Water supply structures of the Ottoman period in Istanbul (Asian side)
A. F. Aydin, I. Koyuncu, A. Demir, D. Aydin, S. Guclu and T. Turken

ABSTRACT

The city of Istanbul has land on both the Asian and European continents. On the European side, many waterways (culverts) were constructed to supply water to the old city; however, on the Asian (Anatolian) side, such water supply structures were limited in number and capacity. Therefore in order to meet the water demand of this side of the city, foundation waterways were built. This study discusses the foundation waterways in the Anatolian side of Istanbul; of which the most important ones are Atikvalide and Kayışdağ. Foundation waterways which were constructed by benefactors performed their functions for centuries and a number of them continue to be in use.

Key words | Anatolian side, Atikvalide, foundation waterways, Istanbul, Kayışdağ, wells

INTRODUCTION

The city of Istanbul, founded in the vicinity of Sarayburnu sub-district in 658 AD has significant geo-political importance. With the Bosphorus connecting the continents of Asia and Europe, the Golden Horn, and the Sea of Marmara surrounding the south coast of the city, along with its ancient culture and modern civilization, Istanbul has become a political, military and trade centre. During its establishment, the water demand of the city was met by groundwater resources (İstanbul’da Tarihte Su Yönetimi 2011).

Initial important water structures were constructed by the Roman emperors. Emperor Hadrian (117–138) constructed a waterway (also known as a water line, channel, culvert, duct, etc.), starting from a spring outside the city wall to the suburbs near the Golden Horn. Emperor Valens (364–378) supplied water from the vicinity of Halkali to Beyazit. It is also recorded that he constructed Valens Aqueducts, also known as Bozdoğan and Mazul Aqueducts. Again during the Valens period, a reservoir was built in Belgrade forest near the city; and the water of Kagıthane creek was collected by channels and ponds, and supplied to the city. Theodosius I the Great (378–395), used the Valens and Mazul aqueducts to construct the third waterway, and also constructed the fourth waterway which has a route from Belgrade forest to Sultanahmet. The Roman and East Roman Empires had taken into account the possibilities of war and drought when constructing both groundwater cisterns and hypaethral cisterns. Among them the most important ones are Aetius, Aspar, and Mokios hypaethral cisterns, along with Basilica, Pileksenus, and Acimusluk groundwater cisterns, of which the first two respectively have 336 and 224 pillars. Water structures constructed by Roman emperors were restored by Byzantine emperors up to certain levels. However, in the latest period of the Byzantine empire, the structures had fallen out of use. The Mazul and Valens aqueducts were recovered from destruction after the restoration carried out by the Ottoman Empire (İstanbul’da Tarihte Su Yönetimi 2011).

WATER SUPPLY AND DISTRIBUTION LINES IN THE OTTOMAN PERIOD

Architectural history of water structures in the Ottoman period

After the conquest of Istanbul by the Ottomans, a new era began in the development of water supply infrastructure.
The population of the city increased so that the water resources became inadequate. Fatih the Conquerer (Mehmet II) reclaimed water structures constructed in the European side of Istanbul by Emperor Valens of the Romans. The Fatih and Turunçlu waterways were then constructed. Subsequently, sultans, ministers, and top officials added new branches to the Marmara Region Water Structures feeding from a spring located near Halkali village. The daily volume of these structures was 4,335 m$^3$ which was enough to meet the demands of the region. Mazul, Valens, Kara and Alipaşa aqueducts are located on Halkali waterway. The Mazul and Valens aqueducts were restored and utilised again. Through these waterways, water was supplied in a continuous manner to the mosques, wells, public fountains, imarets (lodging houses for pilgrims), and military posts outside the city. After this period, the population continued to increase and water shortages were been encountered. Süleyman the Magnificent assigned Sinan the Architect to address this problem. Thus, construction of the Kırkçeşme water structures began in the year 1555. In this period, water was collected from Alibey and Kağıthane creeks into ponds, and came to Eğrikapi, from where it was carried to the city. There were no water pipes able to withstand high pressures at the time, therefore the aqueducts were constructed in valleys to supply water in open channels. The measurements and calculations to construct these architectural structures have turned out to be very precise when compared with modern tools today (İstanbul’da Tarihte Su Yönetimi 2011).

The construction of Uzun, Eğri, Güzelce and Mağlova aqueducts was finished in 1563. The Kırkçeşme water structures fed 158 facilities (94 wells, 15 troughs, 13 baths, 7 town squares, and 10 other units) with a daily volume of 4,200 m$^3$. After Süleyman the Magnificent many benefactors added new structures to improve water capacity and facilities. In the upper parts of the creeks serving as water collection areas, dams were constructed to keep water available regardless of seasonal changes. Kırkçeşme dams include Karanlık (constructed by Osman the Young in 1620), Büyük (constructed by Ahmed III in 1723), Ayvad (constructed by Mustafa III in 1765), and Kirazlı (constructed by Mahmud II in 1818) dams. After the construction of these dams, the daily volume of the Kırkçeşme water structures increased to 10,000 m$^3$. In 1732, for the first time, an attempt was made to solve the problem of water scarcity in the Beyoğlu region through the construction of the Taksim water structures. A daily volume of 800 m$^3$ water, collected from near Bahçeköy, was transferred to the reservoir with a capacity of 2,700 m$^3$ through a 20 km long water distribution line, and circulated with the help of a distribution structure called ‘maksem’ into the 64 wells and public fountains, and three water tanks with a fountain. In 1732, Bahçeköy dam, which was constructed by Mahmud I, Topuzlu, Valide and Mahmud II dams, were considered as part of these structures. The daily volume of the Taksim waters had increased to 3,000 m$^3$ after the construction of these dams. To meet the water demand, spring waters were connected to the wells by small water distribution lines. The most important one was constructed by Abdulhamid II in 1904 and called Hamidiye water, having a daily volume of 1,200 m$^3$. The water derived from the vicinity of Kemerburgaz, and served military posts, palaces and approximately 50 wells located near Beyoğlu, while Kanlıkavak and Sarıyer waters were distributed to Emirgan. Increasing water demand and new construction in the rapidly emerging city enabled Sultan Abdülaziz to give rights to a French company for founding the ‘Dersaadet Water Incorporation’ (Terkos Company). The incorporation was responsible for collecting, distributing, and treating spring and creek waters, groundwater, and primarily the water from Terkos Lake. Figure 1 shows the progress of water supply infrastructure in Istanbul (İstanbul’da Tarihte Su Yönetimi 2011).

Construction of waterways was started to meet the water demand in the Anatolian side of Istanbul, which was initially inhabited by small communities. In the Anatolian side, groundwater supplies were abundant, thus water distribution lines were installed to Kayişağı, Atikvalide, Küçükçamlica, Alemdağ, Beykoz, Karakulak and Işhak Ağa water resources for conveyance to the wells. In Istanbul, just for Üsküdar mosques, wells, and public fountains, 18 long distribution lines were built, and many small water distribution lines were constructed just to supply a single well. The sources of Üsküdar’s water were located near the coastline of Çamlıca. Historically, it has been said that the water in the vicinity of Bulgurlu was so beautiful that it is even mentioned in pilgrim tales. The number of facilities fed from these waters was recorded as 144 in the ‘Foundation Record Book’ (Ab-ı Hayat 2010).
Üsküdar, a beautiful gate some distance from Istanbul, was a small settlement that fell to the Ottomans 101 years before Istanbul. Üsküdar obtained water through galleries dug into hills and had no distribution lines. The Ottomans, who developed the water supply infrastructure outside the city walls, built a total of 35 distribution lines, 18 of which were large, 17 small. The waterways of Üsküdar have a certain significance because 6 of the large lines belonged to Lady Sultans. All the 18 lines collected water from the springs at the bottom of the Çamlıca Hills and distributed it to the fountains, mosques, baths, pavilion fountains, and dergahs on the Anatolian side of the city (Adventure of Water in Istanbul 2009).

The Mihrimah Waterway, the first important line of which was financed by Lady Mihrimah, daughter of Süleyman the Lawmaker, was built by Sinan the Architect. The Mihrimah Waterway has supplied water to the Mihrimah Mosque and complex and is still in use with a daily discharge of 130 m³. The Solak Sinan Waterway, built to provide water for the Mescid was financed by an army commander Solakbaşı Sinan Aga, and was completed in 1547. The Mother Sultan Nurbanu, wife of Sultan Selim II, financed the largest waterway at Üsküdar considering both the length of its distribution line and the discharge (Adventure of Water in Istanbul 2009).

Detailed road maps of the Ottoman waterways in the Anatolian side have been prepared over the years. Namely, İbrahim Paşa Waterway map shows the Damat İbrahim Paşa Waterway, which was one of the most important foundation waters at Üsküdar in 1752–1753. Most of the fountains mentioned in the map have been located by the searches of Kazım Çeçen. The Damat İbrahim Paşa Waterway map is shown in Figure 2 (Abı Hayat 2010).

At the end of the 19th century, it was decided to build new water supply and distribution structures in the Anatolian side of the city similar to those on the European side. In 1888, a payment was given to Karabet Sıvacıyan, who was a representative of a French company, as an initial step in supplying water to the Anatolian side of the city. The foreign-capitalized ‘Üsküdar-Kadıköy Waterworks Company’ constructed the water supply system from Anadolu Hisarı to Bostancı by building the first Elmalı Dam in 1893. Consequently, a water treatment plant was constructed to treat the water supplied from the Elmalı Dam; and an elevation centre with a water pipeline was constructed for piping water down to the Baglarbaşı and Baglarbaşı Water House (Adventure of Water in Istanbul 2009). Over time, these privileged water companies did not deliver as expected and it was decided that the water supply issue should be dealt with in a different manner. Through buying the Terkos Company in 1931 and the Üsküdar-Kadıköy Water Company in
1937, the decision on how to solve this issue was assigned to İstanbul Water Administration (İSİ). Thus, it came about that the water supply for Istanbul was under one establishment.

The volume of distributed to Istanbul was about 35,000 m$^3$ at this time. The water pipelines and distribution systems of the Ömerli Dam were completed by State Hydraulic Works (DSİ). In addition the second Elmalı Dam was constructed on the Elmalı River, the dam was provided with a pumping station (elevation centre), and the water treatment plant was renovated. Finally water distribution systems and elevation centres were constructed on the Prince’s Islands in the Marmara Sea.

The infrastructure of Istanbul reached a point at which it could not be developed further, together with the fact that the shanty towns made the provision of a distribution service much more difficult. Due to the lack of capability within İSİ to provide a water and sewerage system for such a growing population, the necessity arose to create a new body with broader authority and sufficient capability. Therefore, a new organization was formed in 1981 called the Istanbul Water and Sewerage Administration (İSKİ) (İstanbul’da Tarihte Su Yonetimi 2011).

İSKİ was constituted in accordance with the Law No: 2560 and was incorporated with Istanbul Metropolitan Municipality in 1984 in accordance with the Law No: 3009. In 2005, under the Metropolitan Municipality Law No: 5216, the service area of İSKİ was enlarged and the number of city districts (counties) which were provided with services increased from 27 to 39. Due to the fact that the remaining resources supplying water to the city remained outside the service area (boundaries) of İSKİ, jurisdiction also included the Istranca Municipality.

Figure 3 shows the integrated system plans of waterways in Istanbul, drawn as a layer with a computer-aided design tool and incorporated onto a satellite image.

Historical water structures in the Anatolian side

The main water structures which were built in the Ottoman period in the Anatolian side of the city were Atikvalide, and Kayışdağ foundation waters. Other water structures that provided a service for the same area but were smaller in terms of capacity, were the İhsanîye water, fountains in Küçükçamlıca, Alemdağ, Beykoz, Karakulak and Ishak Ağa waters, Sarıkaya Hüdai water, Hamam water, Anatolian fortress water, Paşabahçe water, Sahir Molla water, Alibey water, Yalıköy water, Anadolu Kavağı Mehmet Molla water and many remaining historical foundation waters.

Some of the springs on the Anatolian side are very important water resources, such as; Karakulak Water (Beykoz-Derseki), Çubuklu Water (Beykoz), Göztepe Water, Mehmet Sait Efendi Water (Kandilli-Vaniköy); and among the Çamlıca Waters: Tomruk, Şekerkaya, Büyük Çamlıca, Küçük Çamlıca, Tiiryal Hatun, Kısıklı and Omer Efendi Waters (Çamlıca), Kayışdağı and Alemdağ Waters as well as the Ten-Fountains at Beykoz (Adventure of Water in Istanbul 2009).

Plans of known historical waterways in the Anatolian side were also drawn as a new layer with a computer-aided design tool and incorporated onto a satellite image as shown in Figure 4.
Atikvalide foundation water

**History**

The foundation waters and waterways were mainly constructed by the Sultanas as goodwill to the community. Nurbanu Valide Sultan, who has also been called Atik Valide, was the wife of Selim II and mother of Murat III. There are four mosques and waterways in Üsküdar named after Valide Sultan. Nurbanu Sultan had the biggest waterway constructed in terms of both water pipeline length and...
flow rate to provide water for philanthropic foundations such as mosques, madrasahs, monasteries, poorhouses, schools, local health centres, Turkish baths, and many street fountains. It is assumed that this waterway was constructed between 1582 and 1583 as stated in foundation documents (Foundation Waters Division Report 2012).

Mahpeyker (Kösem) Valide Sultana who was Ahmet I’s wife and Sultan Ibrahim’s mother was named Orta Valide. Çinili mosque and waterway were built under her name. Gülnuş Emetullah Valide Sultana who was the mother of Ahmet III, named as Yeni Valide, had the Cedit Valide Mosque and waterway built. Also Mihrisah Sultana who was mother of Selim III had a waterway constructed.

Technical specifications
The water pipelines and distribution system of Atikvalide waterway were taken from maps of İsmail Remzi dated 1926 and 1930, but these maps and plans show the situation of the year 1926. There were lines added to demolished waterways from the Atikvalide waterway and the demolished lines were not shown. A system plan of Atikvalide waterway drawn on a satellite image is shown in Figure 5.

İsmail Remzi recorded that the waterway was constructed in 1582 and in those times it had a flow rate of 676 m³/day; in 1930 it had a flow rate of 78 m³/day (Adventure of Water in Istanbul 2009).

Atikvalide water fountains
Atikvalide water rises to the surface from three places at Büyük Çamlıca’s Çakaldagi crests and Ümraniye, and the pipeline currently consists of different types and sizes of pipes. The fountains initially fed with the supplied water of Atikvalide but which currently do not receive water from that system are shown in Figure 6.

Due to the massive development of the city, water pipelines have been damaged leaving only two working fountains (Figure 7):
- Üsküdar Cumhuriyet district fountain.
- Üsküdar Yavuztürk district fountain.

Kayısdağı foundation water

History
Kayısdagi foundation water is the largest and most important of the spring waters in the Anatolian side of the city which is still active. It was mentioned in the old correspondence of the ISKI General Directorate archive as the land in which the Kayısdagi water has its source belonged to Sultan Selim I Foundation. It is an upstream water system, which took its name from its region Kayısdagi, and was offered to the public free of charge, distributed in 13 streets in the Kadıköy district with 24 fountains. Due to a lack of sewerage infrastructure in Kadıköy, and as a result of contamination of wells and cisterns, there was an outbreak of typhoid fever. There was

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Figure 5 | System plan of Atikvalide waterway (Google Earth Istanbul Satellite Pictures 2011; Geographic Information Systems Division Data 2012).
much research into providing clean drinking water in the Süreyya Pasha period ( Süreyya İlmen, the former deputy of Istanbul) resulting in the proposal of the Kayışdağ water supply system (e.g. Hamidiye waters). The distribution waterway was built by G. Ropel Company, and the fountains were built by the Şehremini Operator, Emin Erkul, in 1926.

Figure 6 | Examples of fountains which used to be supplied with water from Atikvalide. (a) Atikvalide Mosque wall fountains, (b) Atikvalide fountain with water tank and (c) Atikvalide fountain for a mental institution (Foundation Waters Division Report 2012).

Figure 7 | Fountains which are still supplied with water from Atikvalide. (a) Üsküdar Cumhuriyet district fountain and (b) Üsküdar Yavuztürk district fountain (Foundation Waters Division Report 2012).
**Technical specifications**

The components that make up the Kayışdağ water, are referred to by different names: Nefsi, Kestanelik, Fındıklı, Hacı Ömer, Ayazma (Holy Spring), Zeyneldayı, and Meşelik waters which are collected at the start of the distribution line. There are three storage facilities, Çatakbaşı Kozyatağı and İkbalıye, which flow from upstream down to the fountains via gravity on the 20 km distribution line. The flow rate is approximately 200–250 m³/day in winter; during summer, the flow rate decreases to 100–150 m³/day.

**Kayışdağ fountains**

The Kayışdağ stream flows through 24 fountains, and the number and location of the fountains in the first period of the water supply system is unknown. The list of the known Kayışdağ fountains and their locations is given in Table 1; of these, only four have survived. The photographs of these fountains are also given in Figure 8. One of these is Sahra-i Cedid fountain, named after the mosque near to which it is located. The fountain is decorated with marble ornaments, which has been recognized as the first national architecture of the empire style trend.

<table>
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<th>No</th>
<th>Fountains</th>
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<td>2</td>
<td>Darülaceze Fountain</td>
<td>Kayışdağ Mh. İBB Darülaceze Ataşehir</td>
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<td>K.bakkalköy School Fountain</td>
<td>K.bakkalköy Mh. Kemal Berkant Primary School Ataşehir</td>
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<td>K.bakkalköy Poorhouse Fountain</td>
<td>K. Bakkalköy Mah. Merdivenköy Ave. Ataşehir</td>
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<td>İçerenköy Square Fountain</td>
<td>İçerenköy Mh. Öznyurt Str. Karslı Ahmet Ave. Ataşehir</td>
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<td>Kuşlaönü Fountain</td>
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<td>Hamamönü Fountain</td>
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<td>Camiönü Fountain</td>
<td>İçerenköy Mah. Merkez Mosqur Str. Ataşehir</td>
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<td>Mezarlıkönü Fountain</td>
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<td>11</td>
<td>Kozyatağı Square Fountain</td>
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<td>Kozyatağı Marketplace Fountain</td>
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<td>19 Mayıs Park Fountain</td>
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<td>15</td>
<td>Ruh ve Sinir Hospital Fountain</td>
<td>19 Mayıs Mah. Bayar Ave. Kadıköy</td>
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<td>Sahra-i Cedid Mosque Fountain</td>
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<td>Göztepe Fountain</td>
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<td>Hasanpaşa Mosque Fountain</td>
<td>Hasan Paşa Mah.Kurbağıdere Ave. Kadıköy</td>
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<td>22</td>
<td>İkbalıye Fountain</td>
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<td>Yeldeğirmenı Fountain</td>
<td>Rasim Paşa Mah. Halitağa Ave. Yeni Str.Kadıköy</td>
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<td>24</td>
<td>Altyol Fountain</td>
<td>Cafer Ağa Mah. Bestekar Dilhayat Str. Kadıköy</td>
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<td>25</td>
<td>Fenerbahçe Fountain</td>
<td>Kayışdağ Mah. Üçnar Str. Ataşehir</td>
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<td>26</td>
<td>Ebu Hüreyye Mosque Fountain</td>
<td>Yeni Çamlıca Mah.Reşitağa Ave. kuzey Str. Ataşehir</td>
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<td>27</td>
<td>Merkez Mosque Fountain</td>
<td>Yeni Çamlıca Mah. Emirler Ave.</td>
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İkbaliye fountain was itself made from marble in a traditional manner.

Böcekli Mosque and Göztepe are cast-iron fountains which were constructed to serve the Hamidiye waterways in the 20th century. Cast-iron fountains were used as small public fountains in Ottoman architecture after the industrial revolution. The Göztepe fountain has a polygonal body designed according to the same movement. There is a monogram of Abdulhamid II on one side, and the construction date is carved on the eaves of the fountain. From the excavation study, it was found that where the basin and fountain body meet, there are embossments stating that it was produced in Paris. The renovation also revealed, underneath the later concrete poured in subsequent decades, the actual road levels, channel connections currently renewed, and an original marble basin also currently restored. The
small square surrounding the fountain is today decorated with marble and granite stones designed to keep the pavement at its original level.

The restoration of Altyol fountain was done in 2004 and involved balancing the original marble-coated fountain body and clearing the surface paint with mechanical methods (Figure 9).

In order to provide healthier and clean spring water, the PVC pipeline was replaced with font ductile pipes down to the Ziverbey district.

In addition to these renovations, rehabilitation works were also carried out and the layers of the Hacı Ömer period have been completed. When removing the old catchment, excavations revealed smaller sized galleries belonging...
CONCLUSION AND SUGGESTIONS

In this study, foundation waterways on the Asian side of Istanbul have been discussed. These water structures were built through the support of philanthropists, have been used for centuries, and some of them are still functional. The most important foundation waterways are Atikvalide and Kayışdağ, and the Kayışdağ waterway is still in use. It is a water supply system which has approximately 25 fountains in a 15 km² area. The Atikvalide foundation waterway is damaged in the residential areas, and its usage is diminished as a result.

In the historical progress of foundation waters, drinking water was provided for free as this situation is perceived to be crucial for the benefit of the community. For the sustainability of this public service, construction and financing was provided by charitable persons with the help of local managers and the service has been transformed into the charter concept through time.

Today, in terms of the Spring Water Regulations, water supply points should have a minimum 50 m protection zone, with 15 m for distribution lines and galleries, and 6 m for distribution pipelines. The zone helps to prevent contamination, and to enclose and ensure the amount of water available.

Today, on the Asian side of Istanbul, the formerly most efficient Kayışdağ fountain water system and historical waterways are still in use for the public through persistent efforts of İSKİ’s Water Quality Control Works Department. Similar to historical water structures and other architectural structures of the Ottoman period, the Kayışdağ water network has been renovated over time and has remained in operation into modern Turkey’s first years (1926).

Istanbul’s growing population and the increased water demand has been a historical problem. With the addition of increased migration to Istanbul in the late 1950s, the water basins and water distribution lines were under severe pressure. After 1969, the government gave unilaterally all proprietary rights and nationalization transactions with the settlement units which provide social services to İSKİ which is responsible for both drinking water and sewerage infrastructure. However, the current cases of particular structures along with overwhelming density result in infiltration to soil, due to ground compaction and uneven pavements. Hence with the present system, the water volume provided has been significantly reduced.

Precautions should be taken for prevention of pollution. A major provision is to increase the filtration distance of water leaking underground. This distance is 5 m depending on soil type, structure of the ground, and porosity of the sources. A second measure is to make the ground non-permeable in areas with high possibility of contamination.

In this context, inhabitation and constructions near the protection area of the Atikvalide water system, which is one of the biggest ancient waterways in the Asian side of Istanbul, should be cleared to protect the water supplies.

Major advantages are that the catchment area upstream of Kayışdağ upstream has remained unpopulated, the river mouth is still undamaged, and the fountains are still in public use. Protection of this surviving water resource should be sustained.

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