Heritage Recommendation 601995

Queensland Heritage Act 1992

Under delegation from the Chief Executive, Department of Environment, Science and Innovation, and under the provisions of s.44 of the *Queensland Heritage Act 1992*, I, Catherine Chambers:

Recommend to: vary the entry of the place in the heritage register to add additional land; and revise the place name, statement of cultural heritage significance, history, and description.

Recommendation Date: 28 March 2024

Delegate name/position: Catherine Chambers, Director

Figure 1: Vent inside Roma Street Parkland, near Dark Street (Queensland Government, 2023)

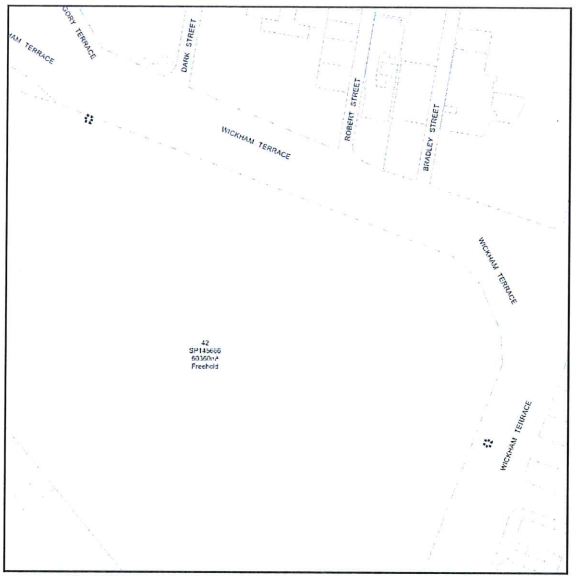

Figure 2: Proposed heritage register boundary (Queensland Government, 2024) (see attached maps)

Place name	Monier Ventilation Shafts, Wickham Terrace
Alternative place names	Monier Stormwater Ventilation Shafts Monier Sewer Ventilation Shafts
Address	500 Wickham Terrace, BRISBANE CITY, 4000
LGA	BRISBANE CITY COUNCIL
PROPOSED RPD	1 ROAD0, Lot 42 SP145686

Queensland Theme

06.03 Building settlements, towns, cities and dwellings: Developing urban services and amenities

Statement of Cultural Heritage Significance

criterion a the place is important in demonstrating the evolution or pattern of Queensland's history	The Monier Ventilation Shafts, Wickham Terrace (c1904-5), are important as rare and early evidence of urban sanitary engineering in Queensland, in particular the need to ventilate gases from stormwater drainage systems at a time when such drains also carried household greywater. Brisbane's Monier vents are early and intact examples of the use of the Monier system of reinforced concrete in Queensland; and are amongst the earliest known pre-cast reinforced concrete structures in the state.
criterion b the place demonstrates rare, uncommon or endangered aspects of Queensland's cultural heritage	The Monier Ventilation Shafts, Wickham Terrace, which are tall, reinforced concrete shafts installed to vent gases from stormwater drains, are a type of vent that has always been rare in Queensland. Of the six Monier vents known to have been constructed in Queensland, four survive in 2023.
criterion c the place has potential to yield information that will contribute to an understanding of Queensland's history	The Monier Ventilation Shafts, Wickham Terrace, have the potential to contribute to our understanding of Brisbane's early urban stormwater drainage schemes, and early pre-cast reinforced concrete technology in Queensland.
criterion d the place is important in demonstrating the principal characteristics of a particular class of cultural places	The Monier Ventilation Shafts, Wickham Terrace, are highly intact examples of reinforced concrete ventilation shafts for stormwater drains. They retain their original location, hexagonal shape, concrete construction, twin ornamental bands on the shaft and cornice near the mouth of the shaft, and their full height, which expelled noxious gases well above the heads of pedestrians. Their location, at the highest points of the early stormwater drainage systems of Spring Hill, is also important in demonstrating the past extent of those systems, and the principles of their ventilation.
criterion e the place is important because of its aesthetic significance	*The Monier Ventilation Shafts, Wickham Terrace, are not important because of their aesthetic significance. Although they may evoke some curiosity as to their purpose from passersby, the simply decorated, tall, hexagonal concrete structures do not display beautiful or picturesque attributes, evocative qualities or symbolic meaning, and are not landmarks.* *The place does not satisfy this criterion at a state level of cultural heritage significance.*
criterion f the place is important in demonstrating a high degree of creative or technical achievement at a particular period	The Monier Ventilation Shafts, Wickham Terrace, are intact surviving examples of one of the earliest known uses of pre-cast reinforced concrete in Queensland.

History

Two Monier ventilation shafts (Monier vents) are located on Wickham Terrace in central Brisbane.[1] The vents, which resemble tall, thin chimneys, are hexagonal in section, pre-cast reinforced concrete structures. One (c1904) is set into the footpath outside Roma Street Parkland, just north of Twine Street; while another (c1905) stands in a garden bed just inside the Parkland, west of Dark Street. They are associated with the first Spring Hill stormwater drainage systems, laid c1879-86.

At the time the vents were constructed, Brisbane's stormwater drains were called 'sewers', as they also carried household sullage (greywater), and this arrangement produced noxious gases which had to be vented from the highest points in the stormwater/sewerage system. The term 'Monier' refers to the reinforced concrete system patented by the French gardener Joseph Monier in 1867 and introduced into Australia in the early 1890s. The Monier vents, now decommissioned as Brisbane's stormwater drains no longer carry greywater, have always been rare in Queensland, and represent one of the earliest known uses of pre-cast reinforced concrete in Queensland.[2] In 2023, two other Monier stormwater vents are known to survive: one near the east end of the south side of Florence Street, Teneriffe (1904) [QHR 602068], and one on St Pauls Terrace, Spring Hill, opposite Gloucester Street (1905) [QHR 602067].

The two Wickham Terrace Monier vents were located at the heads of two separate stormwater drainage systems for the early Brisbane suburb of Spring Hill. The vent on the footpath near Twine Street was at the head of the system for 'Hanley's Valley', located between Leichhardt Street and Wickham Terrace. The vent in the Parkland near Dark Street was at the head of the system for 'Spring Hollow', located between Leichhardt Street and Gregory Terrace.[3]

Spring Hill is part of the traditional land of the Turrbal and Jagera peoples.[4] The suburb was surveyed into suburban 'villa' allotments from 1856, which were soon subdivided into smaller allotments by speculative landowners. Along with Kangaroo Point and Petrie Terrace, Spring Hill was among the earliest of Brisbane's dormitory suburbs, attracting residents from the middle classes to the high land along the ridges, and the working classes to the valleys in between.[5] Trustees were appointed for the Albert Park and Recreation Ground Reserve, just to the west of Spring Hill, in September 1877. This initially had a size of 25 acres, 1 rood and 30 perches (10.3ha), although a much larger area of parkland, reaching to Countess Street and Roma Street, had existed in 1865. Albert Park was eventually incorporated into Roma Street Parkland in 2001.[6]

When Brisbane acquired municipal status in late 1859, there was no system of drainage or sewerage in the town, and the creeks running through the inner city periodically flooded during the 1860s. Brisbane's first drain (1860) was an ovoid stone drain, running down Albert Street from Elizabeth Street to the creek that ran northeast along Margaret Street. Most people dumped refuse in creeks and channels, trusting that stormwater would carry it away to the river, and for some years drainage and sewerage were viewed as the same thing. However, from c1868 the Brisbane Municipal Council developed a policy of 'rainfall to the river' and 'sewerage to the land'. Drainage systems (then called 'sewers') were constructed to carry off stormwater and household greywater; while a sanitary service, based on earth closets, was used for human excreta (nightsoil). The nightsoil was initially collected for burying or burning at a depot (such as the later site of Ballymore Stadium in Herston), and later dumped at sea. A sewage treatment system for Brisbane was finally completed at Luggage Point, Pinkenba in 1923.[7]

The *Brisbane Drainage Act* 1875, under which the colonial government agreed to set aside crown land for sale to finance Brisbane's drainage scheme, provided the impetus for construction of Brisbane's early arterial stormwater drains. These systems were designed by

the colonial government's Engineer for Harbours and Rivers, William David Nisbet (1837 – 1897), and carried out by government contractors under government supervision. Upon completion they became the property and responsibility of the Brisbane Municipal Council, which was also responsible for building subsidiary drains.[8]

By 1878, the inner city was drained by three separate systems: the Frog's Hollow system – a main drain down Albert and Margaret Streets with branches laid by the Brisbane Municipal Council; the Adelaide-Creek Street system, which drained the centre of the town from Makerston Street to Queen Street and the lower sections of Elizabeth and Charlotte Streets; and the Makerston Street system, which served the area between Makerston Street and Petrie Terrace, and between Wickham Terrace and College Road and the Brisbane River.[9]

Between 1879 and 1886 the Brisbane Municipal Council, using government loans, developed an arterial drainage system, again designed by Nisbet, for the densely populated suburbs of Spring Hill and Fortitude Valley, even though part of the Valley then lay outside the Brisbane municipal boundary. These drains, built at a cost of £36,000, carried off both stormwater and household greywater – and relied on rainwater to flush the system into a natural watercourse. Most of this system of 'sanitary engineering' (engineering of waste disposal to preserve human health) initially consisted of open stone drains, until they were covered in the late 1890s.[10]

The drainage of Spring Hill, as envisaged by Nisbet, used the two existing valleys. The southernmost arterial drain, servicing an area of about 83 acres (33.6ha), headed east down Hanley's Valley, following an existing watercourse, crossed Wharf Street near its intersection with today's Turbot Street, and reached Boundary Street near its intersection with Wickham Street. A brick culvert then carried the runoff down Boundary Street to discharge into the Brisbane River at Petrie's Bight. This culvert was meant to prevent water from Spring Hill pooling and stagnating in Fortitude Valley – long a source of complaint from Valley residents. A drain then followed the watercourse as it continued northeast from Boundary Street, alongside Wickham Street, to the foot of the Fortitude Valley near the town's boundary with the Booroodabin Division (which then bordered Brisbane along Gregory Terrace and James Street). The Wickham Street drain then fed into the larger watercourse which flowed southeast from near today's Exhibition show ring, and along today's East Street, before crossing Ann Street and turning to the northeast, past James Street to discharge into the Brisbane River at Child's Creek in Newstead (roughly in a line with the northeast end of today's Waterloo Street).[11]

The northern Spring Hill arterial drain, servicing 205 acres (83ha) of land, ran northeast down Spring Hollow, including along the course of today's Water Street, until it also met the watercourse flowing southeast from the future show ring site, near the northeast end of today's Machinery Street. The Spring Hill Municipal Baths, on Torrington Street, Spring Hill, were opened in 1886 directly above the upper section of the Spring Hollow drain, and the water pumped up to the baths from the Brisbane River was released each evening, to flush the Spring Hollow drain, for the next 75 years.[12]

By 1890, the Brisbane Municipal Council had completed an arterial drainage scheme for the city core, at a total cost of nearly £130,000.[13] The Booroodabin Division was annexed by the Brisbane Municipal Council in January 1903, and in 1908 a loan of £18,500 was secured to enable the Council to complete the drainage of Merthyr, New Farm, Teneriffe, Bowen Hills, Mayne and Newstead by the end of 1909.[14]

Without a proper sewerage system, Brisbane residents still disposed of household and trade waste into the stormwater drainage systems. This led to solid material blocking street channels and gully-holes (especially in dry weather); foul smells emanating from the stormwater drains; and the chronic pollution of local creeks, which became open sewers.[15] Prior to bacterial

theory being widely accepted, the resulting 'miasma' (unpleasant smell or vapour) was thought to cause disease.[16]

The situation was compounded in 1900 with the arrival of bubonic plague in Australia, carried by rats aboard ships arriving from foreign ports. The first case of human plague in Sydney was reported in January 1900, and in Brisbane (a day and a half away by steamer) on 27 April 1900. Between 1900 and 1909, plague broke out in most of Queensland's ports, galvanising the State into developing tighter controls over public health and sanitation.[17]

Where house drains into Brisbane's stormwater drains were not 'trapped' (provided with a water seal to prevent gases escaping from the sewer), rats with plaque-carrying fleas could travel from the sewers into peoples' yards or houses.[18] Untrapped drains also created an olfactory hazard. On 18 February 1901, a motion at a Council meeting called for all gully holes (street entrances into the sewer) to be trapped, to prevent noxious smells arising.[19] In addition, in March 1901, Queensland's first Commissioner of Public Health, Dr Nathaniel Burnett Ham, using the strong coercive powers given to him under the provisions of the *Health Act 1900*, called for the drains in Spring Hill and other districts to be properly trapped.[20]

Dr Ham also requested that the Brisbane Municipal Council erect sewer vents in city streets.[21] Once drains or gully holes into the main sewers were trapped, the sewers themselves had to be adequately ventilated to remove the smell, usually at the highest point of the system.[22]

Sewer ventilation shafts were usually built in iron or steel;[23] and the first Monier (reinforced concrete) vent was not constructed in Brisbane until the early 20th century. Concrete was used prior to, and by, the Romans, but after the fall of the Western Roman Empire its use in Western Europe was fairly limited until the development of Portland cement by Joseph Aplin in Leeds in 1824. Concrete was used in construction in Queensland from Separation, including for the residence 'Goldicott' [QHR 601601] in Toowong in 1885; but it was the invention of reinforced concrete in the late 19th century which led to a building revolution. Embedding iron or steel rods in concrete meant that the concrete, which was strong under compression but weak under tension (bending and twisting), benefited from the tensile strength of the steel; while the steel was protected from fire and rusting by the concrete. Reinforced concrete was touted for its strength, durability, fire-resistant properties, ease of use and its ability to be shaped for a wide variety of uses, including complex, large-scale structures.[24]

Pre-cast concrete, also used by the Romans, added its own advantages to construction. The ability to manufacture concrete components in moulds, at a distance from their final position in a structure, be it nearby or in a distant factory, led to better quality control and consistency of product, a wider range of options, fewer delays due to bad weather, and less formwork clutter on building sites.[25]

The Monier system of reinforced concrete was invented by Frenchman Joseph Monier (1823-1906), a commercial gardener who decided to replace fragile clay flowerpots with concrete pots reinforced with iron mesh. His system was first patented, for horticultural troughs, in 1867, and he later applied for more patents for other uses–including for reinforced concrete pipes in 1868. Monier's was the first true reinforced concrete, based on calculations which ensured that the steel was dispersed so as to take tension and shear forces. Monier sold his rights outside France to local businessmen and engineers for lump sum payments. The German engineer Gustav Adolf Wayss purchased Monier's patent in the mid-1880s and developed it further. Other reinforced concrete systems included those of the French engineer Francois Hennebique (patented 1892), or the American Engineer Julius Kahn (patented 1903).[26]

The Monier system was introduced to Australia in the early 1890s by William Julius Baltzer, a New South Wales (NSW) engineer. Baltzer, in association with contracting engineers Carter Gummow and Co. of Sydney, gained the Australian rights to the Monier system.[27] The company constructed the first Monier structure (a small arch for a stormwater culvert) in

Burwood, New South Wales, in 1894; and a sewer aqueduct linking the Sydney suburbs of Annandale and Balmain soon followed. Carter Gummow & Co (later Gummow Forrest & Company, c1898) also introduced the Monier system to Victoria in 1897, building the Anderson Street Bridge over the Yarra River. Baltzer brought the first Monier pipe-making machine into Australia in 1896, for Carter Gummow & Co, which began making pipes on a small scale near Darling Harbour in Sydney in 1897. The company found that the European system of embedding wire netting in the pipes did not greatly increase its strength, so it tested alternative systems and took out fresh patents. Gummow Forrest & Co was acquired by the NSW government in 1915, which started the State Monier Pipe and Reinforced Concrete Works.[28]

Another company involved in manufacturing Monier pipes, from 1901, was the Monier Pipe Company of Victoria. This was formed by the firm of Monash & Anderson, which had become the Victorian agents for Monier reinforced concrete in 1897. In 1905 the Monash and Anderson partnership was dissolved and a new company, the Reinforced Concrete & Monier Pipe Construction Co. Pty. Ltd, was created.[29]

The first building in Queensland to use the Monier system of reinforced concrete was the Rockhampton Customs House, constructed 1899-1901, where the interior of the dome was constructed of reinforced concrete.[30]

In late 1900, the Brisbane Municipal Council called tenders for the construction and erection of an iron ventilating shaft at Thorn Street, Kangaroo Point, before asking the successful tenderer (Finlayson Bros, the Queensland agents for the Monier system from 1899) to then quote for a Monier vent. Plans of the Monier vent for Thorn Street, costing £55 and signed by Finlayson Bros on 9 January 1901, show a tapering, regular hexagonal shaft, probably pre-cast in a mould. It was 30ft (9.1m) high (with about a metre buried in the ground), and 2ft 9 inches (84cm) wide at the outside of its base. Wall thickness, estimated off this plan, varied from about 3 inches (7.5cm) of reinforced concrete at the base, to two inches (5cm) at the top.[31] No trace remains of this first known Monier vent in Queensland.[32]

Further Monier vents, along with steel vents, were soon built in Brisbane for sewer ventilation purposes. In February 1902, City Alderman (1901–04, North Ward) Richard Gailey (1834 – 1924), a well-known architect, stated that the City Engineer needed to report on providing ventilators ‘at the upper or higher ends of all the existing storm and house sewage drains in the city, beginning with the drains behind Wickham Terrace, and in Spring Hollow, George Street, Merthyr Road, and Bowen Terrace and Clay Street, and afterwards the drains between Main Street and Wellington Road, and at the Woolloongabba railway station’.[33]

The Brisbane Municipal Council (Brisbane City Council from March 1903) responded to such demands for sewer ventilation, and on 30 April 1903, the Works Committee recommended that the City Engineer be authorised to erect sewer ventilating shafts wherever they were urgently required, with an estimated cost of £1,537.[34]

A ventilating shaft for the Florence Street drain in Teneriffe was authorised by the City Council in July 1904, with an estimated cost of £30, which may give a date for the Monier vent on Florence Street.[35] This vent, located at the south side of Florence Street near its eastern end, was placed at the head of a drainage system, begun in the 1880s, which discharged into the Brisbane River downstream from the Bulimba Ferry wharf.[36]

It is also likely that the Monier vent on Wickham Terrace near Twine Street dates from 1904. A Brisbane City Council key plan, 4 chains to an inch (undated), shows two ‘Monier shafts’ on Wickham Terrace, near Twine Street and Lilley Street (latter not extant in 2023), both venting the Hanley’s Valley drainage system. The Monier vent at the head of the Spring Hollow system, inside the Roma Street Parkland near Dark Street, is not yet present on this plan.[37]

The Monier vent near Dark Street appears to postdate March 1905, when Richard Gailey blamed the absence of proper ventilation of the Spring Hollow sewer for cases of dengue fever (actually spread by mosquitos) in Spring Hill. He noted that sewer gases were escaping from gully-gratings along the sewer's route, and people were having to add ventilation pipes to their houses, to draw off sewer gases from their connecting drains.[38]

In response to complaints about a lack of vents in the North Ward (Spring Hill) the City Council authorised £150 for the erection of sewer ventilation shafts in May 1905. In July 1905 authority was given for the erection of a ventilation shaft in Leichardt Street (now St Pauls Terrace in this location) near Gloucester Street.[39]

This Monier vent, located on the footpath on the north side of St Pauls Terrace outside Brisbane Central State School, is on a ridgeline, and could have been at the head of a sewer running either northwest, towards the Spring Hollow drain, or southeast towards the Wickham Street drain (north of Boundary Street), although the latter is more likely, as a drain was constructed down Gloucester Street c1886.[40]

The Monier vent for Spring Hollow may have also resulted from the 1905 funding. It was extant by January 1907, when it was reported that 'the ventilating shaft erected at the upper end of this particular sewer [Spring Hollow] was devised to meet this evil [escape of sewer gas through back pressure through the water in traps]'.[41]

No other Monier vents related to Brisbane's stormwater system are known to have been built, although a smaller, octagonal version (extant, about 3m high, with an attached metal lamp bracket) was constructed in the early 1930s to vent a men's public toilet located in the Williams Street retaining wall [QHR 600135].[42]

The surviving Monier vents in Brisbane are no longer used to vent stormwater drains. Once new sewerage systems, which carried both human waste from water-flushed toilets and household greywater, were installed, Brisbane's stormwater drains no longer required ventilation. The separation of the sewerage system from the stormwater drainage system also solved the dilemma of Queensland's downpours overloading the sewerage system; sewer pipes no longer needed to be large enough to carry stormwater, while stormwater drains could be discharged into waterways with less pollution.[43] In 2023, the four surviving Monier vents (of the six known to have been constructed) are decommissioned, and no longer appear to be connected to active stormwater drains.[44] They survive as remnants of an important improvement to Brisbane's sanitary engineering in the early 20th century.

Description

Two Monier ventilation shafts (Monier vents) are located adjacent to Wickham Terrace in Brisbane City, just outside the boundary of the suburb of Spring Hill. The southernmost of these two vents (c1904) is located on the footpath outside Roma Street Parkland within the Wickham Terrace road reserve, just north of Twine Street, while the northernmost vent (c1905) is located in a garden bed just inside the Parkland, west of Dark Street. The vents were placed at the heads of two separate stormwater drainage systems for Spring Hill (Hanley's Valley and Spring Hollow respectively), to vent the sewer gases produced at a time when Brisbane's stormwater drains also carried household greywater.

Both ventilators are constructed of smooth reinforced concrete, pre-cast in a hexagonal shape, with simple ornamentation, and archival plans indicate they may have up to 1m of their structure underground. The vent set into the footpath near Twine Street, c1904, has a regular hexagonal shape, with base dimensions of approximately 65cm parallel to the road, from face to face (referred to as the 'height' of the hexagon); and about 75cm across the path, from point to point (referred to as the 'width' of the hexagon).[45] Twin ornamental bands are set about halfway up the shaft, which has an estimated height above ground level of around 9m. There is a cornice just below the mouth of the shaft.

The vent in the Roma Street Parkland near Dark Street, c1905, has an irregular hexagonal shape, being approximately 55cm across the garden bed, face to face (height); and about 85cm parallel to the road, from point to point (width). It stands on a rough concrete base slab (160cm long parallel to the road), inside a garden bed retained by a low stone wall. Twin ornamental bands are set over halfway up the shaft, which has an estimated height above ground level of around 9m. There is a cornice just below the mouth of the shaft.

The thickness of the two vents' concrete walls is unknown. Plans of a 30ft (9.1m) tall Monier vent (1901, not extant) in Thorn Street, Kangaroo Point, show a regular hexagonal base with an adjusted dimension of 2ft 9 inches (84cm) from face to face, with c1m of the shaft set underground.[46] A wall thickness of around 3 inches (7.5cm) at the base, reducing to about 2 inches (5cm) at the top of the shaft, can be estimated from this plan.

Features of the Monier vents of state level cultural heritage significance include:

- Their original locations, positioned at the heads of two former stormwater drainage systems for Spring Hill
- The original reinforced concrete fabric of the shafts and their ornamentation
- Any original concrete structure anchoring the base of the shafts either above or below ground level
- Any surviving underground evidence (within their heritage boundaries) of the vents' past connection to a stormwater drainage system.

Features of the Monier vents not of State level cultural heritage significance:

- Any surrounding infrastructure not part of, or not originally associated with, the Monier vents, including footpaths, road surface, garden beds and plantings, landscaping, walls or signage
- Any other modern elements present within the heritage boundaries of the Monier vents.

Illustrations

Figure 3: Vent near Twine Street, from east. (Queensland Government, 2023)

Figure 4: Vent near Twine Street, regular hexagonal base (Queensland Government, 2023)

Figure 5: Vent in Parkland near Dark Street, irregular hexagonal base (Queensland Government, 2023)

Figure 6: Vent in Parkland near Dark Street, ornamentation of shaft (Queensland Government, 2023)

Proposed revised heritage register boundary

The heritage register boundary comprises two separate sections: one contains part of the Wickham Terrace road reserve; and one contains part of Lot 42 SP145686. Each boundary is offset 1.5m from the centre of the ventilation shaft for its northeast, southeast, southwest and northwest extents.

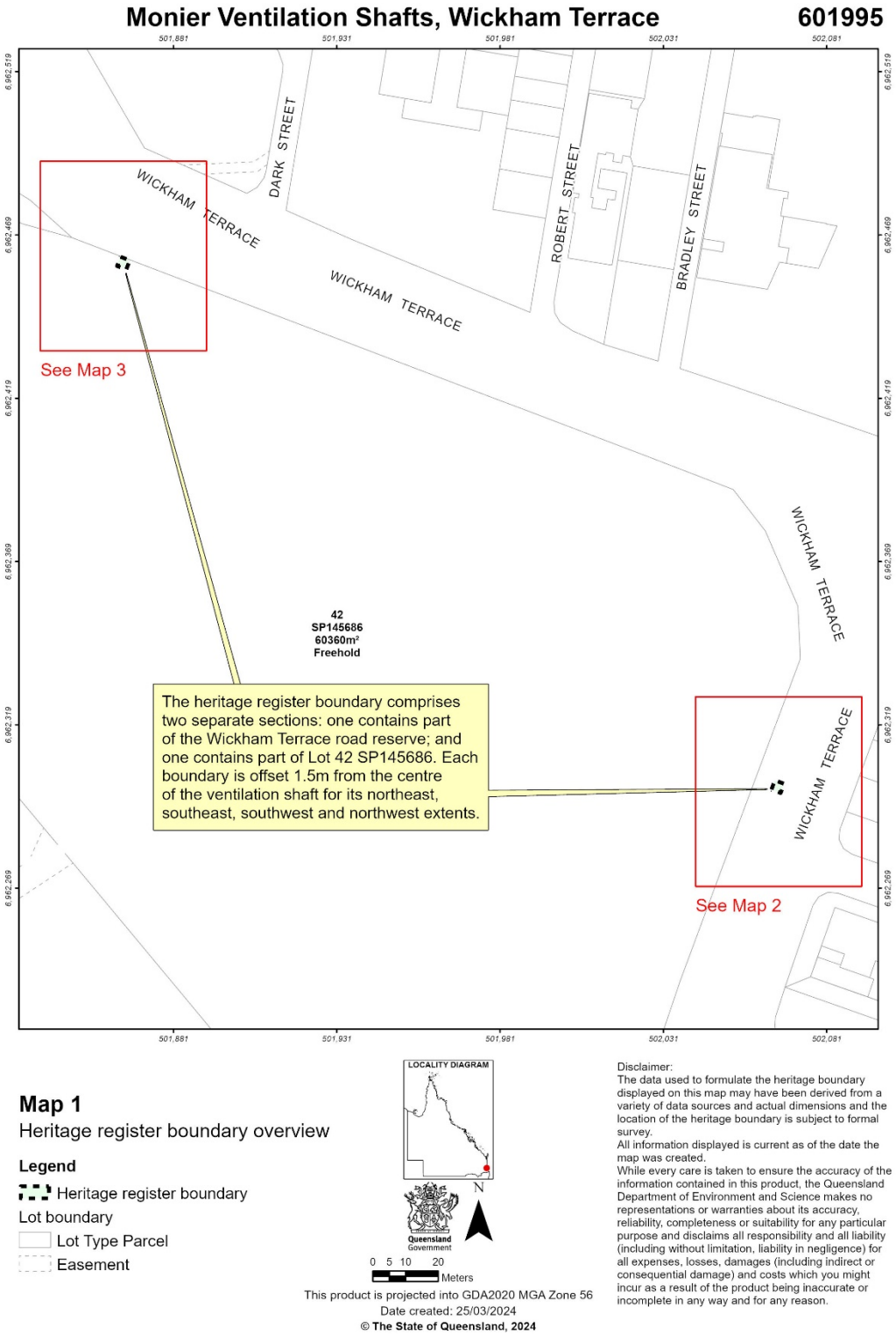

Figure 7: Proposed heritage register boundary, Map 1 (Queensland Government, 2024)

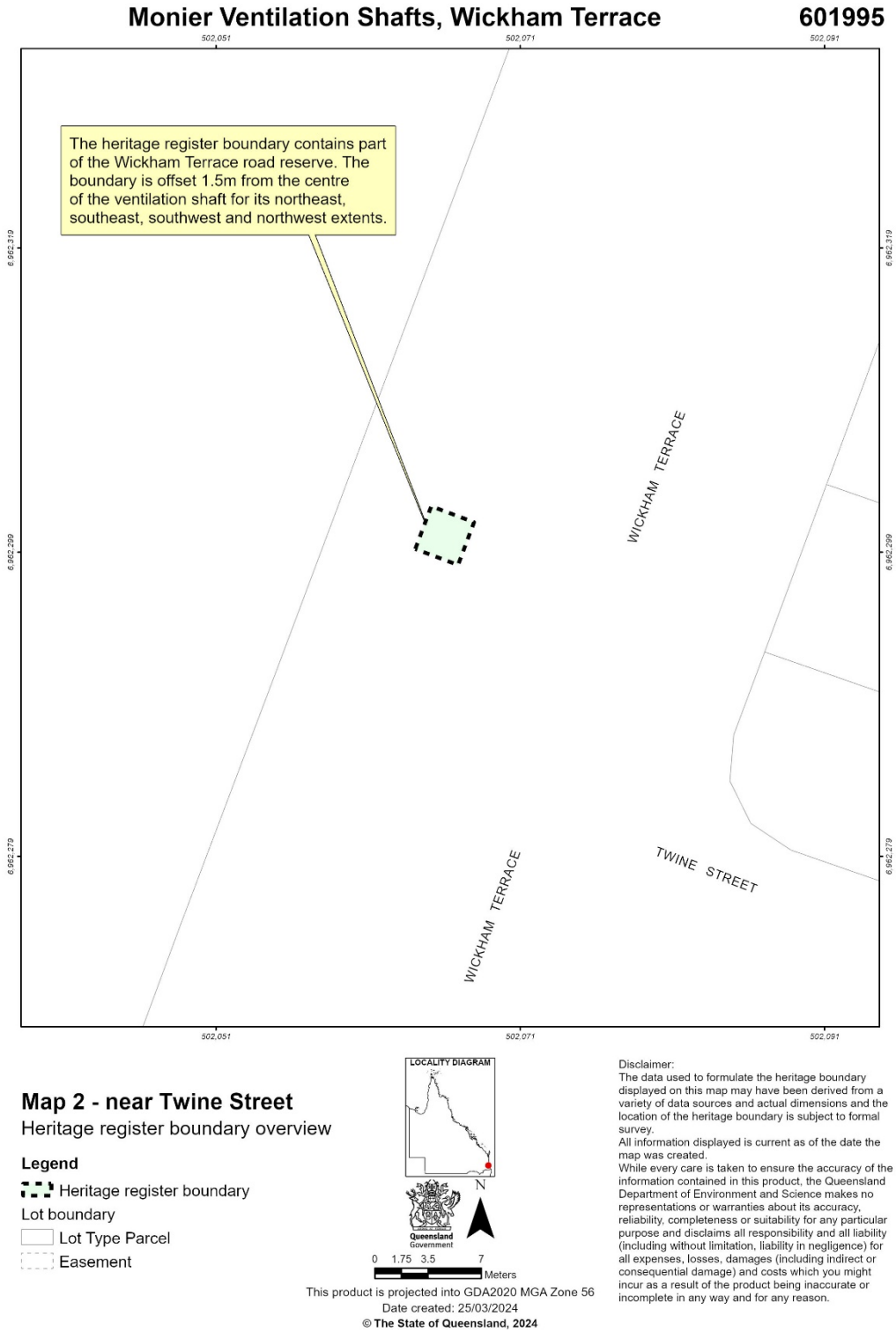

Figure 8: Proposed heritage register boundary, Map 2 (Queensland Government, 2024)

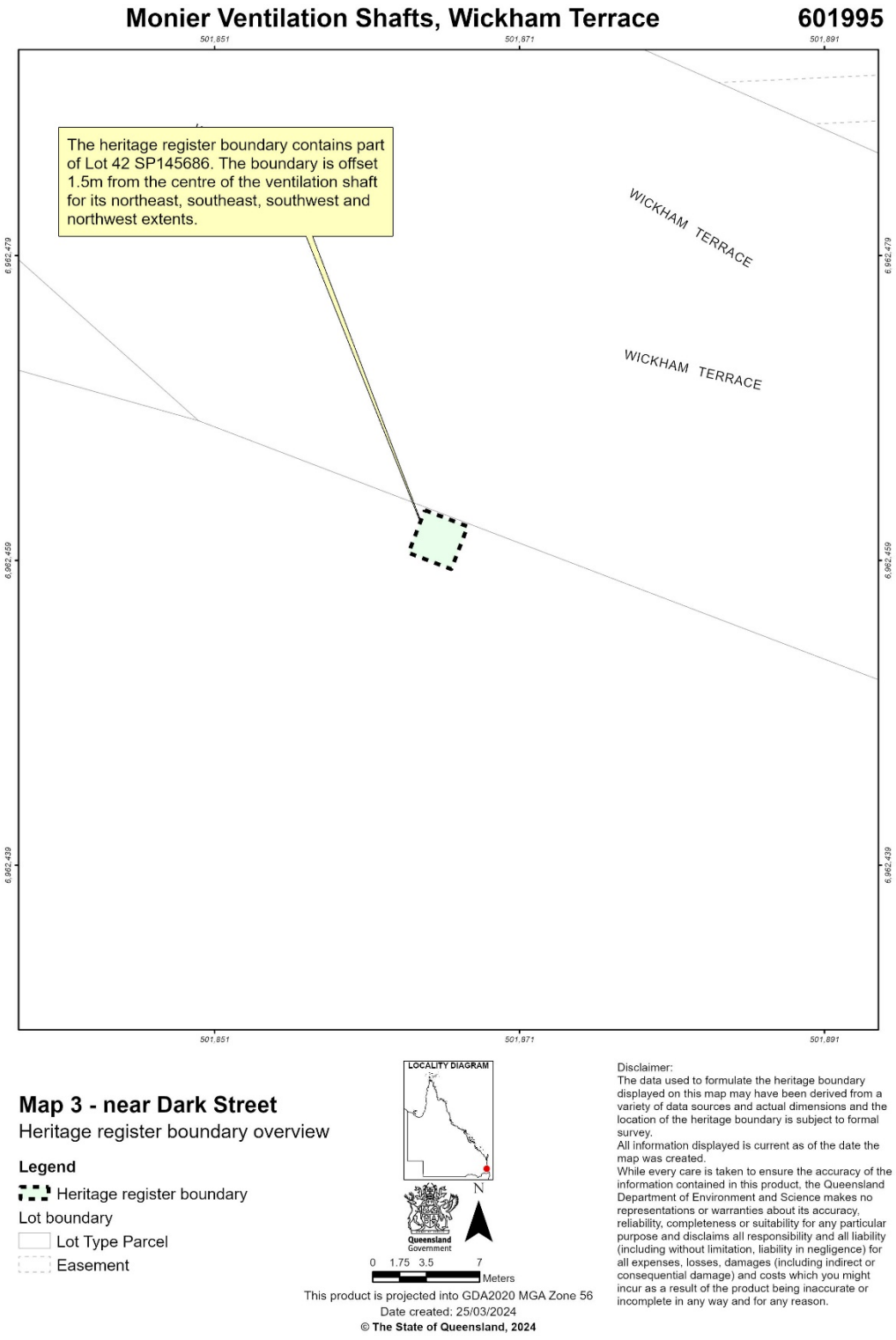

Figure 9: Proposed heritage register boundary, Map 3 (Queensland Government, 2024)

Current heritage register boundary

Figure 10: Existing heritage register boundary (Queensland Government, 2006)

[1] The Monier vents are located just outside the suburban boundary of Spring Hill, although the drainage systems that they served were located inside that suburb.
[2] CAH Oliver, 1995, 'Historic stormwater drainage vents in inner Brisbane suburbs', paper presented to the Institution of Engineers, Australia – Queensland Division, Southern Engineering Conference, Ipswich 20-22 October 1995, p.4 (vent probably pre-cast in a mould); National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts' ('almost certainly the first precast reinforced concrete structures in Queensland'). Note: a sewerage system is made up of sewers, carrying away sewage (waste matter such as faeces, urine or greywater).
[3] Plan of the Town & Environs of Brisbane, County of Stanley, NSW 1858 (Spring Hill subdivided by this time, plan shows Spring Hollow and Hanley's Valley); Brisbane City Council key plan, 4 chains to an inch (undated), cited in National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts'.
[4] Public Map, Department of Seniors, Disability Services and Aboriginal and Torres Strait Islander Partnerships, Cultural Heritage Database and Register, https://culturalheritage.datsip.qld.gov.au/achris/public/public-registry/home (accessed 10 August 2023).
[5] Department of Resources, Survey Plans B123432 and B123433 (1856) and B123436 (1858); 'McWhinneys Brick Cottage', QHR 602248.
[6] Department of Resources, Survey Plan B357, 1865, and Survey Plan N2581, 1877; *Queensland Government Gazette*, Volume XXI, July-December 1877, pp.597, 601; Blake, T. 'Historical overview, Roma Street Parkland precinct', https://www.thomblake.com.au/downloads/HistoryEBrochure.pdf (accessed 9 August 2023), pp.4-6, 16, 20. The 1865 park included a cricket ground adjacent to Countess Street. The opening of an orphanage east of the cricket ground in 1866, the first Brisbane Grammar School site on Roma Street in 1869, and later the Roma Street Railway Station in 1875, all reduced the size of the early park.
[7] G Greenwood and J Laverty, *Brisbane 1859-1959, a history of local government*, Brisbane, Brisbane City Council, 1959, pp.176-7; Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.2; National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts'; Destroyed Place, 602218 'Wheat Creek Culvert'; 'The Storm of Thursday Last', *Brisbane Courier*, 26 January 1869, p.5 (flooding of creek between Queen and Adelaide streets); 'Brisbane Sanitation. The City Engineer's Report', *Brisbane Courier*, 30 January 1894, p.5; 'City sanitary contract', Brisbane Courier, 20 August 1902, p.7; 'The sanitary system', *Morning Bulletin* (Rockhampton), 20 March 1913, pp.9-10; 'Sewerage [sic] treatment works', *Daily Mercury* (Mackay), 24 November 1923, p.10. The creek along Margaret Street was called 'Little Creek' on Tom Petrie's map of early Brisbane (H Holthouse, *Looking back: the first 150 years of Queensland schools,* Brisbane, Department of Education, Queensland, 1975, *p.4*). One of the earliest examples of a civil engineering project by the Brisbane Municipal Council was the Wheat Creek culvert under the intersection of Albert Street and Adelaide Street. Built in 1861, this stone, ovoid culvert was destroyed c2006 during construction of the Inner Northern Busway (Destroyed Place, 602218 'Wheat Creek Culvert').
[8] Greenwood and Laverty, *Brisbane 1859-1959*, pp.177-8.
[9] Greenwood and Laverty, *Brisbane 1859-1959*, p.178.
[10] Greenwood and Laverty, *Brisbane 1859-1959*, pp.178-9, 403-404; Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.1; Brisbane City Archives, BCA1479A, Plan D-3-23, 'Brisbane Drainage, General Plan, Contracts No.7, 8, 9 &10', William D Nisbet, November 1878 (proposed scheme, which included a large open drain along the existing watercourse from Gregory Terrace down East Street, and then northeast to Newstead, but this did not occur); Brisbane City Archives, Plan D-5-69, 'City of Brisbane, Plan showing lines of main drains and catchwater areas', 5 chains to an inch, c1880s. In the latter plan, the upper section of the Spring Hollow system was carried by a brick culvert, until it became an open stone drain from Water Street onwards. The Hanley's Valley system was an open stone drain until it reached the brick culvert at Boundary Street.
[11] Brisbane City Archives, BCA1479A, Plan D-3-23, 'Brisbane Drainage, General Plan, Contracts No.7, 8, 9 &10', William D Nisbet, November 1878; Brisbane City Archives, Plan D-5-69, 'City of Brisbane, Plan showing lines of main drains and catchwater areas', 5 chains to an inch, c1880s; 'Deputation to the Minister for Works', *The Telegraph* (Brisbane), 31 August 1875, p.2; *Brisbane Courier*, 28 February 1876, p.2 (Nisbet's proposals); 'Deputations', *Telegraph* (Brisbane), 22 June 1876, p.3; 'Drainage of Fortitude Valley', *Brisbane Courier*, 25 February 1878, p.3; 'Fortitude Valley Drainage', *Telegraph* (Brisbane), 4 May 1878, p.2. There was some friction between the two local governments over who should fund drainage works in the Booroodabin Division, to carry off sewage originating in Spring Hill ('The Stratton Drain', *Brisbane Courier*, 28 October 1886, p.5. This article refers to 'the Wickham Street drain' as being one source of the sewage that passed through the Board's territory to the river). The

Booroodabin Divisional Board constructed the Stratton drain in the lower Valley, and neighbouring drainage works in the mid-1880s. During the late 1880s it also co-operated with Brisbane in draining parts of New Farm and also drained parts of Rosetta Swamp (between James Street and Breakfast Creek) (Greenwood and Laverty, *Brisbane 1859-1959*, p.403).

[12] Brisbane City Archives, BCA1479A, Plan D-3-23, 'Brisbane Drainage, General Plan, Contracts No.7, 8, 9 &10', William D Nisbet, November 1878; Brisbane City Archives, Plan D-5-69, 'City of Brisbane, Plan showing lines of main drains and catchwater areas', 5 chains to an inch, c1880s; QHR 600313 'Spring Hill Baths'. In 1885 the Brisbane Municipal Council agreed to extend its Spring Hollow drain so it could be connected to a brick tunnel, to be built by the State Government, running under the Acclimatization Society's grounds to empty in Breakfast Creek, thereby 'relieving the lower parts of the Valley of stormwater which would otherwise flow down into land in the Booroodabin Division' (*The Brisbane Courier*, 23 April 1885, p.5).

[13] In addition to Spring Hill and Fortitude Valley, drainage systems were constructed for South Brisbane and Kangaroo Point during 1885-86. In the late 1880s, the Brisbane Municipal Council drained parts of New Farm, and a drainage system for Petrie Terrace, begun in 1883, was completed in the late 1880s. (Greenwood and Laverty, *Brisbane 1859-1959*, p.403).

[14] Greenwood and Laverty, *Brisbane 1859-1959*, p.404; 'City Council' (City Drainage Works), *The Telegraph* (Brisbane), 14 January 1908, p.3.

[15] Greenwood and Laverty, *Brisbane 1859-1959*, p.406; 'Brisbane Sanitation. The City Engineer's Report', *Brisbane Courier*, 30 January 1894, p.5; 'Brisbane Sanitation, "Pools of impurity", City Inspector's Report', *Telegraph* (Brisbane), 29 January 1907, p.7.

[16] National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts'.

[17] L Cazalar, 'When the Plague came to Queensland', pp.78-89, in R Fisher and R Sumner (Eds) 1985, *Brisbane Housing, The River, Health & the Arts, Brisbane History Group Papers No.3*, pp.81-3.

[18] Cazalar, 'When the Plague came to Queensland', p.83.

[19] Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', pp.2, 3.

[20] Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.2; 'Brisbane City Council', *The Telegraph* (Brisbane), 20 March 1901, p.6.

[21] Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.2.

[22] 'Local Government', The Telegraph (Brisbane), 9 October 1894, p.2; 'Brisbane City Council', *The Telegraph* (Brisbane), 29 April 1902, p.3; 'City Council', The Telegraph (Brisbane), 10 March 1908, p.3 (requests for sewer vents at head/highest points of various drainage systems); Brisbane City Council key plan, 4 chains to the inch (undated), cited in National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts' (shows a series of either Monier or steel vents located along the ridges of Spring Hill, at the heads of its stormwater drainage system).

[23] Metal 'stink pipes' were used to ventilate the sewers built in London after the 'Great Stink' of 1858 ('Victorian 'Stink' Pipe Listed', Historic England, https://historicengland.org.uk/whats-new/in-your-area/midlands/shropshire-stink-pipe/#:~:text=They%20were%20modelled%20on%20the,rose%20to%20an%20unbearable%20level (accessed 14 March 2024).

[24] 'The Monier system in arches', *Sydney Mail and New South Wales Advertiser*, 17 November 1900, p.1176; 'A building revolution: the growth of ferro-concrete'*, Daily Mercury* (Mackay), 11 December 1907, p.4; Watson, D, 'Starting a structural revolution: Was Siemon's warehouse Brisbane's first reinforced concrete framed building?' *Queensland History Journal*, Vol.22, No.3, November 2013, pp.233-4 (early mass concrete use in Queensland; 'Goldicott'); N. Hughes, 'A Brief History of Reinforced Concrete Buildings', The Historic England Blog, https://heritagecalling.com/2022/09/22/a-brief-history-of-reinforced-concrete-buildings-in-england/ (accessed 25 March 2024).

[25] Cement Concrete and Aggregates Australia, 'Guide to concrete construction, Pt VI - Section 20. Special concrete applications. Precast concrete', 2020, https://ccaa.com.au/common/Uploaded%20files/CCAA/Publications/Technical%20Publications/PART_VI_-_20_-_PRECAST_CONCRETE_GTCC_2020.pdf (accessed 25 March 2024).

[26] 'A building revolution: the growth of ferro-concrete', *Daily Mercury* (Mackay), 11 December 1907, p.4; L Miles, 1988, *200 years of concrete in Australia*, North Sydney, Concrete Institute of Australia, pp.10-11; 'Joseph Monier', https://en.wikipedia.org/wiki/Joseph_Monier (accessed 23 February 2023); 'Julius Kahn (inventor)', https://en.wikipedia.org/wiki/Julius_Kahn_(inventor) (accessed 26 March 2024); N. Hughes, 'A Brief History of Reinforced Concrete Buildings', The Historic England Blog, https://heritagecalling.com/2022/09/22/a-brief-history-of-reinforced-concrete-buildings-in-england/ (accessed 25 March 2024).

[27] Miles, *200 years of concrete in Australia*, pp.10-11.

[28] Miles, *200 years of concrete in Australia,* pp.11, 89.

[29] 'The Engineer' https://www.monash.edu/records-archives/archives/exhibitions/leading-the-way-sir-john-monash/the-engineer (accessed 23 February 2023); 'The Monier Pipe Company, pipes, culverts, girders and channels', *Leader* (Melbourne), 5 September 1903, p.6.
[30] Watson, 'Starting a structural revolution', p.234; 'The new custom house. A fine building', *Morning Bulletin* (Rockhampton), 31 October 1900, p.6; 'New Custom-House at Rockhampton', *Morning Bulletin* (Rockhampton), 25 March 1901, p.5 (building completed). It is unknown if the Monier dome was pre-cast.
[31] Brisbane City Archives Plan I-12-349, 'Ventilating shaft Kangaroo Point Sewer, design in Monier System', 1900; 'Brisbane Municipal Council', *The Brisbane Courier*, 27 November 1900, p.5 (lowest tender, Finlayson Bros, asked to quote for a Monier vent); 'Brisbane City Council', *The Telegraph* (Brisbane), 10 December 1900, p.2 (£55); Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.4; National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts'; Watson, 'Starting a structural revolution', p.234 (Finlayson Bros the Queensland agents for Monier). The original plan was for a 30ft (9.1m) high riveted wrought iron vent (Brisbane City Archives Plan I-14-627/(1), 'City of Brisbane. Details for Iron Ventilating Shaft', no date). Reinforcing of the concrete in the Monier vent at Kangaroo Point was by 3/8 inch (9mm) vertical metal bars, and ¼ inch (6mm) horizontal bars, tied to a frame of six 2 inch x 2 inch x ¼ inch (50mm x 50mm x 6mm) angle irons (Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.4).
[32] Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', pp.4-5. Dr Ham also urged Maryborough to consider using Monier pipes for culverts along the creek then acting as the town's sewer ('Municipal Council', *Maryborough Chronicle, Wide Bay and Burnett Advertiser*, 5 December 1901, p.4). Tenders in 1902 for a ventilator in Margaret Street, Brisbane, either in brickwork or the Monier concrete system, resulted in a brickwork vent ('City Council', *The Telegraph* (Brisbane), 10 June 1902, p.3; 'City Council', *The Telegraph* (Brisbane), 24 June 1902, p.3.
[33] 'City Council', *The Telegraph* (Brisbane), 4 February 1902, p.3; 'Richard Gailey', Kangaroo Point and Districts Historical Society, https://kangaroopointhistory.com.au/stories/people/richard-gailey/ (accessed 23 August 2023).
[34] Queensland State Archives, A10468, 'Brisbane City Council I'; Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.5.
[35] 'City Council', *The Telegraph* (Brisbane), 19 July 1904, p.11. Tenders for pipe drains in Florence and Ethel Streets had been received in April 1904 (Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.5).
[36] EL Richard, 1993, notes on Early Concrete, including Drainage Vents, in Brisbane, held by BCC Heritage Unit & the Institution of Engineers, Australia – Queensland Division (summarised in Department of Environment and Science, Site File for QHR 601995); Brisbane City Archives, Plan D-7-60, 'Plans and Sections of drain through Florence, Wilson, Kent, Harcourt & Helen Sts', 1887; BCC Plan D-6-47, 'City of Brisbane Drainage, Florence & Ethel Sts MW', 1904. The drain on the 1904 plan extends further southeast along Florence Street than the drain on the 1887 plan.
[37] Brisbane City Council key plan, 4 chains to an inch (undated), cited in National Trust of Queensland, c1997, BNE 1/457 'Monier Ventilation Shafts'.
[38] 'City Council', *The Telegraph* (Brisbane), 14 March 1905, p.3; 'Spring Hill Sewers', *Brisbane Courier*, 15 March 1905, p.3.
[39] 'City Council' *The Telegraph* (Brisbane), 9 May 1905, p.3 (£150) 'City Council', *The Telegraph* (Brisbane), 18 July 1905, p.3 (vent near Gloucester Street). In August 1905, WH Finlayson was paid £48/12/6 for a ventilating shaft, but it is unknown if this relates to the Monier vent on St Pauls Terrace ('City Council', *The Telegraph* (Brisbane), 1 August 1905, p.7).
[40] Brisbane City Archives, Plan D-7-7, 'Pipe drain down Leichardt St [St Pauls Terrace] and Gloucester St, Contract No.27', July 1886.
[41] 'Insanitary conditions. Serious reports. Sewers and Dairies', *Brisbane Courier*, 29 January 1907, p.3
[42] QHR 600135 'William Street and Queens Wharf Road retaining walls'.
[43] Oliver, 'Historic stormwater drainage vents in inner Brisbane suburbs', p.5 (modern sewerage systems eliminated any smell from stormwater drains); 'Sewerage scheme for the City of Rockhampton', report on proposal', *Morning Bulletin* (Rockhampton), 30 August 1928, p.11 (separate systems better for Queensland's climate. Where there were no boundary traps on house drains, sewers could be vented at each house; where there were boundary traps, the sewers needed to have sufficient vents). Detail maps, produced by the Metropolitan Water and Sewerage Board during the course of building sewerage systems in Brisbane's suburbs (the plans include contour lines and individual buildings), are dated 1914 for the areas around the Hanley's Valley and St Pauls Terrace Monier vents, 1915 for the Spring Hollow vent, and 1921 for the Teneriffe vent (Brisbane City Council Libraries, Detail Plans 20, 21, 146, and 195, https://library-

brisbane.ent.sirsidynix.net.au/client/en_AU/BrisbaneImages/?rm=DETAIL+PLANS0%7C%7C%7C1%7C%7C%7C0%7C%7C%7Ctrue (accessed August 2023)).

[44] The Monier vents are not located on stormwater drains or sewer pipes shown on 2023 drainage plans. 'It is our belief the network [of Monier vents] was decommissioned in its entirety when the current infrastructure was built, and nothing suggests it is still connected to the live network'. (M. Horneman, Brisbane City Council, pers. comm. 10 August 2023)

[45] Although the width of a regular hexagon is greater than its height, the hexagon is still regular in shape if it is equilateral (with all sides and angles being equal).

[46] Brisbane City Archives Plan I-12-349, 'Ventilating shaft Kangaroo Point Sewer, design in Monier System', 1900.