Topographic Specificity and the Design of the Baroque Fountains Of Rome

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The fountains of Rome, linked together by subterranean conduits of metal, stone and terra-cotta, are integral elements of Roman civic identity. More than simply isolated monuments, each fountain is part of an aqueduct distribution network and part of a larger hydrological system that also includes the Tiber River, springs, streams, marshes, sewers, aqueducts, wells, conduits, cisterns, floods and rainwater, all linked through topography. By examining fountain distribution networks, rather than individual fountains, new insights will be gained into the role that topography andgravity have played, not only in fountain design, but also in the urban development of Rome. Each aqueduct generated a "family" of fountains rather like far-flung siblings and cousins that shared behavioral characteristics. Unlike mechanical systems that force water into unnatural contortions, a gravity system nurtures, exploits, and enhances water's natural abilities as it flows through its watershed. Allowing for seasonal variation in water volume, each fountain was designed around the distinct, inherent possibilities of the water at a specific location. Whether the water shot in a lofty jet, fell in a rushing cascade, bubbled from a low nozzle, or slipped slowly over a stone lip, it did so because the symbiosis between gravity and topography had been exploited by the design. Hence each fountain told a topographic story that linked it simultaneously backward and forward to the other fountains in its system, to its aqueduct, and to its source outside the city.

Roman fountains, until the 20th century, were fed by a vast, yet simple aqueduct system that exploited the natural law of gravity. Water flowed continuously, and its distribution depended upon the following: the altitude of springs at their source and their distance from the city; the grade of flow; the altitude of holding tanks along the route; the elevation of the service area; the diameter of the pipes; and the amount of water flowing through them. Each aqueduct delivered water to a tank, called a *castellum*, often located just inside the city wall. Here, the water was held at a high elevation, divided into smaller quantities, and sent to smaller secondary *castelli*, to be delivered to public and private fountains in different neighborhoods. From the spring to the *castellum,* the water flowed in large channels, at an average drop of only one half meter per kilometer, with room for air circulation within the channel. From the *castellum* to the fountains, the water flowed under the streets in pipes that constricted its flow and created pressure. The more pressure in the pipes, and the greater the difference in elevation between the level of the pipe in the *castellum*, and the level of the fountain, the higher the water could shoot when finally released. The elevation at which water left a basin determined the theoretical, maximum height it could attain in the next location. The higher the pipe was placed, the higher the elevation at the next stop, but, the lower it was placed, the greater the available pressure. At various points along the distribution route the water might flow into another, lower *castellum*, to be divided again, after which the water could never regain its original elevation.'

The subtleties of this design equation are all the more profound when it is remembered that neither the ancient nor baroque aqueduct and fountain designers, including Giacomo della Porta, Gianlorenzo Bernini, and Domenico Fontana, knew the empirical formula to calculate water flow. The problem was to deliver an unknown and variable quantity of water from a specific location and elevation to a series of fountains, each located at a different distance and a different elevation from the source, and to deliver the water in a quantity sufficient to provide for the needs of each service area, and in a manner appropriate for those needs. The primary means of transmitting practical hydraulic information was via published treatises and illustrated books.[2] The most important treatises were those of Heron of Alexandria, Vitruvius, and Alberti, but none of these provided any quidelines for laying out and designing a distribution network. Hence, I can only assume, that there was a great deal of hands-on, trial and error experimentation to achieve a balance of these variables within each distribution network.

The need for a reliable and pure public water supply was a complicated interplay of public policy, patronage, and real estate development, balanced by the limitations and potentials of a gravity-flow distribution system and a complex topography. Rather than simply directing water where it was wanted, the entire system was built upon optimizing urban potential in areas where water could be delivered. Elaborate political alliances, which will only be touched upon in this paper, were forged or strengthened depending upon the potential for water delivery at a particular site.'

I will briefly introduce the three, pre-industrial, gravity-driven aqueducts still in operation in Rome; the Acqua Vergine, the Felice, and the Paola. Then, I will focus on the public fountains of the Acqua Felice, andexamine how each fits into its waterdistribution network. The Acqua Vergine, based on the antique Aqua Virgo, was restored several times during the medieval and renaissance periods. By 1570 a new branch arrived near the Piazza Di Spagna, at 20.5 meters above sea level (*masl*). It served the low-lying, densely populated Campus Martius area. This branch supplemented the earlier channel that arrived at the site of the Trevi Fountain at 20 *masl* and added acrucial half-meter of head. With little more than a seven meter fall over the entire two square kilometer distribution area, Giacomo della Porta, the designer of the system, and other fountain designers, used every available means to deliver the water as high as possible, for the most impressive and useful display. Sites were re-graded, or fountains partially submerged below street level, as with the Barcaccia and Terrine fountains, to create enough room to manipulate the water. This meant that once released, Vergine water did not rise in jets and sprays, but typically fell in veils and cascades, as seen most dramati-

cally at the Trevi and Quattro Fiume fountains.

The Acqua Felice, which exploited the antique Aqua Alessandrina, was commissioned by Pope Sixtus V. It arrived on the Quirinal Hill at 59 meters in 1587 and provided water to a variety of locations, including the Esquiline, Pincian, and Capitoline hills, the Roman Forum, and the Velabrum. With over 40 meters of head in this system, the water shot or fell, depending upon location and purpose. On hilltops it customarily fell, as at the Moses and Campidoglio fountains. In the valleys, it shot in jets and sprays, as needed in a particular setting; a five-meter high plume for the Triton, or achaste spray for the Madonna dei Monti.

The Acqua Paola, based on the antique Aqua Traiana and named for Pope Paul V, arrived in 1612 at the "Fontanone" on the Janiculum Hill, at 69 meters. Unsuitable for drinking, it delivered water for industrial, irrigation, and display purposes throughout Trastevere, the Borgo, the Vatican, Monte Testaccio, and the Caelian, Esquiline, and Aventine hills. With over 50 meters of fall there was tremendous pressure in this system. The fountains in front of St. Peter's for example, were designed to shoot 6.3 meter high jets of water. They were fed by their own branch of the aqueduct that traversed the *Vatican* hill to a *castellum* in the Vatican Gardens that sent the water directly to the Piazzadi San Pietro. The high pressurein this line was mitigated by a series of castelli that slowed the water, lowered pressure and hence limited its ability display ability at the farther reaches of the network.

THE FOUNTAINS OF THE ACQUA FELICE

The Acqua Felice was originally intended to serve a series of public and private fountains positioned at progressively lower elevations, according to plans developed under the direction of Giacomo della Porta, who also designed many of the fountains.[4] The Moses Fountain, designed by Domenico Fontana is located on the top of the Quirinal hill. It is the *mostra*, or first fountain within a distribution network: the one that announces and celebrates the arrival of waters into the city. Enormous quantities of water fall in a great rush from horizontal apertures in the back wall, at 59 meters above sea level, into a large basin.[5] Already at its highest possible level inside the city, the water could not shoot in great sprays and jets, as one might expect, but, since it was at the beginning of its public journey through the city there was a tremendous amount of water available for display. The *mostra* also acted as the first *castellum* within the city walls. Pipes located near the bottom of this basin (56.5 *masl*), carried Felice water under the via Vente Settembre. The main branch led to strategically placed public fountains that furthered the papal agenda; the Quattro Fontane and the Monte Cavallo. Other pipes lead to public fountains that were under thejurisdiction of the Comune, i.e., the civil government of Rome.

The Quattro Fontane were located at an intersection, crucial to an urban development plan initiated by Sixtus, even though at the time the area was outside the *abitato*, or inhabited area of the city. They dispensed a small amount of drinking water at aconvenient location along a new road developed to link pilgrimage churches. They were "semi-public" fountains provided at the expense of Matteo Mattei. the owner of an adjoining property, as partial payment to Sixtus for the delivery of Felice waters to his newly constructed palace. The new palace helped to stimulate real estate speculation, and the fountains reinforced the logic of the road system.[6] The water arrived at 55 *masl.* Because of the small elevation drop between this intersection and the Moses Fountain, there was relatively little pressure for water display, but enough to allow the water to fall gracefully at a comfortable height for drinking.

Continuing south-west, the water arrived at the Monte Cavallo Fountain located in front of the Quirinal Palace. Originally a papal residence, it is now used by the President of Italy. The symbolic importance of the site necessitated lowering the level of the piazza by more than two meters in order to create enough room for a dramatic water display, in this case, an eight meter drop in elevation from the water source at the Moses. The original fountain was situated at the base of two antique, colossal statues of the Dioscuri. The obelisk was added in 1782. This huge, simple, antique basin replaced the original fountain in 1816. Today, due to rationing, the water barely rises above the nozzle, however, historic photos show an enormously powerful five meter high central geyser.'

Two pipes under the jurisdiction of the Comune continue from here, each intended for a different part of the city. The first led to the Madonna dei Monti Fountain, which was located at the heart of one of the oldest medieval neighborhoods in Rome. It delivered an abundant supply of water for domestic and industrial uses to a dense neighborhood at the edge of the *abitato.* Although this area was served by a continuously flowing natural spring, located nearby. additional water was needed for the growing population. Because the piazza, at 24 *masl* is well below the Moses Fountain, there is a significant zone for the play of water.

By this time the water had traveled nearly a kilometer-and-a-half, and fallen 35 meters. Theoretically, the fountain could have been designed to deliver water at much higher level, however, such a display would have been useless to this specific neighborhood. Rather, the fountain design combines the most effective display of water for propaganda purposes, with the most efficient delivery of water for domestic purposes. Essentially a display fountain, a drinking spout was also originally located at one edge of the lower basin. From here the *acqua caduta* (or overflow water) was sent to the Roman Forum, thencalled the Campo Vaccino, to acattle trough.

Another pipe went to a *castellum* that collected the Felice water before it descended the southeast slope of the Quirinal hill. The placement of the conduits leading from this *castellum* were crucial since the water needed to re-ascend to an elevation of nearly 41 meters on the Capitoline hill. This pipe served the Campidoglio fountains, and also an existing medieval cistern, located under the piazza, that acted as a *castellum* for the new fountains proposed for the Velabrum.

The Piazza di Campidoglio — the political heart of the Roman Comune — was originally served by a triad of fountains: one for propoganda, one for horses and two for drinking. The first fountain reflects the sober nature of the piazza and Palazzo Senatorio, both designed by Michelangelo, and complements the monumental staircase, and the colossal, adorsed, reclining river gods — the Tiber and Nile — who symbolically feed the fountain. Water falls from apertures above the upper trough, and then gently slips in a veil into the lower basin. The elevation of the openings is approximately 41 meters. As with the Moses Fountain, the water could not shoot vertically because it was already at its highest possible elevation. But here, with less available water and pressure, the display is far more restrained, which is appropriate for the setting. The *acqua caduta,* was sent to the "Marforio" fountain, which originally faced into the piazza and served as a horse trough. Here too, the water is already at its highest possible elevation, and can fall only a few centimeters into the ground level basin.

At the foot of the Capitoline ramp are the two Lion drinking fountains. These are the first fountains served by the restored *castellum* under the piazza.[8] The drinking fountains could not have been placed at the top of the hill (as logic might suggest) because of the problem of raising the water from the underground *castellum*, to a convenient height for drinking.

A second pipe delivered water to the Aracoeli fountain. It is five and one-half meters tall, and today the water rises about two meters above that, to nearly 33 *masl.* Typologically similar to the Madonna dei Monti fountain it served a similar urban purpose. Both were situated *en route* to important churches that furthered the Reformation agenda. The Monti was on the route to Santa Maria Maggiore, the fulcrum of the Sistine pilgrimage system, and the Aracoeli was

on a road to the Gesu. Like the Madonna dei Monti fountain, the Aracoeli, promoted papal and comunal propaganda, but was built by the Comune primarily to serve local needs.

The *acqua caduta* from the Aracoeli was sent to an adjacent horse trough, and then headed to the Tartarughe fountain in Piazza Mattei which was originally designed by della Porta as part of the Acqua Vergine distribution network. However the low-level Vergine (20.5 *masl* and two kilometers away) cound not serve the top jet which is about 18 *masl.* This is a good example of the kind of experimentation that must have characterized early fountain design. Della Porta's original 1581 design could not be realized, with Vergine water, but had to await the 1588 arrival of the higher, Felice waters.'

From the Piazza Mattei this same channel continued to the Guidea fountain originally located just outside the north west entry to the walled Jewish Ghetto at 16 *masl.* Della Porta's 1570 plan also called for Vergine water to be delivered here as well. But as with the Tartarughe fountain, the Vergine was unable to reach it.[10] In spite of grandiose appearance of the fountain in this print by Gianbattista Falda, it was actually quite small, measuring less than two meters high. Typically fountain size and water quantity diminshed indirect relationship to the distance from the water source and diminishing water pressure.

Another channel turned down the via del Teatro di Marcello to serve the Campitelli fountain, the last surviving from the original distribution network. Located in the Piazza Campitelli, at 19 *masl*, it was built at the request of three important residents, who jointly commissioned della Porta for the design. They each owned a palazzo (all three designed by della Porta) located in the same piazza.[11] The entire fountain is only three meters high, and the jet of water rises only another meter. Theoretically, like the Madonna dei Monti fountain, the Campitelli could have delivered water at a higher elevation, but a lower display was necessary in order to serve the needs of the neighborhood.

Two important public fountains were added to the Acqua Felice system during the seventeenth and eighteenth centuries: the Triton, by Bernini of 1642 in the Piazza Barberini; and the Bocca della Verità, situated near the Tiber River, by Bizzaccheri of 1717. Although not part of the original della Porta scheme, nonetheless, they relied on the same gravity flow system. Aside from obvious stylistic differences, the essential difference between them is that of topography and gravity. The difference in pressure, due to elevation, water supply, and distance from the source, dictated different displays.

The Triton has one of the most powerful waterjets in Rome.[12] An enormous geyser shoots from his conch shell, reinforcing his muscular form. The magnitude of the water display is possible because the piazza is approximately 25 meters lower than the water level of the Moses Fountain, only about 750 meters away. The Triton, from base to conch, is six meters high, and as seen in this historic photo, the water jet itself is about five meter high, bringing the composition to nearly 44 *masl.* On the other hand the Boccadella Verità Fountain, about five meters tall, is located at one of the lowest points in the city, only 13 *masl.* But the water has traveled nearly three kilometers, and been detained and divided in *castelli* along the way. A plaque on an adjacent building indicates that Acqua Felice water could only rise to 20-21 *masl* (due to seasonal variation) in this piazza."

Once, only Vergine water flowed to Vergine fountains, Felice water to Felice fountains, Paola water to Paola fountains. Each aqueduct, with its unique topographic situation and water quality, described a specific, bounded "water shed" area, outside of which it could not flow. Today the Roman water system includes both gravity and mechanically pumped systems. In some instances aqueduct waters are mixed together. However, the fountains themselves have changed very little. Jets still shoot water up, and cascades still send water down, but due to conservation efforts, less water is delivered now than in the past. With a renewed awareness of topography and the principles of gravity and pressure, the fountains reveai hidden urban dimensions, and it is possible to locate them, and oneself, within the larger water landscape of the city.

NOTES

[1] For discussions of the entire aqueduct system of Rome see Thomas Ashby, *The Aqueducts of Ancient Rome* (Oxford: The Clarendon Press, 1935) or Harry Evans, *Water distribution in ancient Rotne* (Ann Arbor: University of Michigan, 1993). According to Frontinus there were 247 *castelli* in 97 AD. No precise locations are mentioned. Dr. Chuck Hendricks of Lawrence Livermore Laboratories, University of California, provided information about the basic physics of water flow.

[2] The first treatise since antiquity to deal specifically with the design of fountains, *Les Raisons des forces mouvantes,* was written by Salomon de Caus in 1615. It incorporated the work of Archimedes, including the water screw, and the *Pneumatica* of Heron of Alexandria, as well as treatises of Vitruvius. By this time nearly 60 new public fountains had been constructed in Rome. Another important work, *Nouvelle invention de lever l'eau*, was published by his brother Nicholas in 1644, and finally in 1690 the Italian architect and engineer Carlo Fontana, who also designed many fountains, published *Ultissimo trattato dell'acque correnti.* All these texts were extremely useful for later fountain designers, but don't tell us anything about how earlier designers, such as Giacomo della Porta and his contemporaries designed fountains and fountain distribution networks.

[3] Perhaps the most striking example is Matteo Mattei who was directly involved with Pope Sixtus V in the building of four "semi-public" fountains, including three of the Quattro Fontane fountains and the Tartarughe fountain. In each case the fountains were adjacent to his own properties, and in the case of the Tartarughe, Mattei was also involved in it's design.

[4] Giacomo della Porta, under popes Gregory XIII and Sixtus V, had ultimate responsibility for the placement and design of all the public fountains in the system, except for the Moses Fountain. Cesare d'Onofrio, *Le Fontane di Rorna* (Roma: Romana Societa. 1986), p. 221, lists the eight original public fountains proposed in 1587, and the nine that were actually built by 1591.

[5] J. H. Parker. *The aqueducts of Rome* (London: Chatto), p. 109 "the *specus*, (or channel) is three feet wide, and the water in it is usually from three to four feet deep, running with a rapid current about five miles and hour, and constantly flowing day and night."

[6] Simona Benedetti, "Le Quattro Fontane," p. 136, in Maria Piera Sette, *Architetture per la Città.* Several fountains in the city fall into this "semi-public" category including the Babuino, formerly associated with the Ludovisi Palace, and the fountain in front of the Villa Medici. See also d'Onofrio, p. 230.

[7] It is interesting to compare this fountain with the typologically similar Medici Fountain in front of the Villa Medici which is at nearly the same elevation. Not only is the water display at the Medici fountain smaller and more restrained considering the relative importance of Cardinal Medici to Pope Sistux V, but in order to keep the water at the highest possible elevation *enroute* to the fountain, the conduit is nearly two kilometers long.

[8] I have been unable to visit this *castellum* (which was originally a cistern) to ascertain the exact elevation of the pipes. The modern level of the piazza is approximately 38 masl. *Castelli* are usually not more than a meter deep, but cisterns, which were used to store rain water, were often several meters deep.

[9] The Felice was originally proposed by Pope Gregory XIII in 1581, but did not begin construction until 1585. Documents which might explain whether the Tartarughe was designed with the Felice in mind, have not yet come to my attention.

[10] d'Onofrio, p. 272.

[11] d'Onofrio, p. 268

[12] The only higher jets are those of the two fountains in the Piazza

of Saint Peters which are fed by the high elevation Acqua Paula situated nearly 50 meters above the fountains, and the Naiad Fountain which is mechanically pumped.

[13] I have located eight existing plaques, most of which date from the 18th and 19th centuries. There are three for the Vergine, four for the Paola, and one for the Felice. They informed local residents of the amount of head available to deliver water to their residences.