Chapter 1 Introduction

1.0: GENERAL INTRODUCTION

Water is such a deeply ingrained aspect of all civilizations that any study dealing with water can be quickly overwhelmed by data. This is especially true for Roman civilization, where water was many things to many people: political power, divinity, recreation, destruction, or basic survival. The definition and perception of water varied across the multicultural and geographically dispersed territory of the Roman Empire, changing through time as well. So how should we proceed? We start by looking for traces of where water was, what it did, and what kind of footprints it has left behind in the archaeological record. A single city, Ostia, is the focus of this study, more particularly, three of its city blocks. Instead of focusing on the difficulties of dividing water into discrete categories, perhaps now is the "opportunity for open imagination", and to see the overwhelming diversity of categories into which water seeps as precisely the way to form a better understanding of it.[1] To this end, this study has deliberately engaged with modern sustainable resource studies, which have begun to view water as the pervasive and amorphous thing that it is.

This introductory chapter presets several starting points, which act as the foundation for the subsequent chapters and the work as a whole. It begins by outlining the history of how past research approached the topic of water in the Roman world, and situates the study of water in Ostia within the wider context of Roman hydraulic research. Following this, the site of Ostia is introduced, with an overview of its history of excavation, its landscape, and its urban development. In this way, Ostia's dynamic relationship with Rome and with wider socio-technological trends is highlighted. Continuing on from the historical and environmental context, larger diachronic trends in Ostia's hydraulic infrastructure are presented. As a result, the detailed information on individual buildings and their water systems in subsequent chapters can be placed in a dialogue with the broader socio-environmental history of Ostia, as well as within the field of Roman hydraulic research.

1.1: HISTORY OF ROMAN WATER RESEARCH

The study of water in the Roman world originated with the Renaissance fascination of the Roman ability to harness resources and landscapes on a massive scale.[2] This was partly caused by the repair and creation of aqueduct lines in Rome by several Popes to feed the growing population. As with other contemporary trends in the early development of archaeology, the water supply of Rome was seen initially from an external and monumental perspective. Together with the effusive praises of numerous ancient authors on the harnessing of nature and the luxury it afforded (to those who could afford it), the landscape-spanning arches and opulently marbled bath buildings fostered romantic images of togate Romans enjoying their *otium*.[3] Aqueducts themselves were principally studied from an architectural point of view, although Rodolfo Lanciani's 1881 work serves as the

1 Bachelard 1965 [1942 original], 301, *"The mirror which a fountain provides then, is the opportunity for open imagination."* While applying a Freudian lens to water, dreams, and 19th century literature, Bachelard offers a deep study of the personal and emotional experiences possible with water.

2 Coates-Stephens 2003 shows that contrary to popular belief, knowledge on the functioning of aqueducts was never "lost" after the collapse of the Western Roman Empire, but continued through more diversified and small-scale systems from the 7th and 8th centuries throughout the Medieval and Renaissance periods.

3 Such as Pliny the Younger's description of his Laurentine villa (*Ep*. 1.9): *"The sea and shore are truly my private Helicon, an endless source of inspiration. You should take the first opportunity yourself to …. devote yourself to literature or to leisure".*

benchmark of Roman hydraulic studies for its dual examination of the physical components of Rome´s water system and an early commentary on Frontinus.[4] The *De Aqueductu Urbis Romae* of Frontinus seemed to offer a straightforward textbook based on his personal experience as the *curator aquarum*, the figure in charge of water supply to Rome from 97-103 CE.[5] Frontinus provided information on a diversity of topics relating to Rome's water supply, from the amounts provided by each aqueduct, to water theft, to organizing maintenance crews, and even to relevant water laws.

The excavations of Pompeii and Herculaneum revealed traces of complex water distribution systems on an urban level, especially with their water towers.[6] These brick and tufa piers are spread across the city, and help to maintain the aqueduct´s water pressure across the changing topography of the city, while at the same time reducing the full force of the aqueduct from bursting pipes.[7] Together with the bundles of exposed pipes poking up through the streets in both of these cities, Roman water systems began to be appreciated for their small scale uses as well as for the monumental aqueducts.

Interest in monumental bath buildings and aqueducts continued to foster hydraulic research throughout the early 20th century. Ashby (1935) and Van Deman (1934) created invaluable studies on the aqueducts around Rome, tracing every known section of these supply lines. However, it was not until the late 1980s that hydraulic studies developed into a more substantial research field. As a result, research concentrated upon questions such as the symbolic value Roman water systems, how aqueducts functioned, and about ancient hygiene.[8] Critical examinations of the technical statements and numerical figures presented by Frontinus appeared shortly thereafter, resulting in a cascade of literature interpreting his 1st century CE descriptions on technical hydraulic components and its accompanying administrative functions.[9] The disconnect between archaeological evidence and Frontinus' text is now resolved by seeing the *de aquae ductu* less as a literal handbook, but part of a larger genre of elite technical treatises in the 1st century CE.[10] New studies of aqueduct lines in Ephesus and Constantinople continue to demonstrate the complexity and creative solutions utilized by Roman hydraulic engineers to transport water on a measured gradient across hundreds of kilometers.[11]

Specialist conferences on hydraulic aspects of Roman archaeology followed suit, with the Germany-based Frontinus Gesellschaft and the Deutsche Wasserhistorische Gesellschaft coordinating several conferences.[12] The field of Roman water research continues to expand, with specialist works on Roman rivers, Roman health, and Roman bathing produced in the last 20 years.[13] Dedicated handbooks on Roman technology and individual hydraulic components in the early years of the 21st century have provided a much-needed synthesis of the wide ranging spatio-temporal developments in ancient technology.[14] A burgeoning trend in Roman hydraulic research is the numerous studies on ancient latrines and hygiene, which present an incredible new window into the cultural attitudes and urban development of

4 Lanciani 1881.

5 Bruun & Saastamoinen (eds.) 2003 compiled several valuable articles dealing with aspects of Frontinus' life.

6 Camardo *et al.* 2006 for the two water towers in Herculaneum; Ohlig 2001 for an overview of the urban system of Pompeii; Olsson 2015 for the water towers of Pompeii (updating Larsen 1982).

7 Kessener 2003 for functional issues of operating these systems; 2013 for a modern example of this system in Palermo.

8 DeLaine's 1997 study on the process of construction of the Baths of Caracalla remains a standard work in understanding thermal structures; Scobie 1986 based its extrapolations almost entirely on literal readings of ancient sources, such as Seneca's soundscape of a bath (*Ep*. LVI, 1), and Martial's roadside urine jars (*Ep.*VI, 93, 1).

9 Bruun 1991; Bruun 2003 traces the manuscript tradition of the *de Aquae Ductu Urbis Romae* and its reception in early Renaissance technological treatises, especially Alberti's *Decem libri de re aedificatoria* (ca. 1450); Hodge 1992 for a still accessible handbook on Roman aqueducts; Nikolic 2011 explores Vitruvius' technical terminology.

10 Many of Frontinus' terms are still debated, and even parts of his "ideal" water management systems have rarely been archaeologically discovered (e.g. bronze taps). The *De Architectura* of Vitruvius belongs to this genre as well.

11 For Ephesus see: Pickett 2016, Thür 2006, Wiplinger 2006; for Constantinople see: Bono *et al.* 2010, Crow 2006, 2012a, 2012b.

12 Key publications of these conferences are: De Haan & Jansen (eds.) 1996, Jansen (ed.) 2000, Ohlig *et al*. 2002, Wiplinger (ed.) 2006, Ohlig 2008, Wiplinger & Letzner (eds.) 2017

13 Aldrete 2007; Dessales 2013; Hermon 2010; Rogers 2013.

14 Important handbooks are: Oleson 2008, Taylor 2010, Wikander 2000; De Haan 2010 offers an overview of private bath-buildings; Stein 2014 gives an excellent study of Roman water pumps.

these crucial urban systems.[15] Studies dealing with Roman water usage across a wide geographical and temporal range have contextualized many aspects of Roman water within their larger urban, religious, and technological settings.[16] Reflecting the collaboration between archaeologists and hydraulic engineers, several recent studies of ancient Roman and Greek hydraulic systems have made use of computational fluid dynamic models.[17] These digital models are used by hydraulic engineers to design contemporary water systems, to predict places where pipes may burst, or where reservoirs may overflow. As so little contemporary ancient material regarding water technology remains, these digital models hint at the practical and technical limits of Roman engineering knowledge, by indicating more precisely the material and design limits of ancient water features.

These digital studies go beyond flow rate calculations and demonstrate how small-scale changes can dramatically impact the overall system. This shifts the focus from descriptive to prescriptive, presenting the limits within which a hydraulic system could function. The development of hydraulic technology has been and continues to be explored from diverse angles, but the central idea of understanding the technological aspects of water continually return to their inseparability from active cultural values. These technologies can only be created, exist, and ultimately survive due to their appropriateness and (real or perceived) usefulness; modern definitions of efficiency, cost, or yield are seldom the reason for the spread of hydraulic technology in the ancient world.[18] It is the aim of this research to highlight the technological choices made in hydraulic systems in terms of their local and wider context.

15 The work of Gemma Jansen and Ann Koloski-Ostrow established the foundation for this research field; Hobson 2009; Jansen 2002, 2006, Jansen *et al.* 2011; Koloski-Ostrow 2015 all deal with issues of ancient hygiene and sewers.

16 Such as Wilson-Malouta 2013 on water lifting machines in North Africa.

17 Haut & Viviers 2007 (Apamea); Locicero 2017 (Ostia); Ortloff 2014 (Petra); Ortloff & Crouch 1998 (Priene); Ortloff & Kassinos 2003 (Aspendos); Tseropoulos *et al*. 2013 (Knossos).

18 Greene 2000 summarizes the development of this technologically informed paradigm, starting from Finley 1973; Tàbara & Ilhan 2008 for the minor role biophysical constraints actually play in transitions to different types of water sustainability.

1.2: WATER RESEARCH IN OSTIA

While issues relating to the water system of any city cannot be extricated from larger works on urbanism, it is necessary here to outline the main corpus of literature dealing specifically with aspects of the acquisition, distribution, and removal of water within Ostia. The broader academic trends in analyzing the hydraulic features of Rome also have been applied to the study of Ostian hydraulics, such as the focus on monumental bath buildings, and the isolation of such structures from their neighboring buildings. Following the 18th century work of G. Marini, one of the first to consider the wealth of information available from this category of urban evidence, Wickert's publication of the two CIL XIV Supplement volumes analyzed the known brick stamps from Ostia.[19] These were fundamental in dating many hydraulic structures in Ostia.

One of the first monographs on Ostia was created by Paschetto in 1912. In it he collected all evidence of lead pipes, wells, basins, fountains, and sewer lines known in Ostia up to that point.[20] The monograph published on the archaeological remains of the city by Giuseppe Calza in 1953 revealed a much wider system of water management, especially in light of his extensive excavations between 1938-1942.[21] The fundamental text in English on Ostia was produced by Russell Meiggs, which described the historical, textual, and archaeological evidence of Ostia in its wider Mediterranean setting. His discussion on the baths and fountains describes their integration into the urban landscape.[22] Bruun's 1991 work addressed the corpus of lead *fistulae* pipes from Ostia, offering important conclusions on their chronology, ownership, and production.[23] This added an incredible depth and breadth of knowledge to the subject, which was touched upon

19 Wickert 1930 (CIL XIV, Suppl. 1); *ibid.* 1933 (CIL XIV, Suppl. 2).

20 Paschetto 1912, 247-259 presents all evidence of water at Ostia known at that time.

21 Calza *et al.* 1953. This will be referred to in all subsequent references as SO 1.

22 Meiggs 1973, 44-48, 404-420.

23 Bruun 1991; Bruun 1998 focuses on the prosopography of a Tiberius Claudius Aegialus known from a lead pipe under the Terme di Nettuno.

briefly by Barbieri in 1953. Further research of lead pipes in Ostia was carried out by Geremia-Nucci.[24]

While individual bath structures and cisterns were studied,[25] a catalogue of known hydraulic features in Ostia was only created in 1996, by Ricciardi & Scrinari.[26] This work remains fundamental in enumerating many hydraulic features now obscured or destroyed by the tenacious plant growth of the site, yet its catalogue-style layout created a very fragmentary picture for Ostia's water usage. Additionally, many of its functional and dating criteria were unclear, and many of its conclusions have since been revised. The 2002 work of Gemma Jansen dealt with numerous aspects of water in Ostia, and compared its hydraulic strategies with those of Pompeii and Herculaneum. Her work demonstrated the futility of using any single site as a "typical" proxy for water usage in Roman cities, and advocated instead for considering a flexible range of possibilities given local geology, technology, and unique urban characteristics.[27] Jansen's approach and data have been crucial in carrying out this research. Projects relating to individual aspects of the water system of Ostia continued, such as the work of Bukowiecki, Doublouz, and Dessales, who studied the aqueduct lines supplying the city. They researched the monumental urban cistern (*castellum divisorium*) next to the city's eastern gate (Porta Romana), and demonstrated the clever repurposing of Ostia's defunct Republican city wall to transport water to areas farthest from the aqueduct's arrival point.[28] Several studies dealing with the city's *fullonicae* brought to light the ingenious systems of water divisions and reuse present in these industrial complexes in Ostia.[29] Numerous smaller articles on more specific aspects of the water system of Ostia continue to proliferate.[30]

Building upon this diversity of published and archival material dealing with the issue of water in Ostia, this research offers a new perspective on urban water usage through the incorporation of 21st century approaches to water management. It offers a highly detailed diachronic study of water systems in diverse areas of the city, and places the abundant archaeological material from Ostia into dialogue with leading methods for assessing the factors and long-term effects of water usage practices. As high-resolution data for resource consumption and the urban distribution of hydraulic elements at Ostia are unevenly available, this study achieves the dual goal of updating the current *status quaestionis* of hydraulic knowledge of Ostia, while identifying how these systems changed over time in reaction to shifting economic, cultural, and demographic needs. The present research builds upon pre-existing studies on aspects of water flow from Ostia through its incorporation of contemporary strategies for examining water usage. However, the diachronic systems approach taken here would not be possible without the work of the scholars named above. This complementary approach seeks to integrate all available evidence of the city's hydraulic infrastructure, and as the following chapter demonstrates, this holistic perspective can offer new theoretical and methodological perspectives. However, in order to contextualize Ostia's water system, it is crucial to first introduce its history of excavation and local landscape.

1.3: HISTORY OF EXCAVATION

Given its long-lasting effect on a site, its excavation history contributes an equal understanding of the area as the material produced thereof. Ostia is no exception, as it offers a window not only into Roman urban development, but also into the development of the Italian state. While the prominent role of archaeology in 18th and 19th century Italian nationalism can only be

24 Barbieri 1953; Geremia-Nucci 2001, 2006 for an updated study of the lead pipes housed under Ostia's Capitolium; Schiøler 1971 attempted to use electrical currents to trace the path of buried lead pipes.

25 Cicerchia & Marinucci 1992 for the Terme del Foro; Nielsen & Schiøler 1980 for the Terme del Mitra; Medri & Di Cola 2013 for the Terme del Nuotatore; Poccardi 2001, 2006 for overviews of baths in Ostia.

26 Ricciardi & Scrinari 1996, with the data collected between 1980-1986, and the book written in 1991. This will be referred to in all subsequent references as RS I or RS II.

27 Jansen 2002.

28 Bedello *et al*. 2006 and Bukowiecki *et al*. 2008. This was already hinted at by Jansen 2002, 149, 151 as well as Ricciardi & Scrinari, Vol I, 98, 120, 130, 170 and Vol. II, 272.

29 Flohr 2013; Pietrogrande 1977.

30 Bedello Tata & Fogagnolo 2005 for the water wheel in the Terme dei Cisiarii (II, ii, 3); Schmölder 2000 on the public wells and nymphaea at Ostia; Stevens 2005 for water in the Case a Giardino (III, ix).

touched upon here, an outline of Ostia's excavation history is given to demonstrate the changing choices made by succeeding generations of archaeologists, and the resulting tableau of the city. Following the gradual abandonment of Ostia that was completed by the 9th century, the city was already ruinous in some sections, and became used mostly for the harvesting of lime and building materials in the 12th and 13th century.[31] The Renaissance saw a more systematic harvesting of material and antiquities for papal and private collections. As the Papal States dealt with fluctuating levels of Napoleonic control, Pope Pius VII supported excavations at Ostia beginning in 1801, inspired no doubt by the rediscovery of Pompeii in the mid-18th century by de Alcubierre and Weber. These Ostian excavations were led by Carlo Fea, but directed by Giuseppe Petrini, and ended in 1805.[32]

After a nearly twenty-year lacuna, another five-year excavation was begun by the Cartoni brothers (Pietro and Felice), aided by Pietro Tonelli. This was sponsored by the newly elected bishop of Ostia, Giulio Della Somaglia. This excavation was much less systematic than the previous work of Fea and Petrini, and instead favored more private and lucrative interactions with the church, to which the majority of the inscriptions and statuary were given.[33] While previous excavations had delved fragmentarily around the center of Ostia and along its Decumanus, Bartolomeo Pacca focused his research from 1831 on the marginal areas of the city. Pacca shared his papal patron's appreciation for the domestic proximity of antiquities, and had nearly 250 inscriptions and numerous sculptural works from Ostia placed in his private villa on the Via Aurelia, which acted as a private museum.[34] Excavations in 1855 continued under Pietro Ercole Visconti, and were published by his nephew Carlo Ludovico Visconti in 1857 with the support of Pope Pius IX. A good deal of correspondence emerged from Visconti's relationship to the pope, however it is mainly dedicated to the organizational and bureaucratic aspects of the excavation.[35]

With the Risorgimento and the creation of a new Italian government in 1870, the papal directed excavations came to an end. The newly created *Soprintendente per gli Scavi e i Monumenti di Roma* continued the excavation at Ostia in 1871 under Pietro Rosa, offering work at Ostia as paid employment for the residual population of revolutionaries remaining in Rome.[36] Despite Rosa's zeal to continue revealing portions of Visconti's unexcavated structures, his exploration of the northern limit of the city weakened the riparian bulwark, and caused irreparable riverine damage to numerous structures. As opposed to Rosa's almost complete lack of recording, Rodolfo Lanciani took over the Ostia excavations from 1877 until 1889, together with his meticulous system of recording. Lanciani identified the serious temporal discontinuities present in the levels of excavation of the structures at Ostia and attempted to connect these discrete trenches. Luigi Borsari and Giuseppe Gatti performed several emergency trenches between 1897-1905 to deal with flooding events of the Tiber. Following this short intermediate period came the tenure of Dante Vaglieri in 1907, who directed more care at individual structures, especially in the area north of the Decumanus from the Porta Romana to the Caserma dei Vigilies.[37] After Vaglieri's sudden death in 1912, Ostia became a thoroughly "modern" excavation site with a team composed of Guido Calza, Italo Gismondi, and Raffaele Finelli.[38] Calza continued the meticulous work of Vaglieri until the pace of excavation sped up dramatically during 1938-

31 Heres 1998, 143: CIL XIV, 105 for Ostian inscription in Florence's cathedral in 1296, and for the cathedral of Amalfi (S. Andrea) in the 13th century (CIL XIV, 430); Meiggs 1973, 102.

32 Rinaldi 2012, 2, Fig. 1 for a detailed overview of Ostia's excavation history in the 19th century.

33 Marini-Recchia *et al*. 2002, 250 focuses on the 18th century excavation of Ostia.

34 Marini-Recchia *et al*. 2002, 259. Much of the material from Pacca's villa ended up in the collection of the wealthy Viennese Trau family, which sold most of the works in 1937 to various museums and private collectors.

35 Marini-Recchia *et al*. 2002, 261. These letters contain valuable historical data, such as the yearly organization of a group of prisoners brought from Rome to work on the dangerously malarial site in return for a reduction in their sentence.

36 Rinaldi 2012, 3.

37 Olivanti 2002 describes the recycling of excavation spolia for *bonifica* drainage projects of the malarial swamps around Ostia; Paribeni 1916 continued this trend, sending soil from the temple of Hercules ("Volcano") to Rome for road building and other infrastructure projects.

38 SO 1, for Calza's personal description of his sudden change in role, and the continued assistance of the site's excavation supervisor, Roberto Paribeni. The creation of ceramic storage, an on-site library, and archives were cutting edge at the time and continue to be a trove of information for modern researchers.

2 – RAFFORZAMENTO DELL'ARGINE DEL TEVERE CON TERRA DI RISULTA DEGLI SCAVI

Figure 1.1: Reinforcement of the Tiber's south bank using soil and material from Calza's excavation, with Ostia´s Capitolium in the background (SO 1, Tav. XIII).

1942, when Ostia was planned to play an important role in Mussolini's *l'Esposizione Universale Roma*, which ironically never occurred.[39] As a metaphor for bringing life back to the city, he wished that *"Nelle antiche fontane tornerà a scorrere l'acqua…"*.[40]

The removal of much Late Antique and Republican material dates to this period, as the 2nd century CE habitation level was considered more reflective of the Fascist interpretation of the mores and accomplishments of Roman antiquity (Fig. 1.1).[41] Ostia was slated to act as one of many Roman sites portraying an Italy poised between Roman glory (*romanità*), and the Fascist desire to expand upon this version of the past for future success.[42] Calza's work remains a benchmark in all studies of Ostia, yet the excavation and mimetic reconstruction that occurred under his guidance must be seen as one of the most dramatic post-depositional event to have occurred at the site.

After the Second World War, Ostia developed into an archaeological site researched by numerous foreign teams together with the cooperation and assistance of the *Soprintendenza*. Various smaller-scale excavation projects have been carried out, and the past two decades have witnessed a swath of non-invasive surveys, which demonstrate the incredible distribution of structures within the city wall and beyond in every direction, including the north bank of the Tiber.[43] This brief overview of Ostia's excavation history shows the diverse research agendas and historical forces that have been at work in the recent past. These have dramatically impacted the preservation of hydraulic evidence from the city, as the majority of lead pipes known from previous excavations were rarely recorded, or if so, were recorded without proper context. Along the same lines, the wider scholarly distaste for ancient sewer systems stunted the growth of this discipline until relatively recently. The present study offers a *status quaestionis* on the hydraulic

39 Bakker 1987 provides eye-witness testimony of this excavation from a surviving excavator from this period; Calza 1940a, 39; Calza 1938 (GdSc 25, 2 (3-10-1938)): *"In seguito al lavori dell'Esposizioni Universale, sulla zona Ostiense, il Duce ordina il proseguimento degli scavi di Ostia, affinche la zona del mare e la cittá antica riacquistano il loro splendore"*; Giardina & Vauchez 2000, 234.

40 Calza 1940a, 39.

41 SO 1, 44-52 for Calza's decisions on striking a balance on what to excavate, remove, or preserve while excavating 18 ha and 600 thousand cubic meters of soil in four years.

42 Nelis 2011, 136: especially through the increasingly standardized glorifications of archaeological discoveries in the pseudo-scientific journal *L'Urbe* from 1936 onwards.

43 Cébeillac-Gervasoni *et al.* 2006, 138-142 for epigraphic evidence on Ostia's Tiber bridges found by modern dredging; see Heinzelman 2001, *ibid. et al.* 2002 for preliminary results, although it is unclear at the time of writing (ca. 15 years after the geophysical fieldwork), whether a final publication is still forthcoming; Sonnemann *et al.* 2015 for a geophysical study of the unexcavated area directly bordering insulae IV, ii-iv.

evidence of Ostia, and builds upon this rich research tradition to combine many discrete elements of the city's water system.

1.4: LANDSCAPE

Ostia is located about 23 km west from Rome, or a five hour walk along the ancient Via Ostiensis toward the seaside. Water surrounded Ostia in nearly all directions, and offered a changing combination of hydraulic opportunities and challenges, with abundant ground water but frequent flooding. Marine erosion beginning after the 8th century BCE eroded the coastal sand ridges, which caused the coastal freshwater delta to become brackish in the 6th century BCE.[44] Salt water depositions created ideal conditions for the development of the chain of *stagno Ostiense* marshes and rampant malaria, which persisted into the early 20th century. This coastal formation process also created the underlying topography of Ostia, as a cluster of low alluvial mounds that rose only a few meters above sea level.[45] These mounds are located at the confluence of the ca. 400 km long Tiber River and the Mediterranean Sea. However, anthropogenic and tidal forces caused the yellow silt ejected from the river to inhibit the harbor capabilities of Ostia already by the 2nd century CE, and pushed the modern coastline 4 km away from the ancient city.[46] The orientation and location of the ancient coast can be seen today in the position of the modern highway leading to Rome's main airport, Fiumicino. The topographical choice of the city must also have been augmented by the abundance of high quality groundwater, easily accessible through the alluvial soil of the Tiber delta (Fig. 1.2).[47] Like numerous other coastal Mediterranean cities, the site-selection process of Ostia allowed the city to take advantage of both its natural resources and economic capabilities.[48] About 13 km south-east of Ostia, the limestone deposits of the Malafede hills are rich in natural springs,[49] which were later tapped for aqueduct lines to Ostia, Portus, and the villa communities to the south.[50]

Ostia was always a city with water at the core of its identity. Its location beside the Tiber and on the Mediterranean coast afforded it the opportunity to work together with these natural forces for its urban growth and to develop its Mediterranean wide connections. The Tiber continued to experience dramatic flooding events, especially as a result of the widespread agricultural development of land along the upper course of the river.[51] This powerful river acted as an important economic and communication route between Ostia and Rome, while equally inflicting severe flooding events on both of these cities well into the mid-19th century. While this topic has garnered several specialist monographs for Rome, Ostia has not received similar fluvial attention, although it has been suggested that flooding was responsible for the widespread redevelopment of the area north of the forum, or for the successive raising of discrete areas of the city over time.[52]

1.5: URBAN DEVELOPMENT OF OSTIA

A brief description of the urban development of Ostia must be prefaced by two salient points. The first relates to the incredible distribution of unexcavated structures suggested by recent geophysical surveys on both sides of the Tiber.[53] These demonstrate that a serious revision or at least re-conceptualization of urbanism, movement, and economy in Ostia is

44 Belotti *et al*. 2011, 1112.

45 Arnoldus-Huyzendveld & Paroli 1995, 2014 for the coastal dynamics around Ostia; Jansen 2002, 124.

46 Verg. *Aen.* VII, 31 "*multa flavus haerena in mare prorumpit*"; For detailed geoarchaeological studies of Ostia's river harbor basin see Goiran *et al.* 2014; Hadler *et al.* 2015; Salomon *et al.* 2018; Vittori *et al*. 2015; Pepe *et al*. 2016; Wunderlich *et al.* 2017.

47 Mastrorillo *et al*. 2016 for a recent update of Arnoldus-Huyzendveld & Paroli 1995.

48 Crouch 2003 for a geologically focussed approach to Greek and Roman urban site-selection.

49 Bedello Tata *et al.* 2006; Carlut *et al.* 2009; See Sürmelihindi & Passchier 2013 for a detailed overview of the formation process of sinter ($CaCO_3$) in Roman channels.

50 Grandi & Pellegrino 2006, 496-500; Lauro 2006, 501-506.

51 For Roman rivers and flooding: Aldrete 2007; Campbell 2012; Wilson 2008 argues that agricultural expansion and deforestation along the Tiber valley promoted flooding events; Miliaresis 2013, 288 gives a contrary view based on a calculation of the required timber for bath buildings. Calenda *et al.* 2009 for the 19 m tall *muraglioni* built between 1880-1890 to redirect the Tiber's flood waters, which can reach a height of 17 m a.s.l.

52 DeLaine 2002, 71; Hori & Lavan 2015, 626-632 use the elevation model produced from laser scanning data to hypothesize about the effects of Tiber flooding across Ostia's low relief.

53 Stöger 2011, 215-219 for an incorporation of geophysical data into the study of movement patterns in the intramural area of Ostia; Pellegrino *et al.* 1995 for the area within the original oxbow of the Tiber.

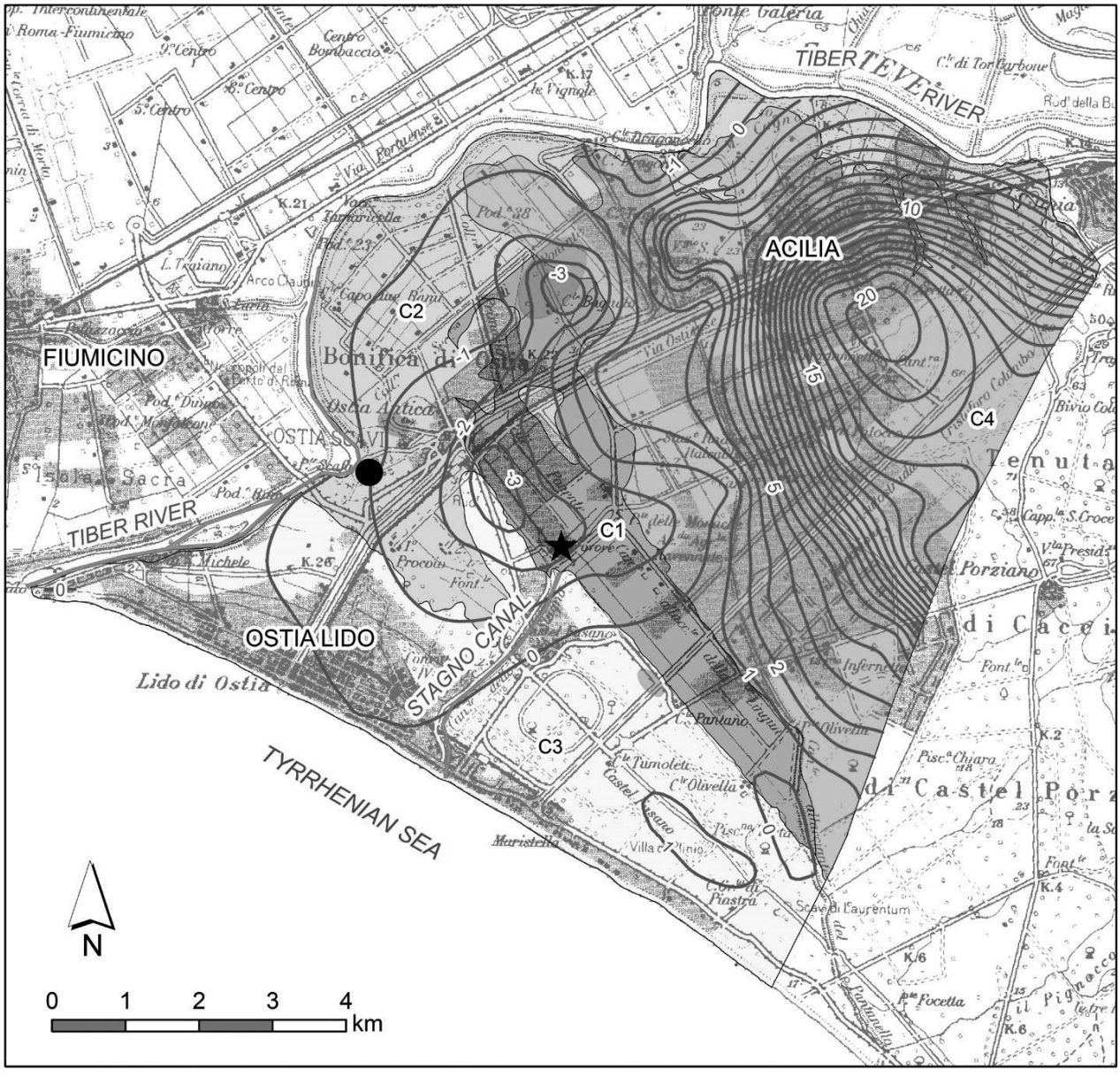

Figure 1.2: The hydrogeological composition of Ostia and the surrounding area. The archaeological site of Ostia is indicated by the dark circle (Mastrorillo *et al.* 2016, 37, Fig. 2).

necessary. The amount and location of currently excavated structures must be seen only as a minimum percentage of the ancient city, and cannot be securely used as a basis for population figures, resource usage volumes, or economic definitions.[54]

Secondly, as discussed above, the excavations between 1938-1942 represent a very distinct idea of how a Roman city *should* have looked at a very static moment in time by creating an ahistorical amalgam of Trajanic, Hadrianic, and Late Antique buildings. While wide swaths of the city were revealed that would not be visible today, equally large quantities

54 Wilson 2014 critically examines the dangers of proxies in shaping our perception of the Roman world.

of architectural and archaeological material were discarded, following contemporary political forces and archaeological practices. This point is not made to sentimentally cringe at the archaeological practices of the past, but rather to make clear that the visible urban evidence from Ostia is as much a product of 20th century perceptions and reconsolidations as the depositional processes of *la vita quotidiana*.[55]

Ostia originated as one of several Roman littoral fortifications to defend the burgeoning military and economic networks of the city of Rome in the early Republican period. The oldest evidence for settlement in the area comes not from Ostia, but from the site of Ficana, slightly further inland than the river estuary, with a small settlement and necropolis dating to the 2nd half of the 4th century B.C.[56] There was a distinct need for the establishment of *coloniae maritimae*, given the contemporary power of the Syracusan fleet, which had recently sacked the Etruscan city of Pyrgi and blocked the establishment of a Roman colony on Sardinia.[57] Although ancient literary sources continued to attribute the founding of Ostia to the legendary king Ancus Marcius in the 7th century B.C.,[58] the tufo blocks of the initial *castrum* and the associated ceramic material suggest a construction date in the late 4th century B.C.[59] This coastal defense was previously organized by the harbors of the cities allied to Rome, and the Ostian venture was organized by the *duoviri navales* from Rome in 311 B.C.

The rectangular *castrum*, or military fort of Ostia, was laid out along pre-existing coastal communication routes, with the Cardo Maximus aligning with the road to the Ager Laurensis to the south (Fig. 1.3). The oblique line of this road continued toward the mouth of the Tiber through the city along the later Via della Foce. The Decumanus was connected to the road leading from Rome to the Mediterranean Sea, which later became the Via Ostiensis. This road crossed the marshes that continued to border the eastern side of the city, despite several ancient land-fill projects with material from Rome.[60]

The creation of the office of *quaestor Ostiensis* in 267 BCE. highlights the growing localized power (or at least organization) of the fleet necessary for the ensuing Punic Wars.[61] Following these wars, Ostia had the opportunity to develop its commercial activities, profiting from the much-needed grain and slaves (among other goods) flowing through its harbor from Sicily and Africa. The civil wars that tore across Italy in the 1st century B.C. were not kind to Ostia, and during the campaigns of Sulla, a perimeter wall enclosing 69 ha was created, between 63-58 BCE.[62] These walls became a statement more of civic pride than strictly defensive structures.[63] It was not until the late 1st and 2nd centuries CE. that the urban infrastructure of Ostia began to develop more rapidly, experiencing a building boom. A large number of bath buildings, grain storage (*horrea*), religious buildings, and multi-story domestic structures date to this period of prosperity for the city. It is also the period best represented by the current state of archaeological preservation at the site.

55 The work on Mussolini and his *disiecta membra* approach to Roman archaeology is vast. For a contextualized approach see Giardina & Vauchez 2000, 212-13; SO 1, 40 for Calza's statement that even though the war efforts accelerated excavation at Ostia, they were done "*con criteri rigidamente scientifici*".

56 Zevi 2002, 16.

57 De Ligt 2014 discusses land division strategies of Rome's early maritime colonies, and the privelege of *vacatio militiae* (exemption from military conscription) allowed only to Ostia and Antium during the Second Punic War (Liv. 27, 38); Sewell 2014 for an updated assessment on non-Roman (i.e. Macedonian) influences for Rome's first colonies; Diod. Sic., XV, 27, 4.

58 The list of ancient sources referring to Ostia's foundation is numerous and a selection is given here to demonstrate the temporal breadth and recurrence of this perception: Cic. *Rep*. II, 3, 5 and II, 18, 33; Dion Hal. *Ant. Rom.* III, 44, 3; Enn. *Ann*. 2, fr. 22; Festus, *Gloss. Lat.* 214; Florus I, 4; Livy I, 33, 9; Pliny *HN* III, 56; Strabo, *Hist.* V, 3, 5. Epigraphic evidence at Ostia also reflects the attribution of the city's founding to Ancus Marcius, e.g. CIL XIV, 4338.

59 Adembri 1996 for the 4th century ceramics (Faliscan, Etruscan, Attic); Martin 1996 for an excavation underneath Ostia's *castrum* walls; Cornell 1995, 321 dates this material between 380-350 B.C.; Sewell 2010 for a wider Mediterranean context of urban planning, beyond a linear Greece-to-Rome model; Sole 2002 for an overview of Republican structures in Ostia; Zevi 1996, 70 dates the castrum to 300 BCE.

60 Much of this overview is based on Meiggs 1973, 21; Tac. *Ann*. XV, 43, 3 for material from the 64 CE fire dumped in the marshes; Tac. *Hist*. IV, 53 for material from a Vespasianic rebuilding of the capital also dumped here.

61 This office is referenced in the mid-1st B.C. inscription of P. Lucilius Gamala (CIL XIV, 375); Cicero (*Mur.* XVIII), defines this Ostian position as undesirable and lacking any real glory or importance (*non tam gratiosam et inlustrem quam negotiosam et molestam*).

62 Zevi 1996, 89 dated these walls to the activities of Cicero, and not to Sulla, as was previously believed.

63 For the symbolic nature of late Republican and early Augustan fortification walls, see Gros 1992, 223.

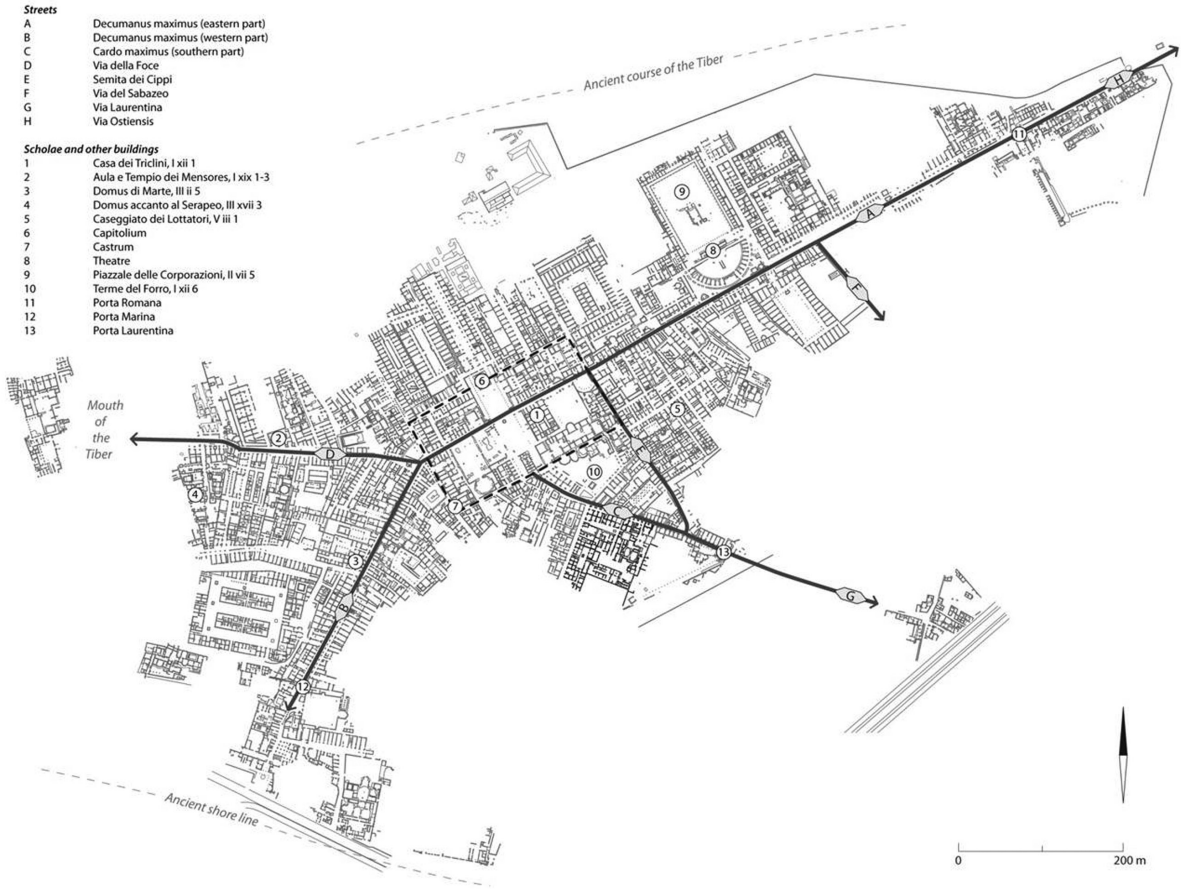

Figure 1.3: Plan of Ostia's excavated structures (Stöger 2011, v, Fig. 0.1).

Already in the early 2nd century CE, the Tiber delta's progradation and the creation of Portus a short distance to the north dramatically reduced the initial *raison d'etre* of Ostia. However, Ostia and Portus functioned together, and their architectural and cultural interconnectivity is being further brought to light by recent work at Portus.[64] As the city moved into the 3rd and 4th centuries there was a final push of urban development, although on a reduced scale, demonstrated by the erection of statues in the forum and the creation of new private and public buildings. From the 3rd century until the 6th century CE, Ostia witnessed several Christian martyrdoms, as well as the death of Monica, the mother of St. Augustine.[65] Christian dedications continued into the 6th and 7th century CE, although Procopius noted the declined character of the city during the Justinianic wars.[66] The integration of Christian festivals with pre-existing Ostian festivals and

64 Bruun 2002 for the *portus utriusque* discussion; Keay *et al.* 2014a combines satellite imagery with ground penetrating radar to highlight the potential for non-destructive research methods at Portus.

65 August. *Conf.* IX, 11, 27 for Monica's death in CE 387 while waiting for the ship to Hippo; To relieve himself of grief, Augustine offers an unexpected etymology of the Greek word "*balneon*", which he sees as meaning "a place for staving off grief"; Boin 2013, 212 for martyrdom of Cyriacus and Aurea; Cébeillac-Gervasoni *et al.* 2006, 152 offer a brief discussion of this inscription; Meiggs 1973, 475, found some truth in Augustine's etymology, with an inscription at the Forum Baths that named a basin as a "λουτρον ἀλεξιπονον", or "a basin for driving away grief".

66 Procop. *Goth.* I, 26,7-13; V, 26, 8-19; VI, 7, 1-3.

Figure 1.4: The Battle of Ostia, as painted by Raphael. The Borgo is depicted in the left of the painting in its position directly on the Tiber River.

games testifies to the dynamic cultural landscape of the city, although interestingly, none of the temples of Ostia were converted into Christian churches.[67] A Christian basilica was built in the south-eastern part of the intramural area of the city, confirming written sources that Constantine had done so.[68] The Christian community slowly moved south-east of the long defunct Republican walls and around the church to the drowned St. Aurea, martyred under Claudius Gothicus (CE 268-70).[69] This church became the focal point of the settlement clumsily named after Pope Gregory IV (r. 827-44 CE): Gregoriopolis. As a final moment of historical glory, Ostia was home to the CE 849 battle where the Aghlabid Saracens of North Africa and Sicily attempted a sea battle against an Italian coalition force (including Pope Leo IV), but were destroyed by a storm; the violent scene was later immortalized by Raphael in a fresco in the Vatican Museum in Rome (Fig. 1.4).[70] The fortification of Gregoriopolis was rebuilt between 1503-1513 by Pope Julius II. A major earthquake in 1557 shifted the course of the Tiber about one kilometer to the north, rendering the tower useless for defensive purposes.[71]

67 Boin 2013, 237; Prudent. *Perist.* II, 353-56 for local religious tension at Ostia over the traditional worship of Vulcan; see Bruun 2012a and Rieger 2004 for a discussion on the pagan-Christian religious interaction in Ostia.

68 Heinzelmann *et al.* 1997 for the basilica near the Porta Sabazeo; for a detailed discussion of the mis-attribution of the Constantinian basilica to III, i, 4, see Chapter 3 in this work.

69 Bauer 2003, 54 for the martyrdom of St. Aurea.

70 Located in the *Stanza dell'incendio del Borgo.* The prisoners captured from this battle built the Leonine wall of Rome, incorporating the Vatican into the Aurelian fortification of Rome.

71 Pepe *et al.* 2016 carried out pollen coring of the previous oxbow of the Tiber, known as the "Fiume Morto".

1.6: OVERVIEW OF OSTIAN WATER INFRASTRUCTURE

The water systems of Ostia were built almost continuously over the city's life, however the system as a whole can be divided into four major phases, when large-scale additions or transformations took place.

1.6.1: 4TH CENTURY BCE- 50 CE

The initial castrum settlement was furnished by wells dug into the groundwater stratum, which can fluctuate up to ca. >0.5 m a.s.l. (Fig. 1.5).[72] Several of these wells exist in the Republican houses built in Regio I and many coeval wells distributed through the city were subsequently raised over the centuries.[73] Adding to this, we can imagine water from the Tiber itself being used for many purposes, although one wonders at the water quality downstream from Rome, where the majority of urban waste was dumped (e.g. corpses, industrial waste, latrine effluvia).[74] Yet, we must suspend modern biases placed upon the perception of water quality, especially when considering the often conflicting ancient sources that discuss the perception and subdivision of water for different purposes.[75] River water of a quality far below modern (i.e. Western, urban) hygienic standards was used until relatively recently in many global cities, and in many places still is. Larger industrial structures and bath buildings continued to run on groundwater throughout the complete history of Ostia, although few bathing structures survive from the early imperial period outside of structural fragments.[76]

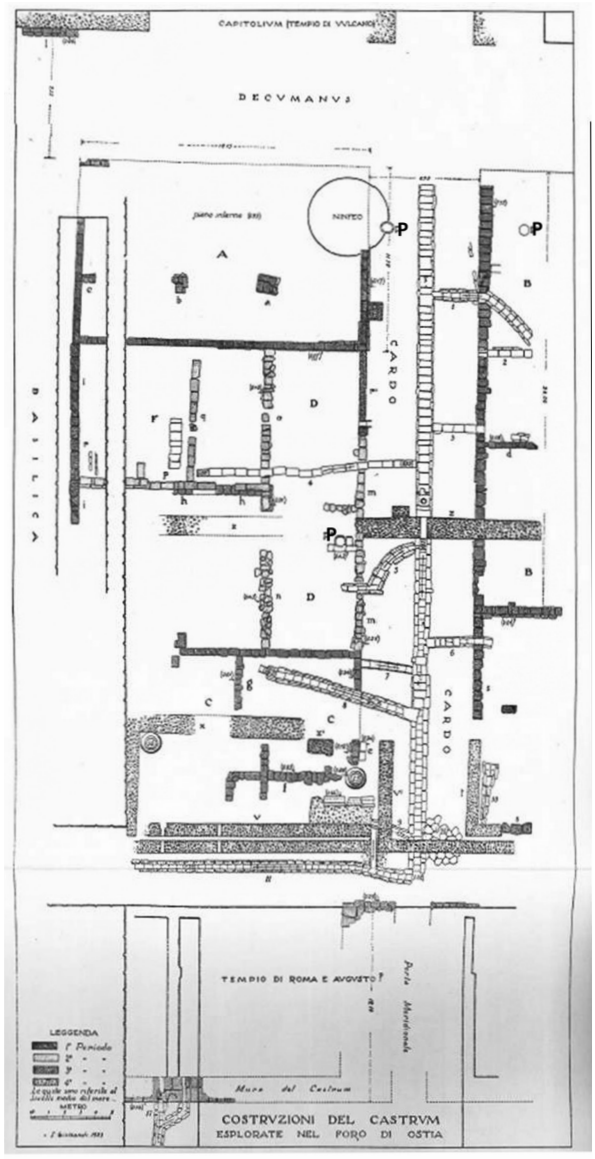

Figure 1.5: Republican wells (indicated by "P") and sections of sewer system identified in the southern part of Ostia's forum (SO 1, Fig. 21). This sewer drained to the south, under the castrum gate.

1.6.2: 50-200 CE

The first half of the 1st century CE saw a dramatic turn for the hydraulic possibilities of the city, as the first aqueduct line was created, drawing water from the Malafede hills ca. 13 km to the east of the city. Evidence for the oldest piped water into Ostia

72 Mastrorillo *et al*. 2016, 36 for a study of the piezometry, or underground dimensions of the groundwater reserve at Ostia.

73 e.g. RS I, 21-27 (sch.1-10).

74 Gal. *De alimentorum facultatibus* III, 29, 722 on the poor quality of fish downstream from Rome.

75 For appreciating diverse definitions of "clean" and "dirty" water, see Kamash 2008 and Rogers 2013; Frontin. *Aq.* XCII for different types of water quality and usage in Rome.

76 The Terme delle Provicie under the Via della Vigile gives an indication of the ground level change at this moment (ca. 1. m). The palaestra of the Terme di Nettuno (II, iv, 2) lies ca. 2 m above an earlier monumental cistern.

comes from an inscribed lead fistula pipe from the so-called Macellum (IV, v, ii), which mentions C. Cartilius Poplicola and an associated *balneum*.[77] This indicates that there was flowing piped water in Ostia already from the late-Augustan period. Repair to this first line was undertaken by Vespasian, recorded in a monumental inscription.[78] As this study examines structural and systemic changes to the urban hydraulic system, it does not begin with the earliest evidence, but slightly later, with the creation of the monumental cistern (*castellum aquae*) next to the Porta Romana. Other large cisterns were built in the early 1st and early 2nd centuries CE that were connected to the aqueduct lines, and acted as localized distribution points for various hydraulic needs. The archaeological remains suggest two separate lines to the city at this time, contrasting with the earlier interpretation of a single line based on the tall brick arches preserved next to the Forum Baths.[79]

While the larger hydraulic structures of Ostia received varying degrees of attention as they were discovered, a substantial number of inscribed lead pipes were originally disposed of without much documentation. These pipes (*fistulae*) constitute an important micro-scale level of information regarding urban water distribution, and where present can offer epigraphic information regarding ownership, individual workshops, or the official responsible for the supply.[80] A sewer line was installed in the 1st century CE, although little is known of this system beyond scattered marble manhole covers and dispersed sewer sections.[81] Only a rough trajectory of its path is known. Branches of this sewer system were created at moments when large areas of the city were raised. An extensive sewer system would have been necessary for waste removal, as the soft underlying geology and the high level of ground water would have ruled out the use of cesspits like at Pompeii. Ostia's sewer likely flowed out in several different directions, taking advantage of the underlying micro-topography of the city. One branch led to the Tiber as the Cloaca Maxima did in Rome. Although this would put the city at risk of severe sewage problems during flooding, it seems that such an issue was considered a normal part of urban life, if we observe the literary and archaeological evidence of Rome's attitude to flooding (Fig. 1.7).[82] Recent excavations in Ostia's river harbour have confirmed this idea, identifying a sewer drain blocked with the same fill material as the harbour itself.[83] Additional sewers along the periphery of the city support this multi-directional solution to the lack of topographical relief within the city.[84]

1.6.3: 200-300 CE

The 3rd century, but especially around the time of the Severan emperors, witnessed many large-scale changes at Ostia. The extramural arches visible to the east of the city are remains of the aqueduct line created in the 3rd century CE. About a dozen brick piers survive directly to the east of the Porta Romana *castellum*, and several arches are preserved in the Medieval Borgo.[85] The oldest historical description of this final aqueduct line comes from notes made by Pope Pius II (r. 1458-1464 CE), who described the incorporation of the aqueduct line into the reconstruction of the nearby medieval Borgo, as well as where the remains of arch bases made contact

77 CIL XIV, 4711.

78 For the inscription see Cébeillac-Gervasoni *et al.* 2006, 147: Imp(erator) Caesa[r Vesp]asianu[s Aug(ustus) pont(ifex) max(imus) trib(unicia) pot(estate)/ VIII imp(erator) XVI[I(?) p(ater) p(atriae) co(n)s(ul) VIII] aquaeductus in colonia ost[iensi---].

79 Bukowiecki *et al.* 2008, 51 for a helpful chart of the different aqueduct lines constructed at Ostia.

80 Bruun 1991, 70 for difficulties in interpreting the epigraphic and prosopographic data on lead fistulae.

81 A growing body of evidence suggests that the position of the marble manhole covers and street-slopes identified by Jansen 2002 can no longer be taken at face value, as the majority of Ostia's streets are now thought to have been completely re-laid in the 20th century.

82 Aldrete 2007, 126, 142, 204-229 outlines the presence of contemporary Roman technology to avert the reintroduction of the daily 50, 000 kg of human waste and immense volume of sediment (10.6 million metric tons per year) into Rome during a flood but the lack of action; Pliny *HN* 36, 104 on the Cloaca Maxima backing up during a flood. Hori & Lavan 2015, 627, Fig. B7 for projected depth of floods in Ostia's forum.

83 Heinzelmann 2001, 324; Heinzelmann & Martin 2002, 8 for a sewer line sloping down toward the river harbor basin with the same sedimentation stratigraphy as the basin itself.

84 Bukowiecki *et al*. 2008, 92 for a sewer in the city gate south of the Porta Romana castellum; David *et al.* 2014 for a sewer section in the Terme del Sileno along the ancient shoreline outside the Porta Marina.

85 Bukowiecki *et al*. 2008, 170: this aqueduct line is more precisely dated to the Severan period; RS I, 91, Fig. 129, 130; The brick piers are heavily overgrown, yet accessible if one ventures through the densely forested area south of the Via delle Tombe. Several aqueduct arches are incorporated into the east side of the convent of the Sant' Aurea church, and are visible from the Via Gesualdo in modern Ostia Antica.

with the Republican city wall.[86] Many bath buildings were repaired in this period, and others show signs of modification, especially with the creation of apsidal rooms and smaller basins. A little studied feature of Ostian hydraulic architecture are the rectangular or semi-circular shafts which run vertically within the walls of many structures.[87] No cohesive typology of these exist, but the shafts have been discussed recently in relation to toilets and kitchens on upper floors, as well as for the drainage and collecting of rainfall (Fig. 1.6).[88]

However, the presence of calcium carbonate (sinter) accumulation in only some of these may point to another usage. The accumulation of sinter is a proxy for the concentrated and long-term presence of water flowing from limestone sources (e.g. aqueducts), with sinter well-known from not only the large cisterns at Ostia, but from aqueducts across the Roman world.[89] Although sinter can form by leaching trace elements of calcium out of mortar and other building material, the amount of eroded mortar necessary to form such thick deposits would surely leave a clear absence from the building's structure.[90]

Within Roman domestic and public structures, drains were not divided into used (grey) water and other categories of waste water. Thus, it is surprising that sinter would accumulate only in certain corners of (some of) these shafts if they were merely open vertical drains for mixed waste, or mixed types of water. In Pompeii, several masonry piers with embedded rectangular recesses have been securely identified as supporting small, localized *castella aquae*, maintaining water pressure through a system of inverted-siphons and distribution basins.[91] Discussions pertaining to the presence of piped aqueduct water on upper floors often rest on height calculations of the terminal channel (*specus*) of a city's aqueduct line. However, Roman water technology was not so rigid and inflexible. Ostia has several medium sized bath buildings supplied by ground water, which was elevated by water wheels or norias. Thus, we should not be surprised to find

Figure 1.6: Examples of a down-drain extending above the ground floor in the Caseggiato dell Serapide (III, x, 3), which still contains a circular ceramic pipe within the masonry shaft.

86 Olivanti 2006, 511-517 for the 1547 map of Eufrosino della Volpaia showing the aqueduct piers following the road from Ostia to Rome.

87 DeLaine 1997, 153 calls these "down-drains", and suggests a Flavian origin of these features.

88 Andrews 2006, 52-62 provides a thorough analysis of the development and function of upper-floor rooms in Herculaneum; Stevens 2005, 119 interprets the external recesses for supply and internal recesses for drainage; Trusler & Hobson 2017 give a well-structured analysis of these down pipes in Pompeii.

89 Grewe 2015, 290-383 describes the use of sinter as a building material instead of marble in dozens of churches in Germany, the Netherlands, and even in England where it was used to pave part of the floor in the Canterbury cathedral.

90 Andrews 2006, 59 offers this unconvincing mortar-leaching hypothesis in his study of vertical pipes in Herculaneum.

91 Ohlig 2001, 352; Peleg 1996; Peleg 2006 for studies of this inverted siphon technology.

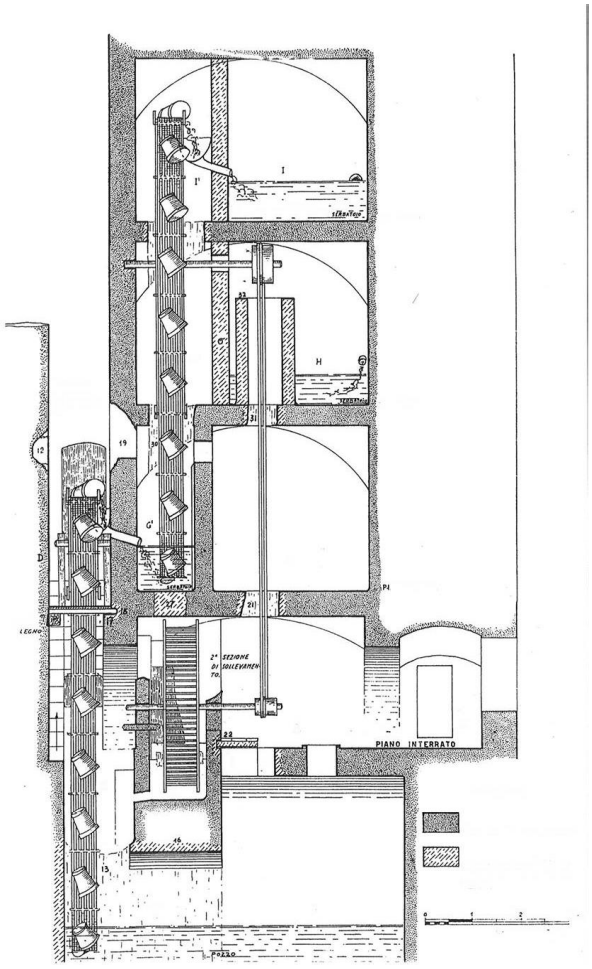

Figure 1.7: Multi-level noria of the Terme della Mitra (I, xvii, 2) at Ostia, with a total height of ca. 15 m (RS I, 155, Fig. 236).

independent pressure systems created within a city, independent of the initial aqueduct channel's height (Fig. 1.7).[92] This suggests a re-framing of how we view life on upper-floors of Roman buildings, especially the large city blocks known in many parts of the Roman Empire.

1.6.4: 300-600 CE

Throughout the dynamic urban developments in Ostia, water was used, recycled, and wasted in a variety of culturally defined ways, reflecting an acute awareness of not only the value of water, but also the diverse possibilities for its reuse. The continuing modification of the water supply system of the city is mirrored in the continual creation and rebuilding of the city's numerous bath structures, which persisted well into the 4th and 5th centuries CE.[93] From the 6th century onwards, the aqueduct lines slowly fell into disrepair, and the population returned to provisioning themselves from the abundant ground water supplies, which in fact had never been absent from the city's landscape.[94] In the late 6th or early 7th century CE a fountain house was built in front of the theater along the Decumanus, under the arch of Caracalla, and augmented by an honorific plaque to St. Cyriacus, an early bishop of Ostia.[95] The creation of public amenities remained an expression of power, now manifested by local bishops or the Pope.

This broad overview of Ostia's urban and hydraulic history has shown that water was anything but static in the life of the city. Habits, objects, and buildings related to water supply, usage, and drainage were constantly changing and reacting to each other. Ostia was a watery city, yet despite this abundance of waters, the inhabitants developed many nuanced approaches to managing and interacting with different types of water. With this background, the challenges of identifying and interpreting traces of water in Ostia's urban fabric can now introduced.

1.7: DATA COLLECTION

This study began initially by recording the existing hydraulic features that have left physical traces within the excavated urban area of Ostia. Three city blocks of Ostia (insulae III, i; IV, ii; V, ii) were chosen as case studies in order to give a representative sample of the hydraulic changes made over time in the city. The main difficulty with this process is the absence of high-resolution chronological data for many structures. However, the choice of which

92 Bukowiecki *et al.* 2008, 157 for detailed heights of the aqueduct at the Porta Marina castellum.

93 August. *Conf.* IX, 12, 32 for Augustine visiting a bath building in Ostia to deal with the recent death of his mother, Monica; Poccardi 2006, 228-235 for these Late Antique baths.

94 RS I, sch. 21a, 21b, pp. 36-37 for the roughly built wells located in the middle of the Decumanus Maximus, with serious implications for urban movement.

95 CIL XIV, 5232.

Figure 1.8: Example of hearty plant growth at Ostia, on the Via della Casa del Pozzo.

city blocks to investigate was guided by pre-existing research. The three city blocks selected have been published to an increasing level of detail: insula III, i is the least published, insula IV, ii has been more thoroughly researched, and insula V, ii is published in the greatest detail.[96] This also presents a feasibility test for the methodology introduced in the following chapter, to prove its functionality with different quantities and qualities of input data. The preserved water features range in size from individual lead pipes to monumental bath buildings, and detailed information on individual drains, pipes, and basin in each insula may be found in Appendix 1. In addition to identifying previously unpublished water features, numerous primary site visits to Ostia were essential to verify existing hydraulic features.

A singular obstacle to the detailed examination of the surviving structures is the plant-growth of Ostia, composed of wild fig and umbrella pine trees, tenacious vines, and wild fennel. Given the exposed nature of the city and its vicinity to the sea, these are ubiquitous and, in some cases, have completely obscured entire buildings (Fig. 1.8).

The author carried out a systematic visual analysis of the standing structural remains. Excavation was not carried out as part of this project, but the internal sections of channels were investigated where possible, by looking through the drainage covers of larger sewers: the entrance holes for water in these cover stones are often long and narrow (Fig. 1.9). An improvised and low-cost tool was utilized by the author to peer inside these channels, to ascertain their orientation, and in most of the cases, their internal composition and dimensions.[97]

A comment will briefly be made here of the difficulties in interpreting the archaeological evidence of Ostia based on the high amount of restored architecture within the city. For nearly every structure in Ostia, the architectural remains were carefully "fixed" or re-built during or immediately after their excavation. These 19th and 20th century skilled brick-layers and masons used ancient bricks and materials in these reconstructions, making the identification of the original aspects of any wall a challenge. A careful diachronic study of this mimetic restoration technique was lacking in Ostia until recently, and now offers a guiding hand to both new and seasoned researchers for interpreting the complex stratigraphy within the standing walls.[98] The difference between an original and ancient wall is possible by a detailed look at the size and color of the bricks, the composition and thickness of the mortar, and by identifying ancient brick stamps.

96 Major publications of each respective insula: III, i: Rose 2005; IV, ii: Stöger 2011; V, ii: Boersma 1985.

97 An extendable mirror of the type used for auto-repairs was extended into the underground sewer or drainage channels. By shining a flashlight onto the mirror, light was reflected into its dark spaces. Visual inspection could then ascertain structural characteristics of the sewers. A metallic measuring tape was then extended and wedged between the parallel walls of the channel to measure its dimensions.

98 Rinaldi 2012 for a detailed study of the development of restorations and heritage management at Ostia; Heres 1982 still remains a fundamental reference. Rinaldi 2018 for a detailed look at this process in the western part of the city.

Figure 1.9: Example of a man-hole cover at Ostia (in insula IV, ii, 1), with its lozenge shaped openings of ca. 3 x 10 cm.

In addition to the archaeological material, relevant literary descriptions of the city were examined for any mentions of local water features, although these rarely gave any direct reference to standing remains.[99] Epigraphic material on dedicatory plaques, statue bases, and funerary inscriptions are valuable troves of information that provide more detailed information on individual structures and on the urban water supply as a whole.[100] Beyond the primary material evidence from the site, this study incorporates archival material from earlier excavations of the site, including a detailed examination of the *Giornale di Scavi*, the unpublished daily notes of the site's excavation.[101] As the names of roads, buildings, and entire areas of Ostia changed during the decades, deciphering these notes can be a challenging but rewarding process. The photographic archives and office of plans at Ostia were equally important to this research, as they preserve evidence of lost or destroyed parts of the city. A database of known hydraulic features was created by combining the archival evidence with field survey and previously published material. This produced comprehensive distribution maps of water features within the studied insulae in Ostia, which were vital for understanding their temporal and spatial distribution.

1.8: INSULAE IN ROMAN CITIES

As the central case studies of this study are city blocks, or insulae, a brief mention will be made to define what constitutes an "insula". Although the term is used extensively by primary ancient sources, it can signify a wide range of architectural configurations, from a group of buildings bounded by streets, to a single multi-storey building, or even to a group of buildings within a city block. In reaction to the 2nd century CE population boom caused by the expansion of Portus, numerous multi-story insulae were created in Ostia to house the blossoming middle class.[102]

If we look at insulae in their single-structure form, the highest floors were in general poorly built, cramped, and often inhabited by the lower or middle class of Roman society. From Rome come the oft-quoted passages and seemingly non-functioning laws describing the slum-like nature of these structures that frequently collapsed or facilitated destructive widespread fires.[103] Wealthier people who also owned the street-front shops usually inhabited the lower levels of the building. There are of course notable exceptions to this trend, and the so-called *medianum*-style of insulae at Ostia have larger rooms and windows, private entrances, and wall paintings.[104] As for the larger spatial definition of insulae, we see a wide variation in the number and composition of structures within an area similar to what we would call a city block. There are about 70 insulae at Ostia, and they show a remarkable diversity in their contemporary styles,

99 August. *Conf.* IX, 23 for an unknown bath building in Ostia; *Dig.* VIII, 2, 13 for an Ostian bath building putting its hot *tubuli* pipes against a shared wall; Livy *Epit.* XXIV, 96 for a flood in Ostia.

100 Bruun 1998; Cébeillac-Gervasoni *et al.* 2006; Van der Meer 2012; CIL XIV, 4711, 1 for an otherwise unknown *balneum* at Ostia.

101 For the sake of convenience, the Giornale di Scavi is referenced throughout this work as "GdSc".

102 Juv. *Sat*. VIII, 171-76 for a (*popina*) portrait of an Ostian pub populated by assassins, coffin-makers, sailors, fugitives, and eunuch priests of Cybele; Juvenal describes the disgraceful nadir of a boastful high-class youth.

103 Strabo, 235 for 70 ft. max height of buildings in Rome.

104 DeLaine 2004; Gering 2002 on the Case a Giardino; Stevens 2005; See discussion on IV, ii, 5 below for a *medianum* style building.

functions, and internal layout.[105] Differing from our modern conception of the division of urban space, we see noxious fulleries next to whirring granaries, and inns sharing a courtyard with mystery cults. In this work, the term insula refers to a collection of buildings bounded together by roads, and that may be connected internally

From a hydraulic perspective, this diversity of structures makes for an interesting reaction to the quotidian needs in bringing, using, recycling, and removing water from any single structure. As discussed above, Ostia was a city with a great deal of flexibility in its choice of water sources, allowing property owners to freely sink one or more wells to reach the ca. 1-2 m groundwater level. Although most insulae had aqueduct-connected fountains, wells, or rainwater basins, many of the main streets had fountains located along their path and especially at intersections and gates.[106] Some of these barrel-vaulted fountains (bauletto) can still be observed in Ostia, together with rope marks on their travertine lips and overflow spouts with concave depressions for the collection of water (e.g. Case a Giardino: III, ix, xx).[107]

1.9: CONCLUSION

While the temporal development of this system will be elaborated upon in subsequent chapters, at this point it is the continuing flexibility of the hydraulic systems of Ostia that should be emphasized. There was never complete dependence on any one single form of water, but rather a range of options for dealing with domestic, religious, industrial, and entertainment needs, themselves dynamically changing together with the cultural composition of Ostia. With the site's historical and geographical background introduced, the subsequent chapter lays out the theoretical perspectives of this work, and introduces a new methodology for conceptualizing the water system of the three insulae under study. The archaeological and archival material follow this, building up to a final analysis that will change our conception of water in Ostia, presenting Roman cities as more flexible and opportunistic than has been previously believed.

105 Packer 1971 for the insulae of Ostia.

106 Meiggs 1973, 239, *"Water could not be piped to the upper floors, and tenants had to draw their supplies from a public source."*

107 RS II, Fontane sch.12, 14, 22, 34, 45(?), 53, 57, 59, 98, 106, 111, 119, 127, (n =14). For the concave depressions see Jansen 2002, 144.