

Origins of the city of Siena and the hydrogeological and geomorphic features of the territory

One of the most beautiful cities in Tuscany, Siena is still characterized by the same architectonic and urban features as in medieval times. As a result Siena city centre has been granted UNESCO World Heritage status. Despite its unique territorial context and setting, Siena is located in one of the worst irrigated uplands in Tuscany. The topography of Siena is strictly linked to the geological and morphological features of the area. The hill on which the city stands is formed of an impermeable clay 'base' over which a permeable layer of sandstone, shoreface sands and Pliocene marine conglomerates has been deposited. The hilly landscape owes its shape to erosion, which has dug deep valleys and brought the underlying clay to the surface. These valleys collect the waters which flow in the springs naturally arising in the lower slopes of the hill, a hydrogeological scenario which, together with the fact that the city of Siena lies near the top of the hill, has made water provisioning in the area a particularly challenging task. Siena is built over an existing Etruscan-Roman settlement whose centre lay on the San Quirico hill until the Late Middle Ages. The ancient city took its name - Castelvecchio - from the first *castrum*, the residence of the bishop, to be built there. The modest amount of water needed by this settlement was supplied by an underground aqueduct dug in Roman times (perhaps following the route of an existing Etruscan system). This aqueduct was severely damaged during the centuries following the fall of the Empire and there remains no direct evidence of its existence. However it is not difficult to imagine that the underground tunnels into which rainwater and small springs flowed in the Classical age were the same channels which, with some alterations, supplied the fountains at the foot of Castelvecchio in the Late Middle Ages. Close examination of the layout of the oldest fountains in the city of Siena shows that they are located (low down and often dug into the hill) all around the area originally covered by the ancient medieval settlement. For example the ancient Fontanella water fountain is located just below the medieval settlement at the foot of a steep slope. The ceiling of the underground aqueduct which feeds this fountain is vaulted in the Etruscan style, while the walls are unlined. As a result the inside of the tunnel is coated with limescale. The effect is beautiful but must have caused serious problems for those who needed limpid water, free from calcite.

The 11th-12th Century: The development of the city, the first solutions to the shortage of water and the preeminent role of Fontebranda

Between the 11th and 12th century, Siena developed considerably in demographic size. As a consequence, the city gradually started to "descend" the Castelvecchio hill and spread towards the Francigena road (an ancient trading route which has connected Northern France to Rome since the 10th century). The city wall was extended to incorporate more agricultural space and enclose many water fountains previously located outside the city. Defensibility and the certainty of a regular supply of clean water were among the primary reasons for the development of the city of Siena. As the population increased and water became one of the most important sources of energy for the early manufacturing industries of the city (finishing of cloth and tanning), demand increased. The areas of the city in which water was most easily accessed (if it is possible to say that access to water can ever be 'easy' in a city which has struggled for centuries against the dryness of its subsoil) became privileged areas for the establishment of the first workshops. One of these areas was Fontebranda. Fontebranda takes its name from a fountain which documentary evidence proves already existed in the 11th century and

which was without doubt the richest of the ancient water supply points. With the establishment of many wool and leather workshops around the fountain, the district of Fontebranda assumed absolute preeminence with respect to other areas of the city. The fountain received special attention from the city's governors who, fully aware that it was a meeting point for traders and craftsmen from all over the world, protected it with a fortress-like monument decorated with statues. Thus Fontebranda fountain became a symbol of the city. Considered one of the most beautiful water fountains in Tuscany, according to the 14th century citizens of Siena, the Fontebranda fountain was the monument travellers passing through Siena wanted to see more than any other building in the city.

The 13th Century: Maximum demographic development and the digging of an intricate water distribution system

The demand for water in Siena reached its height in the 13th century as the city tried to keep up with the industrial production of other Tuscan cities. Having also expanded to record demographic size, Siena had no alternative but to search for new water supplies. The city governors tried to find new underground fonts and direct even the smallest sources of drip water to the public distribution system. New underground channels were dug. The term *buctinus* - which probably derives from the fact that the tunnels had barrel vaulted (a *botte*) ceilings - first appeared in a document dated 1226 in reference to several single channel aqueducts which had supplied the ancient fountains of previous settlements. Distributed throughout the urban fabric according to the needs of the various districts of the city, the fountains were almost always high Gothic-style monumental buildings lightened with round Roman arches and designed in such a way as to ensure the least possible wastage of water. The water distribution system was as simple as it was ingenious. Any water which was not consumed at a drinking water plug went to large pools in which it was collected for use in the case of fire (fires were frequent and extremely serious in Medieval times). Once these pools were full, the precious liquid flowed into animal drinking troughs. Any excess water was then sent to the washhouse for use in washing dirty clothes. Having served every possible use in the city, the water was then transported to tanners, mills and vegetable gardens outside the city walls. The rigour with which water distribution was managed reflects the strategic importance of this vital element in the development of both the economic and the social activities of the city.

Hygiene and protection of water

Water was considered a highly valuable commodity. Indeed, so great was the importance accorded to this precious liquid by the citizens of Siena that great lengths were taken to ensure its purity and to protect it from pollution and theft. During the 13th century, the city governors appointed a series of custodians to ensure compliance with the severe prohibitions set forth in the municipal statute. It was strictly forbidden to perform any activity which could dirty or pollute water near the city's water fountains and anybody found violating these laws was severely punished. Indeed, a woman accused of witchcraft was first tortured and then quartered for having tried to poison one of the city's fountains. The purity of the water was not only guaranteed by keeping a check on possible polluters, it was also ensured through the use of a series of decanting pools, of which there were many in the city. The *galazzoni* were a series of large settling tanks which allowed the water to be clarified by decanting the sediment and lowering the concentration of calcites as the water flowed from one pool to another. The method of purification was as simple as it was ingenious: the flow of water was slowed, thus, the

heaviest particles sank to the bottom and the calcites began to solidify, creating a fine film on the surface of the water. As the calcite film increased in weight, it sank to the bottom of the tank, leaving the water limpid and transparent.

The 14th century: Development of the main Fontebranda aqueduct and digging of the Fonte Gaia system

During the 14th century, the demand for both drinking water and water for industrial purposes increased considerably, especially as the district of Fontebranda continued to expand its production capacity. Thus, it was necessary to increase the length of the **main Fontebranda aqueduct** and the volume of water flowing in it. The aqueduct was extended towards the north of the city where natural water sources were more abundant. The tunnel was dug into two different geological layers: the upper part of the tunnel being dug into permeable rock in such a way that drip water could filter through and the lower part of the tunnel being dug into impermeable rock in such a way that the water could be collected and channelled. However this extension did not suffice to satisfy the increased demand for water and the municipality was forced to commission of a new aqueduct. The new **Fontegaia aqueduct** also collected drip water and water from underground sources to the north of the city, however, rather than being constructed according to the empirical methods previously used to dig the aqueducts of Siena, this time a qualified technician was appointed to draw up a plan. The tunnels had to be high enough for a man to be able to walk through upright and were paved with bricks in such a way as to facilitate maintenance and cleaning of the narrow channel (*gorello*) through which the water flowed. Where infiltration was a risk, the abutments and vault of the tunnels were lined with bricks. The public fountains and wells of Siena were fed by branch channels which divided off from the main aqueduct, which was built on a constant slope and terminated at the fountain in the main square of Siena, Piazza del Campo. Digging commenced simultaneously from the two ends of the tunnel (and not merely at the source as had previously been the practice) and the two teams of diggers met at the halfway point, although the point of conjunction was not always perfectly gauged as can be seen from the signs of "adjustment" in the tunnels. Unlike the Fontebranda aqueduct, the new system of tunnels was dug entirely in the permeable upper layer of rock. The tunnels were dug by labourers, known locally as *guerchi*, who used rudimentary tools and elementary techniques to dig through the seams of sandstone and conglomerate rock. The length of the tunnels is impressive and great precision was required to calculate their gradient and direction. The main tool used for levelling was the plumb line. Each *guerco* carried a wooden or metal set square and a lead line which was used to determine the level of the floor and thus the gradient of the tunnel. The only way to control the direction of a tunnel was by opening - circular or square - apertures at surface level. These apertures also helped ventilate the tunnels and allow rubble to be hauled to the surface.

Fonte Gaia

The digging of the Fontegaia aqueduct took several decades, however water finally arrived in Piazza del Campo in 1343, an event which the Sienese celebrated with pride, satisfaction and a huge party. The singing, dancing, feasting and drinking were described in great detail in the chronicles of the time. This great joy was perhaps the reason why the fountain is known as Fonte Gaia [Fountain of Joy]. As previously mentioned, water played a fundamental role in determining the monumental aspect of many of the buildings in the city of Siena. With the completion of the new aqueduct, the functional supremacy of

the Fontebranda fountain was challenged, although the original 14th century Fonte Gaia fountain had nothing of the monumental or beautiful about it. However, in the 15th century, Jacopo della Quercia was commissioned to design a monumental fountain for the Fonte Gaia aqueduct in Piazza del Campo and the Fontebranda fountain was forced to share its role as aesthetic and functional symbol of the city. The Fonte Gaia fountain was replaced by a copy, the work of Sienese sculptor Tito Sarrocchi in the 19th century. It is interesting to note that the practice of building monumental fountains over the aqueducts of the city of Siena continued into the early 16th century with the construction of the beautiful Pispini fountain which was built at the expense of the residents of the district.

The 15th - 16th century: great Sienese engineers of the Renaissance

The Sienese water supply system offered great challenges to many hydraulic engineers and the fountains and underground aqueducts of the city provided ideal material upon which to conduct numerous research projects. The technical management of the work of maintenance and adaptation of the Sienese water supply system was entrusted to many illustrious technicians such as the architect **Jacopo della Quercia** and the engineer **Francesco di Giorgio Martini**, while the hydraulic problems of Siena were considered in the studies of **Taccola** (Martini's teacher) who seems to have expended large amounts of energy searching for solutions to problems relative to the digging of the aqueduct system. It is no exaggeration to say that the waters of Siena contributed in part to the development of the Sienese school of architects and engineers, one of the leading centres of technical expertise during the period of transition between the middle ages and modern times.

End of the development of the aqueduct system

The search for new water supplies became gradually less important as the population of Siena decreased (thanks to the epidemics of the mid 14th century) and Sienese industrial production finally ceded to the supremacy of other Tuscan cities. As the search for new water sources to the north of the city was hindered by the fact that the border with the Florentine state lay just over 10 kilometres to the north of Siena, during the 15th century, the city focused its energies on increasing the density of the existing aqueduct system. Indeed, the aqueducts dug between the 14th and 15th centuries developed to such an extent as to reach a total length (main and secondary branches) of over **25 kilometres**.

The 18th-19th Century: Maintenance and privatization

Over the centuries many Sienese governors and administrators have had to face the technical challenges laid down by the difficult and ongoing job of maintaining a structure which is as precious as it is delicate. One of the most important maintenance activities is the practice of *sgrumatura*, the scraping and removal of calcareous deposits and scale - caused by infiltration of water - from the walls of the tunnels and the channels. Failure to clean the aqueducts of deposits caused by water seepage leads to erosion of the tunnel walls and obstruction of the channels. This eventually changes the gradient of the tunnel floors and effects the regularity and quality of the water supply. Despite centuries of strenuous efforts to ensure that the supply of water remained a wholly public service (only being managed by private parties under licensing agreements on very rare occasions), between the 17th and 18th centuries, private users were allowed to connect either directly to the main aqueduct or to the secondary branch aqueducts leading to public fountains and wells. Those who could afford it created a private offlet which brought water from the main aqueduct directly to a private well or water tank. The amount of water supplied was controlled by special clay

barricades pierced with small holes whose size regulated the flow of water delivered. The quantity of water supplied (measured in *dadi*, a *dado* being the amount of water flowing through one hole in the barricade per day) depended on the amount paid by the private user. A plaque at the beginning of the private offlet provided information regarding the route followed, the quantity of water carried and the names of the users entitled to the water. These plaques were occasionally used as means of political propaganda, such as in the case of a Sienese citizen who added a fervent *W il Sindaco!* [Long live the Mayor!] to the plaque confirming the entitlement of Mayor Bernardo Tolomei to the water supplied by the aqueduct.

Modern times and current use

The water fountains of Siena continued to serve a fundamental social function right up until the 1960s. Many were used by the city's womenfolk for washing dirty clothes, while the large overflow pool in the district of Fontebranda - no longer the manufacturing centre of the city - was used for many decades as a public swimming pool. Since the construction of the modern aqueduct at the beginning of the 20th century, the water from the old supply system has no longer been used for drinking, however it is still used to supply the cooling systems of many companies, to feed monumental fountains, to irrigate private vegetable gardens and to water the many public gardens in the city. Indeed, the city of Siena is well aware of the importance of water as a precious and non-renewable resource. Yet the old water supply system - both the parts visible at surface level (fountains, wells, public washhouses) and those hidden underground (tunnels, water tanks, decanting pools) - is not only important for its functional capabilities, it is also a vital feature of the history and culture of the city of Siena and, as such, is worthy of protection, restoration and enhancement. Hence the idea of the "**I Luoghi dell'Acqua**" field museum, a cultural project designed to enhance, promote and manage all the historical-architectural (material and immaterial) assets of Siena connected to the supply of water (products, places, systems, cultures). In addition to the cultural aspect, the project will also aim to satisfy the increasing demand for high-quality cultural tourism by offering the possibility to explore many, little known but extremely beautiful, features of the city of Siena. Together with the **Museo dell'Acqua**, the field museum will provide new and important keys to understanding the social development of the city and restore the importance and dignity of a heritage which has made such a significant contribution to the growth and development of the city of Siena.