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Regulating the City

Streetscaping, Sewers, and the Project of Universal Drainage in Philadelphia

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▼ **ABSTRACT** At the end of the eighteenth century, amidst devastating outbreaks of yellow fever there were multiple plans to deliberately inundate the streets of Philadelphia to clean dirt and rubbish from the ground and to purify potentially miasmatic air. This essay examines the infrastructure lying beneath this project—an urban drainage system capable of rapidly and completely moving large quantities of water across and underneath the city's streets without leaving residual fluid to stagnate. From William Penn's initial planning for a gridded city in the 1680s to the creation of projects of deliberate inundation at the end of the eighteenth century, Philadelphia's streets were the objects and sites of projecting as Philadelphians crafted an urban envirotechnical system that used, repurposed, and replaced elements of the area's pre-existing hydrology. Efforts to produce this system consistently encountered problems as city authorities attempted to produce knowledge that could be synthesized across multiple scales.

▼ **KEYWORDS** drainage, urban environment, infrastructure, water

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In the second volume of his *Brief History of Epidemic and Pestilential Diseases* (1800), the wide-ranging intellectual Noah Webster wrote on the importance of water for urban life. It was, he claimed, a widely known fact that Nile floods arrested the ravages of plague. This provided "the *model*" for healthy cities: "What the Nile does once a year for Egypt, fresh streams of water should do every day in the hot season for large towns, they should inundate the streets." Deliberate floods were, for Webster, the best solution to ensuring health because "fresh running water [is] the only article that unites cleanliness with coolness." Water eliminated "the cause of noxious vapours," "cool[ed] the sultry air of a city," and produced "a considerable quantity of new and wholesome air from its own substance." Webster's plan for deliberate flooding was one of several proposals to wash the streets of Philadelphia in response to repeated, devastating outbreaks of yellow fever in the 1790s.[1]

The ambitious plans for washing the streets, cleansing the atmosphere, and cooling the air through deliberate, controlled inundations imagined a new model for the design and regulation to shape the construction of new cities and the reorganization of existing ones. Webster argued that cities in the United States should be built or redesigned around a "natural position" where streets would gradually slope downward from a central elevated point to a bordering river or ocean. Any naturally level areas should be built into "artificial elevations" to ensure that the streets descended in an appropriate pattern. Following these design principles "would give celerity to the water falling in showers, and wonderfully assist in removing filthy substances from the streets" while also providing a "brisker currency" to the air. Deliberate inundation required linking individual streets into a collective and connected system that not only moved people and goods but also rapidly moved water without significant labor—put simply, as hydraulic infrastructure.[2]

This essay examines efforts to manage urban drainage within Philadelphia's streetscape, both the built streets and those that existed only as lines on paper plans, over the long eighteenth century, from William Penn's gridded vision to proposals to deliberately flood city streets to mitigate the risk of epidemic yellow fever. Over the course of the eighteenth and nineteenth centuries, as water historian Adam Levine argues, a process of "encapsulation" submerged many of Philadelphia's creeks into covered sewers, erasing the

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1 Webster, *Brief History*, 2:358–59; 381–83; Webster cited a footnote from Volney as his inspiration for this insight, a claim at odds with Volney's account of the plague in Egypt. See Volney, *Travels*, 155, 157–60, 159 (note). For other plans on deliberate innundation, see Select Council (SelC), Minutes, October 14, 1796–April 17, 1799, 295–96, 306–7; Latrobe, *View*, 3, 7. On yellow fever in Philadelphia, see Golinski, "Debating the Atmospheric Constitution"; Apel, *Feverish Bodies, Enlightened Minds*; Finger, *The Contagious City*, 120–34, 154. Molly Nebiolo has taken on this question, arguing that Philadelphians imagined well-watered streets as part of a healthy landscape. See Nebiolo, "Constructing Health," chap. 3.

2 Larkin, "Politics and Poetics," 328–29; Parrinello, "Water as Infrastructure," 105–6; Webster, *Brief History*, 2:358–59, 399, 402; Pritchard and Zimring, *Technology and the Environment*, 4; Jørgensen, "Cooperative Sanitation," 547–67.

area's hydrology from the surface. For historian Michal McMahon, the identification of Philadelphia's Dock Creek as a problem and efforts to solve it between the 1730s and 1760s were the crucial events in which "settlement and ecology did not peacefully converge" that defined the city's environmental history.[3] Over the course of the long eighteenth century, however, covered sewers coexisted with and were developed alongside surface-level drainage. Indeed, as the plans for deliberate inundation indicate, some contemporaries saw flowing water at the surface level as a necessity for urban public health. How should we reconcile these plans for controlled street-level flooding with the longer trend toward a submerged urban hydrology?

Adopting an envirotechnical analysis of Philadelphia's urban drainage reframes it from a contest between settlement and nature to a series of ongoing efforts to appropriate the area's pre-existing hydrology into an effective drainage system dependent upon shifting ideas of the cityscape, public health, and the atmosphere/climate. In taking this approach, I build upon McMahon's argument that legislation and the creation of municipal institutions such as the Streets Commissioners in the 1760s set the foundation for a comprehensive approach to paving, drainage, rubbish collection, and water provision: This comprehensive approach depended not only upon the creation of laws and institutions but also upon the production and synthesis of knowledge of environmental conditions and human impacts at multiple scales, ranging from the micro-geographies of portions of a street to the entire area of the city and its surroundings. Between the 1760s and the 1780s, efforts to take a comprehensive approach faced consistent challenges because Philadelphia's authorities needed to engage in new patterns of observation, new means of storing and transmitting knowledge, and the use of new tools such as record books and maps to address uncertainties about how to manage water. By 1790, the city authorities had begun to synthesize these different scales and forms of knowledge to plan and build connected surface and subterranean drainage systems capable of managing water across the entire city.[4]

Beginning in 1793, however, a series of devastating outbreaks of yellow fever prompted reassessments of Philadelphia's "situation," the ubiquitous but ambiguous term that, as the editors for this special issue write in the introduction, blurred the boundaries between knowledge and proposals for action by simultaneously seeking to describe natural capacity, previous transformations to environments, and potential improvements. Heightened risk of epidemic disease demanded new projects, such as Webster's, that simultaneously disparaged the failures of the existing urban drainage system but assumed that they could be easily overcome to create a network of streets capable of moving

3 Levine, "The Grid versus Nature," 139, 141–44; McMahon, "'Publick Service,'" 92–94.

4 Pritchard, *Confluence*, 1, 4, 22; McMahon, "'Publick Service,'" 112–13; Parrinello, "Water as Infrastructure"; Burke, *Ignorance*, 84–112. Both Burke and Parrinello focus on larger-scale geography. For a focus on uncertainty, smaller scales, and urban geography, see Vermeulen, "Epilogue." On observation and the storage and transmission of knowledge, see Burke, *History of Knowledge*, 47–54.

large quantities of water across the surface of the city to mitigate the risk of potentially dangerous atmospheric conditions. To do so, however, would require the creation of new knowledge at smaller scales—the location and cause of puddles—and larger ones—the nature of Philadelphia's atmosphere—and the integration of these into plans for managing the city's streets.

Philadelphia began as a project with William Penn's plan for a new type of urban landscape at the center of his colonial enterprise. Penn sought a "high, dry, and healthy" site for a massive city to be divided into "uniforme" streets arranged into a grid. Each house was to be built at the center of a large plot "so there may be ground on each side, for Gardens or Orchards or fields, that it may be a greene Country Towne, w[hi]ch will never be burnt, and allways be wholsome." By doing so, Philadelphia would promote both bodily and spiritual health, preventing the horrors of fire and plague that had recently ravaged London and eliminating the vices Penn associated with urban life.[5]

Penn was a detailed planner—he issued orders on the minimum width of "Great Roades" in 1681—who paid close attention to Pennsylvania's climate, soil, and other natural features, but he had little to say on the hydrology of the site proposed for Philadelphia. His *Letter to the Free Society of Traders* (1683) bore the hallmarks of the entanglement between natural history and projecting that Ted McCormick discusses in his essay. Penn claimed the "*Scituation* and *Soil*" for the Society's lands in Philadelphia promised to allow for diverse manufacturing and trading enterprises. The site of Philadelphia "seems to me to have been appointed for a Town" because, among other reasons, it provided "springs" but was nonetheless "level, dry and wholsom." Surveyor Thomas Holme's map and plan accompanying Penn's text visually reinforced Penn's claim, depicting several small waterways running through the city without disrupting the neat, numbered lots available [**Fig. 1**]. Two years later, Penn again informed potential settlers and investors that the city was "high and dry yet replenished with running streams." Early, rapid growth by 1683 seemed to confirm his assessment of the situation as a natural site for a town.[6]

Penn's emphasis on natural drainage represented a departure from contemporary discussions about gridded landscapes and urban planning. The projector Cressy Dymock's 1651 plan for a rational, geometric settlement pattern in the English Fens presumed drainage ditches as foundational improvements that would remain visible in the reformed landscape. At a more practical level, the Act for Rebuilding the City of London (1667) passed after the

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5 Dunn and Dunn, *Papers of William Penn*, 2:118–21; Nash, "City Planning," 54–64; Finger, *The Contagious City*, 7–20; Zabel, "Penn's Philadelphia," 24–25; Reinberger and McLean, *The Philadelphia Country House*, 52–54; Lewis, *City of Refuge*, 80–84; Milroy, *Grid and the River*, 11–26; Shuichi Wanibuchi argued that Penn saw Pennsylvania as a project, bound up with discourses of improvement, natural philosophy, and political economy, but did not clarify the role of Philadelphia in that project. See Wanibuchi, "William Penn's Imperial Landscape."

6 Wanibuchi, "William Penn's Imperial Landscape," 391–95; Dunn and Dunn, *Papers of William Penn*, 2:98–100; Penn, *A Letter*, 8, 10, [11]; Penn, *A Further Account*, 3.

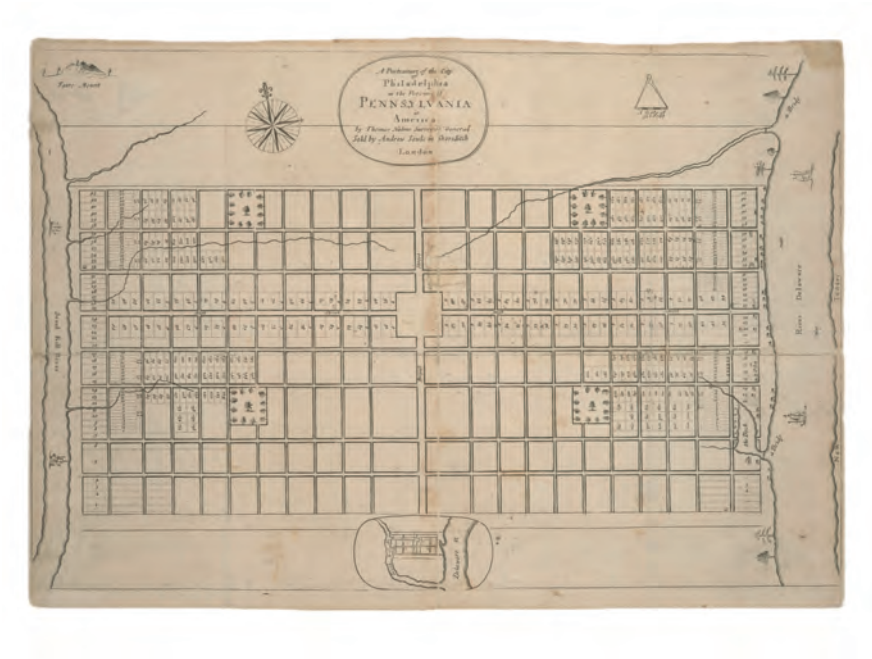

Figure 1. Thomas Holme's "A Portraiture of the City of Philadelphia in the Province of Pennsylvania" was included in William Penn's *Letter to the Committee of the Free Society of Traders* (1683). It visually conveyed Penn's plan for a new urban settlement and the area's waterways. From the New York Public Library, https://digitalcollections.nypl.org/items/510d47d9-7ab5-a3d9-e040-e00a18064a99.

Great Fire mandated "pitching" or determining the grade of city streets and the construction and maintenance of sewers and drains. In response, the Commissioners of Sewers for London issued printed guidelines for raising and lowering streets across the City to improve urban drainage. Debates about competing plans for rebuilding may have taken place behind closed doors, leaving some historians uncertain about how much Penn may have known about or drawn on them, but there were significant efforts to ensure that practical regulations for connected street grading and drainage improvements at a citywide scale were widely distributed.[7] Unlike his contemporaries planning for the English Fens or in London, Penn's words and Holme's "portrait" suggested that Philadelphia did not require improvements to manage drainage.

Philadelphia's residents quickly learned that this was not the case, but colonial authorities struggled to treat standing water as a problem requiring plans at multiple scales rather than as a localized nuisance. A 1693 Philadelphia Grand

7 Ash, *Draining of the Fens*, 285–90; Raithby, "An Act for Rebuilding," 603–12; Commissioners of Sewers, *Rules and Directions*; Milroy, *Grid and the River*, 15–17; Jenner, "Print Culture," 18–19.

Jury complained about the lack of a channel to convey water along Front Street between Chestnut and Walnut Streets, an issue the Provincial Council sought to quickly resolve. Five years later, representative Jonathan Grubb proposed a more systemic approach to stormwater and runoff across the colony, proposing a bill for paving and grading streets and building watercourses to drain stormwater in all Pennsylvania cities and towns. The resulting law, passed in May 1698, created procedures for "pitching, paving, and gravelling" and asserted that well-drained streets were essential to the development of towns and the health and happiness of colonists. Nonetheless, one year later, the inhabitants of High (Market) Street complained about floods and standing water in the streets due to poor grading and blocked watercourses and gutters. Despite the repeated petitions and actions, issues on High Street continued in 1701, with residents complaining that "great sluces of Water at every great Rain" had left the street nearly impassable. The colonial General Assembly and William Penn responded with a commission tasked with "pitching, paving, and Graveling" the city's streets and a budget of £500 to do so "according to the most sparing and cheapest way of management."[8]

This cost-conscious approach and the inability of Philadelphia to levy taxes on its residents hampered any efforts at systematic planning. In 1706, stymied by uncertainty about its taxation authority, Philadelphia's Common Council sought loans from citizens—a situation that remained in place until 1712. That year, the Council attempted to "strictly" enforce a law "for the Regulating and Repairing the Streets and Highways" that required inhabitants to work on the streets themselves, provide laborers at their own cost, or pay 1s/6d. The Council's minutes made it clear that they had little expectation that the city's residents would all collectively turn out for labor and instead saw vigorous enforcement as a mechanism to raise the "Considerable Sum of Money" that street repair required.[9]

With reliable funding, the city began to take a more systematic approach to its streets that saw the first efforts to balance different scales of geographic knowledge. In 1713, the Common Council approved a list for building and pitching of watercourses in eight areas of the city. These early efforts attempted both to appropriate existing hydrological patterns that channeled water into Dock Creek and the Delaware River and to design streets that would be able to carry and direct moving water. The Council, for example, ordered workers to design the watercourse on Walnut Street between Front and Second Streets "to be Divided in the most Convenient Place to run Part to the River and Part to the Dock," guidance implying more active efforts to reshape and regrade streets to control flow.[10] These first plans for connected drainage assumed that the streets themselves, if ordered to work with existing

8 *Minutes of the Provincial Council,* 1:342–43; 527–28, 2:23-25; George et al., *Laws of the Province,* 276–77.
9 Common Council (CC), Minutes, 1704–1709, fol. 19; Minutes, 1710–1718, fols. 7v; 9.
10 CC, Minutes, 1710–1718, fol. 14.

hydrology, could divide and direct water to drain the city. The Council, however, gave little specific direction to those building the watercourses for street-level geographies, leaving it up to the workers implementing these plans to determine where exactly to create high points dividing a street.

By the 1730s, city authorities began to question whether streets alone could manage rainwater. In 1737, the mayor noted that there had been a wave of complaints and Grand Jury presentments about "Impassable" streets. In response, the Council created a series of subcommittees tasked with specific street improvements that included paving, grading, and building both surface-level gutters and covered sewers (called "arches" by contemporaries). The first sewer project was designed to deal with marshy ground at "that Part of High [Market] Street over the Swamp called Center Swamp." The committee was to supervise the creation of a combination of surface-level infrastructure (a seventy-foot-wide causeway and two ditches) and a buried sewer to transform the "Swamp" into a site where water and land were more clearly delineated. Other buried sewers, such as the one on Fourth Street, were intended to help manage higher water volumes overwhelming the street's surface-level drainage capacity rather than to transform a marshy landscape.[11] The city's actions in the 1730s represented a shift toward subterranean drainage technologies to both supplement surface-level actions and more dramatically transform the landscape of the Center Swamp, but the surviving records do not indicate a plan to connect these discrete efforts into a drainage system. In part, this stemmed from the highly specific, local sources of knowledge—petitions and presentments—which city officials used to identify and understand drainage issues. The city's willingness to support more technologically complex and expensive projects and the uncertain relationship between site-specific nuisances and complex, larger-scale hydrology set the stage for a new wave of conflicts and new drainage plans.

From 1739 into the 1760s, controversies about drainage and pollution and projects to address these issues focused on Dock Creek. As McMahon has argued, these debates turned on the disagreements over the relationship between citywide drainage and site-specific sources of pollution in Dock Creek. A complaint from nearby residents published in Benjamin Franklin's *Pennsylvania Gazette* claimed that industrial pollution from tanneries had "choaked the Dock (which was formerly navigable as high as Third-Street)." Representatives of the tanners writing in *The American Weekly Mercury* countered that their activities were not to blame, since Dock Creek was "a Receptacle for all kinds of filth from a very great Part of the Town." Franklin's role in this conflict may have led to his appointment to a committee that developed a highly ambitious plan to dredge and wall the Dock. The committee sought to address issues beyond the edge of Dock Creek, warning that "unless the whole Dock so far as

11 CC, Minutes 1735–1745, fols. 9v–10; McMahon, "'Publick Service,'" 96–103; Johnson, "Hot-Heads," 343–64; Olton, "Philadelphia's First Environmental Crisis," 90–100.

the Third Street be in like manner dug out and cleansed and walled up" that the connection to the "Common Sewer on the South West Branch" of Dock Creek would allow the "dangerous Nusance" to remain. In the end, concerns about cost led to it being abandoned.[12] Nonetheless, the public debate and this project sought to connect localized nuisances to citywide drainage.

During the 1760s the Pennsylvania General Assembly returned to the Dock as part of an effort to systematically organize the paving, sanitation, and drainage of Philadelphia's streets. The series of acts to do so formed an ambitious plan that created tax-funded municipal institutions with the Assembly's backing. The preamble to the first act, passed by the Assembly in March 1762, warned that poor paving (or none at all) had made streets "exceeding deep and miry and almost impassable in wet seasons" and suggested that properly paved and cleaned streets would "greatly contribute to the preservation of the health" of the city. Ensuring systematic drainage was a priority. A combined body of the mayor, aldermen, and regulators was tasked with grading the "streets, lanes, and alleys and common sewers [and] with the degree of descent of each watercourse," a significant shift in who was responsible for producing and acting upon street-level hydrological knowledge. The goal was to ensure quick and consistent "discharging and carrying off of the water into the river."[13] This legislation marked an effort to address drainage proactively through citywide planning rather than reactively in response to localized nuisance complaints.

Executing paving and drainage at the scale of the entire city required new forms of knowledge-making and new authorities to produce knowledge. The Streets Commissioners—the body to oversee these plans—created a minute book that offered far more detailed accounting for drainage work and recorded details about street-level physical geography for the first time. Over the 1760s, the Commissioners reported efforts across the city to repair, rebuild, and expand drainage infrastructure and to address ongoing issues at Dock Creek. The most intense efforts to render the Dock navigable up to Third Street came between 1762 and 1765, with workers dredging and hauling carts of "Mudd and Dirt" and erecting walled embankments.[14] But this took place alongside other efforts to build or improve drainage infrastructure above and below ground, including in areas near Philadelphia's municipal boundaries and at the edges of the built environment [**Fig. 2**]. In 1762, there were repairs to the "common sewer" on Second Street requiring the use of at least 1,500 bricks and a substantial effort to dig new watercourses along Vine and Second Streets,

12 "Mr. Franklin"; "Account of the Tanners"; McMahon, "'Publick Service,'" 97–108; CC, Minutes, 1745–1753, fols. 13r; 16–17r; Double, "Scenic Stream," 9–18.

13 Mitchell and Flanders, *Statutes at Large*, 6:196, 198, 200. For subsequent acts expanding funding or regulating dumping in the streets and watercourses, see 230–46; McMahon refers to these acts as "the systematic response." See "'Publick Service,'" 111–15.

14 Streets Commissioners (SC), Minutes, 1762–1768, 7, 29–30, 95–96 ("Mudd"), 109-111, 127, 181-86, 188 ("Mudd"), 191-92, 206, 215.

Figure 2. Pierre Charles Varlé's "New Plan of the City and Its Environs" (c. 1791) captured the extent of building and changes to the urban environment such as paving over Dock Creek. It set all of this development into a revised version of Penn's initial gridded plan. Unlike plans from the 1680s, however, Varlé's depiction included urban ponds, indicating a more complex understanding of Philadelphia's hydrology. Courtesy of the John Carter Brown Library.

work that pushed beyond the northernmost extent of Dock Creek's branches.[15] In 1765, the commissioners paid for work on two sewers dug across Eighth Street, near the city's western development edge.[16] Over 1767 and 1768, the Commissioners worked to expand paving and the drainage infrastructure that went with it. Workers pitched Sixth Street and "[cut] a Drain leading into Pegg's Run," the creek running roughly parallel to Vine Street. Further south, they built "Welch Gutter[s]" at Fifth and Chestnut and Sixth and Walnut, erected a bridge "over a Gully" further west on Sixth, and "convey[ed] the Water out of a Pond from Ches[t]nut Street near Eighth Street." After a petition from the managers of the almshouse, workers began efforts to clean, repair, and build gutters along Spruce. They extended this work further west, building an arch to create a sewer using a "low place" in Spruce Street between Sixth and Seventh Streets near Pennsylvania Hospital, part of an effort to "render the

15 Ibid., 7, 29–30, 45.
16 Ibid., 184.

Street ready to those two public Institution[s]."[17] Unlike earlier drainage projects which either reacted to nuisances or dealt with a single watershed (Dock Creek) and relied on workers' knowledge of street-level hydrology, the Commissioners directed more systematic efforts to ensure citywide drainage.

This phase of expansion and intensified maintenance saw efforts to incorporate existing paths for water movement into the streetscape at multiple levels from larger waterways such as Dock Creek or Pegg's Run to unnamed low places and gulleys, but new problems emerged as the Commissioners sought to connect streets together. The changing built environment led to failures of older drainage infrastructure, as was the case in July 1766 when an "Extream bad Scituation" developed at Fourth and Sassafrass (Race) Streets "owing to a Channell being cutt a Cross 4th Street."[18] Maintaining consistent flow within Dock Creek continued to require regular dredging, generating material now treated as waste. Efforts to maintain water flow within sewers were described as "cleansing," suggesting a conceptual blurring between the work of clearing sewers and the labor of scavengers, whose job the Commissioners described in newspaper advertisements as "Carrying away the Offals of each Family and keeping the Streets clean." Intensifying material demands saw efforts to reduce costs by, for example, recyling "Larger Spars and Masts" to make gutters and "trunks," structures whose position above or below the streets is unclear.[19] Despite efforts to appropriate and improve natural drainage, the Commissioners found that moving water predictably and rapidly required constant inputs of labor and materials and generated new problems of waste.

Additionally, despite the expanded geography of drainage infrastructure, connections between watersheds and across scales remained both an intellectual challenge and a source of occasional urban flooding. The minutes of the Commissioners up to September 1772 (the last date for which records survive until after the Revolution, when their form and character shifted) record periodic efforts to work with the municipal government to plan for grading groups of city streets to establish patterns for flowing water, hoping that this would eliminate emergency work addressing overflowing sewers, standing water in streets, and inundated cellars. In 1770 and 1772, the Commissioners worked with other parts of the city's government to discuss the "Regulation and descent of the several Water Courses and Streets now about being Paved" at the southern and western edges of the built parts of the city, an approach that sought to incorporate multiple streets within a region together for planning

17 SC, Minutes, 1762–1768, 312 ("Pegg's Run"); SC, Minutes, December 29, 1765–September 8, 1768, fols. 3r, 4, 11–12, 22v, 23r ("Welch Gutter"), 23v, 24v ("low place"), 25r ("Pond"), 36v. On Pegg's Run and Philadelphia's urban development in the eighteenth century, see McMahon, "'Small Matters,'" 160; Kyriakodis, *Philadelphia's Lost Waterfront*, 22–24.

18 SC, Minutes, December 29, 1765–September 8, 1768, fol. 11r.

19 SC, Minutes, 1762–1768, 96, 212, 298; SC, Minutes, December 29, 1765–September 8,1768, fols. 7v,16r, 26v. For the use of the word "trunk," see SC, Minutes, July 14, 1770–September 7, 1772, fols. 33r, 37v.

and work to avoid the problems of earlier projects in which each new action (a paved street or new gutter) risked disrupting the operation of existing efforts.[20]

In the early 1780s, the absence of surviving minute books makes it difficult to assess the granular activities in streets and sewers, but the journal of Jacob Hiltzheimer, a German immigrant who served as a Commissioner before being elected to the Pennsylvania Assembly in October 1786, suggests that Commissioners continued to grapple with the relationship between micro-hydrologies of individual streets and a city-scale hydrology. Hiltzheimer described work at the western edge of the city's built environment, recording activities on Seventh Street with hints of pleasure, since he had a house there, and offered detailed observations on how work was done. He had, for example, watched James Pearson "Regulate the Watercourse a Cross Market Street" at the intersection with Seventh, and consistently conversed with other regulators about their work measuring and grading streets. In addition, Hiltzheimer sought to understand drainage through observations of large patterns—one "Clear and Pleasant" morning, he noted, "Got on my Horse and Took a View of every Street in Town that is Paved"—and through physical labor such as digging a watercourse across Race and Ninth Streets.[21]

Hiltzheimer's journal revealed his efforts as a Commissioner to develop an intimate knowledge of the relationship between weather, drainage infrastructure, and urban life, and to translate this intimate knowledge into the scales of neighborhood and city. On January 6, 1784, he noted that after a night of rain "the Water had Like to run down my Cellar, on acc[ount] of the Quantity of Snow Laying in the water course." This realization sent Hiltzheimer racing on his sleigh with his son Thomas and a friend to observe the state of other watercourses, a practice he regularly repeated. On a "very warme" September morning in 1784, Hiltzheimer joined a gathering of city officials to view the public sewer running from Market Street. The previous month, while away from the city, Hiltzheimer's wife had informed him that rain had led "Water [to] Run in the Peoples Cellars at the Corner of Market and Fourth Streets the water being more than the sewer could Receive"; now he would view the situation himself. "We all agreed," he wrote, "that said Sewer is Not Sufficient to Receive all the Market and fourth Streets Waters at the time of a Smart Shoure of Rain." Two "Laboringmen" were sent "down into the Common Sewer to go up s[ai]d Sewer to Market Street" to measure and record its dimensions with precision down to the inch. The large group of city officials returned to discuss the sewer in mid-September, debating whether to prevent

20 SC, Minutes, July 14,1770–September 7, 1772, fol. 9. The next surviving volume begins in October 1778, but the minutes shift away from recording the location and type of work being done. See SC, Minutes, October 30, 1778–December 28, 1781.

21 Jacob Hiltzheimer, Diary, Vol. 13, November 10, 13–14, 21, 24, and 28, 1783; December 13, 1783; Diary, Vol. 14, March 18, 1784, May 6, 1784, August 6, 1784, September 18, 1784, November 15 and 22, 1784, December 3–4 and 22, 1784; Diary, Vol. 16, October 11, 1786.

flooding during hard rains by moving water on the streets or in sewers, with each side citing precise measurements. Ultimately, they agreed to clean and expand the covered sewer. Hiltzheimer returned in June 1785 to make a simple sketch of the Y-shaped sewer, noting the width and height of the feeder sewers on the northeast and northwest sides of the intersection and the new width of the main sewer, nearly double that of the old. Even with this significant expansion, "Very Hard Rain" led to an overflow that flooded a cellar, "the first Overflow since the New piece of arch been added." A "Smart Shouer of rain" on September 5, 1786 again triggered flooding in nearby cellars. On September 18, another "hard rain" left all four receiver sewers full "but it did not swell so as to reach the Houses."[22] Hiltzheimer's diary shows the efforts to produce multiple types of knowledge—repeated, systematic observations at multiple scales; sketches and plans; and measurement and quantification. The absence of surviving evidence of measurement or sketching for earlier efforts may better reflect the record-keeping of city officials than what was produced, but Hiltzheimer's detailed observations and efforts to connect them to understand citywide patterns seem to represent something new.

Patterns of close observation did not automatically lead to more intensive environmental modifications. Small bridges were efforts to adapt the grid to the existing hydrology. In July 1785, Hiltzheimer visited Vine Street west of Broad Street at the city's center, far from the heart of urban development, "to see the Laborers and to Judge whether Trunks, or Bridges will be best to put over the two small Runs a Cross Vine Street." At the end of the year, he recorded an agreement with a workman named Miller to erect two wooden walls and a plank bridge over "the Run" in Race Street. After finding a "low place" in Walnut Street, the Commissioners re-graded the street to direct the flow of water in a different direction.[23] Even as major projects such as the dredging, walling, and partial enclosure of Dock Creek produced heavily engineered waterways, efforts to build out the grid also maintained micro-hydrologies in the streetscape.

Overall, however, this was a period in which the city expanded paving, extending hardscapes into streets near the city's formal northern and southern boundaries and west of the areas of densest settlements.[24] The largest efforts, however, took place in the south of the city. Workers dug ditches and built sewers in Pine, Spruce, and Cedar/South Streets throughout 1785 and 1786. In April 1785, a large group of seven magistrates, five regulators, and five Commissioners drew up a plan for "Water Courses in the South part of the

22 Hiltzheimer, Diary, Vol. 13, January 6, 1784; Diary, Vol. 14, August 23, 1784, September 3, 6, 16, 1784, November 18 and 26, 1784; Diary, Vol. 15, April 8–9, 1785, May 4, 17, and 19, 1785; June 8, 1785, August 23, 1785, October 4, 1785; Diary, Vol. 16, September 5, 1786.

23 Hiltzheimer, Diary, Vol. 15, May 23, 1785, July 5, 1785, October 7, 1785, November 16, 1785, December 6 and 15, 1785.

24 Hiltzheimer, Diary, Vol. 14, November 20, 1784; Diary, Vol. 15, May 4, 1785, June 1 and 4, 1785, July 9 and 11,1785; Diary, Vol. 16, May 13, 1786, October 4, 1786.

City," ultimately deciding that the water needed to run down South Street to the Delaware River via a large, covered sewer. As Hiltzheimer noted, the plan stalled as the officials sought to coordinate for funding with the state legislature and the neighboring Borough of Southwark. Despite initial agreement, the municipalities were soon at odds. Cost-sharing for sewers remained contentious into the early nineteenth century.[25]

Amidst all these efforts, city authorities undertook new efforts to develop a systematic and connected understanding of drainage across the city, relying on both continued individual observations and the production of new types of records to allow officials to link projects completed over several decades. In November 1784, Hiltzheimer rode his horse in the rain to survey "Several Cross Streets west of Fifth Street from Vine to South Street to see which way to draw off the Water where it stands in Ponds," an effort to comprehensively assess drainage between the city's northern and southern boundaries just beyond the areas of densest settlement. In June 1786, the Commissioners met at Hiltzheimer's house to discuss the cost of books "wherein every Lot of this City is to be Entered and to be kept by the Regulators." The book provided an index to surveys covering each Philadelphia street dating back to Thomas Holme's early work in 1682.[26] While both Hiltzheimer's rainy rides and the survey index sought to integrate streets together, it remained unclear how to collectively analyze or synthesize these distinct forms of knowledge.

Efforts to better understand the specific drainage projects that had been completed and how they fit together into a system took place alongside increasing concerns about the rising maintenance costs for sewers that prompted the city to employ coerced labor from prisoners. The combination of forms of knowledge suggesting a systematic understanding of drainage and concerns about labor led to an ambitious plan that would facilitate drainage across the "Unbuilt parts of the City." The plan began with a survey of High (Market) Street from Ninth Street to the Schuylkill River, moving from an area near the edge of development on the city's eastern side out to the city's western boundary across areas without any significant building, employing the scale of observation Hiltzheimer had practiced but attempting to preserve the gathered knowledge in a durable, circulatable form. An initial proposal prompted "some time spent in Considering and debating that Subject" and an order to make a new draft map of the area. In addition, the Commissioners walked from Sixth Street Schuylkill (Seventeenth Street) to Broad Street and from High (Market) Street to the city's southern boundary at Cedar Street, and then, "having carefully considered the several Natural Courses of the Water towards the Docks, and also those that descend towards Shackaminsing that

25 Hiltzheimer, Diary, Vol. 15, April 29, 1785; Diary, Vol. 16, April 12–14, 20, 22, 25, 27, 1786, May 1, 1786, June 28, 1786, August 2 and 16, 1786; CC, Minutes, February 18, 1799–January 13, 1803, 182, 186–87; SelC, Minutes, October 14, 1796–April 17, 1799, 161; SelC, Minutes, May 2, 1799–May 25, 1803, 65, 188, 191, 254–55, 281, 323.

26 Hiltzheimer, Diary, Vol. 14, November 26, 1784; Diary, Vol. 16, June 3 and 8, 1786; "John Reed's Book."

are now drained off towards the Common Sewer at the New Gaol by some other Conveyance," outlined a new, wide-ranging drainage plan beginning with a "unanimously carried" proposal to raise Center Square by three feet and to grade the streets to direct the flow of water from High (Market) Street east of Broad on a long journey southward to Shackaminsing Creek at the city's southern boundary.[27] This was a plan to link together drainage efforts centered on the watersheds of individual creeks and adjoining streets into a connected system to move water across the entire city.

The Commissioners revisited this proposal at the end of December and finalized the drainage plan to enable building across the remainder of the city. They consulted two maps: "a draught of the City shewing the several Water Courses and the relative descents of most of the Streets in the Unbuilt parts of the City [and] Also a Draught (being a section) of High Street from the Center to the River Schuylkill, shewing the declivities and Elevation of the ground in that space together with the proposed line for the gutters of High Street when properly regulated." The maps, as the Commissioners recorded, detailed the length of streets and gutters to the foot and explained grading by outlining the drop in height with precision down to, in one case, the quarter inch. These efforts to provide a systematic, visual synthesis marked a shift from the spare lines of property surveys and Hiltzheimer's individual, if highly detailed, observations.[28]

The final volume of the Streets Commissioners' minute book, before the agency was temporarily abolished and then recreated as part of a reorganization of the city's government in 1789, showed greater focus on grading streets and gutters to reduce the presence of stagnant water, a running complaint that remained even as subterranean drainage expanded. The Commissioners considered whether to raise or lower intersections and began recording the "ascent" and "descent" of gutters down to fractions of an inch to eliminate, they hoped, any standing water.[29] By the end of the 1780s, as Philadelphia's government sought to continue developing a city along the lines laid out in Penn's gridded vision, drainage had become a crucial concern, sparking a multitude of new projects from the construction of large sewers to the production of index books, maps, and surveys that would allow the Commissioners to preserve, locate, and synthesize knowledge from the grade of individual streets to hydrologic patterns spanning the extent of the city. Drawing on this knowledge, city authorities had set out increasingly ambitious plans to create drainage infrastructures comprised of streets, gutters, sewers, runs, creeks, and rivers linked together into a citywide drainage system.

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27 SC, Minutes, August 24, 1787–June 24, 1788, fols. 3, 24v–25r. Market Street between Twelfth and Thirteenth Streets were the locations furthest west in the city directory. White, *The Philadelphia Directory*, 70, 78.

28 SC, Minutes, August 24, 1787–June 24, 1788, fols. 24v–25r.

29 For complaints about ponds of "stagnated water," see SC, Minutes, December 5, 1786–August 21, 1787, fols. 24v, 34v, 40r; SC, Minutes, June 27, 1788–May 30, 1789, fols. 12v, 13, 22, 29r, 35r.

Conclusion

Repeated deadly outbreaks of yellow fever in the 1790s led to new, harsh judgments on Philadelphia's situation—both the health of its climate and the improvements to its streets. Philadelphia physician Benjamin Rush identified failures in "levelling streets" as the first issue in his 1798 catalog of the "Errors of our City" and called for increased efforts to eliminate stagnant water and promote rapid drainage. Noah Webster offered a grimmer diagnosis: Philadelphia's "position and the alterations in the original plan of the city have doomed it to calamity."[30] The devastating impacts of disease led to demands to reassess drainage at every scale and imbued them with existential significance.

A planned city of gridded streets between the Delaware and Schuylkill Rivers had been a crucial part of Penn's project—the question in the 1790s was whether such a vision remained feasible. For Benjamin Rush and his Philadelphia Academy of Medicine, "certain revolutions in the atmosphere" had dramatically increased the risk from "Putrid exhalations from the Gutters, streets, ponds and Marshy Grounds in the neighbourhood of the City." Their account removed "despair to consider the disease as removed beyond the prevention of human power or wisdom." Philadelphians, fortunately, had the power and wisdom to overcome "a constitution of the atmosphere … which disposes to fever of a highly inflammatory character," but it required greater attention to "cleanliness," particularly in the city's streets.[31]

The power and wisdom that Rush and the Academy envisioned came both from those responsible for new projects—such as a networked water supply—and from the far less prominent individuals and bureaucracies that had worked to translate the grid as a plan into its physical form. The challenge to produce and integrate hydrological knowledge at radically different scales required for rapid urban drainage became more challenging and more urgent. Plans to deliberately inundate the city's streets while preventing any pools of stagnant water called for new investments in the city but also required new syntheses of hydrological knowledge at the scale of the city, in both its built and unbuilt sections, and at the scale of gutters descending fractions of an inch in individual streets. The risk of failure—that pools of stagnant water and dirty streets might spark new outbreaks of yellow fever—had likewise grown. Yet with it too came increased ambitions. A system to cleanse the streets through deliberate flooding without creating pools of stagnant water would not only advance "the value of property, the increase of commerce, and the general prosperity of our city," but "the lives and happiness … of millions yet unborn in every part of the Globe."[32]

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30 Benjamin Rush, "An Account," fols. 25r, 31–32, 141v. On Rush and urban design, see Naramore, *Benjamin Rush*, 170–84; Webster, *Brief History*, 2:404–5.

31 Rush et al, "Report to the Governor," 3–4, 13.

32 Ibid., 14.

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