**x**						
152	D6	conical	**x**						
153	D8	conical	**x**						
154	D8	undefined							
155	D12	conical	**x**						
156	D23	undefined							
157	D23	undefined							
158	D24	conical	**x**						
159	D14-D21 border	cylindrical	**x**						
160	D14	conical	**x**						
161	D14-D20 border	conical	**x**						
162	East of D11	pear	**x**						
163	East of D11	conical	**x**						
164	C1	pear	**x**						
165	C3	undefined							
166	C5	undefined							
167	C6	undefined							
168	C7	undefined							
169	C7	undefined							
170	C13	conical	**x**						
171	C76	conical	**x**						
172	C79	conical	**x**	**x**					
173	C79	conical	**x**						
174	C79	conical	**x**			**x**			
175	On the main road	conical	**x**						
176	C8	conical	**x**			**x**			
177	D44	conical	**x**						
178	D44	conical	**x**						
179	D43	undefined	**x**						
180	D42	undefined							
181	C66	conical	**x**						
182	C62	conical	**x**			**x**			
183	C64	conical	**x**						
184	C58	conical	**x**			**x**			
185	On the road	conical	**x**						
186	On the main road	conical	**x**						
187	Special	conical	**x**						

APPENDIX D

CISTERN DISTRIBUTION MATRIX TABLE

LOCATION	**TOTAL # OF CISTERNS WITHIN A HOUSING UNIT**	**TOTAL # OF CISTERNS ON A ROAD**	**TOTAL # OF CISTERNS NEAR SCARP**	**TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP**	**TOTAL # OF CISTERNS ABOVE 591m.**	**TOTAL # OF CISTERNS ACCORDING TO SIZE**					
						very small	**small**	**medium**	**large**	**very large**	**extremely large**
A5	**1**							**1**			
A6	**1**								**1**		
A6 (west)		**1**					**1**				
A4	**1**						**1**				
A2	**1**									**1**	
A13	**1**								**1**		
A20 *	**3**						**3**				
B65	**1**							**1**			
B66	**1**							**1**			
B59	**1**								**1**		
B52	**1**						**1**				

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
B49 *	2			2			2				
B41	1						1				
B38 *	2						1	1			
B36	1										1
B71 *	2	2					1	1			
B74 *	2	1					3				
B73	1						1				
B72	1						1				
B39 *	2						1			1	
B67 *	2						1	1			
B62	1								1		
B26	1						1				
B27	1					1					
B28	1					1					
B29 *	3					1	2				

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
B30	1						1				
B32	1					1					
B34	1								1		
B35	1									1	
B40	1		1				1				
B16	1						1				
B18 *	4						1		2	1	
B19	1						1				
Main road		1	1	1			1				
B20	1						1				
Junction of A33-A34-A35	1		1				1				
A31	1					1					
A28	1							1			
C43	1						1				
C45 *	8					3	4		1		
A23	1					1					

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
A26 *	**2**						**2**				
C41 *	**2**						**2**				
C38 *	**3**						**2**	**1**			
C34	**1**							**1**			
C33	**1**						**1**				
East of C23-C24 *			**3**			**3**					
C24 *	**2**		**1**						**1**	**1**	
D79	**1**		**1**					**1**			
D78 *	**5**		**2**			**1**	**2 / 1**		**1**		
D70 *	**2**						**1**	**1**			
East of D51; on the main road		**1**					**1**				
D65 *	**4**	**1**	**2**			**2**	**1 / 2**				
D53	**1**								**1**		
D52 *	**2**						**2**				
D51 *	**2**					**2**					

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
D63 *	2						2				
D55	1						1				
D56 *	2						2				
D57	1		1				1				
D38	1	1			1		1				
D37	1	1			1		1				
D35	1						1				
D36		1					1				
D34	1				1		1				
D28	1				1		1				
D26	1				1		1				
Opposite of C1;on road		1			1		1				
Opposite of C1;on road		1			1		1				
C51	1									1	
C50	1							1			
C55 *	2								1	1	

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
C59 *	3						3				
Road between C59-C60		1					1				
C31	1						1				
C29 *	1	1				1 / 1					
C17	1						1				
C10	1							1			
C21	1						1				
C19	1						1				
C27	1							1			
C22	1							1			
D76	1							1			
D72	1						1				
D73	1						1				
D48	1					1					
D49	1						1				

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
D50 *	3					1	2				
B8	1						1				
On the main road		1					1				
On the main road		1									1
B15	1									1	
On the main road		1	1	1		1					
B4	1						1				
B3	1		1				1				
C67 *	2						2				
C70	1						1				
C72	1						1				
C74	1						1				
D6 *	3				3	1	1	1			
D8 *	2				2		2				
D12	1				1		1				

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
D23 *	2				2	1	1				
D24		1			1		1				
D14-D21 border	1				1	1					
D14	1				1		1				
D14-D20 border	1				1		1				
East of D11		1			1		1				
East of D11		1			1		1				
C1	1				1		1				
C3	1				1	1					
C5	1						1				
C6	1						1				
C7	2						2				
C13	1				1		1				
C76	1				1		1				
C79*	3				3	2	1				
On the main road		1			1				1		

Cistern Distribution Matrix Table (continued)

LOCATION	TOTAL # OF CISTERNS WITHIN A HOUSING UNIT	TOTAL # OF CISTERNS ON A ROAD	TOTAL # OF CISTERNS NEAR SCARP	TOTAL # OF CISTERNS ON A ROAD & NEAR SCARP	TOTAL # OF CISTERNS ABOVE 591m.	TOTAL # OF CISTERNS ACCORDING TO SIZE					
						very small	small	medium	large	very large	extremely large
C8	1						1				
D44*	2						2				
D43	1						1				
D42	1						1				
C66	1								1		
C62	1						1				
C64	1						1				
C58	1						1				
On the road		1				1					
On the main road		1				1					
TOTAL	**163**	**23**	**17**	**2**	**29**	**30**	**114**	**17**	**14**	**8**	**2**

Cistern Distribution Matrix Table (continued)

PATTERNS	EXPLANATIONS
	Indicates total number of cisterns in a housing unit, under a size category
	Indicates total number of cisterns on a road, under a size category
	Indicates total number of cisterns near a scarp, under a size category
	Indicates total number of cisterns on a road and near a scarp, under a size category
	Indicates splitting the total of cisterns under the same size category, part of which belongs to the number of cisterns on a road. The number on the left side of the diagonal refers to the number of cisterns on a road.
	Indicates splitting the total of cisterns under the same size category, part of which belongs to the number of cisterns near a scarp. The number on the left side of the diagonal refers to the number of cisterns near a scarp.
	Indicates implicitly splitting the total of cisterns under the same size category where number of cistern is always "1" which is placed on a road and near a scarp at the same time

* (not repeated): Locations of cisterns with respect to names based on housing units are redesigned as single units through A5 and C58, apart from those which are assigned specific names during the field work, in the first column. So, total individual sum of size categories do not match number of cisterns satisfying size categories given in Chapter 4 if any calculation is made.

APPENDIX E

CISTERN COORDINATE TABLE

NO.	LOCATION	EASTING	NORTHING
1	A5	447951	4175937.37
2	A6	447956	4175916.15
3	A6 (west)	447933	4175910.91
4	A4	447923	4175916.90
5	A2	447894	4175904.26
6	A13	447904	4175885.54
7	A20-1	447918	4175781.81
8	A20-2	447916	4175779.92
9	A20-3	447915	4175777.77
10	B65	447775	4175817.87
11	B66	447790	4175825.38
12	B59	447769	4175843.71
13	B52	447739	4175835.12
14	B49-1	447663	4175828.86
15	B49-2	447661	4175833.75
16	B41	447691	4175769.15
17	B38-1	447705	4175766.13
18	B38-2	447705	4175760.79
19	B36	447727	4175757.45
20	B71-1	447790	4175799.10
21	B71-2	447789	4175796.63
22	B74-1A/B	447783	4175783.52
23	B74-2	447784	4175781.70
24	B73	447748	4175778.14
25	B74	447759	4175783.52
26	B72	447747	4175764.64
27	B39	447721	4175766.56
28	B39	447719	4175772.40
29	B67	447718	4175800.01
30	B67	447715	4175793.39
31	B62	447734	4175811.13
32	B26	447819	4175696.90
33	B27	447796	4175707.30
34	B28	447794	4175711.39
35	B29	447777	4175721.55
36	B29	447782	4175722.29
37	B29	447786	4175722.57
38	B30	447768	4175725.04
39	B32	447762	4175745.96
40	B34	447738	4175739.91
41	B35	447731	4175747.91
42	B40	447689	4175761.83
43	B16	447802	4175677.44
44	B18	447795	4175649.20
45	B18	447781	4175651.10
46	B19	447774	4175649.56
47	B18	447790	4175653.46

Coordinate Table (continued)

NO.	LOCATION	EASTING	NORTHING
48	B18	447795	4175657.82
49	Main road	447800	4175629.13
50	B20	447773	4175665.91
51	Junction of A33-A34-A35	447971	4175789.98
52	A31	447968	4175813.46
53	A28	447931	4175878.07
54	C43	447955	4175761.20
55	C45	447944	4175742.86
56	C45	447944	4175740.44
57	C45	447941	4175741.89
58	C45	447938	4175740.19
59	C45	447933	4175730.86
60	A23	447909	4175738.37
61	A26	447902	4175721.00
62	A26	447896	4175708.88
63	C45	447939	4175730.94
64	C45	447939	4175728.38
65	C41	447965	4175728.49
66	C41	447968	4175723.76
67	C45	447949	4175730.75
68	C38	447949	4175706.66
69	C38	447968	4175686.62
70	C38	447966	4175683.28
71	C34	447978	4175631.51
72	C33	447986	4175634.39
73	East of C23-C24	448009	4175592.45
74	East of C23-C24	448012	4175592.52
75	East of C23-C24	448014	4175594.85
76	C24	447991	4175597.67
77	C24	447991	4175594.08
78	D79	447996	4175530.40
79	D78	447999	4175523.32
80	D78	447993	4171515.41
81	D78	447995	4175513.00
82	D78	447999	4175504.01
83	(Pool) D78	447997	4175509.02
84	D78	447997	4175513.00
85	D70	447972	4175502.62
86	D70	447968	4175501.10
87	East of D51; on the main road	447958	4175484.54
88	D65	447953	4175460.00
89	D65	447953	4175454.70
90	D65	447952	4175453.43
91	D65	447947	4175473.36
92	D65	447952	4175470.02
93	D53	447921	4175456.08
94	D52	447929	4175475.69
95	D52	447923	4175469.33
96	D51-1	447935	4175480.02
97	D51-2	447938	4175477.20
98	D63	447912	4175445.16
99	D63	447912	4175435.37
100	D55	447900	4175421.50
101	D56	447895	4175407.80

Coordinate Table (continued)

NO.	LOCATION	EASTING	NORTHING
102	D56	447898	4175406.58
103	D57	447892	4175399.11
104	D38	447869	4175394.83
105	D37	447870	4175399.93
106	D35	447880	4175415.48
107	D36	447888	4175404.29
108	D34	447876	4175426.11
109	D28	447871	4175486.56
110	D26	447881	4175501.64
111	Opposite of C1;on road	447888	4175509.54
112	Opposite of C1;on road	447883	4175506.91
113	C51	447938	4175685.44
114	C50	447941	4175700.22
115	C55	447905	4175663.10
116	C55	447903	4175666.62
117	C59	447906	4175645.45
118	C59	447910	4175644.42
119	C59	447897	4175634.67
120	Road between C59-C60	447918	4175636.89
121	C31	447958	4175648.97
122	C29	447961	4175629.44
123	Below the main road;C29	447949	4175625.29
124	C17	447942	4175622.62
125	C10	447942	4175611.60
126	C21	447959	4175593.19
127	C19	447959	4175577.24
128	C27	447966	4175615.70
129	C22	447966	4175599.77
130	D76	447969	4175587.94
131	D72	447960	4175522.14
132	D73	447952	4175534.86
133	D48	447941	4175514.95
134	D49	447946	4175500.11
135	D50	447940	4175493.48
136	D50	447940	4175491.94
137	D50	447942	4175491.94
138	B8	447838	4175644.41
139	On the main road	447823	4175662.39
140	On the main road	447815	4175652.35
141	B15	447815	4175675.27
142	On the main road	447804	4175623.66
143	B4	447813	4175629.18
144	B3	447819	4175624.71
145	C67	447843	4175622.24
146	C67	447845	4175619.21
147	C70	447847	4175567.65
148	C72	447856	4175546.08
149	C74	447861	4175516.33
150	D6	447810	4175473.99
151	D6	447808	4175472.44
152	D6	447804	4175472.44
153	D8	447819	4175447.62
154	D8	447817	4175443.97
155	D12	447811	4175428.96

Coordinate Table (continued)

NO.	LOCATION	EASTING	NORTHING
156	D23	447860	4175401.12
157	D23	447859	4175395.67
158	D24	447846	4175383.09
159	D14-D21 border	447853	4175427.91
160	D14	447847	4175428.13
161	D14-D20 border	447860	4175440.34
162	East of D11	447837	4175449.15
163	East of D11	447836	4175445.36
164	C1	447889	4175515.85
165	C3	447903	4175531.09
166	C5	447911	4175543.99
167	C6	447912	4175558.55
168	C7	447917	4175563.49
169	C7	447921	4175564.30
170	C13	447906	4175575.50
171	C76	447888	4175550.97
172	C79	447877	4175612.58
173	C79	447879	4175611.20
174	C79	447899	4175609.75
175	On the main road	447908	4175611.67
176	C8	447926	4175579.27
177	D44	447923	4175519.32
178	D44	447923	4175522.55
179	D43	447933	4175493.89
180	D42	447919	4175500.90
181	C66	447856	4175614.95
182	C62	447875	4175624.01
183	C64	447851	4175627.87
184	C58	447893	4175651.83
185	On the road	447923	4175908.87
186	On the main road	447928	4175907.34
187	Special	447826	4175780.33

APPENDIX F

AREA MEASUREMENT TABLE

Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Original location	No*.
A1	342,88		B1	179,05		C1	323,09	164	D1	316,255		main road	3*
A2	162,84	5	B2	189,43		C2	193,44		D2	225,537		main road	20*
A3	404,40		B3	197,71	144	C3	252,29	165	D3	157,493		main road	21*
A4	141,08	4	B4	131,10	143	C4	104,23		D4	322,455		main road	23*
A5	513,74	1	B5	173,46		C5	155,56	166	D5	86,98		main road	49
A6	399,52	2	B6	193,07		C6	254,10	167	D6	212,769	150, 151, 152	main road	58*
A7	-1,00		B7	145,96		C7	98,93	168, 169	D7	44,312		main road	87
A8	-1,00		B8	305,18	138	C8	333,07	176	D8	173,109	153, 154	main road	91*
A9	-1,00		B9	158,82		C9	325,93		D9	97,071		main road	104*
A10	-1,00		B10	204,55		C10	154,93	125	D10	106,343		main road	105*
A11	-1,00		B11	113,64		C12	172,10		D11	130,543		main road	107*
A12	352,60		B12	80,88		C13	138,21	170	D12	151,505	155	main road	111
A13	314,26	6	B13	68,82		C14	164,44		D13	300,996		main road	112
A14	125,28		B14	68,28		C15	348,26		D14**	240,566	160, 161	main road	120
A15	169,02		B15	301,42	141	C16	371,60		D15	157,835		main road	123
A16	358,00		B16	180,86	43	C17	390,50	124	D16	170,666		main road	139
A17	780,99		B17	183,88		C18	545,23		D18	61,942		main road	140
A18	231,00		B18	681,08	44, 45, 47, 48	C19	156,55	127	D19	92,43		main road	147*
A19	339,89		B19	237,89	46	C20	153,59		D20	52,604		main road	158*
A20	202,62	7, 8, 9	B20	121,76	50	C21	156,34	126	D21**	278,422	159	main road	162*
A22	38,61		B21	180,47		C22	217,89	129	D22	223,565		main road	163*
A23	204,12	60	B22	261,58		C23	173,05		D23	261,364	156, 157	main road	175
A24	219,47		B23	75,07		C24	141,67	76, 77	D24	180,872		main road	185
A25	95,99		B24	-1,00		C25	83,82		D25	143,692		main road	186
A26	108,81	61, 62	B25	61,99		C26	52,35		D26	208,166	110		

Area Measurement Table (continued)

Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Original location	No
A27	120,30		B26	352,96	32	C27	114,63	128	D27	76,356		scarp	73*
A28	206,85	53	B27	327,30	33	C28	149,31		D28	184,957	109	scarp	74*
A29	220,90		B28	127,68	34	C29	185,36	122	D29	326,517		scarp	75*
A30	324,34		B29	222,79	35, 36, 37	C30	166,46		D30	346,447		scarp	142*
A31	93,01	52	B30	190,45	38	C31	126,54	121	D31	157,296			
A32	33,56		B31	210,25		C32	146,98		D32	101,433			
A33**	84,02	51	B32	304,74	39	C33	300,19	72	D33	109,177			
A34	145,17		B33	-1,00		C34	260,59	71	D34	128,505	108		
A35	127,54		B34	118,99	40	C35	226,50		D35	201,731	106		
A36	77,87		B35	107,16	41	C36	194,20		D36	103,225			
A37	49,56		B36	106,71	19	C37	107,43		D37	72,731			
A38	75,62		B37	56,28		C38	683,63	68, 69, 70	D38	123,966			
			B38	166,40	17, 18	C39	81,99		D39	82,181			
			B39	270,88	27, 28	C40	214,14		D40	168,738			
			B40	82,30	42	C41	541,78	65, 66	D41	204,633			
			B41	97,95	16	C42	279,58		D42	347,673	180		
			B42	171,33		C43	514,73	54	D43	275,385	179		
			B43	293,02		C44	272,84		D44	364,409	177, 178		
			B44	55,75		C45	376,40	55, 56, 57, 59, 63, 64, 67	D45	155,505			
			B45	307,38		C46	267,52		D46	193,369			
			B46	226,26		C47	144,88		D47	66,444			
			B47	108,20		C48	157,22		D48	103,63	133		
			B48	395,35		C49	84,11		D49	117,381	134		
			B49	407,19	14, 15	C50	169,56	114	D50	153,844	135, 136, 137		
			B50	175,74		C51	295,59	113	D51	226,409	96, 97		
			B51	63,09		C52	108,02		D52	317,97	94, 95		
			B52	443,11		C53	174,29		D53	273,139	93		
			B53	269,84		C54	236,17		D54	166,999			
			B54	143,04		C55	420,32	115, 116	D55	333,399			
			B55	157,73		C56	90,71		D56	210,081	101, 102		
			B56	165,14		C57	323,64		D57	267,871	103		
			B57**	206,37	13	C58	251,26	184	D58	77,645			
			B58	128,84		C59	449,03	117, 118, 119	D59	77,184			

Area Measurement Table (continued)

Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Housing Unit	Area (m^2)	No.	Original location	No.
			B59	112,80	12	C60	73,66		D60	265,176			
			B60	-1,00		C61	158,30		D61	67,546			
			B61	119,43		C62	365,10	182	D62	123,733			
			B62	127,98	31	C63	131,03		D63	318,359	98, 99		
			B63	128,04		C64	252,33	183	D64	197,017			
			B64	135,23		C65	70,37		D65	348,023	88, 89, 90, 92		
			B65	272,97	10	C66	62,00	181	D66	217,761			
			B66	283,74	11	C67	211,75	145, 146	D67	244,805			
			B67	683,68	29, 30	C68	93,80		D68	102,649			
			B68	348,58		C69	196,81		D69	206,952			
			B69	459,43		C70	211,75		D70	176,449	85, 86		
			B70	268,69		C71	280,34		D71	211,747			
			B71	187,26		C72	130,70	148	D72	238,973	131		
			B72	331,36	26	C73	101,37		D73	256,117	132		
			B73	228,33	24	C74	194,42	149	D74	306,189			
			B74	594,28	22, 25	C75	113,41		D75	281,68			
			B75	-1,00		C76	237,68	171	D76	297,724	130		
			B76	-1,00		C77	235,24		D77	97,566			
			B77	-1,00		C78	180,30		D78	432,098	79, 80, 81, 82, 84		
			B78	-1,00		C79	1032,61	172, 173, 174	D79	405,496	78		
			B79	-1,00					D80	211,985			
Total A	**7063,83**		**Total B**	**15237,93**		**Total C**	**17364,44**		**Total D**	**15521,77**			
TOTAL HOUSING AREA	**55187,97**		**Public Areas**	A11, B(75-79)							**55187,97**		
MASK	**23264,92**										**23264,92**		
TOTAL ROAD AREA	**26282,32**										**26282,32**		
TOTAL AREA	**104735,20**										**104735,20**		

1. "**No.**" indicates the identification of cisterns based on housing units, in line with Appendix A, B, C and E.
2. The numbering of cisterns on a main road or scarp at the up-left corner are previously resumed according to their current conditions (status-quo) throughout the study and in all the appendices. They are re-arranged only for this section where (*****) assumes the identification of locations with previously assigned cistern numbers in all the appendices, as the original.
3. (******) indicates the re-identification of cisterns which are shared by two or three housing units, reducing them to a single housing unit.
4. Note that A21 and C11 are not previously assigned to any housing area.

APPENDIX G

NEAREST DISTANCE BETWEEN CISTERNS

No.	Cistern 1	Cistern 2	Distance	No.	Cistern 1	Cistern 2	Distance	No.	Cistern 1	Cistern 2	Distance	No.	Cistern 1	Cistern 2	Distance	No.	Cistern 1	Cistern 2	Distance
1	134	135	1,5	**38**	77	76	3,8	**75**	3	185	5,9	**112**	38	35	9,3	**149**	99	100	14,7
2	135	134	1,5	**39**	95	96	3,8	**76**	90	91	5,9	**113**	67	63	9,5	**150**	126	129	14,8
3	88	89	1,9	**40**	96	95	3,8	**77**	91	90	5,9	**114**	125	128	9,5	**151**	179	178	14,9
4	89	88	1,9	**41**	85	86	4,1	**78**	27	28	6,1	**115**	128	125	9,5	**152**	130	131	15
5	136	135	2	**42**	86	85	4,1	**79**	28	27	6,1	**116**	182	144	9,5	**153**	131	130	15
6	22	23	2,1	**43**	116	117	4,1	**80**	49	141	6,4	**117**	173	174	9,6	**154**	112	113	15,1
7	23	22	2,1	**44**	117	116	4,1	**81**	141	49	6,4	**118**	174	173	9,6	**155**	87	90	15,4
8	8	9	2,4	**45**	161	162	4,1	**82**	163	110	6,5	**119**	97	98	9,8	**156**	164	165	15,5
9	9	8	2,4	**46**	162	161	4,1	**83**	102	106	6,6	**120**	98	97	9,8	**157**	175	168	15,8
10	81	84	2,4	**47**	36	37	4,2	**84**	106	102	6,6	**121**	68	113	10,3	**158**	154	153	15,9
11	84	81	2,4	**48**	37	36	4,2	**85**	158	159	6,7	**122**	113	68	10,3	**159**	132	133	16
12	171	172	2,4	**49**	151	150	4,2	**86**	159	158	6,7	**123**	19	41	10,4	**160**	50	46	16,5
13	172	171	2,4	**50**	152	153	4,2	**87**	166	167	6,7	**124**	41	19	10,4	**161**	169	167	16,5
14	55	56	2,5	**51**	153	152	4,2	**88**	44	47	6,8	**125**	40	41	10,6	**162**	10	11	16,6
15	56	55	2,5	**52**	167	168	4,2	**89**	47	44	6,8	**126**	124	123	11	**163**	11	10	16,6
16	63	64	2,5	**53**	168	167	4,2	**90**	48	47	6,9	**127**	105	107	11,1	**164**	157	156	18,1
17	64	63	2,5	**54**	114	115	4,4	**91**	59	63	6,9	**128**	107	105	11,1	**165**	108	109	18,4
18	7	8	2,6	**55**	115	114	4,4	**92**	29	30	7,1	**129**	119	117	11,2	**166**	60	61	18,9
19	20	21	2,8	**56**	33	34	4,9	**93**	30	29	7,1	**130**	129	125	11,5	**167**	120	121	19,7
20	21	20	2,8	**57**	34	33	4,9	**94**	45	46	7,4	**131**	180	145	11,6	**168**	31	29	20
21	149	150	2,8	**58**	184	185	5,2	**95**	46	45	7,4	**132**	181	171	11,6	**169**	137	182	20,7
22	150	149	2,8	**59**	185	184	5,2	**96**	93	95	7,5	**133**	24	25	12,2	**170**	54	55	21
23	57	55	2,9	**60**	14	15	5,3	**97**	122	123	7,5	**134**	25	24	12,2	**171**	5	6	21,1
24	74	75	2,9	**61**	15	14	5,3	**98**	123	122	7,5	**135**	121	122	12,6	**172**	6	5	21,1
25	75	74	2,9	**62**	17	18	5,3	**99**	16	42	7,6	**136**	138	139	13,3	**173**	39	38	21,8
26	80	81	3	**63**	18	17	5,3	**100**	42	16	7,6	**137**	139	138	13,3	**174**	1	2	22
27	73	74	3,1	**64**	83	88	5,3	**101**	178	134	7,7	**138**	26	24	13,5	**175**	2	1	22
28	176	177	3,3	**65**	103	104	5,3	**102**	78	79	7,8	**139**	61	62	13,5	**176**	32	140	22,1
29	177	176	3,3	**66**	104	103	5,3	**103**	79	78	7,8	**140**	62	61	13,5	**177**	146	147	23,6
30	144	145	3,4	**67**	110	111	5,4	**104**	71	72	7,9	**141**	92	97	13,5	**178**	147	146	23,6
31	145	144	3,4	**68**	111	110	5,4	**105**	72	71	7,9	**142**	43	140	13,6	**179**	51	52	23,7
32	58	57	3,6	**69**	155	156	5,5	**106**	4	184	8	**143**	140	43	13,6	**180**	52	51	23,7
33	100	101	3,6	**70**	156	155	5,5	**107**	142	143	8	**144**	118	116	13,8	**181**	170	165	23,7
34	101	100	3,6	**71**	35	36	5,6	**108**	143	142	8	**145**	160	158	13,8	**182**	148	111	23,9
35	69	70	3,8	**72**	65	66	5,6	**109**	94	93	8,8	**146**	183	116	14,4	**183**	13	31	24,5
36	70	69	3,8	**73**	66	65	5,6	**110**	133	134	8,8	**147**	127	121	14,6	**184**	12	10	26,4
37	76	77	3,8	**74**	109	111	5,8	**111**	82	84	9,1	**148**	165	166	14,6	**185**	53	6	27,6

APPENDIX H

CLASSIFICATION OF CONVERTED CISTERNS IN RELATION TO LOCATION

NO.	LOCATION	CONVERSION CATEGORY						
		Room	Stall	Kitchen	Bath	Weaving Platform	Other Purpose	Unconverted
1	A5		X					
2	A6							Not applicable
3	A6 (west)	X						
4	A4							X
5	A2							X
6	A13							Not applicable
7	A20-1							X
8	A20-2							X
9	A20-3							X
10	B65	X						
11	B66							Not applicable
12	B59		X					
13	B52			X				
14	B49-1							Not applicable
15	B49-2							X
16	B41							X
17	B38-1	X						
18	B38-2							X
19	B36*	X		X*				
20	B71-1	X						
21	B71-2							Not applicable
22	B74-1A/B							X
23	B74-2							X
24	B73*	X	X*					
25	B74*	X	X*					
26	B72							Not applicable
27	B39	X	X*					
28	B39	X						
29	B67							X
30	B67							X
31	B62	X						
32	B26	X						
33	B27							X
34	B28							X
35	B29	X						

CLASSIFICATION OF CONVERTED CISTERNS IN RELATION TO LOCATION

NO.	LOCATION	CONVERSION CATEGORY						
		Room	Stall	Kitchen	Bath	Weaving Platform	Other Purpose	Unconverted
36	B29							X
37	B29							Not applicable
38	B30*	X	X*				X	
39	B32	X						
40	B34							Not applicable
41	B35							Not applicable
42	B40							X
43	B16						X	
44	B18*			X	X*			
45	B18	X						
46	B19						X	
47	B18						X	
48	B18						X	
49	Main road	X						
50	B20						X	
51	Junction of A33-A34-A35							X
52	A31							X
53	A28							X
54	C43							X
55	C45							X
56	C45						X	
57	C45					X		
58	C45**						X**	Not applicable
59	C45							Not applicable
60	A23							X
61	A26							X
62	A26	X						
63	C45	X						
64	C45	X						
65	C41						X	
66	C41						X	
67	C45							Not applicable
68	C38		X					
69	C38							X
70	C38							X
71	C34						X	
72	C33							X
73	East of C23-C24							Not applicable
74	East of C23-C24							Not applicable
75	East of C23-C24							Not applicable
76	C24							X

CLASSIFICATION OF CONVERTED CISTERNS IN RELATION TO LOCATION

NO.	LOCATION	CONVERSION CATEGORY						
		Room	Stall	Kitchen	Bath	Weaving Platform	Other Purpose	Unconverted
77	C24		X					
78	D79	X						
79	D78							X
80	D78							X
81	D78					X		
82	D78							Not applicable
83	(pool) D78							X
84	D78							Not applicable
85	D70	X						
86	D70	X						
87	East of D51; on the main road							Not applicable
88	D65							X
89	D65							X
90	D65							X
91	D65*	X		X*				
92	D65						X	
93	D53		X					
94	D52	X						
95	D52	X		X*				
96	D51-1	X						
97	D51-2	X						
98	D63	X						
99	D63	X						
100	D55*			X*			X	
101	D56						X	
102	D56						X	
103	D57							X
104	D38	X						
105	D37						X	
106	D35		X					
107	D36	X						
108	D34							Not applicable
109	D28	X						
110	D26							Not applicable
111	Opposite of C1;on the road							Not applicable
112	Opposite of C1;on the road							X
113	C51	X						
114	C50							X
115	C55						X	
116	C55						X	
117	C59						X	
118	C59	X						

CLASSIFICATION OF CONVERTED CISTERNS IN RELATION TO LOCATION

NO.	LOCATION	CONVERSION CATEGORY						
		Room	Stall	Kitchen	Bath	Weaving Platform	Other Purpose	Unconverted
119	C59	X						
120	Road between C59-C60*	X	X*					
121	C31							X
122	C29							Not applicable
123	Below the main road; C29	X						
124	C17						X	
125	C10		X					
126	C21							X
127	C19		X					
128	C27						X	
129	C22						X	
130	D76**						X**	X
131	D72							X
132	D73							X
133	D48							X
134	D49							X
135	D50							X
136	D50						X	
137	D50							X
138	B8						X	
139	On the main road						X	
140	On the main road*	X				X*		
141	B15					X		
142	On the main road							X
143	B4							Not applicable
144	B3						X	
145	C67		X					
146	C67		X					
147	C70							X
148	C72		X					
149	C74						X	
150	D6						X	
151	D6						X	
152	D6							X
153	D8	X						
154	D8							Not applicable
155	D12			X				
156	D23							Not applicable
157	D23							Not applicable
158	D24						X	
159	D14-D21 border							X

CLASSIFICATION OF CONVERTED CISTERNS IN RELATION TO LOCATION

NO.	LOCATION	CONVERSION CATEGORY						
		Room	Stall	Kitchen	Bath	Weaving Platform	Other Purpose	Unconverted
160	D14			**X**				
161	D14-D20 border							**Not applicable**
162	East of D11						**X**	
163	East of D11							**X**
164	C1							**X**
165	C3							**Not applicable**
166	C5							**Not applicable**
167	C6						**X**	
168	C7							**Not applicable**
169	C7							**Not applicable**
170	C13							**X**
171	C76						**X**	
172	C79							**X**
173	C79							**X**
174	C79						**X**	
175	On the main road	**X**						
176	C8		**X**					
177	D44						**X**	
178	D44						**X**	
179	D43						**X**	
180	D42							**Not applicable**
181	C66						**X**	
182	C62						**X**	
183	C64						**X**	
184	C58						**X**	
185	On the road							**X**
186	On the main road							**X**
187	Special							**X**
		31	**17**	**7**	**1**	**4**	**40**	**56**
TOTAL (156)								
NOT APPLICABLE (131)								

(*) Cisterns exhibit the properties of two or more categories. However, each is assigned to a category different than the "room" or "other purpose" category. For B18, the "bath" category is preferred.
(**) The conditions of cisterns are unclear. However, they slightly exhibit the properties of other purpose space while it is more probable that C45 can be an unconverted one. Such cisterns are assigned to "other purpose" category.