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8.18 Water Supply of Rome in Antiquity and Today

8.18.1 Introduction

In ancient Rome, water was considered a deity to be worshipped and most of all utilized in health and art. The availability of a huge water supply was considered a symbol of opulence and therefore an expression of power. Springs were the principal sources of water for ancient Rome.

The countryside around Rome offered a spectacular view: it was adorned with an incalculable number of monuments, temples, and villas and it was crossed by sturdy aqueducts with magnificent arcades. The aqueduct as a superelevated monumental work is a typical concept of Roman engineering, although it is possible to recognize that the inspiration and the basic ideas came from the Etruscan technology. The Etruscans did not construct real aqueducts, even though they built hydraulic works like irrigation channels, drainage systems, dams, etc. The Greeks had also constructed similar hydraulic structures, before the Roman influence. Interesting aqueduct remains are found in Rome, Segovia (Spain), Nimes (France), and Cologne (Germany).

8.18.2 Ancient Water Supply of Rome (700 B.C.–A.D. 500)

Rome initially used the water of the Tiber River and water from wells and many small springs that existed inside its town area, such as Acque Lautole, Acque Tulliane, Fonte Giuturna, Fonte Lupercale. Since the 4th century B.C., Rome gradually built aqueducts. The aqueducts conveyed water from springs many kilometers away from Rome. The water passed through underground tunnels and over huge arched bridges that maintained the slope of the flow until they reached the outskirts of Rome where "water castles" distributed the water for public (baths and fountains) and for private uses (Fig. 8.46). Most aqueducts were in the area east of Rome, except one located in the north. Water from all eastern aqueducts was collected in the Porta Maggiore area, called by Romans "ad Spem Veterem" (Fig. 8.47 and 8.48).

The first aqueduct was built in 312 B.C. During the subsequent 600 years, ten more aqueducts were built. The last one was completed in the 3rd century A.D. With completion of construction, there were Aqua Applia, Anio Vetus, Aqua Marcia, Aqua Tepula, Aqua Julia, Aqua Virgo, Aqua Alsietina, Aqua Claudia, Anio Novus, Aqua Traiana, Aqua Alexandriana.

8.18.3 Aqua Applia

No remains are left of the first great Roman aqueduct constructed in 323 B.C. It was entirely underground because of the war against Sannites. Therefore its route is almost unknown. Appius Claudius Crassus (later called Caecus) and Caius Plautius (called Venox) identified the spring sources of water. The aqueduct and the coeval consular road were named after Appius and called Applia. The aqueduct was 16.5 km long, and three main restoration works were carried out by: Quinto Marcio in 144 B.C. to eliminate unauthorized connections by citizens, Agrippa in 33 B.C., and Augusto in 11–4 B.C. to collect more springs and to build a new aqueduct 9.4 km long called Applia Augusta. The original catchment area is not exactly located, however, it is the area east of Rome on the northern slope of Albano Volcano near Pantano Borghese, the ancient Lake Regillo. Total discharge was recorded by Frontino (Sextus Jiulius

Fig. 8.46. Section of Roman aqueduct: *1* Spring and inlet; *2* Bearing wall; *3* Open channel; *4* Arcades; *5* Shafts; *6* Underground channel; *7* Settling basin; *8* Reverse siphon; *9* Main reservoir; *10* Water pipes

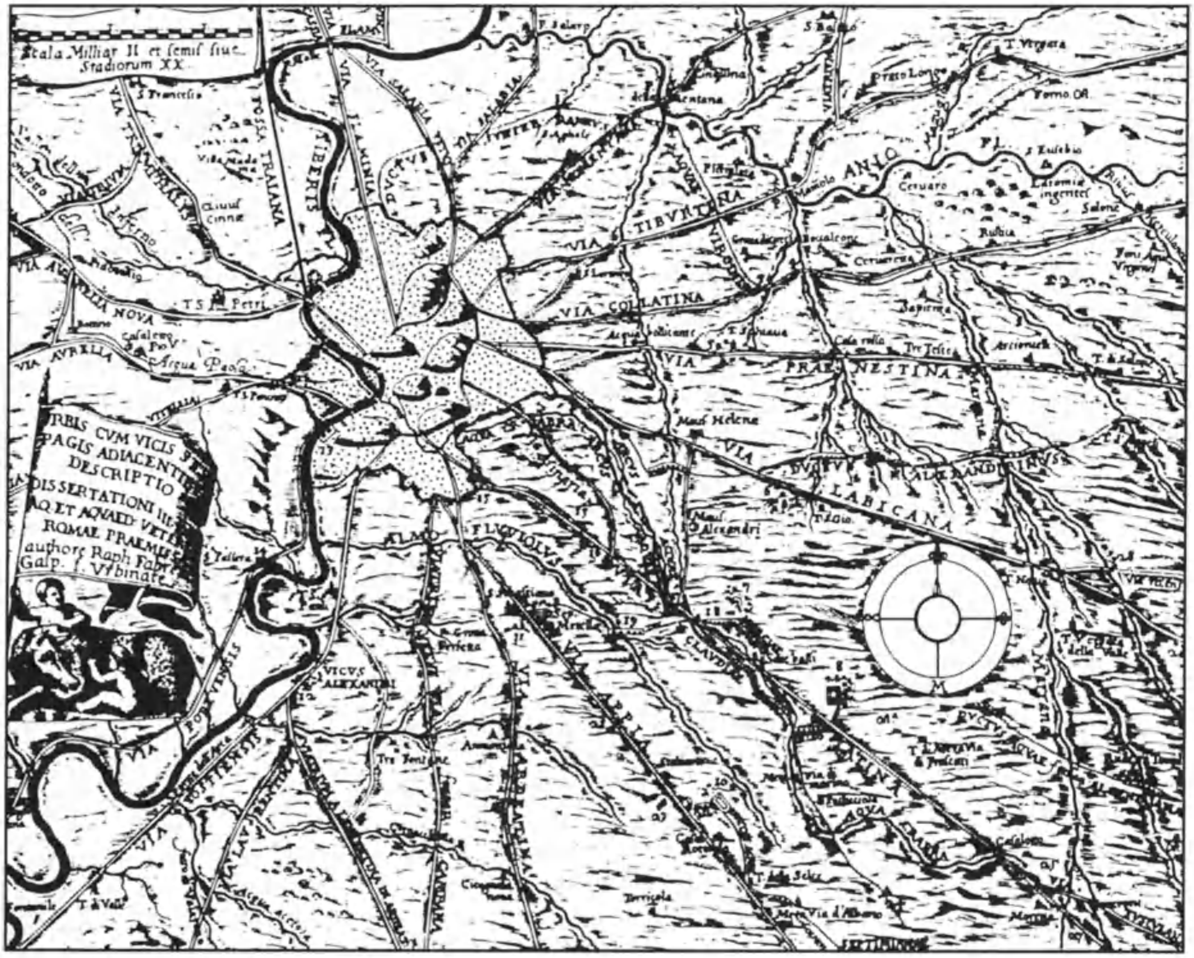


Fig. 8.47. Outline of Roman aqueducts near the city (*dotted area*). Only the 14th District of Rome (Regio XIV) is located along the right bank of Tiber River

Frontinus "curator aquarum", i.e., head of Roman aqueducts or water magistrate, lived at the time of Emperors Domitiano, Nerva, and Traiano). He wrote a fundamental treaty on Roman aqueducts in imperial times to which we often refer, *De Aquaeductu Urbis Romae* A.D. 97–103 Quinaria: a Roman discharge unit equal to 41 472 m^3/d (480 l/s) at the main reservoir near Rome (ad Spem Veterem) was 75 686 m^3/d (876 l/s).

8.18.4 Anio Vetus

Frontino dates the beginning of works for Anio Vetus aqueduct to 272 B.C. It was built by M. Curio Dentato and L. Papirio Cursore with the plunder obtained from the victory over Pirro (Punic Wars). The springs have not been located precisely but are certainly karst springs that were East of Rome, along the Aniene (Anio) River, and not far from the Agosta springs collected later by the Anio Novus aqueduct.

Anio Vetus aqueduct is 64 km long, mainly underground. It has many lumina (shafts), and it follows along the left bank of the Aniene River to Rome. According to Frontino, the aqueduct was restored by Quinto Marcio Re 127 years after its construction, by Menenio Agrippa in 33 B.C., and by Augusto, who provided it with mileage stones. The spring discharge was 182 394 m^3/d (2.11 m^3/s) according to Frontino.

Fig. 8.48. Urban course of aqueducts and location of terminals in ancient Rome

8.18.5 Aqua Marcia

In 144 B.C., the Roman Senate charged Praetor Quinto Marcio Re to restore Anio Vetus and Aqua Appia to prevent undue connections by unauthorized citizens. Meanwhile, the population of Rome had grown and water requirements were constantly increasing. Q. Marcio Re was also charged therefore with building a new aqueduct to ensure more water of good quality. The new aqueduct was supplied by karst springs in the valley of Aniene River. The quality of this water was greatly praised by ancient authors such as Plinio the Old for being fresh and healthy.

The aqueduct worked perfectly for over one century. In 33 B.C. Agrippa carried out the first of many repair works. In 11–4 B.C., Augusto modified the aqueduct structures by collecting more springs, thus doubling the water discharge. In A.D. 79 Tito and later Adriano and Severi restored and kept the aqueduct working. In A.D. 212–213, Caracalla collected new springs (Aqua Antoniniana) to increase the discharge as needed by the huge thermal baths. Diocleziano was ordered to collect new karst springs, promoting the renewal of the entire structure of the aqueduct and its terminal. More restoration work occurred during the time of Arcadio, Onorio, and Popes Adriano I, Sergio II, and Nicola I.

Frontino states that the aqueduct was 91.33 km long. The water ran 80.28 km through underground tunnels and arched bridges (aquae pensiles) (Fig. 8.49). The springs discharged 194 504 m^3/d (2.25 m^3/s), although 30% of it was lost before reaching Rome due to unauthorized private connections, one of the earliest documentations of water theft.

8.18.6 Aqua Tepula and Aqua Julia

Consuls C. Servilio Cepione and L. Cassio Longino in 125 B.C. promoted the catchment of Aqua Tepula. These springs were in the Albano volcanic area near Marino-Castel Savelli. The quality of the water, according to Frontino, was rather poor due to its temperature of 16–17 °C. The name *tepula* means lukewarm. At this source the water from many small springs was also collected by aqueduct.

In 35 B.C., during Agrippa's rule, many additional springs were identified near Grottaferrata and aqueduct restoration was carried out to mix with water from Aqua Tepula to improve its taste and physical characteristics. There was a piscina limaria (settling basin) downstream for the mixing of the water from the two groups of springs. The water was then channeled in two pipes, underground and overland on the Marcia arched bridges about 10 km to Rome. The distance to Tepula Springs to Porta Maggiore (ad Spem Veterem) was about 17.8 km.

Frontino states that the Tepula Springs discharge was 7 550 m^3/d (87 l/s) supplemented with 10 108 m^3/d (117 l/s) drawn from Aqua Marcia and Anio Novus aqueducts. The total discharge of Julia-Tepula Springs at the settling pool was 47 952 m^3/d (555 l/s). Before reaching Rome, Julio aqueduct received about 75 l/s from Aqua Claudia.

8.18.7 Aqua Virgo

Frontino and Plinio the Old wrote a story about a young girl (virgo) who showed the location of some springs to Roman soldiers. Therefore the aqueduct was named after her, however, more probably the name of virgin is due to the purity of the water, which has been praised by the poet Marziale. The Virgo aqueduct is the only one that operated from the time of Augusto up to the present. The aqueduct is underground in volcanic rocks. It reached Agrippa's thermal baths, near Trevi and Navona square fountains that are fed by the Aqua Virgo.

The construction of the aqueduct was ordered by Agrippa and its inauguration took place on 9 June 19 B.C. It was mainly supplied by Salone Springs and its discharge was 99 519 m^3/d (1 150 l/s) according to Frontino. Along its route lateral drainage tunnels branch off 210 l/s of the total discharge. The springs were at the northern border of Albano Volcano, east of Rome, in a marshy area near Aniene River. Restoration works were carried out during the time of Emperor Tiberio, A.D. 36–37; Claudio, A.D. 46–47; and Constantino at the beginning of the 4th century. The slope of the aqueduct tunnel is 4.2 m over a distance of 19 km (0.22%).

8.18.8 Aqua Alsietina

The quality of this water was poor. At the time, however, there was no option to supply the 14th district of the city since that district (Trastevere) is on the right bank of Tiber River, opposite the terminal of the major aqueducts of the town. The water was conveyed to Rome in 2 B.C. mainly to supply the monuments built by Augusto near the Gianicolo. The surplus of water was used to supply the imperial and private gardens and Trastevere fountains (Fontino).

Naval battles or shows (naumachia) were performed in a large pool supplied by Alsietino aqueduct and located in a huge park area where a monumental complex was also built (Fig. 8.50). The elliptical basin (whose axis were 533 and 355 m long) was 1.5 m deep with a storage capacity of 200 000 m^3 of water.

The spring catchment was in the volcanic area of the Sabatini Mountains at the border of Martignano Lake (Lacus Alsietinus), north of Rome. The water of a lake was diverted at an altitude of 207 m by a tunnel. Augusto

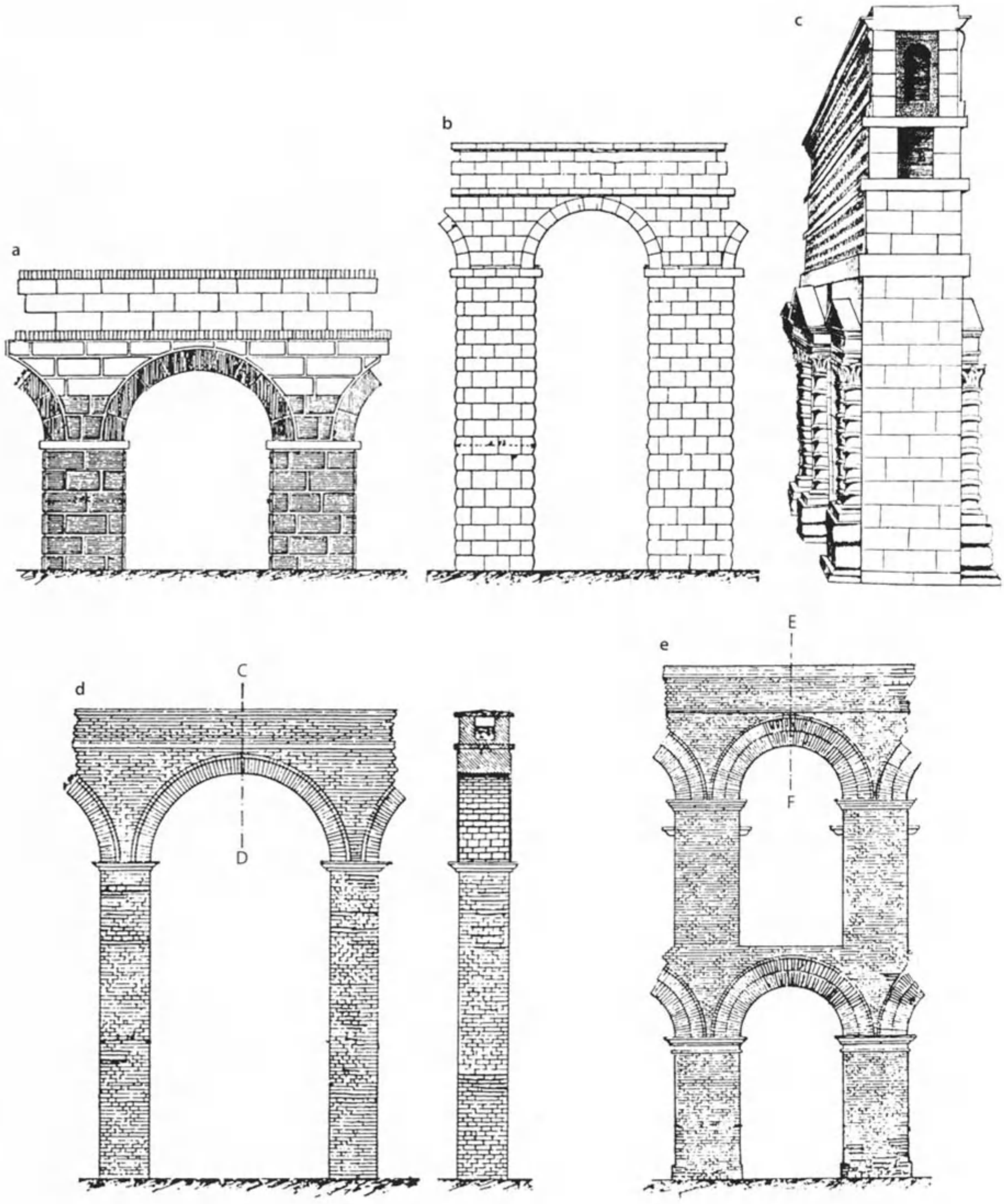


Fig. 8.49. **a–c** Roman aqueduct arcades (arcuationes) were first built in volcanic tuff (tophus) or in travertine squared blocks (opus quadratum). **d, e** Later on during Emporer Silla, the technology was improved by means of brick tiles, which were used to curtain the wall (opus latericium) and to strengthen the arches

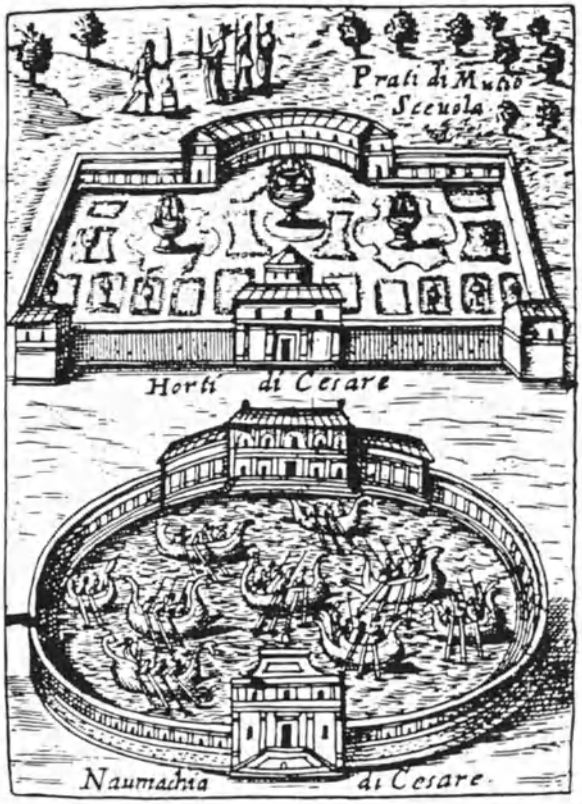


Fig. 8.50. Emperor Augusto's naumachia (naval battle basin)

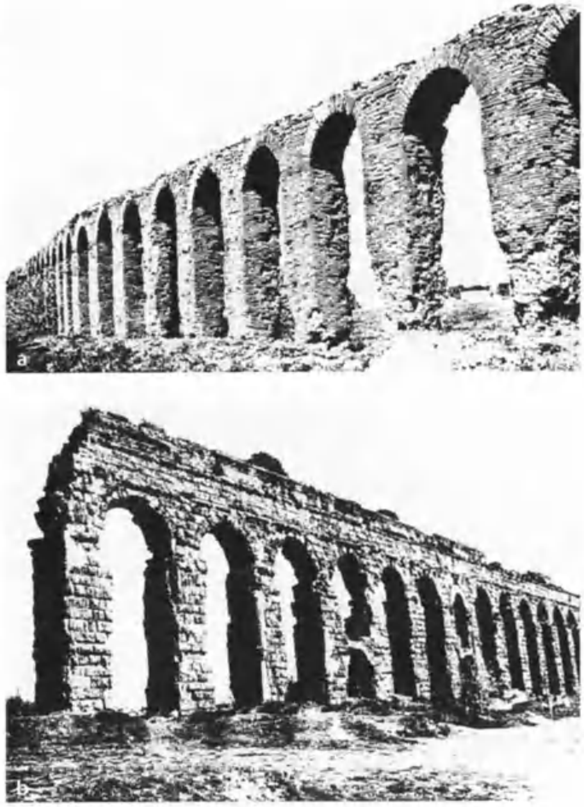


Fig. 8.51. **a** Anio Novus aqueduct near Rome. **b** Emperor Claudio's aqueduct near Rome

probably ordered the catchment to ensure the regular level of the lake. To keep the discharge of the aqueduct constant (16 257 m^3/d), water from Bracciano Lake was collected as well (Frontino). The aqueduct was 32.77 km long, built mainly as a tunnel through volcanic rocks. The water was conveyed 529 m on arcades which underwent great restoration work and structural modification at the time of Traiano (A.D. 109) and in the 18th century during the time of Pope Benedetto XIV.

8.18.9 Aqua Claudia

Caligola started the work of two new aqueducts in A.D. 38: Aqua Claudia and Anio Novus. The works were completed in A.D. 52 by Claudio (Fig. 8.51). Historical writings (Tacito) report, however, that in A.D. 47 water from Aqua Claudia was already distributing water in Rome. Anio Novus is supposed to have been finished 5 years later.

Structural modifications and maintenance works were completed by Vespasiano (A.D. 71), Tito (A.D. 81), and Domiziano. Also, several works of consolidation are due to Adriano, Settimio Severo and Diocleziano. During the Gothic War (A.D. 537), the aqueduct was seriously damaged and restored during Belisario's time. Pope Adriano I in A.D. 776 repaired the aqueduct but its previous discharge had been considerably reduced.

The springs of Aqua Claudia were karst springs (fons Caeruleus, fons Curtius, fons Albudinus, Aqua Augusta) that were located along the right bank of Aniene River, east of Rome and not far from the Marcio aqueduct inlet. Frontino records the spring discharge at the catchment area of 191 190 m^3/d (2 213 l/s). At Spem Veterem, in Rome, this discharge was reduced to 1 341 l/s due to unauthorized connections existing along the aqueduct. Both Aqua Claudia and Anio Novus reached Porta Maggiore (Rome).

From the main reservoir (castellum aquae), the water from the two aqueducts was distributed to all 14 districts of Rome (called Augusto regions) through 92 subsidiary reservoirs (Frontino). The Aqua Claudia aqueduct was 69.75 km long, of which 54.5 km of tunnels and 15.2 km trough arcades were originally built in tuff (tophus).

8.18.10 Anio Novus

The construction of the Anio Novus aqueduct was begun by Caligola in A.D. 38 and completed by Claudio about A.D. 50. Historically, the Anio Novus and Aqua Claudia aqueducts are closely related. Important modifications to both aqueducts were made by Traiano (A.D. 109), and several maintenance and restoration projects are recorded up to the 4th century.

According to Frontino, the aqueduct Anio Novus was built in opus reticolatum (tuff wall) and opus latericium (brick wall). The catchment area was near the Aqua Claudia Springs along Aniene River, from which the aqueduct collected part of its natural discharge, mainly represented by karst groundwater. A large settling basin (piscina limaria) was built near the banks of the river as surface water was muddy during major floods.

To improve the resource quality, some springs of Rivus Hercolanus were collected and drawn to the same aqueduct, and Frontino states that the water quality had the same standard as the celebrated water from Aqua Marcia. Total discharge of Anio Novus is 196 490 m^3/d (2 274 l/s); the aqueduct was 86.876 km long, 73 km of which was in tunnels.

8.18.11 Aqua Traiana

The aqueduct was built by Traiano in A.D. 109–110 to supply the 14th district of Rome (Trastevere) with good, drinkable water. The district was previously supplied by the poor-quality water of Aqua Alsietina. Few data are available about Aqua Traiana as Frontino died and the following civil servants in charge (curatores aquarum) did not register data about new aqueducts.

Many springs were collected to supply the aqueduct. They were scattered in the volcanic area north of Bracciano Lake, northeast of Rome. Although many of the springs have not been located, it is believed that they are those that appear in an 18th century map showing the aqueduct of Pope Paolo V. The Aqua Traiana aqueduct was 32.5 km long. Most of it was underground and partially on arcades. It supplied mainly the Trastevere area and Traiano baths on Colle Oppio. The aqueduct was partially utilized by Pope Paolo V in 1608 and its name at that time changed to Aqua Paola.

8.18.12 Aqua Alexandriana

Emperor Alessandro Severo (A.D. 222–235) decided to build the aqueduct given his name during the last years of his reign. It was the last great aqueduct built in Rome in ancient times. The Emperor intended to supply water to the Campo Marzio baths built by Nerone in A.D. 6 and restored in A.D. 227. The catchment area of the springs is in the volcanic area east of Rome near ancient Gabi, not far from Aqua Appia Springs. During the Gothic War (A.D. 537), the aqueduct was destroyed to cut the water supply of besieged Romans. In 1585 the springs were collected anew to supply Felice aqueduct built by Pope Sisto V. This aqueduct was 22 km long, 8 km in tunnels and 14 km on arcades. Repair works are recorded up to A.D. 500. The Alexandriana and Vergine aqueducts were kept in use during the Middle Ages.

8.18.13 Water Potential and Use in Antiquity

Aqua Virgo and Aqua Traiana-Paola are the aqueducts built during Roman times which are still in use. Total discharge of the ancient aqueducts (excluding Aqua Traiana and Aqua Alexandriana, whose data are missing) was 24 360 quinariae (1 010 258 m^3/d [11.69 m^3/s]). The population of Rome at the end of the 1st century A.D. was about 500 000; consequently, a mean of 1 550 l/d per capita (Fig. 8.52).

At the beginning of the 4th century A.D., the large monuments of Rome supplied by aqueducts are: 11 large baths, 856 public baths, 15 monumental fountains, 1 352 fountains (nimpheos) and basins, and 2 naumachiae (naval battle basins). According to Frontino, water consumption included: 17.2% by the emperor; 38.6% by citizens; and 44.2% by public services. Today, Rome is supplied with 1 987 200 m^3/d (23 m^3/s) of groundwater, mainly from karst aquifers. Its population is 3.5 million, with a per-capita water availability of 500 l/d, including industrial uses.

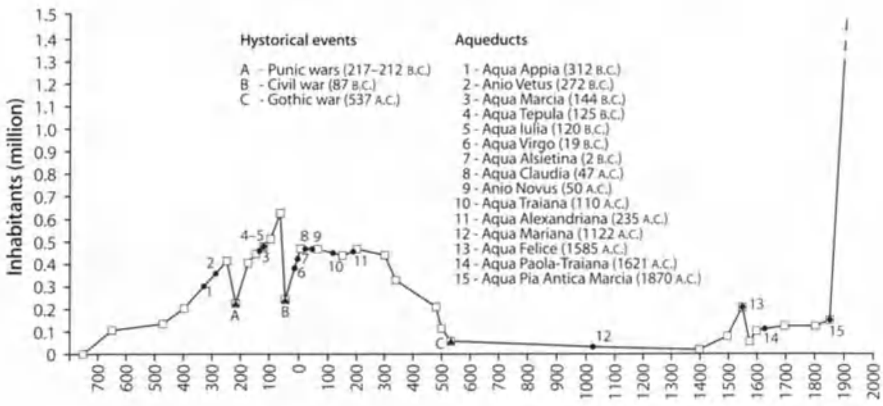


Fig. 8.52.
Demographic trend of Rome and chronology of aqueducts

8.18.14 Decline and Revival of Rome Aqueducts (A.D. 500–1800)

The siege of Rome by Vitige, the king of Goths in A.D. 537, marks the decline of the water supply systems built by Romans. The Goths destroyed the aqueducts to cut water supplies to the besieged city. After a short restoration period by the Byzantine governments, Rome underwent political and economic decay. The aqueducts were neither reconstructed nor maintained and most of the arcades collapsed.

By the end of the Middle Ages, only Aqua Virgo was still in operation. Although the population had decreased considerably, the available water supply was insufficient. Therefore, people used water from the Tiber River and from wells drilled in the urban area. During this time, a great number of Roman buildings, villas, and monuments were torn down to recover bricks and materials for new construction. This practice went on until modern times.

In 1122 Pope Callisto II planned to build the aqueduct Mariano, recovering ancient Roman catchment areas (Aqua Julia and Aqua Tepula). The new water line cannot be compared to the magnificence of the Roman aqueducts. However, many windmills and workshops were located along its country and urban routes; therefore it had economic importance from the Middle Ages to modern times.

In 1570 Pope Pio V restored Aqua Virgo. Pope Sisto V in 1585–1590 collected Aqua Alexandriana's Springs to build the Felice aqueduct, while in 1607 Pope Paolo V Borghese restored Aqua Traiana (later called the Paolo aqueduct). In 1870, Pio IX completed the construction of the Pio aqueduct collecting some of the springs of the ancient Aqua Marcia.

8.18.15 Modern Water Supply of Rome

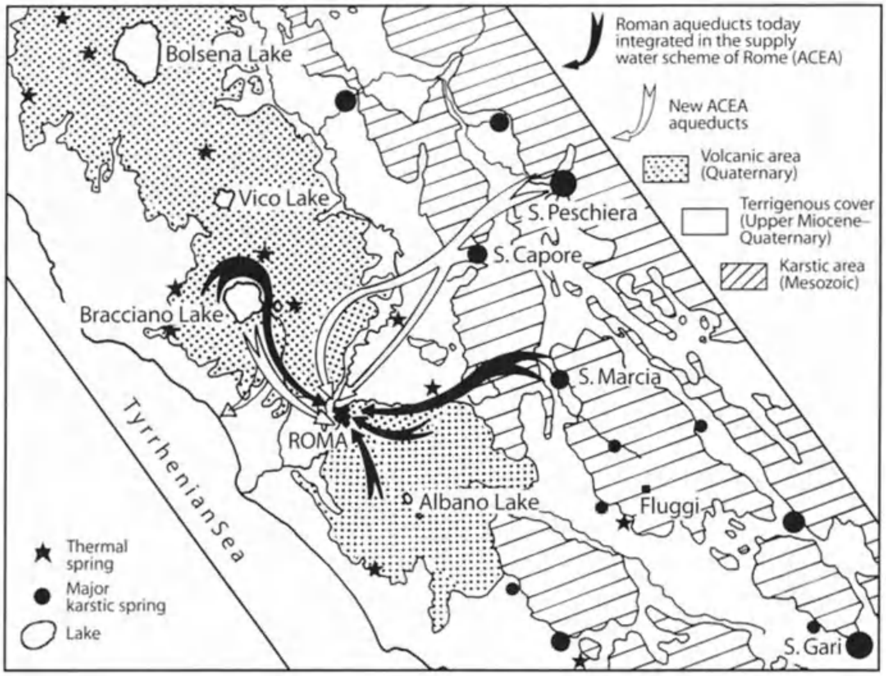
From the end of the papal rule (1870) to 1938, the water supply of the city was administered by the Municipality of Rome. By then, ACEA, which was established during the Fascist period as an electricity production company, took over the management of the water supply of Rome up until the present (Fig. 8.53). In 1964 the ACEA was given responsibility for the water supply of all communities belonging to Rome Municipality. The water supply requirement for Rome at present is about 23 m^3/s, 86% of which is from karstic springs. It is interesting that the water quality standard does not require chemical treatment for human consumption except for chlorination as a preventive measure of organic pollution (Table 8.16).

8.18.16 Marcio Aqueduct

This aqueduct conveys spring water of the ancient aqueducts: Anio Vetus, Aqua Marcia, Aqua Claudia, and Anio Novus, all destroyed by the Goths in A.D. 537. At the time of Pio IX in 1870, a new aqueduct was inaugurated and named Aqua Pia Antica Marcia. Different in technical conception and layout, it carries to Rome only part of the water from springs collected during Roman times.

The population of Rome gradually increased after 1970 by about 2.5% to 3.5 million, and more springs had to be developed to provide water to meet the increased demand. The mean discharge of springs that supply Marcio aqueduct today is 5.0 m^3/s while Roman aque-

Fig. 8.53.
Schematic hydrogeological map of central Italy



ducts produced from the same area about 8.8 m^3/s. These springs are from the karst system of Simbruini Mountains, which has its base level in the Aniene River (321–327 m a.s.l.). The springs occur along the riverbed (linear springs) and along the contact between the karst aquifer and an impervious belt of sandstone (upper Miocene flysch).

The water chemistry is typical of that in the karst aquifer. The mean annual effective infiltration is about 910 mm.

8.18.17 New Vergine Aqueduct

The ancient Aqua Virgo reached Rome at a low elevation and therefore hydraulic constraints did not allow its use extensively for a drinking water supply. In 1901 and 1930 a lifting plant and a new aqueduct 12.7 km long were planned. The springs (25 m a.s.l.) are at the northern slope of the volcanic area of Albano, southeast of Rome. Their mean discharge is 1.1 m^3/s, 0.3 of which is conveyed to the ancient Vergine aqueduct, and 0.8 to New Vergine aqueduct. The groundwater chemistry is not uniform in the catchment area. The water from each spring has a different mineral content. The variability is due to the heterogeneity of the aquifer and to the upwelling of hydrothermal fluids.

8.18.17.1 *Peschiera-Capore Aqueduct*

This aqueduct supplies Rome with about 14 m^3/s. Its construction started in 1935 when the population of Rome was one million. It collects water from two groups of springs: Peschiera (9.0 m^3/s) and Capore (5.0 m^3/s) that belong to different hydrogeological units in the central Apenines range. The aqueduct system is X-shaped and Peschiera and Capore Springs are at two ends. The collecting pipes converge at the Salisano hydroelectric plant, and from there two separate aqueducts run along the two banks of the Tiber River to Rome.

8.19.17.2 *Peschiera Springs*

Located along Velino River with an altitude of 410 m. The mean discharge is 18 m^3/s. The springs are from a homogeneous karst aquifer with a discharge of 26 m^3/s.

Table 8.16. Aqueducts of Rome: mean discharge and chemistry of spring waters[a]

Reference	Peschiera-Capore			Marcio		Nuovo Vergine	Appio-Alessandrino	Paolo-Traiano	
	1, 2	1	2	3	4			5	6
Mean discharge, Q (m^3/s)	13.75	9	5.0	5.0	0.95	0.8	1.2	8 (max)	
Temperature (°C)	11	11	12	10	15	15.5	16	10	15
pH	7.2	7.2	7.3	7.3	6.7	7.3	7.25	8.02	8.0
Conductivity 25 °C (µS/cm)	590	640	580	540	1 460	650	550	540	270
TDS (110 °C)	370	410	375	320	1 030	460	360	354	230
Hardness (°F)	32.5	34.8	29.5	31	74.2	25.5	21.8	11.5	8
Alkalinity ($CaCO_3$)	315	340	270	300	510	275	240	164	112
Organic compounds (O_2)	0.25	0.2	0.25	0.3	0.5	0.35	0.45	0.8	0.5
NH_4									
Ca	110	115	95	87.5	234	78	74	32	15.5
Mg	12.5	15	11.5	21.1	38	18	7.7	8.4	10
Na	4.5	2.5	10	2.51	52.5	31.8	16	43.5	23
K	1.55	2	1.3	0.7	3	36.5	20	39.4	19
NO_2									
NO_3	3.3	2.3	4.3	2	3.5	20.6	14.5	0.7	9
Cl	4.6	3.8	7	5	80	20.5	14.3	45.9	15.9
SO_4	14.5	9.9	27	4.5	215	48	16	40	8.7
P	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
F	0.1	0.07	0.11	0.1	0.25	1.1	1	1.7	1.9
HCO_3	385	415	165	360	622	335	293	200	138
Si	4.5	3	8.2	4.5	10.5	45.5	48	1.5	50
CO_2	14.5	23	12	20.9	210	22	n.d.	2	3.5
O_2	12	7	13.5	10.9	3.5	7.3	n.d.	9.5	13.7

[a] ACEA data: *1* Peschiera Springs; *2* Capore Springs; *3* Acqua Marcia Springs; *4* Acquoria Springs; *5* Bracciano Lake; *6* Acqua Traiana Springs.

The water chemistry of the springs is uniform. The extension of the recharge area (about 1 000 km^2) contributes to the regularity of the aquifer discharge. The mean annual effective infiltration is about 980 mm.

8.18.17.3 *Capore Springs*

These springs are along the bed of Farfa River at an altitude of 246 m. Their mean discharge is 5 m^3/s with a remarkably steady regime. The recharge area is about 280 km^2, while the mean annual effective infiltration is about 570 mm.

8.18.17.4 *Appio-Alessandrino Aqueduct*

This new aqueduct draws groundwater from Roman catchments (drainage tunnels) connected to the Aqua Appia and Aqua Alexandriana and from recently drilled wells. The catchment areas are along the foothills of the volcano Albano at Pantano Borghese, Finocchi, Torre Angela and have a total discharge of 1 200 l/s. Different piezometric levels in the catchment area are related to a heterogeneous reservoir with groundwater flow in perched aquifers. Structural conditions reflect a wide variability of groundwater chemistries related to several hydrothermal gaseous emissions in the area.

8.18.17.5 *Paolo-Traiano Aqueduct*

In the early 1600s the population of the Trastevere urban area had no option but to use the water of the Tiber. The inhabitants of the areas on the left bank of the river could benefit from good quality water from the Vergine and Felice aqueducts. Pope Paolo V Borghese (1605–1621) therefore ordered the reconstruction of the Aqua Traiana imperial aqueduct that had fallen into neglect. In 1946 Pope Innocenzo X Pamphili promoted the development of the aqueduct with a catchment of more springs in the Anguillara volcanic area and later diverted the outlet of the Bracciano volcanic lake (Arrone River).

At present, ACEA's management has further increased the discharge of Paolo-Traiano aqueduct by pumping water from Lake Bracciano to a yield of about 1 m^3/s. In case of emergency due to the breakdown of Roman aqueducts, a temporary additional discharge of 8 m^3/s is possible by drawing the water from Bracciano Lake to the Bracciano aqueduct. To reduce the fluorine content of the water, Paolo-Traiano aqueduct converges at a mixing plant supplied by karst water from the Peschiera-Capore aqueduct.

8.18.18 Water Wells

The increasing population on the outskirts of Rome, new residential settlements, and more agricultural and industrial water demand resulted in the drilling of many private wells. The wells are up to 200 m deep and top aquifers in volcanic terrains whose base level is represented by Tevere (Tiber) and Aniene Rivers. In this area, the so-called mineral water is a commercial activity with several bottling plants and brands. The pH of the water ranges between 6.7 and 7.2, has a salinity between 0.3 and 0.6 g/l, and a temperature between 14 and 18 °C.

I. Povara

8.19 Thermal Springs in Băile Herculane (Romania)

8.19.1 Introduction

In southwestern Romania, in the neighborhood of Băile Herculane Spa, a major positive geothermal anomaly occurs. The anomaly occupies the southern extremity, a transcrustal intra-Carpathian fault, over 300 km long, that starts in the central part of the southern Carpathians, crosses the Danube and extends southward into the Republic of Yugoslavia. North of Băile Herculane, over a distance of 60 km, the fault splits to form a narrow graben, sunken by some 1 000 m with respect to the adjoining structures. The 600-m-thick carbonate formations and the upper part of the underlying granite, trapped inside the graben, form water reservoirs. Thermo-mineral sources occur along the entire length of the western fault of the graben, the most important of them being situated in the neighborhood of Băile Herculane (see Fig. 8.54).

8.19.2 Băile Herculane – Historical References

1. The first facilities were built by the Romans, after A.D. 105, the Roman "termae" being under the auspices of god Hercules. Many votive tables dating from between A.D. 107 and 287 confirm the therapeutical qualities of the water.
2. In 1736, Count Hamilton, sent by Charles III, rebuilt some of the facilities on the old Roman sites.
3. After 1817 (Franz Joseph), the first modern baths and hotels were built.
4. In 1847, Prince Carol presented the spa of Băile Herculane with the bronze statue of Hercules.
5. In 1884 the first thermal water intake well was drilled (Neptun I, 27 m deep).
6. Between 1968 and 1984 seven new hotels, provided with their own balneotherapy facilities were built, and an integrated water distribution system completed. The current lodging capacity of the spa exceeded 3 000 places.
7. Eleven new wells drilled between 1968 and 1978 provided an additional discharge of 23 l/s. The minimum cumulated discharge currently provided by wells and natural springs is 55 l/s (4 750 m^3/d).