



Writing, transmission, and the politics of knowledge in early modern handbooks of water management and hydraulics

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Abstract

This article analyses six handbooks of water management written by publicly employed hydraulic officials in Augsburg, Barcelona, Bologna, Florence, Naples, and Rouen in the sixteenth and seventeenth centuries. So far studied primarily from a local perspective, each of these handbooks has often been described as an exceptional source. By comparing them here for the first time, we argue instead that they formed an emerging genre in early modern Europe. This genre aimed at achieving status for author and discipline alike: by claiming a degree of specialisation and expertise, the hydraulic officials who wrote these six handbooks also claimed a degree of specialisation for their field, water management. We argue that the genre of early modern handbooks of water management has been overlooked in the historiography, and that a focus on it is useful to understand the emergence of increasingly specialised hydraulic experts and their body of knowledge about waters in early modern Europe.

Keywords

Practical knowledge, water management officials, environmental history

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¹ The article has been co-authored by all four scholars; names are accordingly listed alphabetically.

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1. Introduction

The early modern period witnessed a proliferation of technical writings in which artisans and practitioners systematically documented their crafts. These texts manifested a deliberate intent to render specialised knowledge accessible for the common good.² In 2015, Pamela Long pointed out that the content, reception, and use of these practical books, along with the literacy practices of the craftsmen themselves, remained significantly underexplored.³ Interest in early modern technical literature has since grown, with writings on agronomy, horticulture, botany, medicine, practical mechanics, mining, metallurgy, and navigation garnering particular focus.⁴ Writings on water management and hydraulics have also received some scholarly attention; Long herself has for instance studied a group of proposals for improving potable water supply and mitigating flooding in Rome. The authors of these texts, who were of diverse occupational backgrounds and primarily outsiders to the day-to-day management of the city's water systems, based their analyses upon an understanding of natural philosophical principles and ancient hydraulic engineering techniques.⁵ Less well-known, however, are the great many handbooks of practical water knowledge penned in this period by authors involved in the professional administration of hydraulic systems. We contend that this corpus is deserving of deeper analysis.

Bringing together several cases of water management handbooks produced in Europe between 1525 and 1650, this article represents a first attempt to define these sources as a genre and to examine them in a comparative perspective. We pay special attention to the motivations behind their production, the specificities of their various urban and hydrographic contexts, and the content and results of the writings themselves. Although some of the handbooks have long attracted historical attention, this has almost invariably been local and largely antiquarian in nature, focusing on their documentary value for reconstructing historical hydraulic systems, or treating them as archaeological and aesthetic artefacts. In recent years, scholars have begun to examine these texts from the perspective of the history of science and practical knowledge, and a few critical editions have been produced. This academic renewal, we argue, leads to an important revision: although these water manuals were often described as exceptional in local historiographies, our research

² Authoritative introductions to this phenomenon in early modern Europe remain Eamon, *Science and the Secrets of Nature*; Long, *Openness, Secrecy, Authorship*; Smith, *From Lived Experience to the Written Word*; and Zilsel, "The Sociological Roots of Science."

³ Long, "Trading Zones," 846.

⁴ Harwood, "The Green Revolution," 7–31; Savoia, "Skills, Knowledge, and Status," 27–54; Raphael, "Producing Knowledge about Mercury Mining," 95–118; Sánchez Martínez, "Artesanos, cartografía e imperio," 21–41. For an earlier study, see Ciriaco, "Trattati di agricoltura, di idraulica e di bonifica," 45–60.

⁵ Long, "Hydraulic Engineering and the Study of Antiquity," 1098–1138; Long, "Multi-tasking 'Pre-professional' Architect/Engineers," 223; Long, *Engineering the Eternal City*, 19–42.

suggests that they were probably standard administrative tools, and much more common than previously thought.

This does not mean that they were interchangeable: each of the handbooks under consideration refers to a unique, discrete system. Broadly speaking, our sources function as technical-administrative compendia. They detail the infrastructure, supply, and maintenance of specific hydraulic networks, transcending mere technical description to become applied treatises on, for example, pressure maintenance, flow optimization, and even the day-to-day social and political management of complex systems. But unlike contemporary treatises, which aim at a certain degree of generalization, our sources are very particular to the geographical, urban, and political contexts to which they refer. Indeed, they often integrate detailed cartography, scale drawings, and cleaning protocols. It is this how-to, hands-on approach which has led us to conclude that these sources are best described as “handbooks,” or “manuals.”⁶ Between these etymologically cognate terms, we prefer “handbooks” for its inclusion of the word “-book”: though of varying lengths, our sources all display some aspiration to participate in early modern literary culture.

In short, these handbooks sought to codify specialist, localised knowledge in writing. In some cases, they were commissioned by institutions; in others, the initiative came from the authors themselves. Although often addressed to colleagues or successors, they consistently constitute a form of social writing, a concept advanced by scholars such as Brodie Waddell and Jasmine Kilburn-Toppin.⁷ In her study of the texts of London goldsmiths in the sixteenth and seventeenth centuries, Kilburn-Toppin defines social writing as a modality in which individual and institutional voices are intertwined, as authors often combine the style of personal diary with that of institutional chronicle.⁸ In this sense, these works deepen our understanding of identity formation in the early modern period, particularly the articulation of an expert identity.⁹

Crucially, this articulation went hand in hand with the emancipation of expertise about

⁶ Long, “Manuals,” 589–593, discusses “handbooks” and “manuals,” which she treats as synonymous, as a genre that originated in the ancient world and proliferated during the early modern and modern eras. She assimilates under these umbrella terms the very kinds of early modern texts centred in scholarship on the formation of early modern practical knowledge: texts that were at the time called “books of secrets,” “books of art,” and “theatres of machines,” as well as ones that Long and other scholars have variously referred to as “craft,” “artisanal,” “technical,” “practical,” or “how-to” “manuals,” “handbooks,” “books,” or “writings.”

⁷ Waddell, “Writing History from Below,” 239–264; Kilburn-Toppin, “Writing Knowledge, Forging Histories,” 297–314.

⁸ Kilburn-Toppin, “Writing Knowledge, Forging Histories,” 297–314.

⁹ On the articulation by artisan-practitioners of an expert identity through writing, see Kilburn-Toppin, “Writing Knowledge, Forging Histories,” 297–314; Long, *Artisan/Practitioners*; Smith, *From Lived Experience to the Written Word*. On early modern expertise more broadly, see also Ash, “By Any Other Name,” 3–30.

water from other technical and administrative pursuits. Prior to the period examined here, hydraulic matters were typically treated in dedicated chapters in handbooks and treatises of architecture, engineering, mining, medicine, or domestic economy.¹⁰ During the sixteenth century, however, handbooks devoted exclusively to water management began to proliferate, reflecting a growing conception among their authors of the status of hydraulics as a separate discipline – notably prior to the emergence of a theory of hydrodynamics with the work of Benedetto Castelli – and of the specialist nature of their knowledge in this domain.¹¹ The specialisation of experts and of expertise was mutually reinforcing, and the handbooks we study are a testament to this process. By bringing to light a fervent culture of hydraulic authorship in the long sixteenth century, our article helps to show how the seventeenth-century shift toward a mathematical science of hydraulics did not emerge *ex novo* from a purely oral culture of practice, but rather on the heels of a longer set of efforts to empirically describe and codify the hydrodynamic principles of specific water networks.

The main objectives of this article are: to give visibility to this hitherto underexplored genre of sources, by bringing a set of them into dialogue with one another for the first time; and to begin the work of analysing this genre, by defining its nature of “handbooks” and some of its salient technical and political characteristics. We have selected six sources produced in different European cities between the sixteenth and seventeenth centuries. In chronological order, the first source is Jacques Le Lieur’s *Livre des Fontaines* (1525), written in Rouen. The second, produced in Augsburg, is Pilgram Marpeck’s *Bericht der Brunwerk* (1556). The third is Girolamo di Pace da Prato’s *Memoriale*, written in Florence (1558). The fourth, Tommaso Laureti’s *Instruttione*, was produced in Bologna (c. 1580). The fifth, a manuscript by Giovanni Antonio Nigrone, concerns the city of Naples (1585–1609). The sixth, Francesc Socies’s *Llibre de les fonts* (1650), was written in Barcelona.

In the next section we turn to each of these six sources, presenting their hydrographic and urban context, the identity of their authors and their motivation for writing, the contents and aims of the texts, and their reception by contemporaries and scholars alike. In the discussion, we argue that the authors’ decision to codify their hydraulic knowledge in writing is most significant. We account for this transition away from oral transmission towards the written word by considering handbooks of water management as technical *and* political texts, before concluding with some reflections on potential avenues for further research.

¹⁰ See for example Fouquet, “Wissen für die ‚schöne Stadt.’”

¹¹ This disciplinary consolidation was mirrored by a process of administrative specialisation: see for example Geltner, *Roads to Health*.

2. Handbooks of water management in early modern Europe

2.1 Jacques Le Lieur's *Livre des Fontaines*, Rouen (1525)

At the beginning of the sixteenth century, Rouen was among the main urban and commercial centres of the Kingdom of France. Situated near the mouth of the Seine, it served as both a sea and river port and an outport for Paris. Since the thirteenth century, the city's drinking water supply had relied on the Gaalor conduit, which carried water from a spring located in Mont-aux-Malades to Rouen's streets and squares.¹² In the first two decades of the sixteenth century, faced with population growth, the city council built two new water supply systems: the Carville conduit (c. 1500) and the Yonville conduit (c. 1510). Costs were shared equally with the Archbishopric of Rouen, and the new infrastructure served not only the city but also several ecclesiastical institutions, as well as the Archbishop's own residence.¹³

In this context of expansion of the city's hydraulic infrastructure, in 1519 Rouen's city council commissioned Jacques Le Lieur to carry out a study of all three conduits.¹⁴ Le Lieur (active until at least 1541, therefore likely born in the late fifteenth century) was from a noble family belonging to Rouen's judicial aristocracy, and served as notary-secretary to the King of France between 1518 and 1525. He was then appointed to Rouen city council, which he served until 1541. His study of Rouen's hydraulic network, produced with the assistance of the city's master fountaineers and building officials, came to be known as the *Livre des Fontaines* (Book of Fountains). Numbering over 160 pages, it was presented to the city council of Rouen in a black wooden case emblazoned with Le Lieur's coat of arms on 30 January 1525.¹⁵

The *Livre des Fontaines* opens with an introduction in which Le Lieur emphasizes the importance of having sufficient water for urban hygiene and argues that city governors must ensure an adequate supply. The author cites Roman aqueducts as examples, referring to the work of Pliny. As Ursula Sowina has pointed out, Le Lieur's text also reveals a familiarity with the writings of Frontinus and Vitruvius.¹⁶ Following the introduction is a eulogy for Cardinal Georges d'Amboise (1460–1510), the late Archbishop of Rouen and a leading minister under Louis XII, who had been a key supporter of the construction of the city's new water supply conduits. Le Lieur praised him as “an emulator of Roman vir-

¹² Le Lieur, *Le Livre enchaîné ou Livre des fontaines*, 7. For the original manuscript, see BMR, Manuscrits, Ms G3–1 (“*Livre des Fontaines de Rouen* (1526), par Jacques Le Lieur, échevin de Rouen”), <https://gallica.bnf.fr/ark:/12148/btv1b101021843>. Accessed 17 August 2026.

¹³ Sowina, “De l'eau pour la ville,” 23–36; Levollant, “Le Livre des Fontaines,” 243–253.

¹⁴ Ibid., 243–253.

¹⁵ Sowina, “De l'eau pour la ville,” 23–36; Levollant, “Le Livre des Fontaines,” 243–253.

¹⁶ Sowina, “De l'eau pour la ville,” 23–36.

tues, a true supporter ... of the common good.”¹⁷

The body of the text is divided into three chapters, each devoted to one of the city’s principal supply lines (the older Gaalor and newer Carville and Yonville conduits). In these chapters, Le Lieur traces the route of these conduits from their sources to their outlets in urban fountains, describing the investments made for their construction and maintenance as well as the municipal officials responsible for inspecting them. He also addresses legal and regulatory issues concerning rights over the conduits, their passage through private land, and the procedures for establishing branches for private use, often invoking past conflicts over water rights and their resolution.¹⁸ A series of blank pages following each chapter seems to have been intended for future additions to the text.¹⁹

Colossal, panoramic fold-out diagrams of the supply networks were also included in each chapter. Constructed from multiple leaves of parchment fastened together, these images, executed in ink pen and watercolour, display plans of the conduits’ course, with the surrounding rural and urban topography and its built fabric depicted in stunning detail through a mix of bird’s-eye-view, elevation, and perspectival views.²⁰ According to Anne-Bénédicte Levollant, these diagrams measure 4.67 m (Gaalor), 9.30 m (Carville), and 3.30 m (Yonville) in length. They thus monumentalized the city’s hydraulic infrastructure and conferred prestige upon the project of building and maintaining it. The *Livre des Fontaines* also contained a painted panorama of the city pictured from the left bank of the Seine, known today as *La Grande Vue de Rouen*. To commemorate his service to the city, Le Lieur had depicted an inset, framed portrait, towering over the urban fabric, of himself presenting the book to city officials.²¹ He also included his family’s coat of arms, suspended from a tree in the left foreground.

In the text, Le Lieur reflected explicitly on his decision to compose a handbook. He wrote for “our successors,” he explained, “so that with the passage of time the provenance and location of the springs and beginnings of this fountain do not fall into oblivion.”²² He also announced his “care to faithfully write the truth in familiar language” over “[pursuing] great and profound elegance in my description.”²³ From the outset, the *Livre des*

¹⁷ Le Lieur, *Le Livre enchaîné ou Livre des fontaines*, 2.

¹⁸ Sowina, “De l’eau pour la ville,” 23–36.

¹⁹ Levollant, “Le Livre des Fontaines,” 243–253.

²⁰ For the original diagrams, see “Le cours de la Fontaine de Carville,” <https://gallica.bnf.fr/ark:/12148/btv1b10052444v>; “Le cours de la Fontaine de Yonville,” <https://gallica.bnf.fr/ark:/12148/btv1b10050017r>; “Le cours de la Fontaine Gaalor,” <https://gallica.bnf.fr/ark:/12148/btv1b10052443d>. Accessed 17 August 2026.

²¹ Sowina, “De l’eau pour la ville,” 23–36; Levollant, “Le Livre des Fontaines,” 243–253.

²² “[À] noz successeurs, qui sont à venir, et aussy affin que par longueur de temps ne soit mys en oubly d’où vient et où sont les sources et commenchemens de ladicte fontaine...” Le Lieur, *Le Livre enchaîné ou Livre des fontaines*, 7.

²³ “[E]n ayant plus esgard de fidelement escrire la vérité en langue familière que curieusement

Fontaines was thus conceived as a reference for all who engaged in the management of the city's hydraulic infrastructure. As such, it was stipulated that it be kept in the Common Hall of the city council and that it could not be removed from the building. Its other name, *Le Livre Enchaîné* (The Chained Book), derives from the chain that secured it to a lectern in the hall.

Ultimately, these regulations did not prevent the knowledge contained in the book from circulating beyond the Common Hall. In the early seventeenth century, Rouen's master of buildings and fortifications illegally produced a copy of the manuscript, which was eventually confiscated by the city authorities.²⁴ The *Livre des Fontaines* would not be published until 1911, when a facsimile edition was produced in Rouen. Since then, the manuscript has been well known to French scholars, who have tended to emphasize its exceptional character. A later facsimile was published in the early 2000s.

2.2 Pilgram Marpeck's *Bericht*, Augsburg (1556)

The Free Imperial City of Augsburg, in what is now southern Germany, is situated on a plateau overlooking the confluence of two rivers, the Lech and the Wertach. Throughout the Middle Ages, their fast-flowing waters were harnessed to feed canals providing hydro-power for the city's numerous artisanal and industrial activities.²⁵ In the early fifteenth century, the Augsburg city council complemented this grey water network with a municipal drinking water supply system. Tapping freshwater springs south of the city, a new canal was dug to carry the water to the city walls, where water-raising machines filled a series of tanks located on top of dedicated water towers. Thence, drinking water was distributed via a network of underground timber pipes to public fountains dotted around the city's streets and squares.²⁶

A century and a half after its establishment, this system received its first major overhaul at the hands of Pilgram Marpeck. A leader of the early Anabaptist church, Marpeck (c. 1495–1556) was also a skilled hydraulic expert: after learning his trade in the mines of his native Tyrol, he worked in Strasbourg and St Gallen, before settling in Augsburg around 1544. Two years later, the Augsburg city council appointed him *Stadtwerkmeister* (Surveyor of the City's Works) and tasked him to overhaul the main water-raising machine feeding the municipal drinking water supply system. Between 1546 and 1552, Marpeck

observer grande et profonde élégance en ma description." Le Lieur, *Le Livre enchaîné ou Livre des fontaines*, 67.

²⁴ Levallant, "Le Livre des Fontaines," 243–253, here 244.

²⁵ For a recent introduction to the history of Augsburg, with earlier bibliography, see Tlusty and Häberlein, eds., *Companion to Late Medieval and Early Modern Augsburg*.

²⁶ The most complete introduction to the history of Augsburg's water management system, inscribed since 2019 on the UNESCO World Heritage List, is Emmendorffer and Trebesch, eds., *Wasser Kunst Augsburg*.

worked to replace the fifteenth-century machine, likely a chain of buckets set in motion by a waterwheel, with a *Stangenkunst* (rod engine). Equally set in motion by a waterwheel, this machine was at the cutting edge of technological innovation in the mid-sixteenth century: the waterwheel was connected by cranks to several moving rods, which set a series of superposed piston pumps in motion.²⁷

On 24 June 1556, four years after completing this overhaul, and only a few months before his death, Marpeck wrote a *Bericht der brunwerch, wie sy gericht, geornet vnd gehalten sollen werden* (Report on how the waterworks should be set up, arranged, and maintained). This manuscript, which has never been published, consists of a letter to the Augsburg city council, signed by Marpeck.²⁸ Over sixteen pages, the ageing *Stadtwerkmeister* consigns his recommendations for the future management of the municipal drinking water supply system, organised in nine articles,²⁹ along with a description of the system itself, focusing on its operating principles and maintenance.³⁰ This *Bericht* is thus at once a summary of the knowledge and expertise accumulated by Marpeck over more than a decade of hydraulic work in Augsburg, and an indispensable handbook for his successor in managing the municipal drinking water supply system.

In the preamble to his *Bericht*, Marpeck suggests that he is writing of his own initiative. Full of pride in “such [a] newly built waterwork, which is wholly different, nay a completely new invention, work, and machine,” Marpeck is determined that his technological legacy should outlive him.³¹ He points out that he is already busy training his successor, Anthoni Hilleprand, and urges the city councillors in the first article to always appoint “a competent and loyal administrator of the waterworks,”³² for “where many cooks are in one kitchen, good fare is seldom cooked.”³³ The following eight articles about the municipal drinking water system’s management lay out the responsibilities of this administrator, the organization of his subordinates into teams with distinct tasks, and the jurisdiction of the city council over the administrator’s work.³⁴

A shorter technical description follows, concerned especially with the fairness of dis-

²⁷ On Marpeck, his training in Tyrolean mines, and his hydraulic activities in Augsburg, see Martino, “Mining for water?” 26–58.

²⁸ The signature appears to be in the same hand as the text itself, suggesting that the whole document (with the exception of the annotations discussed below) might have been written by Marpeck. See StadtAAu, KA-A, Baumeisteramt, VII: 28d, [1] (P. Marpeck, *Bericht der brunwerck* (1556)).

²⁹ Marpeck, *Bericht der brunwerck*, 1–12.

³⁰ Ibid., 12–16.

³¹ “[S]ollich new gemacht prunwerck gantz auf anderm sin: Ja gar ain new erfindung, werch, vnd kunst ist,” *ibid.*, 2.

³² “[A]in verständigen trewen prunwerchs verwalter,” *ibid.*, 3.

³³ “[W]o vil käch Jn ainer kuchen sein, da werden selten guete speis kocht,” *ibid.*, 11.

³⁴ Ibid., 3–12.

tribution to all recipients of drinking water. If the fifteenth-century system had supplied only public fountains, indeed, by the mid-sixteenth century “the water is also supplied to several people and lords in their own houses.”³⁵ These people paid a fee commensurate with the supply of their tap; it was therefore important that this amount was as stable and comparable as possible across all taps. Marpeck recommended achieving this by ensuring that the diameter of the main wooden pipes was uniform, and that these were laid at the same depth underground.³⁶ The side connections departing from these pipes to supply people’s taps were smaller, and Marpeck recommended that their diameter be proportional to the height at which a tap was placed.³⁷ This allowed him to compensate for pressure differences: taps at a lower height, flowing with greater pressure, were to have a smaller diameter than taps higher up in the city, where pressure was lower. Marpeck explained how to calibrate this: the administrator was to measure outflow over one hour, and ensure it was the same across all taps.³⁸

The one known copy of Marpeck’s *Bericht*, preserved in the collections of the Augsburg Stadtarchiv, is annotated by a different hand. This suggests that the *Bericht* was read carefully by at least one of Marpeck’s successors, though it has not yet been possible to identify who this was. There is also evidence that several of Marpeck’s recommendations were heeded. In 1558, two years after receiving Marpeck’s *Bericht*, the Augsburg city council commissioned a detailed description of the network of underground timber pipes – as had been recommended in the second part of the *Bericht*.³⁹ The job description of the municipal *Brunnenmeister* (Master of Fountains/Waterworks), as recorded in acts of appointment from the seventeenth century, corresponds quite closely to the responsibilities of Marpeck’s proposed administrator.⁴⁰ Water concessions (*Wasserbriefen*) issued by the municipal administration also follow the format prescribed in the *Bericht*.⁴¹

Marpeck’s influence over the municipal drinking water supply system of Augsburg, in other words, was not limited to his technical overhaul of the main water-raising machine:

³⁵ “Auch sunder personen vnd herren Jn der selben herren heiser das wasser aus zue thaylen,” *ibid.*, 1.

³⁶ *Ibid.*, 12–13.

³⁷ *Ibid.*, 13–14.

³⁸ *Ibid.*, 14.

³⁹ *Ibid.*, 4–5. For the records of private water connections, see for example StadtAAu, KA-A, Baumeisteramt, VIII: 212; and StadtAAu, KA-A, Baumeisteramt, VIII: 213, [2.1]–[2.4].

⁴⁰ Whilst it is possible that the office of *Brunnenmeister* was only established after Marpeck recommended the appointment of a *verwalter* in his 1556 *Bericht*, earlier mentions of *Brunnenmeister* employed by the Augsburg city council suggest that the post may have originally been created in the early fifteenth century, when the drinking water supply system was first established, and later reformed in line with Marpeck’s recommendations in his *Bericht*.

⁴¹ Marpeck, *Bericht der brunwerck*, 14–15. For a *Wasserbrief*, see for example StadtAAu, KA-A, Ordner 104 (*Wasserbriefe*).

through his 1556 *Bericht*, he also contributed to an administrative overhaul of the system's management. As well as a record of Marpeck's knowledge and expertise, and a handbook for his successors, the *Bericht* was thus also a blueprint for reform. Its significance, however, has only recently been recognised by scholars of early modern Augsburg, largely thanks to the work of Barbara Rajkay.⁴²

2.3 Girolamo di Pace da Prato's *Memoriale*, Duchy of Florence (1558)

The city of Florence straddles the Arno river at its confluence with the Mugnone. During the Middle Ages, as industrial milling and commerce spread along these fast-flowing waterways, the city grew to be among the largest and most prosperous in Europe. From the thirteenth to the sixteenth century, its territory expanded considerably through conquest and acquisitions, becoming the capital of a regional state encompassing much of Tuscany and the greater part of the Arno river basin. While rivers brought wealth to Florence and its subject towns, they also posed a threat to people's lands and livelihoods when they flooded.⁴³

The central decades of the sixteenth century were a period of exceptional flooding, with more frequent and severe inundations recorded in Florence and its subject towns along the Arno.⁴⁴ In response, the newly-elevated ducal government regulated and restricted access to rivers to stabilize their embankments. They also founded within the Capitani di Parte Guelfa, the state's public works and property magistracy, a dedicated hydraulic office called the Ufficiali dei Fiumi, charged with enforcing river regulations and advising on flood mitigation.⁴⁵

From at least 1550 until the end of his life, Girolamo di Pace (1478?–1562), who hailed from Prato, served these magistracies as an engineer.⁴⁶ While little is known of his early life or formation, his talents were recognized early on at the ducal court, which retained him as a hydraulic engineer from 1534. He was involved in the construction of the water systems at the Medici villa gardens at Castello and Poggio a Caiano, and conducted inspections of rivers across Florence's dominions.⁴⁷

In October 1558, just over one year after an exceptionally devastating flood impacted towns across the Arno river valley, di Pace reflected on all he had learned during his ca-

⁴² Rajkay, "Die Kunst des Machbaren," 68–87.

⁴³ For an accounting of Arno floods in Florence and its countryside, see Morozzi, *Dello stato antico e moderno del Fiume Arno*, 7–66.

⁴⁴ Morozzi, *Dello stato antico e moderno del Fiume Arno*, 26–30 records moderate to severe floods in 1532, 1538, 1542, 1543, 1544, and 1547, for example.

⁴⁵ Murphy, "Flood Mitigation, Territory, and Time," 82–84.

⁴⁶ Di Pace's name seems to appear for the first time in a list of the Capitani di Parte Guelfa's salary allocations dated 6 May 1550. ASF, Capitani di Parte Guelfa, Numeri Neri, 8, f. 147v.

⁴⁷ Lamberini, "Il Tribolo ingegnere," 189, n. 34; Vestri, "Girolamo di Pace da Prato, ingegnere."

reer to compose a lengthy report to Florence's duke, Cosimo I de' Medici, on the state of the duchy's rivers and how to mitigate their floods. Though untitled, the librarian Cesare Guasti (1822–1889) later named the nearly-100-page manuscript *Memoriale sopra la natura, il corso, ed i ripari di quasi tutti i fiumi e fossi dello Stato Vecchio, e sopra i regolamenti, che vi erano stato fatti fino dell'anno 1558, e che si sarebbero dovuti fare nell'avvenire* (Memorial on the nature, course, and repairs of almost all the rivers of the Old State, and on methods for regulating them, imposed until the year 1558, and that ought to be done in the future).⁴⁸ Throughout the text, Di Pace foregrounded his practical knowledge, routinely discussing his “experiments” in the Florentine territory, which involved wading in rivers and measuring embankments firsthand.⁴⁹ While this “experience of things” authorized him to expound on urgent matters of river management, he acknowledged his unease in doing so, explaining that he would much prefer to “put ... [his proposals] into effect today, than to write or talk about them.”⁵⁰ It was his advanced age, which he pegged at nearly 80, and his fear that “any day may be my end,” that motivated him to encode his knowledge for later implementation.⁵¹

Without chapters or other sectional divisions, di Pace's *Memoriale* reads as a chorographical survey of Tuscany's waterways. Starting in Florence, he discusses the Arno and its major and minor tributaries, narrating in vivid detail the behaviour of their waters, identifying current or potential flood hazards, and advising on apposite remedies. Erosion, bed aggradation, weakened and ruptured embankments, and channel obstacles were among the most common problems he observed, especially in the plain of Florence, causing rivers to widen, erupt, and even change their courses. Di Pace noted the recency of several of these issues, offering illuminating testimony of rapid environmental changes underway during these years.

He recommended several by-then routine procedures to remedy these problems, such as dredging beds and reinforcing and raising embankments, as well as straightening meanders and symmetrically aligning opposing tributaries to counterbalance the force of their flows. These interventions were to be carried out according to a set of general principles that can be summarized thus: 1) reparative measures should be taken not only where water breached or overtopped embankments, but also at the original, upstream cause of the flood; 2) modifications to channels should proceed by slowly redirecting the flow of wa-

⁴⁸ The Biblioteca Roncioniana di Prato (BRP)'s autograph draft is catalogued under Carteggi di Cesare Guasti 194.

⁴⁹ BNCF, Palat. 788, f. 47v. Here and below, I cite from a presentation copy in the Biblioteca Nazionale Centrale di Firenze, shelfmark Palat. 788, on which more below.

⁵⁰ “[D]i tutta l'opera predette io le saprei hoggi meglio metterle a effetto che scriverle o dirlo,” *ibid.*, f. 83v.

⁵¹ “[M]a el tempo non melo comporta: perche io sono tanto innanzi con gli anni che io mi avvicino à gli 80, in modo che ... ogni di puo essere el mio,” *ibid.*

ter, rather than by abruptly counteracting or changing its current; and 3) uniform, widespread application of repairs was preferable to sporadic, ad-hoc intervention.⁵² Touted as “other modes, that were not followed in the past,” these principles derived from di Pace’s novel apprehension of Tuscany’s rivers as an integrated territorial network, or what we would today call a drainage basin.⁵³ He showed how all modifications of this system had to be undertaken with a mind to their effect on the whole.

Di Pace’s propositions also had implications for the government of riverside communities.⁵⁴ He issued recommendations intended to broaden compliance with river legislation, which he deemed insufficient, and correct earlier transgressions. In a not-so-veiled criticism of incumbent magistrates, he also called for the appointment of expert ministers devoted specifically to the task of river administration, specifying that they be “men of authority, affable people” capable of coordinating state technicians and earning the trust of subject communities.⁵⁵

Di Pace’s autograph manuscript, marked throughout with his own corrections and additions, is preserved in the Biblioteca Roncioniana di Prato.⁵⁶ At least two other sixteenth-century manuscript copies of the text are in the Biblioteca Nazionale Centrale di Firenze. One, a small octavo volume in an elegant script, appears intended as a presentation copy;⁵⁷ the other, in an unknown hand, attests to wider interest in di Pace’s prescriptions at the time.⁵⁸ Although it is unclear whether Cosimo I ever received di Pace’s *Memoriale*, the Ufficiali dei Fiumi’s legislation and more proactive approaches to flood mitigation in the years to follow suggest that the engineer’s recommendations were known and heeded in the 1560s and 1570s.⁵⁹

Historical study of di Pace’s *Memoriale* can be traced back to the eighteenth century, when Giovanni Targioni Tozzetti used it to understand the historical hydrography of the Florentine plain and derive solutions to flood problems in his own day. He published ex-

⁵² Di Pace first mentions these approaches on f. 3v.

⁵³ “[P]er bene che si seguire altri modi che non si faceva per il passato,” *ibid.*, f. 3v.

⁵⁴ Murphy, “Flood Mitigation, Territory, and Time,” 94–95.

⁵⁵ “[D]elli huomini che havessino a mettere à effetto tal cose, bisognerebbe anchor che fusse qualche persona, et huomini d’authorita, persone amorevole, et havessino poche altre faccende: et che pigliassino questa per loro faccenda, per che è cosa di grande importanza,” BNCF, Palat. 788, f. 25v.

⁵⁶ BRP, Carteggi Cesare Guasti, 194.

⁵⁷ BNCF, Palat. 788, ff. 2r–94r. Antonio Lupicini’s *Discorso sopra i Ripari delle inondazioni di Fiorenza* (1591) follows from ff. 96r–103r. The presentation manuscript is catalogued under the alternate title of “Discorso dei fiumi, fossi, laghi, e foci marine del Dominio Fiorentino, e de’ loro disordini e rimedi: al Duca di Firenze”; see Ministero della Pubblica Istruzione, *I Codici Palatini*, II:1, 318.

⁵⁸ BNCF, Landau Finaly 97, which is not explicitly catalogued as a copy of the text.

⁵⁹ Murphy, “Flood Mitigation, Territory, and Time,” 100–101.

cerpts of the text in his *Relazioni d'alcuni viaggi fatti in diverse parti della Toscana*.⁶⁰ Cesare Guasti also studied the *Memoriale*, and produced a complete manuscript copy in 1844, perhaps in preparation for a critical edition.⁶¹ Whereas twentieth-century scholars of Tuscan hydraulics and water management have largely continued to use di Pace's text as a record of historical hydrography, Di Pace's understanding of flow dynamics and his vision for institutional reform have been emphasized only more recently.⁶²

2.4 Tommaso Laureti's *Istruzione*, Bologna (1580)

The northern Italian city of Bologna is located at the southern edge of the Po Plain, at the foot of the Apennines, down whose slopes flow the rivers Reno and Savena, flanking the city to the west and east respectively. Since the twelfth and thirteenth centuries, part of their waters was deviated into the city by means of canals to provide hydropower for the city's trades – most notably its silk industry, which flourished from the fifteenth century onwards. Ruled as a largely independent Commune, then a Signoria through much of the late medieval period, Bologna was annexed to the Papal States in 1506, and remained under Papal rule throughout the early modern period.⁶³

From 1560 to 1565 the city was governed by the Bishop of Narni, Pier Donato Cesi. During his five years as Papal Vice-Legate in Bologna, Cesi undertook a grand campaign of public works, aimed at remodelling the city after the example of Rome.⁶⁴ In 1563, Pope Pius IV issued a brief mandating Cesi to renovate an underground conduit bringing drinking water to a fountain on the city's main square, originally built in the 1520s. Cesi seized the opportunity to undertake a much more ambitious project, and hired Tommaso Laureti to design two whole new fountains.⁶⁵ Laureti (c. 1530–1602) was known as “il Siciliano” after his native city, Palermo. His father was probably the Neapolitan painter Mario de Laureto, and the young Tommaso also trained as a painter, with Sebastiano del Piombo in Rome. From the early 1560s he was in Bologna, initially working as a painter

⁶⁰ Targioni Tozzetti first references di Pace in print in his *Disamina d'alcuni progetti*, 16–23, 74, and includes excerpts from the *Memoriale* in his *Relazioni d'alcuni viaggi*, vol. 5, 19–35, 89–96, 234–236, 255–256; and idem, vol. 8, 338–343.

⁶¹ Guasti's copy is in the BRP, Carteggi di Cesare Guasti 45. See on this text Petri, “Il Memoriale sui fiumi,” 64–65.

⁶² Petri, “Il Memoriale sui fiumi”; Rombai, “La ‘politica delle acque’ in Toscana”; Ferretti, “‘Imminutus crevit’: Il problema della regimazione idraulica dai documenti degli ufficiali dei fiumi di Firenze (1549–1574)”; Murphy, “Flood Mitigation, Territory, and Time”; Martino, “Hydraulic Philosophy in Early Modern European Cities.”

⁶³ For a recent introduction to the history of Bologna, with earlier bibliography, see Blanshei, ed., *A Companion to Medieval and Renaissance Bologna*.

⁶⁴ For Cesi's campaign of public works in Bologna, see Bocchi, “Shaping the City,” 91–97.

⁶⁵ Tuttle, *The Neptune Fountain in Bologna*, 21–53; a transcription of the papal brief is in the book's Appendix: Doc. 1, 186–187.

with Pellegrino Tibaldi. He would remain in the city until his definitive return to Rome twenty years later.⁶⁶

The smaller of the two fountains commissioned by Cesi, now known as Fontana Vecchia, was completed by 1565, just as the Vice-Legate's mandate came to an end and he was recalled to Rome.⁶⁷ The larger fountain, however, was only completed in 1567: known as Fontana del Nettuno, it stands to this day as one of the most famous monuments of Bologna. As Richard Tuttle has demonstrated, its final design was the outcome of a collaboration between Laureti and the young Flemish sculptor he had hired in Florence, Giambologna.⁶⁸ The latter modelled and cast the bronzes adorning the fountain, including the monumental Neptune after which it is named, while Laureti designed the fountain's pedestal and basin, as well as the hydraulic infrastructure needed to bring water to the fountain.⁶⁹

It is this infrastructure, which also fed the Fontana Vecchia, which Laureti described in detail in a handbook entitled *Istruttione del Laureti intorno alla Fonte agl'Illustrissimi Signori Quaranta del Reggimento* (Laureti's Instruction about the Fountain to the most Illustrious Senators of Bologna).⁷⁰ It was only written around 1580, for two reasons. First, the late 1570s saw the first campaign of repairs on the Bolognese fountains' water supply system, overseen by Laureti himself.⁷¹ Second, in 1580 Laureti was preparing to leave Bologna for Rome. This second reason for writing was made explicit in the preamble to the text, as well as in the preface to one of the presentation copies of the *Istruttione*.⁷² Laureti therefore intended to leave a trace of his knowledge and expertise in Bologna prior to his departure.

Over seventeen manuscript pages, Laureti's *Istruttione* follows the water's flow from the entrails of the hills south of Bologna to the fountain's spouts in the city's main square.⁷³

⁶⁶ Grasso, "Laureti, Tommaso, detto il Siciliano."

⁶⁷ Tuttle, *The Neptune Fountain in Bologna*, 145–157. This fountain was entirely designed by Laureti, and executed by the same stonecutters who also worked on the architectural elements of the Fontana del Nettuno.

⁶⁸ Ibid., 55–103. The sculptor's full name, Jean de Boulogne, was italicised as 'Giambologna', which has become the standard way to refer to the artist.

⁶⁹ Ibid., 55–103 (for Giambologna's bronzes) and ibid., 131–161 (for Laureti's work on the water supply). Laureti also received other hydraulic commissions, most notably in the villa and garden of Cardinal Filippo Guastavillani at Barbiano: see Grasso, "Laureti, Tommaso, detto il Siciliano."

⁷⁰ Laureti, "Istruttione del Laureti intorno alla Fonte agl'Illustrissimi Signori Quaranta del Reggimento." In Tuttle, *The Neptune Fountain in Bologna*, Appendix: Doc. 36, 208–214.

⁷¹ Tuttle, *The Neptune Fountain in Bologna*, 158.

⁷² Laureti, "Istruttione intorno alla Fonte, dedication to Cardinal Filippo Guastavillani." In Tuttle, *The Neptune Fountain in Bologna*, Appendix: Doc. 37, 214.

⁷³ As Laureti himself outlines in the preamble to his "Istruttione," in ibid., Appendix: Doc. 36, 208.

Laureti dutifully pointed out that he was not responsible for the entirety of the system: work on reviving the 1520s water conduit, just as Pius IV had ordered, had been directed by Domenico Passarino, a Bolognese mason.⁷⁴ Laureti had been tasked to augment this water supply, so he followed “all the indications given by good authors concerning the search for water” and selected an adequate spot at Valverde.⁷⁵ There, he dug drainage adits tapping water veins within the hills, which were faced with bricks and vaulted. These converged into an octagonal chamber where the water was allowed to decant, before flowing through a series of further purifying pools and wells, until it reached the final section of the ancient Roman aqueduct of Bologna. This was reopened to carry the water to the city’s Porta San Mamolo, where it was joined by the renovated 1520s water conduit.⁷⁶

The final stretch of the water supply system, which ran underground until Bologna’s main square, receives particular attention in the *Istruttione*. Laureti had devised a conduit of watertight pipes: to explain how their earthenware segments fitted together, he included drawings, as well as recipes for two different types of waterproof mortar. Stone joints were added at regular intervals, with a dual purpose: while some included vents to let the air out as the conduit was filled with water, others featured openings which permitted the passage of a rope.⁷⁷ As Laureti explained, the rope had to feature knots; once introduced into the conduit by means of a float, it could then be moved to and fro between two openings, the knots scouring the pipe as they brushed against its sides.⁷⁸ Displaying the same concern for the water supply system’s future upkeep, Laureti also explained how stone plaques embedded in an adjoining wall indicated the position of vertical shafts under the street surface, allowing workers to reach the underground conduit.⁷⁹

Laureti was not, on the other hand, concerned with administrative organization, and made no recommendations about it. That question may have already been settled with the Bolognese authorities when Laureti set pen to paper or, more plausibly, this absence may be explained by the relatively small scale of the system, which supplied two public fountains only. At the end of his *Istruttione*, Laureti included ideas on how to expand the system and increase the water supply, by tapping additional sources – but such works were

⁷⁴ Though he is not mentioned in Laureti’s *Istruttione*, his name is recorded in Cesi’s account book for the whole hydraulic project: see Tuttle, *The Neptune Fountain in Bologna*, 137. Work on reopening the 1520s water conduit began before Laureti was hired and was completed by 1564.

⁷⁵ “[T]utti quelli indicii, che scrivono i buoni auttori intorno all’investigar delle acque.” Laureti, “Istruttione” in Tuttle, *The Neptune Fountain in Bologna*, Appendix: Doc. 36, 208.

⁷⁶ Tuttle, *The Neptune Fountain in Bologna*, 141–145.

⁷⁷ Laureti, “Istruttione,” 209–212. For a discussion of Laureti’s text see Tuttle, *The Neptune Fountain in Bologna*, 143–145.

⁷⁸ Laureti, “Istruttione,” 213.

⁷⁹ *Ibid.*, 210.

never carried out, either in his lifetime or afterwards.⁸⁰

Laureti's *Istruzione* has survived in no fewer than five manuscript versions, all copies of the original, which appears to be lost.⁸¹ Whilst two of these were likely presentation copies prepared on Laureti's behalf for his patrons, the existence of a further three suggests that the *Istruzione* was still deemed useful in later decades.⁸² In the 1600s, for example, Guglielmo Fava transcribed and annotated Laureti's *Istruzione*: as Tuttle has suggested, this was probably because he was responsible for the renovation works carried out on the water supply system at the time, together with Cristoforo Seta.⁸³

If the name of Giambologna has remained associated with Bologna's Fontana del Nettuno to this day, the sculptor's fame has overshadowed Laureti's contribution – which unlike Giambologna's was not limited to the fountain statuary, but extended to the whole water supply system. Tuttle's monograph on the fountain, published posthumously in 2015, included a transcription of Laureti's *Istruzione* in the Appendix. As well as reassessing Laureti's role in Cesi's fountain project, Tuttle has made this important handbook available for a wide audience.

2.5 Giovanni Antonio Nigrone's *Vari disegni*, Naples (1585–1609)

One of the largest cities of early modern Europe, Naples overlooks a large gulf along the Tyrrhenian shore of southern Italy. A ducal then royal capital in the Middle Ages, it entered the Aragonese orbit in the fifteenth century, and in the early modern period it was the residence of a Spanish viceroy.⁸⁴ Without a major river, Naples depended for its water supply primarily on the complex underground system known as the Formale Reale (or Regio), fed by the Bolla aqueduct, which distributed water via reservoirs carved out of tuff and a network of clay and lead pipes.⁸⁵ As a growing population pushed this infrastructure to its limits, the densely settled coastal areas, due to their topography and higher elevation, had to rely increasingly upon groundwater wells and rainwater cisterns to meet their needs.

Giovanni Antonio Nigrone was the scion of a Neapolitan family with some connec-

⁸⁰ Tuttle, *The Neptune Fountain in Bologna*, 157. Bologna's water supply system ended up being completely overhauled in the nineteenth century, like that of many other European cities.

⁸¹ All five copies are in the Biblioteca Comunale dell'Archiginnasio in Bologna; we have relied on the edited version published as Laureti, "Istruzione" in Tuttle, *The Neptune Fountain in Bologna*, Appendix: Doc. 36, 208–214.

⁸² Sambin de Norcen, "Introductory note" to Laureti, "Istruzione" in Tuttle, *The Neptune Fountain in Bologna*, 206–207.

⁸³ Seta was the city's *fontaniere* (fountaineer), while Tuttle records the title of 'Cavaliere' (Knight) for Fava, suggesting the latter was of higher social status. See Tuttle, *The Neptune Fountain in Bologna*, 158.

⁸⁴ For a recent introduction to the history of Naples, with earlier bibliography, see Astarita, ed. *A Companion to Early Modern Naples*.

⁸⁵ Carnevale, "Tecnici e imprenditori dell'acqua nella Napoli moderna," 79.

tion to Florence. In 1585 he left Naples, likely fleeing legal issues, for Rome, where he worked for Cardinal Ferdinando de' Medici at the Villa Medici, and where he also claimed to have corrected errors in the Acquedotto Felice. In March 1590, he followed his patron to Florence, where he designed fountains for the Palazzo Pitti and Medici villa at Pratolino; it was also in Tuscany that he studied Hero of Alexandria's writings on pneumatics and automata. After his return to Naples only a couple months later, he served as "fontanaro e ingegniero de acqua" (fountaineer and water engineer) for the Tribunale della Fortificazione, overseeing the technical maintenance of the drinking water supply network, monitoring concessions to prevent frequent water theft, and ensuring public hygiene following incidents of contamination in the reservoirs. In this capacity, he directed public works such as the Poggio Reale street fountains, completed between 1603 and 1604, and worked for noble families such as the Carafa and Orsini. In 1607, he obtained a license from the Roman Inquisition to read censored astrological treatises to explore links between water engineering and celestial phenomena.⁸⁶

At some point after his return to Naples, Nigrone received an institutional order from an authority (whose identity he does not specify) to provide a comprehensive report on all matters relating to water in the city. Though Nigrone clearly had the intention of publishing his report, he was never able to do so, perhaps owing to the death of his patron Paolo Regio, Bishop of Vico Equense, in 1607. Accordingly, in a later dedicatory letter for his manuscript, drafted around 1609 and addressed to the Neapolitan official and collector Giovan Simone Moccia, Nigrone cites the persuasion of friends as the catalyst for writing, and frames the project as fulfilling a request from his eldest son, Orazio, for an explanation of natural phenomena such as fires and earthquakes and their effects on waterways.⁸⁷

Written in clear, direct prose, and blending Tuscan and Neapolitan dialects for practical accessibility, Nigrone's manuscript is organized into a comprehensive encyclopaedic structure, divided primarily into the themes of hydraulic engineering, natural philosophy, history, and practical knowledge. Although it originally appears to have been conceived as a single body of text in folio format, the manuscript is now preserved in two volumes. This division resulted from a reorganization carried out by the Capuchin friars of the convent of S. Efreim Nuovo between the seventeenth and eighteenth centuries.⁸⁸ Volume I, titled *Vari Disegni*, primarily contains the visual material, comprising 325 folios dedicated to fountain designs; Volume II, titled *Vari Discorsi*, focuses on theoretical and technical texts, consisting of 218 folios.

The manuscript treats Naples as a central, living entity, whose survival and splendour

⁸⁶ Tchikine, "Giovanni Antonio Nigrone," 179–190.

⁸⁷ Gentilcore, "Between Practical Knowledge and Self-Promotion," 24.

⁸⁸ Nigrone, *I disegni e i discorsi*, vol. I, 23.

depend on the expert management of its water, its history, and its terrain. Accordingly, the work examines the city from its subterranean foundations to its aristocratic heights. Nigrone meticulously details the city's hydraulic system, explaining the infrastructure of the Formale Reale and the distinction between underground masonry canals (*formali*) and surface clay pipes (*intufolature*). He documents critical public health issues, such as the discovery of human and animal corpses in water reservoirs, and denounces the fraud and corruption of water officials who illegally diverted supply.

Nigrone proudly declared himself a “fountaineer and water engineer,” and believed that such “practical men” should oversee matters of urban hydraulic governance.⁸⁹ Their hands-on experience lent them both authority and credibility; indeed, in his view, only “people knowledgeable in this profession” could be entrusted with accurately measuring water concessions and detecting illegal diversions and other frauds.⁹⁰ That said, he also asserted that engineers ought to also have a firm grasp of the “four elements, the spheres, the underworld, spirits, and other things,” lamenting that “no one these days knows anything about these treatises.”⁹¹ In Nigrone's view, knowledge of this broad array of fields supported the work of water management; a firm grasp of astrology, for example, could help with locating and conducting waters hidden underground.⁹² His interests were indeed wide-ranging: the manuscript discusses street paving, agriculture, Naples's history and apocryphal origins, seismic risks, and architectural and urban measures that could be taken to mitigate them. Almost always, however, such topics are treated in relation to water management.⁹³ This also includes his mapping of the geography of elite power and leisure: Nigrone lists the noble patrons for whom he designed fountains in prestigious districts, some of which he also drew (Fig. 1), and provides a treatise on the therapeutic virtues of the thermal baths in Pozzuoli and Ischia.

⁸⁹ After his address to the reader, Nigrone affirmed that “la seguente opera è tutta disegnata, dipinta, lavorata, scritta e composta per mano mia di Giovanni Antonio Nigrone di Napoli, fontanaro e ingegnere di acqua,” Nigrone, *I disegni e i discorsi*, vol. I, 399. “La terra allagata e tutti questi danni vengono perché non c'è un uomo pratico che le veda spesso e le sappia aggiustare,” *ibid.*, 221. The passages quoted here and through the rest of this section are from the edition's “Trascrizione interpretativa,” which modernizes Nigrone's spelling and orthography.

⁹⁰ “[D]ove sono e precisamente nella città di Napoli e delle frodi di dette acque che son fatte, fanno e faranno per non essere governate da persone sapienti in tal professione,” *ibid.*, 219.

⁹¹ “[I]l vostro Nigrone, autore del presente libro, essendo egli ingegnere di acque, va parlando e scrivendo dei quattro elementi, delle sfere, dell'inferno, spiriti e altre cose ... poiché della mia professione nessuno di questi tempi sa una particella di questi trattati,” *ibid.*, 243.

⁹² *Ibid.*

⁹³ As Loffredo, “La questione dell'attendibilità,” 167, notes, “Il manoscritto affronta temi molto eterogenei, ma la vocazione idraulica è preponderante, essendo il suo nucleo fondamentale.”



Fig. 1 – Fountain design for the loggia of the palace on via Toledo (Naples) for the Royal Counselor Scipione de Curtis. Giovanni Antonio Nigrone, *Varii disegni*, MS-XII-G-59, f. 33 (Plate 6). Courtesy of the Ministero della Cultura © Biblioteca Nazionale di Napoli.

For Nigrone, images held the same relevance as the written word. *Vari Disegni* contains designs for fountains as well as detailed drawings of levelling instruments, hydraulic machinery, and experimental technologies, such as a diving apparatus. *Vari Discorsi* includes astrological charts, maps of the globe and of the heavens, climatic diagrams, illustrations of pneumatic mechanisms, and garden designs. These pictures serve a dual role, both elucidating Nigrone's technical ideas and advertising his competencies as a polymath.

Held in the National Library of Naples, Nigrone's manuscript and its author have been the subject of considerable study since the late nineteenth century. Early scholarship focused on the artistic merits of its drawings and their documentary value for reconstructing lost Neapolitan gardens, and sought to recover its bibliographical history and provenance.⁹⁴ The manuscript has enjoyed renewed interest among scholars of the history of science, art, literature, architecture, engineering, and more, whose multi- and interdisciplinary analyses have brought significant attention to Nigrone's wide-ranging contributions, culminating in 2024 with the publication of a critical edition of his manuscript.⁹⁵

2.6 Francesc Socies' *Llibre de les fonts de la Ciutat de Barcelona* (1650)

Though sited on the Mediterranean coast between the mouths of the Besòs and Llobregat rivers, Barcelona's drinking water supply in the early modern period was relatively limited. It depended on a system of *mines d'aigua*, qanats that conveyed water to the city from the nearby aquifers of the Collserola mountains. This urban drinking water system began to take shape in the fourteenth century, and progressively expanded through the addition of new sources and conduits between the late fourteenth and fifteenth centuries.⁹⁶

Seasonal climatic fluctuations always affected how much water reached the city, but in the early seventeenth century, a prolonged drought that dramatically curtailed supply prompted a significant overhaul of the system. It began in 1626, after a period of relatively abundant rainfall, and lasted into the 1640s, affecting Barcelona and much of Catalonia. The water levels of the rivers and qanats declined precipitously, decreasing the supply of water to the city's fountains and, at times, forcing the suspension of milling activity. To address this problem, from 1626 through the 1630s, municipal authorities undertook

⁹⁴ In 1880 Volpicella, *Giovan Battista del Tufo*, first recognized the manuscript's value in documenting historic Neapolitan gardens; Angelo Borzelli's 1902 biographical essay, *Giovanni Antonio Nigrone*, rescued Nigrone from obscurity; the manuscript's drawings were used as a key iconographic source for lost gardens in Mormone, *Disegni per fontane*.

⁹⁵ See for example Edelstein "Acqua viva e corrente," 187–220; Tchikine, "L'anima del giardino," 129–153; Mansi, "Le fontane di Giovanni Antonio Nigrone"; Loffredo, "La villa di Pedro de Toledo a Pozzuoli," 100–121; Tagliagamba, "I manoscritti di Giovanni Antonio Nigrone," 85–98; and the essays in Nigrone, *I disegni e i discorsi*, vol. II. For the critical edition of Nigrone's manuscript, see *ibid.*, vol. I.

⁹⁶ Guàrdia and Hostench, "Saber i pràctiques hidràuliques," 123–154.

projects to extend *mines d'aigua*, tap new sources, and maintain the existing channels to improve flow efficiency.⁹⁷ Although period sources frequently invoke the drought as a justification for these interventions, they cannot be understood solely as a response to climate stress. Instead, the drought merely amplified the vulnerabilities of a system already under considerable pressure due to its limited and environmentally contingent sources and entrenched conflicts over management and access rights.

The value of reliable information about Barcelona's drinking water system and its management became especially apparent in this context. Appointed by the city in 1620, Francisc Socies served as water officer and fountaineer (*mestre de les fonts*) for more than 30 years and was responsible for renewed efforts to maintain and expand the system during the 1630s. In 1648, the Barcelona city government petitioned him to "write a book of the said fountains ... for the clarification of his successors."⁹⁸ In commissioning Socies, an elderly man with no direct heirs, to set down his knowledge in writing, the city aimed to safeguard and regulate access to this knowledge, for their request to Socies specified that the book would remain "perpetually ... in the house of the present city."⁹⁹

Socies delivered the 262-page *Llibre de les fonts de la Ciutat de Barcelona* (Book of Fountains of the City of Barcelona) to the city government on 14 November 1650.¹⁰⁰ The text, which is organized into 116 short chapters, discusses the major pipe bringing water to Barcelona, its distribution to public and private fountains across the city, and explores its catchment, that is, the *mines d'aigua* of the Collserola mountains. Concerned with the health of Barcelona's residents, Socies prioritized supply to public and collective-use fountains and sought to regulate private access so as to prevent water theft. Throughout the text, he referenced his hands-on experience and demonstrated his intimate knowledge of the network by consigning site-specific maintenance advice to future managers, sometimes referring to documents preserved in the city archive. He also encouraged these readers to take notes of future changes to the water system in the margins of the book pages, so as to ensure that the *Llibre de les fonts* would form a living, up-to-date record.¹⁰¹

The handbook's chief contribution lay in offering a detailed guide to ensuring that the flow of water was as efficient as possible, addressing perennial problems that became critical in the context of drought: managing pressure, clearing sediment that blocked pipes and, above all, controlling water theft. By meticulously tracing the path of water, the text addresses the major physical challenges of the time: regulating flow without loss of pres-

⁹⁷ Gorostiza, Martí Escayol, and Barriendos, "Controlling Water Infrastructure," 913–927; Barriendos and Gorostiza, "El context climàtic del Llibre de les fonts," 213–245.

⁹⁸ AHCB, CCiAM, Registre de Deliberacions, 02.01/1B. II-159, 1650, f. 325v.

⁹⁹ Ibid., ff. 325r–326v.

¹⁰⁰ AHCB, CCiAM, Manuscrits, 01/1G-076, *Llibre de les fonts*. Available at <https://catalegarxiu-municipal.bcn.cat/detail/130417682>.

¹⁰¹ Martí Escayol, "Vetx los anys com més anam són més estèrils de pocas ayguas," 155–187.

sure over distance. This required a holistic understanding of the hydraulic variables of the system: the initial flow, the friction accumulated within long conduits, the precise changes in level across the city's topography, and the need to maintain a constant gravitational gradient. The approximately 60 illustrations, featuring sectional drawings, elevations, and scaled plans, helped Socies to explain his findings and demonstrate the effects of pipe volume, slope, and length on the flow of water across the network (Fig. 2).

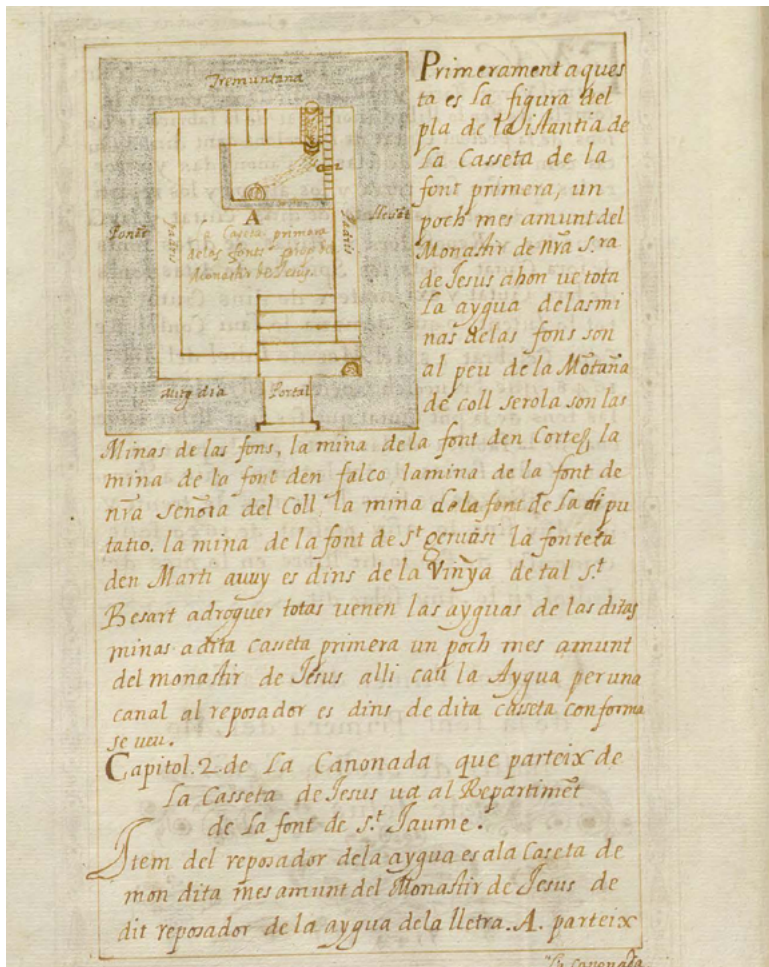


Fig. 2 – Plan of the first fountain house, near the Monastery of Nostra Senyora de Jesús, Barcelona. Arxiu Històric de la Ciutat de Barcelona (AHCB), Consell de la Ciutat i Ajuntament Modern (CCiAM), Manuscrits, 01/1G-076, *Llibre de les fonts*, chapter one.

The *Llibre de les fonts* enabled Barcelona's municipal government to strengthen its control over the circulation of water within the city. Socies described how he had relocated pipes from the interiors of private buildings to channels beneath the streets to prevent illegal connections. He also developed an iconographical key intended to help public authorities locate this hidden infrastructure. By interspersing his text with a series of 74 crosses that corresponded to identical ones incised into building facades, he keyed components of the urban network to his written apparatus.

The creation of the book illustrates the politics of knowledge in early modern Barcelona. The city government sought to institutionalise forms of knowledge traditionally within the exclusive purview of city water officers and transmitted within families, from father to son or son-in-law. In 1614, years before Socies took office, the city government had already requested that the water officer hand over to the city's chief scribe "the book that ... [he] possesses concerning the secrets of the fountains" so that it might be copied. The absence of further records suggests that the officer did not comply with the request and instead transmitted it to his son-in-law, who succeeded him in the post and preceded Socies.¹⁰²

The first modern reference to the *Llibre de les fonts* dates to 1917, when the historian Francesc Carreras i Candi highlighted its significance, noting that the manuscript was an extraordinary document that "deserved all honours" in the history of Barcelona's water services.¹⁰³ However, it was not until the 1990s that Antònia Maria Perelló Ferrer provided the first comprehensive study of the manuscript, of Francesc Socies, and of the professional practice of fountaineers within the context of seventeenth-century civil architecture.¹⁰⁴ The manuscript was subsequently featured in the 2011 exhibition *La revolució de l'aigua a Barcelona*.¹⁰⁵ In each of these cases, it was presented as an extraordinary source, only situated within a broader tradition with the publication of a complete critical edition in 2022.¹⁰⁶

3. Discussion

Already at first glance, both similarities and differences among the six handbooks presented here are numerous. In this discussion, we will focus in particular on similarities across these technical-administrative compendia, and what they tell us about their nature as technical *and* political sources. First, however, let us summarize some of their most salient differences. Hydrographically, some handbooks were concerned with a single aqueduct or drinking water supply system, while others considered a whole river basin. Their contexts ranged from territorial states and their capitals to Free Imperial Cities and provincial cen-

¹⁰² Gorostiza, "Francesc Socies," 45–90; Gorostiza, "Guerres d'aigua i paper," 247–287.

¹⁰³ Carreras y Candi, *Geografía General de Catalunya*.

¹⁰⁴ Perelló Ferrer, *L'arquitectura civil del segle XVII a Barcelona*.

¹⁰⁵ Guàrdia, *La revolució de l'aigua a Barcelona*.

¹⁰⁶ Martí Escayol, Gorostiza, and Cazeneuve i Descarrega, *El Llibre de les fonts*.

tres within larger polities. The background and status of their authors was equally varied, from city councillors and professional painters to artisan-practitioners and municipal or state officials. Whether acting of their own volition or in response to a commission, they each set pen to paper for a host of different reasons, ranging from professional handover, to explicating a system expansion or overhaul, to resolving problems such as flooding or drought, or some combination of these factors. What resulted were handbooks ranging in length from a few leaves to hundreds of pages, some beautifully presented and lavishly illustrated, others little more than working drafts.

Crucially, however, our authors all *did* set pen to paper, drawing upon their professional experiences to write about water management. Despite the variety manifest across these texts, then, it was their authors' shared decision to encode their site-specific hydraulic knowledge for their rulers and successors in an instructive, practicable manner that justifies treating them as a distinct genre.

The codification of information about water management was highly significant, for this kind of knowledge and expertise was normally tacit, transmitted orally to apprentices who were more often than not related to the office holder.¹⁰⁷ In some instances, as was the case in Barcelona, we know that written instructions facilitated this transmission from father to son, but they were jealously guarded and have left no trace in the archive. Part of this knowledge and expertise was also shared by a large number of people, comprising not only the municipal officials and overseers who penned our six sources, but also the varied professional figures they worked with, from specialised artisans to day labourers, some in public employ, others freelancers. Here, by contrast, we have six instances of handbooks which were produced by a single author for – and sometimes at the request of – the public administration, and which have therefore survived in their records. This highlights the double nature of these sources, at once technical and political, which we will analyse in turn.

3.1 Handbooks as technical sources: archives of embodied skill, claims to specialisation

A purely technical analysis of this corpus reveals a sophisticated, pragmatic mastery of hydraulic principles centred on flow dynamics. For the bulk of the handbooks treating urban water supply systems, a paramount technical preoccupation was the problem of pressure equalization – an engineering solution directly aimed at ensuring the reliable and equitable distribution of water across the urban fabric, from public fountains to privileged institutions. For di Pace, the sole author discussed here who focused on riverine flood mitigation, stabilizing riverbeds and improving channel capacity were chief concerns. Most of the authors under consideration here were also concerned with sediment – particularly its transport, accumulation and effects on hydraulic systems – thereby underscoring how

¹⁰⁷ Ferretti, “Imminutus crevit,” 116.

these systems, and their histories, consist of more than water alone.¹⁰⁸

Several of these handbooks, in addition to technical description, also provided cartography and visual records as didactic or heuristic tools. This is evidenced by the detailed foldable panoramas in Jacques Le Lieur's manual, by Laureti's and Nigrone's drawings, as well as by Socies's practice of cross-referencing carved street markings with identical drawings in the manual's margins to locate hidden infrastructure. These works are thus far from static inventories; they constitute a prescriptive engineering culture that actively engaged with the period's most critical water management challenges.

As Pamela Smith has argued, couching skills and expertise in writing served a dual purpose: preserving practical knowledge and claiming social status in a text-based world.¹⁰⁹ The preservation of knowledge and expertise could be threatened by critical junctures of generational transition or the expert's departure, leading to codification in writing rather than oral transmission. Marpeck, Socies and di Pace, for example, all wrote their reports shortly before their death. In Bologna, by contrast, Laureti drafted his *Istruzione* just before departing for Rome, seeking to leave a record of his expertise.

These urban hydraulic manuals functioned as "technologies of credibility."¹¹⁰ By systematically documenting solutions to concrete problems – such as leaks, fraud, and epidemics – and by narrating their successful interventions to municipal authorities, hydraulic experts professionalized their trade and constructed a model of authority based on expert testimony and public utility. In doing so, these texts anticipated the core protocols of experimental science – the importance of reliable witnessing, detailed material description, and the persuasive communication of results – but they did so from within the "trading zones," that is, the interstitial social spaces where Latin-educated scholars (often humanists or natural philosophers) engaged in sustained communication and collaboration with experienced artisans and workshop-trained professionals, that existed between artisanal practice and municipal governance.¹¹¹

The authors' claim to essential expertise rested on strategically different foundations of knowledge. While Marpeck, Di Pace, and Socies built their authority on an erudition of practice – their lived experience constructing and maintaining water networks and their unparalleled familiarity with the urban and regional environments where they worked – Nigrone cultivated an erudition of synthesis, weaving together workshop skills with references to natural philosophy. Several authors, including Le Lieur and Nigrone, also show awareness of ancient sources, especially the Roman hydraulic expert Frontinus, who had

¹⁰⁸ Parrinello and Kondolf, "The Social Life of Sediment."

¹⁰⁹ Smith, *From the Lived Experience to the Written Word*.

¹¹⁰ Shapin, *A Social History of Truth*.

¹¹¹ Long, "Trading Zones," 840–847. For a recent discussion of the boundaries of knowledge within such trading zones, see Marcon, "Boundaries of Knowledge."

similarly authored a handbook of water management.¹¹² All authors, with the exception of Marpeck, also give nature an important epistemological place: by recommending that interventions be done in accordance with its laws – chief among them the flow of water – rather than against them, they position themselves as privileged interpreters of the natural order. Their shared goal was indeed to use authorship as a means of self-legitimation, transforming a manual trade into recognized science and climbing the social ladder of knowledge.

Self-legitimation for the handbooks' authors as hydraulic experts came at the expense of the visibility of the underlying collective labour. Several of our sources mention the large teams of workers, be they craftsmen or conscripted labourers, required to carry out the hydraulic projects and ongoing maintenance described, with Marpeck, Di Pace, Nigrone, and Socies all emphasising the importance of providing effective leadership to them. The authors thus positioned themselves as essential intermediaries between municipal or princely authorities and these workers.¹¹³ Presented as an anonymous collective, the latter nonetheless provided crucial labour and skills, some of which are likely to have been tacitly appropriated by our authors, and presented in their handbooks without acknowledgement.¹¹⁴

This article thus contributes to the scholarly study of early modern hydroculture by examining it as a case of practical knowledge formation from below, a process driven equally by artisanal experience and a strategic desire for public communication. Water management and the expansion of hydraulic systems called for a unified vision and coordinated long-term planning, a challenge that required the mobilization of expert knowledge, a large-scale strategy, and sustained maintenance. These handbooks were thus fundamental epistemic instruments. They generated collective forms of water knowledge – knowledge solidly rooted in social experience, work, and material practice – through the codification of empirical knowledge based on problem solving. Accordingly, we position these water management handbooks as a necessary material and social precedent for seventeenth-century experimental philosophy in general, and for the establishment of modern hydraulic theory in particular, which is conventionally traced back to the publication of Benedetto Castelli's *Della misura dell'acque correnti* (1628), the first treatise to offer a mathematical description of flow dynamics.¹¹⁵

¹¹² On the importance of ancient sources for early modern hydraulic experts, see also Morgan, *Nature as Model*, 124–148.

¹¹³ On the status of experts as intermediaries, see Ash, "Introduction," 13–18.

¹¹⁴ For an attempt to recover the skills of anonymous, female hydraulic labourers see Mukerji, *Impossible Engineering*.

¹¹⁵ See on this process, at least as it developed in Italy, Maffioli, *Out of Galileo*; and Maffioli, "A Fruitful Exchange/Conflict," 197–228.

3.2 Handbooks as political sources: strategic value of water control

These hydraulic handbooks emerged in urban and hydrographic contexts where water was a strategic asset and a tool of political control, and by extension, where knowledge about water became equally strategic. This status was driven by several converging factors: a significant growth in urban population, which required the expansion of water networks (and increased the complexity of the supply and distribution systems); the increasing autonomy of municipal governments from traditional guild structures; the preservation of the rigid social hierarchies of *ancien régime* societies, which structured and legally and materially restricted access to water; and environmental pressures such as recurrent floods or droughts, which intensified pre-existing water conflicts and made evident the value of control over water. The confluence of these factors, among others, triggered a competition for control over hydraulic knowledge and, as a consequence, in some cities pitted the water craftsmen who possessed the expertise against the institutions they served.

The aim of urban administrations was to codify and transfer to public oversight knowledge that had previously been personal and familial. This process of committing practical, day-to-day knowledge to writing followed an institutional logic of control, aimed at ensuring future management and the continuity of hydraulic infrastructure in the absence of the expert's direct heirs. The very act of writing transformed the tacit, private, and ephemeral knowledge of master artisans into stable, normative documents that could be appropriated by the urban administration. Consequently, many handbooks also functioned as legal instruments, capable of ratifying the city's property rights over strategic resources like water against competing powers, such as the Church. Whether a system of piped drinking water or a river basin, the water networks profiled in each handbook were understood as socio-political environmental systems of great magnitude and complexity. Managing them required a coordinated effort combining expert practical knowledge, large-scale planning, and sustained maintenance over time. Consequently, the authorities of the era approached water management as a challenge as political as it was technical, whose solution demanded the mobilization of the government's full logistical and coercive power.

Long and Smith also situate the textual production of artisanal knowledge within its political context, arguing that the consolidation of modern centralized territorial states created an urgent demand for technical expertise, both to produce advanced military technologies and to craft the material representations of authority essential to state-building.¹¹⁶ We suggest that this framework applies with equal force to the domain of water

¹¹⁶ Long, *Openness, Secrecy, Authorship*, 102–142; Smith, *From the Lived Experience to the Written Word*. On the “use of the built environment as evidence for the authority of state,” see Smith, *Architecture in the Culture of Early Humanism* (quote on 50–51), and on the related “manifest-taccon” of public authority in early modern cities, Griffiths, *Information, Institutions, and Local Government*.

administration in the realm of city-state, territorial state, and municipal governance alike. Far from being mere passive recipients of their superiors' demands, several of the authors we study also strategically mobilised their knowledge to suggest administrative reform. In doing so, they argued that the increasing specialisation of their expertise and the rising status of their profession should be matched by a corresponding specialisation in administrative structures.

We therefore argue that these handbooks had a public purpose, functioning as meeting points between the individual and the institutional voice. We frame them in the type of social writing that Kilburn-Toppin and Waddell have defined. Unlike the "literature of the ego," social writing was intended for a community and not only the individual. This purpose was manifested in a hybridity of styles: a single manuscript could integrate the tone of a personal diary, the structure of an institutional chronicle, the rigor of a scientific treatise, the precision of cartography, and the detail of administrative records.

The imperative to secure urban water supplies, prevent catastrophic flooding, and ensure public health was a fundamental concern of early modern governance, directly linked to fiscal stability, social order, and the legitimization of government.¹¹⁷ When, in his best-selling *Reason of State* (1589), Giovanni Botero explained that it was the "duty" of rulers to "drain swamps ... and aid and support those who undertake similar works," he articulated something that civic and state administrators had known intuitively for centuries: the prudential management of water was central to the protection and promotion of the *bonum commune*, on which their authority chiefly rested.¹¹⁸ Handbooks, technical manuals, reports, and surveys on water management – commissioned by city councils, dedicated to ruling princes, or presented as unsolicited advice to the authorities – were therefore crucial instruments of the art of government. By codifying practical knowledge about fountains, aqueducts, springs, and river defences in written and drawn form, these texts transformed personal and private knowledge into a systematic administrative resource. This allowed municipal governments to standardize and assert control over the natural environment and the bodies of their subjects. Thus, the rise of this specific stream of technical literature was a direct response to the hydrological imperatives of state-building in the early modern period, reflecting a strategic mobilization of expertise to manage territory, project power, and ensure urban survival.

¹¹⁷ See for example Geltner, *Roads to Health*; Mukerji, *Impossible Engineering*; Ash, *The Draining of the Fens*; Tomory, *The History of the London Water Industry*; Else, *The Politics of Water*.

¹¹⁸ Botero, *The Reason of State*, 134–135. On the medieval origins of the political ideology of the *bonum commune* (common good) see Kempshall, *The Common Good in Late Medieval Political Thought*, and Dumolyn, "The Common Good." For more on Botero's ideas about the importance of water management to the art of government, see Murphy, "Giovanni Botero."

4. Conclusion

This article has presented six examples of handbooks of practical water knowledge produced in early modern Europe. Juxtaposed and compared for the first time, they make one thing abundantly clear: these are not exceptional expressions of some local genius, but instances of a broader genre which deserves recognition and study as such. This genre, the hydraulic handbook, was both technical and political, and reflected a strategic reconfiguration of site-specific practical knowledge as a vector of power and authority in early modern Europe. Hydraulic handbooks functioned simultaneously as archives of embodied practical knowledge, as claims to specialised expertise, and as instruments in the service of the broader political objective of water control. They appeared during the sixteenth and seventeenth centuries as growing cities and states with expanding administrative structures increasingly sought to control rivers and hydrographic systems, or to manage and expand water supply – in a word, to govern waters.

In response to the political demand for hydrological control and urban stability, then, the primary function of water management handbooks was to codify and resolve practical, urgent problems – from managing droughts and floods to ensuring equitable water distribution. This process transformed the previously tacit, private, and ephemeral expertise of fountaineers, engineers, and builders into stable, normative, and administrable documents. They were, in essence, books born of necessity, intended for daily use and consultation by municipal officers and their successors to sustain social life.

The administration of water and hydraulic networks transcended the merely technical to become a central political instrument. If technical instruction in the workings of specific systems was crucial for the next generation of hydraulic experts, who would go on to manage these systems day-to-day, then from the point of view of governing elites, the control of water was essential to maintain order, public health, social hierarchies, and economic stability. Consequently, the practical knowledge codified in contemporary handbooks served a dual purpose: it was a fundamental epistemic instrument that generated experience-based and collectively validated knowledge for practitioners, and it was also a strategic tool of governance. These handbooks allowed the authors – often artisans trained in workshops – to legitimize their identity as experts and elevate their social status in the face of both the period's academic hierarchy and the large number of labourers actually needed to perform hydraulic work. At the same time, these handbooks had a particular value within *ancien régime* societies, where the regulation of a vital resource reinforced existing power structures. Thus, more broadly, our analysis argues that knowledge in this context was strategically reconfigured as a vector of power, credibility, and social control, prefiguring works such as Castelli's seminal treatise, and integrating technical practice within the fabric of political authority.

The knowledge and expertise presented in this article also began life orally, as a conver-

sation in the Barcelona city archives. Our own reasons for codifying them into writing are more prosaic than those of early modern hydraulic experts, but one aim does motivate us as much as them: the desire to transmit what we know to others. We hope that this article will serve as encouragement to bring more handbooks of early modern water management and hydraulics to the light and, crucially, into conversation with each other.

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Barcelona

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AHCB, CCiAM, Registre de Deliberacions, 02.01/1B.II-159, 1650, ff. 325v.-326v.

Florence

ASF = Archivio di Stato di Firenze, Capitani di Parte Guelfa (CPG), Numeri Neri (NN) 8.

BNCF = Biblioteca Nazionale Centrale di Firenze, Manoscritti Palatini [Palat.] 788.

BNCF, Landau Finaly 97.

Naples

BNP = Biblioteca nazionale di Napoli, Francesco Antonio Nigrone, *Vari disegni di Giovanni Antonio Nigrone* (ms. XII.G.59–60).

Prato

BRP = Biblioteca Roncioniana di Prato, Carteggi di Cesare Guasti 194.

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