

Prominent Features of the Augustan Aqueduct in the Naples Bay Area

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Abstract

The great Aqua Augusta aqueduct served the Naples Bay area with fresh water during the time of the Roman Empire. There are very prominent features of the Aqua Augusta, some that are extraordinary when considering other great aqueducts in the Roman Empire. For example, the deep tunnels allowed access to a spring water source from a separate watershed, which resulted in transbasin diversion of the water supply. Each one of the prominent features was engineered to provide water to the public for various uses. The prominent structures included other shallower tunnels (with two major types of construction), hydraulic chutes, arcades (one to an island), baths (located along a well-travelled road), and storage reservoirs. Also, there is the epigraph discovered at the water source. Important villas that may have influenced the alignment of the aqueduct are also discussed.

Keywords:

Aqua Augusta; aqueduct; Roman; Pompeii; water supply.

INTRODUCTION

The aqueduct *Aqua Augusta* was one of the greatest of all of the aqueducts in the Roman Empire. It was exceptional in size and technical complexity. The main trunk of the aqueduct was about 103 kilometers (km) and the branches were an additional 60 km (Libertini et al., 2014). This grand public works project provided water to a large geographical area and, in doing so, crossed the boundaries of several natural watersheds in the Naples Bay area. The overall route of the *Aqua Augusta* and the prominent features addressed are shown in Figure 1.

The aqueduct is estimated to have been built between 33 and 12 B.C. when *Marcus Vipsanius Agrippa* was *curator aquarum* in Rome (De Feo and Napoli, 2007). The main goal of the aqueduct was to provide water to two main harbors of the Empire, the civilian one of *Puteoli* and the military one of *Misenum*. It also served a number of other cities attested to in an epigraph regarding repairs that took place in the time of Constantine the Great (circa A.D. 324

to 326): *Puteoli*, *Nola*, *Atella*, *Neapolis*, *Cumae*, *Acerrae*, *Baia*, and *Misenum* (Miccio and Potenza, 1994). Catalano (2003) and our archaeological field evidence shows that a branch of the *Aqua Augusta* also served the coastal cities of *Pompeii* and *Herculaneum*.

Other important additional aims of the *Aqua Augusta* included the provision of water to colonies and settlements linked to the Augustan political power and to several illustrious residences in the area. This helps explain the considerable investment made in the aqueduct, estimated between 150 million and 450 million *sestercii* (Duncan-Jones, 2010). This cost was several times the cost of the massive baths (*thermae*) of Caracalla in Rome and within the range of costs for two of the aqueducts serving Rome (as documented by Pliny the Elder).

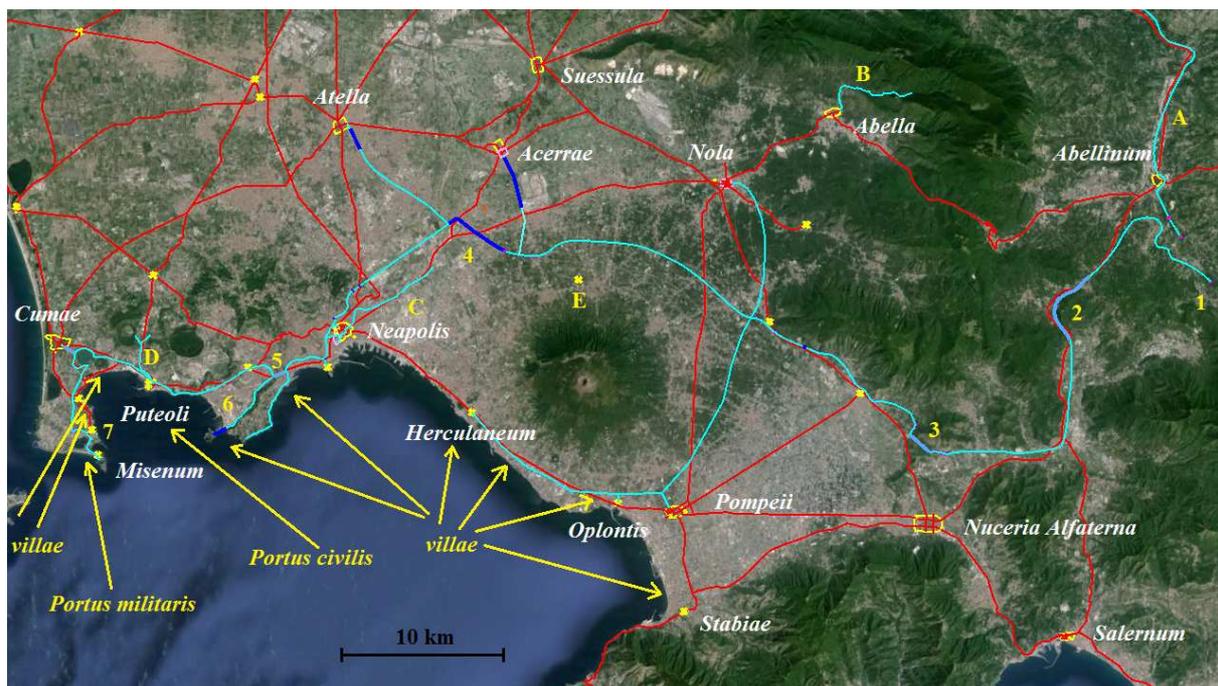


Figure 1. The route of *Aqua Augusta*. The main roman roads (*viae*) and towns (*civitates*) are indicated. Other ancient aqueducts: A) *Beneventum a.*; B) *Abella a.*; C) *Bolla a. of Neapolis*; D) *Gauro a. of Puteoli*. Some other points of interest: E) *villa Augusti*; 1) springs (where the epigraph was found); 2) *Forino tunnel*; 3) *Mt. Paterno tunnel*; 4) *great arcade of Pomigliano d'Arco*; 5) *crypta neapolitana*; 6) *baths of via Terracina*; 7) *piscina mirabilis*.

The aqueduct carried plenty of water of great quality from springs in the area of *Serino*, south of the ancient settlement of *Abellinum*, to the end of the route in *Misenum*. The choice of the springs of the *Serino* area as origin (*caput aquae*) of the aqueduct appears bold and extreme for the technical possibilities of the time. Tunneling and arcades were both used along the route. The engineering feats that were accomplished are apparent by inspection of the special features along the path of the *Aqua Augusta*.

Several of the prominent features of the *Aqua Augusta* are presented and discussed in order of the alignment and flow of the channel. The data for the alignment shown on the figures are from field work by the authors and literature sources.

SPRINGS AND THE MARBLE EPIGRAPH

The aqueduct was fed by springs to the south of *Abellinum*. In the segment from the springs to the Forino Tunnel, there is no evidence of noteworthy population centers in ancient times that were served by the aqueduct. The populous *Nuceria Alfaterna* (present day Nocera Inferiore and Nocera Superiore), which was near the route of the aqueduct, was served by local springs. This segment was constructed in the area of Serino, a forested area with a wealth of rich sources of high quality spring water. This watershed is drained by the Sabato River. The *Aqua Augusta* tapped two major springs within the watershed: the Acquaro and Pelosi springs.

A marble epigraph was found near the Acquaro spring in August 1936 during construction excavation to connect the spring to the modern aqueduct supplying the City of Naples. The exceptional epigraph, dating from the time of Constantine the Great (circa A.D. 324 to 326), measures 1.86 x 0.86 x 0.17 meters (m) (De Biase, 2006).

The first segment of the aqueduct was also an area of mountainous terrain, where the aqueduct followed the contours of the hills in the present day Aiello del Sabato and Cesinali areas. The Roman engineers used “cut and cover” methods where they could excavate into the slopes. These shallow (2 to 3 m deep) sections were built with a concrete rubble framework to enclose the aqueduct section with typical dimensions as shown in Figure 2a. The “cut and cover” construction was common in aqueducts throughout the empire. The time needed for construction of these sections was short when compared to deeper tunnel construction, shown in Figure 2b, that was chiseled into limestone. However, the cut and cover sections were also subject to local land slips, especially in the steeper slope segments of the aqueduct. One such land slip occurred recently, exposing an area that the authors felt privileged to inspect, shown in Figure 3a.

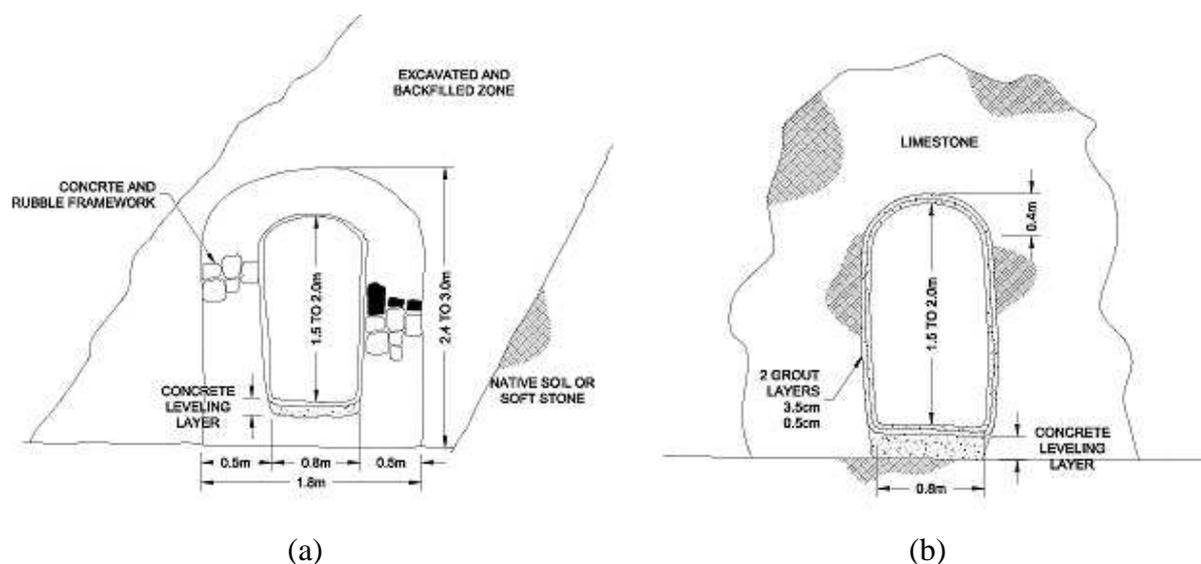


Figure 2. (a) Cut and cover bench into hillside section; (b) Deeper tunneled section.

FORINO TUNNEL – TRANSBASIN DIVERSION

The Roman engineers designed the *Aqua Augusta* to take water from the Sabato River watershed to other watersheds along the route. This transbasin diversion of water required that the design of the alignment of the aqueduct turn to the west in the area of Cesinali to follow the Vallone della Contrada and pass under the Monti di Forino.

The major transbasin diversion of the water from the Sabato River to the Sarno watershed was accomplished by the construction of the Forino Tunnel at the location shown in Figure 1. This unique tunnel had a length of approximately 6 km and is remarkable in that it is known to be one of the longest tunnels found in any Roman aqueduct or drain project (Keenan-Jones, 2010). The Forino Tunnel was chiseled in tufa and limestone bedrock at a maximum depth of nearly 70 m and with horizontal bends or curves in the tunnel. A typical tunnel section is different than the cut and cover section as shown in Figure 3b.

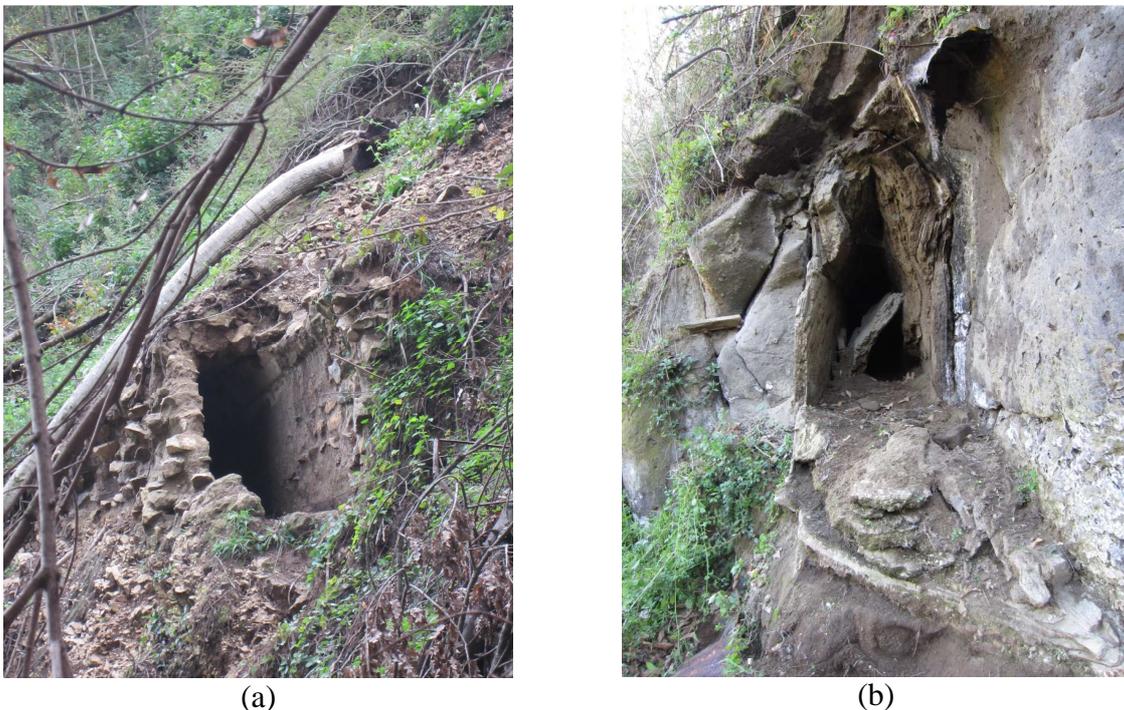


Figure 3. (a) A cut and cover section exposed by a small landslide near the municipality of Cesinali (in the province of Avellino); (b) Photograph of the hydraulic chute tunneled section at Mt. Paterno Tunnel.

The Forino Tunnel included an additional 1.5-km-long steep chute at the downstream end of the tunnel (caduta della Laura) that descended more than 150 m (a slope of 10 percent) which was a hydraulic transition that impacted flow. In 1840, the route of the *Aqua Augusta* was surveyed by Felice Abate in an evaluation commissioned by the City of Naples to investigate the restoration of the Augusta for a water supply to the City (Abate, 1842). For the Forino Tunnel section, Abate identified only two shafts for the entire 6-km length of tunnel. The tunnel and access shafts were filled with sediment and were inaccessible when Abate performed his survey. Today, the Forino Tunnel remains unexplored.

The *Aqua Augusta* continued from the exit of the Forino Tunnel in a much shallower section (although there are no archaeological remnants in this section) through the area of present-day Mercato San Severino. Then the aqueduct turned west towards Castel San Giorgio with the “cut and cover” shallower tunnel sections following the contours along the side of the hills in the area. It then reached the area of Mount Paterno (before and after this mountain, there are various archaeological remnants as directly observed by the authors).

MOUNT PATERNO TUNNEL AND HYDRAULIC CHUTE

The Mount Paterno was a barrier to a direct route of the aqueduct to the Sarno plain. Therefore, the Romans constructed a tunnel of about 1.5 km, descending an elevation difference of about 13 m, from 83 to 70 m above sea level (asl) (Vv. Aa., 1883).

There is much more known about the mount Paterno Tunnel than the Forino Tunnel. Abate in his survey discovered various deep shafts where he was able to identify the alignment of the tunnel. One of the unique aspects of this section is that there was a hydraulic chute at the end of the tunnel where the slope of the channel was at least 15 percent, which created a hydraulic jump in the water flow. This resulted in a “full flow” section where the flow constantly filled the channel section. In March 2015, the authors observed a section of the chute, see Figure 3b. Thick calcium carbonate deposits up to the top vault of the channel section are shown, indicating the full flow conditions that persisted. This hydraulic condition certainly controlled the flow capacity of the aqueduct in this segment.

BRANCH TO POMPEII AND HERCULANEUM

There were many branches of the *Aqua Augusta*; however, one of the most significant is the branch to *Pompeii*, because *Pompeii* has such a special place in archaeological history. The branch headed south, turning gently around the Vesuvio (*Vesuvius mons*), in the direction of *Pompeii*, where the supply by an aqueduct sufficient for the needs of the town is well documented (Catalano, 2003). It is probable that the aqueduct did not point directly towards *Pompeii*, but that it remained on a higher altitude and continued towards *Oplontis*, where the present-day Torre Annunziata, and *Herculaneum* (now Ercolano), are located, and the channel served several villas set along the path on the south side of *Vesuvius*. The remains of an aqueduct near *Herculaneum* and of a *castellum aquae* in the town were found (Catalano, 2003).

Some researchers have judged that the alignment of the main channel of the *Aqua Augusta* should have followed this southern route on its way to *Neapolis* rather than being located on the northern slopes of *Vesuvius mons*. However, this hypothesis cannot be proven. In fact, a path south of *Vesuvius* would have been a technically very demanding undertaking with prohibitive costs. To reach *Neapolis* at an altitude of about 41 m asl (i.e., that of Ponti Rossi and of the arches near via Vergini, the main remains of the ancient aqueduct in modern Naples) it would be necessary to overcome the valley of the *Sarnus* River with a series of arches over 14 km long and the valley of the *Sebethus* River with another arcade with a length of almost 10 km. Moreover, the two long arcades would have had a considerable height, up to

40 m in the central parts of the valleys. In addition, a path south of *Vesuvius* did not allow the aqueduct to serve the towns of *Nola*, *Acerrae*, and *Atella*.

In contrast, the path chosen by the Romans first ran just below the surface on the divide between the valleys of *Sarnus* and *Clanius* Rivers and, after going on the north side of the slopes of *Vesuvius*, then ran on the divide between the river valleys of *Sebethus* and *Clanius* Rivers with an arcade of approximately 3.6 km and of limited height. Moreover, this route allowed for opportune branches to provide water to the aforementioned towns (Figure 4).

THE VILLA OF THE EMPEROR AUGUSTUS

The Emperor *Octavianus Augustus* was often in Campania and had several properties in the Naples Bay area. It is noteworthy that several of these properties were in *Pausillypon*, *Baiae*, and *Nola*. Since the *Aqua Augusta* was planned and constructed during the reign of *Augustus*, some researchers have inferred that the path of the *Aqua Augusta* was influenced by these property locations.

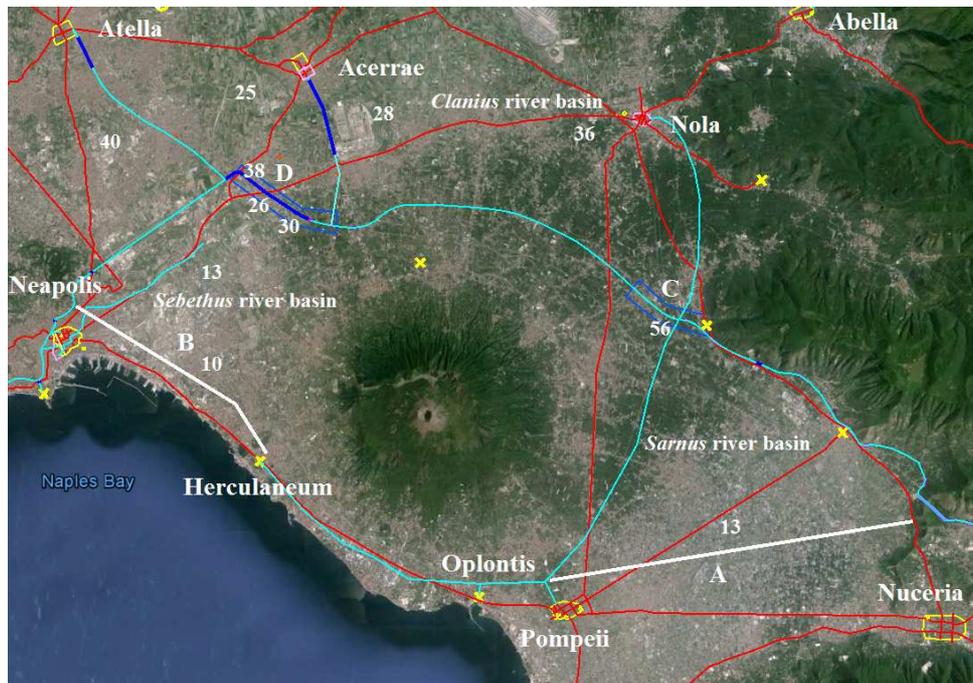


Figure 4. A hypothetical path south of the *Vesuvius mons* would have required the construction of two long and very expensive arcades (A and B). In contrast, the path built by the Romans passed on the divides (C and D) between the valleys of the small river *Clanius* on the north and of the small rivers *Sarnus* and *Sebethus* on the southern side. These valleys have slopes so subtle as to be visually imperceptible. However, the heights of the divides were another story, with the Campania plain reaching *Neapolis* with an elevation of 41 m asl. The elevations of some areas are indicated in meters asl.

In the segment of the aqueduct in the vicinity of the north slopes of *Vesuvius mons* near *Nola*, the sumptuous front part of a *villa* was found under several meters of volcanic deposit.

Ongoing archaeological excavations have led to the interpretation that it was the famous villa owned by *Augustus* (by inheritance from his natural father, *Gaius Octavius*). It was in this villa (not yet fully excavated) that *Augustus* chose to die in A.D. 14 (D'Arms, 1970). Some have believed that the alignment of the *Aqua Augusta* was planned on the north side of *Vesuvius mons* (rather than to the south) because of the Emperor's villa. However, the *villa* was located about 80 m above the level of the aqueduct in that area. The predilection of the great emperor for the place, so much so that he chose it for his last days of life, may not have been motivated by the fact that it was a family property, however. The villa was surrounded by *civitates* and places where *Augustus* had assigned lands to loyal veteran soldiers and where he could be surrounded by people who deeply liked and respected him.

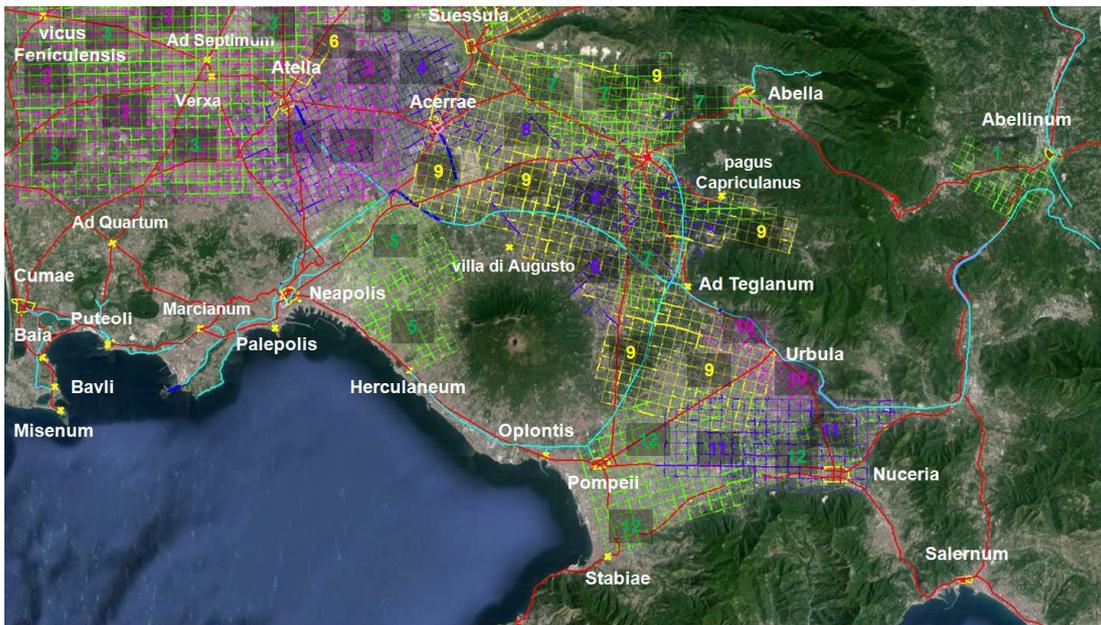


Figure 5. The *villa of Augustus* (*villa di Augusto*) surrounded by the *centuriationes* ordered by him and where many of his veterans were allocated: 1 = *Abellinum*; 2 = *Ager Campanus I*; 3 = *Ager Campanus II*; 4 = *Acerrae-Atella I*; 5 = *Neapolis*; 6 = *Atella II*; 7 = *Nola I-Abella*; 8 = *Nola II*; 9 = *Nola III*; 10 = *Nola IV-Sarnum*; 11 = *Nuceria I*; 12 = *Nuceria II*. Data for the *centuriationes* are from Chouquer et al., 1987 and, only for *Suessula centuriatio*, from Libertini, 2013. The image was proposed in a recent meeting (Libertini et al., 2016).

POMIGLIANO d'ARCO ARCADE

There were three major stretches of arched construction in the *Aqua Augusta*: (i) *Mura d'Arce*, (ii) the arcade near *Pomigliano d'Arco*, and (iii) the *Ponti Rossi*. Together, these three account for 3.6% of the total length of the main channel of the aqueduct.

The *Pomigliano d'Arco* arcade seems to have been one of the longer continuous stretches of *opus arcuatum* in an ancient Roman aqueduct (Keenan-Jones, 2010). There are very few material remnants of this arcade; however, it has been shown to have a length of about 3.6 km and a maximum height of over 12 m. In a small final stretch, the canal bridge, oriented towards the north-west, had to change direction, towards the south-west. Although it does not

exist today, this arcade bridge long survived the deactivation of the aqueduct. This is known because in the early Middle Ages, many towns were known for their locations beyond the arches of the aqueduct (in the perspective from *Neapolis*), such as *foris arcora* (beyond the arcade; e.g. *Pumilianum foris arcora*, present day Pomigliano d'Arco, *Licinianum foris arcora*, Licignano, part of present day Casalnuovo di Napoli, *Mascarella foris arcora*, extinct medieval center) or also *a foris arcora* (likely, present day Afragola) (Libertini, 2011).

TUNNEL AT THE CRYPTA NEAPOLITANA

In the first century B.C., the gulfs of *Neapolis* and *Puteoli* were divided by the *Pausilypon* (Posillipo) hill. Therefore, the road that connected these locations was long and traversed steep hills and it was a long journey. At the end of the first century B.C., a major road tunnel was constructed, the *crypta neapolitana*, at 5 m high, 4.5 m wide and 705 m long. It was built by *Lucius Cocceius Auctus*, an engineer who came from this area and probably worked for *Agrippa*. The route of the *Aqua Augusta* also required that a tunnel be constructed through the *Pausilypon* hill.

The aqueduct tunnel at the *crypta neapolitana* is the third major tunnel in the route of the aqueduct. The aqueduct tunnel does not lie in the road tunnel, but actually runs separate and parallel to it at a height of 50 cm from the base of the tunnel on its north side.

Before the tunnel, the aqueduct branched and reached the large imperial *villa* near la Gaiola at the end of *Pausilypon* hill, also known as *villa Pollii* after its first owner (*Vedius Pollio*), where there is a long tunnel (about 770 m), the Grotta di Seiano, which lies on the other side of the hill.

AQUEDUCT ARCADE TO AN ISLAND

Immediately after the tunnel, another secondary branch ran along the side of the hill to a unique section of the *Aqua Augusta* system. This section crossed over the sea and provided water to the small island of *Nisida* (Nisida) (Lettiero, 1560), where there were sumptuous residences, in particular that of *Lucullus* (D'Arms, 1970) but also that of *Marcus Iunius Brutus*, in which *Brutus* and *Gaius Cassius Longinus* plotted to assassinate Julius Caesar in 44 B.C. (Lancaster, 2007).

There is little in the way of archaeological evidence of this constructed section (thought to be *opus arcuatum*), other than piers that were identified as Roman construction (Cardone, 1992).

This section is unusual in that it appears to be one of only two examples of a Roman aqueduct crossing saltwater, with the other at Cadiz, the ancient port city in southwest Spain (Keenan-Jones, 2010).

BATHS OF VIA TERRACINA

The building of the Roman aqueducts provided water in quantities that promoted the proliferation of bath complexes. The baths were central to the Roman social life, and their importance grew from the late first century B.C. into the first century A.D. There were several

baths in the *Neapolis* region before the construction of the *Aqua Augusta*. However, there were many other baths built likely because of the construction of the *Aqua Augusta*.

There were frequent travelers on the Roman road system in the Naples Bay region because the area was known for the resorts and villas of the Roman elite. At the end of the *crypta neapolitana*, the new road bent to the north and reconnected with the old road. Here, there was a resting place for travelers (*Marcianum*) with a thermal spa complex. The remnants of the *Aqua Augusta* have been excavated near the baths of via Terracina and the aqueduct provided the water used in the bath complex.

The baths of via Terracina are extraordinary since the complex appears to have been located specifically for traveling clientele, rather than located in a community for residents. It was a major complex with three principal baths: the *apodyterium*, the *frigidarium*, and the *caldarium*. The complex included a semi-circular latrine that was flushed with the water from the aqueduct. The complex is a major archaeological site today.

STORAGE RESERVOIRS – PISCINA MIRABILIS

As shown in Figure 1, after turning around the south side of lake *Avernus* (lago d’Averno), the aqueduct headed towards *Baia* and *Bavli*, and finally reached *Misenum* and its military port. The port was the main and fundamental goal for the construction of the aqueduct, ending *inter alia*, in the imposing *Piscina Mirabilis* (De Feo *et al.*, 2010) and in other cisterns (*piscinae*) in the area, much like the so-called Dragonara near Miseno cape, and Cento Camerelle, Lusciano, and Cardito in *Puteoli*. The area needed imported water. In particular, the military port needed large quantities of water and for this critical necessity the aqueduct was essential. Later, with the fall of the Roman military power and the decay of the fleet, the military port lost its function and consequently the *Aqua Augusta* lost the fundamental reason for its existence.

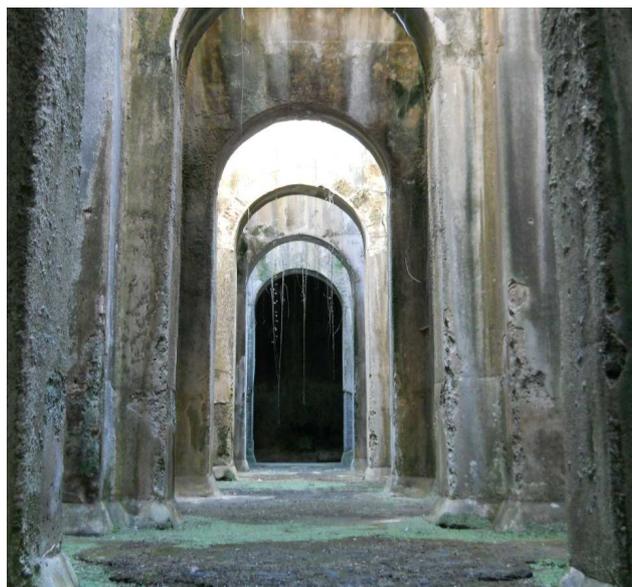


Figure 6. Photograph of the interior of the *Piscina Mirabilis*.

CONCLUSIONS

There are many prominent features of the *Aqua Augusta*. The technical characteristics of the work, author observations, and the documentation of classical texts and archaeological evidence tell the story of a magnificent water conveyance achievement by the Romans (Lettiero, 1560; Abbate, 1842 and 1862; Vv. Aa., 1883; Miccio and Potenza, 1994).

The prominent features and extraordinary aspects of the *Aqua Augusta* include the epigraph discovered at the Acquaro Pelosi springs, Forino Tunnel, Mt. Paterno tunnel, the branch to *Pompeii* and *Herculaneum*, *Octavianus Augustus'* villa, the Pomigliano d'Arco arcade, the *Crypta Neapolitana* tunnel, the baths of via Terracina, and the *Piscina Mirabilis*. These features of the *Aqua Augusta* demonstrate how unique this aqueduct was in the Roman Empire, and in world history.

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