

# Colonial Sanitation, Urban Planning and Social Reform in Sydney, New South Wales 1788 – 1857

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*Issues relating to water, drainage and sewerage dominated the development of Sydney, during the first century of European settlement, yet archaeological evidence relating to these areas is rarely interpreted within its proper historical context. During the nineteenth century, crime, violence and poverty were often linked to environmental conditions. Many social reformers blamed poor sanitation for 'social evils'. Using technical, historical and archaeological evidence of drainage and sewerage systems, this paper examines the transfer and adoption of technological information, the historical context of sanitation reform and living conditions in Sydney and the application and adaptation of techniques and their impact on social reform for the period 1788 to 1857.*

*Discussions of the social conditions of nineteenth-century Sydney are often influenced by images of working-class slums. Despite the poor living conditions, the engineering capabilities in Sydney were comparable to European cities. This study indicates that the colonial Government in NSW was undertaking proper town planning measures before such initiatives were recognised by the British government. The seemingly insignificant subject of colonial sanitation has the potential to reveal a myriad of issues related to the social, technical and historical development of New South Wales.*

Issues relating to water supply, drainage and sewerage are vital components of urban planning and were major concerns during the early development of Sydney. The availability of fresh water determined the site of European settlement along the Tank Stream. The City Corporation and three commissioners were dismissed over problems of inadequate water supply and sewerage during the 1840s and 1850s in Sydney. The influence of the 'Health Movement' permeated through many professions, including medicine, science and engineering. Sewerage and drainage constituted a major part of Sydney's early development, yet this aspect of history has largely been overlooked. As Clark noted, 'water supply systems, roads and sewerage systems...are conveniently ignored or hurriedly skipped over'.<sup>1</sup>

The history of nineteenth-century drainage and sewerage in Sydney encompasses many issues. It reveals the historical development of Sydney, changing social ideals and expectations of sanitation and health standards, and the transfer and adaptation of technical information. It has been noted within the discipline of Australian historical archaeology that little documentary evidence about early nineteenth-century drainage and sewerage systems exists.<sup>2</sup> While recognising the void in historical research, archaeologists have yet to utilise the archaeological evidence for gaining a better understanding on this subject.

## THE INTERFACE OF ARCHAEOLOGY AND HISTORY

A small body of historical work has been produced on the subject of nineteenth-century sewerage and drainage in Sydney.<sup>3</sup> The majority of these documentary studies concentrate on the deterioration of the Tank Stream into an open sewer and then proceed to the construction of the 1857 sewerage system in Sydney. Due to the limited documentary evidence on Australian drainage systems prior to 1857, these studies assumed that little or none existed.

Focusing on one form of evidence (whether it is documentary or material) can produce a limited interpretation of the past. Documentary evidence consists mostly of official records, which are usually produced by the dominant social group. This generally presents only one perspective of the past. As Connah noted, another problem associated with official records is that they will often indicate that something was done,

but will be uninformative of how it was done.<sup>4</sup>

Focusing on one form of evidence can produce a limited interpretation of the past. Historical archaeology provides an opportunity to redress the shortcomings of relying solely on documentary evidence. Various archaeological excavations in Sydney and country New South Wales have uncovered drainage systems. These include those at the site of First Government House, Parramatta, the Great North Road and Goat Island. Despite the research potential of archaeology, the majority of drainage and sewerage systems that have been exposed in various excavations are usually dealt with in passing and generally viewed in historical and technical isolation.

When viewed within a wider context, a seemingly insignificant subject such as drainage and sewerage has the potential to reveal a myriad of issues related to the social, technical and historical development of early colonial New South Wales.

## TECHNICAL CONTEXT

Initial drainage techniques emerged primarily from agricultural and road engineering practices. Road and agricultural drainage techniques shared the common aims to:

1. Carry off surface water; and
2. Remove water, which had settled in the subsoil due to the natural porosity of the ground.<sup>5</sup>

The introduction of drainage to towns and cities was a gradual process. Following the industrial revolution, increasing urban population and growing public expectation for improved sanitation services precipitated the development of uniform drainage systems within urban centres.<sup>6</sup> Up until the mid-nineteenth century, town drainage in England and Australia was mostly restricted to surface drainage methods, including ditches and gutters.

Ash middens and cesspits were the primary means for managing sewage up until the mid-nineteenth century. As urban populations increased, problems associated with water contamination and the spread of water diseases such as cholera and typhoid also emerged. The growth of sewers began from the early nineteenth century. The application of agricultural and road drainage to urban environments was unsatisfactory. Road and agricultural drainage were not designed to remove sewage.

Drainage during this period included:

1. Surface drainage
2. Covered drains; and
3. Ovoid drains

### Surface Drainage

The purpose of surface drainage was to carry off surface water by making the road section higher in the centre than at the sides. This was achieved by forming gutters or ditches along the edge of the road, which then disposed the water through some side channel to a natural watercourse.<sup>7</sup> The formation of gutters or ditches along the side of a road is the most basic form of drainage. This drainage type was constructed by simply excavating a channel along the edge of the road.

Not all writers specified the dimensions for side drains. Dobson recommended that the gutters should be "shallow...[and] at intervals to intercept and throw the water off".<sup>8</sup> Gilmore, however, recommended that for flat and level areas, the side drain should be at least 2½ to 3 feet lower than the bottom road covering.<sup>9</sup> More sophisticated designs consisted of base and sides paved with tiles or stone.<sup>10</sup> This usually occurred in urban centres where the formation of gutters was required to be of greater permanence. Tiles were an expensive material and rarely recommended.<sup>11</sup>

Side drains or ditches were problematic because they required continual maintenance. Smith stated that such drainage 'should never, except from necessity, be adopted, being apt to get filled with mud and grass,...which often chokes them'.<sup>12</sup> Gilmore's solution to this problem was to construct a covered drain under the ditch, and then to fill the ditch with straw or hay and stone and brick fragments (Fig. 1).<sup>13</sup>

### Covered Drains

Covered drains are a more complex form of side drains. The simplest form is often referred to as the 'box drain'. The floor of the drain was constructed in either flagging stone or brick, with sides made from the same material. The drain was covered with flagging stones or bricks, or as Gilmore suggested, with stone corbelled out to meet above the centre of the drain (Fig. 2).<sup>14</sup> Alternative designs included the use of different materials (such as thin stone and mortar), or the formation of rough arches rather than a rectangular structure.<sup>15</sup>

The joints at the top of the drain were usually open to allow the flow of water to enter freely into the drain. Box drains were often covered with a layer of stone or gravel to prevent earth or soil washing into the drain, and to assist in the flow of water into the drain. A more elaborate system involved covering the drain with a layer of straw, hay, or fine brushwood before filling the trench with the stone, brick and gravel rubble.<sup>16</sup>

The box drain was the main form of drain design up until the mid-nineteenth century. Highly problematic, it was common for the entire volume of the drain to be completely filled and blocked.<sup>17</sup> Their main fault was the broad flat bottom, which allowed mud and sand to accumulate. Additional problems were caused by the assumption that main covered drains should be large enough for a person to crawl through for the purpose of cleaning them out. Writing in 1912, Taylor encountered box drains in London that were at least 2 feet wide by 2 feet 6 inches high (0.6 metres by 0.75 metres).<sup>18</sup> Such a large drain area reduced the flow, increasing the likelihood of silting and blockage.

Circular or barrel drains were rarely mentioned by road engineers. They were not recommended as they were considered expensive and required inlets and iron grates. They were also thought to be less effective than box drains.<sup>19</sup> It should be noted that brick-barrel drains were frequently used in N.S.W.



Fig. 1: Gilmore recommended that the drain be filled with straw and stone fragments and covered with earth to prevent blockage (Gilmore 1876:41).

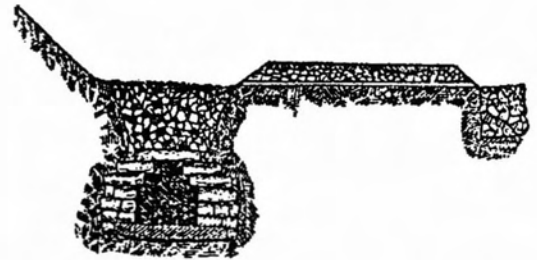


Fig. 2: Box drains were easily constructed from stone blocks forming the sides, base and cover (Gilmore 1876:54).

### Ovoid or Egg-Shaped Drains

The development of the ovoid or 'egg-shaped' drain marked a dramatic improvement in the effectiveness of drainage systems (Fig. 3). John Phillips first designed the ovoid drain during the 1840s.<sup>20</sup> Phillips also developed the 'separate system' in 1847, advocating that for the proper drainage of towns, separate drainage systems were required for stormwater and sewage.<sup>21</sup>

Due to the ovoid shape, the flow of water is concentrated at the bottom of the drain. Even when the quantity of liquid fluctuates, the ovoid shape always achieves the greatest depth of flow. This reduces the friction, thereby decreasing the likelihood of silting and blockage.<sup>22</sup>

The curved form of the section also provided greater strength to resist external pressure.<sup>23</sup> This meant less risk of the structure collapsing and requiring repair. Thomas observed that ovoid drains, which were only one brick thick, were found to be capable of withstanding any pressure applied to them.<sup>24</sup> Unlike box drains, ovoid drains could be constructed to a size large enough to admit a person without affecting the flow efficiency of the system.

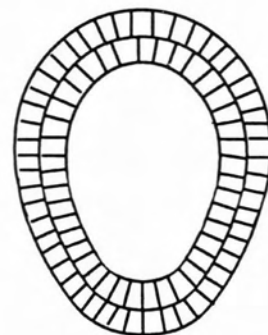


Fig. 3: The ovoid drain marked the turning point in the development of effective drainage systems (Drawing A. Wong).

## SEWERAGE SYSTEMS

Methods of sewage disposal can be categorised into two groups: the dry method and the water-carriage method. As the name suggests, the water-carriage method was reliant upon a steady and reliable water supply. Due to the erratic supply of water in most cities during the nineteenth century, the 'dry method' was the main means for sewage disposal until the late-nineteenth century.

### Dry Method

Up until the end of the nineteenth century, cesspits or privy pits served as the primary method for the treatment of liquid and solid waste in Europe and Australia. Two types of cesspits were used: fixed or excavated cesspits; and movable cesspits. Despite the distinction between the two types, cesspits were rarely made to any definite specifications.

In *The Australian sanitary inspector's text-book*, Bruce and Kendall described the cesspit as:

a large pit, often 3 to 4 ft. square, and 4 ft. or more deep. This pit, also, frequently merely a hole dug in the soil, sometimes loosely bricked round the sides, to keep the earth falling in, and occasionally having a loose unjointed brick bottom.<sup>25</sup>

Sometimes the privy seat was placed directly over the cesspool, forming the only means of covering the pit.

Cesspits were used to contain house slops as well as human waste. As nearly all cesspits were neither well constructed nor watertight, the waste matter would often permeate through the surrounding soil and pollute any nearby well or water supply. Cesspits were rarely cleaned out. Once full, another pit was often dug nearby.

Movable cesspits consisted of tanks or barrels, which were continually removed when full and their contents disposed.<sup>26</sup> The 'pail-system' could be viewed as a form of movable cesspit. Bruce and Kendall commented that there were no regulations for the provision of satisfactory made house pails,

most of which leaked. In some areas of England, a two-pail system was implemented which involved replacing the full pail with as empty clean one. This had the advantage that there was no double pouring, thus reducing the risk of spillage. The provision of night-pails by the government also meant that proper air-tight receptacles would be used, decreasing the smell and spillage usually associated with nightsoil.<sup>27</sup> A few municipalities in New South Wales had adopted the double-pail system by the beginning of the twentieth century.<sup>28</sup>

### Early Sewers and the Water Carriage Method

Early developments of the water carriage system involved removing sewage into larger cesspits or vertical shafts. In New Zealand, some towns were drained into several large cesspits which overflowed with stormwater during periods of heavy rain.<sup>29</sup> Underground drainage did exist in some English towns from the late 1700s, but it was illegal to discharge sewage into these drains.<sup>30</sup>

Early sewers resembled the types of drains used for road and agricultural purposes. These included the various types of box drains and brick-barrel constructions. A survey of the early sewers in Manchester provides an overview of other forms of underground drains built during the nineteenth century (Fig. 4). From the early 1800s, box drains were constructed with inverted arch bases. The sides and base consisted of bricks, and covered with stone flagging. This form was also reversed, with a flat stone base and brick arch cover. From the 1830s, oval forms emerged, constructed from brick.

The problem of blockage and a reduced scouring rate caused by wide flat drain bases was partially solved with inverted bases. It was not until the development of the oviform drain during the 1840s that silting problems were minimised. Clayware pipes also emerged from the mid-1800s and were a more economical form of drainage. From this period, the majority of sewers were built in either oviform or with ceramic pipes.

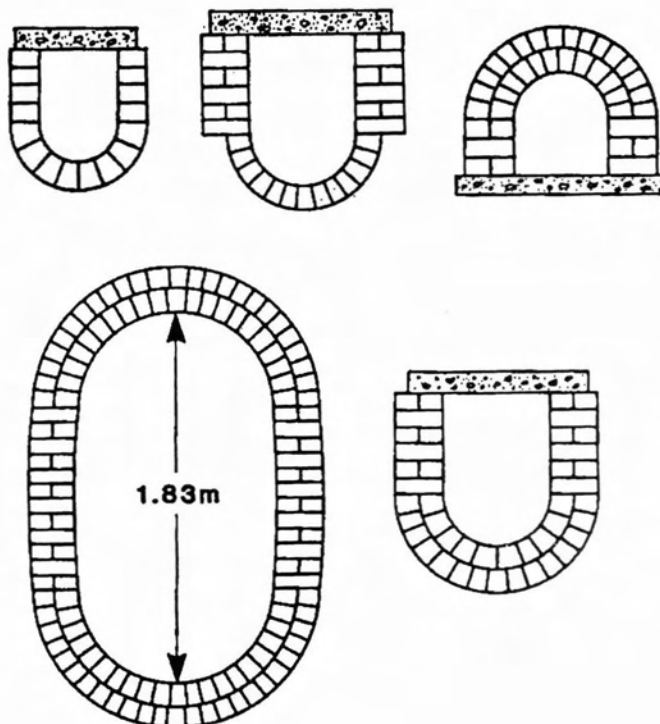


Fig. 4: The top row shows the types of sewers developed during the early 1800s. The bottom row of drains emerged after the 1830s (Drawing A. Wong).



The majority of sewerage systems were constructed after the release of Chadwick's *Report of the sanitary conditions of the labouring population of Great Britain* in 1842. It recommended that uniform drainage systems be established, with self-cleansing velocities. As regular water supplies were established, water carriage drainage became possible. With more households connected to water mains however, the amount of refuse water produced also increased.

Drainage systems constructed during the mid-1800s usually combined sewage and stormwater.<sup>31</sup> Such systems were required to carry sewage, household slops and stormwater. As the system was linked to households and streets, a backflow of sewage would occur during periods of heavy rain. The size of drains also increased in order to receive the quantities of stormwater which caused huge blockage problems during dry spells.

A 'separate' system was developed during the 1840s which removed sewage and stormwater through separate drains. It was realised that sewage only constituted a small proportion of the overall waste material. Under a separate system, smaller drains could be constructed, resulting in better velocity and cleaning.<sup>32</sup> Unpolluted stormwater could be discharged into nearby watercourses without a high risk of pollution.

While town drainage was derived from road and agricultural techniques, the need to effectively remove sewage

resulted in specific sewerage designs emerging during the nineteenth century. The period up until the mid-nineteenth century was characterised by experimentation. Engineering designs for proper sewerage were often combined with popular assumptions regarding the effects of sewage on health and the environment.

The separate water-carriage system, which emerged during the mid-1800s, has formed the basis of modern drainage and sewerage systems. It must be emphasised that the development of this system was neither inevitable, nor was it the only alternative. In cities, such as Paris where a reliable water supply was not established until the late-1800s, effective cesspit designs were produced. Due to the association of disease and social degradation with cesspits, however, greater effort was given to the development of an underground drainage system. The desire to have a system, which transported sewage away, resulted in the adaptation and improvement of agricultural and road drainage. Techniques for increasing drain velocity were developed in preference to improving cesspit designs.

### THE SOCIAL PLIGHT OF SANITATION IN N.S.W. 1788 - 1857

The description of sanitation conditions during the nineteenth century provides an insight into the living standards in Sydney during this period. Historians such as Kelly and Fitzgerald have undertaken analysis of this period.<sup>33</sup> As Kelly noted, a wealth of documentary evidence exists providing a record of the standard of accommodation and sanitation facilities. The poor living conditions in Sydney during the nineteenth century are often perceived as 'substandard' when contrasted to modern expectations but documentary evidence from other Australian cities indicate that Sydney was not an exceptional case.

#### Sewerage, Drainage and Environmental Determinism

The abundance of social commentary concerned with the sanitary condition of urban centres corresponds with the emergence of the 'public health' campaign in Britain. The sanitary reform movement in Britain did not gather momentum until after the epidemic of Asian cholera in 1831-32. It was realised that diseases such as typhoid and cholera were directly linked with contaminated water. Motivating the social reform movement was the ideology of environmental determinism. From the mid-nineteenth century, moral and scientific arguments for better sanitary conditions were used to invoke social change.

Supporters of environmental determinism believed that the physical environment shaped the moral character of the individual. Chadwick's *Report of the sanitary condition of the labouring population of Great Britain* argued that public dirt caused disease and social problems. The report led to the passing of the *Public Health Act* of 1848, which required the inspection of towns, the removal of nuisances, and the provision of piped water.<sup>34</sup>

Elements of the public health movement permeated through many professions including medicine, science and engineering. In Australia, it was not uncommon for newspaper commentaries, medical societies and town engineers to link social well-being with environmental factors. The Australian Health Society in Melbourne was established to educate and induce change in sanitary matters in the public and legislative realm (Fig. 5).<sup>35</sup> In Sydney, crime and violence were often identified with the poorer areas of the working class. In 1865, Rawlinson commented, 'show me a dirty undrained locality in your town, and I will show you the seat of perpetual debility, fever and death'.<sup>36</sup> Overcrowded and dirty conditions were the supposed causes of social degradation.

The observations of W.S. Jevons, a N.S.W. government assayer, provides one of the first records of drainage and

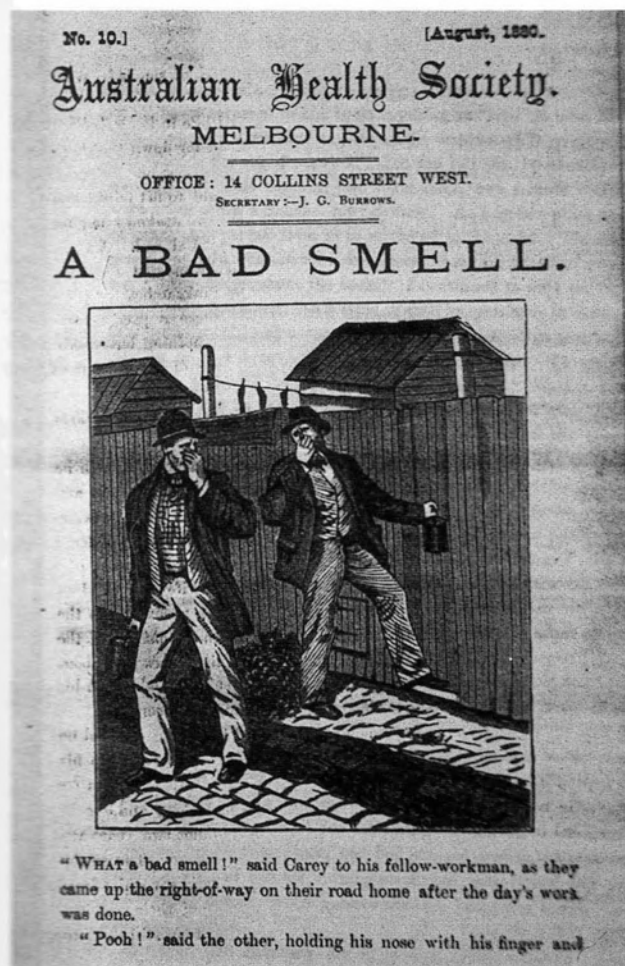


Fig. 5: The Australian Health Society published stories for public education, which often linked social well-being and morality to environmental factors (Girdlestone 1877).

sewerage conditions in Sydney. Titled the 'Social Cesspool of Sydney', Jevons wrote the article in 1858 about the Rocks. He described the:

...utter absence of all means of drainage or of removing filthy matter...that in many cases the foul drainage of one cottage trickles down the hill till it encounters...the back or front wall of the house below; here it accumulates, soaking down into the foundation, or sometimes actually running in at the door.<sup>37</sup>

A Royal Commission into the conditions of the working classes of the metropolis in 1859 reinforced Jevons' observations. The Commission found that 'in more recently erected dwellings the means of drainage and ventilation are almost entirely neglected'. Some areas of Sydney were compared 'in forms as aggravated as in the old cities of Europe'.<sup>38</sup>

### Government Schemes for Drainage and Sewerage

Two main drainage and sewerage schemes were undertaken in Sydney during the nineteenth century. Considered the first designed sewerage system for Sydney, five main outfall brick and stone sewers were completed in 1857. In 1877, the Sewerage and Health Board under the advice of W. Clark, formulated the Bondi Ocean outfall to the north, and the sewage farm near Botany Bay towards the south. These later schemes were completed in 1889 and transferred to the newly formed Board of Water Supply and Sewerage.

Contrary to popular belief, the 1857 sewerage system was not the first designed system for Sydney (thought it may have been the first constructed). Plans for a uniform drainage and sewerage system were made as early as 1835. The proposed system was markedly different to the 1857 sewer outfall system, and indicates a different level of knowledge and technology in the colony.

From 1830, the Surveyor-General was responsible for the construction of roads and drainage in New South Wales. Within Sydney, part of this responsibility was delegated to the Town Surveyor. In March 1835, the Town Surveyor, Felton Mathews completed a general plan of drainage and sewers for the town of Sydney. A summary of the proposed plan was provided by Mitchell in a letter to the Colonial Secretary in 1835.

Mitchell noted that there were 'very few, if any drains existing of sufficient magnitude to be of any service in a general and effectual system of drainage' and proposed a system of stone box drains along the middle of principal streets with side drains linked to each house.<sup>39</sup> With a proposed width of 4 feet wide (1.17 m), Mathews considered stone drains as a 'deviation from general practice'.<sup>40</sup> Tenders for the construction of brick-barrel drains had been called in 1834. Only one tender was submitted and the cost was 'at such an exuberant rate' that it was rejected.<sup>41</sup> The large proportion of stone drains constructed during the early part of the 1830s may have been due to the shortage and high expense of bricks.

By 1837, the general plan for the drainage and sewerage had altered with a preference towards brick rather than stone, and the use of brick-barrel drains. Most of the changes were probably initiated by Captain Barney from the Royal Engineers Department. Barney had been requested to comment on the state of drainage and sewerage in Sydney.

Barney recommended that brick was a better material than stone for drainage construction.<sup>42</sup> It was explained that unless the stones were properly worked and pointed, water would easily penetrate the drain and wash the mortar from the joints. Soil would then enter the drain, causing the structure to eventually collapse. As stone drains were expensive to repair, bricks were considered the more economical option.

In defence of the state of drainage in Sydney, Mathews explained in 1837 that the drains constructed to date were meant only as temporary measures until a proper system of drainage and sewerage was implemented. Mathews agreed with Barney that brick was a superior material over stone for drains and that:

Everyone at all conversant with the subject, must be well aware of the superiority for this purpose of good brick over stone and in proof of that such has always been my opinion.<sup>43</sup>

Under the new scheme, the proposed drains included brick-barrel drains, flagged stone drains and arched stone drains. This system was to be linked to either Darling Harbour or into the Tank Stream, which led into Sydney Harbour. Such outlets were similar to the combined system that was to be constructed in 1857.

The 1837 proposed plan was not undertaken. Despite warnings against the construction of drainage lines without the provisions of an overall plan, limited drainage works were undertaken during the 1830s. Most of these works occurred around the commercial areas of George, Market, King and Kent Streets. It was noted that during heavy storm, the rainwater would rush down Market Street causing a deep channel to be cut across George Street, which damaged the street and carriages.<sup>44</sup> Drainage construction during this period was aimed primarily at solving immediate problems rather than creating a comprehensive system. Drainage works declined from the late 1830s. This may be due to the push towards incorporating the City of Sydney, which was passed in 1842. The onset of the 1840s depression also resulted in the decline of public programs.

### The 1857 Combined System Outfall

Sewerage and drainage problems continued to be of major concern following the incorporation of the Sydney Municipal Council. Drainage programs were continuously deferred due to the Council's inability to agree on a sewerage system, debates on the benefits (and disadvantage) of underground systems and the amount of tax to be levied.<sup>45</sup> In 1852, the *Sydney Corporate Abolition Act 17 Victoria 33* was passed, dissolving the Council. Three Commissioners were appointed with the responsibility of providing better sewerage and cleansing for Sydney. The Commission appointed the position of City Engineer and appointed W.B. Rider in 1854.

Rider was responsible for initiating the trigonometrical survey for Sydney, which was revised in 1865. These maps provide invaluable details of Sydney during the mid-nineteenth century. The Commissioners were criticised for the apparent



Fig. 6: The construction of the 1857 combined drainage system in Pitt Street. The smaller drain to the left was designed for overflow during heavy rain (Mason 1857: 13).





Fig. 7: Sketch published in Sydney Punch, commenting on the pollution from the drainage outlets in 1869 (Sydney Punch 3 July 1869).

delays in the commencement of drainage works, claiming the trigonometrical survey was unnecessary. Works began on the main outfall sewers in 1855. The underground sewerage system was completed in 1857, and consisted of five principal outfalls, which discharged into Blackwattle Bay, Darling Harbour, Sydney Cove, Bennelong Point and Woollloomooloo Bay (Fig. 6).<sup>46</sup> Rider specified the use of oviform drains, recognising their economic construction and efficient design. It was also intended that secondary sewer lines would be constructed along every street to provide drainage to every house. It was hoped that all open ditches and cesspools in the City would be abolished.

Despite the introduction of underground sewerage in 1857, sanitation facilities did not improve for the majority of Sydney residents. The problem was due to the limited area of drainage, the combination of stormwater and sewage and the outfall location, rather than the structural form. It was thought the tides would carry the sewage away and there were arguments that the discharge of sewage into the harbour would not be detrimental to public health.<sup>47</sup> It became apparent that such a system was causing serious pollution to the waterways. It not only contaminated the shores and water, but also silted up the harbour.<sup>48</sup> The discharge of untreated sewage resulted in the suspension of solid matter within the harbour forming banks in low tide (Fig. 7). Vessels avoided anchorage at Farm Cove on account of the smell described as being 'so offensive, that they could not have credited it, without personal experience of it, and that no description yet published equaled the foul reality'.<sup>49</sup>

In 1877, the *Report to the Government of N.S.W. on Sydney's drainage* indicated that most suburbs still relied on surface gutters in the streets. The reliance on cesspits resulted in the contamination of water supplies. Even within the city area, less than 50 percent of all households were connected to the sewers at the end of 1876.<sup>50</sup> The 1877 report recommended the sewerage system be expanded to include the drainage for the suburbs and to divert the outfall further away from the city area (namely the Bondi Ocean Outfall and the Botany Bay sewage farm, later transformed into an ocean outfall). This new scheme also introduced the 'separate system', separating sewage from stormwater.

## THE ARCHAEOLOGY OF COLONIAL DRAINAGE 1788-1857

The archaeological investigation of First Government House, Sydney indicates that the need for drainage was recognised from Phillip's arrival in 1788. Few written specifications for the construction of drainage systems were provided or survive. The level of technical understanding, implementation and adaptation of drainage engineering methods can be assessed through the physical evidence during the period 1788 to 1857.

### Surface Drains

Surface drains and gutters were the primary means of drainage in Sydney during the nineteenth-century. The construction of modern roadways has resulted in the loss of many of these original features. Surviving evidence of nineteenth-century surface gutters exist in many inner-city side streets. The guttering was primarily formed from sandstone blocks with a slightly curved base (Fig. 8). This form of guttering was also used in Melbourne during the same period.

### Covered Drains

Box drains were used widely throughout Sydney up until the mid-1800s. They were constructed in a variety of materials and forms.

The excavation of the site of First Government House in Sydney uncovered examples of covered drains constructed in the period immediately after European arrival. The drainage system included box drains with bedrock base, bricksides and sandstone slab capping. Brick barrel drains constructed during this early period were also located. Built during two construction phases, the drains were dated to the late 1790s, c.1811 and c.1828.<sup>51</sup> Sections of the drainage system were left



Fig. 8: Some original sandstone has survived within the inner-city area. This example was located in Darlinghurst, Sydney (A. Wong).

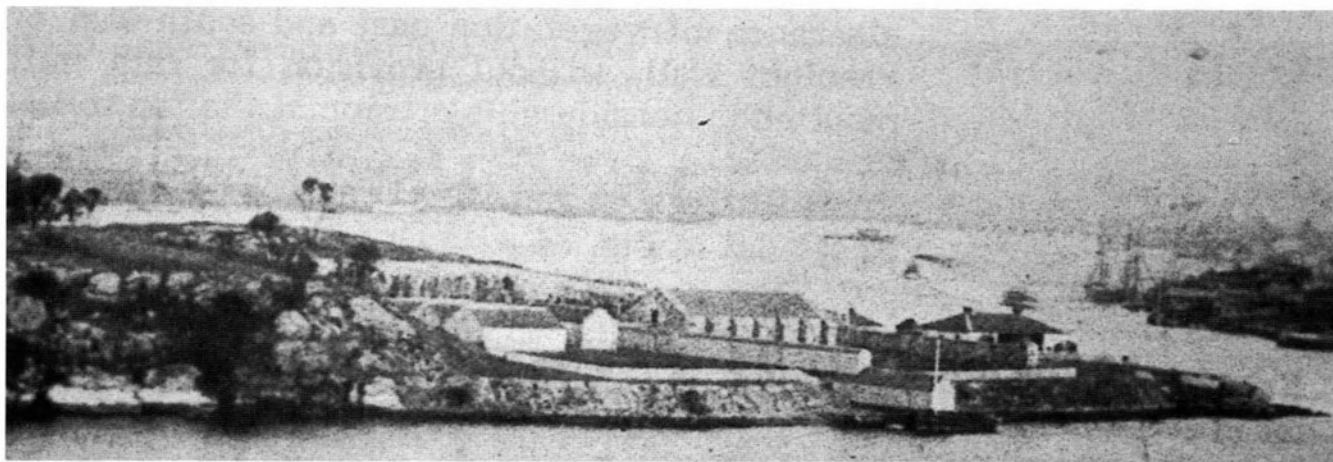


Fig. 9: The Magazine Precinct on Goat Island from Ball's Head 1885 (W.A. Gullick, ML Q981/G).

exposed as part of the Museum of Sydney.

Box drains continued to be used during the 1830s. Archaeological investigations undertaken on Goat Island uncovered two forms of covered drains. A drainage system relates to the powder magazine precinct constructed on Goat Island in 1839. The main buildings in this complex include the Queen's Magazine, the cooperage, kitchen and barracks. The Queen's Magazine is the earliest and largest powder magazine in Australia, with its barrel vault, massive buttressing and detailed ventilation system. Its well-insulated walls are two metres thick and three metres thick at the buttresses.

The Magazine Precinct was constructed as a response to increasing amounts of gunpowder imported to the colony during the early 1830s. The gunpowder was used mostly for public works and government defence purposes.<sup>52</sup> After the Legislative Council passed an Act for the better regulation of storing and carriage of gunpowder in 1836, the Queen's Magazine was required to store privately-owned gunpowder in addition to Crown supplies. The two main requirements when storing gunpowder are to keep the substance cool and dry. An effective drainage system would have been vital for the function and design of the magazine.

Excavations undertaken near the cooperage exposed a box drain constructed on the quarry floor. The drain was formed

from two parallel lines of edge laid stone slabs, covered with another capping stone (Fig. 11). The drain was directly linked to the sub-floor drainage of the cooperage via a channel beneath the cooperage wall.<sup>53</sup>

A different drainage system was uncovered at the Queen's Magazine.<sup>54</sup> Unlike the cooperage, this box drain was cut into the quarry floor, forming a moat along the edge of the building (Fig. 12). The drain had a shallow dish base. One side of the drain had a vertical face, the other side was cut at an angle towards the Magazine. Running the length of the building, the system also had side drains branching out. The drainage system was relatively unblocked, with only a shallow layer of silt and rubble at the base. A substantial amount of rainwater was found in the drain. As there is no natural water supply on the island, it is likely that the drainage system fed into a water tank.

The difference between the drainage systems located at the Queen's Magazine and the cooperage indicates the application of different methods for different functions. The Magazine required a reliable system to ensure that water was diverted away from the powder. A box drain excavated into bedrock is less liable to collapse, decreasing the likelihood of drain blockages. The cooperage would not need such stringent requirement, resulting in the more economical design constructed with sandstone slabs.

### Brick-Barrel Drains

One of the earliest examples of brick-barrel drains was uncovered in Parramatta in 1981.<sup>55</sup> The section of drainage was uncovered at 126-138 George Street. The archaeological investigation found that the drainage system was closely linked to the topography and planning of Parramatta.<sup>56</sup> Governor Phillip recognised the farming potential of Parramatta, but the area was located within a shallow river valley. The area around the town was prone to flooding and poorly drained. Originally, water would flow down a shallow gully, which led to river flats forming swamps or ponds. Except during heavy rain, this catchment area did not connect with the river. The purpose of the brick-barrel drain was to follow the shallow gully and carry the stormwater directly to Parramatta River, decreasing the likelihood of the town flooding.

Located just below the ground level, the brick-barrel drain was constructed with two courses of about 200 mm bricks. Built from sandstock brick, the internal diameter ranged from 1.2 to 1.3 m (Fig. 13). This conforms to the general assumption that drains had to be large enough to allow access for cleaning. The system was dated to the 1820s, which coincides with the building program initiated under Governor Macquarie. Attempts were made by Macquarie to enforce building regulations, thereby improving the conditions and standards of buildings. It is possible that such improvements continued after the departure of Macquarie in 1821.

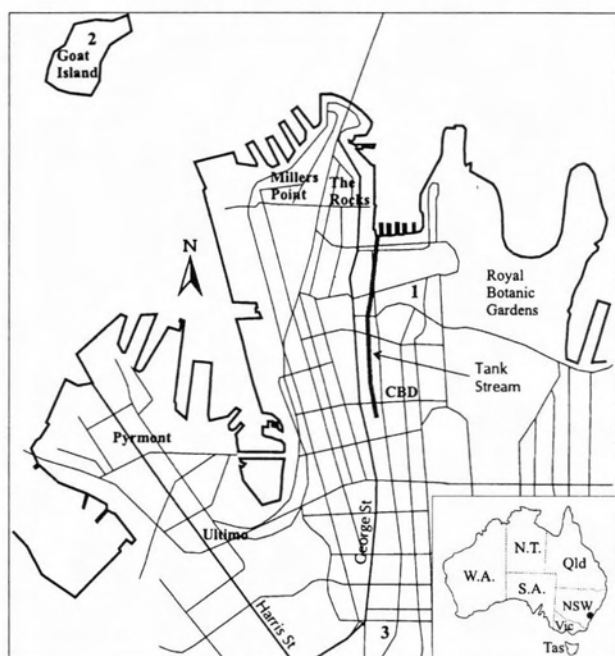


Fig. 10: Location map of sites: 1 First Government House; 2 Goat Island; 3 AGL site.

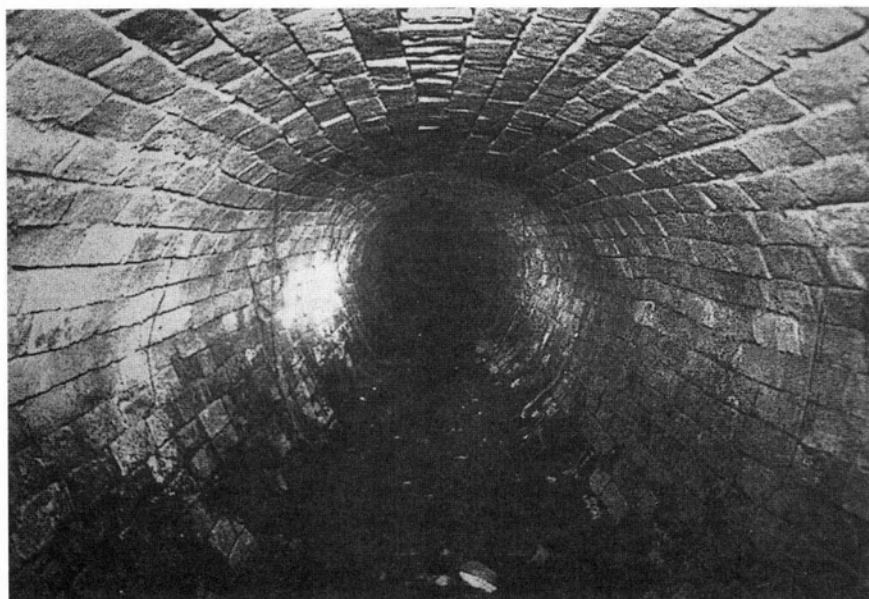


Fig. 11: Excavation of box drain located adjacent to the cooperage, Goat Island (Denis Gojak).



Fig. 12: The drainage system associated with the Queen's Magazine was excavated into bedrock (A. Wong).

Fig. 13: A section of the brick-barrel drain located in Phillip Street, Parramatta (Ted Higginbotham 1981).





While Parnell considered brick-barrel drains as expensive and less effective than box drains, it was realised by the 1830s that box drains were liable to blockage. Brick drains were thought to require less maintenance than stone drains. It would certainly have been easier to replace sections of a brick drain than one constructed from stone.

### Arched Drains

Large arched drains were usually constructed in Sydney to cover natural watercourses.<sup>57</sup> By the mid-nineteenth century, the majority of creeks in Sydney were transformed into open sewers, receptacles of rubbish and human waste. Examples of arched construction include the Haymarket drain uncovered during excavation of the AGL site, the Macquarie Culvert in the Royal Botanic Gardens and the Tank Stream.<sup>58</sup>

The current Haymarket area was originally low swampy land, about two kilometres south of Sydney Cove. The land was drained by a creek, which originated in Surry Hills to the southeast and crossed the current Belmore Park to the alignment of Hay Street, and into Darling Harbour. Due to the availability of clay, the area was used initially used as brickfields for a period from 1788.

The relocation of the Cattle Market and the Hay and Corn Market during the 1830s to Haymarket, increased the commercial activity in the area. Tenders were called in 1835 to construct a stone drain behind the Corn Market and in 1839 for a drain at the new Corn Market.<sup>59</sup> It is likely that the creek, which ran through the current Belmore Park, was utilised as part of the drainage system at this time. In 1848, the creek was described as 'the drain through the Government Paddocks' and designated as the 'common sewer for the allotments that had been sold in its neighbourhood'.<sup>60</sup>

Part of this drainage system was uncovered during excavation at the former Australian Gas Light Company site in the Haymarket.<sup>61</sup> The drain consisted of a large stone base with a brick vaulted cover. The cut sandstone base was constructed with sandstone block sides to a height of 0.9 metres. The internal height and width was 1.6 metres. The arch was constructed from two layers of brickwork.

The drain contained layers of fill to a depth of 1.3-1.4 metres. Such silting problems were associated with flat bases, which reduce the scouring rate. Artefacts from these deposits were dated to the mid-nineteenth century, corresponding to the documentary evidence for the construction of the drain.

The Tank Stream was generated by seepage springs from the joints of the underlying sandstone in the current Hyde Park area (Fig. 14). The stream became a definite water channel from King Street, flowing to Sydney Cove. With a reliance on cesspits and surface drainage, the Tanks Stream quickly became polluted and was abandoned as a water source by 1826.

The catchment area of the Tank Stream was diverted with the construction of the 1857 combined sewerage system. The diversion 'comprised of 500 feet in length of stone culvert of elliptical form'.<sup>62</sup> Cesspits and stormwater continued to overflow into the stream, sustaining the sewage problem. The *Sydney Morning Herald* in 1860 commented:

The principal public work in progress for the improvement of the city is the covering in of the Tank Stream. The existence of an open sewer through the heart of the city has constituted, for several years a traditional grievance...<sup>63</sup>

The process of covering the Tank Stream began in 1860. Apart from the use of steel pipes and reinforced concrete box section during the twentieth century, three forms of drainage forms were used. In 1860, the Sydney City Council completed the section between Hunter Street and Curtin Place. Constructed in masonry, the structure consisted of a covered archway 1.5 metres high by 3 feet wide (Fig. 15). In 1867, an

oviform sewer was completed along the course between Hunter and King Street (Fig. 16). Part of the section remained uncovered until the construction of the General Post Office and Martin Place. Measuring 1.4 metres high by 1 metre wide, 37 metres of the oviform structure was built. From Bridge Street to Alfred Street, the Tank Stream became an archway combined with an oviform base (Fig. 17). This section was built in 1878 and is approximately 1.7 m high by 1.1 m wide. The oviform base was constructed from brickwork and the archway was built in sandstone.<sup>64</sup>

The gradual process in covering the Tank Stream provides a physical record of the different methods of drainage construction during the nineteenth century. The drainage forms used were comparable to the examples observed in Manchester. Drainage forms such as the arched covered drains, which were developed during the 1830s continued to be used after the 1860s. The use of the Tank Stream as part of a combined stormwater and sewerage system continued until the 1980s.

The brick double-arched culvert in the Sydney Royal Botanic Gardens is one of the earliest surviving examples of drainage construction in New South Wales (Fig. 18). Built as part of Mrs Macquarie's Road, the culvert dates to 1816. As well as carrying water under the roadway, the culvert also served the additional function as a bridge.

While the southern section was rebuilt when the roadway was widened the northern section retains its original brickwork. The culvert was built in sandstock brick, mostly in stretcher

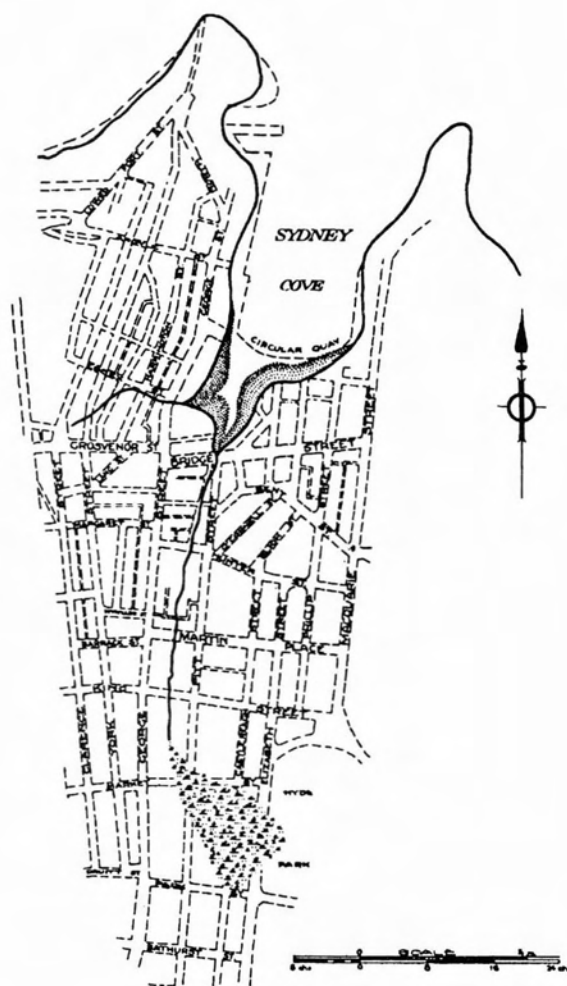


Fig. 14: The catchment area of the Tank Stream, Sydney (Henry 1939).

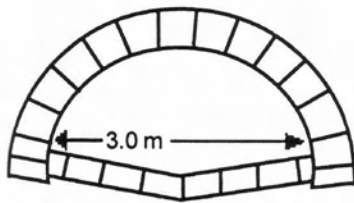


Fig. 15: Most of the Tank Stream is currently enclosed by a stone arch and base.

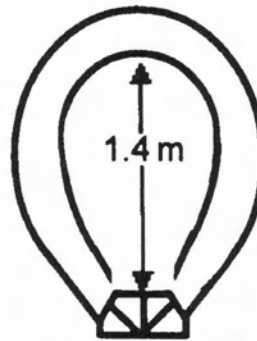


Fig. 16: The oviform sections were built in brick and rendered with cement.

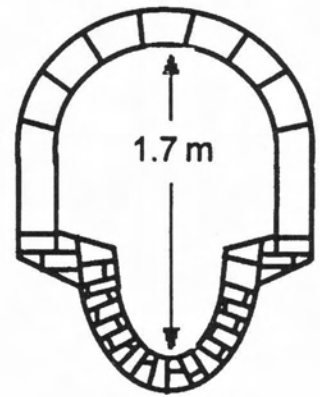


Fig. 17: A section drain that combines an arch cover with an oviform base.

bond, and the outer skin was not properly bonded with the main structure, resulting in structural problems. This building technique indicates a lack of building knowledge. This structure provides a record of the buildings skills and material available during the early period of European settlement.

While the form of the culvert is common, the age and material used within its historical context makes it a significant item. Other culverts and small arched bridges were built during the early nineteenth century, but most have collapsed or were dismantled due to poor construction and inadequate knowledge. This brick culvert appears to be the only brick example from this period. The majority of other brick culverts did not appear until the 1880s with the construction of railway bridges.

Due to the poor quality of bricks produced during the early nineteenth century, there was a greater reliance on stone for public works. For road and drainage works outside Sydney, materials were obtained locally. Surviving culverts constructed prior to 1857 were mostly constructed in either stone or timber.

## CONCLUSION

The settlement of Sydney coincided with the development of town drainage in Britain. The development of drains from

agricultural and road designs to effective sewers was observable in the archaeological and historical record between 1788 to 1857.

Technically, the drainage systems constructed prior to 1857 were comparable to those constructed in Britain and Europe. New drainage technologies, such as the development of the oviform structure, were quickly adopted in Australia.

When considered within the context of the available technology, the colonial government and the Sydney Municipal Council were not as incompetent as portrayed in many contemporaneous accounts. While acknowledging that the sanitation standard was extremely poor during the nineteenth century, effective solutions did not emerge until the 1850s.

The 1835 and 1837 plans for drains and sewers in Sydney are significant for two reasons. Firstly it indicates the level of knowledge present in the colony. While the proposed system included all existing techniques, no innovative designs were produced during this period. Secondly, the intent to establish a general system during the 1830s demonstrates efforts by the colonial government to undertake proper town planning measure before such initiatives were recognised by the British government. The agency for change and social improvement

Fig. 18: With a possible date of 1816, this double brick culvert, in the Royal Botanic Gardens and part of Mrs Macquaries Road, is one of the earliest surviving examples in Sydney. Showing the northern side, the dry pressed bricks at the top of the structure are later additions (A. Wong).





did not always originate from Britain.

The analysis of colonial drainage systems has demonstrated the importance of incorporating more than one form of evidence. Through the use of technical, historical and archaeological evidence, the period up to 1857 is highly significant for the development and application of town drainage systems. Developments during this period formed the basis for the current system of drainage and sewerage, and to the overall urban and social planning of Sydney.

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## NOTES

- 1 Clark 1979:54.
- 2 Higginbotham 1981; Thorp 1986, 1991.
- 3 Beder 1990, 1993; Beasley 1988; *Sydney Water Board Journal* 1951; Clarke & Coltheart 1990; Clark 1979.
- 4 Connah 1988:3.
- 5 Smith 1843.
- 6 Reed 1982:3.
- 7 Spalding 1894:28.
- 8 Dobson 1880:103-4.
- 9 Gilmore 1876.
- 10 Karskens 1985:203.
- 11 Smith 1843:11; Gilmore 1876:3.
- 12 Smith 1843:7.
- 13 Gilmore 1876:41.
- 14 Gilmore 1876:54.
- 15 Smith 1843:9.
- 16 Gilmore 1876:61.
- 17 Smith 1843:12.
- 18 Taylor 1912:86.
- 19 Parnell 1833:95.
- 20 Shone 1891:158.
- 21 Shone 1891:159.
- 22 Thomas 1865:15-16.
- 23 Thomas 1865:15.
- 24 Thomas 1865:16.
- 25 Bruce & Kendall 1901:264.
- 26 Thomas 1865:5.
- 27 Bruce & Kendall 1901:269.
- 28 Bruce & Kendall 1901:270.
- 29 Campbell 1876:32.
- 30 Reed 1982:270.
- 31 Waring 1889:28.
- 32 Waring 1889:31.
- 33 Kelly 1979; Fitzgerald 1987.
- 34 Pickstone 1996:318.
- 35 For examples of articles published by the journal, see Girdlestone 1877; *Australian Health Society* Melbourne 1880.

- 36 Rawlinson 1865:3.
- 37 *Sydney Morning Herald* November 1858.
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- 39 Letters to Colonial Secretary from Surveyor-General 1835, SR4/2299.
- 40 Letters to Colonial Secretary from Surveyor-General 1835, SR 4/2299.
- 41 Letters to Colonial Secretary from Town Surveyor 1837, SR 4/2383.
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- 43 Letters to Colonial Secretary from Town Surveyor 1837, SR 4/2383.
- 44 Letters to Colonial Secretary from Town Surveyor 1837, SR 4/2383.
- 45 *Sydney Morning Herald* 10 January 1845.
- 46 Aird 1961:129.
- 47 Brown 1876:260.
- 48 Brown 1876:261.
- 49 Brown 1876:261.
- 50 Clark 1877:6.
- 51 Proudfoot *et al.* 1991:82-83.
- 52 Kerr 1987:4.
- 53 Gojak 1996:17.
- 54 Heritage Group DPWS 1997.
- 55 Higginbotham 1981; 1983.
- 56 Higginbotham 1983:35.
- 57 Wong 1997:51.
- 58 Annable 1989; Heritage Group DPWS 1998; Beasley 1998; Henry 1939.
- 59 Annable 1989:16.
- 60 Colonial Secretary to the Town Clerk, City Corporation, 29 July 1848. Colonial Secretary Correspondence; Letter sent to the City Corporation 1842-1856 4 Vol. CRS 25.
- 61 Annable 1989.
- 62 *Sydney Morning Herald* 1 April, 1858.
- 63 *Sydney Morning Herald* 21 August, 1860.
- 64 MacIllwaith 1952:78-82.

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