A Recently Discovered Spring Source of the Aqua Traiana at Vicarello, Lazio

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We report on an important spring source among the headwaters of the Aqua Traiana, the aqueduct introduced by the emperor Trajan to Rome in 109 CE. Located at Vicarello, adjacent to the celebrated thermal bathing complex of Aquae Apollinares, the vaulted gallery and its various intake and offtake branches are preserved in a restoration of the 17th century for use in the Acqua Paola. The question of when precisely this sector of the aqueduct was begun gains special relevance when one considers that Domitian built a large villa in the immediate vicinity and seems to have exerted his personal influence over the development of the bathing complex, too. We argue that Vicarello may have been the birthplace of the Aqua Traiana and that the collection of water there initially was confined to the villa, the nearby bath complex, and within the complex, a monumental nymphaeum. As more springs in the region became available, Domitian may have laid plans for what would become the Baths of Trajan in Rome. We trace the hypothetical stages through which his vision for a small local aqueduct expanded into a grand urban project, eventually to be appropriated and largely implemented by Trajan.[1]

INTRODUCTION

In the year 1612, Pope Paul V (Camillo Borghese) inaugurated a new aqueduct at Rome. In truth, the Acqua Paola was not entirely new; it was an ingenious reappropriation of antiquity. Many of its sources and conduits drew from the Aqua Traiana, a long-defunct system introduced almost

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exactly a millennium and a half earlier that had carried water to Rome from the west, unusually, rather than from the more familiar and aquiferous foothills of the Apennines. Implanted directly into the ancient aqueduct's source architecture on the north and west slopes around Lake Bracciano some 40 km northwest of Rome, the resulting hybrid offers a rare opportunity for archaeologists and historians to study the longue durée of an isolated hydrological system that even today contributes to the city's urban water supply.[2]

Realized under the direction of the Venetian engineers Giovanni Fontana and Pompeo Targone, the Acqua Paola borrowed many, but not all, of the spring sources first appropriated for the emperor Trajan's aqueduct. The dedicatory inscription of the Acqua Paola on the Fontanone, the famous display fountain adorning the Janiculum Hill in Rome, confirms that the project was a hybrid, completed "by restoring old conduits and adding new ones" (veteribus . . . ductibus restitutis, novisque additis). Yet the dedication propagates an egregious error, taking the reconstituted ancient aqueduct to be the Aqua Alsietina, a low-grade line introduced by Augustus directly from the neighboring Lake Martignano. This can be forgiven, for the only textual evidence of the Aqua Traiana's existence in 1612 was a Trajanic coin issue offering no certain information about the aqueduct other than its name. By 1680, the record had been set straight by inference; but only in the 19th and 20th centuries did new discoveries robustly confirm the Traiana's identity. Even its dedication date, 24 June 109 CE, is now known.[3]

The Aqua Traiana makes no appearance in *De aquaeductibus urbis Romae* by the water commissioner Sextus Iulius Frontinus, which was published too early in Trajan's reign (98–117 CE) to assist us. Yet Frontinus signals an unusually keen imperial interest in the city's water distribution system; at the emperor's pleasure, he had conducted a thorough audit of the urban system resulting in a substantial reconfiguration of the existing aqueducts (Frontin., *Aq.* 64, 87–93). Significantly, the author also hints at a "new distribution regime" (nova erogatio) "with augmentations" (cum incremento), about which "nothing more should be said unless it is completed" (intellegi oportet non esse ea ponenda nisi consummata fuerint). Ever eager to enumerate Nerva's and Trajan's prior and ongoing redistributions and adjustments, Frontinus modulates his tone momentarily, solemnly auguring an imminent and more ambitious undertaking.

Completion took about a decade. Dedicated with great fanfare in 109 CE, the aqueduct opened almost concurrently with its companion monuments: the Baths of Trajan, in the heart of Rome, overlooking the lower Forum Romanum and Colosseum, and (five months later) a *naumachia*, a vast, grandstand-encircled pool intended for naval spectacles in the Vatican suburbs.[4] Later the Aqua Traiana would power the city's grain mills. Indeed, it was so critical to Rome's survival during the Gothic siege of 537–538 CE that, when the enemy cut the urban aqueducts, engineers of the besieged general Belisarius were compelled to develop an innovative method of powering mills using

[2] Aqua Traiana: Quilici 2009; Curatolo et al. 2010; Taylor et al. 2010, 2016; Taylor 2012; O'Neill 2014; Cifarelli and Marcelli 2017. Acqua Paola: Bruun 2001; Rinne 2010, 138–54.

[3] Bloch 1944. On the original identification, see Fabretti 1680, 49–55; Evans 2002, 56–60, 117. On the evidence that the Aqua Traiana was still known by name in the High Middle Ages, see Taylor 2000, 221–22; 2002, 17; Bruun 2001, 305–9. To the sources cited there we can now add a papal letter of 1005 CE describing topographical features near the monastery of San Cosimato, "where there are gardens with fruit orchards, together with a conduit of waters from the Traianum, in which there are two [?] chambers where once there were three water-mills" (in quo sunt domora cum hortuis pomatis, simulque cum forma aquarum e [aqueductu?] Traiano, due [MSS: suo] in quo sunt camere, ubi olim fuerunt aquimoles tres; von Pflugk-Harttung 1880–1886, 2:57, no. 93; our emendation). All the textual variants are corrupt; the manuscript most resembling our emendation, C, reads "forma aquarum et traiano suo." The editor emends to *raiano,* which is nonsensical. Whatever its original form, the text seems to confirm our opinion that ancient aqueduct-powered grain mills attached to the Aqua Traiana ran down the Janiculum onto the floodplain.

[4] On the *naumachia,* see Buzzetti 1968. The *Fasti Ostienses* preserve precise dates for the dedications of the Thermae Traiani (22 June) and the Aqua Traiana (24 June). They also record the gladiatorial fights staged on (or in) the *naumachia* over six days between the dedication date of 11 November and the concluding date of 24 November (Degrassi 1947, 201; Vidman 1982, 47, pls. 12, 13). The surprising omission of a staged *naumachia* within the new complex designed precisely for that purpose may be owing to the season. Domitian had sponsored a *naumachia* in November at his own venue built somewhere near the Tiber River (location unknown); when a wintry storm hit during the event, he prohibited the audience from taking shelter, causing many to die of exposure (Dio Cass. 67.8.2–4; Suet., *Dom.* 4.2). The five-month lag between the dedications of Trajan's baths and his *naumachia* bespeaks unanticipated delays in completing the latter.

the Tiber River.[5] After the siege, Belisarius himself may have authorized the aqueduct's restoration (*CIL* 11 3298), but excavations at the American Academy in Rome disclose that an important urban branch of the Traiana, one of perhaps two that had powered the mills, was never cleared of its defensive blockage from the siege.[6] Much reduced in volume and scope, the aqueduct continued to serve western regions of Rome, and especially the Vatican, until at least the ninth century.[7]

Paul V's reanimation of the Aqua Traiana probably exceeded the medieval output but it fell short of earlier volumes. The *Fasti Ostienses,* which commemorate its dedication in 109 CE, describe its waters as "issuing throughout the city" (aquam tota urbe salientem), revealing an amplitude the modern line has never challenged. Currently, there is no feasible way to measure the Traiana's volume retrospectively.[8] But the Acqua Paola initially delivered about 14,900 m^3 per day (750 *oncie*), a flow that the engineer Carlo Fontana (no relation to Giovanni) augmented to about 28,800 m^3 per day (1,450 *oncie*) in the 1670s by tapping the lake itself.[9] By ancient standards, this volume is modest. We can compare it to a recent estimate made for the Anio Novus, the second of Claudius' great urban aqueducts, in its final, reduced phase. Even then the conduit, choked with centuries of encrusted lime, carried a volume three to five times greater than Fontana's.[10] The most obvious reason for this disparity is that the pope was denied access to the Traiana's most copious catchment system, the Santa Fiora and its sister springs, then owned by Virginio Orsini. Fontana marveled at the volume the Fiora spring was producing in his day, but it remained out of the pope's reach even then.[11]

The Aqua Traiana's many spring sources have always defied easy identification and quantification. They rarely appear on official maps. Some, like the Carestia, have gone dry and fallen from memory; others flow with water but remain tucked away on private property or hidden in impenetrable underbrush, which thrives on their moisture. A fair number, consigned to various states of neglect or oblivion, remain attached to the Acqua Paola system.

RECENT SCHOLARSHIP ON THE AQUA TRAIANA SOURCES AND THEIR ENVIRONMENT

The spring sources mostly lie around the western and northern sides of Lake Bracciano (fig. 1). Perhaps because of their difficulty of access, studies of Rome's ancient aqueducts published in the last 150 years say little about the sources, focusing instead on the main conduit closer to Rome and its distribution within the city.[12] The South Etruria Survey done by the British School at Rome never ventured far into this area, probably for the same reasons. It did include surface surveys in 1986 and 1992 at Vicarello, however, and the ensuing report has provided invaluable context for all subsequent fieldwork done in the region and for

[5] Procop., *Goth.* 5.19.8–19. On the mills, see Wilson 2000; Taylor 2010; and their bibliographies.

[6] Wilson 2000, 232–36.

[7] Wilson 2000, 239–45.

[8] Under the right conditions, flow in ancient conduits can be measured within a reasonable margin of error; see Blackman 1978; Keenan-Jones et al. 2015. The Aqua Traiana's volume could be estimated if a sector of its main channel with a regular gradient approximating the mean were isolated. The problem remains that such conditions do not apply to any known preserved sector of the main conduit of the Aqua Traiana, much of which is evidently still in use as the Acqua Paola. The sector passing under the main building of the American Academy in Rome, on the Janiculum, is original, but it was only one terminal branch of the aqueduct; moreover, its location at a point just uphill from a millrace complicates the measurement of volume.

[9] Fontana 1696, 179–87; Heilmann 1970, 656 n. 8. On the volume of the *oncia* as calculated in the mid 17th century, see Rinne 2010, 59. Fontana's method (1696, 29–30) employs a portable sluice gate set into a solid, three-sided box that can be installed athwart a free-flow channel. After blocking the channel with this apparatus, he could adjust the size of the rectangular sluice opening until the water level behind it stabilized, then record the volume of flow by calculating the area of the opening. Such a system must temporarily (a) create a fairly static basin behind the opening by minimizing flow speed, and (b) ensure that, once equilibrium is established, the vertical distance between the top of the opening and the surface of the water behind it (i.e., the head, or *peso*) is uniform in all measurements. This determines flow volume without a timing device. For similar methods possibly adopted by Frontinus, see Taylor 2000, 33–39.

[10] Keenan-Jones et al. (2015) estimate a volume range of 120,960 ± 34,560 m^3/day. Though the Aqua Traiana never accumulated sinter, all the eastern aqueducts did.

[11] Virginio Orsini, while conceding numerous springs from Vigna Orsini northeast to the Fosso delle Ferriere and the Calandrina, retained full rights to the Fiora, Matrice, and Carestia in order to operate mills in the Fosso della Fiora; see Rinne 2010, 139–40; Felluca and Germani 2017, 178–79. The main sources, along with the Orsini property, passed to the Odescalchi family in 1696.

[12] Lanciani 1880; Van Deman 1934; Ashby 1935; Taylor 2000.

FIG. 1. Map of major features associated with the headwaters of the Aqua Traiana. Phase one (pink), partly obscured by later phases, concentrated first on Vicarello and soon thereafter on the Fosso della Calandrina to its east (background © 2019 Google. ArcGIS basemap sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL. Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community. Additions by R. Taylor).

this article.[13] The publication in 2009 and 2010 of the Aqua Traiana's primary source, Santa Fiora, reignited interest in the problem of its other sources,[14] and, since then, explorers have been turning up new parts of its network regularly. Their published notices, though archaeologically significant, tend to be brief and narrowly distributed.[15] A new partnership between the Sovrintendenza Capitolina ai Beni Culturali, ACEA (the regional utility overseeing the public water system), and groups of speleologists promises a more systematic approach to studying the complex networks of the Aqua Traiana.[16] Meanwhile, a team under the direction of Giuseppe Cordiano has combined surface survey, geophysical prospection, and excavation to produce an ongoing multivolume historico-topographical study of the area around Lake Bracciano.[17] Though the aqueduct is not a dominant component of these studies, they contribute greatly to the understanding of the region's historical and environmental context, particularly, from our immediate perspective, with regard to Domitian's control of the area near the sources, and to the abrupt and permanent rise of the lake level in the 60s CE. A reassessment of the thermal bath and nymphaeum complex at Vicarello has further illuminated the early history of the Aqua Traiana as well, again by cementing Domitian's presence in the landscape enclosing it.[18]

Our own work aims to balance prospection for architecturally systematized water sources with a broad historical and environmental perspective. This article does some of both: it presents our investigations of a large, multioutlet spring source of the Aqua Traiana,[19] and it tries to situate this important feature within the broader context of that aqueduct's introduction, design, and impact on the local landscape. We conclude that this source probably played a critical role in the earliest phases of the Traiana, early enough even to have predated Trajan's reign altogether.

THE CISTERNS AND BRIDGE

Built around the spring's outlets is a structure that we call the long springhouse. The abandoned springhouse lies on the estate of Vicarello on the northwest side of Lake Bracciano (fig. 2). Set into the steep west slope of a ravine called Fosso delle Ferriere, it once lay almost adjacent to early modern ironworks from which the ravine gets its name. It lies only 200 m from an ancient locale of some renown, the thermo-mineral sanctuary and spa known as Aquae Apollinares, a venerable pilgrimage site that yielded one of the richest votive deposits ever recovered in Italy.[20] At the core of this sanctuary is a hot spring; sheltered under an abandoned 19th-century resort hotel, it still wells

[13] Hodges 1995.

[14] Quilici 2009; Curatolo et al. 2010; Taylor et al. 2010.

[15] Felluca (2017) has published photographs of a major source that she identifies as the Acqua di Venere, a name she takes from the contract of 1608 between the pope and Virginio Orsini. Evidently comparable in scale to the Santa Fiora and Carestia sources, but with unique architecture, it features such Roman elements as *opus latericium* walls, a niche adorned with pebbles to mimic a grotto, and plastered vaulting painted in Egyptian blue. The location for this site appears in Felluca and Germani 2017, 178, fig. 3. Filippi et al. (2015) briefly introduce a source along the Boccalupo known as Venticinque Vene (see fig. 1, lower left), which we explored and reported on in 2016. They also briefly present a site they call Cinque Vene, which appears labeled as such on Felluca and Germani's map (2017, 179); this is perhaps the same source we call Sorgente Isidori 1 (not noted on fig. 1; see infra n. 41). Germani and Colombo (2015) track an important sector of the main conduit from the Santa Fiora; this was the route rediscovered by Fontana, whose maps one of our team published in 2014 (Fontana 1692, 1695a–c; O'Neill 2014). Some of these names are derived from the 1789 map of the Acqua Paola system, which will be introduced below.

[16] Cifarelli and Marcelli (2017) reveal another previously unpublished source of the Aqua Traiana, an interesting and rather complex springhouse at Sette Botti just east of Vicarello. We have examined a simpler source nearby featuring an octagonal umbrella vault that encloses a small spring emerging from a basalt outcrop. The brickwork in the offtake appears to be ancient in places, but a replastering of the domed chamber in 1829 (so attests a charcoal inscription on the wall) obscures the masonry of its walls and vault.

[17] Accardo 2007; Cordiano 2011a, 2018.

[18] von Falkenstein-Wirth 2011.

[19] One member of our team (Isidori) discovered the site in 2016. Felluca (2015) found and reported on it independently, along with the northern sources labeled on the 1789 map "tre sorgenti fra scoglie ristaurate" (three sources among stabilized[?] cliffs). She presents only a brief description of each.

[20] Marchi 1852; Colini 1967–1968; Künzl and Künzl 1992. The name Aquae Apollinares Novae is derived from the Peutinger map; for a reconsideration of its identity as the baths at Stigliano, see Taylor 2019. We favor the hypothesis that Vicarello, being the older of the two pilgrimage sites, was simply called Aquae Apollinares.

FIG. 2. Satellite map of the Aquae Apollinares at Vicarello with major features discussed in this article (background © 2019 Google, additions by R. Taylor).

forth, flowing into the adjacent stream. In Imperial times, a bathhouse encompassed the spring in a similar manner, but Roman taste required the delivery of cold water to mix with the hot; thus the long springhouse and the thermal bath almost certainly had a functional relationship.

The landscape around the thermal baths of Vicarello abounds with interesting hydrological and cultural features.[21] The baths and the adjoining monumental nymphaeum, the latter built during Domitian's reign (81–96 CE) and probably with his sponsorship, have attracted attention in recent years, but the site is overgrown and neglected.[22] Just north of these lie two adjacent features: a long vaulted structure nicknamed La Porcareccia (The Pigsty) and a much smaller vaulted ruin adjacent to it (figs. 3, 4).[23] Built of Imperial-period *opus latericium,* both are evidently cisterns associated with the aqueduct features nearby. They have received no archaeological scrutiny, and the particularities of their roles in the hydraulic landscape remain uncertain. However, in 1836, Paolo Bondi da Fiumalbo reported on recent excavations at the site that seem to confirm the connection; he noted the discovery of an ancient lead pipe on the uphill side of the cistern and a brick drain leading down to the stream.[24] Presumably this pipe ran down from the masonry offtake channel of the long springhouse.

That channel crosses the Fosso on an aqueduct bridge roughly 160 m northwest of La Porcareccia (see figs. 2, 5). Its outer masonry resembles that of other bridges in the Acqua Paola source network around Lake Bracciano, all abandoned. Though overgrown, this bridge and the channels connected to it are almost completely intact; they convey water across the creek and eastward, evidently past the Roman baths all the way to the Paola's main conduit. The sources of this water are several, and include our springhouse, which lies just up the slope west-southwest of the bridge.

THE LONG SPRINGHOUSE

We turn now to that springhouse, the primary water source above the bridge. The British School surveyors seem to have missed it altogether. Probably, they were unaware of a large map (fig. 6) preserved in the Archivio di Stato di Roma, perhaps dating to 1789, that details the entire network of the Acqua Paola system known at the time and, at some point thereafter, was meticulously annotated and supplemented in pencil

FIG. 3. The long vaulted structure called La Porcareccia (The Pigsty), a Roman cistern, located just north of the ancient thermal baths of Vicarello, looking southeast (photogrammetric model by R.B. Gorham).

FIG. 4. Ruined Roman cistern southeast of La Porcareccia, looking northeast (R.B. Gorham).

FIG. 5. Aqueduct bridge northwest of La Porcareccia at Vicarello, looking south (R. Taylor).

[21] Hodges 1995.

[22] Colini 1979; Virgili 1988; Hodges 1995; Cordiano 2003; 2011b; von Falkenstein-Wirth 2011; Taylor 2019.

[23] Colini 1979, fig. 16; Accardo 2007, 148–49, UT 26 (G. Cordiano); Taylor et al. 2016, 15–16. On the origin of the name, see Bondi da Fiumalbo 1836, 77.

[24] "An excavation was undertaken just outside that edifice [i.e., La Porcareccia] that revealed a large lead conduit; this ran underground from the upper area where the branch of the Aqua Traiana runs as it descends from the hill of the ironworks and discharged into a finely built brick basin situated on the outer floor of the aforementioned side. Thus the excavation was continued below this, where there emerged a very handsome brick drain which from that point ran in a straight line to its point of discharge into the stream of the ironworks in front of the baths" (78).

(fig. 7).[25] Using this map as a guide for field reconnaissance, and with the additional assistance of documents in the Archivio and elsewhere, explorations over the last decade have confirmed that most of the sources captured for Pope Paul Borghese's aqueduct in the early 17th century had already been systematized in the Roman Imperial period into the Aqua Traiana network.[26] Ancient springhouses and connecting channels were restored, adapted, and consolidated whenever possible. In some cases, the pope's men saw little need to reengineer ancient features, confining repairs to the walls and vaulting. In other cases, source architecture was rebuilt and redesigned from the ground up, preserving only the floor and lower walls of the offtake channel.

The springs arrayed along the ravine at Vicarello were on its west bank. To be forced eastward toward the baths, their waters had to flow together across the stream. The map indicates that source conduits in this sector flowed along the ravine's western slope from points both north and south of the bridge before joining to send their combined contents downhill and across it (see fig. 7, features 61, 62, 63 [in light pencil], and 64). All of these features have been confirmed on the ground. A presumed feature 65 is missing from both the map and the key. We focus here on the most important and complex node, 62, the long springhouse.

Features Above Ground

The west slope above the bridge bears artifacts commonly associated with the Aqua Traiana / Acqua Paola system, while others are seemingly unique. At roughly 225 masl, perhaps 12–15 m above the elevation of the bridge deck, a narrow, irregular terrace lies nestled against a heavily fractured cliff face (fig. 8). That terrace encloses the subterranean main gallery and subsidiary channels of the springhouse, which we discuss below.

FIG. 6. Map of the Acqua Paola system, perhaps from 1789. Rome, Archivio di Stato di Roma, Collezione Disegni e mappe, 10-113/2.

The Cippi, Pozzi, and Buttress

The terrace abounds with unexpected features that immediately signal the presence of a significant hydraulic system just beneath the surface. Aboveground markers for subterranean aqueducts—commonly called *cippi* if they are small and solid, *pozzi* or *tombini* if they are hollow and provide vertical access through a gap in the masonry—are a well-known feature of the landscape of the Acqua Paola. Across the system they vary considerably in size and shape, ranging from small, squared stone markers to waist-high masonry pyramids to cylindrical towers enclosing access shafts. Our investigations revealed two *pozzi* and four *cippi* seated on this irregular terrace. The *pozzi,* numbered 1 and 2 in figure 8, enclose square access shafts, but only Pozzo 1 currently provides entry through a breach in the masonry. The largest of the group, it takes the shape of a keyhole in plan rather than the customary circle. Its projection points directly to the small, V-shaped Cippo 2, just uphill, and to the circular Cippo 1 beyond that. A third marker, Cippo 3, is pressed directly against the end of a curious buttress of *opus latericium* shoring up the cliff face, and a fourth, Cippo 4, lies just to its north. A labyrinthian conduit, which we refer to as the zigzag feeder channel, runs

[25] Rome, Archivio di Stato di Roma, Collezione Disegni e mappe, 10-113/2. The date and occasion for the production of this map are not entirely certain, but we conjecture that it was produced by the architect Andrea Vici on request by Mons. Giuseppe Vai, Presidente delle Acque, in either 1786 or 1789.

[26] Archivio di Stato di Roma, Presidente Acquedotti Urbani, Busta 738:1, *Misure e stime.* Documents recording the work are unnumbered within the *busta,* but are placed in chronological order from 13 October 1608 to 30 July 1614.

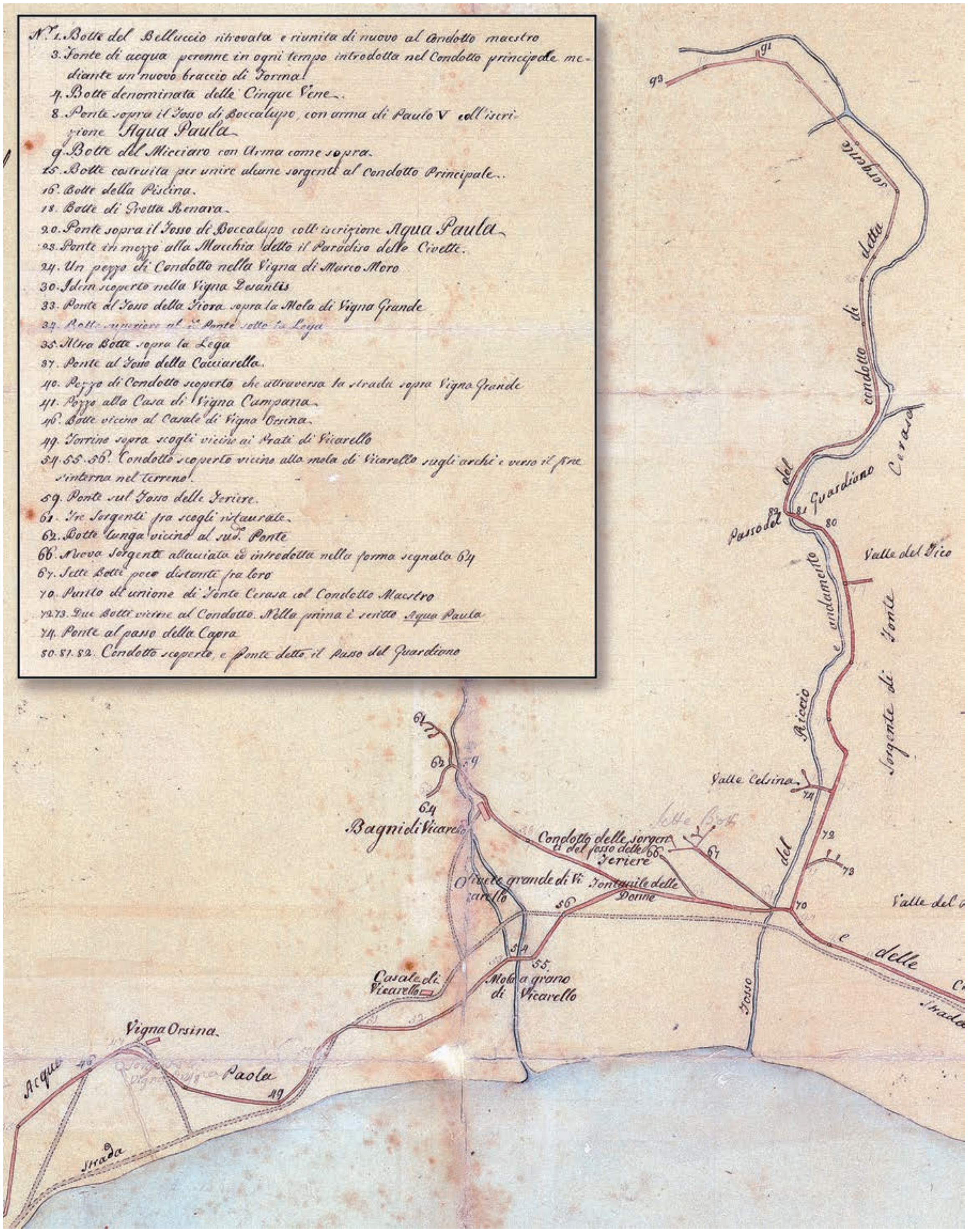

FIG. 7. Detail of the Vicarello region from the map in fig. 6, with one magnified section of the numbered list as an inset.

beneath these features. The *cippi* are meant as approximate place markers for a cluster of water sources that emerge from grottoes behind the rock face; all of these sources feed into the zigzag channel.

These markers belong to the Acqua Paola phase, not the ancient one. Yet the most visible feature on the terrace, the buttress around which they cluster, is overtly Roman. The buttress can only mean that

FIG. 8. Features on the terrace directly above the north end of the long springhouse: *top*, foreshortened northward view; *bottom*, overhead view (photogrammetric models by R.B. Gorham).

already in Roman antiquity the fractured cliff wall needed shoring up to protect the fragile infrastructure beneath it from any potential rockfall.

The Multivaulted Structure

The most prominent and puzzling feature visible above ground lies some 30 m south of the *cippi.* Projecting from the cliff face and straddling the terrace, the crumbling ruins of a vaulted structure can be seen, again built in Roman brick and concrete (fig. 9). Now encumbered in an amorphous mass of earth and roots, it once took a rectangular form enclosing several adjacent barrel vaults, each projecting transversely from the cliff. The walls and three visible piers are badly degraded, but small parts of the brick facing can still be seen. The axes of rotation of its collapsed concrete barrel vaults (two of which can be easily extrapolated from fig. 9) run perpendicular to the long springhouse gallery interred at their feet. The function of this vaulted structure is far from obvious, but, as we shall see, its continuity with the subterranean system suggests a functional kinship with the brick buttress farther north.

FIG. 9. Elevation view of the multivaulted structure aligned with a section drawing of the subterranean main gallery of the long springhouse. Piers 3, 5, and 7 appear to continue from the floor of the subterranean main gallery up through the vaulted structure. Red arrows indicate visible brick faces (photogrammetric models by R.B. Gorham; composite by R. Taylor).

The Springhouse Complex in Brief

The main part of the long springhouse is a barrel-vaulted chamber 41.5 m long and divided into two sections: the main gallery, a rectangular space 27.5 x 1.3 m in plan with a fall from south to north of 0.6 m; and the northern channel, 14.0 m long, where the width and height of the main gallery contract and the channel skews slightly westward (fig. 10). At the end of the northern channel, a separate channel, drawing water from various points in the rock face below the terrace level on the west, joins it; the combined contents are then discharged down a steep offtake. This second feature is the zigzag feeder channel mentioned above. In the early modern period, access to the underground structures was provided by Pozzi 1 and 2. Pozzo 1 stands above the junction of the northern channel and the zigzag feeder channel. A hole in its east side gives access to the square manhole shaft inside it.

In aggregate, the long springhouse corresponds to feature 62 on the 1789 map, designated as "long basin near the bridge" (botte lunga vicino al . . . ponte; see fig. 7). At the time of our initial investigation (June 2017), the region was suffering a drought. Water flowed freely here nonetheless, maintaining a depth of 2–4 cm. The sources feeding the complex can be divided into three groups. At the south end, a small brick-lined feeder channel, almost on axis with the main gallery, joins it by means of an irregular hole knocked through the end wall of the main gallery (online fig. 1).[27] At the north end, the zigzag feeder channel collects water from several grottoes just below ground and joins the northern gallery beneath Pozzo 1 (see fig. 10). But the outstanding feature of the whole complex is the west wall of the main gallery. This contains 13 robust arches of brick and concrete built up against the exposed rock face, from which issue several rivulets near floor level (figs. 11, 12; online fig. 2). A smaller, 14th recess (numbered 0 on the plan) is quadrangular; its top side is a roof tile angling slightly upward toward the south end wall, to which it is anchored (see online fig. 1).

The arched west side of the gallery leaves the piers exposed, but higher up, at the level of the arches, the surface has received a rough and very thin layer of

[27] See AJA Online for additional, online-only figures.

cement. The east wall carries a much thicker application of glossy white plaster that tapers off at knee level, leaving the lower walls of the entire chamber exposed. A faint graffito in the plaster concluding with the date 1889 provides a terminus ante quem or perhaps a commemoration of the plastering itself.[28] No evidence can be seen that a lining of any kind was ever applied to the lower zone of the main gallery (online fig. 3).

The Arcade. We have numbered the arches from south to north, beginning with the quadrangular false arch designated Arch 0 (see figs. 10, 11). The piers dividing them are numbered in the same direction; Pier 1 directly precedes Arch 1, and so forth. The crowns of the arches rise to a roughly uniform height of about 1.6 m (give or take 10 cm) above floor level. As all of them form semicircles, the result is that those of larger radius spring from a lower point on the piers than the smaller ones. Varying also in depth and spacing, the arches nevertheless present a sense of grandeur, cohesion, and unity. With a few modified exceptions, each arch and pier directly abuts the lava cliff face behind, leaving no space for water to circulate between the arcade and the rock (online fig. 4). In part, this design accounts for the variability of the sizes and spacing of the arches, for every spring outlet needed to align with an arch, not a pier. Thus, a given arch may accommodate one outlet, or two, or none at all. However, in some cases (Piers 4, 5, 11), the masonry was partially hacked away to liberate a second outlet that must have appeared only after the gallery's initial construction (fig. 13; online fig. 5). Surely some of the now-dry fissures in other arches gushed at the time of the initial construction.[29]

For all its evident repairs, modifications, and rebuilding, the origins of this arcade are unmistakably Roman. The clearest evidence that the gallery conforms to an ancient plan is found in Piers 3, 5, and 7. Though extensively repaired and refaced, these piers form a vertical continuum with the multivaulted Imperial-era concrete structure above ground (see fig. 9). At their cores, the piers are concrete down to the foundations. The plinths of Piers 3, 5, and 7 (again, those that extend or extended above ground) consist of one or two courses of *bipedales* (square bricks 2 Roman ft. to a side; fig. 14; online fig. 6). The existing arches themselves all appear to be modern; the soffits of all but one are coated with a thin layer of mortar that bears the rough impression of reeds, a technique that we associate with the 17th century (see online fig. 4). As we shall see, the vaulting of the main gallery and

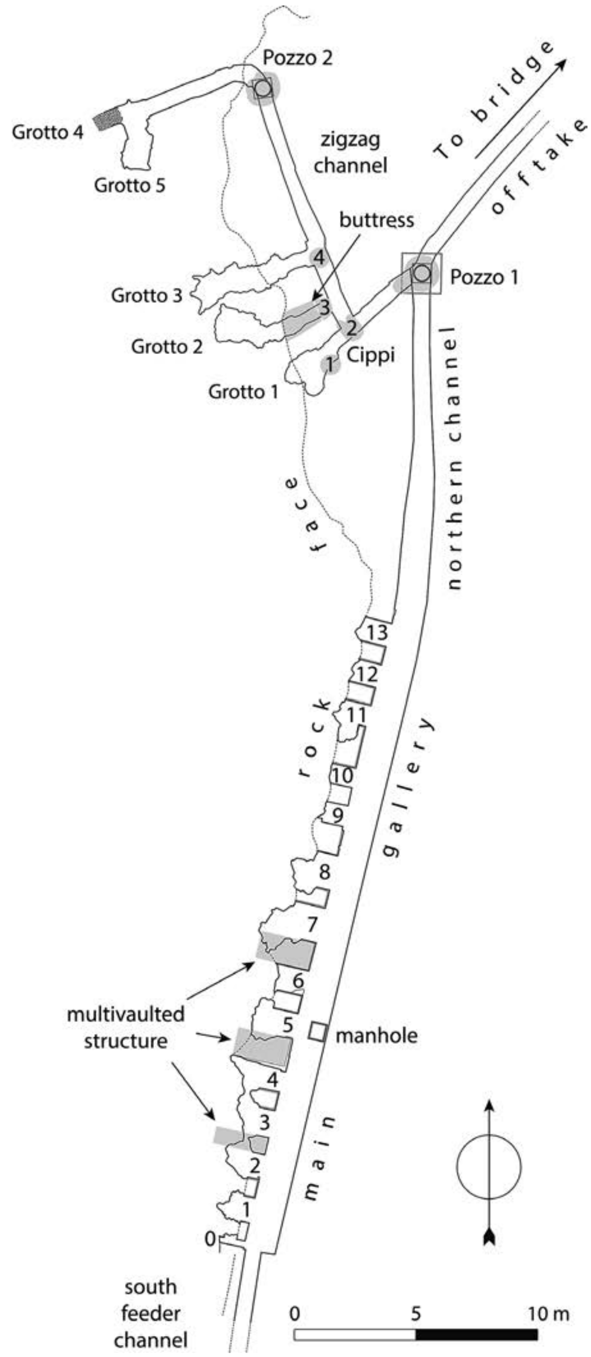

FIG. 10. Plan of the long springhouse and the system of water sources at its north end (drawing by R. Taylor and R.B. Gorham).

[28] The graffito appears at eye level on the east wall near the south end of the main gallery.

[29] Since the water flows northward, the piers show greater wear on the south side.

FIG. 11. Section elevation of the main gallery, looking west. As in fig. 10, the arches are numbered 1–13 from south to north (left to right), and the piers 1–14; the quadrangular opening south of Arch 1 is numbered 0 (photogrammetric model by R.B. Gorham; composite by R. Taylor).

FIG. 12. Main gallery of the long springhouse, looking north (R. Taylor).

FIG. 13. Water emerging from behind Pier 4 in the main gallery at Vicarello, looking northwest (R.B. Gorham).

FIG. 14. Main gallery, looking north (R. Taylor).

the secondary channels reveals a similar technique, an indication that all these arches were built concurrently under Paul V.

Table 1 provides the horizontal linear dimensions and basic features of each pier and arch. While the arches date to the Borghese restoration, the cores and brick facings of several of the piers are demonstrably ancient. The plinths of Roman *bipedales* survive under most of the odd-numbered piers (3, 5, 7, 9, 11) and under the wall framing the final arch (13) on its right side. The fact that even-numbered freestanding piers lack visible *bipedales* is intriguing, and suggests one of two things: either these piers did not exist in the Roman phase, and double-diameter arches (presumably shallow in height relative to their breadth) vaulted the same span as those above ground; or all the piers were present in the Roman phase, but the aboveground structure was envisioned from the start, encouraging the use of more robust materials—*bipedales* or stone blocks—at the bases of the odd-numbered piers. We prefer the second explanation, based on the evidently Roman modular units manifested in many arches and piers (discussed below).

Bipedales appear only at toe level on our site, but other Roman brickwork can be identified by several criteria. Because Roman masons tended to fracture bricks into random lengths, the statistical variability of brick face length in ancient construction exceeds that of the modern. Bricks that fall short of modular length often reveal these fractures by their irregular or nonvertical edges. Fully modular square bricks were characteristically sawed diagonally by Roman masons into quarters. Though the practice varied, the resulting triangles are often found in the Aqua Traiana system displaying the full length of a modular brick (*bessalis,* roughly 8 Roman inches to a side) on the face (20–21 cm) and corners that angle back at 45°. Three such isosceles right triangles are visible on the ledge where the zigzag channel discharges into the offtake (online fig. 7, left). Wear and discoloration are also significant diagnostic aids. On Pier 11, the three lowest courses, all Roman except for some repairs on the left, are worn clean and smooth from the water's constant scouring action (online fig. 8). But the 14 courses above them, also Roman, are stained a uniform gray from centuries of occasional contact with higher water levels; this thin charcoal-colored deposit is a distinctive chemical signature of the water sources in this region (see online fig. 7). The early modern replacement bricks at the right impost are much cleaner and brighter; they suggest that in recent centuries, the water has rarely risen as high as it once did.

The multivaulted structure bears closer scrutiny. The ancient brickwork on the right face of Pier 5 of the subterranean main gallery can be seen to continue upward behind the left side of Arch 5, hugging the rock face closely; the interface has crumbled away in places and has been replaced with crudely mortared fieldstone patches filling the gaps (online fig. 9). The brick continues above ground for a few courses, visible as a small patch of facing on the otherwise naked concrete of the second visible pier of the multivaulted structure, Pier 5 (see fig. 9). Piers 3 and 7 are not so visible below ground, but, above ground, crisp Roman brickwork appears on both sides of 3 and the left side of 7.

All this implies that the underground arcade was repeated above ground, but with arches at double width springing from odd-numbered piers. The original extent of the multivaulted structure is unknown, but clearly a vault sprang southward from Pier 3 (see fig. 9); a northward extension from Pier 7 seems likely, too. While this structure could have served as a monumental marker of the springhouse, or even a storage space, its raison d'être was structural. Evidently the augmentation of mass at this precarious point on the slope was meant to buttress the arches below in place and, like the little buttress to the north, help retain the lava face behind, the fragility of which in this area is downright alarming (online fig. 10). But we should also consider its rhetorical inflection. We know that several sources of the Aqua Traiana were monumentalized for public view; the Santa Fiora and Carestia springhouses, for example, featured oculus-lit chambers with central statue niches.[30] This one, having a direct line of sight to the celebrated Aquae Apollinares, was no exception.

The spacing and width of the arches and piers in the main gallery is opportunistic, accommodating the irregularities of the water sources in the rock face behind. Yet some basic design principles are clearly in evidence. First, the diameter of the southernmost six arches hovers around 1.19 m each, or about 4 Roman feet (1 Roman ft. = 0.296 m).[31] Second, the arcade reveals an even stronger preference for piers

[30] Taylor et al. 2010; Taylor 2012.

[31] The precise average is 1.187 m; the greatest deviation from this among the six arches, at 1.15 m, is 3.12%.

TABLE 1. Dimensions and properties of the main gallery arcade.

Feature	Width (m)	Height (m)	Depth (m)[a]	Properties
Pier 1	0.66	–	–	Modern brick and mortar, several courses hacked away from NE corner at springing level
Arch 1	1.18	1.42	0.90	Modern brick and mortar; plank-bed plaster impression on soffit
Pier 2	0.66	–	–	Modern brick and mortar
Arch 2	1.15	1.56	1.10	Modern brick and mortar; combined plank- and cane-bed plaster impressions on soffit
Pier 3	0.66	–	–	Large block of brown tuff surmounted by two courses of *bipedales*. Smaller Roman bricks continue up for 11 courses; completed with modern brick and mortar. Ancient brick is partially hacked away on S side.
Arch 3	1.22	1.66	1.25	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 4	0.66	–	–	Modern brick and mortar
Arch 4	1.20	1.70	1.60	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 5	1.30	–	–	Irregular reddish lava (?) block on S side, flanking peperino block on N side; one course of *bipedales* above them. Smaller Roman bricks continue up for about 15 courses; completed with modern brick and mortar. Vertical groove for temporary dam cut into pier up to course 17.
Arch 5	1.20	1.70	1.85	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 6	0.64	–	–	Modern brick and mortar
Arch 6	1.17	1.65	1.10	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 7	1.26	–	–	One course of *bipedales* surmounted by smaller Roman bricks, 16 ancient courses on S side, 11 courses on N side. Completed with modern brick and mortar.
Arch 7	1.58	1.65	1.10	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 8	0.66	–	–	Modern brick and mortar
Arch 8	1.56	1.60	1.64	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 9	1.28	–	–	One course of *bipedales* surmounted by a mix of Roman and modern bricks for about 17 courses; completed with modern brick and mortar. Vertical groove for temporary dam cut into pier near S end.
Arch 9	0.94	1.60	1.00	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 10	0.66	–	–	Modern brick and mortar
Arch 10	0.94	1.55	1.20	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 11	1.76	–	–	One course of *bipedales* surmounted by 14 or 15 courses of Roman bricks. Some modern bricks inserted on N side; S side is completely modern.
Arch 11	1.00	1.54	1.32	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 12	0.67	–	–	Modern brick and mortar
Arch 12	1.12	1.50	1.17	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 13	0.67	–	–	Mostly modern brick and mortar, but fragment of *bipedalis* at bottom NE corner
Arch 13	1.02	1.55	1.15	Modern brick and mortar; cane-bed plaster impression on soffit
Pier 14	–[b]	–	–	Two courses of *bipedales* surmounted by modern bricks; modern wall is misaligned with *bipedales* for several meters, skewed about 3° counterclockwise

[a] Depth, measured from the face of one pier to the rock behind, varies within each arch and is provided here simply to approximate the unevenness of the rock face.
[b] Continues as west wall.

approximating 0.66 to 0.67 m in breadth; fully nine of 13 express this bias (if we include Pier 8 at 0.64 m). Clearly, the basis for this choice is not the standard *bipedalis* at roughly 0.59–0.60 m to a side.[32] It could be argued that the module is three early modern *palmi* (0.67 m), but that would not account for Pier 3, which is ancient and carries the very same width up into the two-vaulted structure. Rather, it is the *bessalis,* the 8-inch workhorse of Roman brick masonry, that determines the module: at 0.21 m per brick, with space for mortar between, it fits neatly across the pier face in triplets.[33] Consequently, we contend that the footprint of the original arcade was not altered significantly in the 17th century.

Thus far, this architecture is unique in our survey of Aqua Traiana sources. A fairly uniform, but quite distinct, method was employed by Pope Paul's engineers among the Aqua Traiana's southernmost sources in the Fosso Boccalupo (see fig. 1, bottom left).[34] At these sources, the water emerges through peaked gaps low in the wall, their tops framed by pairs of pitched bricks. At Botte Micciaro along this branch, 38 of these gaps surround the springhouse chamber (fig. 15). The nearby Venticinque Vene springhouse has similar rows of intakes in a chamber with a longer, narrow footprint.[35] Such pentagonal perforations, also found at two small springhouses nearby (Sorgenti Isidori 1 and 2), seem to be entirely of the 17th century. Their offtakes, however, some built on floors of *bipedales* or *sesquipedales* (1.5 Roman ft. to a side), reveal their Roman origins even if the original architecture of the intake chambers is lost.[36] By contrast, the arches and piers of Vicarello conform closely to their ancient antecedents.

The Modern Brickwork in the Main Gallery. We measured ancient and early modern bricks at Piers 1–7, 9, 11, and 14. The 17th-century bricks were made to roughly the same thickness (though with different lengths and widths) as the Roman ones for ease of mating one fabric to the other.[37] Throughout, the early modern bricks ranged in length from 25 to 26 cm, in width from 12 to 13 cm, and in thickness from 3 to 4 cm. Six courses of bricks typically measured 29 cm high. These measurements agree with those we have made at the Botte Micciaro, which we know to have been rebuilt from the ground up for the Acqua Paola (see fig. 15).[38] Some smaller bricks were seen at Pier 2. They measured 21 cm (facing out) and were routinely 4 cm thick. Just north of the arches, in the northern channel, two misalignments are visible between the side wall and the Roman bricks at its base. Pier 14 (actually the south terminus of the north channel's west wall) rotates off its base of *bipedales* by about 3° counterclockwise, marking a slightly more westward orientation on this side of the northern channel after the Borghese rebuilding (see online fig. 6). Somewhat farther north, however, the east wall skews in the opposite direction, as three battered courses of ancient *bessales* at floor level demonstrate (online fig. 11). These discrepancies suggest that the original narrowing took a slightly sinuous course, first right, then left.

The early modern bricks correspond to standard sizes used in Rome between 1600 and 1631, particularly at Palazzo Sapienza and the church of S. Giovanni dei Fiorentini.[39] The bricks for those monuments were most likely produced in Rome, while the Acqua Paola bricks, we suggest, came from both Rome and local

[32] Pier 3 is anomalous in that the tuff block serving as its plinth is smaller than the pier itself, and the *bipedalis* between the two still does not match the width of the pier.

[33] Only the anomalous Pier 3 combines this standard width with well-preserved ancient brickwork, and though it has been hacked away on its left side, what remains suggests that in alternating courses the front bricks were indeed laid in triplets. The results are often approximate, and the maintenance of strictly modular brick lengths across large areas is rarely seen in the Aqua Traiana.

[34] Taylor et al. 2016.

[35] Felluca and Germani 2017, 179–80. The offtake, which preserves Roman brickstamps of two types (*CIL* 15 29b, 97b), merges with a conduit bearing two brickstamp types of the Trajanic era (*CIL* 15 811f, 811d).

[36] The Micciaro, according to Nibby (1849, 3:260) was "built anew by Paul V" (costrutta di nuovo da Paolo V). This language implies a comprehensive reconstruction of a preexisting feature. The springhouse interior shows no evidence of ancient Roman work, but some years ago we found a loose brick cut at a 45° angle in the standard Roman manner there (Taylor et al. 2016, 10, figs. 18, 19). The nearby springhouse of Venticinque Vene likewise shows no evidence of Roman work in the main gallery, but the floor and lower walls of its offtake are Roman, with Trajanic brickstamps in places (Taylor et al. 2016, 10–17).

[37] Similar care to match the thickness of the original bricks can be seen at various sectors of the Traiana/Paola arcade along the north boundary of the Villa Doria Pamphilj at Rome. Here, the early modern bricks are often laid alternately as headers and stretchers, making them easy to distinguish from the ancient brickwork to which they are bonded, but the thickness module is almost identical. Later repairs tend to use much thicker bricks.

[38] Supra n. 36.

[39] Giustini 1997, 72, table 7.

FIG. 15. Botte Micciaro along the Fosso Boccalupo; part of the 17th-century Acqua Paola. Springwater emerges from the peaked openings low in the wall on three sides (M. O'Neill).

sources. At least two production centers are attested in this period near Vicarello: at Mazzano Romano northeast of Trevignano, and at Manziana, northwest of Bracciano, where brick furnaces are documented as early as 1572 and 1589, respectively.[40]

Other Features of the Main Gallery. Like the arches, several sectors of the barrel vault of the main gallery were built in a distinctive fashion with the soffit bedded in canes (fig. 16, left); other vault modules, evidently at random, were built in the more familiar technique employing planks (see fig. 16, right). Both methods, and indeed all the vaulting we observed at this site, probably belong to the Borghese restoration.[41] The vault is thrown together haphazardly and its profile is shallow, probably to avoid lateral displacement of the loosely heaped marsh reeds set on the centering frames before the application of the mortar.

Opposite Arch 5 in the main gallery, a manhole shaft of the 19th or 20th century with a square frame and stone lid pierces the vault. A ladder of iron rungs descends down from it on the east wall.[42] Though this springhouse must have been maintained until the 20th century, there is no evidence of recent upkeep in the gallery. The lid was buried in dirt and had no marker above ground. Tree roots have been allowed to invade the conduits, and the aboveground markers are

[40] For Mazzano, see Giustini (1997, 39, figs. 13–16) and "Fornace di Mazzano" on the Lazio region's website: www.parchilazio.it/schede-531-fornace_di_mazzano. For Manziana, see Archivio di Stato di Roma, Ospedale di Santo Spirito, Busta 965, vol. 2, 696r–99r, "Affitto della fornace de mattoni," di 30 dicembris 1589. Architect Ottaviano Mascherino visited the Manziana quarries and *fornaci* in late summer 1589; see Sturm 2017, 111 n. 47. Bondi da Fiumalbo (1836, 104) notes that the very ancient kilns for making bricks ("le fornaci antichissime per la costruzione dei mattoni") near Trevignano occupied an area known as Campo la Fornace.

[41] We have documented the cane-bed technique at several sites along the southern and western sector of the Acqua Paola system, including the Micciaro and two small sources along the Boccalupo that we have named Sorgente Isidori 1 and 2. These latter two sources are probably the ones lightly marked as 5 (or 6?) and 7 on the 1789 map. The next source upstream is correctly identified, again lightly, as Venticinque Vene. These are not visible in fig. 6 or 7 but can be seen on a high-resolution scan of the map.

[42] The lid is carefully and precisely drafted around the edges, top and bottom. The rest of the underside is rusticated. We have seen similar lids at other sources in the system, square and round. The workmanship is suggestive of the 19th or early 20th century.

FIG. 16. Two views of the barrel vault of the main gallery: *left*, the ceiling was bedded on canes; *right*, on planks (R. Taylor).

covered in undergrowth. Trees now grow on the two-vaulted structure and the nearby bridge.

Up to the main gallery's narrowing point there is no indication of the presence of *cocciopesto,* the mottled, terrazzo-like, hydraulic cement that lines most of the system's conduits. We could find no evidence that any kind of waterproof lining had ever been applied to the bricks or floor here, or to the arch piers. The floor is mostly underwater and in some places is covered with sand, debris, or the dense mats of root hairs. A long segment of what appears to be the original bedding for the floor, however, is clearly visible on the north end of the gallery and extends into the narrower channel where *cocciopesto* appears on top of it. It consists of large chunks of unshaped dark stone, probably the local Sabatine basalt, set into gray mortar to form a rough but carefully leveled pavement (see online fig. 11).[43]

The omission of *cocciopesto* from the main gallery might seem surprising, but in fact it is the norm for source architecture of the Traiana/Paola system. As a rule, springhouses in this network lack hydraulic cement linings, presumably for two reasons: (1) the water traveled slowly enough inside them to allay concerns that the rough, naked surfaces would hinder its movement; and (2) permeable by definition, springhouses are often designed on the supposition that whatever water is lost through leakage or absorption is more than offset by water introduced by the same principles. Indeed, in assessing the utility of *cocciopesto* in aqueducts, we should not be inordinately influenced by the common Roman practice of lining static hydraulic systems with this material. In cisterns and plunge baths, the lining serves to minimize leakage or absorption through the materials of the surrounding basin and to facilitate cleaning. In aqueducts, the main interest was in maximizing flow.[44] Waterproof and

[43] The use of mortared lava chunks (basaltic or not) in Roman architecture around Lake Bracciano is widespread; e.g., they are used almost exclusively in the *opus reticulatum* of the so-called Villa Claudia at Anguillara. Lava reticulate also appears in the Aqua Traiana: pristine bands of it run above several courses of *bipedales, sesquipedales,* and *bessales* in the walls of a conduit that runs under the restaurant known as Acqua delle Donne, just west of Sette Botti, probably feature 66 on the 1789 map. This conduit connects to an independent and as yet undiscovered source of the Aqua Traiana at Vicarello. The toponym Fontanile delle Donne appears on the 1789 map right where the Vicarello branch meets the main conduit of the Paola (see fig. 7). A Rio delle Donne is listed in Virginio Orsini's contract of 1608 as one of the sources he withheld from the pope (Felluca and Germani 2017, 179). Now dry, the conduit runs south directly toward the main conduit of the Acqua Paola, but whether it joins the system or bypasses it is unknown.

[44] Hodge 2002, 98 and bibliography; Motta et al. 2017, 1157–62. The advantage extends beyond hydrodynamics, for in

polished to a sheen, *cocciopesto* was the perfect material to minimize hydraulic friction in areas where the water was in motion. It was consequently deployed in many intake and offtake conduits of the Aqua Traiana where flow speed was highest; the main aqueduct channel and its largest branches were never without it.[45] Even in the sector under discussion, *cocciopesto* on the lower walls and floor becomes evident soon after the main gallery begins to narrow—that is, precisely where the water flow gains momentum (see online fig. 7, left, wall at left and floor). It lines the walls of the zigzag feeder channel and the offtake channel.

One further remark must be made about *cocciopesto* in the system: it was widely applied to conduits and terrace surfaces during the Borghese reconstruction. It often appears in the Acqua Paola construction records (discussed below), and the 17th-century material mimics its ancestor in the Aqua Traiana system so closely that the two cannot easily be distinguished even under laboratory examination.[46] In consequence, its diagnostic value for identifying ancient work is questionable, even when the material is applied directly to Roman masonry. The principles of its use changed little over time, and Paul V's engineers doubtless were attentive not only to the Roman formula they were replicating but equally to the manner in which it had been applied in the ancient system.[47]

The South Feeder Channel

Not long after the main gallery was completed in antiquity, a supplementary feeder channel was added from the south. This is certainly depicted as the southern conduit bearing features 63 and 64 on the 1789 map, leading directly to our "botte lunga" (see fig. 7, feature 62). Approaching the main gallery almost on axis with it, the south feeder channel arrived through a crude breach of the meter-thick south wall (see online fig. 1). As its floor is well above that of the gallery, the water it delivered simply cascaded out of the breach onto the gallery floor. At some point, perhaps when the volume of flow diminished, a large groove was cut into the floor of the south channel, reducing the fall slightly. The channel walls are built in characteristic *opus latericium* with many triangular *bessales* cut at 45° and many others roughly broken to fit; remains of a *cocciopesto* lining still adhere to the brick in places (online fig. 12). The vault and the lining are early modern, but the channel proper cannot long postdate the ancient gallery because the Roman brickwork in both appears identical. As in the zigzag channel, parts of the original walls have undergone crude repairs with mortared fieldstone. Since the Borghese restorations tended to replace brick with brick, these repairs probably came later, and the *cocciopesto,* which covers all phases, appears later still.[48]

Not far upstream the south channel bends west. A brief investigation beyond this point revealed that it subsequently doglegs south again to parallel the ravine, but we did not trace it to the sources. The precise location of the sources can be inferred from pyramidal Cippo 5 and Pozzo 3, both near the northern edge of the vast Vicarello olive grove (see fig. 2). Like Pozzo 2, which overlies the second bend in the zigzag channel, Pozzo 3 is sealed shut with stone and mortar, allowing no access today.

The Offtake

The volume of water issuing from the rock face behind the arches of the main gallery, supplemented modestly by the south channel, was enough to maintain a depth in the main gallery of 2–4 cm even during the drought of 2017. The water flows from south to north in this sector; within the narrower northern channel, the velocity of flow and gradient both increase (online fig. 13). At the north end of the northern channel, at Pozzo 1, the channel, now only 0.5 m wide, veers

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calcareous contexts it also minimizes the accumulation of lime and facilitates its removal.

[45] Notable exceptions exist among the smaller channels. Consistently, in the southernmost sector of the Aqua Traiana, the sources to the west of Lake Bracciano, at Venticinque Vene, Micciaro (see fig. 15 herein), and Cinque Vene at the very least, have channel floors that are paved in bare brick, allowing the occasional precious brickstamp to be documented; see Filippi et al. 2015; Taylor et al. 2016, 10–14; Felluca and Germani 2017.

[46] We are grateful to Elettra Santucci for this information.

[47] Early modern emulation of ancient methods is especially evident in the sector running under the Acqua delle Donne restaurant, where a pristine section of *cocciopesto* adheres to both ancient and modern masonry. Not only is the material applied to a height and thickness comparable to Roman practice, it also copies the Roman habit of running a quarter-round molding along the junctions of floor and walls.

[48] The downslope side was a matter of considerable concern in this sector. In 2019, we observed a mass of masonry that had been applied against the east wall of the main gallery on the outside at its partially exposed southern end. This feature probably extends northward, but is obscured by brambles and the precipitous slope discourages access.

about 65° to the right, and immediately the gradient increases as the water proceeds diagonally down the steep slope of the ravine toward the bridge (see fig. 10; online fig. 7). This abrupt turn forms the right-hand crossbar of an oblique T-junction. The left crossbar is the lower leg of the zigzag feeder channel, the collector conduit for a small catchment system. Directly in alignment with the offtake, this leg discharges its water over a low shelf at the crossing of the T, right beneath the Pozzo 1 access shaft (fig. 17). Now mingled together, the waters from the zigzag channel and the narrow northern channel flow collectively into the offtake.

The offtake proceeds down the slope to the east-northeast, meeting the bridge to cross the stream. *Cocciopesto* clings to the masonry in patches, the surface of which, like much of the rest of this system, has been whitened by the efflorescence of mineral salts. The descent to the bridge from the terrace is quite steep at the start, heading obliquely down the slope, but the gradient diminishes as the channel bends northward. Near the bridgehead a separate conduit from the north meets this one, corresponding to the offtake from the northern sources designated on the 1789 map as feature 61 (see fig. 7). The key calls those sources "three restored springs among the rocks" (tre sorgenti fra scogli ristaurate). Felluca has reported briefly on them.[49] We hope that this cluster of sources and their offtake can eventually be explored further.

FIG. 17. Junction of the zigzag channel (upper center) and the narrow northern channel (just left of center), looking southwest from the offtake (R.B. Gorham).

FIG. 18. Middle leg of the zigzag channel, looking north-northwest (R. Taylor).

The Zigzag Feeder Channel

The zigzag feeder channel was explored in full (fig. 18). The distinctly Roman brickwork similar to that seen elsewhere in the system, characterized by a proliferation of *bessales* and their fragments cut or broken at an angle, is evident throughout this sector in the lower and middle levels of the walls. Like most secondary channels in the Aqua Traiana system, the conduit is just large enough to accommodate a slim person in a crouch: 0.5–0.6 m across and about 1 m high (fig. 19). Parts of the walls are mantled in *cocciopesto.* As in the main gallery, the vaulting alternates between the cane-bed and plank-bed technique. From Pozzo 1, at the north end of the narrow northern channel, the conduit proceeds 6 m to the west-southwest, following a straight path directly into Grotto 1, which breaches a tufaceous subterranean protrusion from the rock face (see fig. 10). This source is represented by Cippo 1 above ground (see fig. 8). Up to the grotto entrance, the channel's walls were originally clad in Roman brick, extant at lower levels (online fig. 14). Early modern brick and neatly applied *cocciopesto* are well preserved on the north side of this entrance. For most of the distance along the approaching channel, however, the brickwork has been replaced with crude patches of mortared fieldstone postdating the Borghese restorations. The grotto itself has been hacked to widen the source fissures within it, which in summer 2017 were almost dry.

A few meters outside Grotto 1, the zigzag channel takes a sharp turn to the north-northwest, proceeding on a roughly straight path (see figs. 10, 18). We call this sector the middle leg. As in the lower leg, parts of the original brickwork, especially on the right side, have been overlaid or replaced with fieldstone and mortar applied haphazardly. Along this sector, Grottoes 2

[49] Felluca 2015, 17.

FIG. 19. Views looking out toward the middle leg of the zigzag channel: *left*, from Grotto 2; *right*, from Grotto 3 (R.B. Gorham).

and 3 open off the west side, each of them breaching the rock face. Cippi 3 and 4 mark them above ground (see figs. 8, 10). Water issues from fissures inside both grottoes, and each has been worked to allow a small person to stand inside.

In both Grottoes 2 and 3, the tall, narrow entrance corridors that culminate in the characteristic beveled brick doorframe on the interior, neatly mantled in a dado of *cocciopesto,* are partially blocked by a lower, ramping vault of mortared fieldstone nested inside them (see fig. 19). In each case, this lower vault, which is simply packed into the higher one, drops the original ceiling by half. It begins in the corridors about halfway between each grotto and the middle leg and proceeds, ramping downward, toward the latter (online fig. 15). This nested vault set within a larger one resembles a similar feature in the Botte Micciaro offtake. In both cases, the soffit shows the corrugated impression of the cane-bed centering technique. The brick doorframe in Grotto 3 extends into an arch. All this work, except for the crude fieldstone repairs, appears to be of the 17th century, but the Roman elements in the zigzag channel suggest that some, maybe all, of these feeders are ancient. If they were not, the Roman buttress shoring up the exposed rock face on the terrace directly above them would have been pointless (see figs. 8, 10). In fact, our photogrammetric alignment of the features above and below ground shows that the Roman brick facing of the buttress must be an upward extension of the brick walls of the Grotto 2 feeder channel. The buttress literally straddles the channel, resting directly atop its vault.

The nested vault at the exit channel from Grotto 2 therefore must have been a 17th-century contrivance to counteract the weight of the ancient buttress saddling it, and the technique was replicated next door (in the exit channel from Grotto 3, above which there was no buttress) for symmetry's sake. Improvisation was a constant necessity in springhouse design, where no two sources warranted precisely the same architectural treatment.

The zigzag channel's middle leg continues on a straight path north-northwest for approximately 8 m to a second access shaft, the one crowned by Pozzo 2, and then turns left to the west-southwest, terminating in Grotto 5 (see fig. 10). A person can stand upright in this access shaft. The vertical distance from the floor to the top of the shaft's square section is roughly 3 m; it continues in cylindrical form up into the *pozzo* for another meter (online fig. 16). Toeholds are visible in the mortar-and-fieldstone masonry on two opposing sides. All this masonry, as in the smoothly curving walls adjacent to it, appears to be early modern, but, as one progresses beyond the middle leg of the zigzag channel and the *pozzo* shaft and rounds the bend to the left, the walls of the access shaft change abruptly to exposed living rock, evened out in places with a thick coat of mortar (online figs. 17, 18). No bricks can be seen in the *pozzo* shaft or anywhere in this area. Grotto 4, neatly excavated from the rock, lies just beyond the shaft, but it is dry and has been blocked with rubble.

Grottoes 4 and 5 are cut entirely from a striking formation of stratified tuff. Underlying the thin coating of brittle lava forming the rock face, this colorful, striated pyroclastic stone hosts the aquifer. Even the rubble blocking Grotto 4 is composed of it. In Grotto 5, water issues from three crevices cut into its walls (fig. 20). At its very crown, above three thick bands of red and rose, the ancient excavators reached the ceiling of gray lava, which they left almost untouched.

FIG. 20. Grotto 5, looking south (R.B. Gorham).

The Vaulting

The continuous barrel vault covering the main gallery comprises a sequence of easily distinguished modules varying in length (see fig. 16). More or less at random, modules display either of two techniques. In one, the mortar is laid directly upon planks set lengthwise in a fairly haphazard manner; this is the norm for vaulting restorations around the Acqua Paola system. The other, cane bedding, is a venerable technique used for millennia. It appears in several parts of the Traiana/Paola system, always in an early modern context.[50] In all probability, the entire vault system at our site belongs to the Borghese restoration, along with the arches, most of which also demonstrate the cane-bed technique (see table 1).[51] This method required loose canes (in this case, the ubiquitous marsh reeds) to be strewn longitudinally upon a centering frame. Before the masonry load was added, a thin layer of mortar was applied directly onto the canes (see fig. 16; online fig. 4). Allowed time to set, the mortar consolidated, stiffened, and strengthened its pliable reed backing into a thin, hard shell before additional mass was laid upon it, deterring deformation or shifting of the reeds.

The result is curiously eclectic but functional and durable. After all, vaulting played no role in the hydrodynamics of the system; it was there simply to protect those parts that did. Except for the arches, the vaults appear to have been built hastily, with no attention to uniformity or creating smooth, transitional surfaces. Considered more important, at times, was the outer surface treatment: the main gallery's vault extrados, as we shall see, was regularized into a flat terrace with a protective *cocciopesto* surface.

EARLY MODERN DOCUMENTATION

As noted above, the 1789 map of the Acqua Paola system refers to our springhouse simply as "botte lunga" (long basin). Nibby, writing in the 1830s, calls it "botte delle Ferriere," associating it with the nearby ironworks, now lost from sight;[52] other documents, however, call the feature by the place name Venere. The references to Venus obviously evoke antiquity, but their toponymy in this region is unstable. On Fontana's maps, an area near the shore between Vigna Orsini and Vicarello is labeled, in one case, Vigna di Venere and,

[50] We have observed cane bedding at Micciaro (only in the blocked entrance gallery) and at Sorgenti Isidori 1 and 2. In Isidori 2, the tiny vault is built entirely in this manner; in the slightly larger Isidori 1, half the vault is in plank bedding, the other half in cane.

[51] Our supposition that gangs working in each style collaborated simultaneously on the project seems confirmed by the fact that occasionally a bricolage of both the cane and plank techniques was employed for the centering of a single vault, even though one technique always dominates within each module.

[52] Nibby 1849, 3:260.

in the other, Bagni di Venere.[53] These areas lie some 3 km southwest. Yet on a hastily sketched map of the 17th century from the Orsini Archives at the University California, Los Angeles (UCLA), the name "condutto di Venere" (conduit of Venus) can be identified unambiguously with the springhouse itself: it represents an arcade running south–north and connected to the bridge crossing the Fosso delle Ferriere (fig. 21, feature A).[54]

The original Venere, we contend, lay close to the places where Fontana heard the name. In the south corner of what is now the Vigna Orsini, there once stood a lavish, 9 x 9 m pedimented shrine of the second century CE dedicated to a goddess, the lower half of whose cult statue was unearthed in 1911 (see fig. 1, "Sanctuary of Venus?"). If the recent identification of this structure as a temple for the statue is correct, then the draped, seated marble figure was enshrined just 120 m from a small springhouse, possibly of Roman origin, and the adjacent Aqua Traiana / Acqua Paola conduit.[55] North of the shrine extends a great protected forest (see fig. 1, "Macchia sopra Venere") that forms the west boundary of the Vicarello estate today. The form and drapery are probably derived from a Demeter/Ceres type, as the excavator noted, but by the second century CE variants of the type were applied indiscriminately to several goddesses, including Venus in her more stately, queenly guises. If this was Venus, she may have been worshiped here as the local protectress of the spring and conduit in this immediate area. We conjecture that, sometime in the Middle Ages, the entire *macchia* took the goddess' name, thereby dispersing the toponym around its edges. The UCLA map provides the basis for our hypothesis, for it labels the wooded slopes west of the long springhouse "Machie sopra Venere" (see fig. 21, feature K).

We are fortunate also to have records of the restoration and construction work of the Acqua Paola at many sites. Known as the *misure e stime,* these handwritten payment ledgers document the labor costs for the preparation and construction of the aqueduct. In their particulars, the ledgers robustly confirm Pope Paul V's declaration on the *fontanone* inscription at Rome that his new aqueduct restored ancient sources. References in the ledgers to ancient aqueduct remains at the work sites are ubiquitous. One site record is of particular interest to our present inquiry, for it appears under the heading "Botte di Fonte Venere."[56] Each of its individual entries briefly describes the type of work and/or the thing worked on (walls, brickwork, vaulting, plastering, application of *cocciopesto,* clearing and preparation, earth removal); provides a quantitative estimate (*stima*) in *palmi* (0.2234 m) referring often to the length, width, and depth of the area or volume cleared, cleaned, or built; and calculates a cost in *scudi* (silver coins), accordingly. At the bottom of some pages, the recorder tabulates the number of bricks used, but not their cost; these bricks were thus probably the pope's own.[57] Included are the following:[58]

> Containment wall of the downslope side of said basin, length 127 *palmi,* regulated height from the foundation to the [vault] impost 10 *palmi,* thickness 5¼ *palmi.* If you deduct for the brick facing of said [wall], there remains: length 122 *palmi,* height 3 *palmi,* thickness 6¾ *palmi* — 31.91 *scudi.*

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[53] Fontana 1695a, b. Nothing today is known of baths in the immediate vicinity of Fontana's toponyms, apart from a small bathing suite in the adjacent lakefront villa, which was defunct after the 60s CE (Cordiano 2018). On Felluca's "Acqua di Venere," supra n. 15. Her toponym may be misplaced.

[54] Orsini Family Papers, collection no. 902, box 273, folder 1: Roma–Acqua Paola 06 1500–1719, held at the Department of Special Collections of the Charles E. Young Research Library, UCLA. The map pertains to a lawsuit brought against the Collegio Germanico-Ungarico over water rights.

[55] Shrine: Cordiano 2018, 125–26 (G. Cordiano), 237–40 (M. De Pari). Finds: Stefani 1911; Accardo 2007, 145–47 (G. Cordiano). An entrance to the springhouse has been maintained into modern times.

[56] Archivio di Stato di Roma, Presidente degli Acquedotti Urbani, Busta 738, folder 1:29v–31v.

[57] On papal brickworks at Rome, see Giustini 1997. The recorded totals of bricks consumed—476 on the first page, 207 on the fourth—are small; we conjecture that the papal treasury was buying many additional bricks from local sources. This portion of the *misure e stime* is unconcerned with the cost outlays for materials; the tallying of papal bricks consumed, then, might have been a cross-check to align records of consumption at the site with the independent papal accounts for supply.

[58] P. 29v: "Botte di Fonte Venere. Muro della sponda dalla banda di sotto a detta Botte lon p. 127; alt reg^{ta} con Il fondam^{to} sino all' imposta p. 10 g^{sso} p. 5¼ se ne difalca per la fodera di mattoni a detto lon p. 122 alt p. 3 g^{sso} p. 6¾ resta — sc. 31.91. Muro della d^{a} fodera di mattoni di didentro dove corre l'acqua lon p. 127 alt p. 3 g^{sso} tutto [p.] 1 e sue ligature fa — sc. 4.76. Muro della sponda rincontro detta che attacca con il monte lon p. 127 alt p. 10 g^{sso} p. 5 reg^{ta} se ne difalca in detta li pilastri vecchi lon insieme p. 24½ alt p. 10½ g^{sso} p. 5 et se ne difalca per la fodera di mattoni a detta lon p. 102½ alt p. 3 g^{sso} p. ¾ resta netto — sc. 24.48. . . ." P. 29r: "Astrico sopra detta volta di cocchie piste lon p. 127 lar p. 20 reg^{to} se ne difalca per li 3 pilastri vecchi lon insieme p. 14 lon [*sic*] p. 8½ resta sc. 24 p. 21 monta — x 31.47."

FIG. 21. Sketch map from the 17th century showing the hydraulic features of the Vicarello region. University of California, Los Angeles, Orsini Family Papers, collection no. 902, box 273, folder 1: Roma–Acqua Paola 06 1500–1719 (courtesy Library Special Collections, Charles E. Young Research Library, University of California, Los Angeles).

> Wall of said brick facing on the inside where the water runs: length 127 *palmi,* height 3 *palmi,* thickness all 1 [*oncia? palmo?*] and their bonding [i.e., of modern to ancient brick?] totals — 4.76 *scudi.*
>
> Containment wall, opposite that [downslope side], affixed to the hill: length 127 *palmi,* height 10 *palmi,* thickness 5 *palmi.* . . . If you deduct from said [wall] the ancient piers amounting altogether to length 24½ *palmi,* height 10½ *palmi,* and thickness 5 *palmi,* and if you deduct them from the brick facing of said feature, the net length is 102½ *palmi,* height is 3 *palmi,* and thickness is ¾ *palmi* — 24.48 *scudi.* . . . [There follow 5 entries on various walls.]
>
> Paving of *cocciopesto* on top of said vault: length 127 *palmi,* regular width 20 *palmi;* if you deduct from it the three ancient piers, which together are 14 *palmi* across and 8½ *palmi* deep, there remain 24 *scudi,* 21 *palmi,* amounting to — x 31.47.

The order of itemized tasks does not reflect the work's chronological progress, and the entries can be terse and perplexing. Yet enough of the individual features described square with our Vicarello site to demonstrate that they are one and the same. The first three entries describe the east and west (i.e., downslope and upslope) walls of the main gallery; that, at least, is what we surmise from the linear measurements and the reference to *pilastri vecchi* in the upslope wall, which are the surviving piers of the ancient arcade that were kept in place and incorporated into the new masonry. The fourth entry cited here evidently refers to the application of a *cocciopesto* floor to the terrace covering the main gallery vault. The most interesting and challenging parts of these entries are the deductions: clearly the recorder tried to calculate in a way that did not duplicate costs or charge the papal treasury for ancient masonry incorporated into the new work. Deductions of length are often straightforward; how height and especially thickness were accounted for, however, given that the fusion of ancient and modern masonry was irregular and far from modular, is less easy to understand. For our purposes, it is enough to make a few simple observations. First, on the downslope (i.e., east) wall of the gallery, which is continuous and essentially featureless, restoration work extended along all but 5 *palmi* of its length (122 of 127 total) but only above the height of 7 *palmi*; that is, restoration was confined to the top 3 *palmi* of the wall's full finished height of 10. This record implies that almost all the brickwork visible below the 19th-century plaster, and much of it concealed by the plaster up to head level, is ancient. The visible masonry does indeed follow the Roman norms of variability and angularity as described above (see figs. 12, 14; online fig. 3).

The length of the sector described, 127 *palmi* (28.37 m), matches the whole arcaded stretch of the main gallery (27.5 m) plus a short distance down the northern channel to where a correction of 3° was made in the east wall's orientation, as noted above. The height of both parallel walls, 10 *palmi* (2.234 m), also accords with our measurements from floor to vault crown (2.2–2.4 m)—that is, to the terrace level. The more challenging part comes with reference to the piers, the *pilastri vecchi* mentioned in the third and fourth cited entries. In each case, they are plainly being deducted from the whole, though exactly how is unclear. In the third entry, the salvaged portions of the piers, taken cumulatively in width (*lon[ghi] insieme*), amount to 24½ *palmi* or 5.47 m. This total roughly matches the four piers where we see the most evidence of ancient brickwork, Piers 3, 5, 7, and 11. In aggregate, they measure about 5 m horizontally (see table 1). That said, the entry more probably refers not to the visible brick facings but to the concrete cores of several piers that stood to vaulting height, thus 10½ *palmi* (2.35 m), on the upslope side and determined the full thickness of the wall, 5 *palmi* (1.1 m). We know, for example, that the cores of Piers 3, 5, and 7 (3.22 m in aggregate) thrust upward through the terraced surface to the multivaulted structure. Thus, we may suppose these cores were included along with those that possibly lie behind Piers 1, 9, and 11. In fact, a Roman core of concrete with lava *caementa* can be clearly seen behind Pier 11 on its right side, where the brick facing has been hacked away down through its foundational *bipedales* to clear a path for an emergent source; in this sense, it compares to Pier 5 (see online fig. 5, left). Admittedly, the application of a single value for height (aggregate? shared? averaged?) is problematic, whatever solution we seek.

The multivaulted structure appears more clearly in the fourth cited entry, which documents the application of *cocciopesto* to the outdoor terrace floor atop the vault of the main gallery. Here, the record keeper deducts the area occupied by "the three ancient piers"—that is, those of the multivaulted structure—from the overall area of flooring; the cumulative breadth of the piers as recorded, 14 *palmi* (3.13 m), closely approximates our lateral measurement of Piers 3, 5, and 7 below ground (0.66 + 1.30 + 1.26 = 3.22 m). Today, this terrace floor is completely obscured by a slope of loose earth (see fig. 9).

The source of the south feeder channel is probably a "botticella picola" (little reservoir) mentioned on the record's fourth page "which takes water from the hill toward the valley of olives [val d'oglioli]." Its antiquity is assured by the fact that another entry records the cost "of having removed the earth and rocks from said *botticella*."[59] Today, the main gallery lies only 100 m from the edge of Vicarello's venerable olive grove, and Pozzo 3, aligned with the south feeder channel, stands just inside it (see fig. 2). Conditions may have been similar four centuries ago.[60]

Other unusual entries seem to reflect the unique nature of our site. One describes a "wall that juts out

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[59] P. 30 recto: "Muro della sponda dalla banda di sotto alla botticella picola passato la d^{a} che piglia l'acqua del Monte verso val d'oglioli [=olioli] lon p. 47 alt p. 3½ g^{sso} p. 3 fa — sc. 2.47. . . . Per haver levato la terra e selci per detta botticella — x 7."

[60] The grove may date back as far as the papal concession of the Vicarello estate to the Collegio Germanico-Ungarico in 1573.

behind said [wall, i.e., the one containing the arcade], and which attaches to the lava."[61] Recording a length of 113 *palmi* (25.24 m), this entry probably references the cementing of the piers and arches to the cliff face directly behind the full length of the arcade. Two other entries document the construction of short walls, presumably parts of the zigzag channel system, near an "ancient mass" (massiciro anticho) that we interpret as the buttress of Roman brick-faced concrete shoring up the cliff (see fig. 8).[62]

THE CONSTRUCTION SEQUENCE

Here we offer a few observations about the likely sequence of ancient construction at this unique spring source. Presuming there was little in the way of systematized architecture at the site before the Imperial period, this sector of the Aqua Traiana's source architecture was probably begun on lower ground to the east where water would not interfere with construction. Thus, the earlier cistern above the bath, lower channel east of the bridge, bridge, and offtake would have been built before any part of the main gallery or its subsidiary intakes. At the sources, work began by clearing earth, trees, and debris from the rock face in order to isolate the water outlets. Grottoes do not occur naturally in this geological context, so those along the zigzag channel were probably hollowed out artificially to follow the veins of water. During construction, water was diverted from the sources, perhaps with portable lead troughs as described by Frontinus (*Aq.* 124). Each rivulet in isolation could be easily channeled just a few meters east and down into the ravine. Firm concrete foundations and retaining structures would come next, ensuring that the gallery and zigzag channel would remain anchored to the precarious hillside. Again, completely in the open air, the main gallery's west wall with its arcade was built directly against the rock face, its arches and piers carefully calibrated to provide clearance around each outlet. Work proceeded up two stories, beginning with the lower arcade and extending to the vaulting of the aboveground structure.

The east wall of the gallery and the outer walls of the zigzag channel (if it is contemporaneous), along with any necessary external buttressing, could be built at a fairly late phase, perhaps after the diversion troughs were dismantled and water was released directly into the gallery. Also, before the release, *cocciopesto* would have been applied to the areas with stronger and faster flow, particularly the narrower northern channel and the offtake. The gallery's vaulting could be built swiftly, even as water flowed around the workmen's feet. Finally, the vaulted areas at this level were interred in a terrace that extended the entire length of the complex, and *cocciopesto* was applied to its surface.

Compared to the main gallery, the zigzag channel represents a more aggressive method of capturing water. Hacking out grottoes may have seemed necessary to the very same men who designed the arcade, if only because of the emerging water's divergent behavior. In some cases, excavating a small fissure will increase its flow; in others, no intervention is needed. That said, the distinctive approach evident in the grottoes may represent a second phase following closely on the first. After all, the little channel from the south, barging rudely through the gallery's south end wall, clearly came later, but not much later. After the vaulting of the zigzag channel, the *opus latericium* buttress was thrown up against the cliff face as a prophylactic measure. All the vaulting and the lower part of the buttress were then interred with terrace fill.

EXPANSION OF THE ANCIENT SYSTEM AROUND VICARELLO

Vicarello has barely figured in the written history of the Aqua Traiana. Between 2009 and 2012, we determined that the mother source of Trajan's aqueduct originated to the southwest of Vicarello, at the church of Santa Fiora near Manziana and at two

[61] P. 29 recto: "Muro che ricresce dietro a d$^{\text{to}}$ che attaccha con la selcie lon p. 113 alt p. 6 reg$^{\text{to}}$ g$^{\text{sso}}$ p. 2 reg$^{\text{to}}$ fa — sc. 6.78." The fact that this "wall" is more like a series of irregular piers of masonry surmounted by a more or less continuous zone above the arches highlights the provisional nature of estimating volume in three dimensions. The term *reg[ola]to* probably refers to a geometric formula that tries to average out gaps and irregularities. A second entry on the following page, harder to interpret, refers to a "wall extending a barrier/restraint from said lava" (muro che crescie quale serra con la selcie det[ta]).

[62] P. 29 recto: "Wall running alongside said vault from the [?] above, 51 *palmi* long, 6 *palmi* high, 4 *palmi* thick, if one deducts 4 *palmi* of length, 6 of height, and 4 of thickness where the ancient mass stands, total 5.64 *scudi*. . . . Wall of another section that extends 12 *palmi* in length past the mass, 6½ *palmi* high, 3 *palmi* thick, regulated: 1.17 *scudi*." (Muro che fa fianco a detta volta dalla passe [?] di sopra lon p. 51 alt p. 6 g$^{\text{sso}}$ p. 4 se ne difalca dove è il massiciro anticho lon p. 4 reg$^{\text{to}}$ alt p. 6 g$^{\text{sso}}$ p. 4 resta — sc. 5.64. . . . Muro d'un'altro pezzo che crescie lon p. 12 passa il massiciro alt p. 6½ g$^{\text{sso}}$ p. 3 reg$^{\text{to}}$ — sc. 1.17).

supplementary sources nearby, the Carestia and the Matrice (see fig. 1, at left below inset).[63] In 2016, we hypothesized that the entire southernmost tract of the Aqua Traiana—the sources along the Fosso Boccalupo west of the lake—represents a second phase of construction added to the aqueduct after the completion of the primary Santa Fiora branch several kilometers to the north (see fig. 1).[64] Our objective now is to bring Vicarello's long springhouse into this developing narrative and to inquire whether the copious waters of Santa Fiora did in fact beget the Aqua Traiana or whether the origins of the aqueduct might more appropriately be assigned to Vicarello itself.

The southernmost sources of the Aqua Traiana were small and remote. Though the Acqua Paola granted them a second life, it is no accident that the entire tract again lies in ruins today. Plainly, its benefits have not been worth the cost of maintenance. What about the Vicarello sources? Today, their output is limited but not insignificant. They may even still feed the Acqua Paola system; the conduits we have observed remain sound despite their complete dereliction. Perhaps it was not strictly the collective volume of Vicarello's sources that informed their history in the Roman phase; perhaps it was their early attraction to Trajan's ambitious and enterprising predecessor, Domitian.

We have now discussed Vicarello's three known local water sources, marked 61, 62, and 64 on the 1789 map (see fig. 7). Their collective offtake conduit ran directly above Domitian's thermo-mineral baths and probably supplied the complex with cold water already during his reign (see fig. 2). Indeed, the collective evidence suggests that the entire enterprise of the Aqua Traiana began with Domitian, most likely at Vicarello itself, for here, in the later years of his reign, the emperor owned and developed a large villa estate.[65]

[63] Quilici 2009; Taylor et al. 2010; Taylor 2012.

[64] Taylor et al. 2016, 10–17. Cassio (1756–1757, 1:170) recognized that the headwaters of the ancient system came from Fosso della Fiora, but he lamented that they were "lost" (*smarrite*) to the Acqua Paola, by which he must have meant unavailable rather than dry; under Paul V the Santa Fiora spring was abundant but likewise out of the pope's reach, as we have seen.

[65] On Domitian's villa, see Virgili 1988; Cordiano 2003; 2011b; Accardo 2007, 163–64, UT 49 (G. Cordiano); Taylor et al. 2016, 22–23; Taylor 2019. The villa's foundations are still visible in places beneath an early modern manor house. The fairly advanced Domitianic date derives from the brickstamps found there of the known types *CIL* 15 1000a and 1096g.

The huge size differential of the two aligned cisterns here (La Porcareccia and the small cistern about 20 m to its southeast, see figs. 2–4) may confirm the very thing we wish to suggest: that the water supply to the baths was initially modest but was augmented greatly when the emperor realized the full potential of the springs along the ravines at Vicarello (Fosso delle Ferriere and Fosso della Calandrina to its east). The Porcareccia cistern, some 10 x 40 m in plan, dwarfs its southeastern neighbor, whose seeming redundancy might best be explained by its sudden obsolescence in the face of a massive upgrade.[66] The UCLA map plainly indicates that the ancient source network along this watershed surpassed the early modern one, for it documents several sectors of dead conduit on the west bank of the Fosso delle Ferriere some distance to the north. Feature N in our figure 21, a *conduto vechio,* never belonged to the Acqua Paola and thus did not appear on the 1789 map. How to interpret *conduto* M in figure 21, which runs athwart N, is anybody's guess. Both probably belong to an ancient system that has never been explored. Other sources still, utterly without documentation, remain to be found, if local eyewitness testimony is to be believed.

Interestingly, evidence to the east suggests that a conduit paralleling the Calandrina creek underwent two distinct construction phases in the Roman Imperial period. Just above a ford called Passo del Guardiano (see fig. 1), the conduit originally crossed the stream diagonally on a bridge faced with *opus reticulatum* and brickwork. This bridge, now mostly obliterated, was replaced by another just upstream. The second, a bridge of completely different design and construction, remains mostly intact (fig. 22). Its angled abutments are clad in dry ashlar masonry, a feature shared by several bridges in the Acqua Paola system, including the one at Vicarello (see fig. 5). Until a few years ago, a large fallen chunk of the first bridge lay in the creekbed directly downstream, parted from its vault, the *cocciopesto* channel floor overturned to face the viewer (fig. 23). A standing sector of the abandoned bridge on the left bank confirms the character of its outer facing (fig. 24).

Engineers of the Acqua Paola restored or replaced all the bridges of the Roman system, commemorating their work with identical AQVA PAVLA inscriptions

[66] Accardo 2007, 148–49, UT 26 (G. Cordiano).

FIG. 22. The second, later bridge over the Fosso della Calandrina at Passo del Guardiano, looking southwest (R. Taylor).

FIG. 23. A fallen segment of the water channel from the first bridge above Passo del Guardiano as seen in 2011 (R. Taylor).

FIG. 24. Standing remains of the first bridge at Passo del Guardiano, looking northeast (R. Taylor).

centered on the vertical faces of each bridge (online figs. 19, 20).[67] Initially, we presumed that the later bridge at Passo del Guardiano belonged mostly to the 17th century with later repairs. Certainly the fieldstone-and-mortar facings and patches are modern. But we have since observed that the blocks cladding the abutments, where they have not been repaired or replaced, conform consistently to a module that is 1 Roman foot in height. Where the cladding has eroded away on this bridge (see fig. 22), the underlying core looks and behaves like the Roman concrete we have seen in the long springhouse and elsewhere in the system, with very hard mortar encasing large chunks of lava *caementa*.[68]

The fragmentary arch of *bipedales* and facing of *opus reticulatum* of the collapsed earlier bridge is instantly recognizable as Roman imperial architecture (see fig. 24). Springing from the bluff rather than the creekbed, it has no visible abutments on either side. Unusually,

[67] Inscriptions remain in situ on several bridges in the system: Ponte Ciurlo and Ponte di Pettinicchio, both crossing the Fosso Boccalupo, and the two-arched Ponte delle Civette. We discovered an identical inscription, detached from the second Calandrina bridge after a restoration, lying overturned in the woods nearby. A patched area over the arch where it was originally affixed is visible in fig. 22.

[68] That this bridge lacks Roman bricks is unsurprising. Stone ashlar facing was preferred for Roman bridges in central Italy (Galliazzo 1994, 2:51–106). On the Paola system bridges, there is no easy way to distinguish ancient blocks from modern ones. Yet some of the original ashlars and voussoirs have evidently migrated. Fallen elements could be reused haphazardly, with the curious result that many voussoirs are not tapered, as evidenced abundantly on the Ponte delle Civette and Ponte di Pettinicchio. Nor do they generally meet symmetrically at the arch crowns where a keystone would be expected (see fig. 22; online fig. 19). The exposed arcade of the Acqua Paola's main conduit just northeast of the Vicarello farmstead (the *archi* represented in fig. 21, feature I) even displays voussoirs that have been installed upside down.

the bridge crossed the stream diagonally. The small diameter of its surviving arch fragment demonstrates that it was a multiarched, viaduct-style bridge with piers footed in the creekbed. These piers, which evidently were not even countersunk into the bedrock, proved vulnerable to floods in a way that the clear span of the second bridge is not. We have seen evidence of the ferocity of floods in this ravine; after lying where it fell for an unknown span of time, the chunk of this fallen bridge that we saw in 2011 (see fig. 23), weighing many tons, was washed far downstream in the course of a single season of heavy rainfall.

For a bridge to fail so soon after its completion may have provoked enough embarrassment to effect a sweeping redesign of the system's bridges that included massive, bastion-like abutments faced in an adamantine material and clear spans to avoid cutwater piers. Another scenario presents itself, however, one that leaves the bridge in place but useless. The *cocciopesto*-lined channel of this bridge is roughly 55 cm across and not much deeper than that; it also presents an unusual ovoid section in its bottom half (see fig. 23). When it was built, not every source upstream may yet have been tapped; fully 10 features above the bridges are numbered on the 1789 map (features 83–92, many in light pencil; see fig. 7, right side). A later effort to maximize the system's volume might have overmatched this narrow bridge, rendering it as obsolete as the little cistern supplanted by the Porcareccia at Aquae Apollinares. As it happens, a section of conduit attached to the second bridge can be examined just downstream. This is noticeably larger than the earlier channel, being about 65 cm wide, flat-bottomed, and lined with *cocciopesto* up to 1 m or more.[69] The labeling of this creekside tract as *condotto scoperto,* "discovered conduit," on the 1789 map (see fig. 7, feature 80) is clear evidence of its antiquity. Yet, ancient as it was, it had already been augmented at least once long before Pope Paul's workmen arrived. For the young creature to grow, it had to shed its confining exoskeleton.

THE HISTORICAL CONTEXT

What were the political dynamics underlying this relentless sweep of water resources? In truth, the motivating force behind most of the great aqueducts serving ancient Rome resembles impulse more than need. Despite Frontinus' bland assurances that the Aqua Claudia and Anio Novus—both projects initiated by Caligula, not an emperor noted for civic spirit or prudence—were brought to Rome "because the seven aqueducts then existing were deemed insufficient to satisfy the public needs and private pleasures of the day,"[70] one might respond that, from an ambitious emperor's perspective, the needs and indulgences of his capital city could never possibly be satisfied.

The same murky standard applies to the Aqua Traiana. At the time of its construction, nine existing aqueducts, several of them already augmented beyond their initial capacities, were deemed inadequate for a city whose population had grown only modestly since the age of Julius Caesar, when Rome was served by four aqueducts, or the age of Augustus and Agrippa, who had added the fifth, sixth, and seventh (Frontin., *Aq.* 5–12).[71] The operative word governing the introduction of new aqueducts, it seems, was not *need* but *opportunity.* Opportunity knocked for the Aqua Traiana not at a single decisive moment but in increments. Few would challenge this aqueduct's conventional etiology, that it was introduced to supply Trajan's great public baths, dedicated only two days before the aqueduct itself. But such a grand objective, not just the largest bath complex ever built up to that time but especially a citywide network of "water issuing throughout the city" (aquam tota urbe salientem),[72] probably was not realized in a single visionary phase. As water became available, the vision expanded accordingly. If we admit that the Aqua Traiana emerged in phases, then we can also suggest that, like the Aqua Claudia and Anio Novus before it, this was a project begun by one emperor and inherited by another.

[69] In itself, either conduit could have managed the full volume of water. The concern here is whether a maintenance worker could operate within the conduit while it was in full flow.

[70] ". . . cum parum et publicis usibus et privatis voluptatibus septem ductus aquarum sufficere viderentur" (Frontin., *Aq.* 13). Bruun (1997) perceives a perpetual excess of demand over supply in the ancient Roman aqueduct system—in our opinion, on shaky evidence, all of which can be ascribed to opportunity rather than shortage. He is certainly right that no population estimate for the city can be made on the basis of water supply.

[71] Lo Cascio (1997) estimates that the population at Rome supported by the grain dole prior to Caesar's land reform comprised some 700,000 people, a number that would still likely exclude several hundred thousand additional residents (among whom he counts landowners and slaves). This *plebs frumentaria* shrank considerably with the reforms but was back up to about 600,000 in the Augustan era.

[72] On the inscription recording the dedications, supra n. 4.

Phase One: Prioritizing the Baths and Villa

Domitian himself, it seems, had a prominent presence at Vicarello. It is plausibly argued that he owned a great villa complex just south of Aquae Apollinares, surely the finest of the Roman residences around the lake.[73] He also took interest in this therapeutic sanctuary, the historical cynosure of the Vicarello district, where a splendid new nymphaeum arose late in his reign.[74] But during this first phase, aiming only to supplement the adjoining thermal baths with fresh, cold water, his builders would have sought only easily available springs along the Fosso delle Ferriere. The sources of our long springhouse were the lowest-hanging fruit of all, being only 200 m away. Their initial output, perhaps drawing just from the arcade, was commensurate with the smaller of the two cisterns north of the Vicarello nymphaeum.

Meanwhile, Domitian may have been acquiring considerable tracts of land in the vicinity of Vicarello and probably at other locations around the lake. Opportunity presented itself in a most unexpected way. Lake Bracciano had suffered a mysterious and ultimately crippling inundation sometime after 60 CE. The precipitously elevated waterline never retreated, leaving every lakeside villa, along with roads, docks, and other infrastructure, permanently flooded.[75] (Domitian's villa complex was built on a bluff overlooking the lake, well out of harm's way.) This situation probably left the entire district around the lake in financial distress, as property values plummeted and wealthy Romans abandoned their riparian retreats.[76] Domitian and Titus were already experienced in the affairs of land purchase and redistribution; the aftermath of Vesuvius had acquainted them with the economic realities visited on a landscape of disaster.[77] Here arose an opportunity to purchase productive lacustrine land at bargain prices. As the abundance of local springs grew more evident to the emperor, his targets of acquisition may have expanded up the ravines where most of the springs emerged. Phase one, then, was distinguished by an expansive program of land purchases, perhaps with an eye to hydraulic exploitation, but as yet without a systematic plan.[78] No precise dates can be ascribed to these projects, but the late Domitianic brickstamps found at the villa[79] would suggest they unfolded in the early 90s CE.

Phase Two: Consolidating the Sources

These land purchases, which we attribute to Domitian, may have begun as a purely local concern. Initially, the small cistern sufficed to supply the baths. But at some point very late in his reign, the emperor seems to have initiated a second phase of the Aqua Traiana's development, realizing that, in the aggregate, the springs around the lake, many of which would have already fallen under his control, were abundant enough to supply an entirely new urban aqueduct. Nero and Titus each had introduced large new public baths to the *urbs*. Both had been compelled to redistribute existing water resources or at best to add new sources to existing aqueducts.[80] For Domitian, and subsequently Trajan, the opportunity arose to sponsor another urban bath complex on a gargantuan scale but without resorting to massive reallocations of existing water resources.[81]

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[73] Cordiano 2011b.

[74] Cordiano 2003; von Falkenstein-Wirth 2011; Taylor 2019.

[75] Cordiano 2007, 2011c. The terminus post quem for abandonment is determined by the discovery, in the context of a submerged site on the lakeshore, of a Claudian sestertius countermarked in the Neronian period.

[76] Taylor et al. 2016, 21–23.

[77] Taylor 2015.

[78] We might approach this hypothetical land grab from another angle, too. Already by the early Middle Ages, vast tracts of land west of the lake were in papal hands. Marazzi (1997, 416) has proposed that this unusual concentration of patrimonial holdings was owing precisely to the Church's inheritance of imperial landholdings in the region, centered on Vicarello. Our scenario strengthens that hypothesis.

[79] Supra n. 65.

[80] Taylor 2000, 201–6.

[81] On the possibility that Domitian initiated the Baths of Trajan on the Oppian Hill, see Anderson 1985. Volpe (2010, 2012) disputes this hypothesis. Documenting rates of progress inscribed in paint by work teams on the masonry in the substructures of the western corner of the bath platform, she estimates that construction began sometime around the time of a fire recorded at the Domus Aurea in 104 CE (Oros. 7.12.14; Jer., *Ab Abr.* 2120) and was effectively complete by mid 109—a hypothesis favored by numerous scholars in the past. But the task of working backward to the beginning of the project is mere guesswork founded principally on DeLaine's estimation (1997) that all but the peripheral elements of the Baths of Caracalla, undertaken two centuries later, were built *ex novo* in roughly five years. Volpe's work has focused on the far western corner of the bath complex, whereas Anderson remarks most forcefully on the lack of Trajanic stamps in the walls that cut through the Oppian wing of the Domus Aurea. A number of Domitian's projects were halted upon his death and resumed only later (Anderson 1985, 506–7).

The top priority was to harness the abundant Fiora–Carestia–Matrice branch; in truth, it was no branch at all, but the first leg of the ancient aqueduct's main conduit scaled appropriately for the purpose (see fig. 1). Then the systematic exploitation of smaller or more remote sources began in earnest. At our Vicarello site, the south feeder channel was probably added to the main gallery at this time, and perhaps also the zigzag channel and the northern sources labeled as feature 61 on the 1789 map (see fig. 7). With these additions, the Porcareccia cistern (see fig. 3) was built to supply Domitian's monumental new nymphaeum and also his villa to the south. At this point, the first Calandrina bridge may have been abandoned for the new, ampler version. The Acqua delle Donne spring and the Sette Botti, all issuing from the zone between Vicarello and the Fosso della Calandrina, probably joined the system in this phase, perhaps approaching the mid 90s. The nymphaeum, which seems too large for the baths beside it, might best be explained as an advertisement for the project intended primarily for elite clients, who began to frequent the baths at the emperor's invitation.[82] Adorned with a statue of Apollo, it clearly referenced these *Aquae Apollinares.* Its size and extravagance, though, befitted the kind of ceremonial architecture a Roman patron might well situate at the headwaters of a long-distance aqueduct.[83]

Phase Three: Supplementing the System

Nerva (r. 96–98 CE) and then Trajan (r. 98–117 CE) inherited Domitian's enterprise, which could not have progressed very far on the ground. Saddled with an incipient thermal bath project in the heart of the city, each may have regarded the aqueduct with skepticism. Perhaps this combination of opportunity and reluctance impelled Nerva to appoint the astute and aggressive water commissioner, Frontinus, to undertake sweeping reforms and consolidations.

Ultimately, lubricated with Dacian war spoils, the project went forward. Though no brickstamps have yet been recovered from the Santa Fiora–Carestia source complex, we conjecture that its beginnings fall within phase two, when Domitian's more ambitious plans were set in motion (see fig. 1). But the southernmost tract, along the Fosso Boccalupo, has yielded numerous stamps at ground level that point unambiguously to Trajan's patronage. In some cases, they potentially date to the second half of that emperor's principate, even after the aqueduct's dedication date in 109.[84] Thus phase three, which may have begun after Trajan's conclusion of the Dacian Wars in 106 CE, is characterized by the capture and addition of networks of smaller sources prospected in the far south. Only after the Santa Fiora sector went into operation was the long southernmost conduit added to the system. Originating at Pisciarelli, it continued southeast down the Fosso Boccalupo, then turned north to follow the slopes above the lakeshore as far as Vigna Orsini where it joined the original conduit from Santa Fiora (see fig. 1). This branch added approximately 8 km to the Aqua Traiana's overall length, and its sweep was so complete that in fair weather it probably drained the Boccalupo creek almost dry.

Effects on the Town of Forum Clodii

Such clean sweeps of water sources never occur without profound effects on local interests. At some point during Trajan's reign, the town of Forum Clodii, situated along the Via Clodia between the Boccalupo sources and the Fosso della Fiora (see fig. 1),[85] erected a cryptic public inscription thanking the emperor for his largesse in responding to their need for water:[86]

> The Claudiani [i.e., citizens of Forum Clodii], to the best and most indulgent emperor, because he brought the water necessary for the benefit and health of the public across a great distance [*s*[*patium*]], having first built the works at his private expense.

Any thought that Trajan dealt a card to the Claudiani from his enormous deck of water resources for the Aqua Traiana falters at the words "per longum spatium." Forum Clodii was not far from the Santa Fiora spring; in fact, an enormous ruined cistern known in modern times as Le Colonnacce lies directly alongside

[82] On the changing clientele of the Aquae Apollinares under Domitian, see Cordiano 2003.

[83] On the statue and its context, see Jaeggi 2011; von Falkenstein-Wirth 2011, 90–101; Cordiano 2011c, 45–68.

[84] Felluca 2015, 16–17; Filippi et al. 2015; Taylor et al. 2016, 10–17; Felluca and Germani 2017, 179–80.

[85] The town has almost completely disappeared from the archaeological record. On its location, see Accardo 2007, 108–10 (G. Cordiano), 139–42, UT 17 (M. Bacci).

[86] *CIL* 11 3309: "[–] optimo [et indul]gentissim[o principi] quod aqu[am usi]bus et salub[ritati publi]cae necessa[riam per] longum s[patium] structis oper[ibus im]pensa fisci s[ui duxit] Claudiani."

the Via Clodia just 1.4 km south and downhill from Santa Fiora (see fig. 1).[87] Predating the Trajanic era, this cistern bids fair to have served as a regulation tank of suitable capacity for the whole town, which lay mostly below it in the direction of the lake.[88] By commandeering the Santa Fiora source, and all the other significant springs in the vicinity, Domitian's (and Trajan's?) engineers had appropriated much of the town's supply of perennial groundwater. But, being both *optimus* and *indulgentissimus* (so it suited the townspeople to say), Trajan seems to have compensated the Claudiani with water from a completely separate source lying some distance away.

Whence these waters came, and how they were conducted to a town whose topography remains elusive to this day, is a matter of barest speculation.[89] The simplest proposal may yet be the best: that the town, deprived of water from the more abundant sources to its north, eventually got relief from the southernmost sources added to the Aqua Traiana system late in Trajan's reign. Running north along the lake eventually to join the main Santa Fiora conduit at Vigna Orsini, this sector would have passed the town at an elevation not much higher than 200 masl. But only neighborhoods at a lower elevation could benefit from it. So where was the town center? The church of San Liberato, where many of Forum Clodii's inscriptions are preserved, lies well to the conduit's west and a good 75 m higher (see fig. 1). On the other hand, a study of the church reports that the remains of a Roman Imperial-era bath of the second or third century lay "only 300–400 m east of the campanile"[90]—that is, straight downhill toward the lake and very close to the conduit. If Forum Clodii was actually centered here, near the lakeshore, then our scenario is plausible; however, under those circumstances, the words "[per] longum s[patium]" (across a long distance) would be referring to new sources (along the Fosso Boccalupo) that were barely farther from town than the old (perhaps Santa Fiora). We might therefore revise this heavily interpolated phrase to read "per longum specum" (through a long channel), thereby shifting the emphasis from the remoteness of the sources to the overall length of the conduit. In that case, Forum Clodii would have been replenished from the new 8 km extension of the Traiana but not at any great distance from its sources. The town lay roughly two-fifths of the way along this sector (see fig. 1).

Still, the hypothesis remains to be tested. One way forward would be to subject the entire Forum Clodii area to intensive survey, both remote and on the ground. If the town was down by the lakeshore, it may be buried under alluvium from the Fosso della Fiora. If it was on the slopes, there should be discernible evidence of its features in the forest. As recently as 1666, Lukas Holste claimed that "mighty remains" and "many ancient monuments" could be seen near the church.[91] The original sources for Le Colonnacce may yet be undiscovered but detectable. Other features of the hydraulic landscape deserve investigation, too. For example, the mysterious complex known as La Fortezza, up the wooded slope from the cistern, reveals walls of Roman *opus reticulatum* set within a puzzling, half-interred matrix of later barrel-vaulted construction.

FUTURE WORK ON THE AQUA TRAIANA

If Vicarello was the cradle of the Aqua Traiana project, then closer analysis of the site, assisted by remote sensing data of the region, should elucidate its phasing and history. Further, there can be little doubt that sources upstream, yet unseen by us, were ample. Presumably, the ironworks near the long springhouse were either hammer or bellows mills powered by springwater, for rainfall alone, collected into the stream's tiny

[87] Nibby 1849, 1:318; see also Taylor et al. 2016, 18–21. Nibby's measurements are 34 x 180 ft.

[88] Parts of the cistern were modified and reused in post-Antique times and abandoned in turn. The outer walls and a row of piers, however, are made of Roman *opus caementicium.* Though no facing technique is discernible on the wall surfaces, the horizontal rows of *caementa* and the iron-hard consistency of the mortar, not to mention massive fallen vaults of the same material, leave little doubt as to the structure's antiquity. Precise dating is a greater challenge, but an unfaced structure of this sort is likely to be earlier (Republican) rather than later (Imperial).

[89] In 2016, we tentatively proposed that the source could have been the one *ex Sabatino,* once tapped by Augustus to supplement the Aqua Alsietina (Frontin., *Aq.* 71), which was much reduced by Trajan's day; see Taylor et al. 2016, 20–21. To be sure, the phrase *ex Sabatino,* referring to the region around Lake Bracciano (ancient Lacus Sabatinus), does not imply long distance, but it may still have been far enough removed from the town's accustomed sources to have been deemed *per longum spatium.* Certainly, it would have been good political form to emphasize the distance and expense in such an inscription.

[90] Christie et al. 1991, 334. We find no further report on this structure, and we have found nobody who can confirm its existence. We have not gained access to the property in the vicinity.

[91] Holste 1666, 44.

watershed, almost certainly could not have sustained it. Clear evidence of damming is visible in places along the ravine.[92]

In addition to the short- and longer-term objectives we defined earlier with reference to the Aqua Traiana project, we hope to undertake a sediment coring survey of the Lake Bracciano region to better understand the interactions between humans and the environment over the longue durée but with a particular emphasis on the relationship that developed between this region and the metropolis of Rome in antiquity.

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