THOMPSON SQUARE BRICK DRAIN, WINDSOR, NSW

Heritage Mitigation and Options Report

AAJV
(an Austral & Extent Joint Venture)

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EXECUTIVE SUMMARY

INTRODUCTION

During the course of archaeological salvage works within the area identified as Area 1 in the Detailed Salvage Strategy for the Windsor Bridge Replacement Project impact zone, evidence of a brick barrel drain was located. This report analyses the drain and investigates mitigation measures for retaining its significance within the context of the approved bridge replacement project.

INVESTIGATION RESULTS

Research has determined that this drain is the work of local men, John Howe and James Magrath, who were contracted by Governor Macquarie to construct the drain between 1814-1815. The alignment of the drain falls directly in the alignment of the proposed new bridge abutment, which would largely, if not completely, remove the drain. An alternate footing design for the bridge abutment (Option 2) has been developed which would allow the barrel drain, though not all of the surface box culverts, to be retained in situ beneath the new bridge abutment. A range of mitigation measures are explored in this report, leading to the recommendations below.

RECOMMENDATIONS

In summary, the AAJV makes the following recommendations for the management of the barrel drain:

- Select Option 2 is the best option for conserving the maximum amount of historic drain fabric;
- Advice from Jacobs regarding vibration levels (Appendix D) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from Jacobs regarding the compression impacts (Appendix E) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from International Conservation Services regarding separation between the drain fabric and infill materials (Appendix F) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- The DPE-approved Heritage Manager will verify and approve the position of the proposed footing pile locations prior to piling commencing;
- A piling trial incorporating vibration monitoring should be undertaken in advance of construction, to determine the vibration impacts on the drain. In the event those impacts are unacceptable, the piling method should be reviewed for lower vibration methods;
- In the event an acceptable method of piling cannot be determined which would leave the drain substantially intact, further archaeological investigation and recording should be undertaken prior to construction;
- No machinery is to operate on top of the drain at any time, unless the potential compression impacts have been reviewed by an engineer and any necessary mitigation measures implemented;
- A section of box culvert could be carefully recorded by the archaeologists and removed by conservators for conservation and secure storage prior to future reinstatement in an indoor context (e.g. Windsor Museum or a Council-nominated location). This option should be discussed with key stakeholders prior to making a final decision to remove a section of culvert;

- Intact bricks and artefacts associated with the drain should be retained for future interpretation works, although this is likely to be off site interpretation due to the fragility of the items;
- In the event no party is interested in accepting a section of the box culvert, barrel drain or recovered bricks, a small sample of bricks (10-20) should be retained within the archaeological collection and the remainder may be reburied on site or discarded;
- Detailed proposals for interpreting the drain and its feeder lines, and the story of its construction and role within the early town of Windsor should be integrated into the final Interpretation Plan for the project area.

CONTENTS

1 PROJECT SUMMARY 10

1.1 INTRODUCTION 10

1.2 Site Location and Identification 10

1.3 Limitations 10

1.4 Author Identification 10

2 HISTORICAL BACKGROUND TO THE DRAIN 13

3 DISCUSSION OF OTHER BRICK DRAINS OR SIMILAR STRUCTURES PREVIOUSLY INVESTIGATED AROUND SYDNEY 19

3.1 Early Examples of Drains 19

4 ANALYSIS OF THE THOMPSON SQUARE DRAIN 28

4.1 Physical Description of the Drain 28

4.2 Materials 44

5 STATEMENT OF SIGNIFICANCE 60

5.1 Statement of significance 60

5.2 Assessment of significance 61

6 OPTIONS FOR THE DRAIN 63

7 REVIEW OF IMPACTS OF PROPOSED REVISED ABUTMENT DESIGN 65

8 DISCUSSION OF OPTIONS AND ALTERNATIVES 68

9 DISCUSSION OF MITIGATION MEASURES – OPTION 2 72

9.1 Trial of piling methodology 72

10 COMPARATIVE INTERPRETATIONS 73

11 DISCUSSION OF INTERPRETATION OPTIONS 82

12 CONSULTATION 83

13 RECOMMENDATIONS 84

14 CONCLUSIONS 85

15 REFERENCES 87

APPENDICES 88

Appendix A - Howe and Magrath Contract (ML MSS 106 Item 37) 88
Appendix B – Transcript of Howe and Magrath Contract 91
Appendix C - Proposed Revised Abutment Design (Jacobs) 93
Appendix D - Advice from Jacobs re vibration impacts 94
Appendix E - Advice from Jacobs re compression impacts 95
Appendix F - Advice from International Conservation Services 96
Appendix G - Advice from Jacobs re heritage management 97

LIST OF FIGURES

Figure 1: Map of the WBRP test excavation project area. 11

Figure 2: Image of the southern Windsor Prodge Replacement Project area with the location of the drain and its general course indicated. (Source: Jacobs 2018) 12

Figure 3 - Brick drain and possible pier pad. (Source: AAJV 2018) 16

Figure 4 - Brick drain showing cut for 1937 sewer line. (Source: AAJV 2018) 17

Figure 5 - Drain outlet adjacent to the location of the wharf in 1986. (Source: Higginbotham 1986 (2): 41) 18

Figure 6 - Sydney's early combined sewer and stormwater system. (Source: Aird 1961: 134ff) 21

Figure 7 - Brick barrel drain (10-12 RM2) at the First Government House site. (Source: Bickford 1983, Fig 21). 22

Figure 8 - North face of the 1813-16 Royal Botanic Garden culvert showing original lower portions and later dry-pressed brick replacement above. (Source: Wong 1999, Figure 18) 22

Figure 9 - A complete section of the brick barrel drain, 1822-27, Parramatta, NSW in 1981. (Source: Higginbotham 1981) 23

Figure 10 - Intact section of the Port Macquarie barrel drain (Source: E. Higginbotham and Associates (2009)) 23

Figure 11 - Headwall pit of the Port Macquarie barrel drain (Source: E. Higginbotham and Associates (2009)) 24

Figure 12 - Remnant barrel drain (left) 1820-1840 feeder line into the Tank Stream (predating the Tank Stream Channel) and its later nineteenth century ceramic drain replacement (Source: Godden Mackay 1998, vol 1 p. 59) 25

Figure 13 - Conservatorium site, Sydney. Detail of the northern dish drain and the later phase pit during archaeological excavation. (Source: Casey and Lowe (2002): 156) 26

Figure 14 - Elliptical drain, cross-section, Conservatorium site prior to removal (Source: NSW Department of Public Works and Services 2001) 26

Figure 15 - Barrel drain excavated beneath Campbell's Stores in The Rocks, March 2018. This drain is 1400mm in diameter and a section approximately 3000mm long was exposed. It is to be retained in situ. (Courtesy Austral Archaeology 2018) 27

Figure 16 - Oviform brick drain (circa 500x700mm) found in Auckland, NZ, dating from c1865. (https://www.cityraillink.co.nz/crl-heritage/) 27

Figure 17 - Overlay on White's 1827 Survey 30

Figure 18 - Overlay on White's 1827 Plan 31

Figure 19 - Overlay on Thompson's 1827 Plan 32

Figure 20 - Overlay on Abbott's 1831 Sketch Plan 33

Figure 21 - Overlay on the 1835 Town Plan 34

Figure 22 - Overlay on the 1841 Town Plan 35

Figure 23 - Overlay on the 1842 Allotment Plan 36

Figure 24 - Overlay on Hancock's 1871 Plan 37

Figure 25 - Overlay on the 1894 Survey Plan 38

Figure 26 - Overlay on the 1894 Road Resumption Plan 39

Figure 27 - Overlay on the 1948 Road Plan 40

Figure 28 - Overlay on the 2016 Aerial Photo, Prior to Archaeological Testing 41

Figure 29 - Overlay on the 2018 Aerial Photo Showing Archaeological Management Zones 42

Figure 30 - Overlay on the 2018 Aerial Photo 43

Figure 31 - Vertical view of exposed crown of brick drain with remnant lime rendering in Sondage 3. (Source: AAJV 2018) 46

Figure 32 - Feeder brick box drain for the main drain alignment. (Source AAJV 2018) 46

Figure 33 - Feeder brick box drain for main drain alignment. (Source AAJV 2018) 47

Figure 34 - Feeder line (foreground) crossing main drain showing slumping of the box drain above the shoulders of the main drain (Source: AAJV 2018) 47

Figure 35 - Brick shaft for the main drain alignment. (Source RMS 2018) 48

Figure 36 - Vertical view of the blocked drain in Sondage 6. South is to top of image. Note the 'slumping' of the bricks at the crown of the drain indicating the collapse which blocked the drain and required physical intervention. (Source: AAJV 2018) 49

Figure 37 - View of brick drain in Sondage 6 with later (19th/20th century) headwall and vitrified ceramic pipe inserted at base. (Source: AAJV 2018) 50

Figure 38 - Diagram of interpreted elements of drain exposure. (Source: AAJV 2018) 50

Figure 39 - Diagram showing interpretation of exposed external surface of the drain 51

Figure 40 - Exposed section with cut for drain indicated. (Source: AAJV 2018) 52

Figure 41 - Plan of the exposures of the drain in Thompson Square – preliminary drawing. (Source: AAJV 2018) 53

Figure 42 - Elevation of the drain headwall in sondage 6 – looking south. For location see Figure 41 (Source: AAJV 2018) 54

Figure 43 - Bed of sandstock Brick 1 from drain arch with cratered surface, probably from the expansion of water vapour during firing. Note the possible scribe line (indicated). (Source: AAJV 2018) 55

Figure 44 - Bed of sandstock Brick 1 from drain arch showing strike side. Note the uneven trimming of the brick with each point on the side indicated. (Source: AAJV 2018) 55

Figure 45 - Strike of sandstock Brick 2. (Source: AAJV 2018) 56

Figure 46 - Bed of sandstock Brick 2. (Source: AAJV, 2018) 56

Figure 47 - Detail of Sample 1 mud mortar showing inclusion of calcined shell and larger calcined shell fragment. (Source: AAJV 2018) 57

Figure 48 - Detail of Sample 1 mud mortar showing small charcoal fragments (red) and organic matter -sawdust/chaff (blue) inclusions. (Source: AAJV 2018) 57

Figure 49 - Sample 2 of Patent cement. C.f with mortar. Note the larger consistent sand grain size (Source: AAJV 2018) 58

Figure 50 - A section of one of the box culverts with evidence of former timber coverings. (AAJV March 2018) 59

Figure 51 - Typical cross section of abutment and drain (Jacobs) 66

Figure 52 - Detailed cross section (Jacobs) 66

Figure 53 - elevation showing drain and new abutment. The hatched areas are where the foam packers will be placed. In other areas, the existing soil will be left in situ. (Source: Jacobs) 67

Figure 54 - Plan showing relationship of the piles to the drain. (Source: Jacobs) 67

Figure 55 - In situ exposed section of the 1822-27 brick barrel drain, Parramatta, NSW 74

Figure 56 - Section of the displaced Tank Stream located within the GPO as one of the interpretation stations. 75

Figure 57 - Tank Stream Walking Map 76

Figure 58 - Wheat Creek Culvert, Brisbane 77

Figure 59 - Wheat Creek Culvert, Brisbane 77

Figure 60 - Glass panel installed above a well at the Newcastle Convict Lumberyard. The viewing window is in such poor condition from physical damage and condensation that the well beneath is no longer visible. 78

Figure 61 - External viewing window for footings at Museum of Sydney. The small kiosk (circled in red) houses a small display of the footings of First Government House.This is however in a managed museum context. 79

Figure 62 - Glass floor over drainage within the Museum of Sydney. Again this is within a managed, climate-controlled museum context. (Source: https://www.tripadvisor.com/LocationPhotoDirectLink-g255060-d256854-i84397826-Museum_of_Sydney-Sydney_New_South_Wales.html#84397826) ... 80

Figure 63 - Barrel drain at the Glasshouse, Port Macquarie (courtesy ICS). http://www.icssydney.com.au/index.php?id=347 81

Figure 64 - Interior view of the Glasshouse barrel drain (courtesy Higginbotham & Associates). http://www.higginbotham.com.au/portmacquarie2.html 81

1 PROJECT SUMMARY

1.1 INTRODUCTION

The Windsor Bridge Replacement Project will construct a new three-lane bridge 35 metres downstream of the existing Windsor Bridge. Associated works include new approach roads and intersections to connect the new bridge to the existing road network. The work will entail the removal and backfilling of the existing bridge approach roads and the removal of the existing bridge once the new bridge is operational. Landscaping, interpretation and urban design work is to be undertaken throughout the project footprint including the Thompson Square Conservation Area.

As part of a program of archaeological works, site inspections of the study area were carried out between April and July 2016. This was followed by a program of archaeological testing undertaken between August and November 2016. The results of this testing were then used to inform the Historical Archaeology Report and the Detailed Salvage Strategy that provided guidance for archaeological salvage works (now complete).

During the course of salvage excavation in Area 1 conducted between October 2017 and March 2018, the remains of an early nineteenth-century drainage system servicing Thompson Square were exposed. This system of brick and timber drainage lines is the subject of this report, which considers the significance, conservation and interpretation options for the drains.

The AAJV (a joint venture of Austral Archaeology and Extent Heritage [formerly AHMS]) has been commissioned by NSW Roads and Maritime Services (hereafter 'RMS' or 'the proponent'), to prepare a Heritage Mitigation and Options Report on the drain.

1.2 Site Location and Identification

The subject area is located at Windsor, within the Hawkesbury Local Government Area (LGA), approximately 57 kilometres north-west of Sydney. The town is situated on the southern bank of the Hawkesbury River, close to the foothills of the Blue Mountains (**Figure 1**).

The southern archaeological excavation project area incorporates part of Thompson Square (**Figure 2**).

1.3 Limitations

Investigation of the drain was limited to exposures within Area 1. Any information regarding the location of the line of the drain outside Area 1 is inferred. This report does not review the Aboriginal cultural heritage values of the subject area. The report is not intended to be a final or interim report on the archaeological findings within Area 1.

1.4 Author Identification

This report was prepared by Graham Wilson and Matthew Kelly, Senior Archaeologists at Extent Heritage (part of the AAJV). The site drawings were completed and digitised by James McGuinness of Austral Archaeology (part of AAJV). GIS overlays were prepared by Tom Sapienza of Extent Heritage. Excavation Directors David Marcus (Austral) and Anita Yousif (Extent) also made input to the report.

This report was reviewed by Dr MacLaren North, NSW Director of Extent Heritage Pty Ltd and Justin McCarthy, Director of Austral Archaeology Pty Ltd, Co-Principals of the AAJV.

Figure 1: Map of the WBRP test excavation project area.

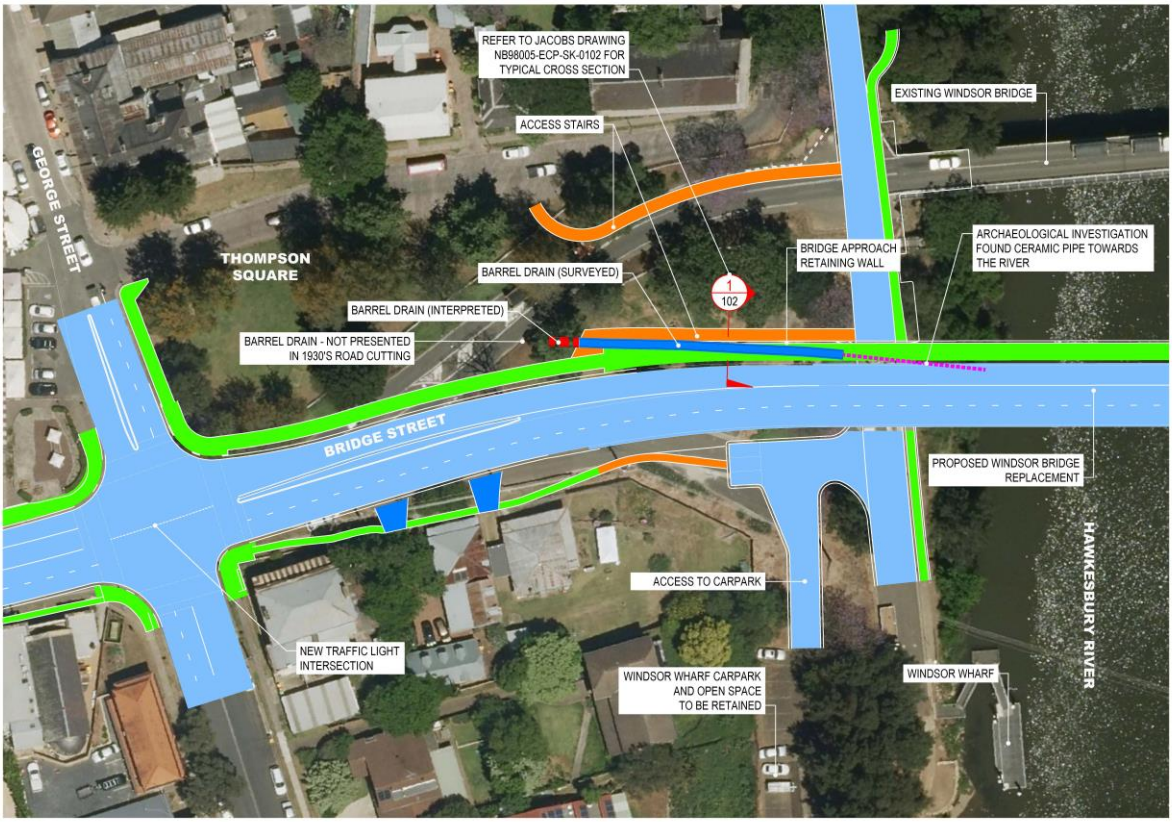


Figure 2: Image of the southern Windsor Prodge Replacement Project area with the location of the drain and its general course indicated. (Source: Jacobs 2018)

2 HISTORICAL BACKGROUND TO THE DRAIN

Underground drainage and sewer works do not figure prominently in the documented history of the early Colony. Underground drainage systems were constructed for Government House, Sydney at an early date (1788 and 1797). These drains were primarily brick or stone box drains. The system was later complimented between 1795 and 1800 with underground sewers by which time the privies were connected to a brick barrel drain that discharged off site.[1]

The first completed major public drainage program appears to be that constructed by Rowland Hassall at Parramatta in 1814-1815. The drain extended from George Street to the Parramatta River. The contract was for a drain and tunnel thus:

> *GOVERNMENT AND GENERAL ORDERS. Head Quarters, Sydney, Saturday, 22 April, 1815*
>
> *Mr. Rowland Hassall Amount of his Contract for making a Drain and Tunnel from George Street to the River at Parramatta £147.13 .0.* [2]

This was an example of public works being undertaken by private contractors, a system that was favoured by Governor Macquarie, though the construction of this drain was not the first, or only example of this occurring. Three years after the construction of Hassall's drain the death of a child is reported at Parramatta where the body was discovered in a cavity of a brick barrel drain that crosses Phillip Street.[3]

The Thompson Square drain was preceded by Hassall's Parramatta drain which was completed while the Thompson Square drain was still under construction. The drain at Thompson Square was undertaken between 1814 and 1816 by private contractors John Howe and James Magrath.[4] On 8 August 1814 Howe and Magrath signed an agreement with the Government for an integrated program of works at Thompson Square that included the construction of a wharf, the reduction of the gradient in Thompson Square from the river to George Street and the construction of a sewer.[5] Construction was to be completed within twelve calendar months and was to include a system of channels that fed the drain. The cost of the work was £350 and 350 gallons of Bengal Rum (or other spirits). The full contract and a transcription are appended as Appendices A and B respectively.

This first contract was followed by a second contract dated 24 April 1815. This was essentially a variation on the first contract providing greater details on how the wharf should be constructed – the cost of this additional work was £600.[6] Part payments for the work were as follows:

Quarter ending 10 September 1814	£100
Quarter ending 31 December 1814	£75

1 Proudfoot (1991): 52

2 Sydney Gazette and New South Wales Advertiser 22 Apr 1815 p.2

3 Sydney Gazette and New South Wales Advertiser 5 December 1818 p 1

4 Note there are various spellings of this name as "Magrath" and "McGrath". We have adopted the Magrath spelling as that is the spelling used in the 1814 contract (See Appendix A).

5 SLNSW ML MSS 106 Article 37 (Howe papers)

6 SLNSW ML MSS 106 Article 88 24 April 1815

Quarter ending 30 June 1815	£100
Quarter ending 30 September 1815	£200
Quarter ending 31 December 1816	£150

The works were well in hand in early 1816 when Howe and Magrath's work at Windsor became a concern. In a letter from March 1816 the Colonial Secretary J T Campbell, wrote to James Mileham JP and Richard Fitzgerald Esq of Windsor.

> *"It having been lately represented to the Governor that a very inferior and bad description of timber and other materials having been latterly used in the construction of the Government wharf at Windsor, by Messrs Howe and Magrath the contractors for that works and the square leading thereto, in the town of Windsor and it being further stated that the workmanship is very slight and insufficient, contrary to the true intent of the contracts,"*
>
> *"H.E is herein pleased to herein order and direct that you shall constitute yourselves into a committee of Survey on the said Public Works, calling to your assistance any well qualified respectable Carpenter in your neighbourhood and that you proceed with such assistance with Survey and inspect the materials and workmanship thereof at whatever time or times you may deem expedient, reporting thereon in writing to His Exc, And in the event of your discovering any deficiency in either in the materials or workmanship you are to require the Contractors to replace such insufficient work or materials at their peril and to replace it or them with such other as you may consider conformable to the terms of the contract itself."*
>
> *"For reference to said contract you are entitled to call upon and demand of the contractors to show the contract itself - and should they refuse to alter bad materials or bad workmanship and to render them conformable to the true spirit and meaning of the original contract you are hereby authorised and directed to put a stop to the work altogether until His Exc's pleasure shall be made known".*[7]

Mileham and Fitzgerald responded with the view that the labourers had been left largely unsupervised and that significant elements should have been supervised by the employers. Some of the materials themselves were also deemed to be unfit for purpose and needing replacing. It may be suggested that the same situation may have existed with the drain – badly supervised work utilising materials not designed for the job. However, by the time the committee was formed to investigate the work the drain was presumably buried. The work undertaken by Howe and Magrath appears to have generally been problematic and was one of the shortcomings in Macquarie's policy of using private contractors in this context. In June 1816 the Hawkesbury district was affected by a major flood that swept a portion of the troublesome wharf away. In November 1816 as a response to this situation Macquarie wrote:

> *In consideration of the greater part of the Govt. Quay or Wharf already erected by the contractors having been carried away or destroyed by the late Floods of the Hawkesbury, I have this day agreed on an estimate made out and submitted to me by Mr. Greenway the Govt. Civil Architect of the additional Expense of repairing and Completing the same in solid and durable material (agreeably to a Plan thereof made out by Mr. Greenway), to allow and pay unto Messrs. Howe and Magrath the additional sum of Two Hundred and Twenty (including Twenty Pounds for Mr. Greenway's trouble in planning and directing the Work) Pounds Sterling; allowing them also for payment such Iron and Spike Nails from the stores as can be spared - with a carpenter and Pair of Sawyers off the store; the*

[7] Col. Sec. March, 1816 Report of committee of survey re new Government wharf at Windsor (Reel 6046; 4/1736 pp.61-3.

> *Contractors now engaging to complete the said Quay or Wharf in Eight months from this date*.[8]

There is no indication that any further works or repairs were undertaken on the drain, or whether it had been affected by the flood. The contractors were paid £150 for works undertaken up to 31 December 1816 but the final payment of £316.10.- was not made until the quarter ending 31 March 1820.[9]

The recent investigation of the drain has revealed at least two instances where the drain was perforated and one area of collapse and reconfiguration. The drain was also pierced, or at least modified in the nineteenth century by a square hole designed to accommodate a possible pier pad (Figure 3). The precise date of this work, and its associations have yet to be determined. The drain was also cut through for the construction of a new concrete sewer line in 1937 (Figure 4).

The subsequent history and the origin of the drain have been the subject of much speculation, including stories identifying the drain as a 'smuggler's tunnel'. The first instance of this story appearing in print dates to 1924. George Reeve in the Windsor and Richmond Gazette 18 January 1924 linked the structure to the smuggling of illicitly-distilled alcohol:

> *the large bricked 8 x 10 conduit or tunnel leading from where Thompson's store site was to the river, parts of which can still be seen by an observant eye was constructed specially to draw up the barrels containing the rum which was illicitly manufactured on a wholesale scale*.[10]

The same spurious anecdote was re-told two years later in the same publication:

> *It is not generally known that in Windsor there is a secret underground tunnel. It commences at the corner of the upper park in Thompson Square, and apparently runs for some distance towards George-street. Though the inlet can now hardly be detected it conveys the impression that an ordinary person could comfortably walk into the tunnel. It is certainly a relic of the past— the good old days' when considerable quantities of liquor were smuggled into the Hawkesbury district. It is close to the Windsor Wharf, and who knows whether a secret still is not hidden there? An investigation would no doubt prove interesting*.[11]

The story was resurrected in 1976 by R. S. Arndell using the above newspaper reports as the basis for the supposed 'smuggler's tunnel'. This may have also been the source of the story linking the Macquarie Arms, Windsor, with the 'tunnel' since Arndell describes a similar tunnel at the former Macquarie Arms Inn, Pitt Town. Similar stories were told regarding hotels in The Rocks and, doubtless, other places where alcohol, commerce and shipping mixed.

By 1980 the story had such currency that the then Windsor Council attempted to sponsor an investigation of the 'smuggler's tunnel' under a National Estate Program grant. Historian Douglas Bowd however, intervened and gave a cogent explanation of the structure's true purpose.[12] In 1986 an investigation of Thompson Square's heritage values was undertaken by Edward Higginbotham in

[8] L. Macquarie Journal 14 November 1816 SLNSW ML A773 p.64

[9] Higginbotham (1986(2)): pp. 28-29

[10] *Windsor and Richmond Gazette* 18 January 1924 p.1

[11] *Windsor and Richmond Gazette* 15 October 1926 p.4

[12] See Hawkesbury Historical Society http://hawkesburyhistoricalsociety.blogspot.com.au/2016/02/smuggles-tunnels.html

for the then Hawkesbury Shire Council.[13] The survey identified the outlet of the drain adjacent to the wharf but the location was not mapped (Figure 5). The foreshore, and this portion of the drain if it survives, is now obscured by a gabion wall.

Figure 3 - Brick drain and possible pier pad. (Source: AAJV 2018)

[13] Higginbotham, Edward, *Historical and Archaeological Investigation of Thompson Square, Windsor, NSW* for the Hawkesbury Shire Council Windsor, NSW, July 1986

Figure 4 - Brick drain showing cut for 1937 sewer line. (Source: AAJV 2018)

Figure 5 - Drain outlet adjacent to the location of the wharf in 1986. (Source: Higginbotham 1986 (2): 41)

3 DISCUSSION OF OTHER BRICK DRAINS OR SIMILAR STRUCTURES PREVIOUSLY INVESTIGATED AROUND SYDNEY

3.1 Early Examples of Drains

The earliest identified use of brick drains and sewers in the colony of New South Wales are those referred to in Section 2 associated with First Government House Sydney. These were the earliest drain systems constructed in the Colony. Sewerage and drainage did not become significant elements in public works until the governorship of Lachlan Macquarie commencing in 1810. A small example that may have influenced the design of the Thompson Square drain was the construction of double-arch brick culvert carrying Mrs Macquarie's Road over a small stream in the Royal Botanic Gardens, Sydney. Construction took place between 1813 and 1816 using brick in the same configuration as that used later in the Thompson Square drain. The culvert was investigated by Higginbotham in 1992 and in terms of construction technique the following was observed:

> *The northern face of the culvert is showing distinct signs of imminent collapse. The brickwork over the arches on the northern face has lost a proportion of its bonding material, and has also detached itself from the brickwork forming the remaining length of the arched culverts. This is not surprising given the header bond predominantly used in the arches, which may have contributed to some longitudinal weaknesses in the overall structure. Other examples of similar construction are predominantly stretcher bond in two skins of brickwork, thereby overcoming this problem. The poor awareness of bonding suggested by the original brickwork may indicate the nature of labour in the early Colony, between 1813 and 1816, when only bricklayers with limited skill may have been available.*[14]

The next reference to underground drains constructed at Government expense is that undertaken by Hassall at Parramatta in 1814-15 described in Section 2 above.

One of the best-known and most thoroughly investigated early brick drains in New South Wales is the brick barrel drain at Parramatta. This has been extensively described by Higginbotham who identified two phases of construction, 1820-27 for the brick barrel section and the 1840s for the sandstone box section.[15] Higginbotham's dating of the brick section of the drain was based on a combination of evidence. Firstly, the presence of Government "broad-arrow" bricks in the fabric indicates it was a Government work. The reuse of bricks from the Convict Barracks suggests a date after 1820-22 and the absence of a mention of the installation of a drain in Parramatta in the "Blue Books" of the Colony after 1828 suggests that the drain dates to an earlier period. He therefore concludes that the likely date for the work is 1822-1827. The presence of bricks marked with a broad-arrow in the drain's construction may not preclude it being work conducted by a private contractor. In 1831 for example, calls for tenders were made for the installation of a brick barrel drain at Liverpool and the notice remarks that the Government will supply the bricks and the successful tenderer the labour and time for the work.[16] The possibility remains that part of the drain may have been constructed in 1814-15 by Rowland Hassall. This earlier dating is unlikely to be resolved unless an earlier barrel drain in Parramatta is physically located and identified.

[14] Higginbotham (1992): p. 4

15 Higginbotham (1983), p.37.

16 Sydney Gazette and New South Wales Advertiser, 10 September 1831. While the offer of bricks was later withdrawn it does open the possibility that Government produced materials may have been supplied to private contractors to complete jobs for Government sites.

In 2007 Higginbotham investigated one of two brick barrel drains associated with the convict settlement at Port Macquarie, NSW. The drain, constructed between 1839 and 1842, had an internal diameter of 1m and a surviving headwall pit. The drain is still a functioning stormwater conduit

Excavations undertaken by Casey and Lowe between 1998 and 2001 at the Conservatorium of Music, Sydney exposed a complex system of drains that included box drains, barrel drains and an elliptical drain dating to the 1840s. The system of drains was located around the former Government Stables and reveal changing design responses to the problem of ponding stormwater as well as waste-water removal. The elliptical drain constructed in the 1840s was removed in part and considered for interpretive display.

By the late 1830s brick barrel drains were a common feature of major public works programs. The style of construction remained a standard until the 1850s after which time civil sewerage and drainage programs employed larger drains with a range of geometries, primarily oviform and elliptical drains (such as the Tank Stream Channel, Sydney). These were generally bonded with a strong mortar and provided with an internal sealing layer of patent cement.

These early structures were generally combined sewer and stormwater drains, sometimes replacing earlier open channel drains or channelised natural watercourses. A major program of drain-building occurred in the 1850s in central Sydney, in response to the growing city and the risk of disease from open sewers. Five major combined sewer/stormwater drains were constructed in the 1850s, including the Tank Stream, Bennelong Sewer (also known as Fort Macquarie), Wattle Street Sewer and Hay Street Sewer (Figure 6).[17] These consisted in various locations of arched stone channels and brick oviform structures. The Tank Stream, for example, was initially constructed in arched stonework in the 1850s and later extended to the south in brick oviform in the 1870s.The major Bondi Ocean Outfall Sewer was similarly constructed with a large central brick barrel in the 1880s.

As mass production and concrete technology emerged in the late nineteenth century, stone and brick construction gave way to the use of precast or cast in situ concrete structures, as well as a progressive separation of sewerage and stormwater. Technology continued to evolve, with steel and, later, plastic piping largely replacing masonry and concrete for all but the largest sewer structures.

[17] Aird, (1961) pp 128-130.

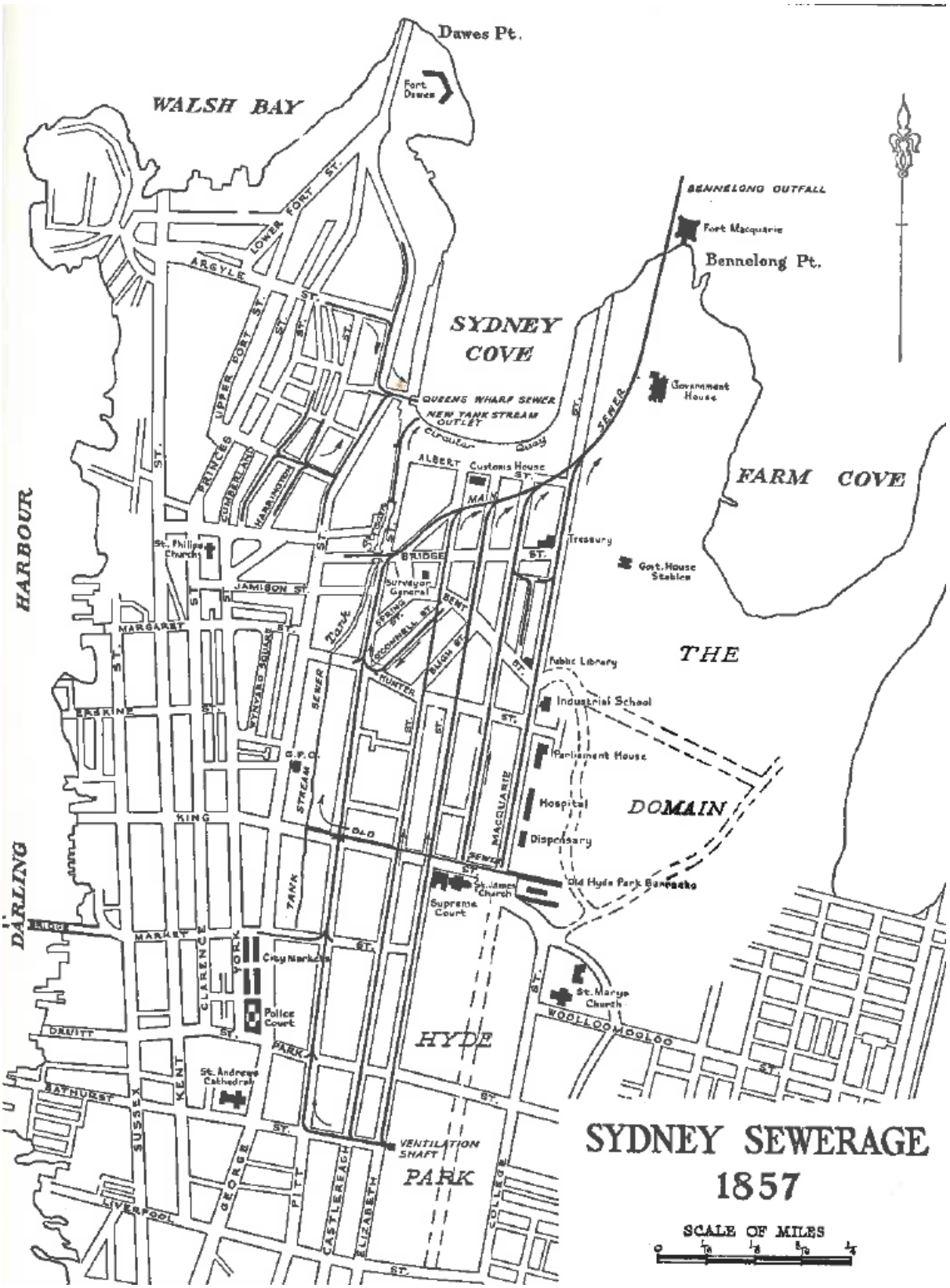


Figure 6 - Sydney's early combined sewer and stormwater system. (Source: Aird 1961: 134ff)

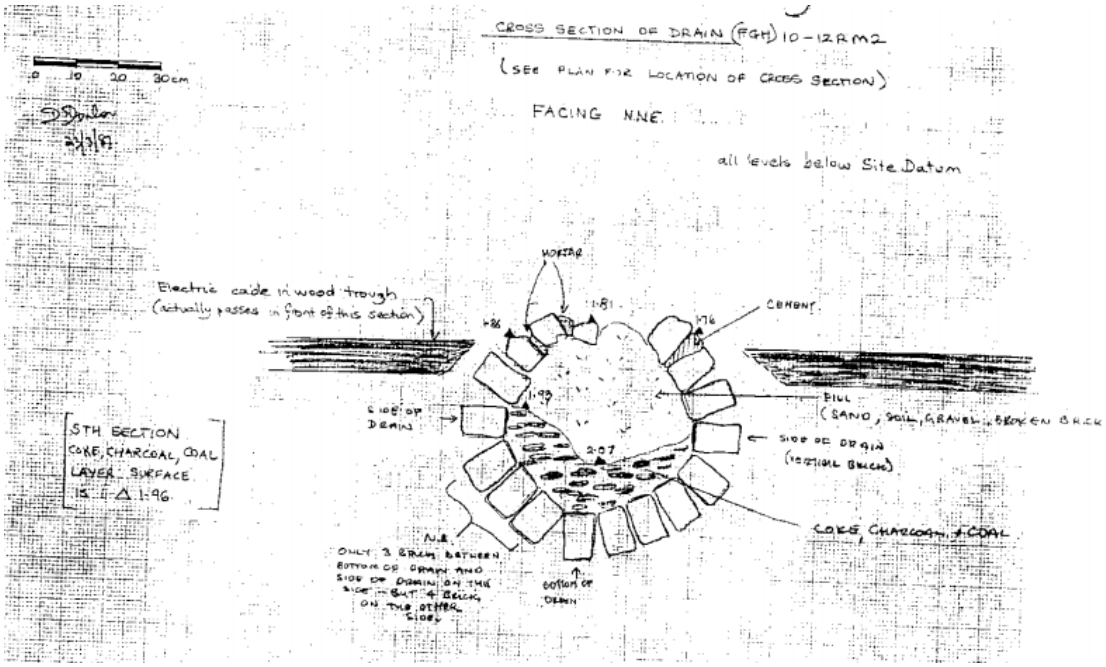


Figure 7 - Brick barrel drain (10-12 RM2) at the First Government House site. (Source: Bickford 1983, Fig 21).

Figure 8 - North face of the 1813-16 Royal Botanic Garden culvert showing original lower portions and later dry-pressed brick replacement above. (Source: Wong 1999, Figure 18)

Figure 9 - A complete section of the brick barrel drain, 1822-27, Parramatta, NSW in 1981. (Source: Higginbotham 1981)

Figure 10 - Intact section of the Port Macquarie barrel drain (Source: E. Higginbotham and Associates (2009))

Figure 11 - Headwall pit of the Port Macquarie barrel drain (Source: E. Higginbotham and Associates (2009))

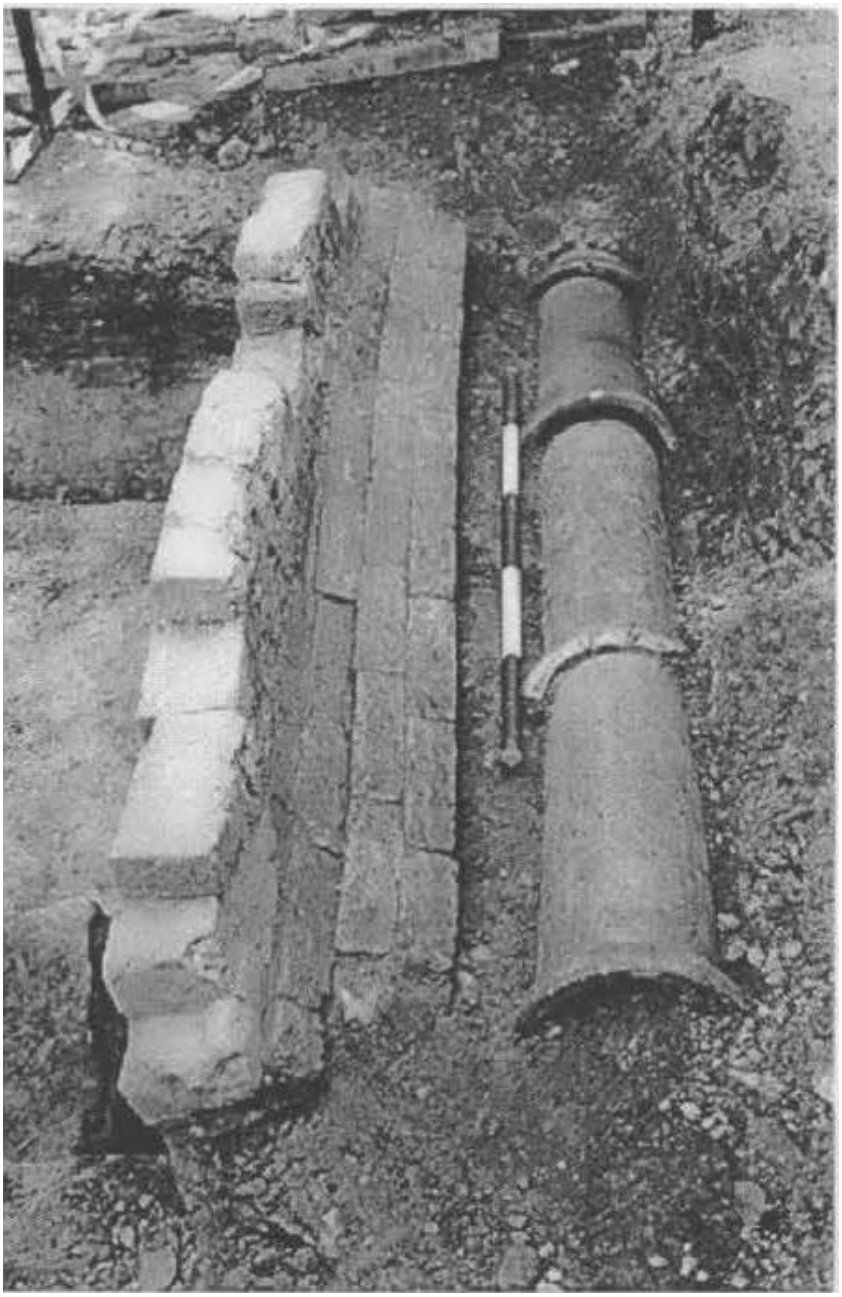


Figure 12 - Remnant barrel drain (left) 1820-1840 feeder line into the Tank Stream (predating the Tank Stream Channel) and its later nineteenth century ceramic drain replacement (Source: Godden Mackay 1998, vol 1 p. 59)

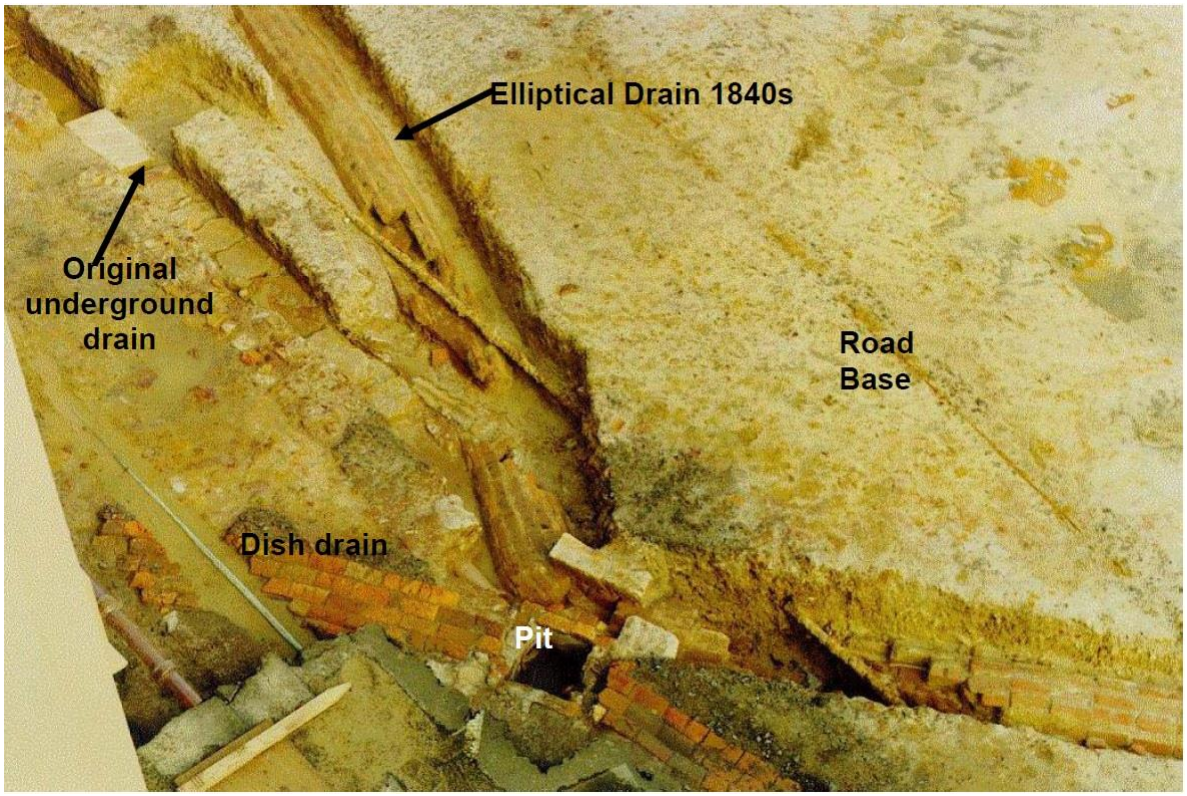


Figure 13 - Conservatorium site, Sydney. Detail of the northern dish drain and the later phase pit during archaeological excavation. (Source: Casey and Lowe (2002): 156)

Figure 14 - Elliptical drain, cross-section, Conservatorium site prior to removal (Source: NSW Department of Public Works and Services 2001)

Figure 15 - Barrel drain excavated beneath Campbell's Stores in The Rocks, March 2018. This drain is 1400mm in diameter and a section approximately 3000mm long was exposed. It is to be retained in situ. (Courtesy Austral Archaeology 2018)

Figure 16 - Oviform brick drain (circa 500x700mm) found in Auckland, NZ, dating from c1865. (https://www.cityraillink.co.nz/crl-heritage/)

4 ANALYSIS OF THE THOMPSON SQUARE DRAIN

4.1 Physical Description of the Drain

Although commonly described as a brick 'barrel' drain the structure was a combined sewer/stormwater drain that appears to have attempted an ovoid or ellipsoid form rather than a circular-sectioned barrel drain. The main drain structure consists of a shallow inverted segmental arch forming the base (invert). The walls are straight battered (receding slope) walls topped by a low, segmental arch in the south and a full arch in the north. The invert was constructed as a single skin of brick laid in stretcher bond. The walls were laid as two skins constructed using English bond. The arch is two skins thick with three courses laid in stretcher bond rising from the spring line with the remainder of the arch carried out in header bond. The single crown course is laid as a soldier course. The drain has an internal height of 1.30m an invert width of 700mm, a height from invert to the spring line of 800mm and a width at the spring line of 970mm.

In barrel and oviform drain construction all courses are usually laid in stretcher bond with the width of the drain and depth of invert determined by the expected carrying capacity in both dry-weather flow (daily discharge of effluvia without the addition of surface water) and stormwater flow. The invert of the Thompson Square drain is essentially a dish-drain that would not have operated efficiently as a sewer in dry-weather. The use of five different brick segments (stretcher invert, stretcher batter walls, stretcher arch segment from spring-line, header arch and soldier crown course) is a reasonable indication that the structural principles of drain construction were not well understood by the designer. The drain appears to be an attempt to construct an ovoid/ellipsoid drain without the knowledge of the geometry that provided drains of this type with strength and the ability to cope with variable flow regimes. The use of header courses for the vault is more typical of low-arched window and door heads rather than long vaults. The decision to use this form may have been driven by the designer's experience or by an inability to create long sections of formwork that would allow stretcher courses to be constructed. The exemplar for this type of construction appear to be the Lady Macquarie's Road culvert constructed between 1813 and 1816.

In the sections of the drain exposed to date all feeder lines discharged through the top of the vault rather than through the walls. The feeder lines themselves consist of simple brick box drains or culverts that were capped with timber slabs and then covered over. Gully traps may have been installed at intervals along the feeder lines to intercept surface water. Only the brick bases of the gully traps survive with the result that the depths of their columns and surface presentation are unknown. It is unclear if a system of surface drains was also installed adjacent to the roadways. The streets of Sydney were supplied with open drains designed to carry run-off but were used as a place for dumping refuse resulting in the issue of Government orders as early as 1810 to prevent the dumping of filth on the public roads or in drains.[18] The feeder lines had also been subject to collapse. Settling of fill on the shoulders of the main drain had resulted in the slumping of the feeder lines on either side of the main drain, which likely made them inoperable.

Archaeological exposure of the drain has afforded good opportunity to observe the fabric and techniques of construction. Sondage 6 at the northern end of the archaeological excavation area located the drain at approximately 4.5m below the surface. The excavation of this sondage revealed that the drain had been accessed here at least once before during its operational life. At some stage after its initial construction the drain had collapsed at this point and had thus become blocked. This collapse was apparent from the slumping of some of the arch headers and soldier bricks towards the north. Part of the western lower wall of the drain had also collapsed in that location. The collapse and

[18] Sydney Gazette and NSW Advertiser 22 September 1810 p. 1

consequent blockage had necessitated the excavation and repair of the drain at this point along its course. This repair consisted of the removal of the collapsed bricks, the insertion of a large vitreous ceramic pipe into the mouth of the drain and the construction of a new stabilising headwall to seal the collapse (see Sections 4.2.2 and 4.2.3 below). The materials associated with this repair are consistent with a late nineteenth or early twentieth century date. Given the history of severe flooding in this area, it is likely that the discharge (northern) end of the drain was of necessity rebuilt on multiple occasions due to flood damage.

The archaeological program exposed small portions of the drain itself and larger sections of the infilled cut in which the drain is set. A number of feeder lines contemporary to the drain were also exposed and examined. The line of the drain is inferred from these investigations and the condition and inter-relationship of the drain to the feeder lines is not yet known.

The following series of images show the overlay of the barrel drain on various maps and aerial photographs ranging from 1827 to 2018. This sequence also assists in understanding the various changes to the roadways and topography which have led to some of the impacts observed on the barrel drain and adjacent surface culverts.

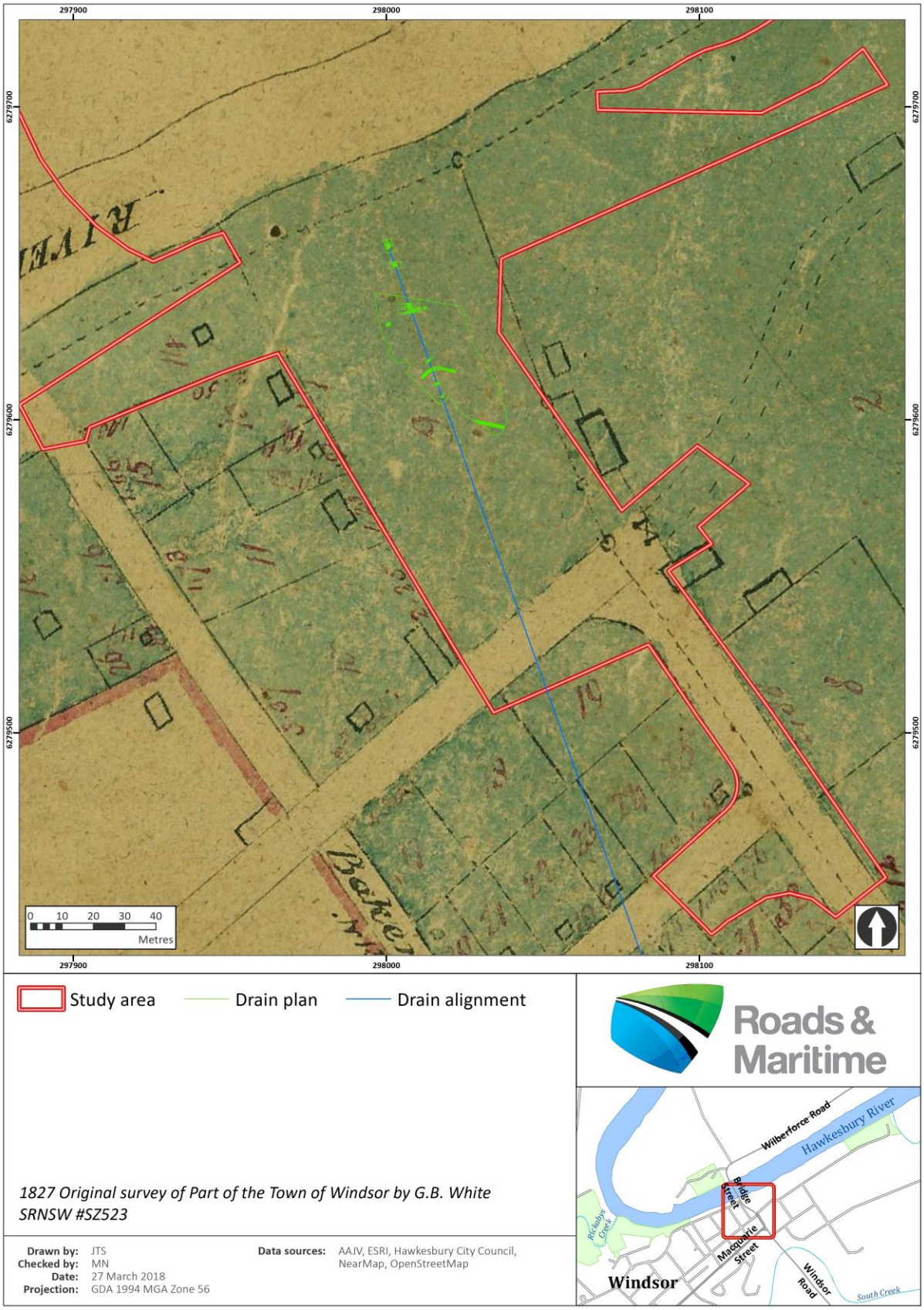


Figure 17 - Overlay on White's 1827 Survey

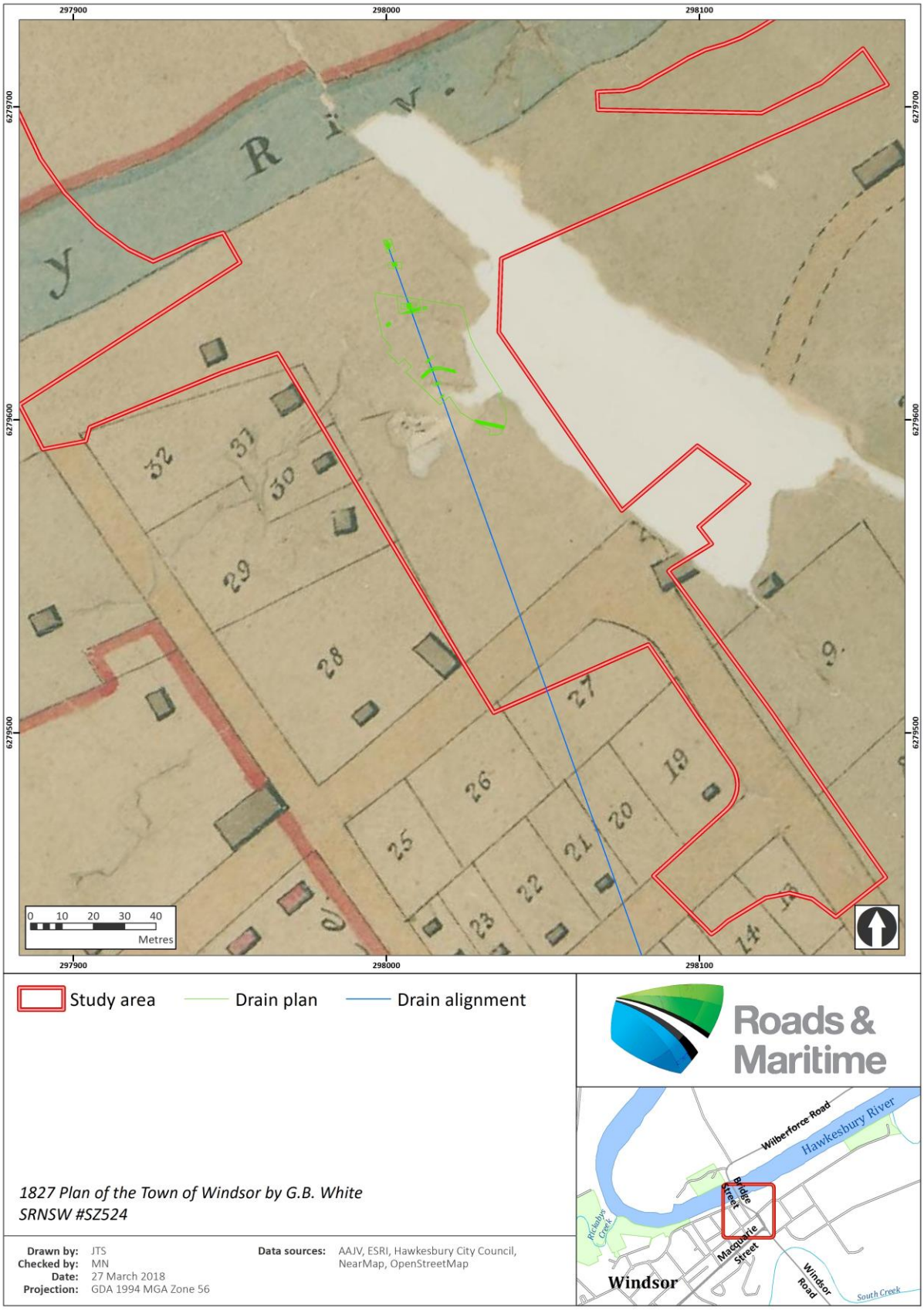


Figure 18 - Overlay on White's 1827 Plan

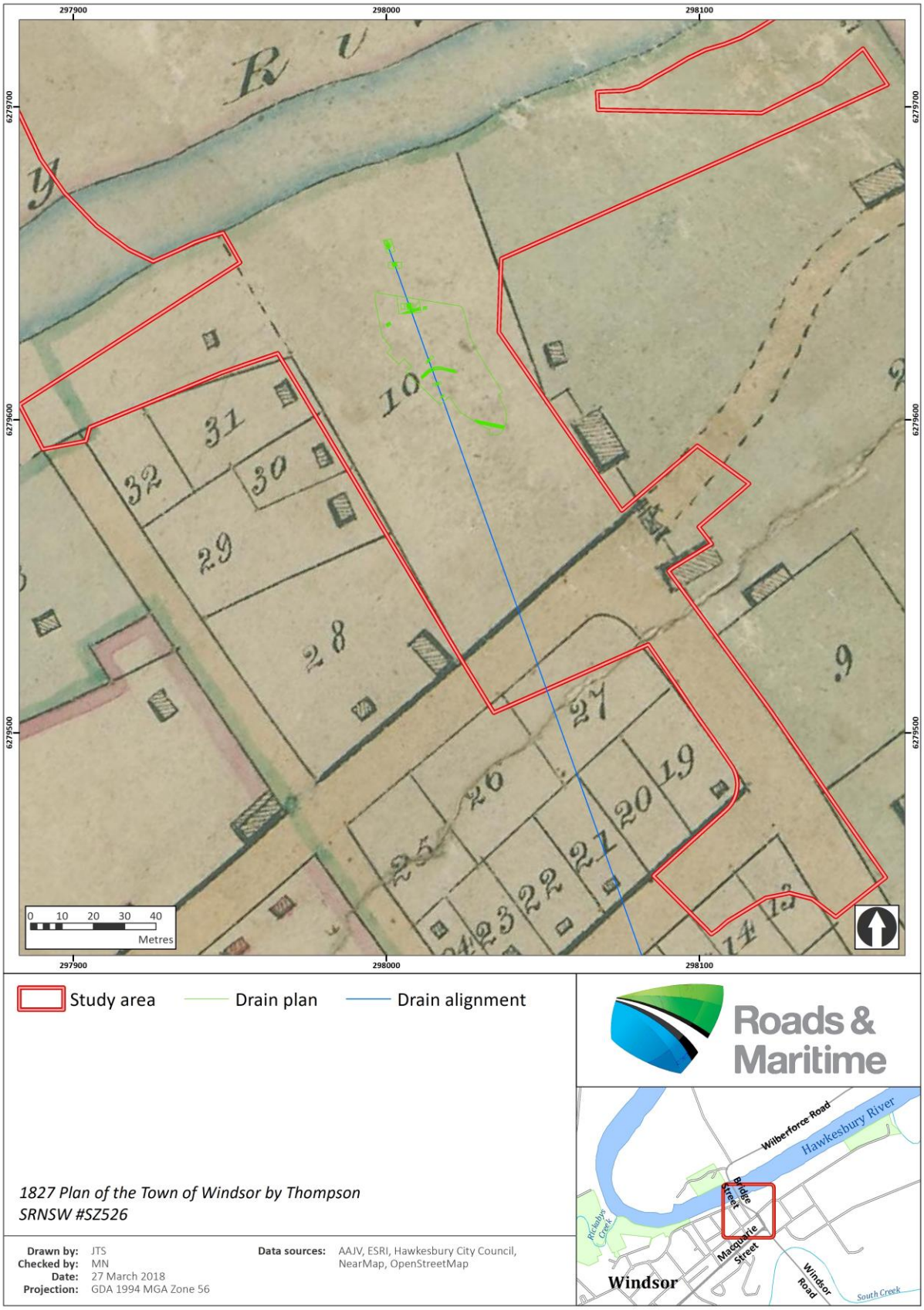


Figure 19 - Overlay on Thompson's 1827 Plan

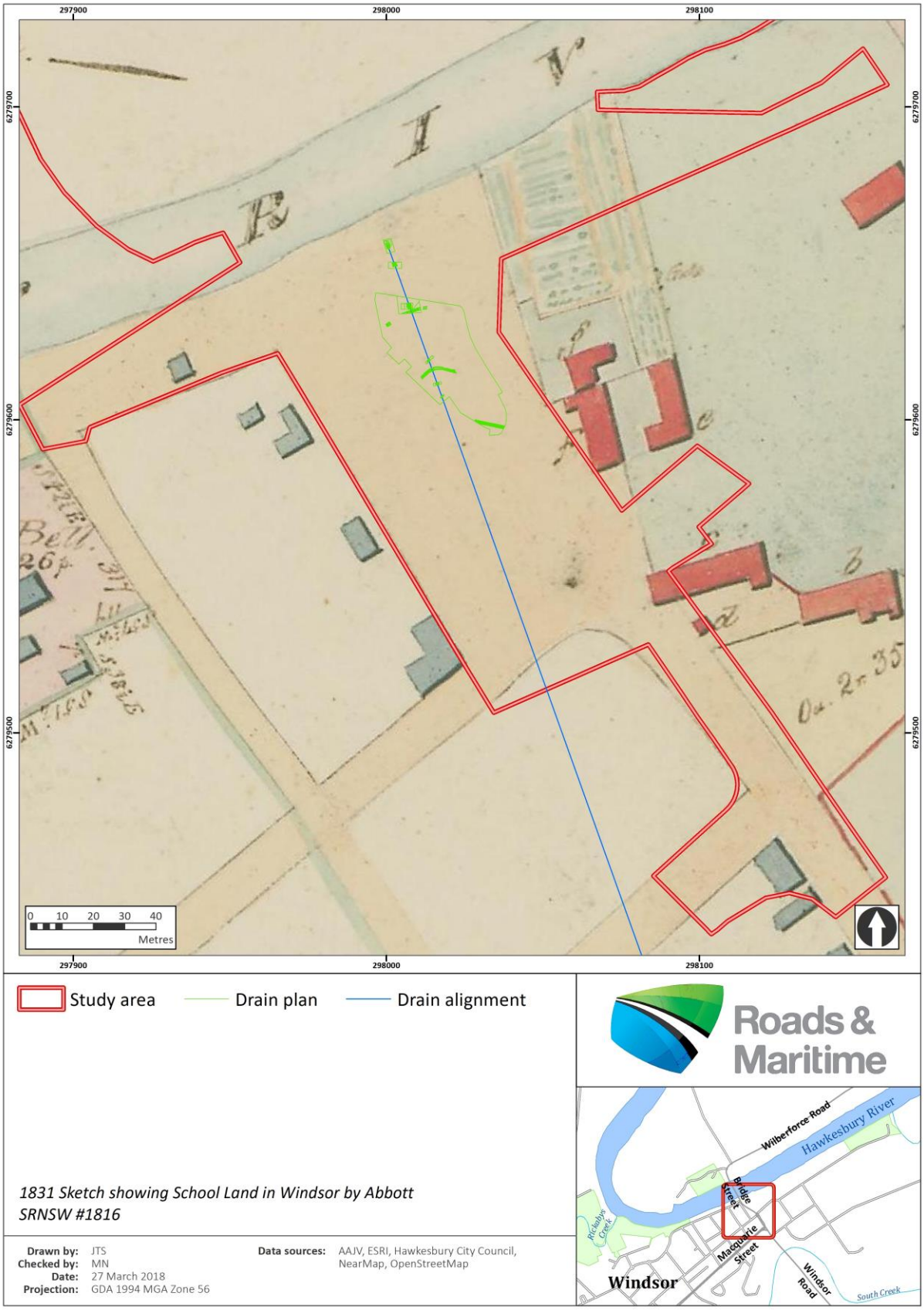


Figure 20 - Overlay on Abbott's 1831 Sketch Plan

Figure 21 - Overlay on the 1835 Town Plan

Figure 22 - Overlay on the 1841 Town Plan

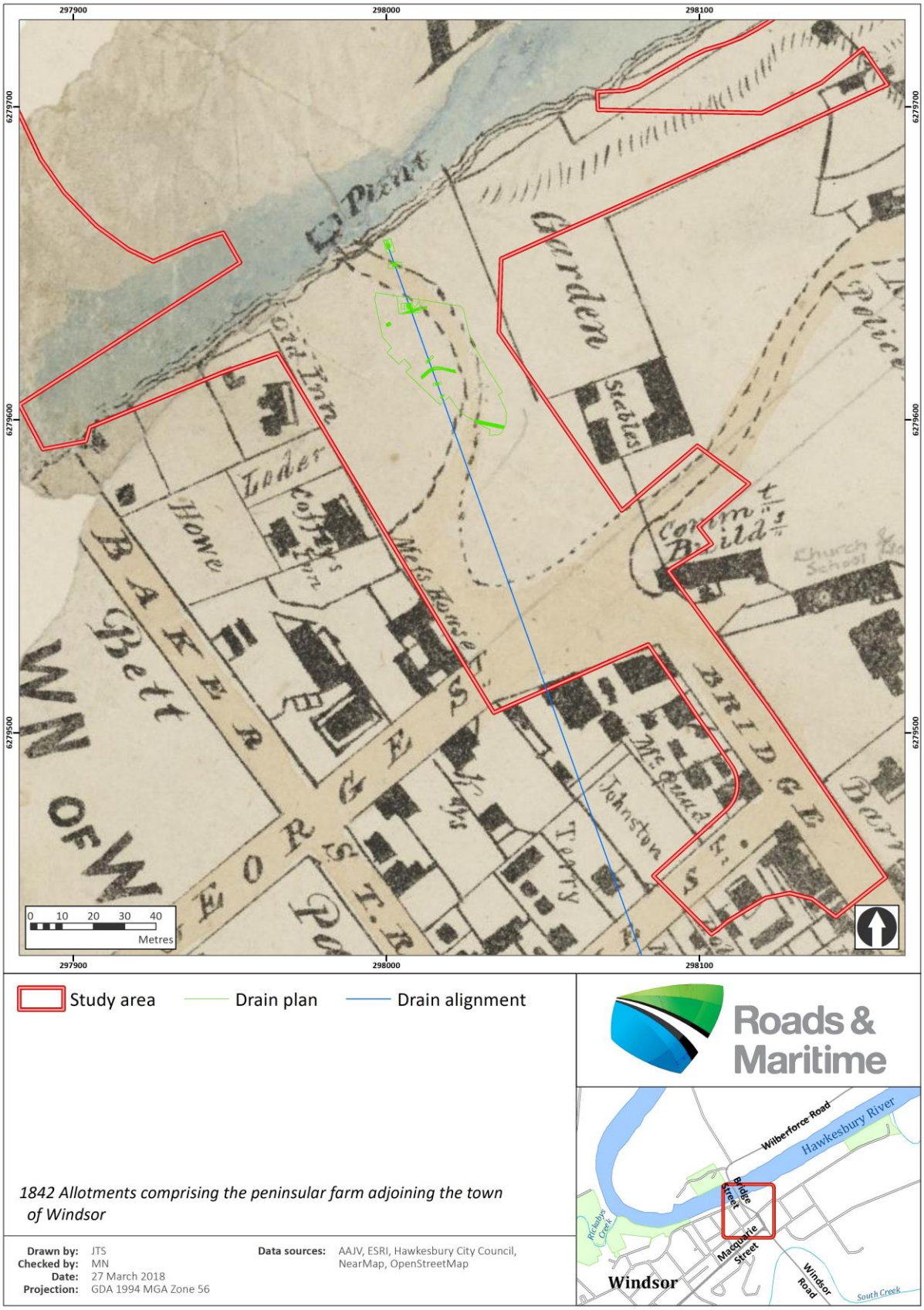


Figure 23 - Overlay on the 1842 Allotment Plan

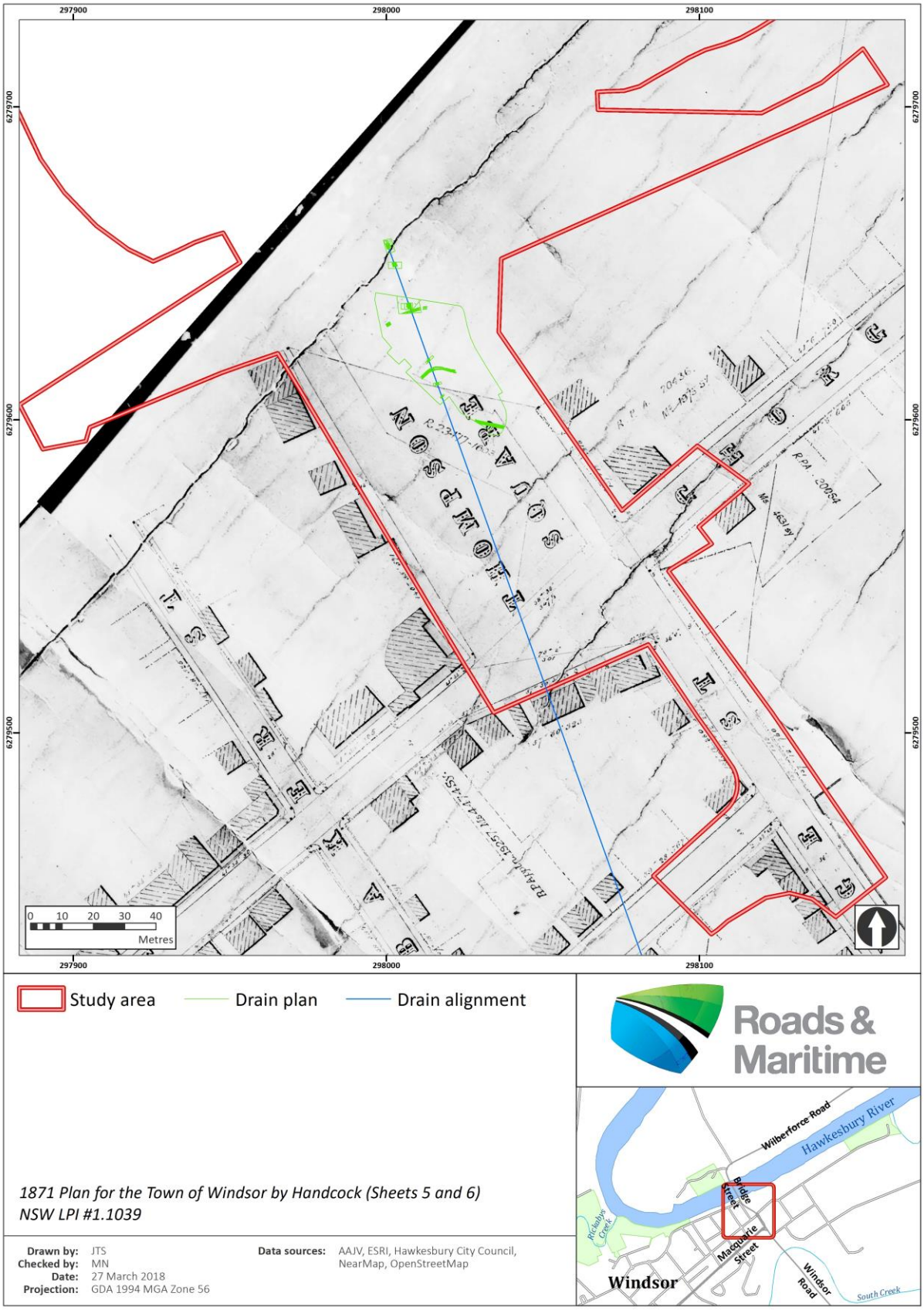


Figure 24 - Overlay on Hancock's 1871 Plan

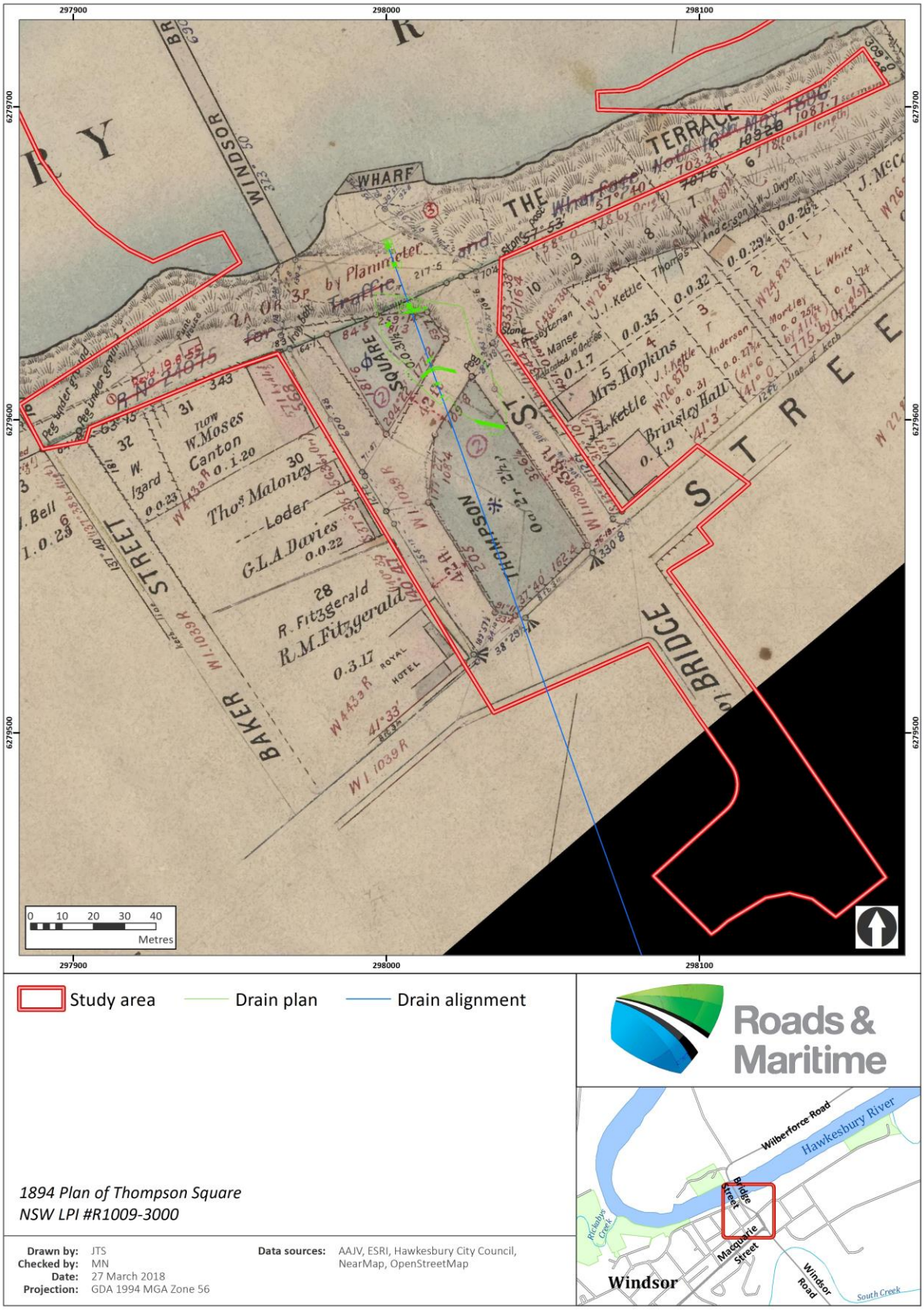


Figure 25 - Overlay on the 1894 Survey Plan

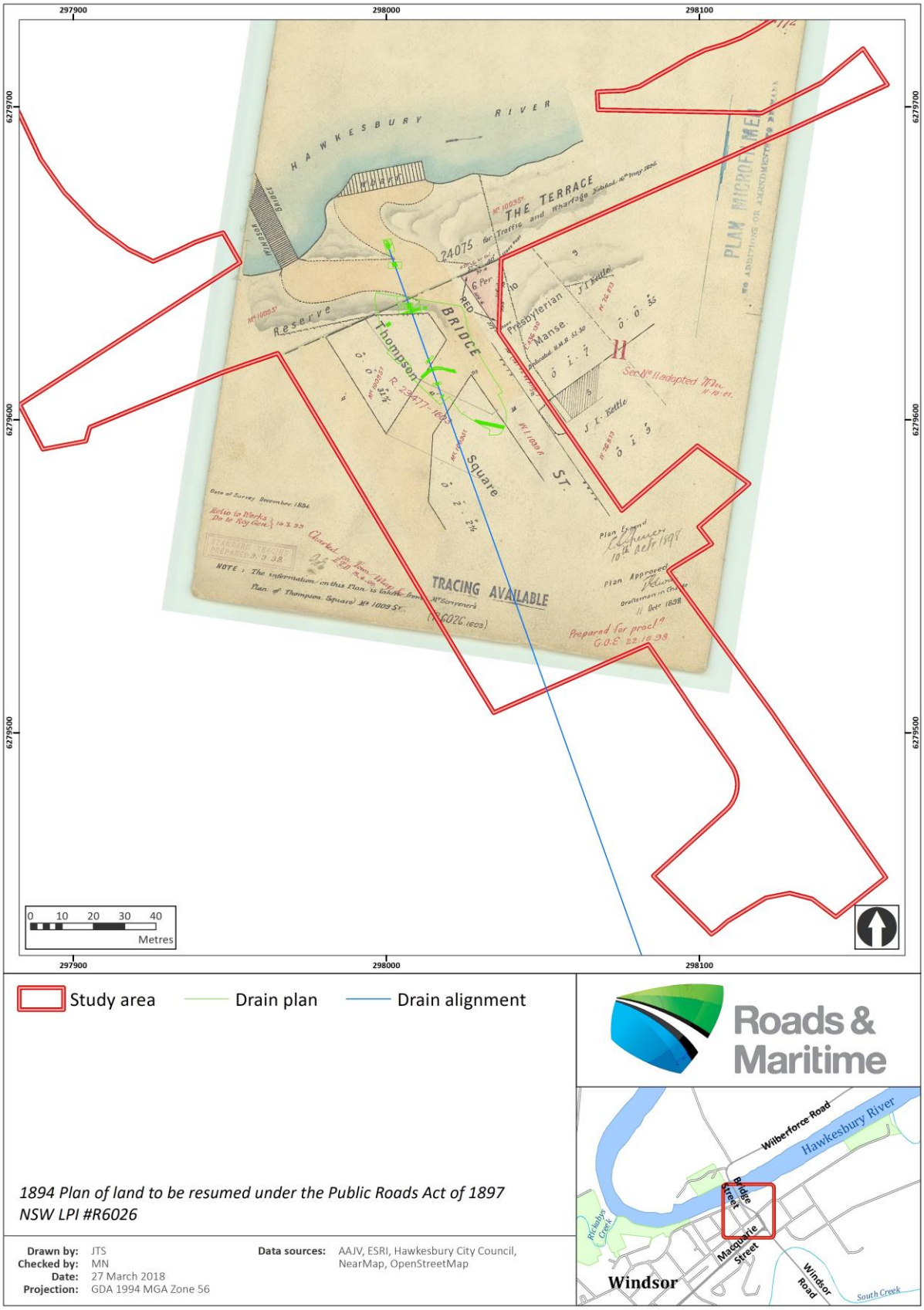


Figure 26 - Overlay on the 1894 Road Resumption Plan

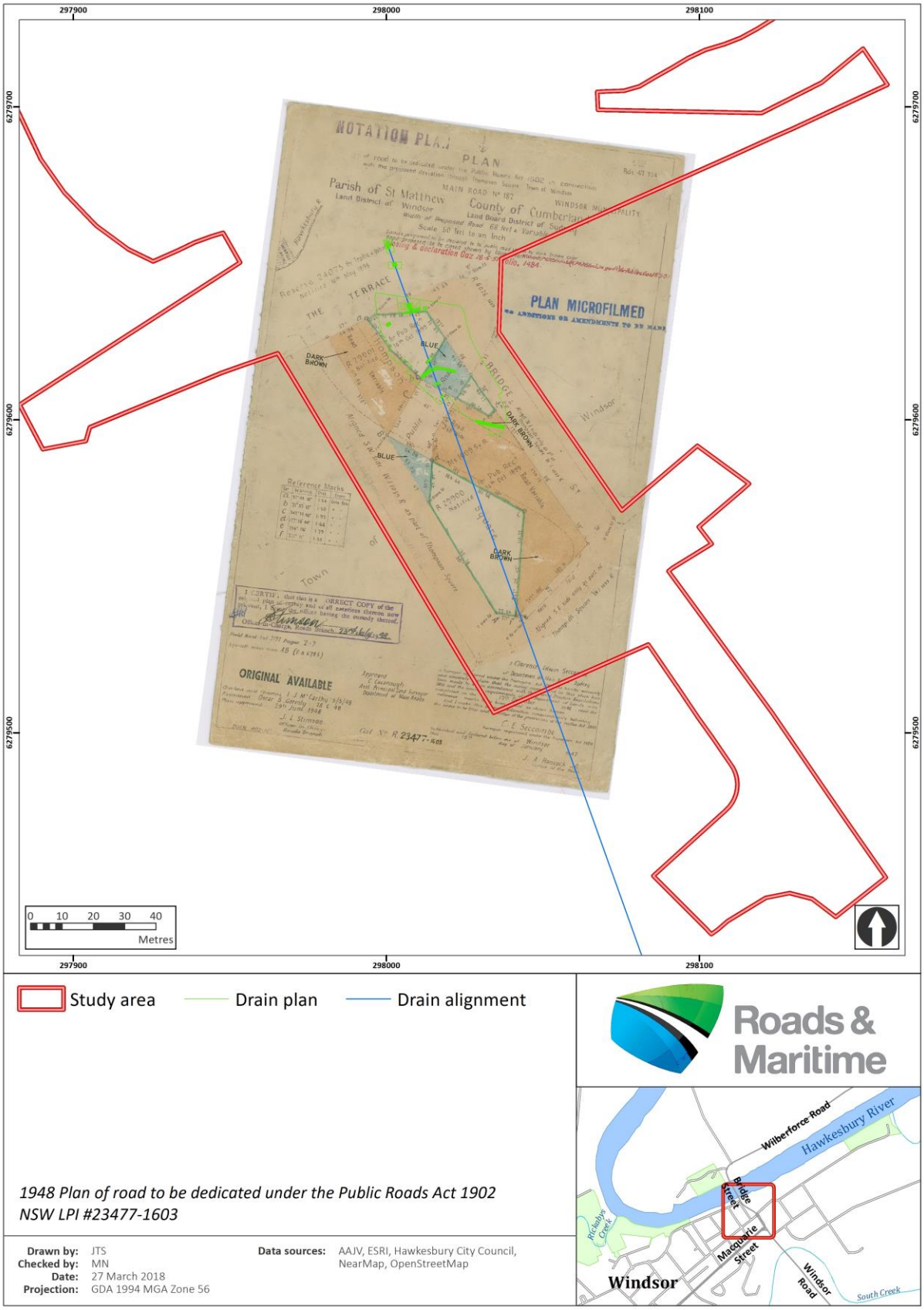


Figure 27 - Overlay on the 1948 Road Plan

Figure 28 - Overlay on the 2016 Aerial Photo, Prior to Archaeological Testing

Figure 29 - Overlay on the 2018 Aerial Photo Showing Archaeological Management Zones

Figure 30 - Overlay on the 2018 Aerial Photo

4.2 Materials

4.2.1 BRICK SAMPLES

Two bricks were sampled from those recovered from Sondage 6. Both were sandstock bricks with evident strikes and hack marks along the sides. Neither of the sample bricks had frogs, government Broad Arrows nor other identifying marks.

Brick One had dimensions at one end of L225mm x W110mm x H60mm with the other end trimmed down, post firing, to a width of only 70mm (both other dimensions remaining the same) (see Figure 43 and Figure 44). This trimming was uneven with one face trimmed from approximately half way along the brick's length while the opposite face was trimmed at a sharper angle for only a quarter of its length. There is what appears to be a remnant scribed line in one surface of the brick possibly as a guide for the trimming.

The face opposite the strike exhibits considerable "cratering" from possible expansion of water/gas vesicles in the clay during the firing. The cratering and trimming revealed some larger ironstone (5-10mm) inclusions in the clay body of the brick. Brick One had presumably been trimmed for use in the arch section of the drain with the position of the taper indicating its intended position as part of the soldier course at the crown. The trimming would have been designed to allow this brick to form the critical wedge shaped "keystone" of the arch structure. The unevenness of the trimming demonstrates knowledge of the required shape for this brick course but a lack of care in the workmanship.

Brick Two had dimensions of 225mm x 110mm x 60-62mm and was a consistent medium orange colour, with well mixed clay containing some large (1-2mm) rounded quartz sand particles and iron stone inclusions (see Figure 45 and Figure 46).

It is recorded that Phillip brought over not only 10,000 bricks, but brick moulds, suggesting that there may be some consistency in brick sizes from the establishment of the colony.[19] However, there is wide variability of brick size within buildings or work of the same period and even within single brickyards. There is therefore no necessary correlation between brick dimensions and period of use. Nevertheless, the recorded dimensions of the sample bricks are similar, though not identical, to those recorded for the Macquarie period at Old Government House in Parramatta (see Table 1).

Period	Length (mm)	Width (mm)	Height (mm)
1790	235.0	114.3	69.91
Hunter's 1800	225.4	101.6	60.3
1815 Macquarie Addns	222.3	114.3	63.5
Greenway's	222.3	114.3	63.5

Table 1 - Brick Dimensions from Old Government House, Parramatta (Source: Lewis, p6.01.04)

[19] See Pearson, S, Building Materials Analysis, First Government House Site, Sydney, Heritage Resource Services, 1988, p 5.

4.2.2 MORTAR SAMPLES

Two samples of the bonding material were obtained from separate portions of the body of the drain in Sondage 6. Sample one was removed from the arched section at the crown of the drain while sample two was obtained from the headwall of the blocked section of the drain.

The detailed close-ups of sample one are shown in Figures 47-48. Investigation of this sample revealed that it comprises a very friable dark brown mud mortar with a small fraction of lime in the form of calcined shell fragments, some up to 2mm. The detailed close up photos also revealed small charcoal inclusions and fragments of organic matter – possibly manure or sawdust. This information is entirely consistent with other early colonial mortars.

Sample two was a much harder dark yellowish concrete comprising large consistently sized sand grain aggregate and a patent cement. The evidence of the constituents of sample 2 is consistent with a late nineteenth or early twentieth century date.

4.2.3 VITREOUS CERAMIC PIPE

At the base of the headwall of the drain a vitreous ceramic pipe (VCP) has been inserted to allow continued flow of waste/storm water past the headwall. This glazed pipe is a buff colour and has an external diameter of 270mm (with the collar 330mm). This form of pipe is of a late nineteenth or early twentieth century date.

4.2.4 DISCUSSION

The sandstock bricks and the mud mortar are consistent with an early nineteenth century period of construction (1815). The absence of broad-arrows on the bricks is not inconsistent with them being supplied by a government brickyard. The design of the drain noted above indicates that the drain's failure is attributable largely to flaws in its original design. Brick drains constructed in the period immediately following the construction of the Thompson Square drain reverted to the barrel drain configuration that became a standard throughout the 1820s and 1830s. It was not until the 1850s that oviform drains of a scale similar to the Thompson Square drain were employed in NSW for civic projects. This includes the system of five main drains/sewers in Sydney constructed in the early 1850s. In this respect the Thompson Square drain was almost 40 years ahead of its time in terms of intent, albeit inexpertly constructed. The execution of a drain on this scale required materials, skills and an understanding of drain geometry that were unavailable in the Colony in 1814.

Figure 31 - Vertical view of exposed crown of brick drain with remnant lime rendering in Sondage 3. (Source: AAJV 2018)

Figure 32 - Feeder brick box drain for the main drain alignment. (Source AAJV 2018)

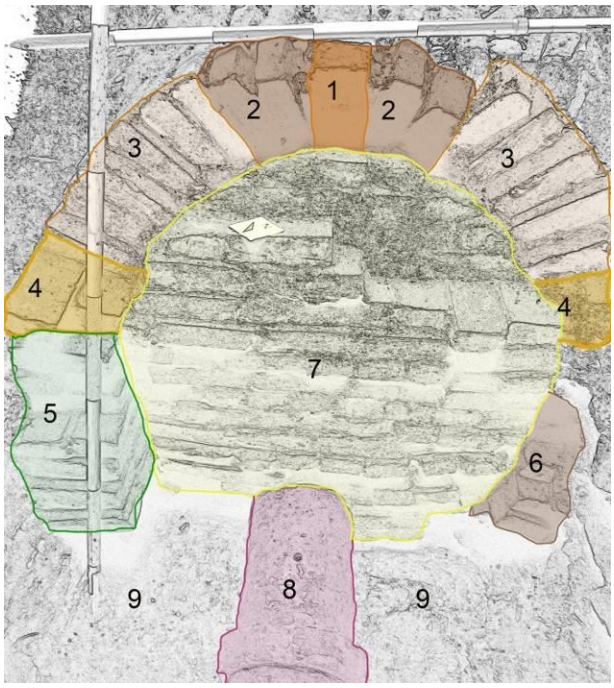
Figure 33 - Feeder brick box drain for main drain alignment. (Source AAJV 2018)

Figure 34 - Feeder line (foreground) crossing main drain showing slumping of the box drain above the shoulders of the main drain (Source: AAJV 2018)

Figure 35 - Brick shaft for the main drain alignment. (Source RMS 2018)

Figure 36 - Vertical view of the blocked drain in Sondage 6. South is to top of image. Note the 'slumping' of the bricks at the crown of the drain indicating the collapse which blocked the drain and required physical intervention. (Source: AAJV 2018)

Figure 37 - View of brick drain in Sondage 6 with later (19th/20th century) headwall and vitrified ceramic pipe inserted at base. (Source: AAJV 2018)



1 Soldier sandstock brick at crown - collapsing

2 Collapsing sandstock arch headers

3 Sandstock header courses for arch (6 courses)

4 Sandstock stretcher courses for arch springing (3 courses)

5 Vertical walls English bond (6 courses visible)

6 Collapsing wall stretcher bond

7 Later (19th c) drain headwall with re-used sandstocks and yellow patent sandy concrete

8 Vitrified ceramic pipe 270mm diameter

9 Basal Clay

Figure 38 - Diagram of interpreted elements of drain exposure. (Source: AAJV 2018)

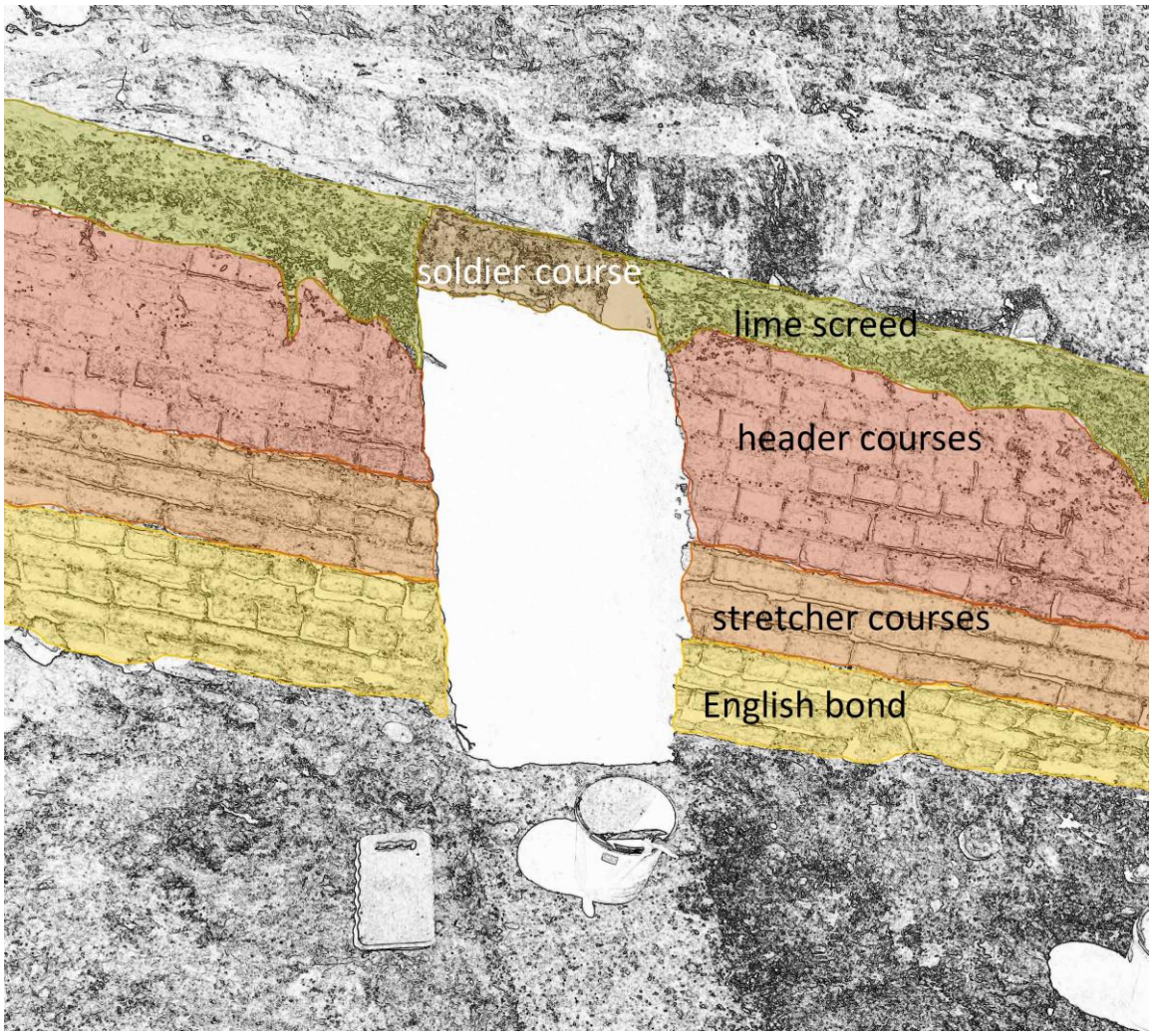


Figure 39 - Diagram showing interpretation of exposed external surface of the drain

Figure 40 - Exposed section with cut for drain indicated. (Source: AAJV 2018)

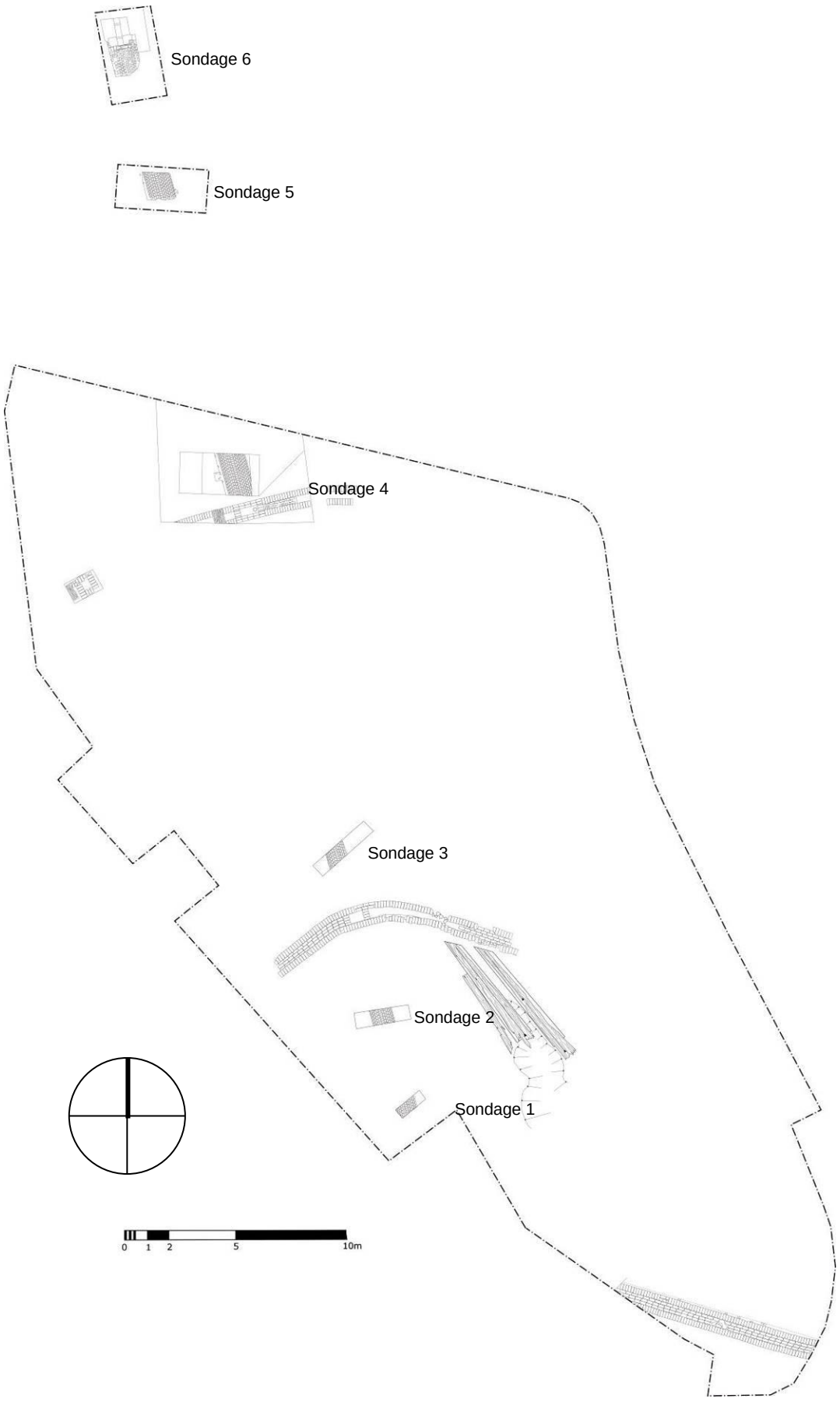


Figure 41 - Plan of the exposures of the drain in Thompson Square – preliminary drawing. (Source: AAJV 2018)

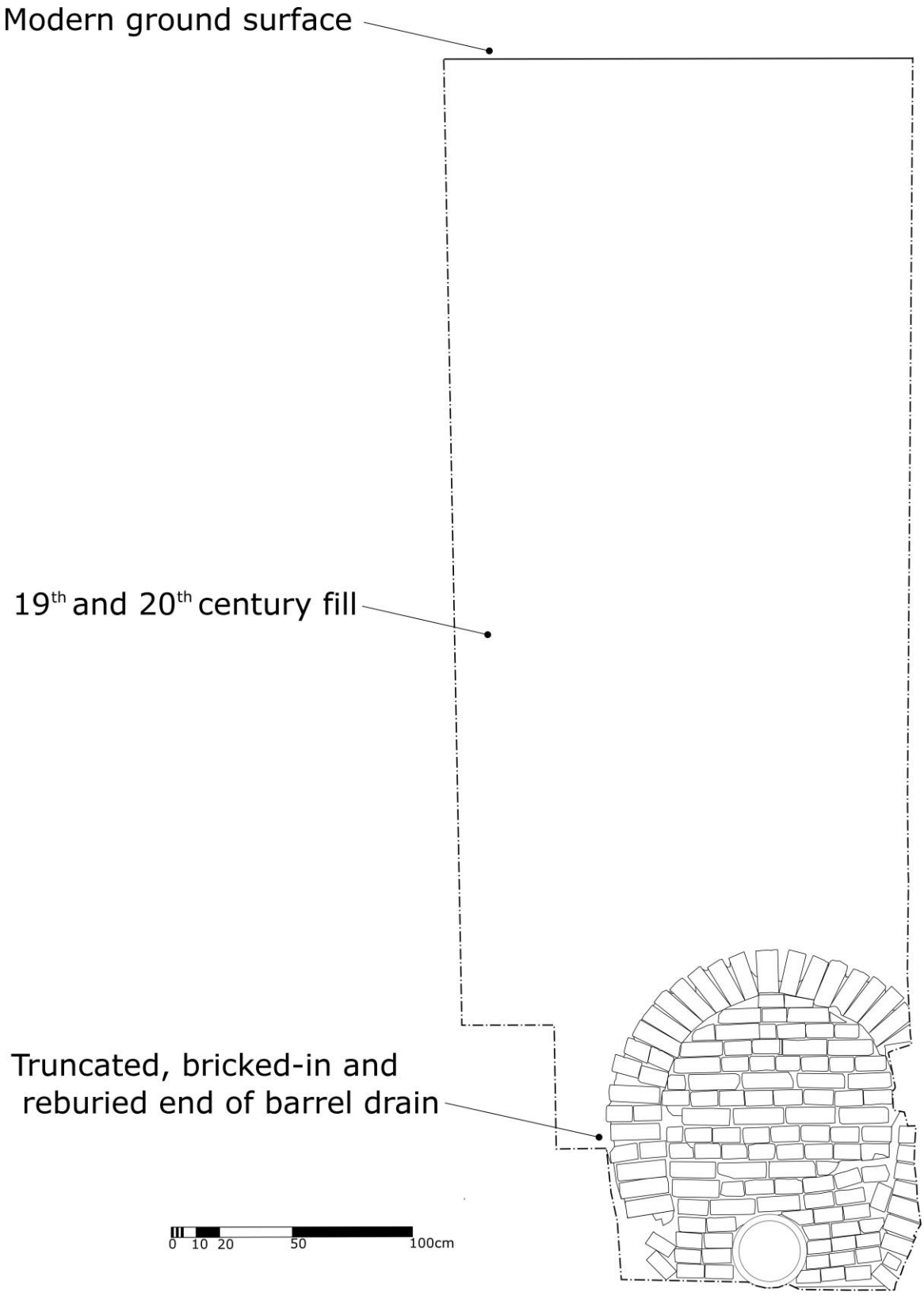


Figure 42 - Elevation of the drain headwall in sondage 6 – looking south. For location see Figure 41 (Source: AAJV 2018)

Figure 43 - Bed of sandstock Brick 1 from drain arch with cratered surface, probably from the expansion of water vapour during firing. Note the possible scribe line (indicated). (Source: AAJV 2018)

Figure 44 - Bed of sandstock Brick 1 from drain arch showing strike side. Note the uneven trimming of the brick with each point on the side indicated. (Source: AAJV 2018)

Figure 45 - Strike of sandstock Brick 2. (Source: AAJV 2018)

Figure 46 - Bed of sandstock Brick 2. (Source: AAJV, 2018)

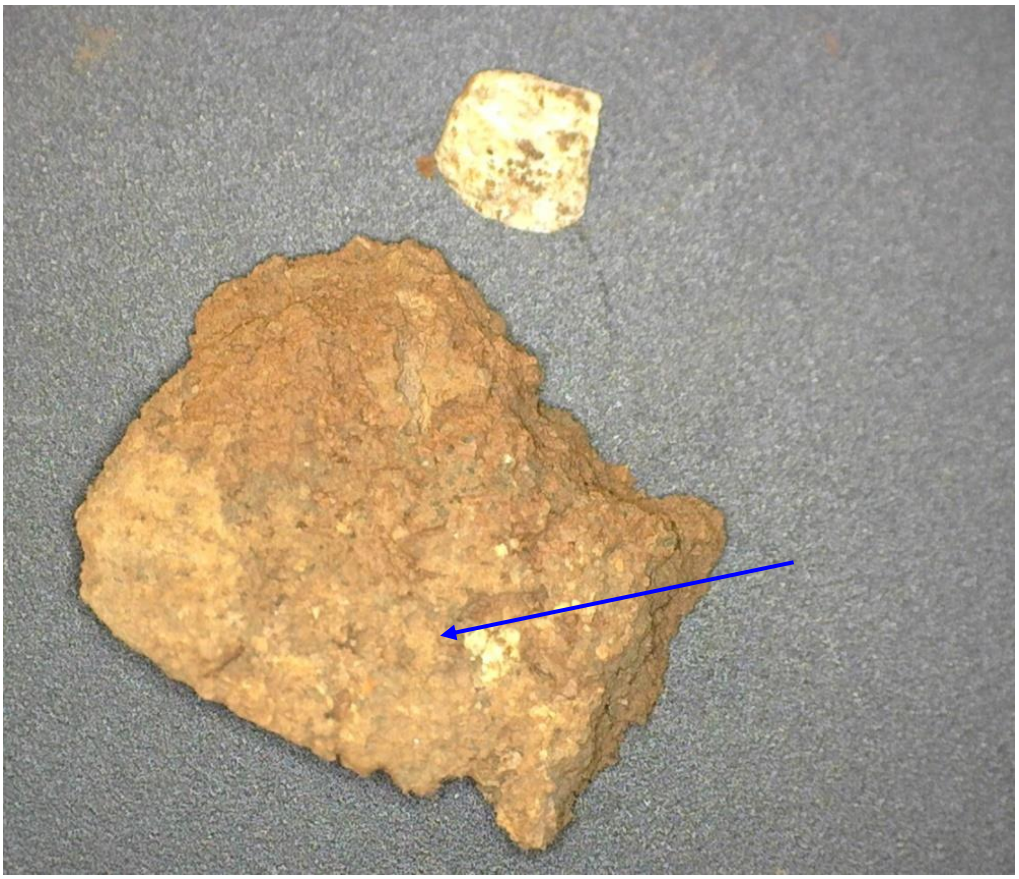


Figure 47 - Detail of Sample 1 mud mortar showing inclusion of calcined shell and larger calcined shell fragment. (Source: AAJV 2018)

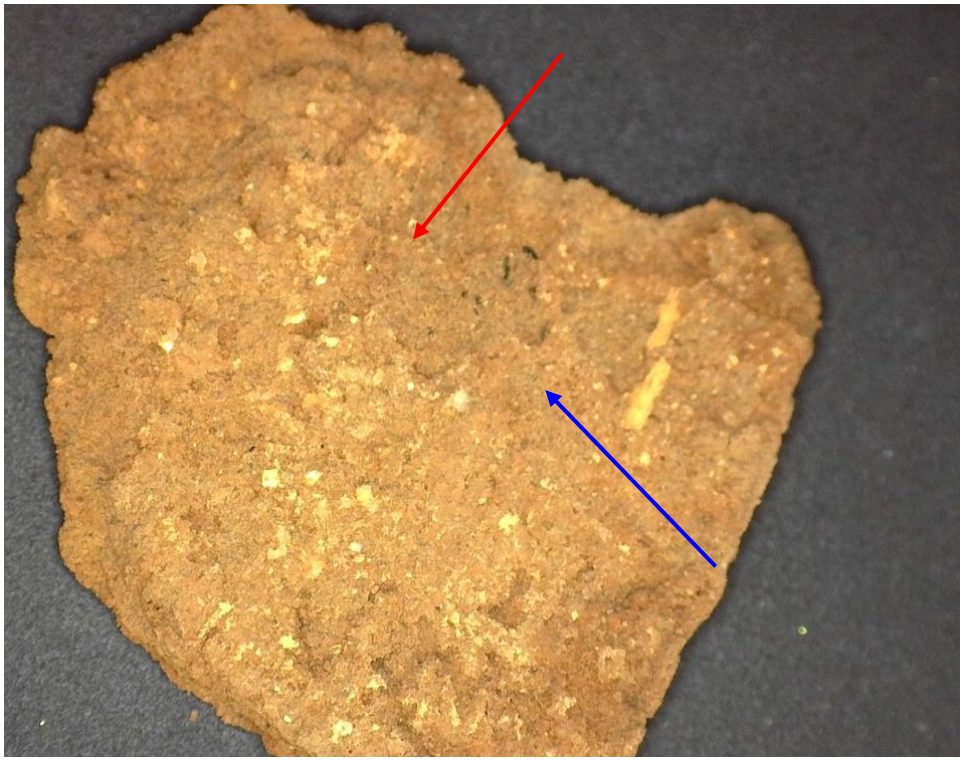


Figure 48 - Detail of Sample 1 mud mortar showing small charcoal fragments (red) and organic matter -sawdust/chaff (blue) inclusions. (Source: AAJV 2018)

Figure 49 - Sample 2 of Patent cement. C.f with mortar. Note the larger consistent sand grain size (Source: AAJV 2018)

Figure 50 - A section of one of the box culverts with evidence of former timber coverings. (AAJV March 2018)

5 STATEMENT OF SIGNIFICANCE

5.1 Statement of Significance

The following statement of significance applies to all structures associated with the drainage works constructed within Thompson Square between c.1814 and c.1820. The elements considered by this statement of significance includes the main brick drain, the associated brick feeder lines (box drains) and the brick shafts that connected the feeder lines to the main drain.

The drainage system is located within the SHR listed Thompson Square Conservation Area (SHR Item 00126). The site is listed for its townscape values with the statement of significance as follows:

> *Thompson Square is one of the oldest public squares in Australia and notable for the large number of Colonial Georgian buildings which surround it. It is the only public space remaining from the original town and has played an important part in the history of the town. It is the only remaining civic space as laid out by Governor Macquarie and is a vital precinct in the preservation of the early Colonial character of Windsor. The Square reflects Macquarie's visionary schemes for town planning excellence in the infant colony (Sheedy 1975).*

The listing does make reference to Macquarie's planning scheme but does not refer to the drain as a contributory element. Since the townscape values were in part determined by Macquarie's initial vision the drain was an essential part of an integrated development that saw the creation of the square through the modification of ground levels, the provision of a wharf, better access to the river from George Street and the provision of a sewer/drainage line that would serve buildings that may have been constructed around the Square at some future date.

In regard to the significance of the drain and the associated system of contemporary feeder lines, in terms of its place in the history of sanitary engineering in Australia, this set of structures has importance as one of the earliest examples of the integration of underground services in the planning of a precinct. Its place in the evolution of drainage systems is less clear. The general concept, demonstrated for the first time at Windsor, would be adopted as standard during the second half of the nineteenth century. The Thompson Square drainage system however, suffered from the use of materials and a geometry that was unsuited to the function for which it was intended. The construction program also resulted in a number of flaws that included the collapse of feeder lines and later collapse of at least one section of the main drain itself. The drain was ahead of its time in concept but was not repeated in the systems installed in the following years in Sydney, Parramatta and elsewhere in the Colony. The simple barrel drain became the norm in the first half of the nineteenth century until patent cements were more widely available in New South Wales. In this respect the drain is unique, and its importance lies in its failure. The drain has direct associations with Governor Macquarie as a town planner and with local men John Howe and James Magrath as constructors. The drain was also the source of a number of local myths dating from the early twentieth century - and still current - regarding the use of the drain as a 'smuggler's tunnel'. The myth is by no means unique and variations can be found in many nineteenth century ports around the world. The myth however, is firmly rooted in the local psyche. The drain should be regarded as a State significant item.

Historic themes

Australian theme (abbrev)	New South Wales theme	Local theme
4. Settlement-Building settlements, towns and cities	Towns, suburbs and villages-Activities associated with creating, planning and managing urban functions, landscapes and lifestyles in towns, suburbs and villages	Developing civic infrastructure and amenity
7. Governing-Governing	Government and Administration-Activities associated with the governance of local areas, regions, the State and the nation, and the administration of public programs - includes both principled and corrupt activities.	Developing roles for government - providing community facilities-
9. Phases of Life-Marking the phases of life	Persons-Activities of, and associations with, identifiable individuals, families and communal groups	Associations with Governor Lachlan Macquarie, 1810-1821
9. Phases of Life-Marking the phases of life	Persons-Activities of, and associations with, identifiable individuals, families and communal groups	Associations with Hawkesbury residents John Howe and James Magrath

5.2 Assessment of Significance

SHR Criteria a) [Historical significance]	The Thompson Square drain is one of the oldest surviving examples of Colonial sewer and drainage infrastructure for public use. It was a key element in the early 19th century design of Thompson Square. State significance
SHR Criteria b) [Associative significance]	The drain has direct associations with Governor Lachlan Macquarie and his vision for Windsor. The drain is also directly associated with prominent local men John Howe and James Magrath who were responsible for construction. State significance

SHR Criteria d) [Social significance]	The Thompson Square drain was the source of local myths regarding the 'Smuggler's Tunnel' and has become the focus of community action within recent years. Local significance
SHR Criteria e) [Research potential]	The drain and its feeder system are of some research potential, particularly in regard to the system's relationship with buildings subsequently constructed around Thompson Square. Local significance
SHR Criteria f) [Rarity]	The Thompson Square drain is a unique design due primarily to its failure resulting from flaws in construction and the use of unsuitable building materials. Local significance
Integrity/Intactness:	The Thompson Square drain is likely to be partially intact for much of its course, from the modified north end to the south-eastern side of Bridge Road. It has been truncated at the south by the 1937 alignment of Bridge Road. It is not known if any sections of the drain survive further to the south. Remnants of earlier outlet structures may survive behind the gabion wall at the river's edge.

6 OPTIONS FOR THE DRAIN

This section reviews the options for conserving the barrel drain in light of the existing approved bridge design, as well as an alternate design.

Approved Bridge Footing Design

The existing bridge design includes the construction of a new concrete abutment structure along the eastern side of the project area.

A comparison of the approved design with the alignment of the brick barrel drain indicates that the existing design would require the removal of most, if not all, of the brickwork up to nearly the south-eastern edge of Bridge Street, as the footing alignment for the approved abutment design is essentially directly aligned with the barrel drain (by coincidence).

Construction of this design would require the excavation of a row of bored concrete piles, with a concrete capping beam on top. This design would require either the removal of the barrel drain prior to the piling work, or piling through the existing barrel drain.

In the first circumstance, the archaeological excavation of virtually the entire length of the barrel drain would be required to allow it to be recorded through measured drawing and photography prior to construction. There would be opportunity to recover some or all of the brickwork, though for reasons of practicality it is likely only a small “slice” of the drain could be retained and removed intact. The remaining brickwork could be salvaged and stored for some future use and interpretation, however the fragile nature of the bricks, related to their initial low firing temperature, means that certainly some of the bricks would be damaged during disassembly and transport, and any retained bricks would not be suitable for use other than in a controlled museum environment. The bricks could not, for example, be used as brick paving, as they would quickly degrade.

If the drain were not fully excavated and removed prior to piling, careful placement of the piles may result in some small sections of the drain remaining undisturbed and in situ, but in general the drain would be cut multiple times by the piling process, which would cause a range of damage to the structure which could not be easily controlled or rectified. The surface brick box culverts would also be damaged during this process, and likely destroyed unless salvaged, due to the nature of the construction processes.

The complete excavation of the drain would create a range of conservation and storage issues and, it should be noted, would require a secure, climate-controlled facility to house the material in the longer term. It would also facilitate long-term condition monitoring. Based on materials conservation advice, any section of the drain left exposed for a significant period of time would quickly degrade due to environmental and physical factors.

Proposed Amended Bridge Footing Design

Following the discovery of the barrel drain, RMS instructed the bridge designers, Jacobs, to investigate alternate footing designs for the southern bridge abutment, which would allow for the retention of as much of the barrel drain as possible.

Several iterations of a new footing option were explored, and materials conservation advice was sought from specialist conservators International Conservation Services. The core concept for the new footing design was to place a row of bored concrete piles on either side of the barrel drain, with the concrete capping beam spanning the distance between the piles, thus providing an abutment footing platform which bridged over the barrel drain and would conceal the drain but conserve it in

situ, and largely intact. This proposal would still require sections of the surface box culverts to be removed.

Under this proposal, the piles will be located a minimum of 1500mm off each side of the barrel drain. Where the proposed capping beam is less than 500mm, the void above the drain will be filled with a piece of custom formed Styrofoam, which will bridge the drain and serve as sacrificial formwork for the concrete of the capping beam while it is being poured. In other areas where the distance between the top of the drain and the formwork is greater than 500mm, the space will be backfilled with clean fill. Approximately 10m of the southern end of the barrel drain will also remain under the open space within the reconnected sections of Thompson Square, following the completion of the bridge construction.

The use of Styrofoam for this purpose has been reviewed by conservators, who have indicated that the material is inert and will have no conservation impact on the drain.

This option will retain the vast majority of the drainage system intact, however it will be enclosed beneath the new bridge abutment. The engineering requirements and site geometry do not leave scope for sections of the drain to be left exposed, which would have a range of conservation and management issues in any event.

This proposal will require the majority of the surface brick box culverts to be removed, where the line of piling intersects with the surface drains or the drains are affected by utilities. Due to the shallow nature of the surface drains, they are also at a risk of construction damage. The box drains have been thoroughly recorded through measured drawing and photography during the archaeological investigations, and an option should be considered to disassemble and carefully salvage a section of culvert for potential interpretation. This would be placed in secure storage for assessment as an interpretive device. Other intact bricks from the culverts within the zone of construction impact will also be salvaged for interpretive use.

Recommendation

On the basis that the proposed alternate bridge abutment footing design is feasible from an engineering perspective, and will allow for the greater retention of historic fabric in situ, it is recommended that the alternate abutment footing design be adopted. The detailed impacts of that design are discussed below.

7 REVIEW OF IMPACTS OF PROPOSED REVISED ABUTMENT DESIGN

The revised abutment footing design consists of a series of bored piles placed approximately 1500mm either side of the drain, that are then capped with a poured concrete capping beam. The piles are proposed to be poured to minimise vibration. As the areas for the piles have already been archaeologically investigated they do not require archaeological monitoring.

Where more than 500mm of space exists between the top of the drain and the underside of the proposed capping beam, the drain will be separated from the capping beam in the following manner:

- Where the top of the drain remains unexcavated – by the remaining (existing} soil
- Where the top of the drain has been exposed – by covering with a layer of geotextile and clean sand fill

Where 500mm or less space remains between the underside of the proposed capping beam and the top of the barrel drain, custom cut Styrofoam packers will be placed atop the drain, separated by a layer of geotextile.

These various covering materials will separate the wet concrete from the historic material and the soil, clean sand or Styrofoam packers will spread the load of the wet concrete above the drain, to manage any compression issues.

Once the capping beam has been poured and cured, the drain will be fully enclosed and protected beneath the new structure. The new abutment can be constructed above the capping beam with no further impact upon the historic drain.

It is anticipated that all of the existing barrel drain fabric will be able to be retained, however the surface box culverts will be cut by the new abutment footings, and it may be necessary to lower the height of the sumps by several courses in order to accommodate the new capping beam. These areas will be recorded prior to removal, and intact bricks will be removed and retained for interpretation, if requested by stakeholders.

See Appendix C for a full set of plans.

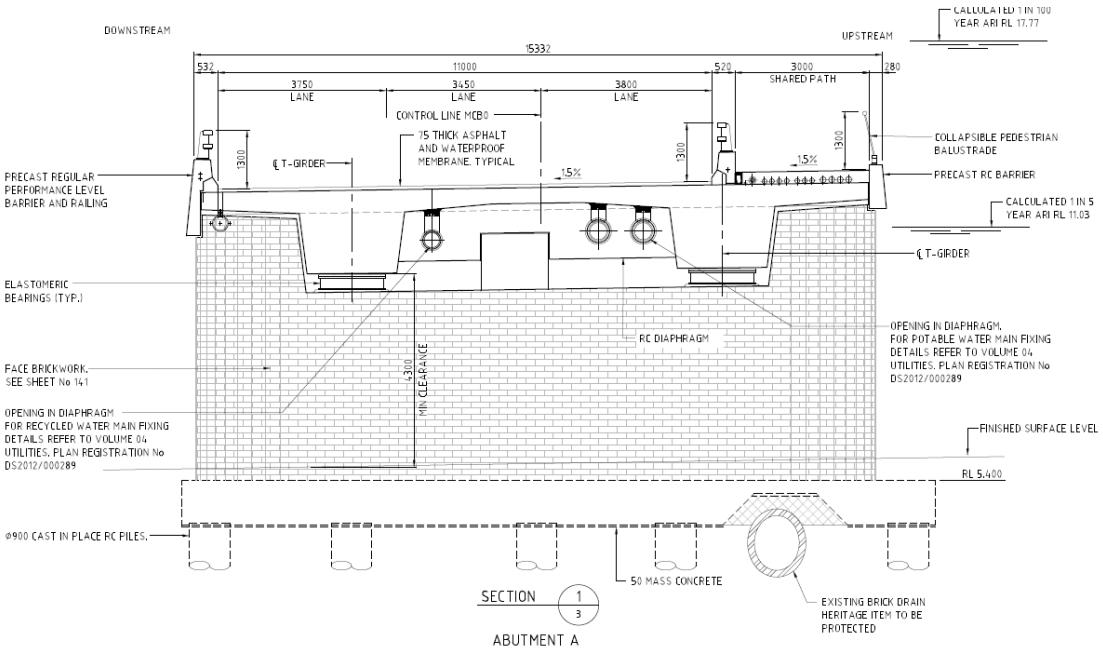


Figure 51 - Typical cross section of abutment and drain (Jacobs)

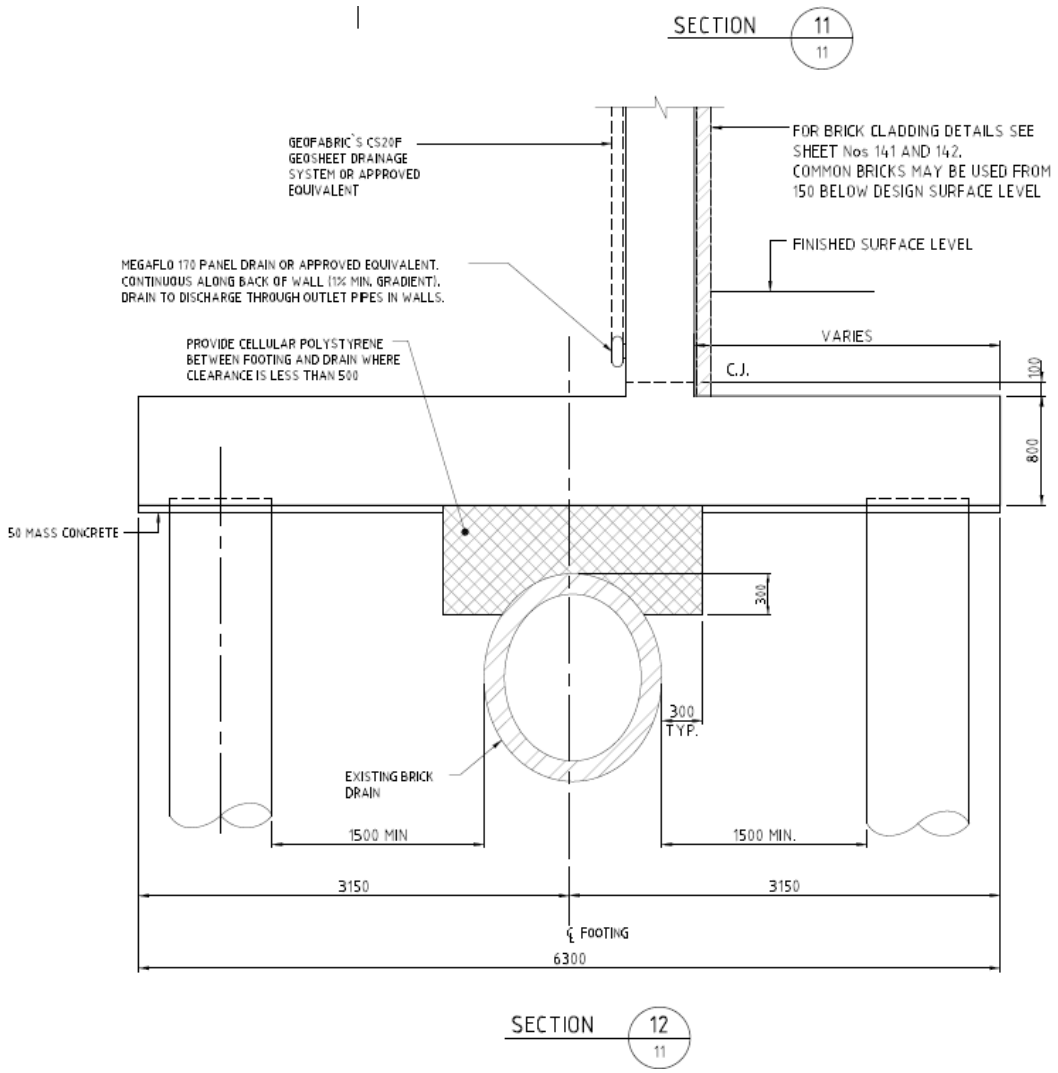


Figure 52 - Detailed cross section (Jacobs)

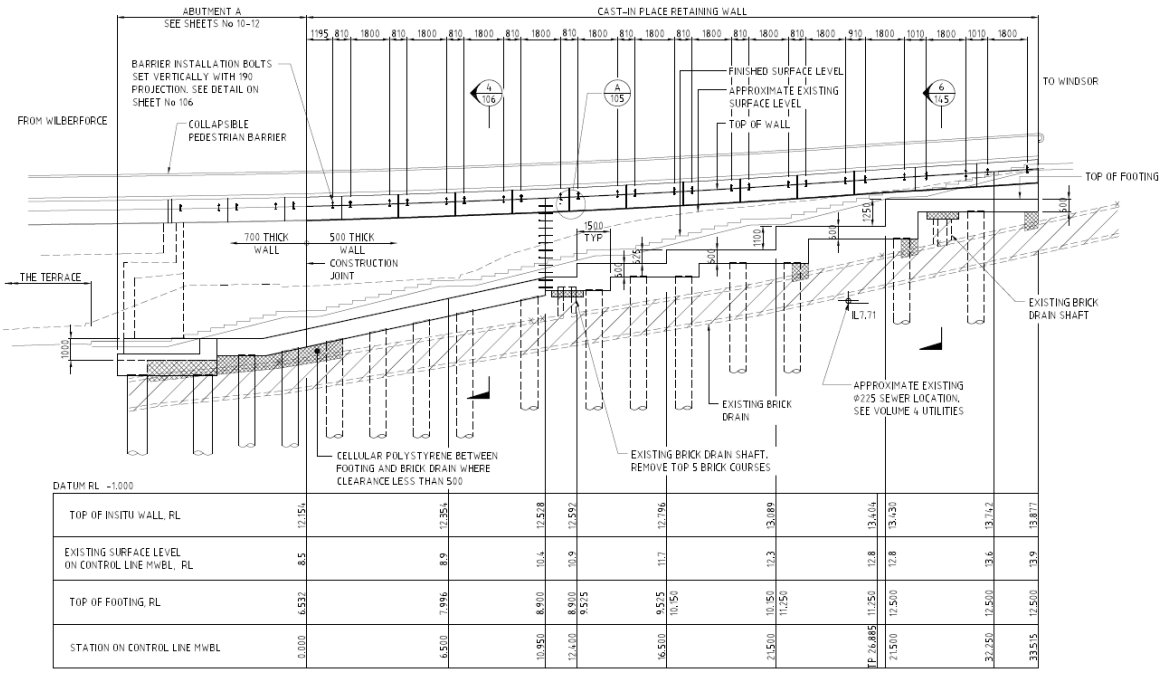


Figure 53 - elevation showing drain and new abutment. The hatched areas are where the foam packers will be placed. In other areas, the existing soil will be left in situ. (Source: Jacobs)

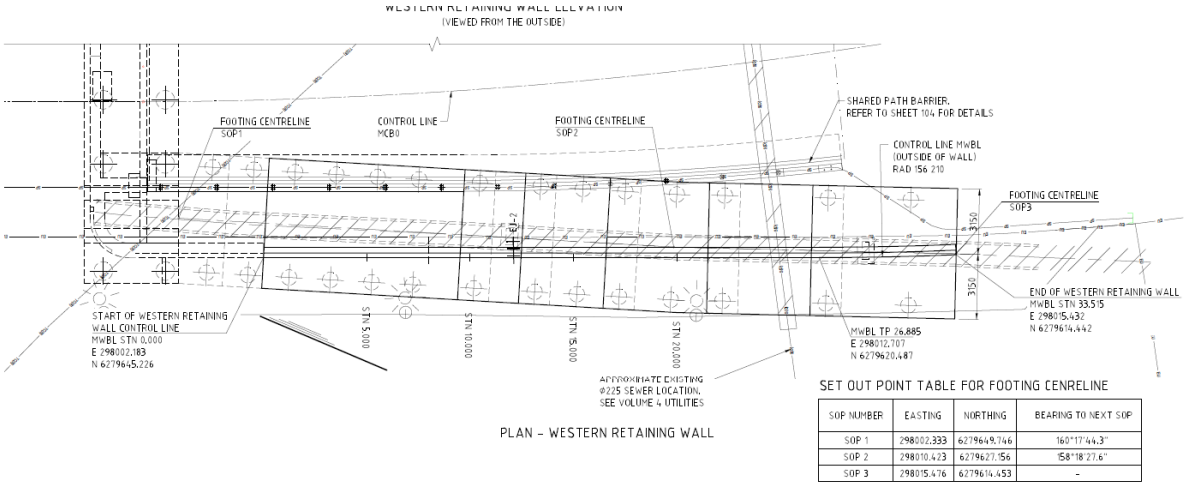


Figure 54 - Plan showing relationship of the piles to the drain. (Source: Jacobs)

8 DISCUSSION OF OPTIONS AND ALTERNATIVES

Within the scope of the approved bridge replacement project, there are essentially only two alternatives – the "do nothing" option, which involves implementing the approved bridge design, and the alternate abutment footing design, which will enclose the drain within the new footing design. The drain, as a drain, was never designed to be exposed. An option for open-air display of a section was considered unfeasible because of the friable nature of the materials used in the construction of the drain as well as the drain's inherent design flaws. Similarly, complete or comprehensive salvage with a view to reconstruction would require the addition of new materials in order to maintain the structural integrity of the drain. This would be a poor interpretive outcome.

Option 1 – Record and Remove

If the "do nothing" option is selected, the drain will be largely destroyed by the approved bridge abutment design. Small sections of the drain may survive the piling and construction of the capping beam, but this is not guaranteed, and the remains would be fragmented and inaccessible.

Under this option, a greater level of archaeological salvage should be undertaken, including complete excavation of the drain, drawing in plan and section, exposure of the full depth of the drain to allow recording in elevation and in cross-section, and archaeological monitoring during demolition. It may also be prudent to retain a larger quantity of bricks for future use and interpretation, and consideration should also be given to removing an intact cross-section of the drain for potential display off site.

This option would have a substantial heritage impact on the drain structure and would leave little intact and in situ remains following the completion of the bridge abutment works. Any unexcavated sections outside of the bridge construction zone would be preserved in situ, however any surviving elements within the bridge construction zone could not be left exposed, as they would quickly deteriorate from environmental and physical factors.

Option 2 – Proposed Concrete Footing Enclosure

Option 2 involves implementing the proposed revised bridge abutment footing design. This involves placing a series of bored concrete piles approximately 1500mm off either side of the drain, which will then support a concrete capping beam, which will in turn serve as the new foundation for the bridge abutment. This will transfer the load of the abutment around the barrel drain, allowing it to be retained largely in situ, although it will be inaccessible.

This option will have a minimal direct impact on the barrel drain, as a separation layer of either geofabric and Styrofoam or geofabric and clean sand fill will be placed between the surface of the brick drain and the underside of the capping beam.

The vibration impacts associated with the boring of the pile holes have been reviewed and acceptable limits have been determined by an engineer, which will not affect the drain (see Appendix F).

The compression impacts of the wet concrete during the concrete pour have also been evaluated by an engineer and the compression from the wet concrete will be less than the compression which had previously existed during the period the drain was buried under 2+ metres of soil.

The materials conservation issues have also been reviewed by a conservator and their advice has been incorporated into the revised design. The conservation measures proposed, both in the short-term and long-term include management to prevent desiccation during any exposure, filling of the drain to prevent salt crystallisation and erosion and the use of geotextile separation fabric and clean sand fill prior to reburial.

The design of Option 2 will allow the existing portion of the drain within the project area to be retained in its current form. Much of the drain will be able to remain unexcavated and thus protected within the existing ground conditions. The surface culverts will be partially demolished by the line of the new pile construction however this impact is similar to the impact of Option 1 and is unavoidable given the site constraints. All elements to be removed will be recorded, and it is proposed to carefully salvage a section of a box culvert by a conservator for future reconstruction and interpretation, while intact bricks will be salvaged for interpretation.

It should be noted that the Office of Environment and Heritage has indicated in its advice of 19 April 2018 that it does not support the relocation of a section of the box culvert. The decision to relocate a section of the culvert will therefore be driven by the desires of local stakeholders, including Hawkesbury City Council and the Windsor Museum. From an archaeological perspective, only a small number of bricks need to be retained as a sample of the drainage system (10-20 in total); the drains have already been recorded in sufficient detail in the archaeological salvage excavations. In the event no parties indicate a desire and willingness to receive either a section of the box culvert or any removed bricks, these items will be discarded.

Further details of the box culverts that are impacted by the works are shown in design plan and long sections included in Appendix G.

Three sections of box drain were uncovered within Area 1. The box drain section at the top (southern) portion of the slope is labelled as Box Drain No 1. The section at the lower (northern) portion of the slope is labelled Box Drain No 3. The impacts on each section is as follows:

Box Drain No 1

The surveyed section of the box drain would be damaged by the road pavement construction and needs to be salvaged. The levels of the road could not be raised as it would prevent driveway access to the adjoining property. Further archaeological investigations will be undertaken in Area 2 prior to construction commencing in that area. If further sections of drain are uncovered, these will be archivally recorded. Salvage is also expected to be required due to new underground utilities (electricity and communications) that are to be laid to service the properties, and to be laid at a minimum depth due to safety and operation reasons.

Box Drain No 2

The surveyed section of the box drain would be damaged by the construction of the pile cap for the western retaining wall and therefore needs to be salvaged. The pile cap is designed to bridge over and protect the main brick drain. The level of the pile cap is unable to be raised as it would raise the level of the adjoining stairs making the stairs and the grassed area of Thompson Square too steep for pedestrian access and maintenance. Prior to construction further investigations will be extended to the west of Area 1 for archival recording. Salvage of this section would be required to provide access and a level platform for the piling rig required to construct the protection system for the main brick drain. Within Area 2, subject to finding further sections and the level of the box drain, there may be an opportunity to retain a significant section of the drain. The design, therefore, requires as part of the investigations to survey any new section of drain uncovered to determine if it could be retained.

Box Drain No 3

The surveyed section of the box drain would need to be salvaged for the same reasons as Box Drain No 2. If further sections of the box drain are uncovered in Area 2, it will also need to be salvaged due to the construction of the eastern retaining wall at this location. Investigations undertaken to date assessed that the box drain ends approximately 7 metres west of the main brick drain. However, if further sections of drain are encountered these would be archivally recorded and salvaged to allow for the piling rig to construct the protection system for the main brick drain.

The archaeological investigations also found two brick shafts that connect the box drain branches to the main brick drain. These are referred to as sumps in the Appendix G plans and sections. For the southern shaft this was found at sufficient depth that it can be overlaid and protected in the same manner as the main drain. For the northern shaft the greater part of the structure can be retained except for the top 5 courses of brickwork that will need to salvaged.

All of the bricks recovered from the box drains and shafts will be stored and preserved while consultation on options for interpretation are discussed with stakeholders as detailed further in Section 11.

The Aboriginal archaeological salvage program excavated and recovered all *in situ* cultural materials identified within the impact corridor. This consisted of the excavation of ~50m^2 of a sand deposit, within which ~1,500 Aboriginal objects were recovered. Based on the test excavations, these artefacts are all considered to date to >17,000 years ago, with the upper (younger) portion of the site likely lost through more recent post-European activities. In addition, all historical units within the drain cut, which itself consisted of the re-deposited sand unit, was sieved and all Aboriginal objects recovered. This assemblage consisted of 15,000 items, and based on typology, consisted of a mixture of Pleistocene (>10,000 years) and Holocene (<10,000 years) assemblages. Overall, densities of Aboriginal objects varied between ~30/m^2 in the controlled excavations and up to ~300/m^2 in the drain cut. Although it must be highlighted that controlled excavations only retained ~1m of a truncated soil profile, whereas the drain cut was some 2-3m deep, and contained perhaps three times this volume, albeit heavily mixed. By cubic metres, artefact densities are ~30/m^3 in the controlled excavations compared with ~100/m^3 in the drain cut.

The archaeological program excavated much of the drain and associated cut to the under-lying pre-Aboriginal natural soil units, composed of a coarse sand to the east, and Londonderry Clay to the west (the drain being constructed at least partially on the interface of the two). This includes the south and central areas of Area 1, between the entrance to Old Bridge Street and extending just north of the east-west sewer main crossing. It also includes a large sondage undertaken immediately south of the carpark at the northern fringe of Area 1. Option 2 in these areas would have no additional impact on Aboriginal heritage, since it has all been either:

i) previously destroyed by the installation of the drain and/or later historical activities; or
ii) has been recovered either through controlled excavation and/or from bulk sieving of the historical units in these areas.

However, between the two areas there is a portion of historical deposits – incorporating primarily the barrel drain cut and associated redeposited sand unit – that would be affected by Option 2, and that would contain Aboriginal objects.

In these areas, Option 2 would result in an increase impact to Aboriginal heritage. Specifically, based on the values above, the deposit contains artefact densities of ~300/m^2 and likely total ~2,500-5,000 artefacts depending on how the area is defined. It must be highlighted, however, that any Aboriginal objects within these deposits will be heavily mixed and have limited research potential (noting an assemblage of 15,000 is already subject to analysis), and as such can be considered of relatively low scientific significance.

Conclusion

Neither option allows for original drain fabric to remain exposed in situ. Given the fragility of the remains and their location within a public park, keeping a section of the drain exposed for interpretation is a poor conservation option.

Even with Option 2, the finished ground levels are such that it is not possible to place a “viewing window” into a chamber containing a section of the drain. This may also create engineering issues requiring additional structural works which have not been investigated. Again, any such viewing chamber would have a number of difficult conservation issues.

Off-site interpretation, or representative interpretation within Thompson Square are the better options to maximise the conservation of the historic fabric.

On the basis of the above analysis, Option 2 will allow for a greater retention of historic fabric in situ and thus is the preferred option.

9 DISCUSSION OF MITIGATION MEASURES – OPTION 2

The implementation of Option 2 will require a range of careful mitigation measures to ensure the historic drain fabric is maintained and conserved during the construction of Option 2. To this end, the following mitigation measures are recommended:

- Advice from Jacobs regarding vibration levels is implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from Jacobs regarding the compression impacts is implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from International Conservation Services regarding separation between the drain fabric and infill materials is implemented within the Construction Environmental Management Plan and monitored accordingly;
- Undertaking a trial of the piling method to monitor vibration impacts;
- The DPE-approved Heritage Manager will verify and approve the position of the proposed footing pile locations prior to piling commencing;
- No machinery is to operate on top of the drain at any time, unless the potential compression impacts have been reviewed by an engineer and any necessary mitigation measures implemented;
- Detained consideration for the interpretation of the drain be identified within the final Interpretation Plan for the project;
- Interpretation of the drainage system as a whole including the feeder lines.

9.1 Trial of Piling Methodology

RMS proposes to trial the piling methodology to assess the level of vibration impacts. The purpose of the proposed piling trial is to refine the piling procedure to ensure the brick barrel drain is not damaged. During the trial the vibrations will be monitored and the piling procedure will be adjusted to reduce vibrations should there be a possibility of harm to the brick barrel drain.

The piling trial will include installing a pile remote from the barrel drain, monitor vibrations and adjust the piling methodology to minimise vibrations. Following this a pile will be excavated, in accordance with the piling methodology, adjacent to an exposed section of the brick barrel drain roof. The vibrations and the barrel drain will be monitored and piling methodology adjusted if required. The trial will be monitored by an archaeologist.

In the event no acceptable options are found which would allow a section of the drain to be retained in situ, options for additional archaeological excavation and salvage in part or whole would be investigated. It should be noted however that with the exception of the southern end of the barrel drain, which extends beyond the construction zone, the location, configuration and construction methodology of the drain has been thoroughly investigated and recorded. Exposure of the full extent of the drain would allow for it to be recorded prior to removal, but would reveal little in the way of additional archaeological information about the site.

10 COMPARATIVE INTERPRETATIONS

A number of nineteenth century drains have been the subject of interpretation both as in situ items and as displaced sections. A section of the 1822-27 Parramatta brick barrel-drain for example, was retained in situ and incorporated into the fabric of a new structure (Figure 55). A brief interpretive plaque was also installed as part of the display.

A complete section of the Tank Stream Stormwater Channel was displaced and reset as part of works undertaken at the Sydney GPO (Figure 56).[20] This section of drain dates to the 1870s and is interpreted within the GPO complex and linked to other interpretive devices such as a walking map along the route of the former drain. Sydney Water continues to provide access to the sandstone section of the Tank Stream for guided public tours several times per year.

Wheat Creek (Big Creek) Culvert was a heritage-listed item at Adelaide Street, Brisbane constructed in 1861 (Figure 58). The culvert was removed in June 2015 in order to construct the Inner Northern Busway. A short section was removed and reconstructed as a feature in the King George Square busway station. The section of culvert is essentially a barrel drain constructed using stone rather than brick. Interpretation consists of the reconstructed section in association with information panels.

Sections of smaller barrel drains relating to First Government House are conserved and displayed within the Museum of Sydney on Bridge St, Sydney (Figure 61-62).

Sections of drain nineteenth-century drains are also exposed within the Glasshouse complex, Clarence and Hay Streets, Port Macquarie (Figures 63-64).[21]

The Office of Environment and Heritage have advised[22] that sections of drains recovered from the Conservatorium of Music in the late 1990s have been reburied within the grounds of State Records at Kingswood, however these are not interpreted or visible to the public.

These sections of drain are mainly interpreted ex situ and/or within an indoor, managed context. All of these ex situ examples are constructed using brick or stone of a relatively good quality bonded with a high-quality cement that has allowed the integrity of a section of drain to be retained without the need for deconstruction and reconstruction. Placing of open-air viewing chambers, except in a museum context, has rarely been successful. The examples below highlight some of the issues with the approach of exposing archaeological remains below viewing panels. See Figures 60-62 below.

[20] A further section is held in storage by the Museum of Applied Arts and Sciences, Sydney

[21] Higginbotham & Associates (2009) Report On The Archaeological Excavation of the Todd Holden Site, 18-20 Clarence Street, Port Macquarie, N.S.W. Higginbotham reports this drain to be approximately 1000mm in diameter, and still in service.

[22] OEH letter to RMS dated 19 April 2018

Figure 55 - In situ exposed section of the 1822-27 brick barrel drain, Parramatta, NSW

Figure 56 - Section of the displaced Tank Stream located within the GPO as one of the interpretation stations.

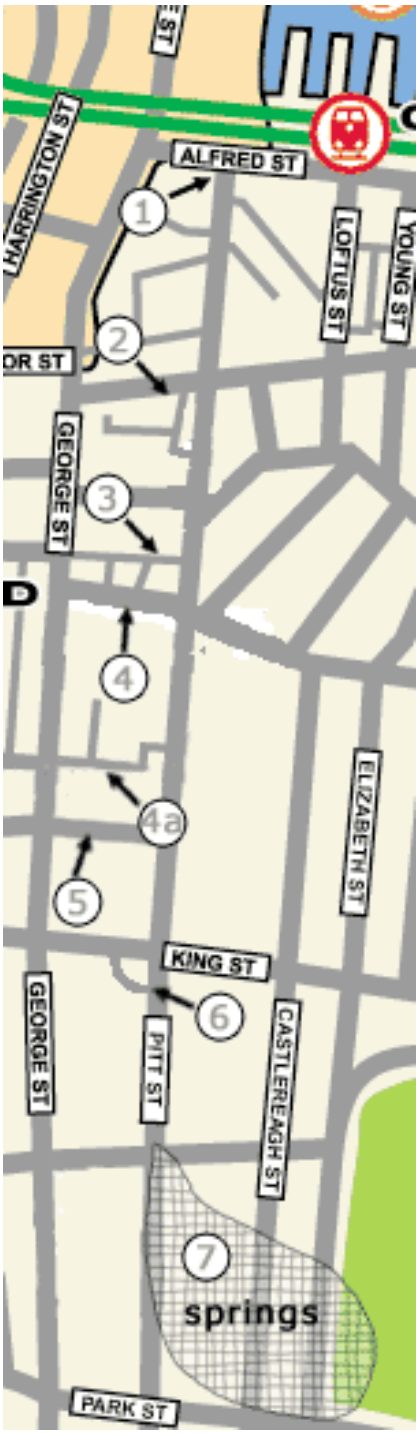


Figure 57 - Tank Stream Walking Map

Figure 58 - Wheat Creek Culvert, Brisbane

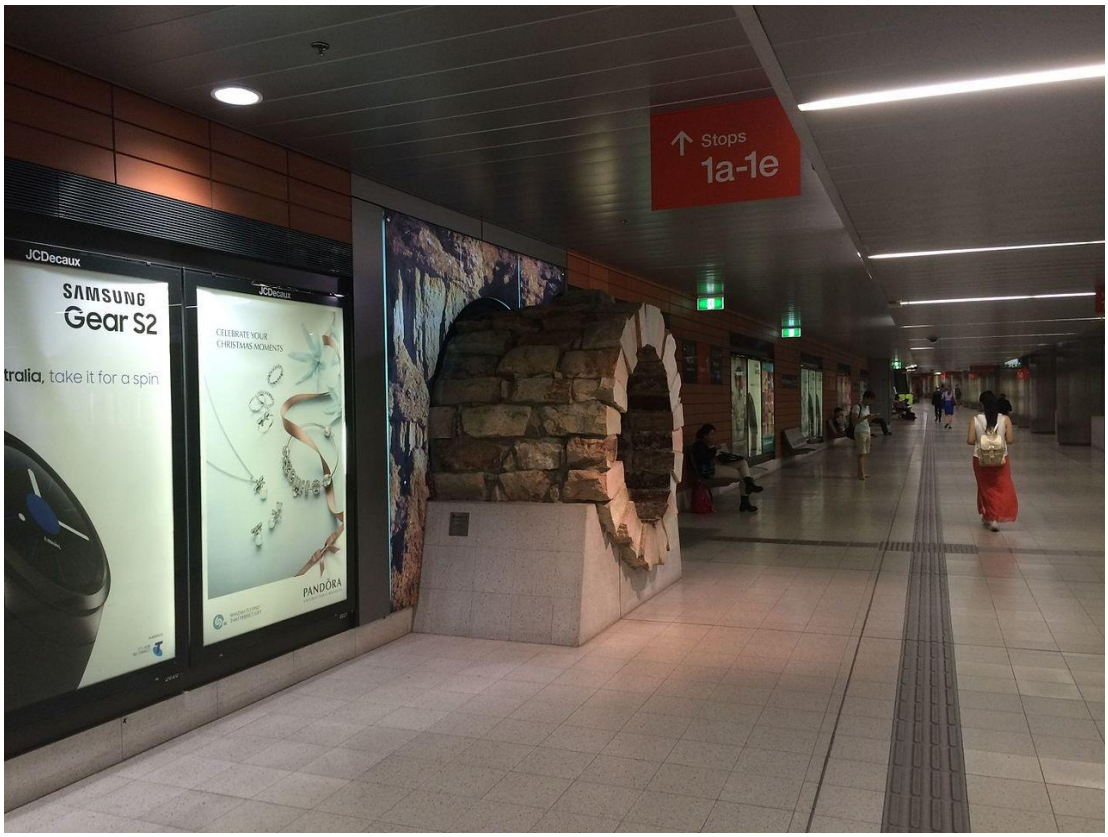


Figure 59 - Wheat Creek Culvert, Brisbane

Figure 60 - Glass panel installed above a well at the Newcastle Convict Lumberyard. The viewing window is in such poor condition from physical damage and condensation that the well beneath is no longer visible.

(http://historyservicesnswblog.blogspot.com.au/2012/11/convict-lumber-yard-at-newcastle.html)

Figure 61 - External viewing window for footings at Museum of Sydney. The small kiosk (circled in red) houses a small display of the footings of First Government House.This is however in a managed museum context.

(http://www.environment.nsw.gov.au/heritageapp/visit/ViewAttractionDetail.aspx?ID=5045710)

Figure 62 - Glass floor over drainage within the Museum of Sydney. Again this is within a managed, climate-controlled museum context.
(Source: https://www.tripadvisor.com/LocationPhotoDirectLink-g255060-d256854-i84397826-Museum_of_Sydney-Sydney_New_South_Wales.html#84397826)

Figure 63 - Barrel drain at the Glasshouse, Port Macquarie (courtesy ICS).
http://www.icssydney.com.au/index.php?id=347

Figure 64 - Interior view of the Glasshouse barrel drain (courtesy Higginbotham & Associates).
http://www.higginbotham.com.au/portmacquarie2.html

11 DISCUSSION OF INTERPRETATION OPTIONS

Interpretation of this structure, as with any type of site, should aim to explain the significant aspects of the site to an audience that may not necessarily be familiar with the site's broader historical context or the engineering details of this type of structure. This is often most successfully undertaken where the object survives in situ within the broader context of its surroundings. Drains and sewers, however, were designed to be buried with the enclosing earth and fill being essential in maintaining the structural integrity of the drain. This is particularly the case with the Thompson Square drain in which construction was achieved using friable, under-fired brick and a bonding medium composed of earth and vegetable matter with very little lime.

Exposure of any section of the drain in situ is likely to result in accelerated deterioration and is not recommended.

It should also be remembered that the drain itself tells only a very limited part of the story of early 19th century Windsor, and the story of its construction, use and ultimate replacement needs to be worked into an overall understanding of the development of Windsor over time.

One option, subject to stakeholder wishes, is to carefully record a section of box culvert for removal by conservators for conservation and secure storage. If the material is considered useful for interpretation it may be reinstated in an indoor context (e.g. Windsor Museum or a Council-nominated location). The Windsor Museum option may not be viable since there are in situ drains on display and any additional drain-related material may be a source of confusion. In the event no local stakeholder expresses a desire to take custodianship of a section of the box culvert, this option should be discarded.

Intact bricks and artefacts associated with the drain should also be retained for future interpretation works, although again this is likely to be off site interpretation due to the fragility of the items. A small sample (10-20) should be retained within the archaeological collection, however again if no stakeholder seeks custodianship of salvaged bricks they may either be reburied on site or discarded.

Detailed proposals for interpreting the drain, and the story of its construction and role within the early town of Windsor should be integrated into the final Interpretation Plan for the project area.

12 CONSULTATION

For the purposes of developing the approach to managing the barrel drain, the following entities were consulted with and/or notified about the potential in situ retention of the drain:

- Office of Environment and Heritage – via letter and in discussion with RMS between January and April 2018, including written comments dated 19 April 2018
- Department of Planning and Environment – via letter and in Project Control Group Meetings between January and April 2018, including written comments dated 20 and 24 April 2018
- Windsor Community – via a RMS Community Update flyer in March 2018
- Hawkesbury City Council – via a RMS Community Update flyer in March 2018
- Hawkesbury City Council Heritage Committee - via a site visit in February 2018
- Windsor Bridge Parliamentary Committee of Enquiry- via a site visit in March 2018
- A meeting between OEH, DPE and RMS was held in April 2018. The issues discussed included the approach to redesign, adequacy of technical advice from the material conservator, vibration specialist and structural engineer. The concerns raised by OEH have been addressed in this report

In addition, specialist advice was sought from:

- International Conservation Services – in relation to materials conservation issues
- Jacobs – in relation to engineering design, vibration and compression issues

The specialist advice from International Conservation Services and Jacobs is contained within the Appendices to this report.

13 RECOMMENDATIONS

In summary, the AAJV makes the following recommendations for the management of the barrel drain:

- Select Option 2 is the best option for conserving the maximum amount of historic drain fabric;
- Advice from Jacobs regarding vibration levels (Appendix D) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from Jacobs regarding the compression impacts (Appendix E) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- Advice from International Conservation Services regarding separation between the drain fabric and infill materials (Appendix F) should be implemented within the Construction Environmental Management Plan and monitored accordingly;
- The DPE-approved Heritage Manager will verify and approve the position of the proposed footing pile locations prior to piling commencing;
- A piling trial incorporating vibration monitoring should be undertaken in advance of construction, to determine the vibration impacts on the drain. In the event those impacts are unacceptable, the piling method should be reviewed for lower vibration methods;
- In the event an acceptable method of piling cannot be determined which would leave the drain substantially intact, further archaeological investigation and recording should be undertaken prior to construction;
- No machinery is to operate on top of the drain at any time, unless the potential compression impacts have been reviewed by an engineer and any necessary mitigation measures implemented;
- A section of box culvert could be carefully recorded by the archaeologists and removed by conservators for conservation and secure storage prior to future reinstatement in an indoor context (e.g. Windsor Museum or a Council-nominated location). This option should be discussed with key stakeholders prior to making a final decision to remove a section of culvert;
- Intact bricks and artefacts associated with the drain should be retained for future interpretation works, although this is likely to be off site interpretation due to the fragility of the items;
- In the event no party is interested in accepting a section of the box culvert, barrel drain or recovered bricks, a small sample of bricks (10-20) should be retained within the archaeological collection and the remainder may be reburied on site or discarded;
- Detailed proposals for interpreting the drain and its feeder lines, and the story of its construction and role within the early town of Windsor should be integrated into the final Interpretation Plan for the project area.

14 CONCLUSIONS

The brick drain at Thompson Square is an early example of a major program of civic works undertaken in New South Wales. This was an ambitious project that sought to provide Windsor with wharfage facilities as well as improving access from George Street to the Hawkesbury River. The brick drain was to operate as a sewer and stormwater line that may have served existing buildings along the eastern side of the square, and future buildings one the western side. The drain is however not shown on any known plan or map of the area and this is at this stage conjectural. Future archaeological work along the periphery of the area investigated to date may clarify this.

Like many of Macquarie's public works responsibility for the work was vested in private contractors who were given access to Government assets. In the case of the Thompson Square drain the contractors were local men – John Howe and James Magrath. Howe, a free settler, succeeded Andrew Thompson as the licensed auctioneer at Windsor by his successful management of the sales of Thompson's property, which earned the favour of Governor Lachlan Macquarie, Thompson's chief beneficiary. Howe would later rise to the position of Chief Constable and Coroner. James Magrath was a former convict who arrived from Ireland in 1802 and following release commenced farming in the Hawkesbury district. He would accumulate significant land-holdings in the district. In 1813, prior to the Thompson Square works Howe and Magrath had been contracted to complete and repair the road from Sydney to Windsor and to build a toll-bridge over South Creek at Windsor.

The drain built through Thompson Square was of a significant scale in both length and carrying capacity matched only by the drain constructed in Parramatta in 1814-1815 by Rowland Hassall. The ambitious nature of the project exceeded the capabilities of its builders and the quality of materials used in its construction. The design appears to have been based on the Lady Macquarie's Road culvert in the Royal Botanic Gardens, Sydney. The use of wood, rather than stone or brick, for covering the box culverts feeding into the barrel drain appears to have been an expedient which may have been related to cost, or a retrofit over a culvert which was originally left open. The use of mud mortar rather than lime may have been a product of price cutting or the unavailability of good quality lime.

The drain is a rare example of sewer/drainage works forming part of an early nineteenth century integrated civic construction program in New South Wales. The scale and form have not yet been recorded elsewhere, possibly indicating that smaller-scale brick barrel drains could be constructed more efficiently and at less cost to provide adequate servicing for settlements that still had small populations. Drains and sewers of the scale of the Thompson Square drain do not generally reappear as standard forms until the 1850s in Sydney by which time a large, concentrated population required sanitary services to improve living conditions and to curb disease. By the 1850s the geometry of drain construction was better understood and in most instances the design flaws that characterise the Thompson Square drain were avoided.

The drain has strong associations with Governor Lachlan Macquarie and his ambitions to transform the Colony through major public works that recognised the development of regional settlements as centres of population for both bond and free inhabitants. Although the intent may have been noble, the execution was less so. The drain also has direct associations with two notable Windsor inhabitants John Howe and James Magrath, both of whom played significant roles in the development of the Hawkesbury district.

The question of what was being drained and sewered remains unanswered. This may only become apparent once all of the available field data has been collated and analysed. Similarly, the extent of the main drain remains unclear. The head has not been located but it can be assumed that is located

north of George Street while the condition of the outlet cannot be examined due to the gabion wall that now forms the river foreshore.

15 REFERENCES

Aird, W V, *The Water Supply, Sewerage and Drainage of Sydney.* MWS&DB Printer: Sydney, 1961.

Annable, Rosemary*, Archaeological Excavations on the former Australian Gaslight Company Site, Haymarket, NSW,* A Report for Australian Construction Services (NSW Region) Department of Administrative Services, October 1989.

Arndell, R S, *Pioneers of Portland Head: builders of Ebenezer Church and School, early settlers of the Hawkesbury and Hunter rivers and squatters of the north-west New South Wales and southern Queensland, including family genealogies*, Epping, NSW, 1976.

Bickford, A, *The Archaeological Investigation of the First Government House Site, Phillip Street, Sydney. First Interim Report*, report to Premier's Department and Department of Environment and Planning, 1983.

Casey and Lowe Pty Ltd, *Archaeological Investigation Conservatorium Site Macquarie Street, Sydney* for NSW Department of Public Works and Services July 2002.

CRM, *Statement of Heritage Impact, Archaeological Site, Former Hawkesbury Hospital* for Hawkesbury City Council, December 2002.

Godden Mackay Pty Ltd, *Angel Place Project 1997,* for AMP Asset Management Australia Ltd, 1998.

Higginbotham, Edward, *The excavation of a brick barrel drain at Parramatta, NSW*, Report for The Heritage Council of NSW. 1981.

Higginbotham, Edward, "The excavation of a brick barrel drain at Parramatta, NSW", *Australian Journal of Historical Archaeology,* Vol. 1, 1983: 35-39.

Higginbotham, Edward, *Report on Historical and Archaeological Investigation of the Hawkesbury Museum, 7 Thompson Square, Windsor, NSW* for the Hawkesbury Shire Council Windsor, NSW, February 1986.

Higginbotham, Edward, *Historical and Archaeological Investigation of Thompson Square, Windsor, NSW* for the Hawkesbury Shire Council Windsor, NSW, July 1986.

Higginbotham, Edward, *Historical and Archaeological Assessment of the Brick Culvert, Lady Macquarie's Road, Royal Botanic Gardens, Sydney, NSW*, The Royal Botanic Gardens, Sydney, 1992.

Higginbotham, Edward and Associates, Report on the Archaeological Excavation of the Todd Holden Site, 18-20 Clarence Street, Port Macquarie, NSW Summary of main findings, July 2009

Mider, Dana*, The Former Grace Brothers Site at Broadway Archaeological Assessment*, Report prepared for Noel Bell Ridley Smith and Partners, February 1996.

NSW Department of Public Works and Services, *Redevelopment of the Sydney Conservatorium of Music and Conservatorium High School. Interpretation of the Elliptical Drains and Eastern Rock Cut Drain*, January 2001.

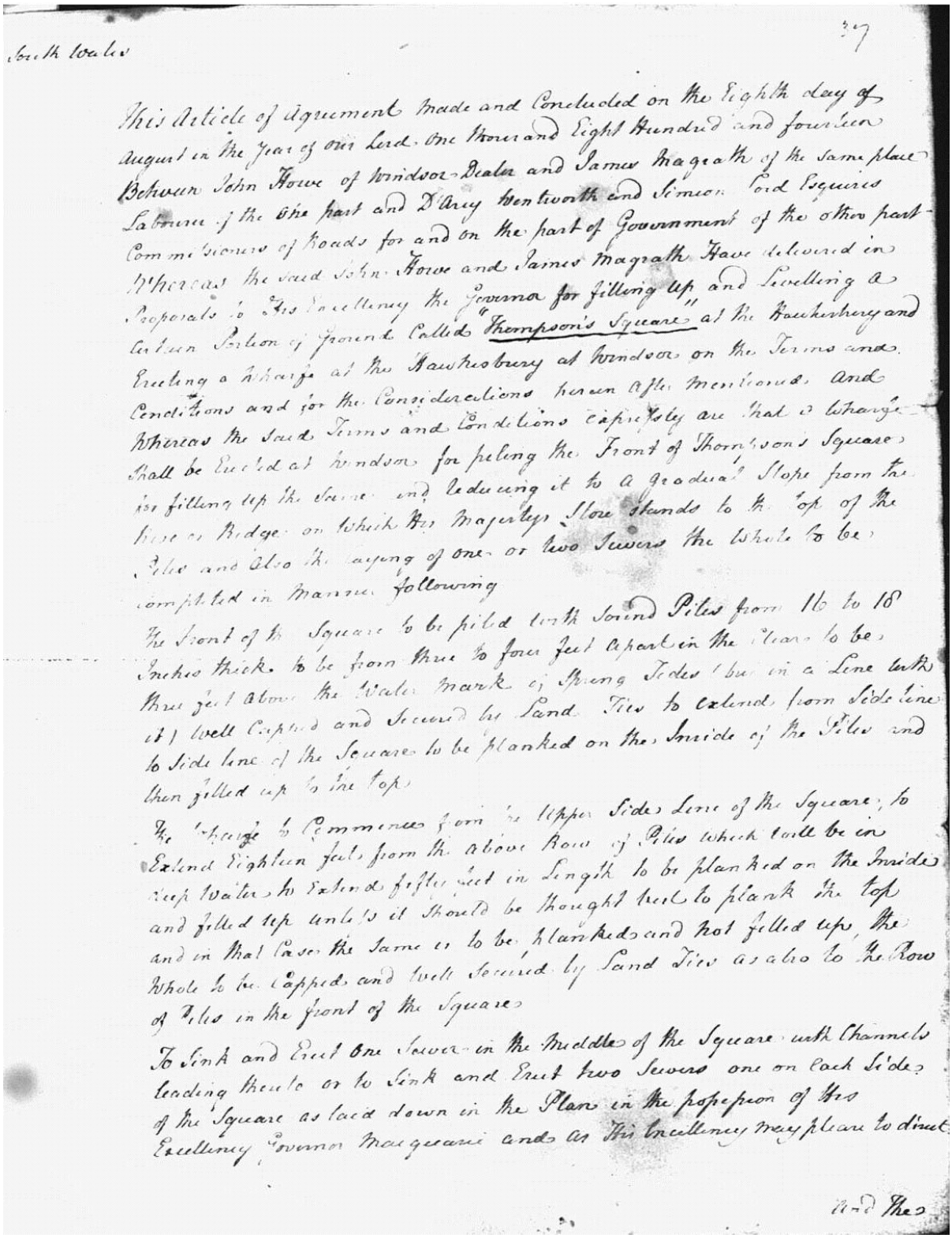
Pearson, S, *Building Materials Analysis, First Government House Site, Sydney*, Heritage Resource Services, 1988.

Proudfoot, Helen (et al), *Australia's First Government House*, New South Wales. Department of Planning, Sydney 1991.

Wong, Anna, 'Colonial Sanitation, Urban Planning and Social Reform in Sydney, New South Wales 1788 1857', *Australasian Historical Archaeology,* Vol. 17, 1999: 58-69.

APPENDICES

Appendix A - Howe and Magrath Contract (ML MSS 106 Item 37)



South Wales

37

This Article of Agreement made and Concluded on the Eighth day of August in the Year of our Lord One Thousand Eight Hundred and fourteen Between John Howe of Windsor Dealer and James Magrath of the same place Labourer of the one part and D'Arcy Wentworth and Simeon Lord Esquires Commissioners of Roads for and on the part of Government of the other part Whereas the said John Howe and James Magrath Have delivered in Proposals to His Excellency the Governor for filling up and Levelling a certain Portion of Ground Called Thompson's Square at the Hawkesbury and Erecting a Wharge at the Hawkesbury at Windsor on the Terms and Conditions and for the Considerations hereon after mentioned and Whereas the said Terms and Conditions Respectively are that a Wharge shall be Erected at Windsor for piling the Front of Thompson's Square for filling up the same and reducing it to a Gradual Slope from the Rise or Bridge on which His Majesty's Stone Stands to the Top of the Pile and Also the laying of one or two Sewers the Whole to be completed in Manner following

The Front of the Square to be piled with Sound Piles from 16 to 18 Inches thick to be from three to four feet apart in the Clear to be three feet above the Water mark of Spring Tides but in a Line with it well Capped and Secured by Land Ties to extend from Side Line to Side Line of the Square to be planked on the Inside of the Piles and then filled up to the Top

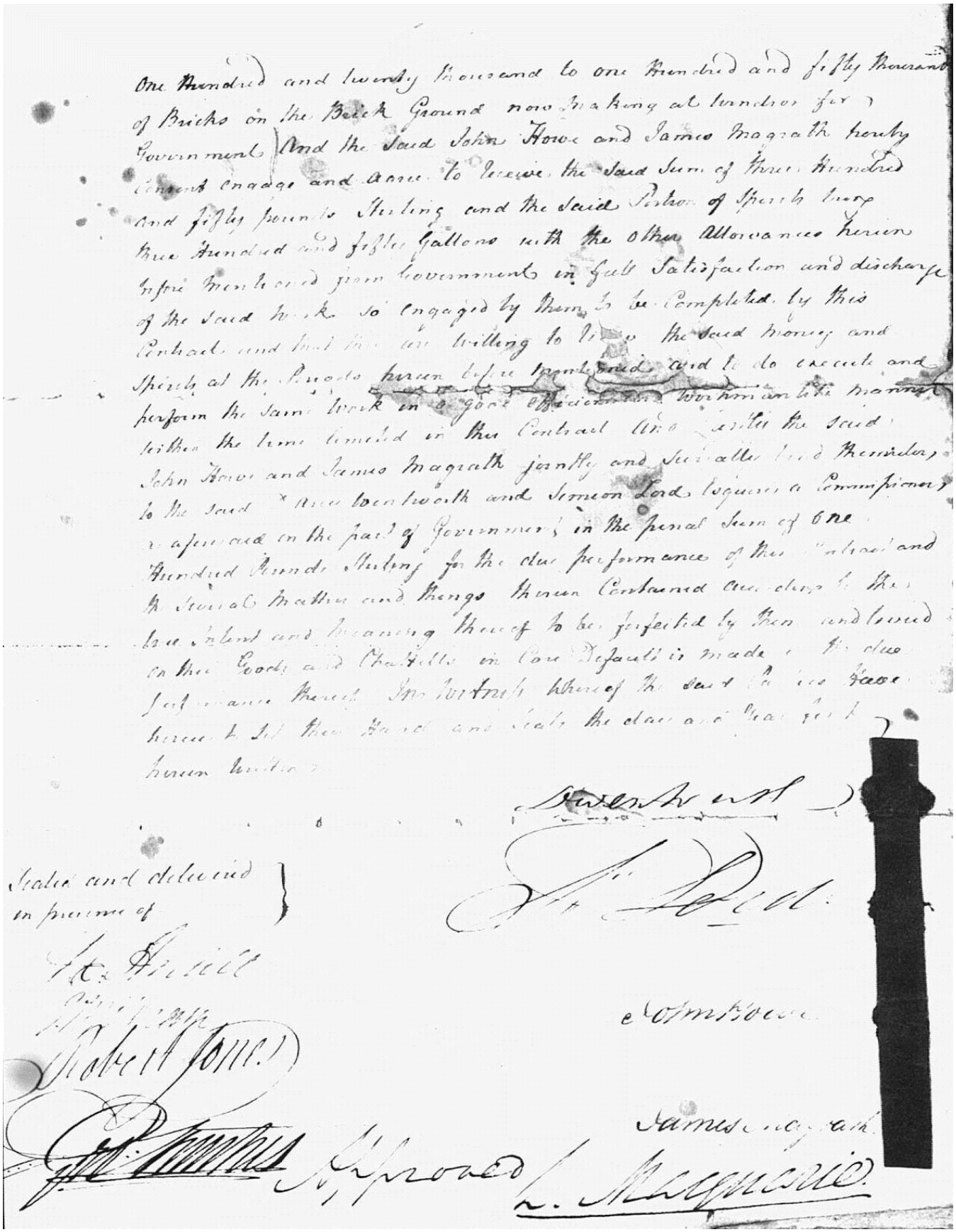
The Wharge to Commence from the Upper Side Line of the Square to Extend Eighteen feet from the above Row of Piles which will be in deep Water to Extend Fifty feet in Length to be planked on the Inside and filled up unless it should be thought best to plank the Top and in that Case the same is to be planked and not filled up, the Whole to be Capped and well Secured by Land Ties as also to the Row of Piles in the front of the Square

To Sink and Erect One Sewer in the Middle of the Square with Channels leading thereto or to Sink and Erect two Sewers one on each Side of the Square as laid down in the Plans in the possession of His Excellency Governor Macquarie and as His Excellency may please to direct

And the

The said John Howe and James Magrath hereby Covenant promise warrant Undertake and Contract to and with the said D'Arcy Wentworth and Simeon Lord Esquires as Commissioners aforesaid on the part of Government that the work and Labor in and about the said premises shall be done executed and performed in a good substantial and workmanlike manner and shall be Commenced upon as soon after this Agreement is perfected as possible and shall be Completed and finished within twelve Calendar Months from the day of the date hereof without any Delay or Loss of time and from time to time and at all times shall be subject to the Inspection of His Excellency the Governor or any Person His Excellency may please to appoint to Examine and Inspect the same in the Course of its Progress In Consideration of which the said D'Arcy Wentworth and Simeon Lord as Commissioners as aforesaid for and on Account of Government Do hereby promise engage and Undertake to pay and deliver unto them the said John Howe and James Magrath the Sum of Three Hundred and fifty pounds Sterling and three Hundred and fifty Gallons of Rectified Rum or other Spirits of the best kind Usually Imported such Sum of Money and Portion of Spirits to be paid and Delivered as follows in four equal proportions that is to say One fourth part to be paid and Delivered at the Commencement of the Work and two other fourth parts during the progress thereof and the fourth or last remaining proportion to be paid and Delivered when the Whole of the said Work is finished and perfected in pursuance of the Tenor of this Contract and Covenant thereunto And it is further Understood and Agreed that they the said John Howe and James Magrath shall be Allowed the Use of the Bullocks Timber Carriages Carts &c. that are now allowed to and for the Turnpike Road for the Term of Six Months from the date hereof And Moreover that they shall be furnished to make from

One



One Hundred and Twenty Thousand to one Hundred and fifty Thousand of Bricks on the Brick Ground now making at Windsor for Government And the said John Howe and James Magrath hereby Covenant engage and agree to receive the said Sum of Three Hundred and fifty pounds Sterling and the said Portion of Spirits Two Three Hundred and fifty Gallons with the other Allowances herein before Mentioned given Government in full Satisfaction and discharge of the said Work so engaged by them to be Completed by this Contract and that they are willing to receive the said Money and Spirits at the Periods herein before mentioned and to do execute and perform the same Work in a good Workmanlike manner within the time limited in this Contract And for the said John Howe and James Magrath jointly and severally bind themselves to the said Andrew Loenhardt and Simeon Lord Esquires a Commissioner as aforesaid on the part of Government in the penal Sum of One Hundred Pounds Sterling for the due performance of this Contract and of Several Matters and things therein Contained and duly to be performed by them and bound on their Goods and Chattels in case Default is made in the due performance thereof In Witness whereof the said Parties have hereunto Set their Hand and Seals the day and Year first herein written

Sealed and delivered in presence of

Robert Howe

James Magrath

Appendix B – Transcript of Howe and Magrath Contract

New South Wales

This article of agreement made and concluded on the eighth day of August in the year of Our Lord One Thousand Eight Hundred and fourteen between John Howe of Windsor – Dealer and James Magrath of the same place Labourer of the one part and D'Arcy Wentworth and Simeon Lord Esquires Commissioners of Roads for and on the part of Government of the other part Whereas the said John Howe and James Magrath have delivered in Proposals to His Excellency the Governor for filling up and levelling a certain Portion of Ground called "Thompson's Square" at the Hawkesbury and Erecting a Wharfe at the Hawkesbury at Windsor on the Terms and Conditions and for the Considerations herein after mentioned and whereas the said Terms and Conditions expressly are that a Wharfe shall be erected at Windsor for piling the front of Thompson's Square for filling up the same and reducing it to a gradual slope from the Rise or Ridge on which His Majesty's Store stands to the top of the Piles and also the laying of one or two sewers the whole to be completed in Manner following

The Front of the Square to be piled with sound Piles from 16 to 18 inches thick to be from three to four feet in the clear to be three feet above the water mark of Spring Tides (X) in a Line with it, well capped and secured by Land Ties to extend from Side Line to Side Line of the Square to be planked on the Inside of the Piles and then filled up to the top.

The Wharfe to commence from the Upper Side Line of the Square to Extend Eighteen feet from the above Row of Piles which will be in deep Water to Extend fifty feet in Length to be planked on the Inside and filled up unless it should be thought bad to plank the top and in that Case the same is to be planked and not filled up, the whole to be Capped and well secured by Land Ties as also to the Row of Piles in the front of the Square.

To Sink and Erect one Sewer in the Middle of the Square with Channels leading thereto or to Sink and Erect two Sewers one on each side of the Square as laid down in the Plan in the possession of His Excellency Governor Macquarie and as His Excellency may pleas to direct and

the said John Howe and James Magrath hereby Consent and promise warrant undertake and Contract to and with the said D'Arcy Wentworth and Simeon Lord Esquires as Commissioners as aforesaid on the part of Government that the Work and Labor in and about the said premises shall be done executed and performed in a good substantial and workmanlike manner and shall be Commenced upon as soon after this agreement is perfected as possible and shall be Completed and finished within twelve Calendar months from the day of the date hereof without any Delay or Loss of time from time to time and at all times shall be subject to Inspection of His Excellency the Governor or any person His Excellency may please to appoint to (X) and Inspect the same in the Course of its Progress In Consideration of which the said D'Arcy Wentworth and Simeon Lord as Commissioners as aforesaid for and on account of Government Do hereby promise engage and undertake to tender and pay unto to them the said John Howe and James Magrath the sum of Three Hundred and fifty Pounds Sterling and three hundred and fifty Gallons of Bengal Rum or other Spirits of the best usually Imported. Such sum of Money and Portion of Spirits to be paid and tendered as follows in four equal proportions that is to say one fourth has to be paid and tendered at the Commencement of Work and two other fourth parts during the progress thereof and the fourth or last remaining proportion to be paid and tendered when the Whole of the said work is finished and perfected in pursuance of the tenor of this Contract and (X) thereof. And it is further understood and agreed that they the said John Howe and James Magrath shall be allowed the use of the Bullocks Timber Carriage Carts &c that are now allowed to and for the Turnpike Road for the term of six months from the date hereof and moreover that they shall be permitted to make from

one hundred and twenty to one hundred and fifty thousand of Bricks on the Brick Ground now making at Windsor for Government And the said John Howe and James Magrath hereby consent engage and agree to receive the said sum of three hundred and fifty pounds sterling and the said Portion of Spirits being Three hundred and fifty Gallons with the other Allowances herein before Mentioned from Government in full Satisfaction and discharge of the said work so engaged by them to be Completed by this Contract and that they are willing to (X) the said Money and Spirits at the (X) herein before mentioned and to do execute and perform the same work in a good efficient and workmanlike manner within the time limited in the Contract And (X) the said John Howe and James Magrath jointly and severally (X) (X), to the said Darcy Wentworth and Simeon Lord Esquire a Commissioner as aforesaid on the part of Government in the penal Sum of one hundred pounds sterling for the due performance this Contract and the several matters and things therein contained (X) to the (X) Intent and Meaning thereof to be forfeited by them and levied on their Goods and Chattells in Case Default is made of the due performance thereof In Witness whereof the said (X) (X) herein to set their hand and seals the day and year (X)

Sealed and delivered in the presence of:

D Wentworth

S Lord

H Antill

(X)

Robert Jones

(X)

John Howe

James Magrath

Approved L Macquarie

Appendix C - Proposed Revised Abutment Design (Jacobs)

SCHEDULE OF DRAWINGS

1. COVER SHEET
2. SCHEDULE OF DRAWINGS
3. GENERAL ARRANGEMENT - SHEET A
4. GENERAL ARRANGEMENT - SHEET B
5. GENERAL ARRANGEMENT - SHEET C
6. LAUNCHING SEQUENCE - SHEET A
7. LAUNCHING SEQUENCE - SHEET B
8. FOUNDATION LAYOUT
9. CAST-IN-PLACE PILE DETAILS - SHEET A
10. ABUTMENT A CONCRETE - SHEET A
11. ABUTMENT A CONCRETE - SHEET B
12. ABUTMENT A CONCRETE - SHEET C
13. ABUTMENT A REINFORCEMENT - SHEET A
14. ABUTMENT A REINFORCEMENT - SHEET B
15. ABUTMENT A REINFORCEMENT - SHEET C
16. ABUTMENT A REINFORCEMENT - SHEET D
17. ABUTMENT B CONCRETE - SHEET A
18. ABUTMENT B CONCRETE - SHEET B
19. ABUTMENT B CONCRETE - SHEET C
20. ABUTMENT B REINFORCEMENT - SHEET A
21. ABUTMENT B REINFORCEMENT - SHEET B
22. ABUTMENT B REINFORCEMENT - SHEET C
23. ABUTMENT B REINFORCEMENT - SHEET D
24. PRECAST PILE CAP CONCRETE
25. PRECAST PILECAP REINFORCEMENT - SHEET A
26. PRECAST PILECAP REINFORCEMENT - SHEET B
27. PIERS 1 TO 4 CONCRETE
28. PILE CAP REINFORCEMENT
29. PIERS 1 TO 4 REINFORCEMENT
30. BEARINGS - SHEET A
31. BEARINGS - SHEET B
32. BEARINGS - SHEET C
33. BEARINGS - SHEET D
34. BEARINGS - SHEET E
35. BEARINGS - SHEET F
36. BEARINGS - SHEET G
37. DECK CONCRETE - SHEET A
38. DECK CONCRETE - SHEET B
39. DECK CONCRETE - SHEET C
40. DECK CONCRETE - SHEET D
41. DECK CONCRETE - SHEET E
42. DECK CONCRETE - SHEET F
43. DECK CONCRETE - SHEET G
44. DECK CONCRETE - SHEET H
45. DECK CONCRETE - SHEET I
46. DECK CONCRETE - SHEET J
47. DECK CONCRETE - SHEET K
48. DECK CONCRETE - SHEET L
49. DECK SEGMENT A - REINFORCEMENT SHEET A
50. DECK SEGMENT A - REINFORCEMENT SHEET B
51. DECK SEGMENT A - REINFORCEMENT SHEET C
52. DECK SEGMENT A - REINFORCEMENT SHEET D
53. DECK SEGMENT B - REINFORCEMENT SHEET A
54. DECK SEGMENT B - REINFORCEMENT SHEET B
55. DECK SEGMENT B - REINFORCEMENT SHEET C
56. DECK SEGMENT C - REINFORCEMENT SHEET A
57. DECK SEGMENT C - REINFORCEMENT SHEET B
58. DECK SEGMENT D - REINFORCEMENT SHEET A
59. DECK SEGMENT D - REINFORCEMENT SHEET B
60. DECK SEGMENT D - REINFORCEMENT SHEET C
61. DECK SEGMENT E - REINFORCEMENT SHEET A
62. DECK SEGMENT E - REINFORCEMENT SHEET B
63. DECK SEGMENT F - REINFORCEMENT SHEET A
64. DECK SEGMENT F - REINFORCEMENT SHEET B
65. DECK SEGMENT F - REINFORCEMENT SHEET C
66. DECK SEGMENT G - REINFORCEMENT SHEET A
67. DECK SEGMENT G - REINFORCEMENT SHEET B
68. DECK SEGMENT G - REINFORCEMENT SHEET C
69. DECK SEGMENT H - REINFORCEMENT SHEET A
70. DECK SEGMENT H - REINFORCEMENT SHEET B
71. DECK SEGMENT H - REINFORCEMENT SHEET C
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73. DECK SEGMENT I - REINFORCEMENT SHEET B
74. DECK SGEMENT I - REINFORCEMENT SHEET C
75. DECK SEGMENT J - REINFORCEMENT SHEET A
76. DECK SEGMENT J - REINFORCEMENT SHEET B
77. DECK SEGMENT J - REINFORCEMENT SHEET C
78. DECK SEGMENT J - REINFORCEMENT SHEET D
79. DECK SEGMENT J - REINFORCEMENT SHEET E
80. DECK SEGMENT J - REINFORCEMENT SHEET F
81. DECK PRESTRESSING - NOTES
82. DECK PRESTRESSING - LAYOUT - SHEET A
83. DECK PRESTRESSING - LAYOUT - SHEET B
84. DECK PRESTRESSING - DETAILS
85. DECK PRESTRESSING - SECTIONS - SHEET A
86. DECK PRESTRESSING - SECTIONS - SHEET B
87. DECK PRESTRESSING - SECTIONS - SHEET C
88. PRESTRESSING REINFORCEMENT - SHEET A
89. PRESTRESSING REINFORCEMENT - SHEET B
90. PRESTRESSING REINFORCEMENT - SHEET C
91. PRESTRESSING REINFORCEMENT - SHEET D
92. PRESTRESSING REINFORCEMENT - SHEET E
93. PRESTRESSING REINFORCEMENT - SHEET F
94. PRESTRESSING REINFORCEMENT - SHEET G
95. PRESTRESSING REINFORCEMENT - SHEET H
96. PRESTRESSING REINFORCEMENT - SHEET I
97. PRESTRESSING REINFORCEMENT - SHEET J
98. PRESTRESSING REINFORCEMENT - SHEET K
99. PRESTRESSING - TENDON PROFILES
100. PRESTRESSING - TRANSVERSE TENDONS - SHEET A
101. PRESTRESSING - TRANSVERSE TENDONS - SHEET B
102. RETAINING WALL ARRANGEMENT - SHEET A
103. RETAINING WALL ARRANGEMENT - SHEET B
104. SHARED PATH BARRIER - ARRANGEMENT
105. RETAINING WALL SECTIONS - SHEET A
106. RETAINING WALL SECTIONS - SHEET B
107. RETAINING WALL REINFORCEMENT - SHEET A
108. RETAINING WALL REINFORCEMENT - SHEET B
109. RETAINING WALL REINFORCEMENT - SHEET C
110. RETAINING WALL REINFORCEMENT - SHEET D
111. RETAINING WALL REINFORCEMENT - SHEET E
112. RETAINING WALL REINFORCEMENT - SHEET F
113. FOOTWAY ARRANGEMENT AND DETAILS
114. DECK EXPANSION JOINTS - SHEET A
115. DECK EXPANSION JOINTS - SHEET B
116. DECK EXPANSION JOINTS - SHEET C
117. APPROACH SLAB - SHEET A
118. APPROACH SLAB - SHEET B
119. DECK LONGITUDINAL DRAINAGE - SHEET A
120. DECK LONGITUDINAL DRAINAGE - SHEET B
121. PRECAST BARRIER LAYOUT
122. PRECAST BARRIER DETAILS - SHEET A
123. PRECAST BARRIER DETAILS - SHEET B
124. PRECAST BARRIER DETAILS - SHEET C
125. PRECAST BARRIER DETAILS - SHEET D
126. PRECAST BARRIER DETAILS - SHEET E
127. PRECAST BARRIER DETAILS - SHEET F
128. PRECAST BARRIER DETAILS - SHEET G
129. PRECAST BARRIER DETAILS - SHEET H
130. PRECAST BARRIER DETAILS - SHEET I
131. PRECAST BARRIER DETAILS - SHEET J
132. TRAFFIC BARRIER RAILING LAYOUT
133. TRAFFIC BARRIER RAILING PANELS - SHEET A
134. TRAFFIC BARRIER RAILING PANELS - SHEET B
135. TRAFFIC BARRIER RAILING DETAILS
136. PEDESTRIAN RAILING PANEL TYPES
137. PEDESTRIAN RAILING DETAILS - SHEET A
138. PEDESTRIAN RAILING DETAILS - SHEET B
139. BAR SHAPES DIAGRAM - SHEET A
140. BAR SHAPES DIAGRAM - SHEET B
141. BRIDGE ABUTMENT CLADDING - SHEET A
142. BRIDGE ABUTMENT CLADDING - SHEET B
143. CAST-IN-PLACE PILE DETAILS - SHEET B
144. ABUTMENT A CONCRETE - SHEET D
145. RETAINING WALL SECTIONS - SHEET C
146. RETAINING WALL REINFORCEMENT - SHEET G
147. RETAINING WALL REINFORCEMENT - SHEET H

Rev.	Date	Description	By	Ch'd	App'd
3	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

FOR TENDER

JACOBS

WINDSOR DOCUMENT CONTROL No NB98005-DG-BR-0001

REGN. No. OF PLANS

DS2012/000155

BRIDGE NUMBER 11386

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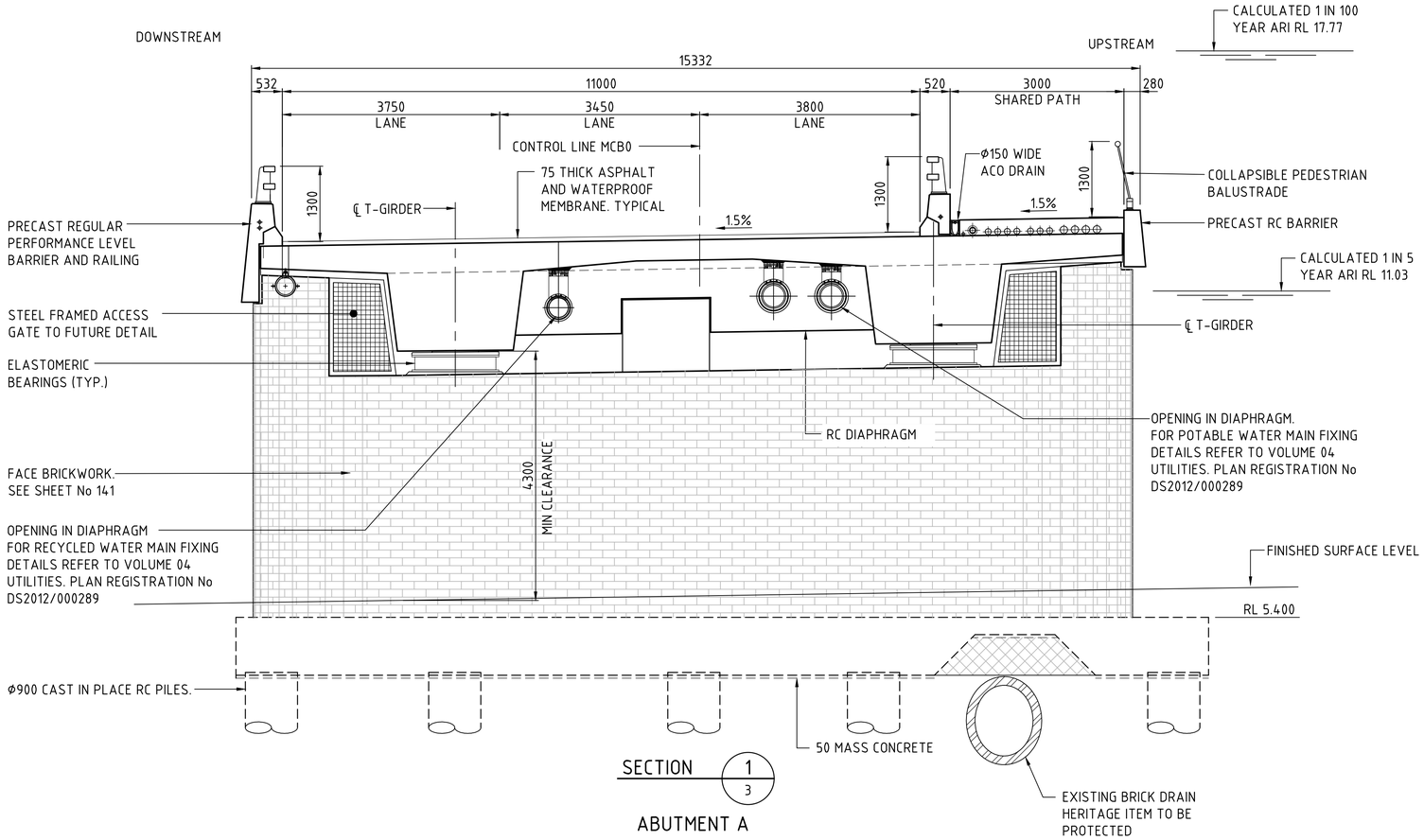
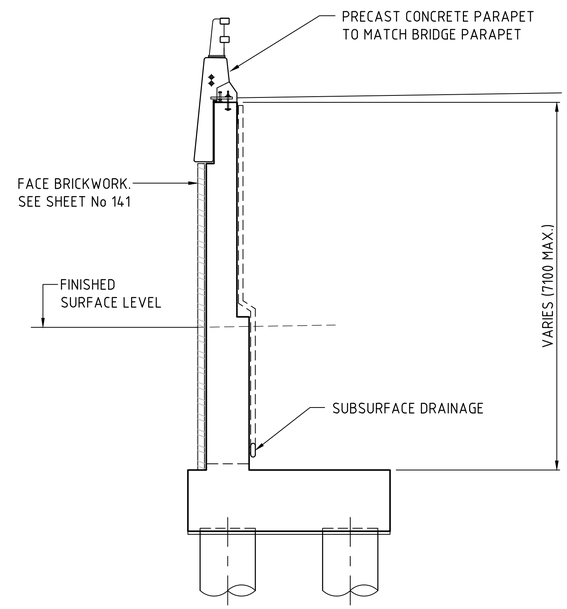
ISSUE 3



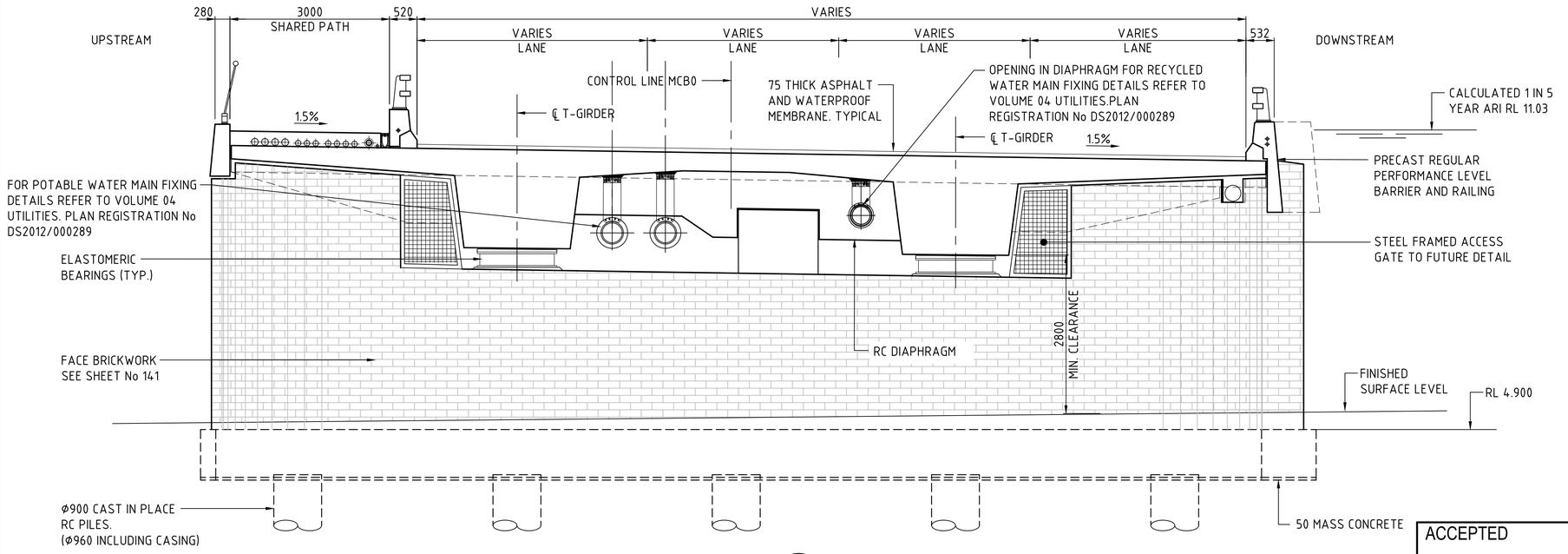
SECTION 1/3

ABUTMENT A



SECTION 3/3

SOUTHERN APPROACH EMBANKMENT RETAINING WALL



SECTION 2/3

ABUTMENT B

FOR TENDER

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 3.

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1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

GENERAL ARRANGEMENT - SHEET B

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING I.C.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 4 ISSUE 3

ACCEPTED

PRINCIPAL BRIDGE ENGINEER

DATE

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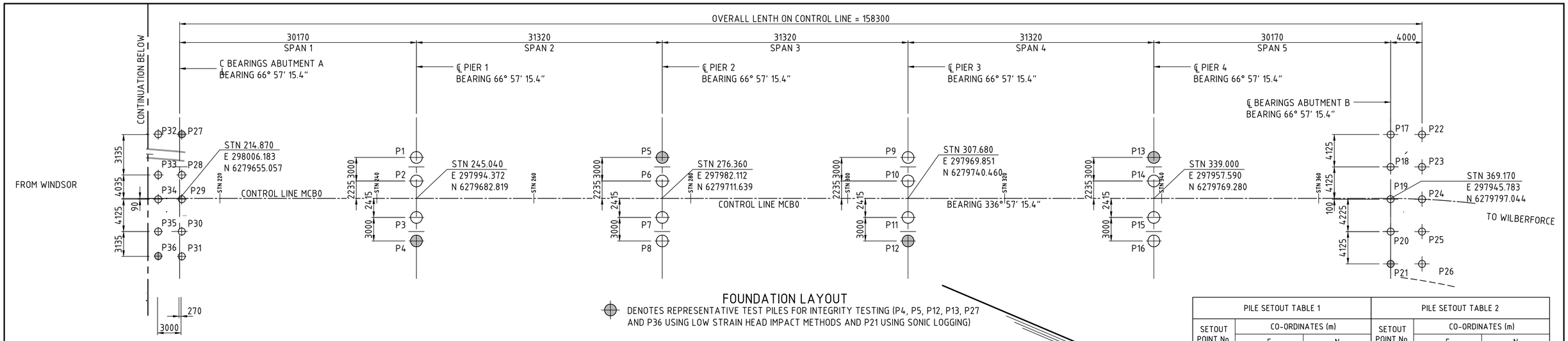


FOUNDATION LAYOUT

DENOTES REPRESENTATIVE TEST PILES FOR INTEGRITY TESTING (P4, P5, P12, P13, P27 AND P36 USING LOW STRAIN HEAD IMPACT METHODS AND P21 USING SONIC LOGGING)

GENERAL NOTES

SCALE 0 2.5 5 10 15m OR AS SHOWN

CONCRETE EXPOSURE CLASSIFICATION (EXCEPT PILES P17 TO P26): B1
CONCRETE EXPOSURE CLASSIFICATION FOR PILES P17 TO P26: B2
MINIMUM 28 DAY COMPRESSIVE STRENGTH OF CONCRETE SHALL BE 40MPa.
NOMINAL COVER TO REINFORCEMENT NEAREST TO THE CONCRETE SURFACE SHALL BE 70mm UNLESS SPECIFIED OTHERWISE.
NOMINAL COVER TO REINFORCEMENT NEAREST TO THE CONCRETE SURFACE FOR PILES P17 TO P26 SHALL BE 85mm.
REINFORCING BARS SHALL BE GRADE D500N TO AS/NZS.4671 UNLESS NOTED OTHERWISE.
HELICES SHALL BE GRADE D500N.
UNLESS SPECIFIED OTHERWISE, THE MINIMUM DEVELOPMENT LENGTHS AND LENGTH OF LAP SPLICES SHALL BE AS FOLLOWS:

BAR SIZE	N24	N28	N32
A) VERTICAL BARS	1000	1250	1525

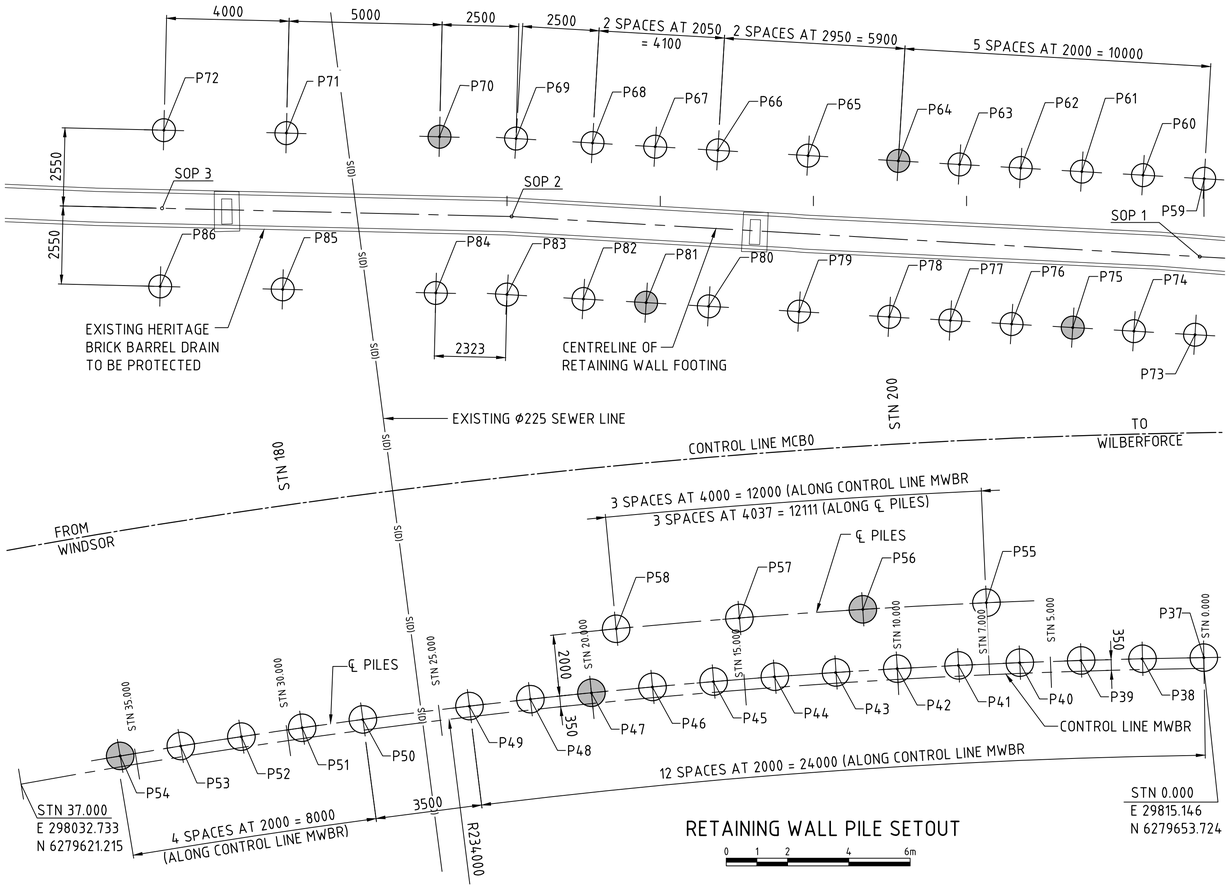
UNLESS SHOWN OTHERWISE ON THE DRAWINGS LAPS ON ADJACENT BARS ON ANY FACE SHALL BE STAGGERED (OFFSET) BY NO LESS THAN 1.3 x THE LAP LENGTH.
HELIX SHALL BE ANCHORED AT EACH END WITH 1.5 TURNS ADJUSTED TO ZERO PITCH AND ANCHORED BY A HOOK AROUND A MAIN BAR A MINIMUM 300mm EXTENSION INTO CORE CONCRETE.
MAXIMUM DESIGN CAST-IN-PLACE PILE LOADS :

	DESIGN AXIAL COMPRESSION		DESIGN MOMENT
	SERVICEABILITY	ULTIMATE	ULTIMATE
P1 TO P4 & P13 TO P16	7050kN	10800kN	5790kNm
P5 TO P12	6100kN	8440kN	4620kNm
P17 TO P26	4510kN	6150kN	1560kNm
P27 TO P36	3500kN	4300kN	270kNm
P37 TO P47	1330kN	1820kN	610kNm
P48 TO P54	670kN	860kN	1430kNm
P55 TO P58	-1320kN	-2133kN	360kNm
P59 TO P86	1190kN	1430kN	370kNm

THE AXIAL LOADS AND MOMENTS TABULATED ARE NOT CONCURRENT, BUT ARE MAXIMUM VALUES IN EACH CASE FOR THE PARTICULAR PILE.
ROCK SOCKET DESIGNS ARE BASED ON THE FOLLOWING UNFACTORED GEOTECHNICAL STRENGTH PARAMETERS FOR ULTIMATE LOADING :-
MEDIUM TO HIGH STRENGTH SANDSTONE / SILTSTONE TO AS1726
ULTIMATE END BEARING CAPACITY = 20 000kPa
ULTIMATE SHAFT ADHESION = 600kPa
VERY LOW TO LOW STRENGTH SANDSTONE / SILTSTONE TO AS1726
ULTIMATE END BEARING CAPACITY = 3000kPa
ULTIMATE SHAFT ADHESION = 150kPa
GEOTECHNICAL REDUCTION FACTOR FOR PILES P1 TO P16: ϕ=0.55
GEOTECHNICAL REDUCTION FACTOR FOR PILES P17 TO P86: ϕ=0.40
SOCKET ROUGHNESS R2 (OR BETTER)
ROCK SOCKETS SHALL BE INSPECTED DURING EXCAVATION AND APPROVED BY A GEOTECHNICAL ENGINEER PRIOR TO CASTING OF PILES.
THE PILE CONTRACT LEVEL SHALL BE RAISED OR LOWERED, TO OBTAIN THE SPECIFIED MINIMUM SOCKET LENGTH.
WHERE CONTRACT LEVEL IS TO BE RAISED OR LOWERED BY MORE THAN 1m, THE PRINCIPAL SHALL BE NOTIFIED.
PILE DESIGN PARAMETERS ASSUME BASE AND SHAFT CLEAN UP BY MECHANICAL AND/OR AIR LIFT CLEAN UP TECHNIQUES. REDUCTIONS IN THESE PARAMETERS AND A REVIEW OF THE SOCKET LENGTH BY THE DESIGN ENGINEER MAY BE REQUIRED IF CLEANING TECHNIQUES ARE NOT EFFECTIVE AS DETERMINED ON SITE BY A GEOTECHNICAL ENGINEER.
PILES TO BE CONSTRUCTED IN ACCORDANCE WITH RMS B58 AND B59.

SET OUT POINT TABLE FOR FOOTING CENRELINE

SOP NUMBER	EASTING	NORTHING	BEARING TO NEXT SOP
SOP 1	298002.333	6279649.746	160°17'44.3"
SOP 2	298010.423	6279627.156	158°18'27.6"
SOP 3	298015.476	6279614.453	-



RETAINING WALL PILE SETOUT

0 1 2 4 6m

FOR PILECAP SETOUT REFER TO DRAWING SHEET 102 &103

DENOTES REPRESENTATIVE TEST PILES FOR INTEGRITY TESTING (P47, P54, P56, P64, P70, P75 AND P81) USING LOW STRAIN HEAD IMPACT METHODS.

FOR TENDER

PILE SETOUT TABLE 1			PILE SETOUT TABLE 2		
SETOUT POINT No.	CO-ORDINATES (m)		SETOUT POINT No.	CO-ORDINATES (m)	
	E	N		E	N
P37	298014.823	6279653.587	P62	298002.459	6279641.830
P38	298015.642	6279651.759	P63	298003.134	6279639.947
P39	298016.476	6279649.938	P64	298003.808	6279638.064
P40	298017.326	6279648.124	P65	298004.803	6279635.287
P41	298018.192	6279646.318	P66	298005.797	6279632.509
P42	298019.072	6279644.519	P67	298006.488	6279630.579
P43	298019.969	6279642.727	P68	298007.180	6279628.649
P44	298020.880	6279640.944	P69	298008.023	6279626.296
P45	298021.806	6279639.168	P70	298008.947	6279623.973
P46	298022.748	6279637.400	P71	298010.795	6279619.327
P47	298023.705	6279635.640	P72	298012.273	6279615.610
P48	298024.677	6279633.889	P73	298005.238	6279649.198
P49	298025.664	6279632.146	P74	298005.912	6279647.315
P50	298027.426	6279629.116	P75	298006.586	6279645.432
P51	298028.454	6279627.397	P76	298007.261	6279643.549
P52	298029.496	6279625.686	P77	298007.935	6279641.666
P53	298030.552	6279623.985	P78	298008.609	6279639.783
P54	298031.624	6279622.292	P79	298009.604	6279637.006
P55	298015.953	6279646.356	P80	298010.599	6279634.229
P56	298017.730	6279642.727	P81	298011.290	6279632.299
P57	298019.568	6279639.130	P82	298011.981	6279630.369
P58	298021.468	6279635.564	P83	298012.824	6279628.015
P59	298000.436	6279647.478	P84	298013.685	6279625.858
P60	298001.110	6279645.595	P85	298015.534	6279621.212
P61	298001.785	6279643.713	P86	298017.013	6279617.496

CONTINUATION ABOVE

Rev.	Date	Description	By	Ch'd	App'd
4	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT WINDSOR

FOUNDATION LAYOUT

JACOBS
NSW GOVERNMENT Transport Roads & Maritime Services
ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
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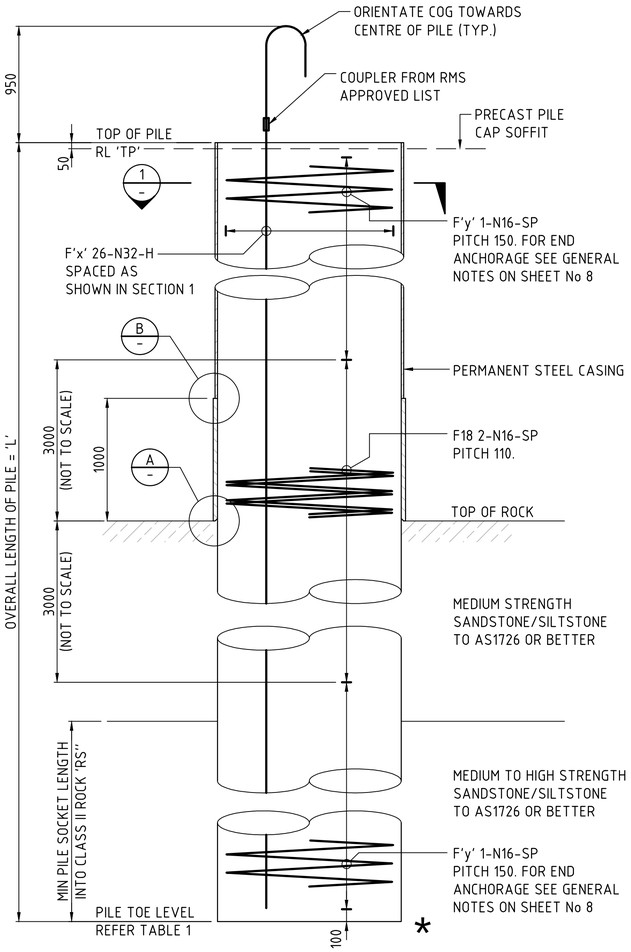
FACSIMILE 02 8849 2818

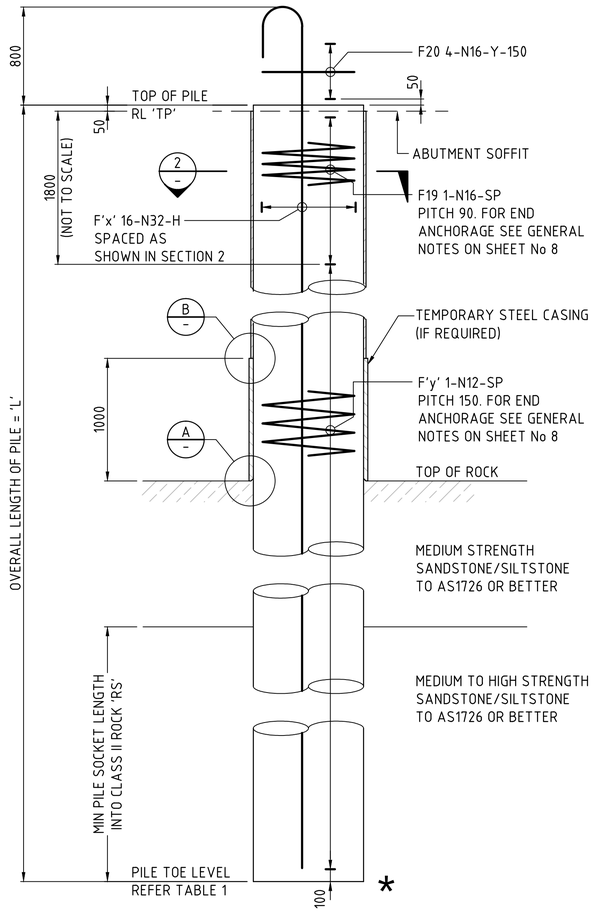
NB98005-DG-BR

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING I.C.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 8 ISSUE 4

Plot Date: 09 Apr 2018, - 09:08:35 Cad File: C:\Users\shuffla\appdata\local\project wise\mes_projects\dms00616\NB98005-ECP-DG-0008-0009.dwg

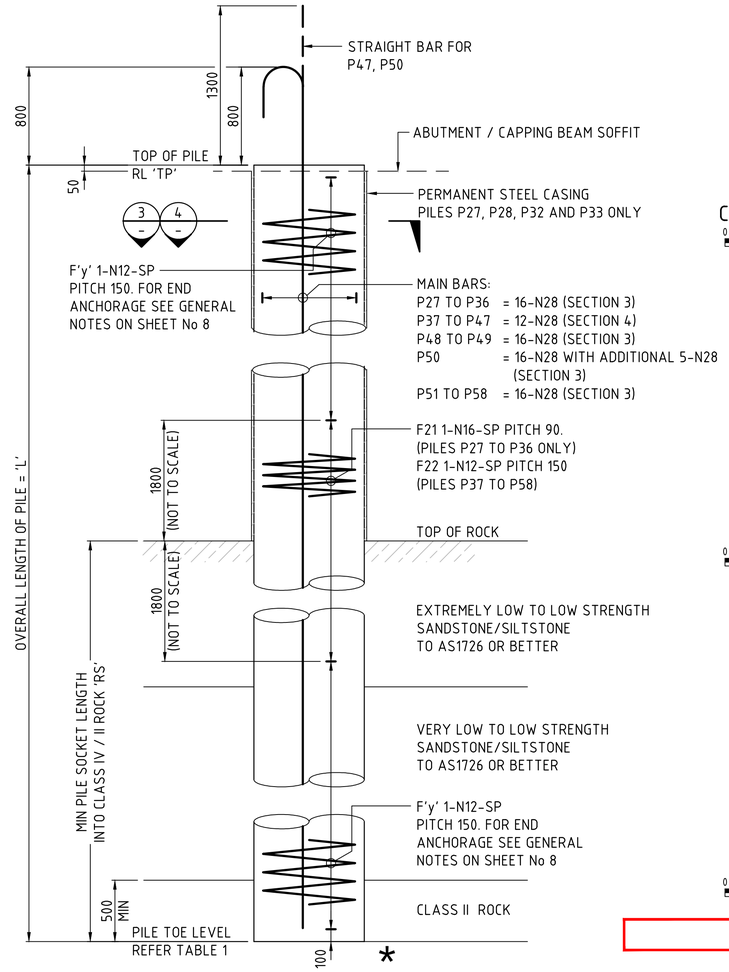


PILES P1 TO P16

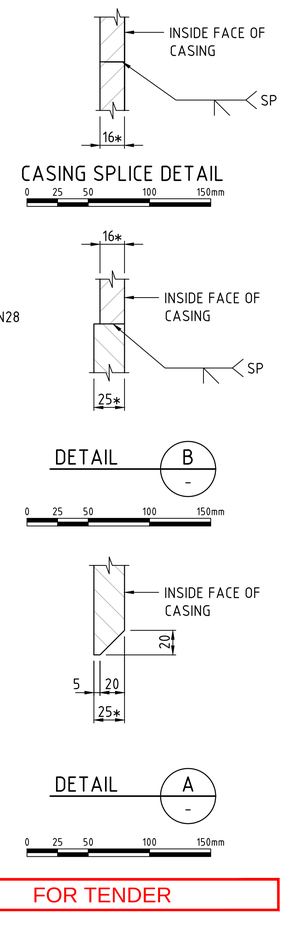


PILES P17 TO P26

CAST-IN-PLACE PILES



PILES P27 TO P58



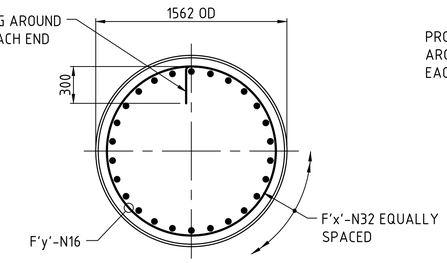
FOR TENDER

* BASE OF SOCKETS TO BE FLUSHED CLEAN TO ENSURE NO RESIDUAL DEBRIS OR LOOSE MATERIAL IS PRESENT AT TIME OF POURING CONCRETE WITHIN SOCKET.

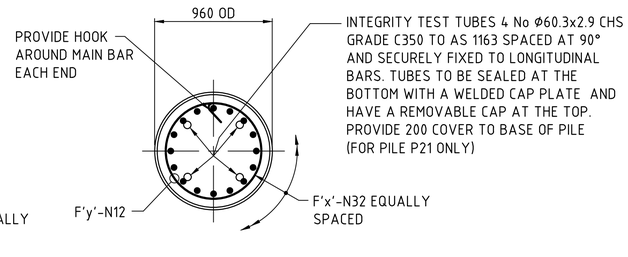
GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN

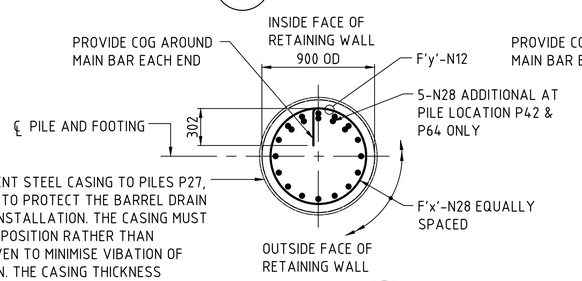
FOR GENERAL NOTES SEE SHEETS No. 8 AND 143.
CASING STEEL SHALL CONFORM TO AS 3678 GRADE 250.
WELDING SYMBOLS ARE TO AS 1101 PART 3.
THE WELDING CATEGORY SHALL BE SP TO AS/NZS 1554 PART 1.
ALL STEEL CASING WELDING SHALL CONFORM TO THE REQUIREMENTS OF RMS B201
* PERMANENT STEEL CASING INDICATIVE. PILING CONTRACTOR TO CHECK FOR ADEQUACY FOR INSTALLATION TECHNIQUE.



SECTION 1

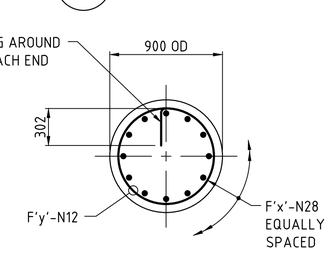


SECTION 2



PROVIDE PERMANENT STEEL CASING TO PILES P27, P28, P32 AND P33 TO PROTECT THE BARREL DRAIN DURING THE PILE INSTALLATION. THE CASING MUST BE SCREWED INTO POSITION RATHER THAN VIBRATED OR DRIVEN TO MINIMISE VIBATION OF THE BARREL DRAIN. THE CASING THICKNESS SHALL BE SIZED BY THE CONTRACTOR BUT SHALL NOT BE LESS THAN 12mm THICK. REFER TO SHEET No 143 FOR ADDITIONAL NOTES.

SECTION 3



SECTION 4

TABLE 1 - CAST-IN-PLACE PILES

PILE No	PILE TOE LEVEL	MIN ROCK SOCKET LENGTH 'RS'	TOP OF PILE RL 'TP'	OVERALL LENGTH OF PILE 'L'	BAR MARK F'x'	BAR MARK F'y'
P1 TO P4	RL -8.100	3500	RL -0.100	8000	F1 26-N32-H	F7 1-N16-SP
P5 TO P8	RL -15.100	3500	RL -0.100	15000	F2 26-N32-H	F8 1-N16-SP
P9 TO P12	RL -15.700	3500	RL -0.100	15600	F3 26-N32-H	F9 1-N16-SP
P13 TO P16	RL -15.400	3500	RL -0.100	15300	F4 26-N32-H	F10 1-N16-SP
P17 TO P21	RL -15.400	3500	RL 4.050	19450	F5 16-N32-H	F11 1-N12-SP
P22 TO P26	RL -15.400	3500	RL 4.050	19450	F6 16-N32-H	F12 1-N12-SP
P27 TO P36	RL -1.200	4000	RL 4.450	5650	F13 16-N28	F16 1-N12-SP
P37 TO P47	RL 0.400	4000	RL 4.450	4050	F14 12-N28	F16 1-N12-SP
P48 TO P50	RL 1.900	4000	RL 5.950	4050	F13 16-N28	F16 1-N12-SP
P51 TO P54	RL 3.400	4000	RL 8.950	5550	F13 16-N28	F16 1-N12-SP
P55 TO P58	RL -1.100	5500	RL 4.450	5550	F15 16-N28	F17 1-N12-SP

Rev.	Date	Description	By	Ch'd	App'd
3	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

CAST-IN-PLACE PILE DETAILS - SHEET A

JACOBS — NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
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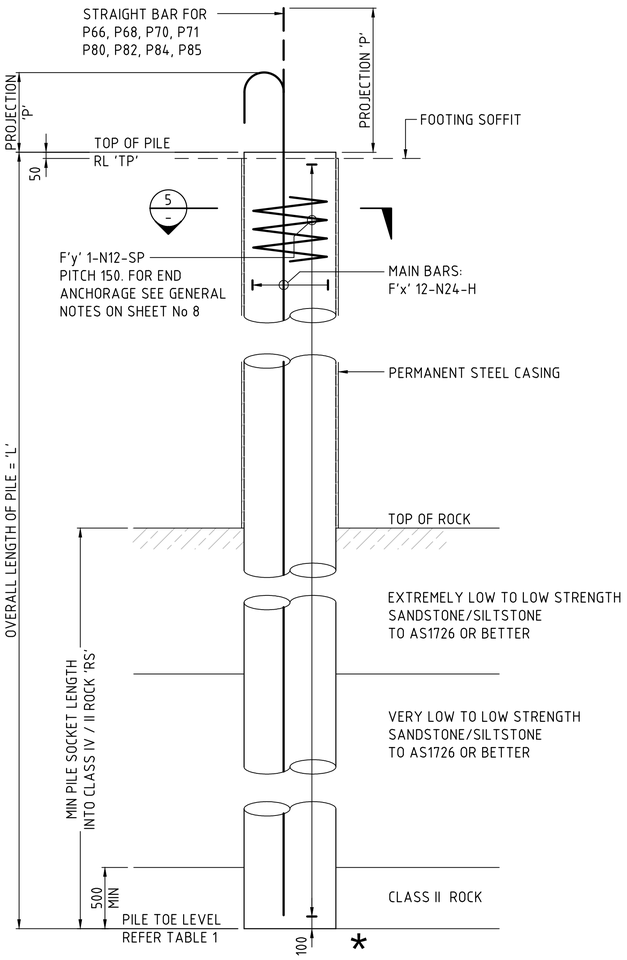
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING I.C.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 9 ISSUE 3

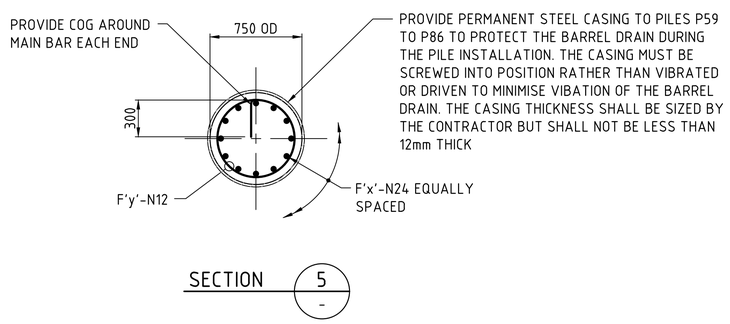
Plot Date: 09 Apr 2018 - 14:49:22 Cad File: C:\Users\shuth1a\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0008-0009.dwg



PILES P59 TO P86

CAST-IN-PLACE PILES

* BASE OF SOCKETS TO BE FLUSHED CLEAN TO ENSURE NO RESIDUAL DEBRIS OR LOOSE MATERIAL IS PRESENT AT TIME OF POURING CONCRETE WITHIN SOCKET.



PROVIDE PERMANENT STEEL CASING TO PILES P59 TO P86 TO PROTECT THE BARREL DRAIN DURING THE PILE INSTALLATION. THE CASING MUST BE SCREWED INTO POSITION RATHER THAN VIBRATED OR DRIVEN TO MINIMISE VIBATION OF THE BARREL DRAIN. THE CASING THICKNESS SHALL BE SIZED BY THE CONTRACTOR BUT SHALL NOT BE LESS THAN 12mm THICK

SECTION 5 -

TABLE 2 - CAST-IN-PLACE PILES

PILE No	PILE TOE LEVEL	MIN ROCK SOCKET LENGTH 'RS'	TOP OF PILE RL 'TP'	OVERALL LENGTH OF PILE 'L'	BAR MARK F'x'	BAR MARK F'y'	PROJECTION 'P'
P59, P73	RL -1.200	3500	RL 5.350	6550	F18 12-N24-H	F29 1-N12-SP	650
P60, P74	RL -1.200	3500	RL 5.602	6802	F18 12-N24-H	F30 1-N12-SP	650
P61, P75	RL 1.900	3500	RL 6.037	4137	F19 12-N24-H	F31 1-N12-SP	650
P62, P76	RL 1.900	3500	RL 6.470	4570	F20 12-N24-H	F32 1-N12-SP	650
P63, P77	RL 1.900	3500	RL 6.902	5002	F21 12-N24-H	F33 1-N12-SP	650
P64, P78	RL 1.900	3500	RL 7.334	5434	F22 12-N24-H	F34 1-N12-SP	650
P65, P79	RL 3.400	4000	RL 7.972	4572	F23 12-N24-H	F35 1-N12-SP	650
P66, P80	RL 3.400	4000	RL 8.350	4950	F24 12-N24-H	F36 1-N12-SP	1000
P67, P81	RL 3.400	4000	RL 8.975	5575	F25 12-N24-H	F37 1-N12-SP	450
P68, P82	RL 3.400	4000	RL 8.975	5575	F25 12-N24-H	F37 1-N12-SP	1000
P69, P83	RL 4.900	4000	RL 9.600	4700	F26 12-N24-H	F38 1-N12-SP	450
P70, P84	RL 4.900	4000	RL 9.600	4700	F26 12-N24-H	F38 1-N12-SP	1200
P71, P85	RL 6.400	4000	RL 10.700	4300	F27 12-N24-H	F39 1-N12-SP	1200
P72, P86	RL 6.400	4000	RL 11.950	5550	F28 12-N24-H	F40 1-N12-SP	450

FOR TENDER

HERITAGE BARREL DRAIN PROTECTION NOTES

THE HERITAGE BRICK BARREL DRAIN UNDERLYING THE SOUTHERN APPROACH WESTERN RETAINING WALL AND ABUTMENT A MUST BE PROTECTED DURING THE CONSTRUCTION OF THE ABUTMENT AND RETAINING WALLS. THE FOLLOWING MEASURES MUST BE UNDERTAKEN TO PROTECT THE BARREL DRAIN:-

PILING RIGS,CRANES AND TRUCKS SHALL NOT BE DRIVEN OVER THE TOP OF THE BARREL DRAIN.

PERMANENT STEEL CASING SHALL BE USED FOR THE INSTALLATION OF THE PILES ON EITHER SIDE OF THE BARREL DRAIN AS NOTED IN SECTION 5 ON THIS DRAWING AND ALSO ON SHEET No 9.

VIBRATION IN THE BARREL DRAIN SHALL BE LIMITED TO 10mm/s PEAK COMPONENT PARTICLE VELOCITY. TRIAL VIBRATION MONITORING AND CONSTRUCTION VIBRATION MONITORING SHALL BE IN ACCORDANCE WITH RMS G1.

WHERE THE COVER TO THE BARREL DRAIN FROM THE ABUTMENT AND RETAINING WALL SOFFIT IS LESS THAN 500mm, THE BARREL DRAIN ROOF SHALL BE PROTECTED WITH POLYSTYRENE FOAM THAT EXTENDS 300mm NOMINALLY BELOW THE TOP OF THE BARREL DRAIN. THE POLYSTYRENE SHALL HAVE A COMPRESSION STRESS AT 10% DEFORMATION OF 105kPa +/-10% IN ACCORDANCE WITH AS2498.3.

THE DEPTH OF WET CONCRETE IN THE FOOTING PLACED OVER THE BARREL DRAIN ROOF SHALL BE LIMITED TO 1000mm MAXIMUM. WHERE THE DEPTH EXCEEDS 1000mm AT THE STEPS, THE CONSTRUCTION WILL NEED TO BE STAGED WITH A HORIZONTAL JOINT THROUGH THE STEP SO THE WEIGHT OF THE UPPER SECTION OF THE FOOTING CAN BE SUPPORTED ON THE COMPLETED SECTION BELOW. A MINIMUM OF 25MPa CONCRETE STRENGTH WILL BE REQUIRED IN THE LOWER SECTION OF THE FOOTING BEFORE THE CASTING OF THE UPPER SECTION.

THE COMPACTION OF THE BACKFILL OVER THE FOOTING SHALL BE UNDERTAKEN WITH A NON VIBATING ROLLER.

GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN

FOR GENERAL NOTES SEE SHEETS No. 8 AND 9.

Rev.	Date	Description	By	Ch'd	App'd
1	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

CAST-IN-PLACE PILE DETAILS - SHEET B

JACOBS
NB98005-DG-BR

NSW GOVERNMENT Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
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NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN S.H.	J.S.	DS2012/000155
DRAWING A.S.	I.C.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 143 ISSUE 1

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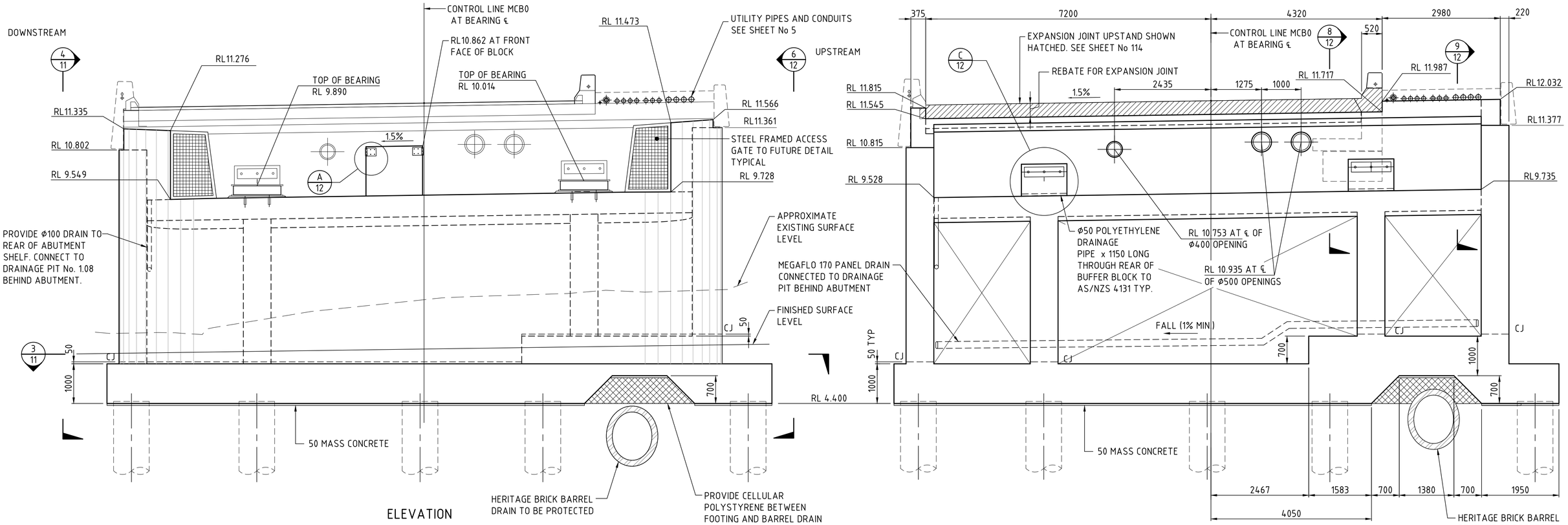

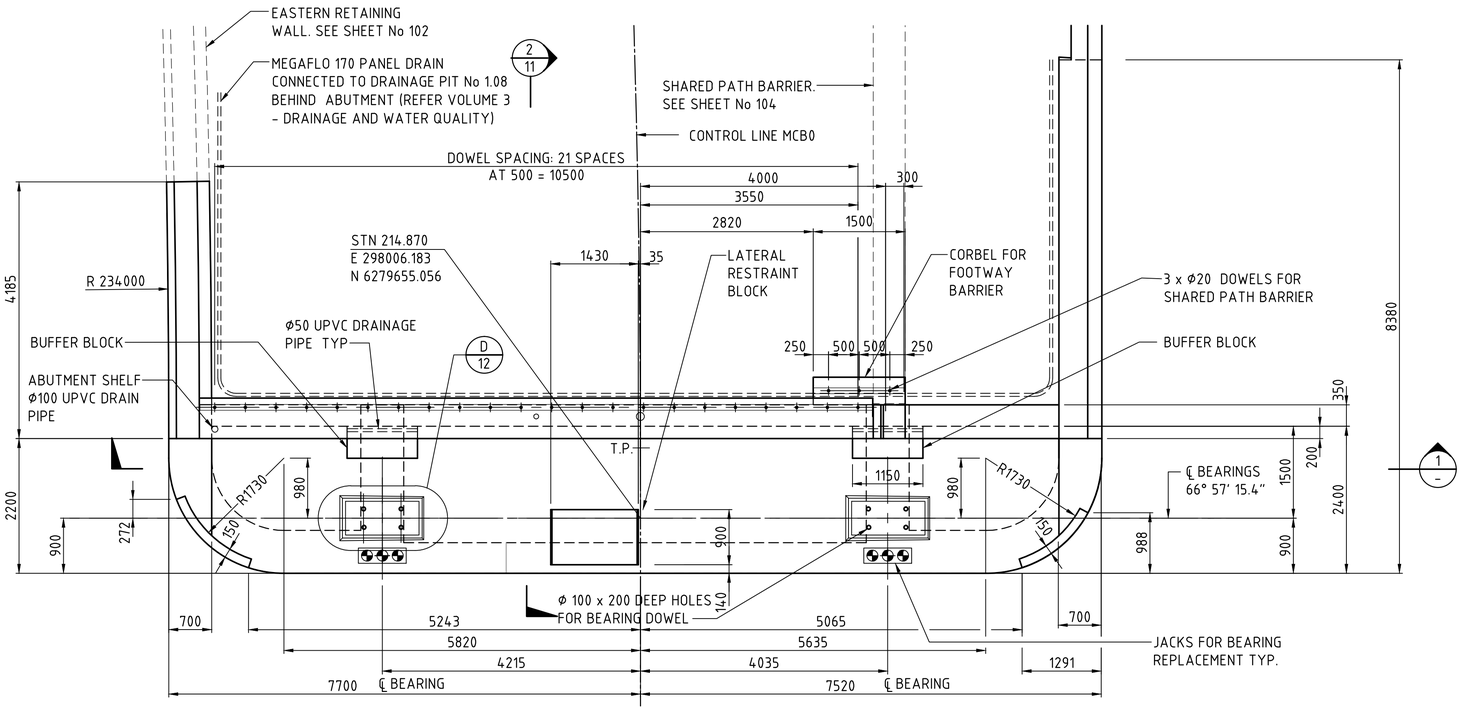

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN

MINIMUM 28 DAY COMPRESSIVE STRENGTH OF CONCRETE SHALL BE 50MPa.
MINIMUM 28 DAY COMPRESSIVE STRENGTH OF MASS CONCRETE SHALL BE 20MPa.
CONCRETE EXPOSURE CLASSIFICATION: B1.
EDGES SHALL BE CHAMFERED 20 x 20 AND RE-ENTRANT ANGLES
FILLETED 20 x 20 UNLESS SPECIFIED OTHERWISE.
CJ DENOTES CONSTRUCTION JOINT.
DENOTES JACKING POINT FOR 245 DIA FLAT JACK 200 TONNES CAPACITY.

FOR TENDER

Rev.	Date	Description	By	Ch'd	App'd
3	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A CONCRETE - SHEET A

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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27 ARGYLE ST. PARRAMATTA
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PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING D.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 10	ISSUE 3

Plot Date: 09 Apr 2018, - 11:53:08
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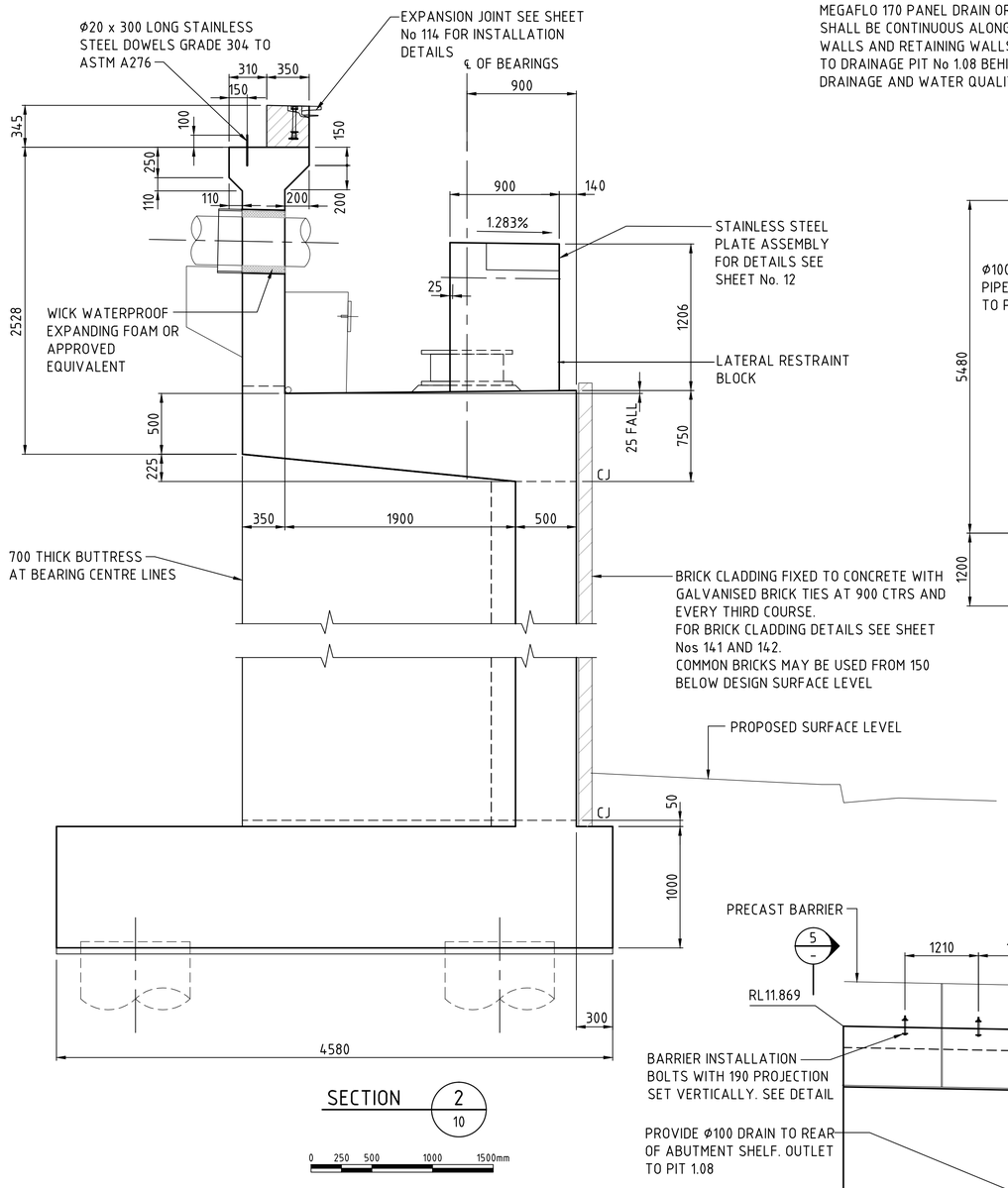
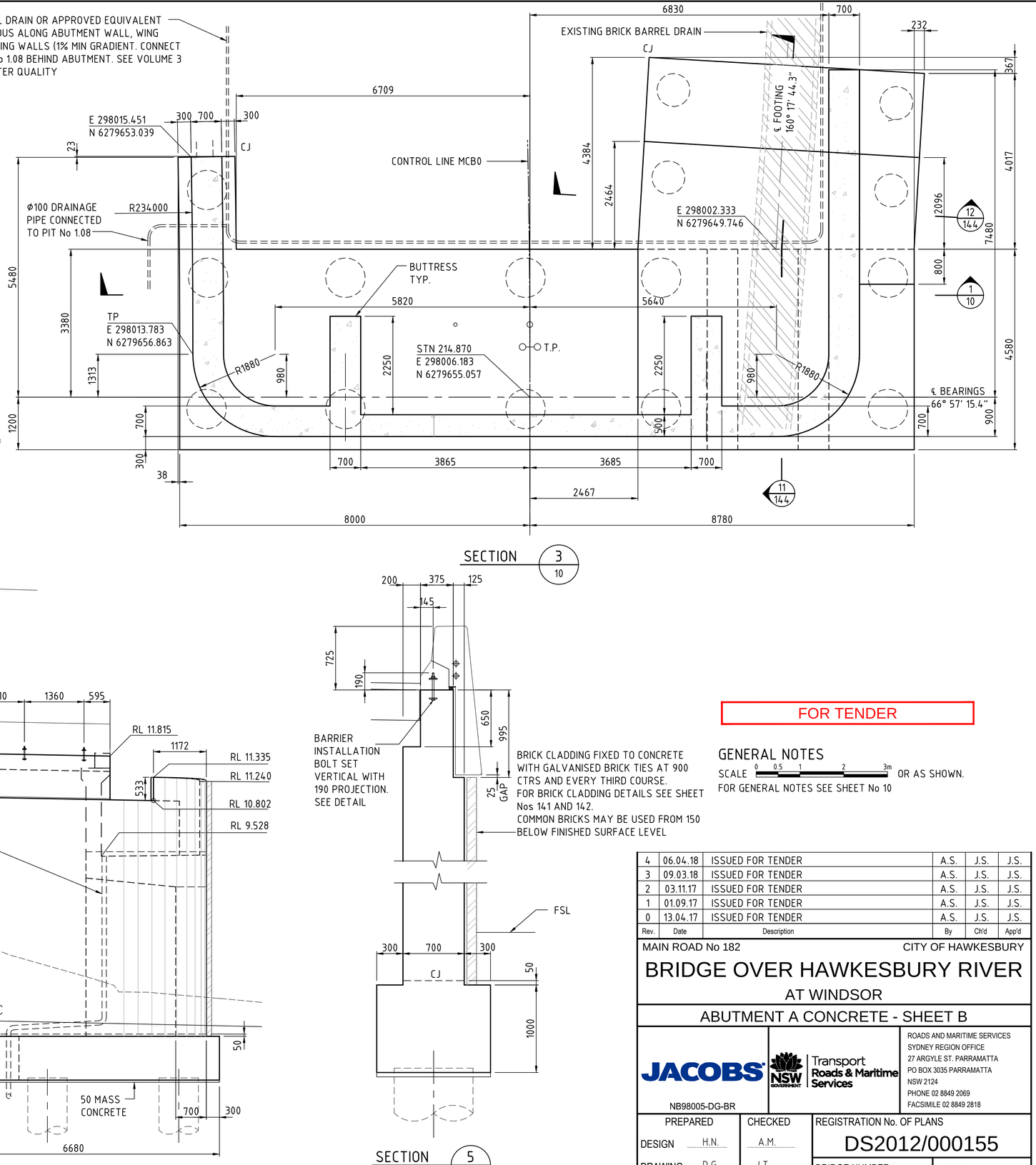
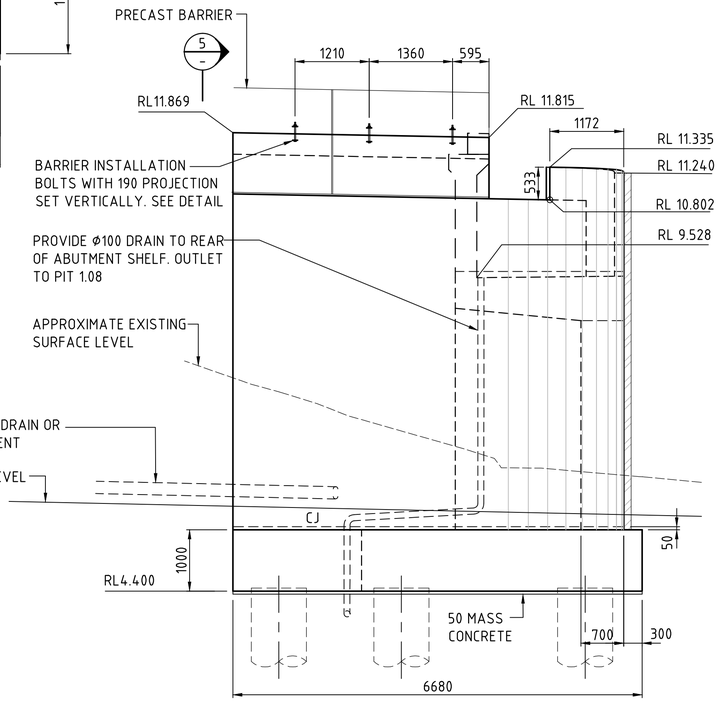


SECTION 2 / 10

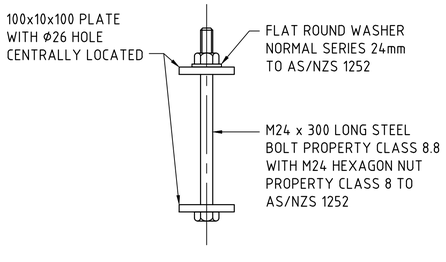


SECTION 3 / 10

SECTION 5 / -



VIEW 4 / 10



BARRIER INSTALLATION BOLT

22 ASSEMBLIES REQUIRED FOR ABUTMENTS

FOR TENDER

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 10

Rev.	Date	Description	By	Ch'd	App'd
4	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

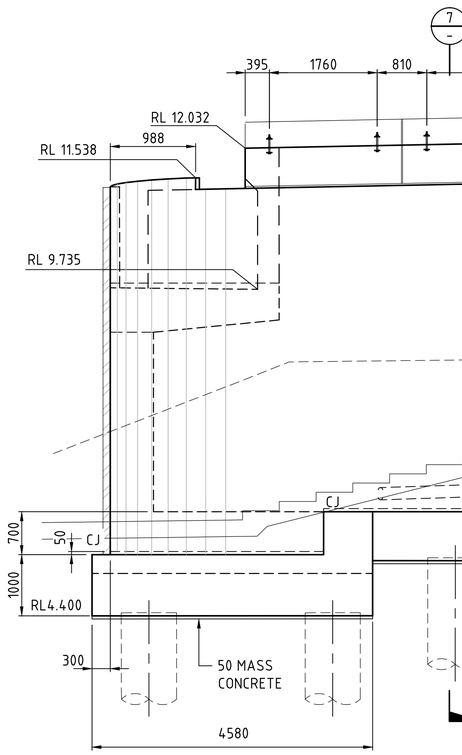
AT WINDSOR

ABUTMENT A CONCRETE - SHEET B

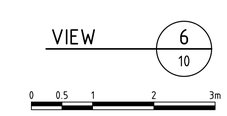
JACOBS
NB98005-DG-BR
Transport Roads & Maritime Services NSW GOVERNMENT
ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

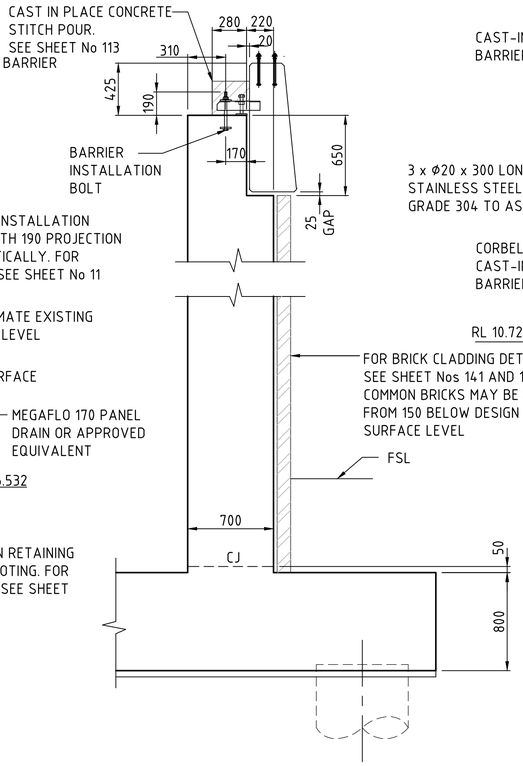
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING D.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 11	ISSUE 4

Plot Date: 09 Apr 2018, - 09:15:42 Cad File: C:\users\shuttla\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0010-0012.dwg



VIEW 6/10





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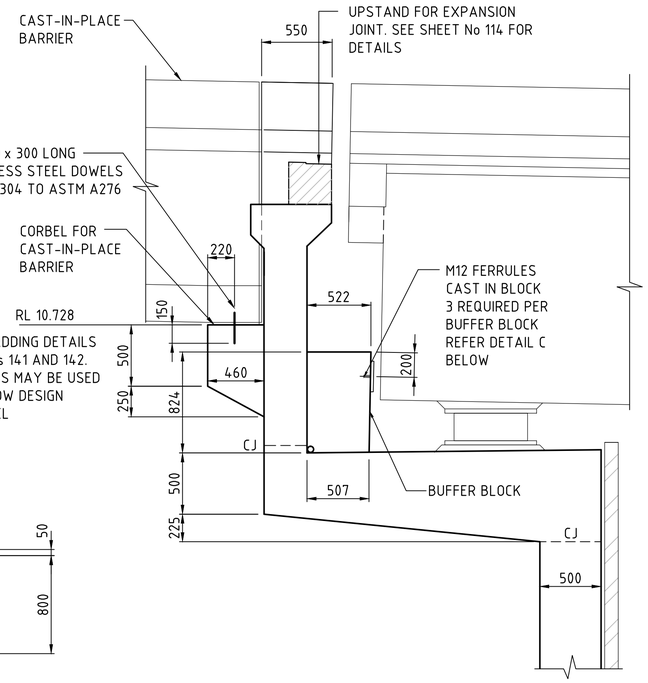

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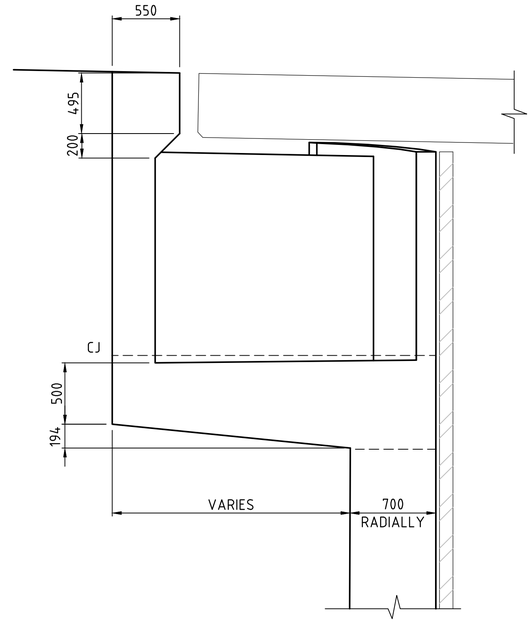

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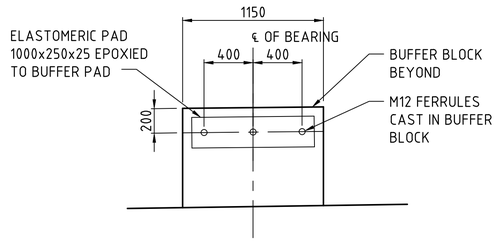

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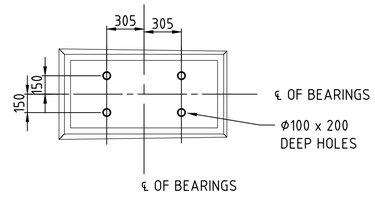

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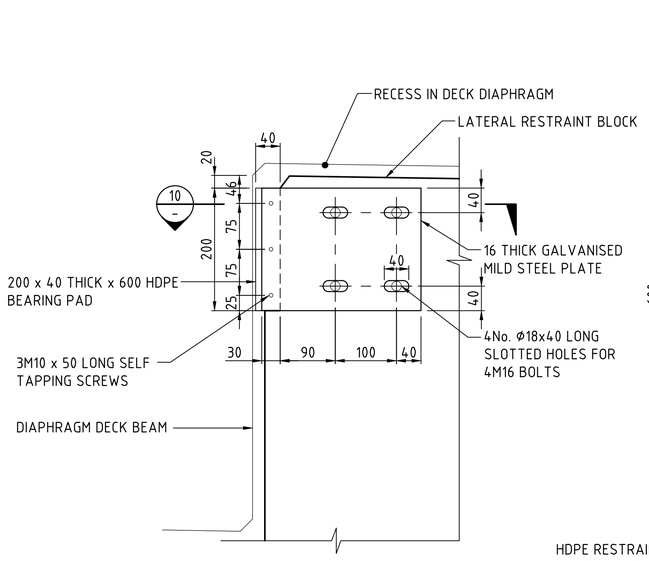

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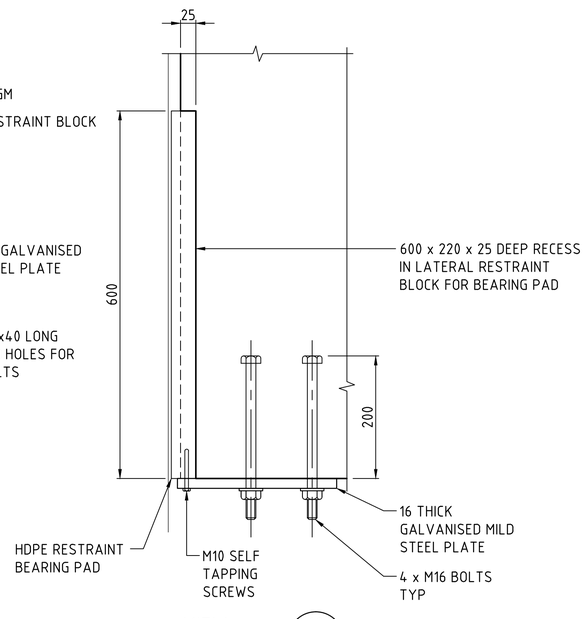


VIEW 10/-

GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 10

Rev.	Date	Description	By	Ch'd	App'd
4	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A CONCRETE - SHEET C

JACOBS

NB98005-DG-BR

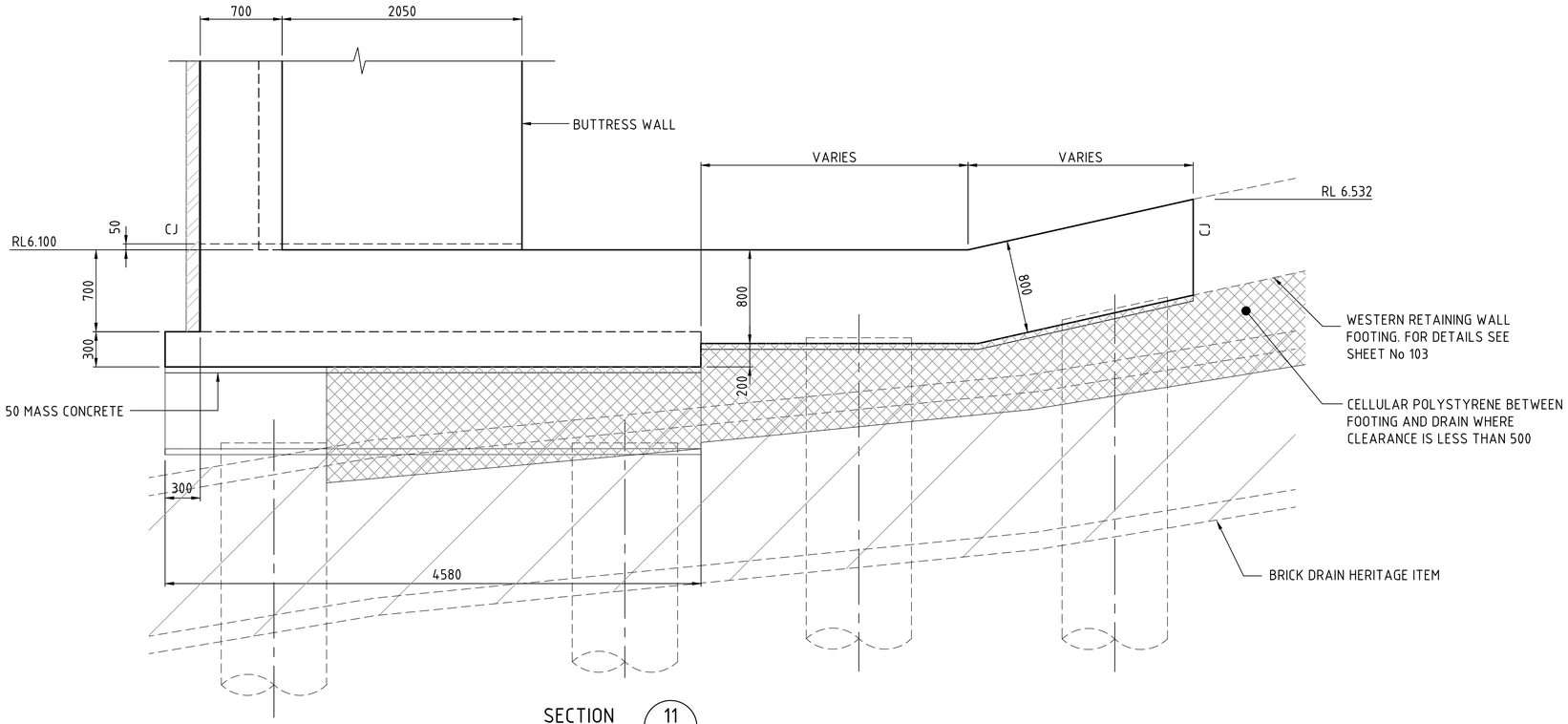
NSW GOVERNMENT Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

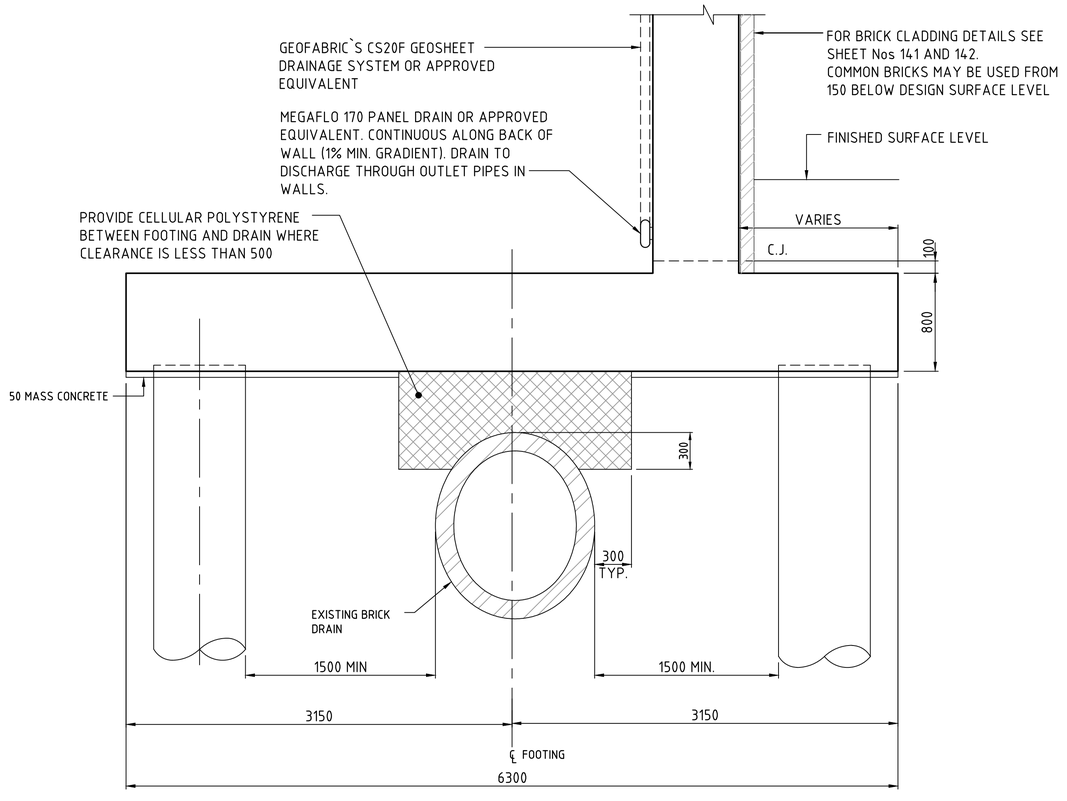
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING D.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 12	ISSUE 4

FOR TENDER

Plot Date: 05 Apr 2018, - 14:24:15 Cad File: C:\users\shutt\appdata\local\projectwise\mrs_projects\dms00616\NB98005-ECP-DG-0010-0012.dwg



SECTION 11 / 11



SECTION 12 / 11

GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 10

Rev.	Date	Description	By	Ch'd	App'd
1	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	09.03.18	ISSUED FOR TENDER	A.S.	I.C.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A CONCRETE - SHEET D

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ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
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NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN S.H.	J.S.	DS2012/000155
DRAWING A.S.	I.C.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 144 ISSUE 1

FOR TENDER

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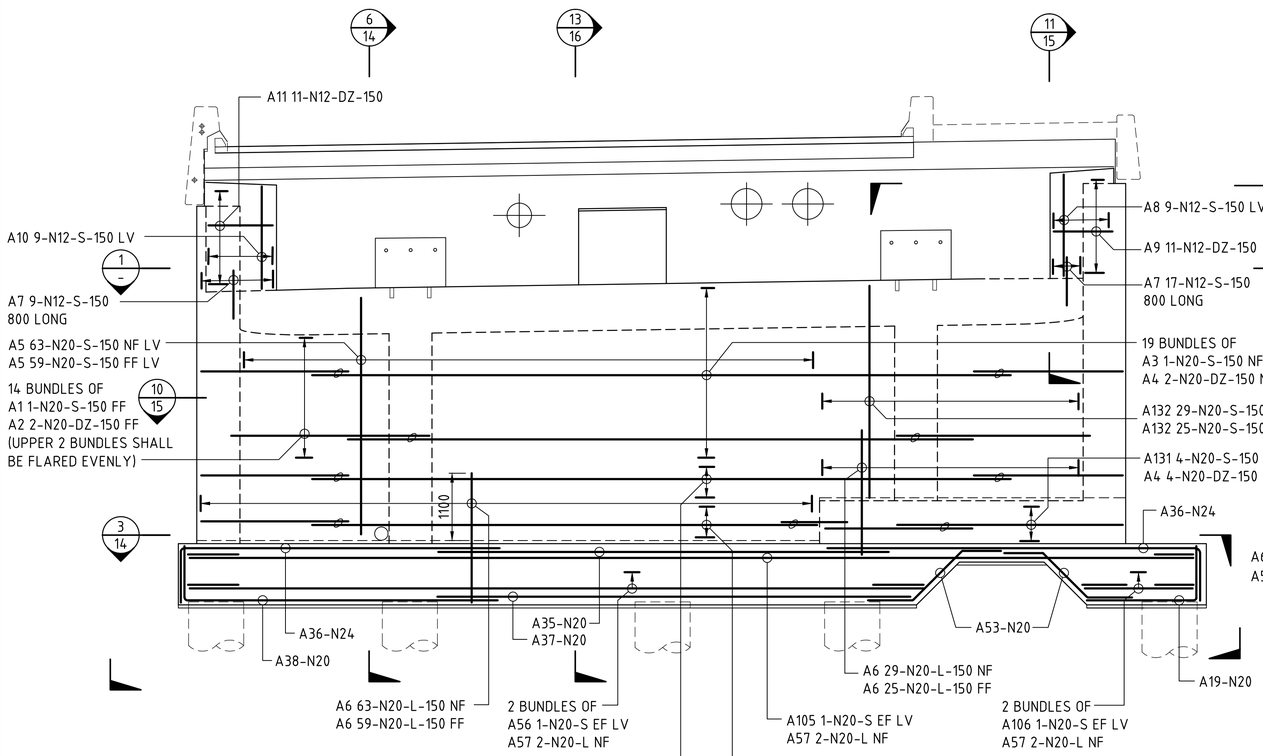
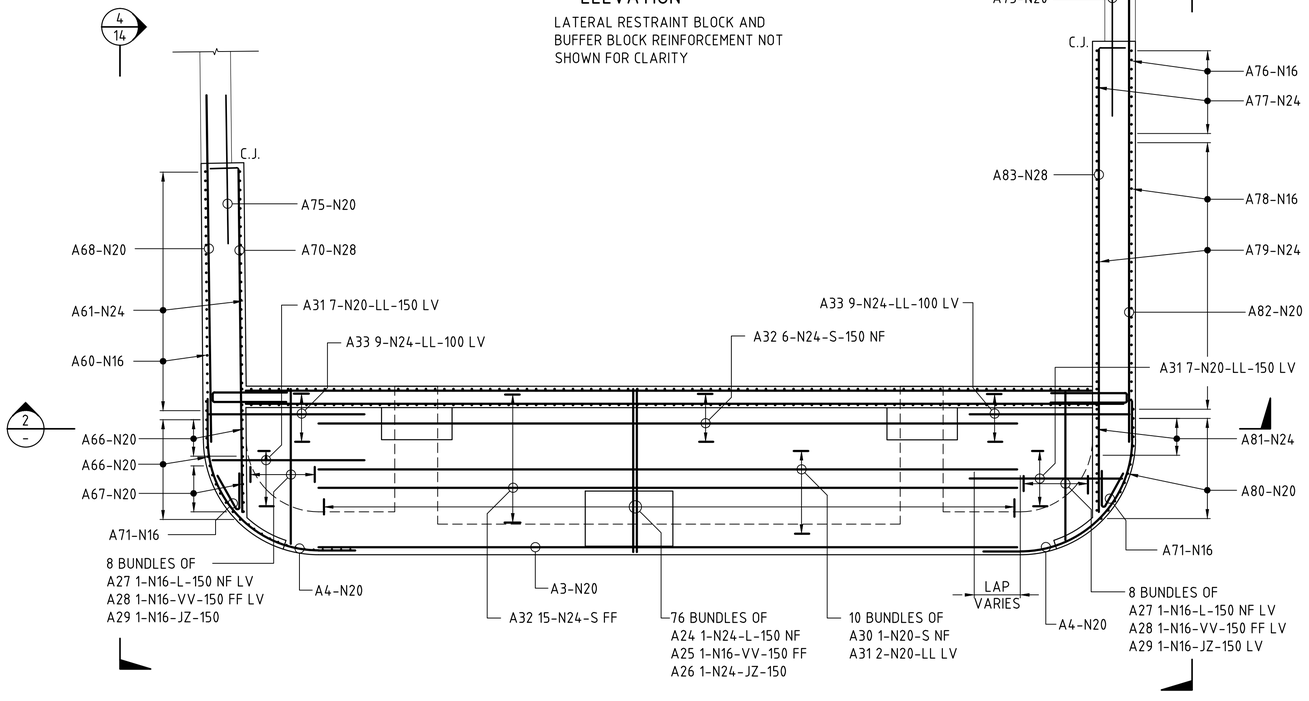
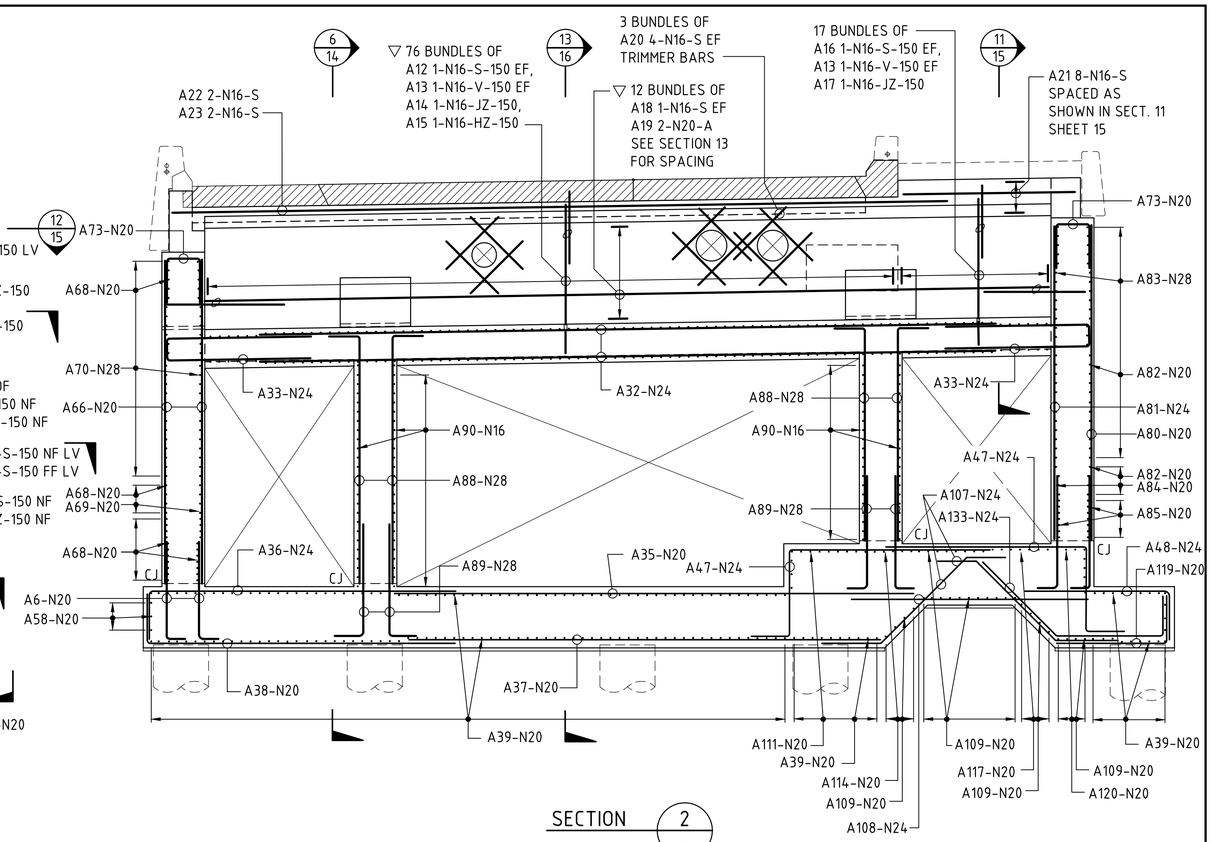


ELEVATION

LATERAL RESTRAINT BLOCK AND BUFFER BLOCK REINFORCEMENT NOT SHOWN FOR CLARITY



SECTION 1



SECTION 2

▽ A12 AND A18 BARS MAY BE CUT WHERE NECESSARY TO CLEAR HOLES

GENERAL NOTES

1. SCALE 0 0.5 1 2 3m OR AS SHOWN.
2. NOMINAL COVER NEAREST TO THE CONCRETE SURFACE SHALL BE 45mm UNLESS SPECIFIED OTHERWISE
3. REINFORCEMENT BAR SHALL BE HOT ROLLED DEFORMED BAR TO AS/NZ 4671 GRADE 500N
4. UNLESS OTHERWISE SPECIFIED, THE MINIMUM DEVELOPMENT LENGTHS AND LENGTH OF LAP SPLICES SHALL BE AS FOLLOWS:

BAR SIZE:	N12	N16	N20	N24	N28	N32	N36
HORIZONTAL BARS WITH >300mm OF CONCRETE CAST BELOW THE BAR:	475	700	975	1300	1625	2000	2375
OTHER BARS:	350	500	750	1000	1250	1525	1825

5. UNLESS SHOWN OTHERWISE ON THE DRAWINGS, LAPS ON ADJACENT BARS ON ANY FACE SHALL BE STAGGERED (OFFSET) BY NO LESS THAN 1.3 x THE LAP LENGTH.
6. BARS MAY BE DISPLACED WHERE NECESSARY TO CLEAR EXPOSED PILE BARS, RECESSES, DOWELS AND ANCHOR BOLTS.

FOR TENDER

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A REINFORCEMENT - SHEET A

JACOBS — NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING J.G.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 13 ISSUE 2

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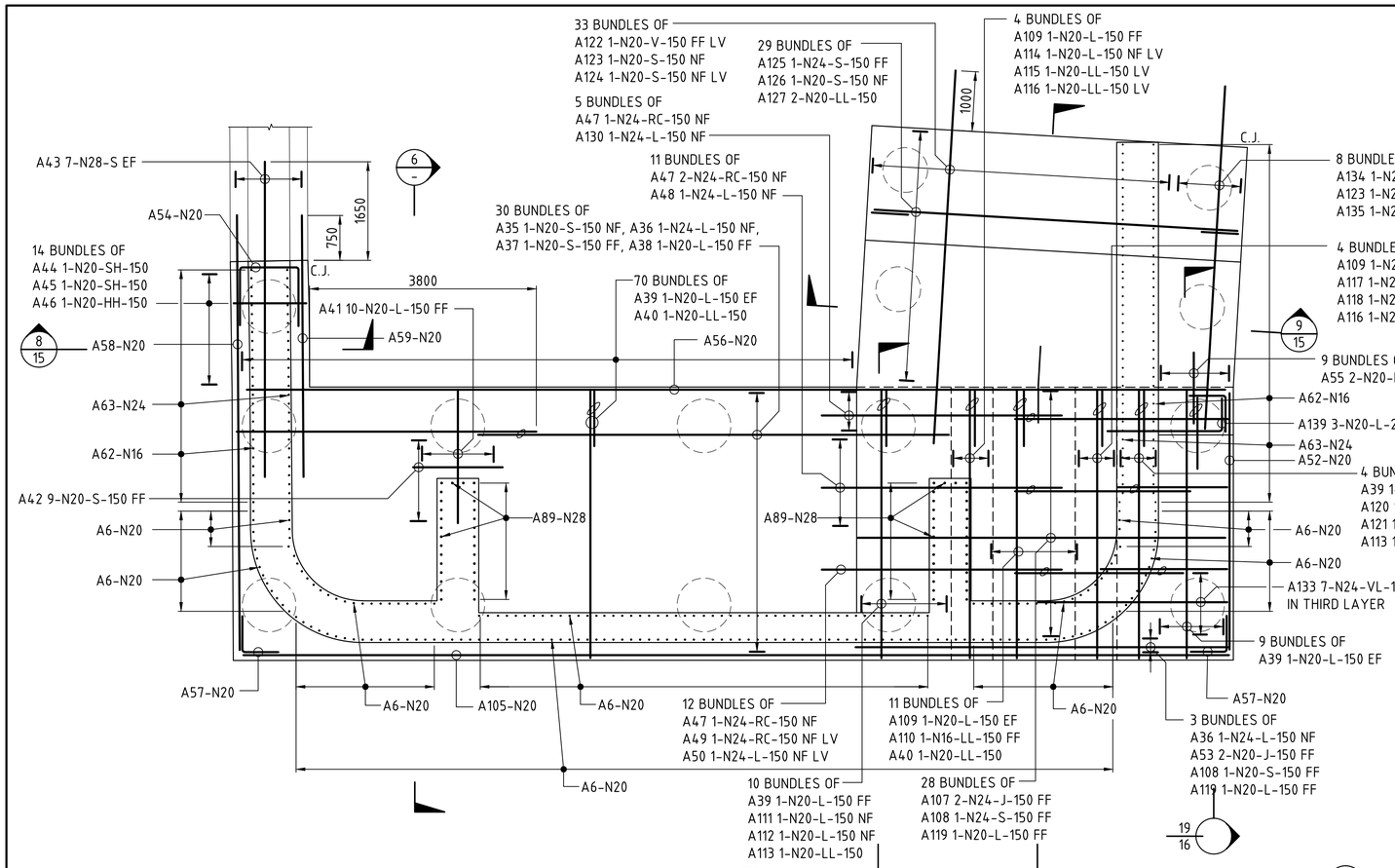
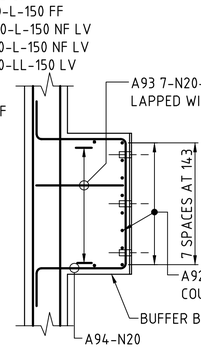


SECTION 3/13



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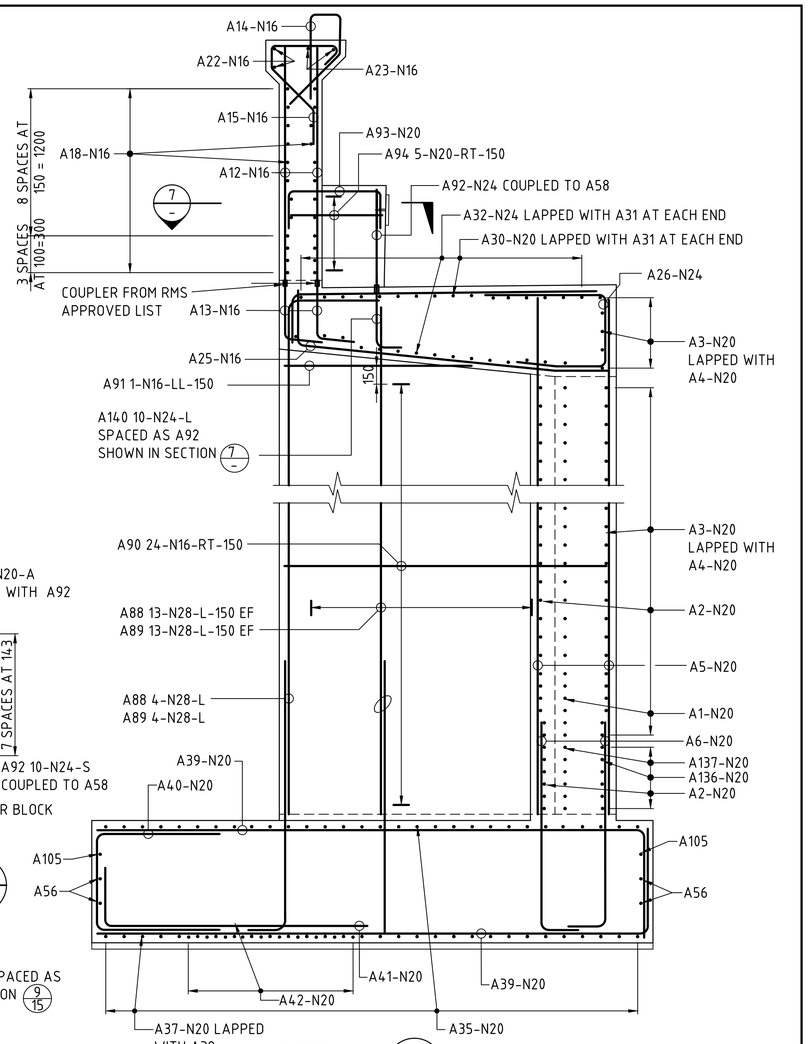

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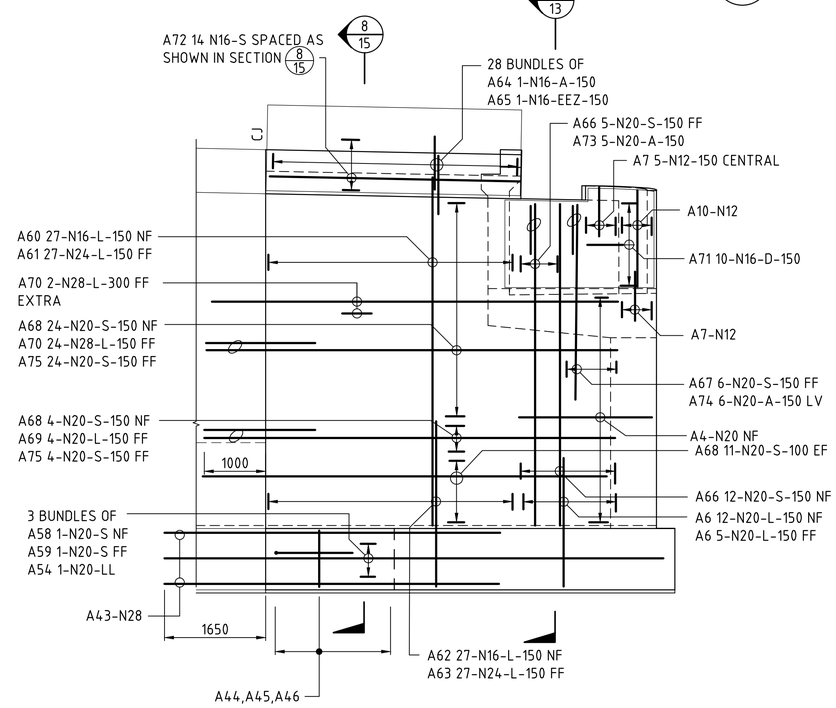
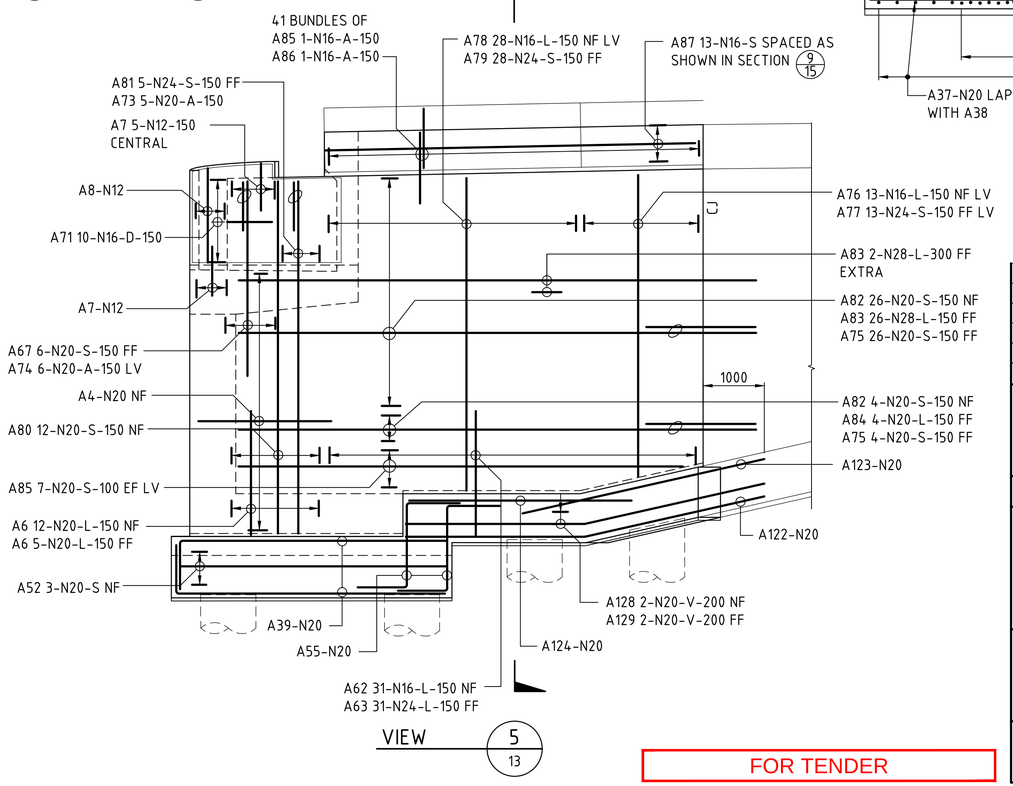


VIEW 4/13



VIEW 5/13

0 250 500 1000 1500mm

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 13

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT WINDSOR

ABUTMENT A REINFORCEMENT - SHEET B

JACOBS — NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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27 ARGYLE ST. PARRAMATTA
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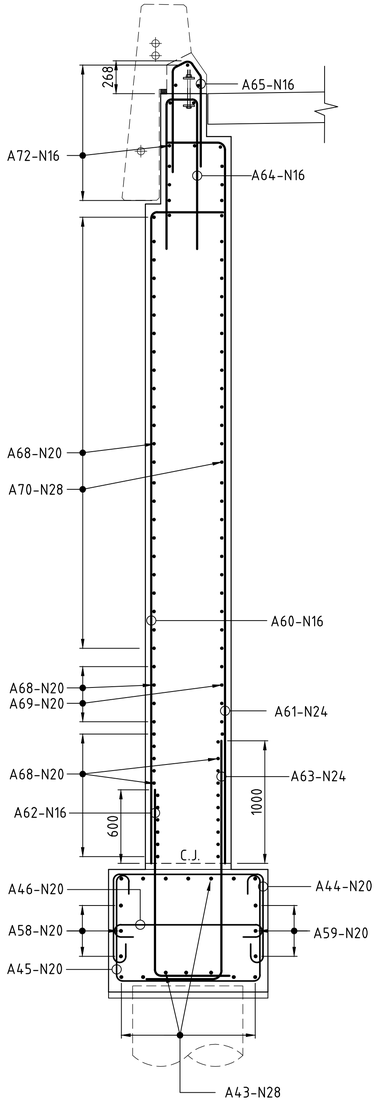
FACSIMILE 02 8849 2818

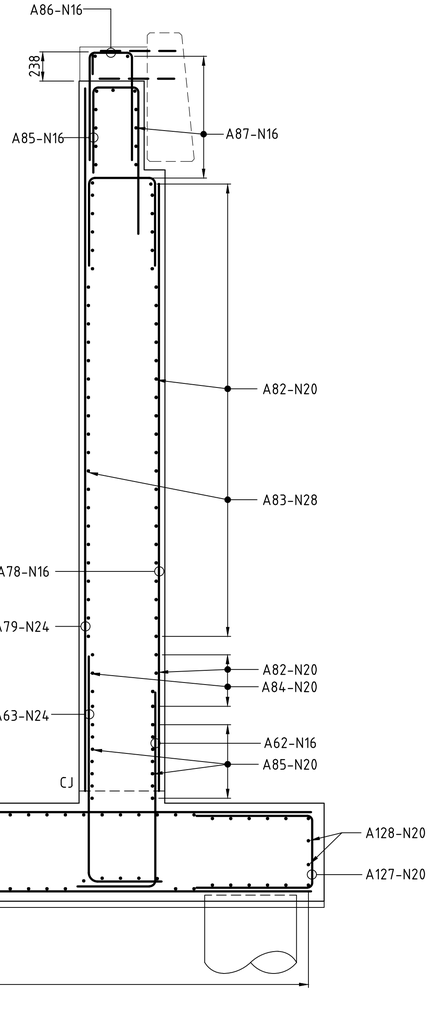
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 14	ISSUE 2

FOR TENDER

Plot Date: 09 Apr 2018, - 09:48:20 Cad File: C:\users\shuftie\appdata\local\project wise\mrs_projects\dms00616\NB98005-ECP-DG-0013-0016.dwg



SECTION 8 / 14



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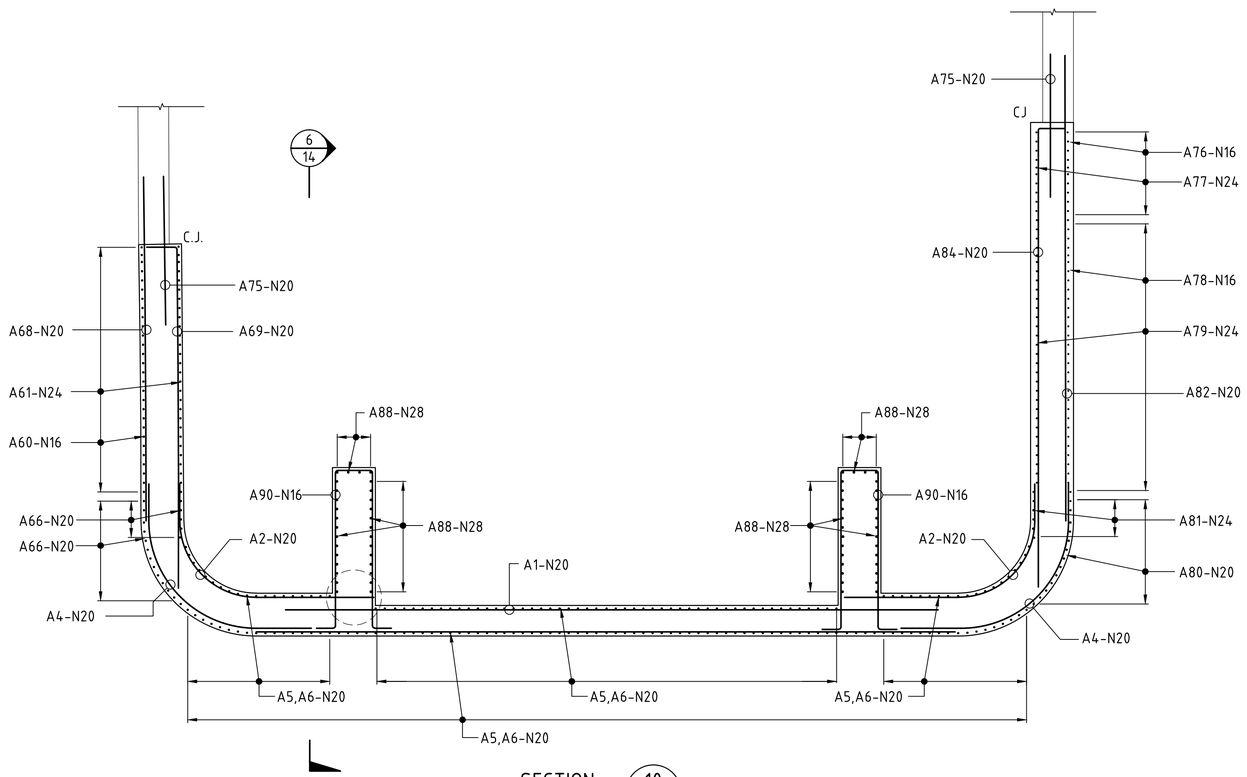
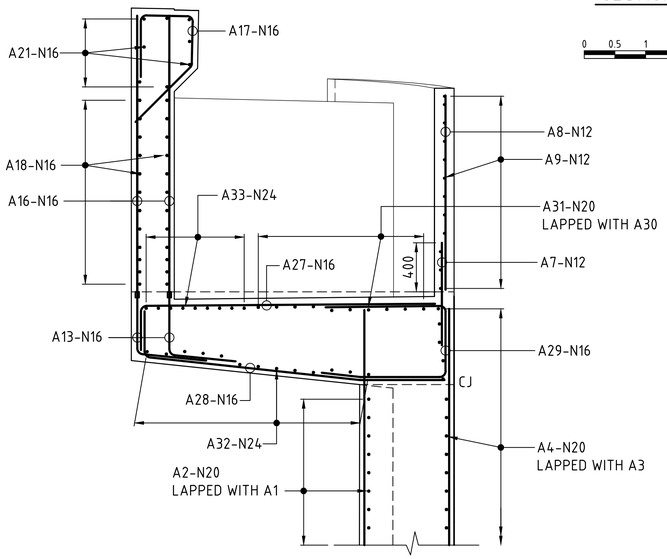


SECTION 10 / 13

0 0.5 1 2 3m



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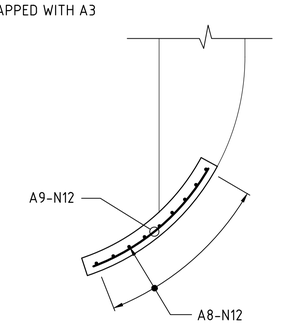

SECTION 12 / 13

FOR TENDER

GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 13

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A REINFORCEMENT - SHEET C

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
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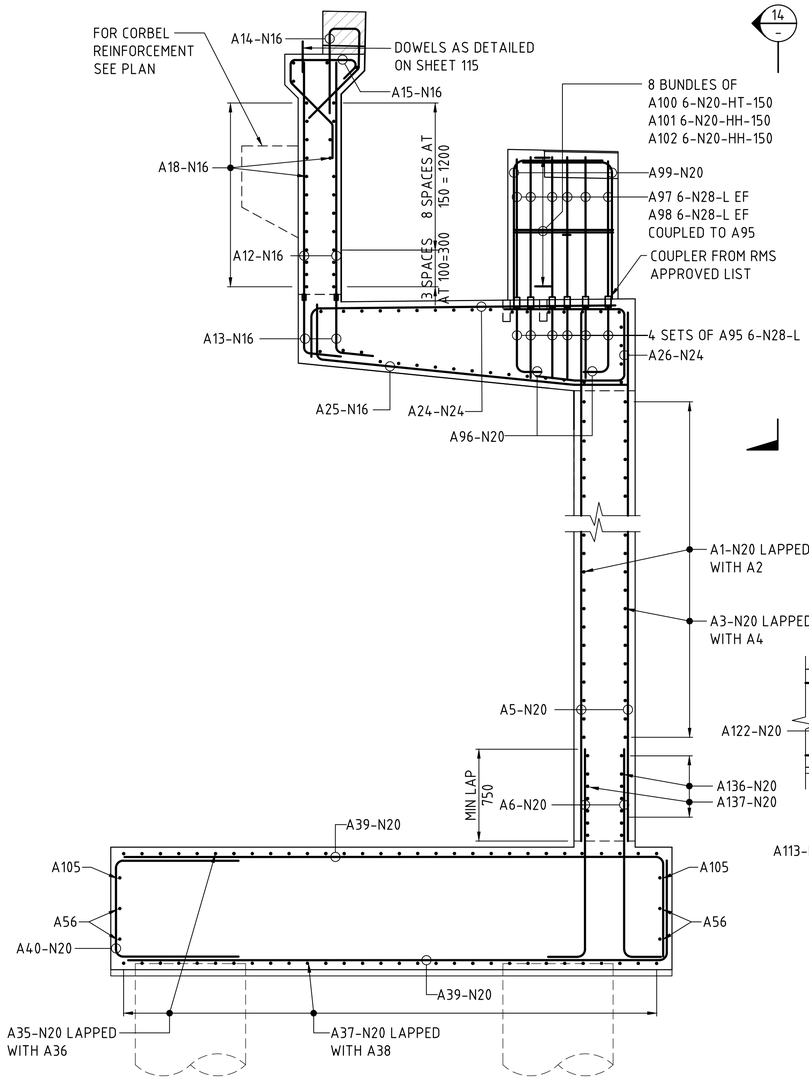
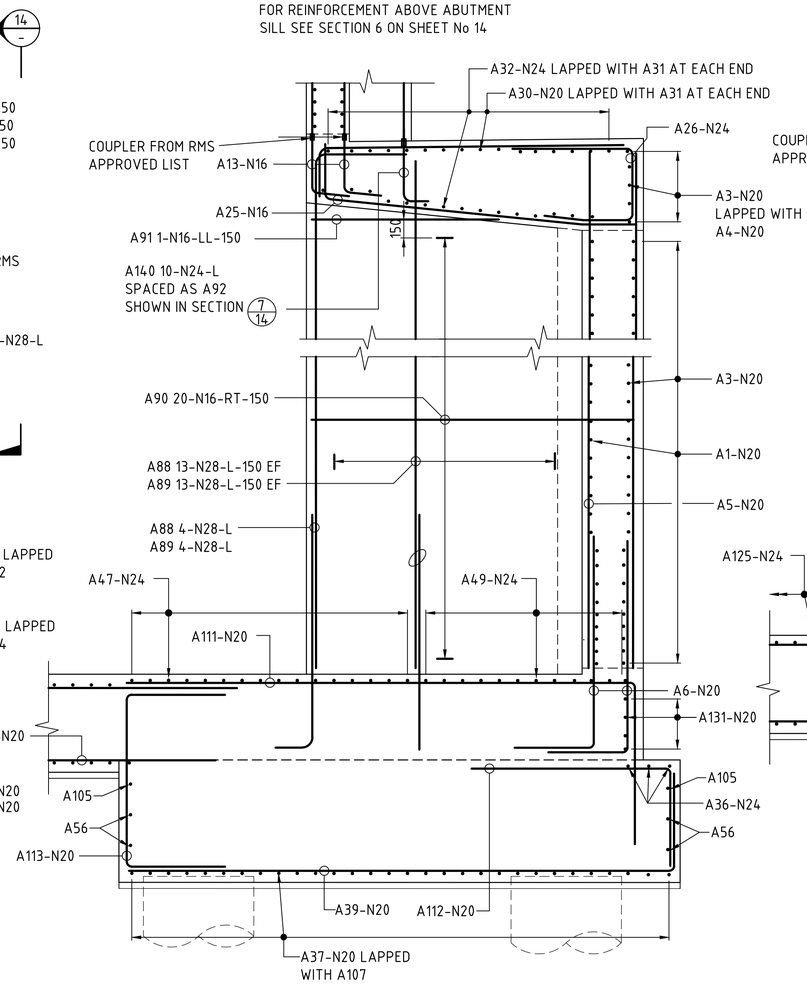
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

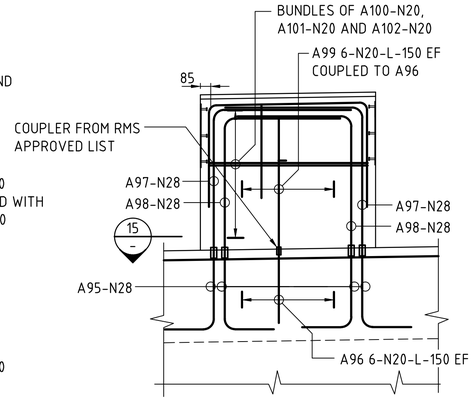
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 15	ISSUE 2

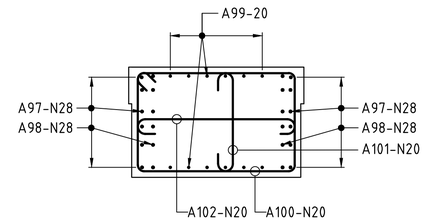
Plot Date: 09 Apr 2018, - 09:48:45 Cad File: C:\Users\shuttla\appdata\local\project+wise\rms_projects\dms90616\NB98005-ECP-DG-0013-0016.dwg



SECTION 18 / 14







SECTION 15 / -

VIEW 14 / -

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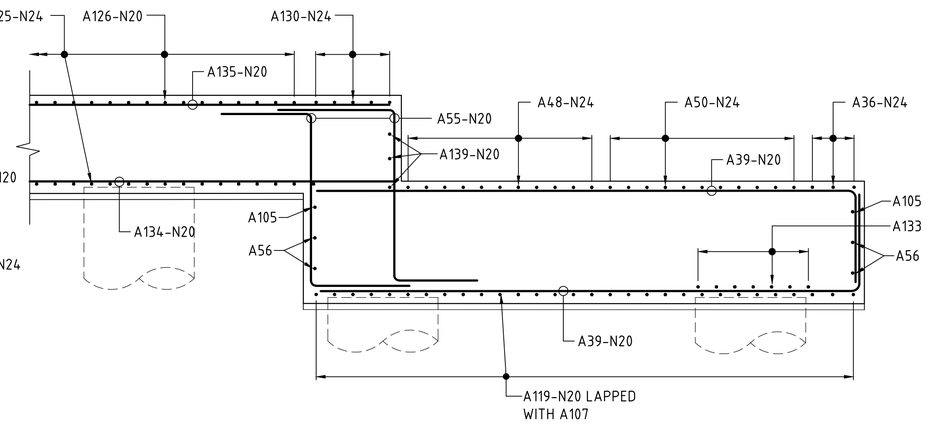
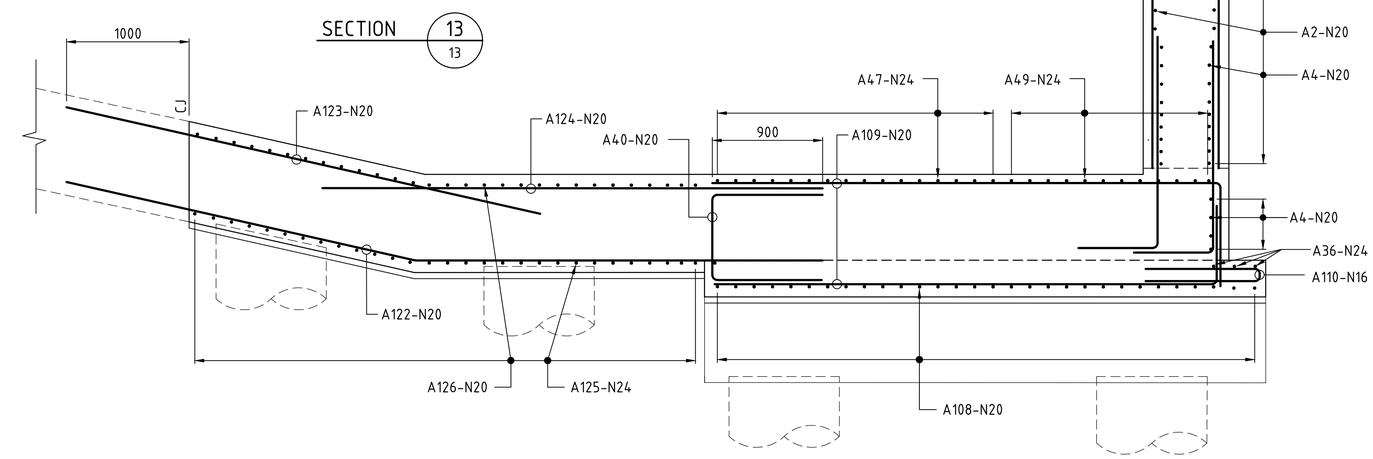


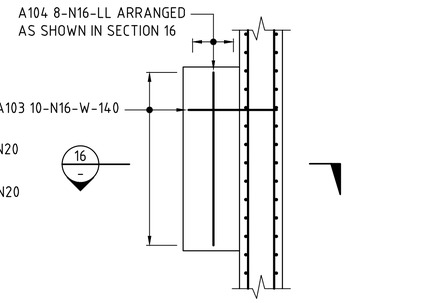
SECTION 19 / 14

FOR TENDER

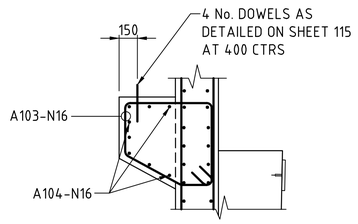


SECTION 13 / 13

SECTION 17 / 14



SHARED PATH BARIER CORBEL - PLAN



SECTION 16 / -

GENERAL NOTES

SCALE 0 250 500 1000 1500mm OR AS SHOWN

FOR GENERAL NOTES SEE SHEET No 13.

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

ABUTMENT A REINFORCEMENT - SHEET D

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED		CHECKED	
DESIGN	H.N.		A.M.
DRAWING	J.G.		I.T.

APPROVED DESIGN QA RECORDS

DIRECTOR

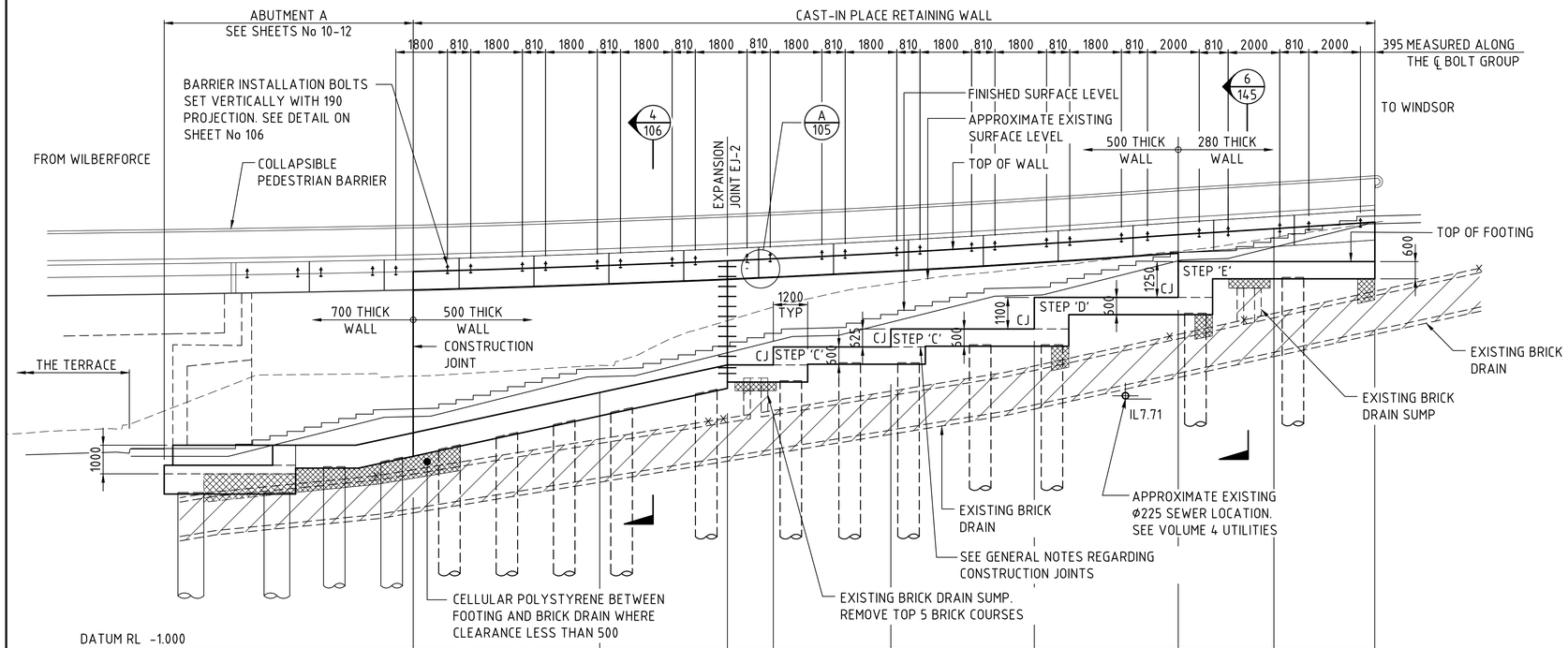
REGISTRATION No. OF PLANS: DS2012/000155

BRIDGE NUMBER: 11386

ISSUE STATUS: TENDER

SHEET No. 16 | ISSUE 2

Plot Date: 09 Apr 2018, - 09:49:18 Cad File: C:\Users\shutt\appdata\local\projectwise\mrs_projects\dms00616\NB98005-ECP-DG-0013-0016.dwg

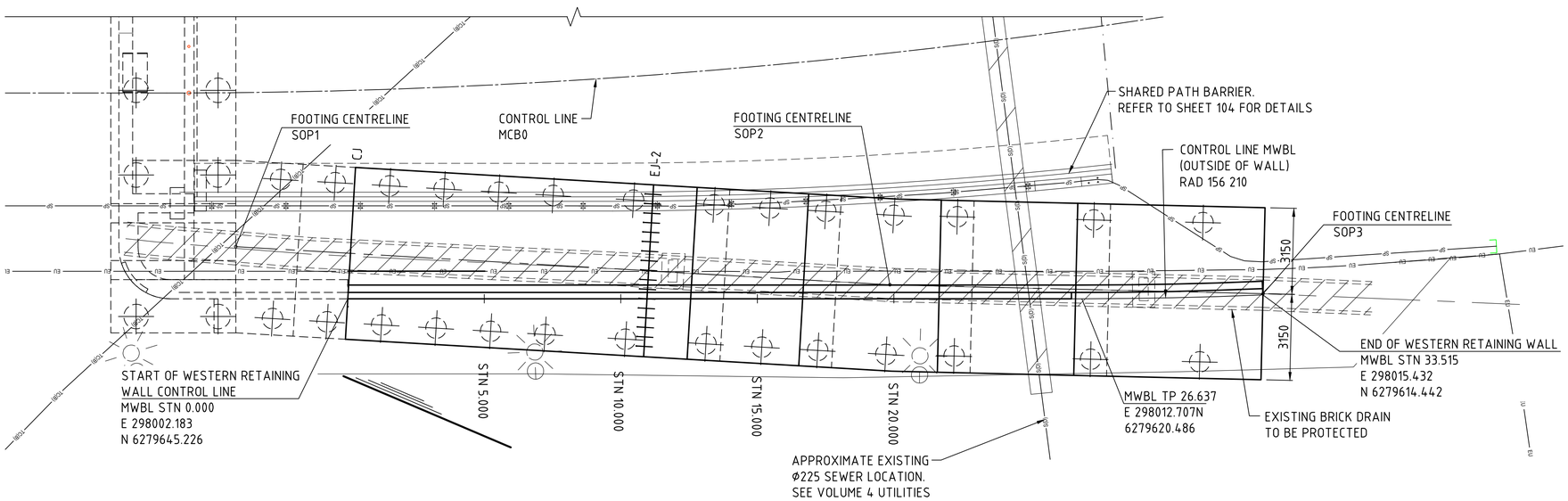


DATUM RL -1.000

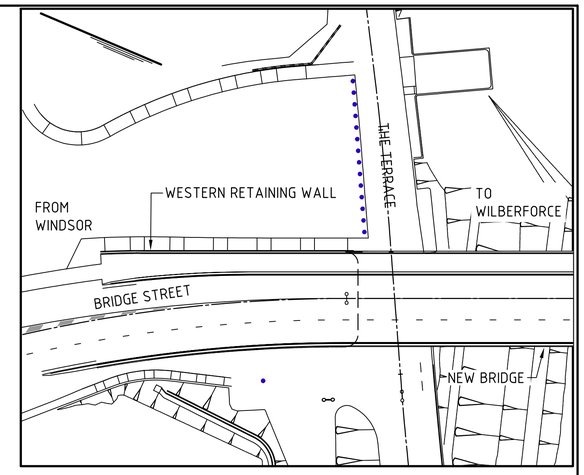
TOP OF INSITU WALL, RL	12.154	12.354	12.528	12.599	12.804	13.099	13.404	13.440	13.646	13.877	
EXISTING SURFACE LEVEL ON CONTROL LINE MWBL, RL	8.5	8.9	10.4	10.9	11.7	12.3	12.8	12.8	13.3	13.9	
TOP OF FOOTING, RL	6.532	7.996	8.900	8.900	9.525	9.525	10.150	10.150	11.250	11.250	12.500	12.500	12.500
STATION ON CONTROL LINE MWBL	0.000	6.500	10.950	12.550	16.650	21.650	TP 26.885	26.650	30.000	33.515	

WESTERN RETAINING WALL ELEVATION

(VIEWED FROM THE OUTSIDE)



PLAN - WESTERN RETAINING WALL



SITE PLAN

NOT TO SCALE

FOR TENDER

GENERAL NOTES

SCALE 0 1 2 4 6m OR AS SHOWN

FOR GENERAL NOTES SEE SHEET No 105.

FOR FOOTING SETOUT POINT COORDINATES SEE SHEET No. 8.

A HORIZONTAL CONSTRUCTION JOINT HAS BEEN PLACED IN EACH OF THE STEPS TO LIMIT THE LOADING OF WET CONCRETE ON THE EXISTING BRICK BARREL DRAIN. THE UPPER SECTION OF THE STEPS SHALL NOT BE POURED UNTIL THE LOWER SECTION HAS REACHED 25MPa AS PER THE BARREL DRAIN PROTECTION NOTES ON SHEET No 143

Rev.	Date	Description	By	Ch'd	App'd
4	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT WINDSOR

RETAINING WALL ARRANGEMENT - SHEET B

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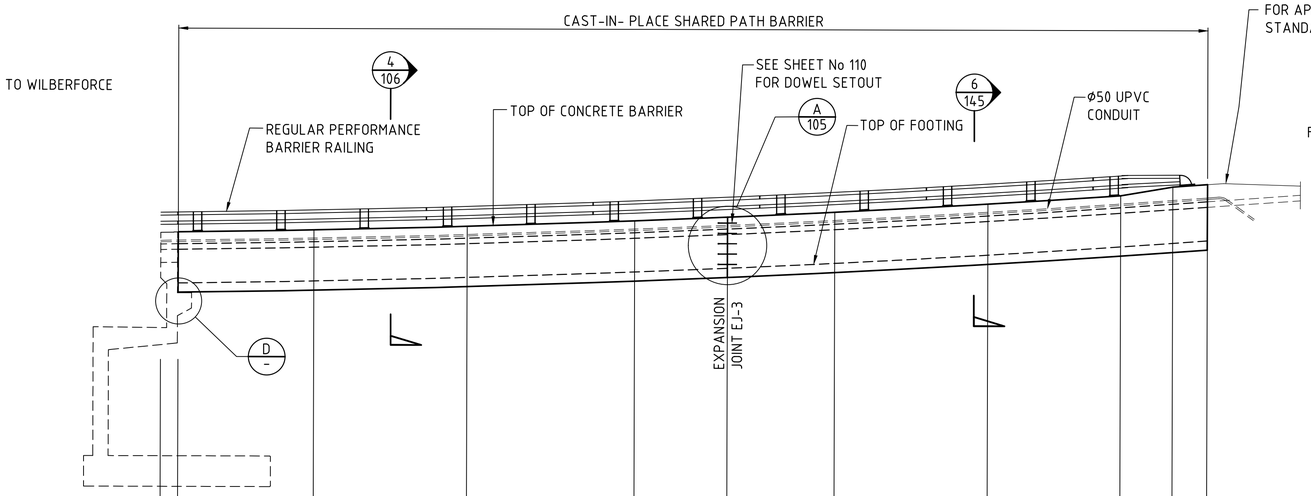
ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING J.G.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 103 ISSUE 4

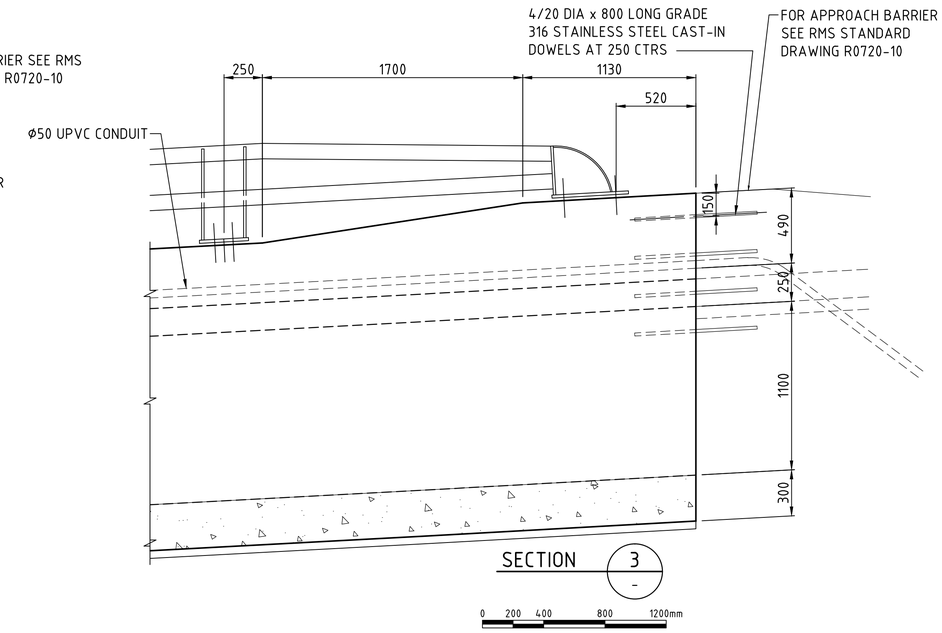
Plot Date: 09 Apr 2018, - 10:10:19 Cad File: C:\Users\shuffa\appdata\local\project wise\rms_projects\dms90616\NB98005-ECP-DG-0102-0112.dwg

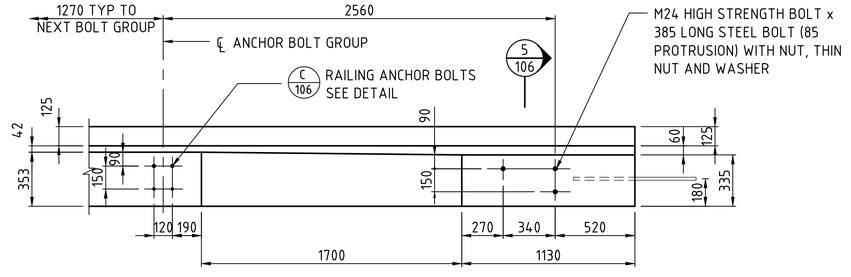


DATUM RL 0.000

TOP OF CONCRETE BARRIER, RL	12.714	12.723	12.801	12.931	13.122	13.251	13.420	13.702	13.985	14.275	14.358
EXISTING SURFACE LEVEL, RL	8.5	8.5	8.6	8.6	9.2	10.3	11.4	12.3	12.5	12.7	13.0
TOP OF FOOTING, RL	N/A	11.043	11.121	11.251	11.447	11.571	11.740	12.022	12.305	12.425	12.508
DISTANCE ALONG ROAD FACE OF BARRIER	0.000	0.570	5.000	10.000	15.469	TP 18.500	22.000	27.000	31.334	33.034	34.164

ELEVATION - SHARED PATH BARRIER AND FOOTING

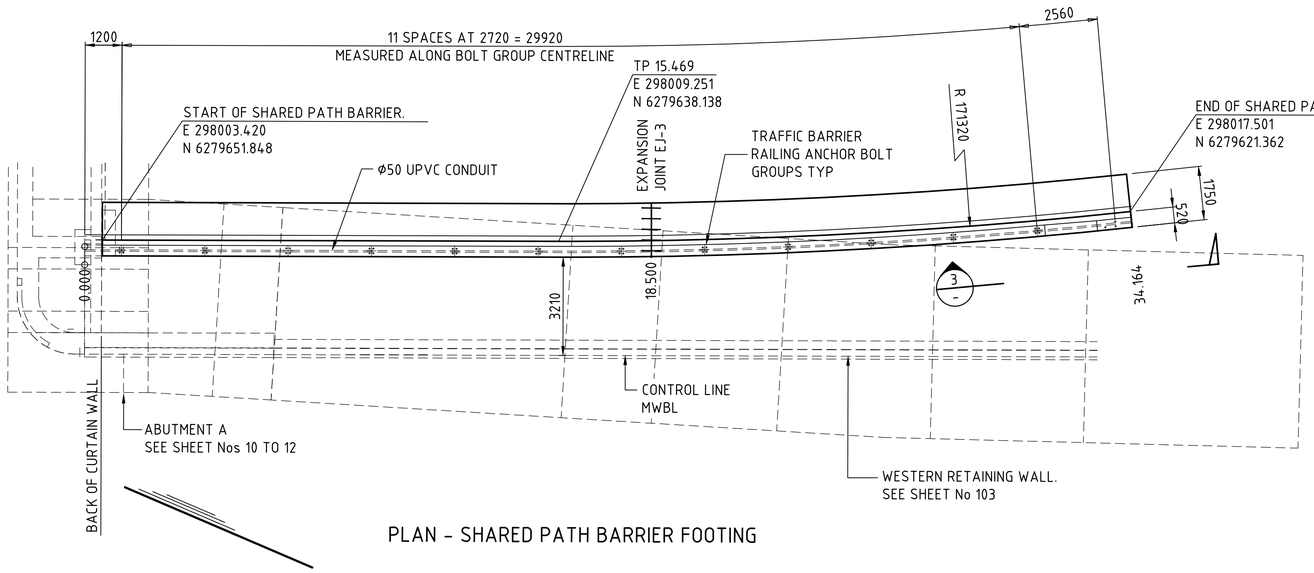




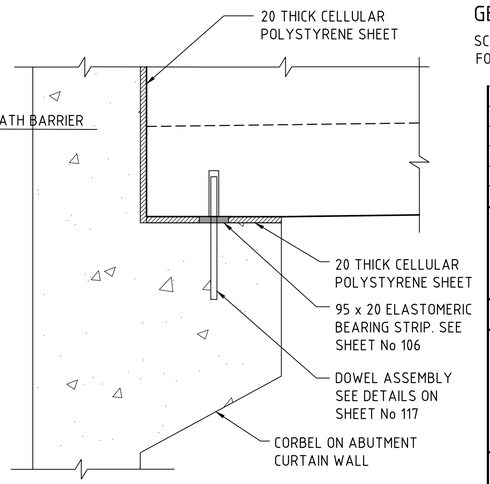
PLAN - BARRIER TERMINATION

0 200 400 800 1200mm

FOR TENDER



PLAN - SHAPED PATH BARRIER FOOTING



DETAIL D/-

0 100 200 400 600mm

GENERAL NOTES

SCALE 0 1 2 4 6m OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 105.

Rev.	Date	Description	By	Ch'd	App'd
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

SHARED PATH BARRIER - ARRANGEMENT

JACOBS

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ROADS AND MARITIME SERVICES
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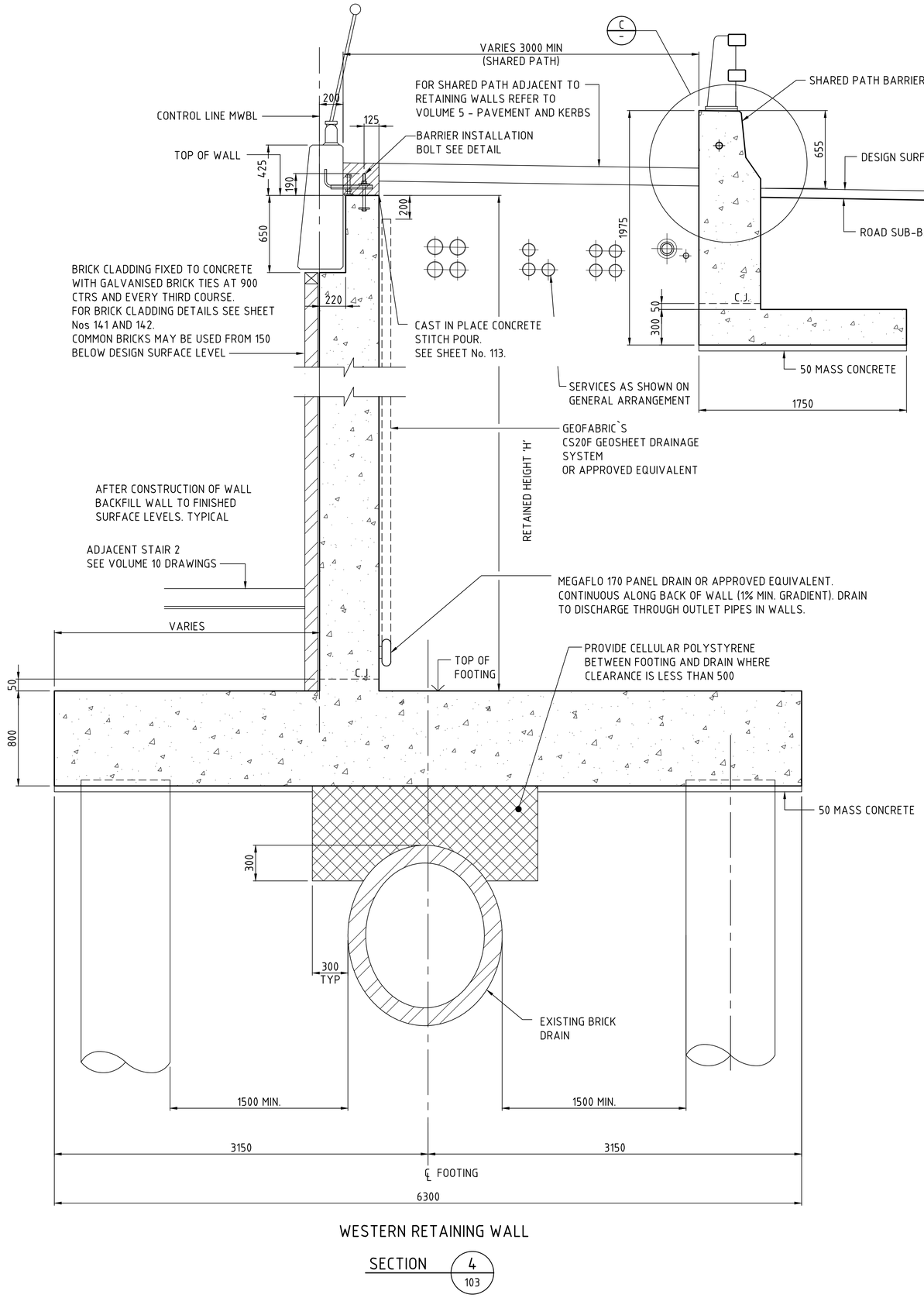
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

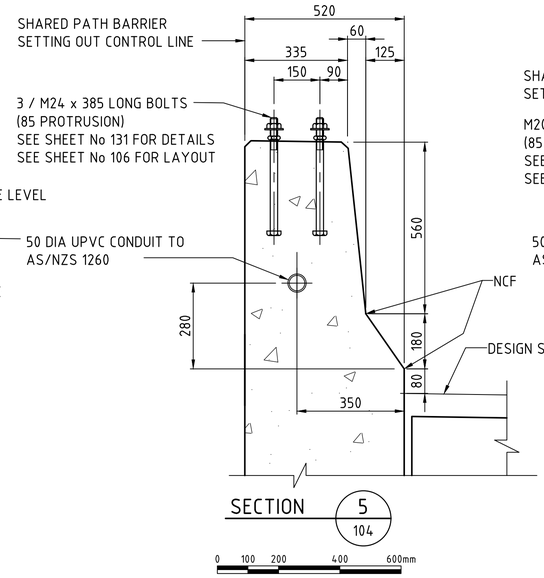
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 104	ISSUE 3

Plot Date: 09 Mar 2018, - 17.04.26 Cad File C:\users\shuttla\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg

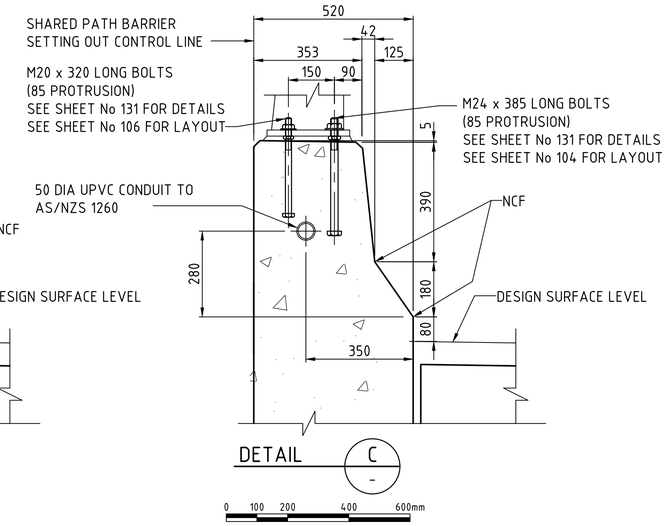


WESTERN RETAINING WALL

SECTION 4/103

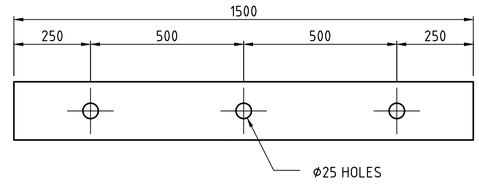


SECTION 5/104

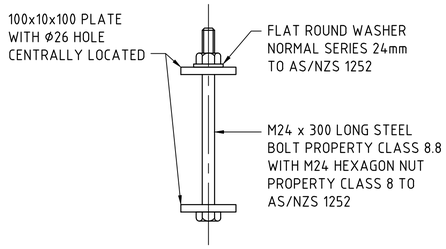


DETAIL C/-

0 100 200 400 600mm



BEARING STRIP - SHARED PATH BARRIER
NOT TO SCALE
DUROMETER HARDNESS 60
1 NO. REQUIRED



BARRIER INSTALLATION BOLT
52 ASSEMBLIES REQUIRED FOR RETAINING WALLS

0 50 100 200 300mm

FOR TENDER

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 105.

Rev.	Date	Description	By	Ch'd	App'd
4	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
3	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

RETAINING WALL SECTIONS - SHEET B

JACOBS

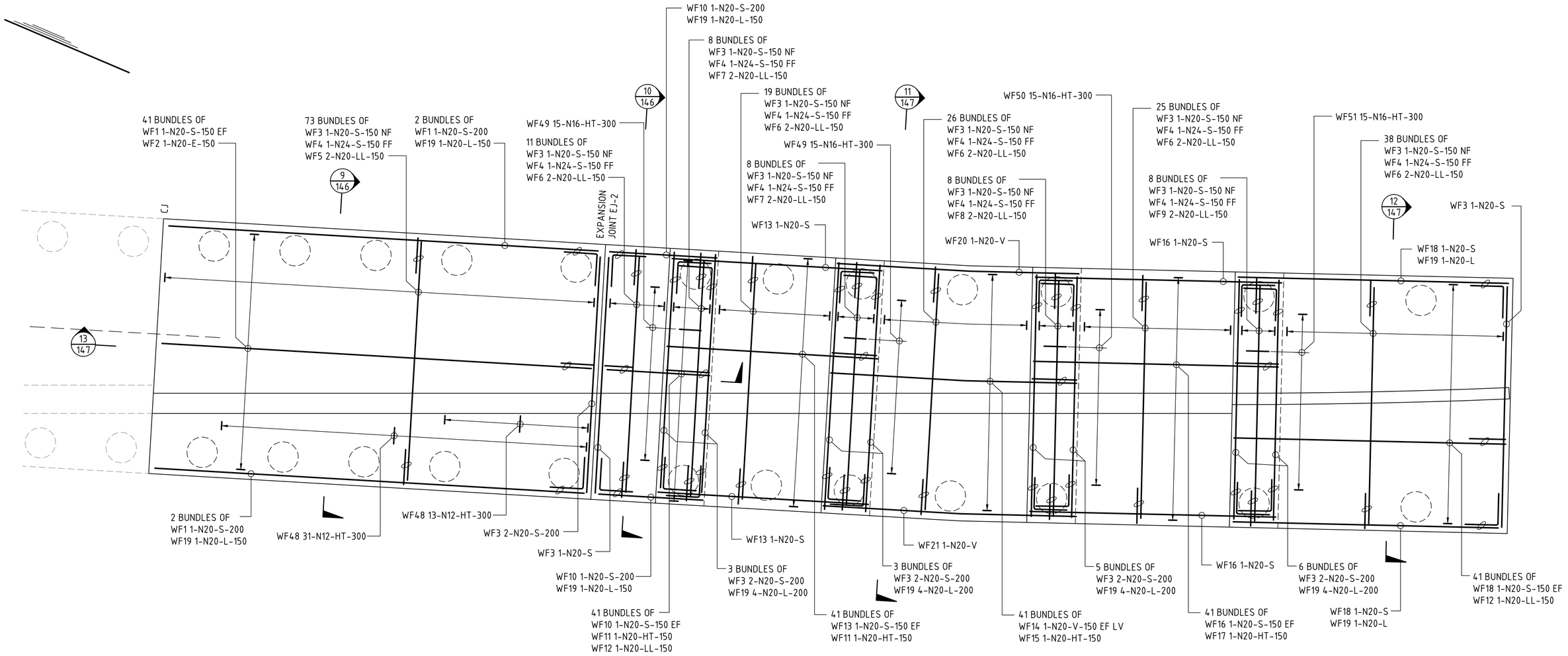
NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 106	ISSUE 4

Plot Date: 06 Apr 2018, - 18:07:19 Cad File: C:\users\shuffla\appdata\local\project wise\mrs_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



PLAN – WESTERN RETAINING WALL FOOTING

FOR TENDER

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN

REINFORCEMENT SHALL BE GRADE D500N UNLESS SPECIFIED OTHERWISE.
NOMINAL COVER TO REINFORCEMENT NEAREST TO THE CONCRETE SURFACE SHALL BE 45mm UNLESS SPECIFIED OTHERWISE.
UNLESS OTHERWISE SPECIFIED, THE MINIMUM DEVELOPMENT LENGTHS SHALL AND LENGTHS OF LAP SPLICES SHALL BE AS FOLLOWS:

BAR SIZE	N12	N16	N20	N24	N28	N32	N36
a) HORIZONTAL BARS WITH >300mm OF CONCRETE CAST BELOW THE BAR.	475	700	975	1300	1625	2000	2375
b) OTHER BARS	350	550	750	1000	1250	1525	1825

UNLESS SPECIFIED OTHERWISE, LAPS ON ADJACENT BARS ON ANY FACE SHALL BE STAGGERED (OFFSET) BY NO LESS THAN 1.3 X THE LAP LENGTH.
NF-DENOTES NEAR FACE
FF-DENOTES FAR FACE
EF-DENOTES EACH FACE
LV-DENOTES VARIABLE LENGTH BARS
REINFORCEMENT SHALL BE DISPLACED WHERE NECESSARY TO CLEAR ANCHOR BOLTS, RECESSES AND DUCTS.
REINFORCEMENT SHALL BE EQUALLY SPACED UNLESS STATED OTHERWISE.

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET B

JACOBS
NB98005-DG-BR

Transport Roads & Maritime Services
NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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27 ARGYLE ST. PARRAMATTA
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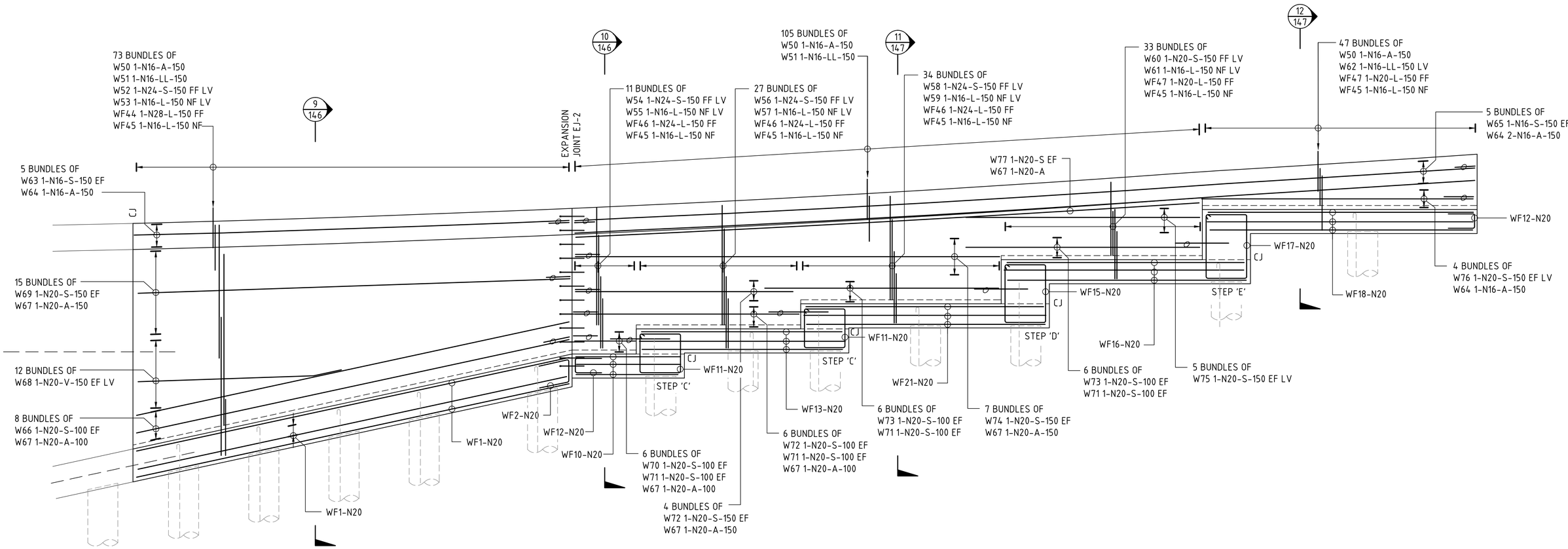
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 108	ISSUE 2

Plot Date: 09 Apr 2018, - 10:24:42 Cad File: C:\Users\shuttla\appdata\local\project wise\tms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



WESTERN RETAINING WALL ELEVATION
(VIEWED FROM THE OUTSIDE)

FOR TENDER

GENERAL NOTES
SCALE 0 0.5 1 2 3m OR AS SHOWN

FOR GENERAL NOTES RELATING TO THIS SHEET SEE SHEET No 108

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER
AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET C

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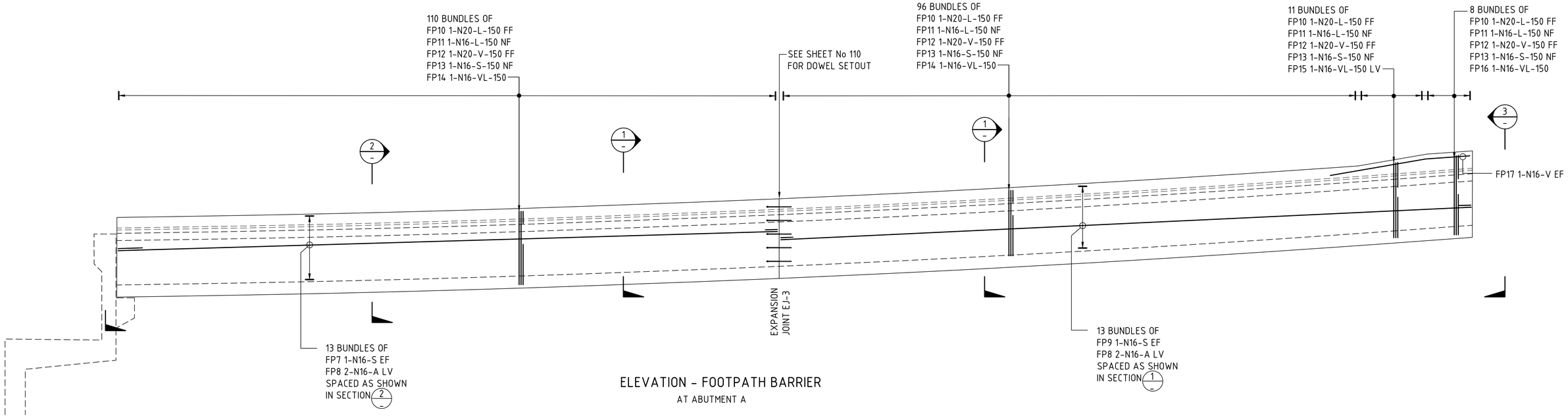
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

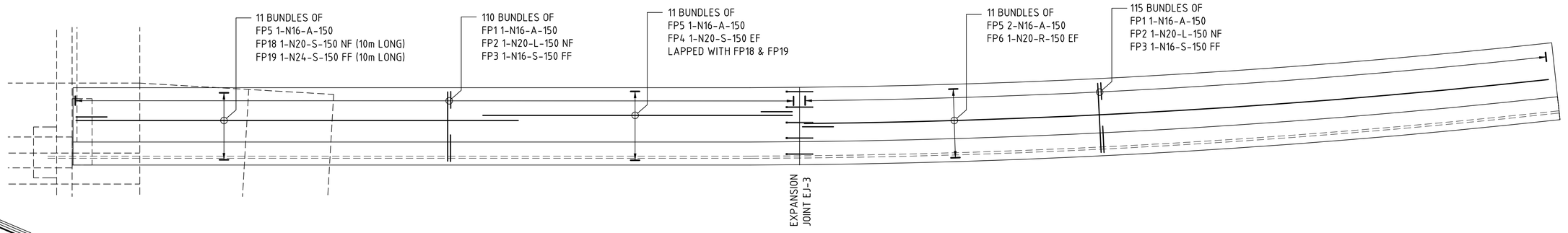
PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING J.G.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 109 ISSUE 2

Plot Date: 06 Apr 2018, - 18:06:18 Cad File: C:\users\shuftia\appdata\local\project wise\rms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



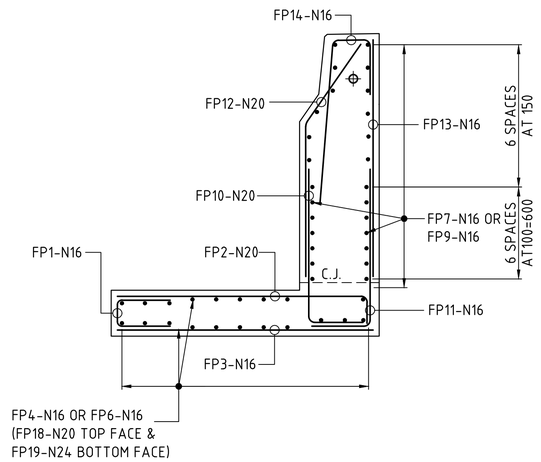
ELEVATION - FOOTPATH BARRIER

AT ABUTMENT A

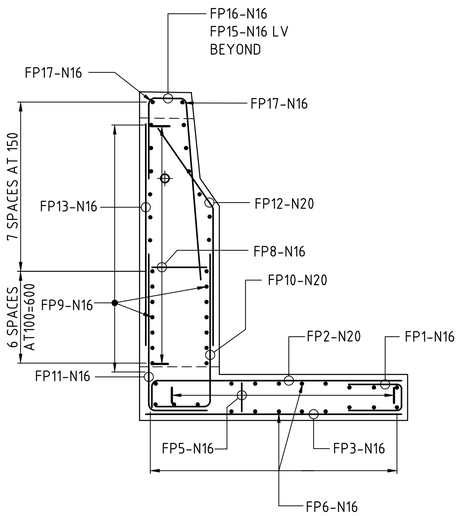


PLAN - FOOTPATH BARRIER

AT ABUTMENT A



SECTION 1 - 2 - SIMILAR EXCAEPT AS NOTED IN BRACKETS



SECTION 3 -

FOR TENDER

GENERAL NOTES

SCALE 0 0.5 1 2 3m OR AS SHOWN.

FOR GENERAL NOTES SEE SHEET No 105.

Rev.	Date	Description	By	Ch'd	App'd
3	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
2	03.11.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET D

JACOBS — NB98005-DG-BR

NSW GOVERNMENT Transport Roads & Maritime Services

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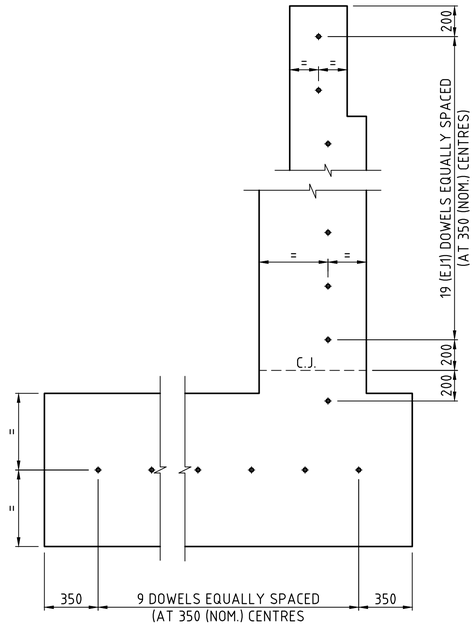
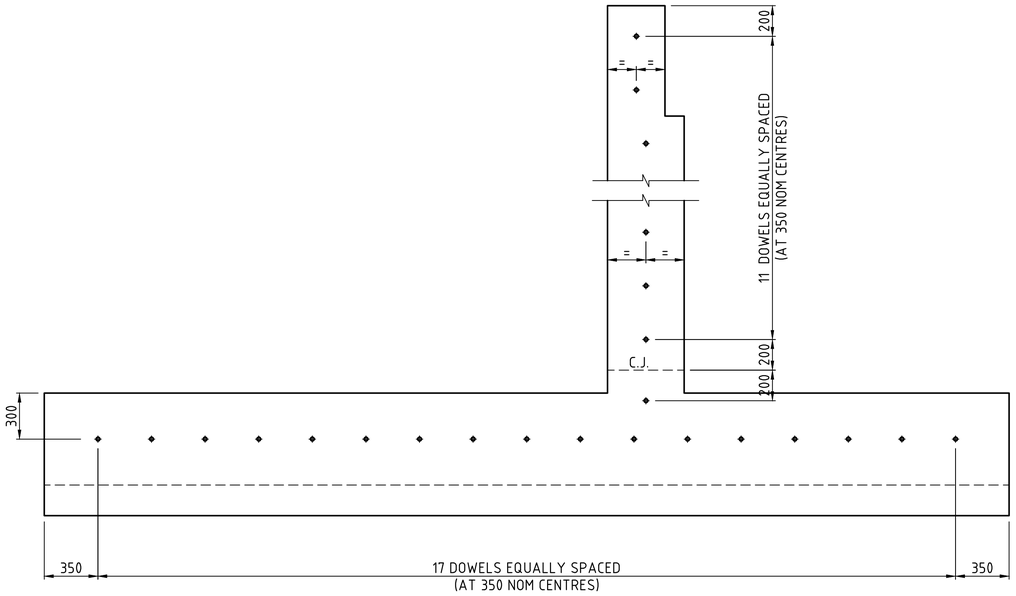
PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 110	ISSUE 3

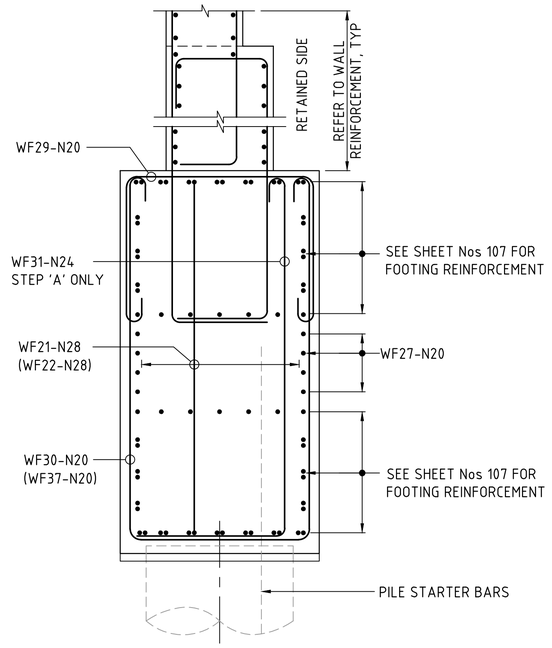
Plot Date: 09 Apr 2018, - 10:29:11 Cad File: C:\users\shuffla\appdata\local\project wise\mrs_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



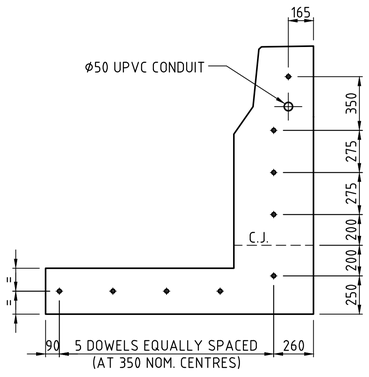
STAINLESS STEEL DOWEL
SETOUT AT EXPANSION JOINT
'EJ1'



STAINLESS STEEL DOWEL
SETOUT AT EXPANSION JOINT
'EJ2'

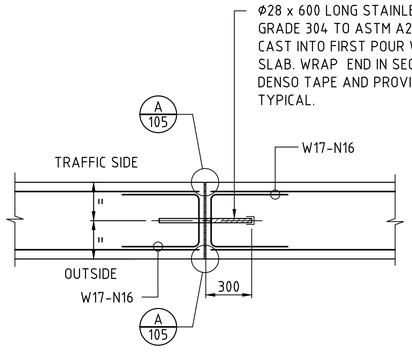


SECTION 4/-



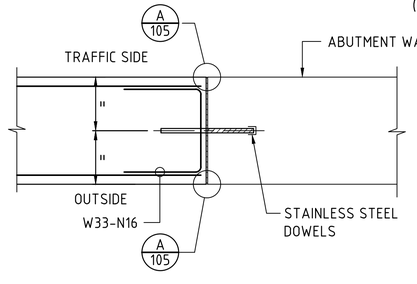
STAINLESS STEEL DOWEL SETOUT AT
EXPANSION JOINT 'EJ3'

SEE SHEET No 104 FOR LOCATION OF EXPANSION JOINT



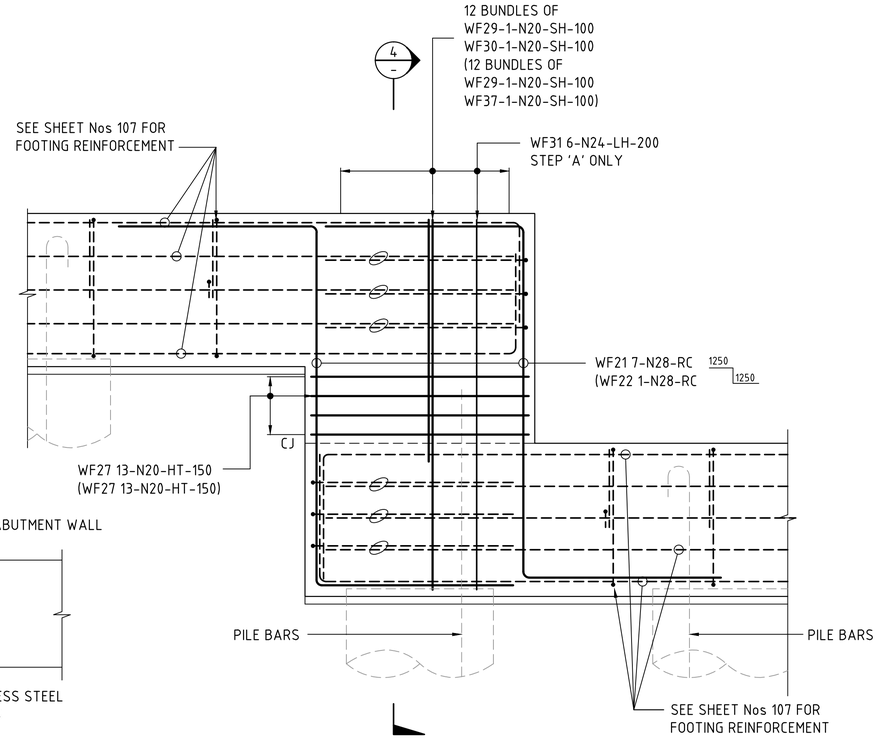
WALL EXPANSION JOINT 'EJ-1 & EJ2'

SEE SHEETS No 102 AND 103 FOR LOCATION OF EXPANSION JOINTS



WALL EXPANSION JOINT 'EJ1'
(BOTTOM OF WALL - 700 THICK)

REFER SHEET No.102 FOR LOCATION OF EXPANSION JOINT



STEP 'A' AND 'B' DETAIL

STEP 'A' SHOWN, STEP 'B' SIMILAR EXCEPT WHERE SHOWN IN BRACKETS
SEE SHEET No 102 FOR LOCATION OF STEPS
FOR STEPS 'C', 'D' AND 'E' SEE SHEET No 146

FOR TENDER

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 108.

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER
AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET E

JACOBS — NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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27 ARGYLE ST. PARRAMATTA
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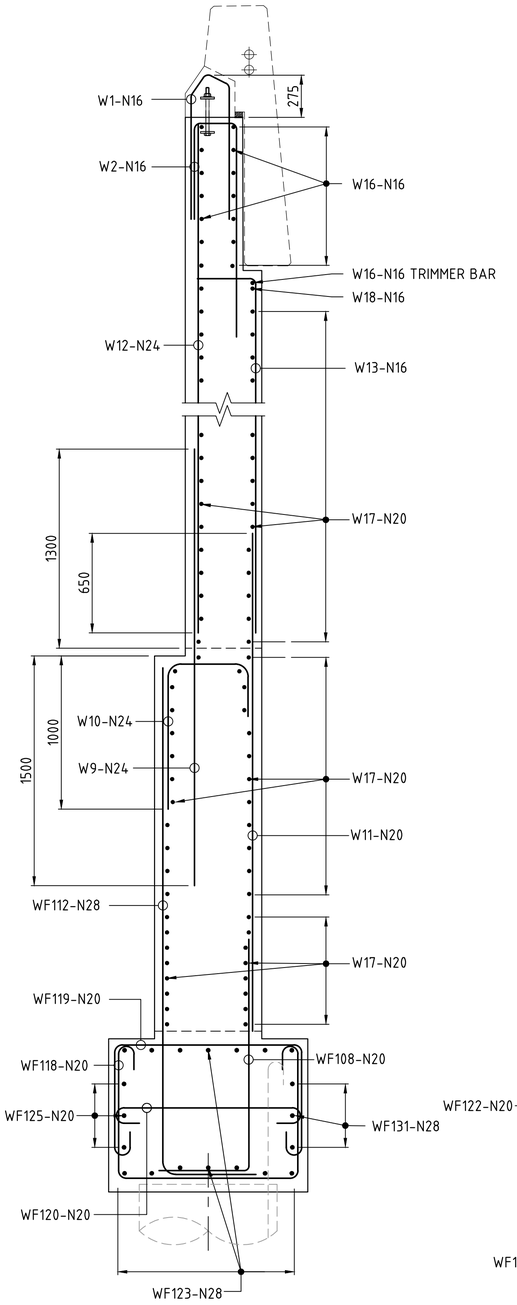
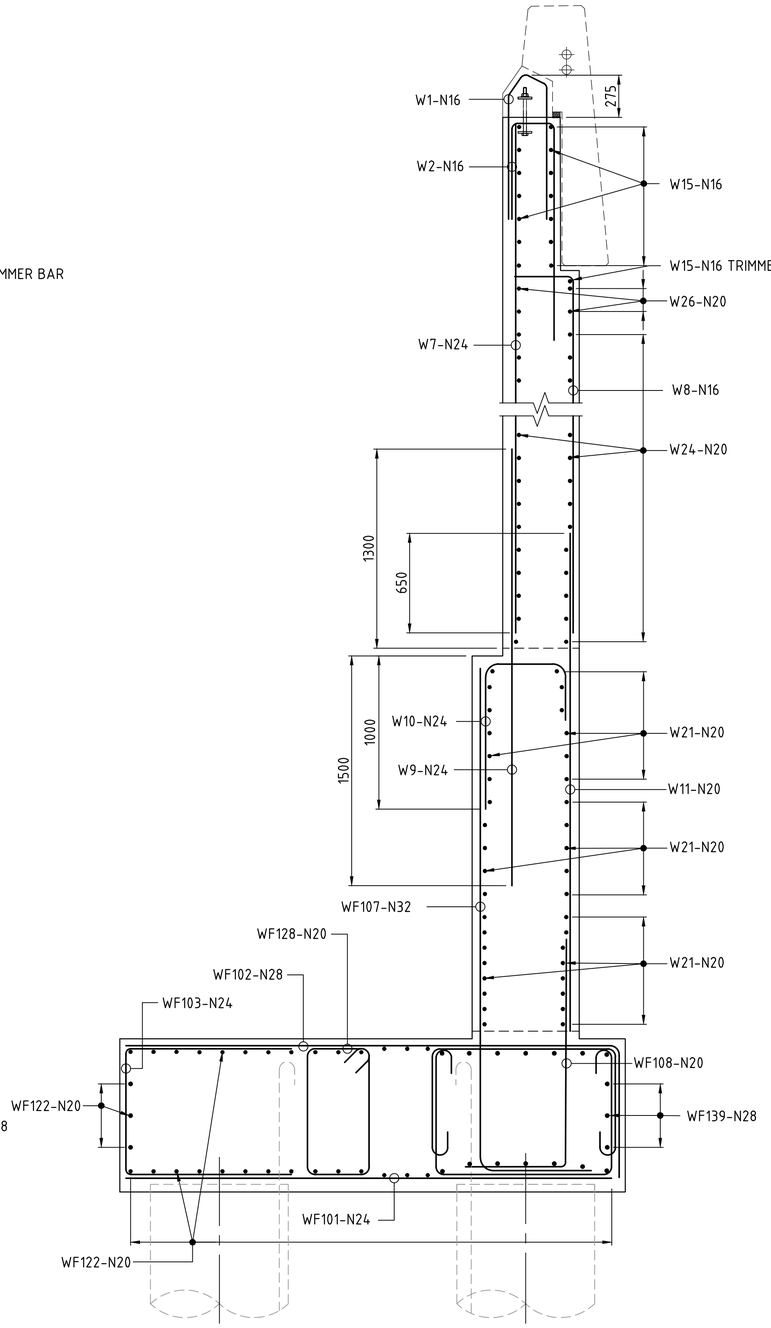
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING J.G.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 111 ISSUE 2

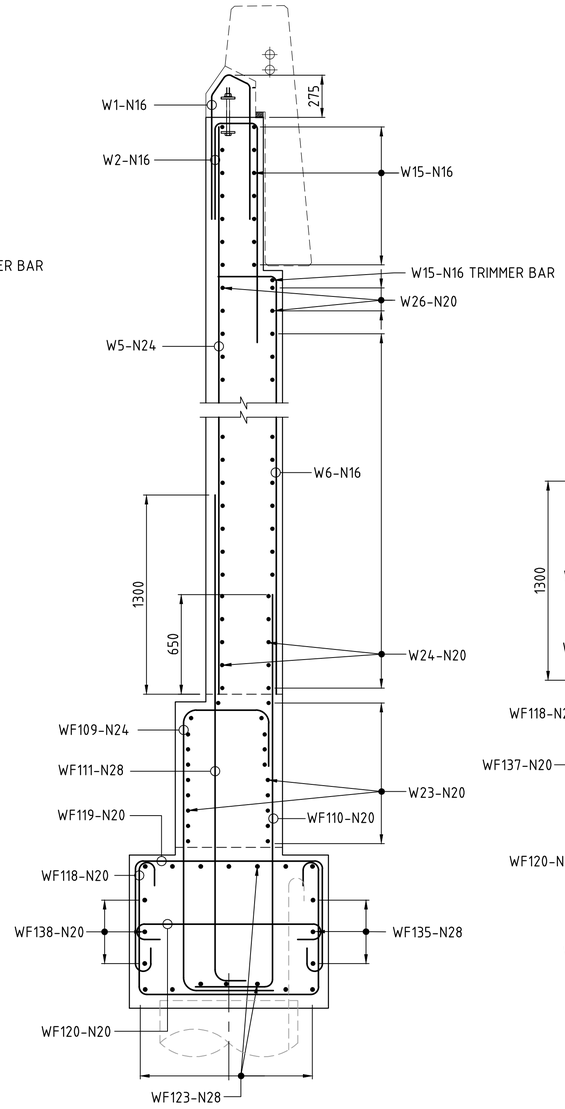
Plot Date: 09 Apr 2018 - 12:06:19 Cad File: C:\Users\shutha\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



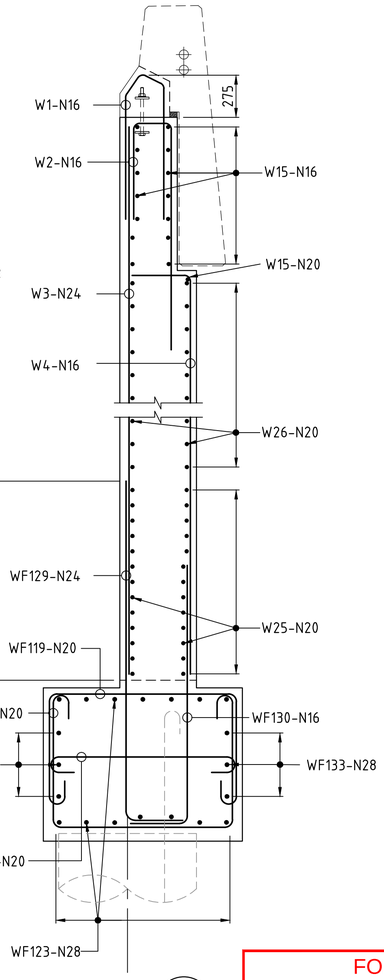
SECTION 5 / 107



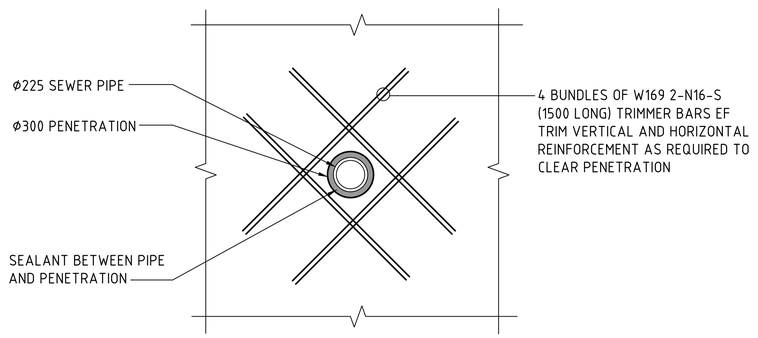
SECTION 6 / 107



SECTION 7 / 107



SECTION 8 / 107



TYPICAL DETAIL AT WALL PENETRATION FOR EXISTING SEWER

FOR TENDER

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 108.

Rev.	Date	Description	By	Ch'd	App'd
2	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
1	01.09.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	13.04.17	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET F

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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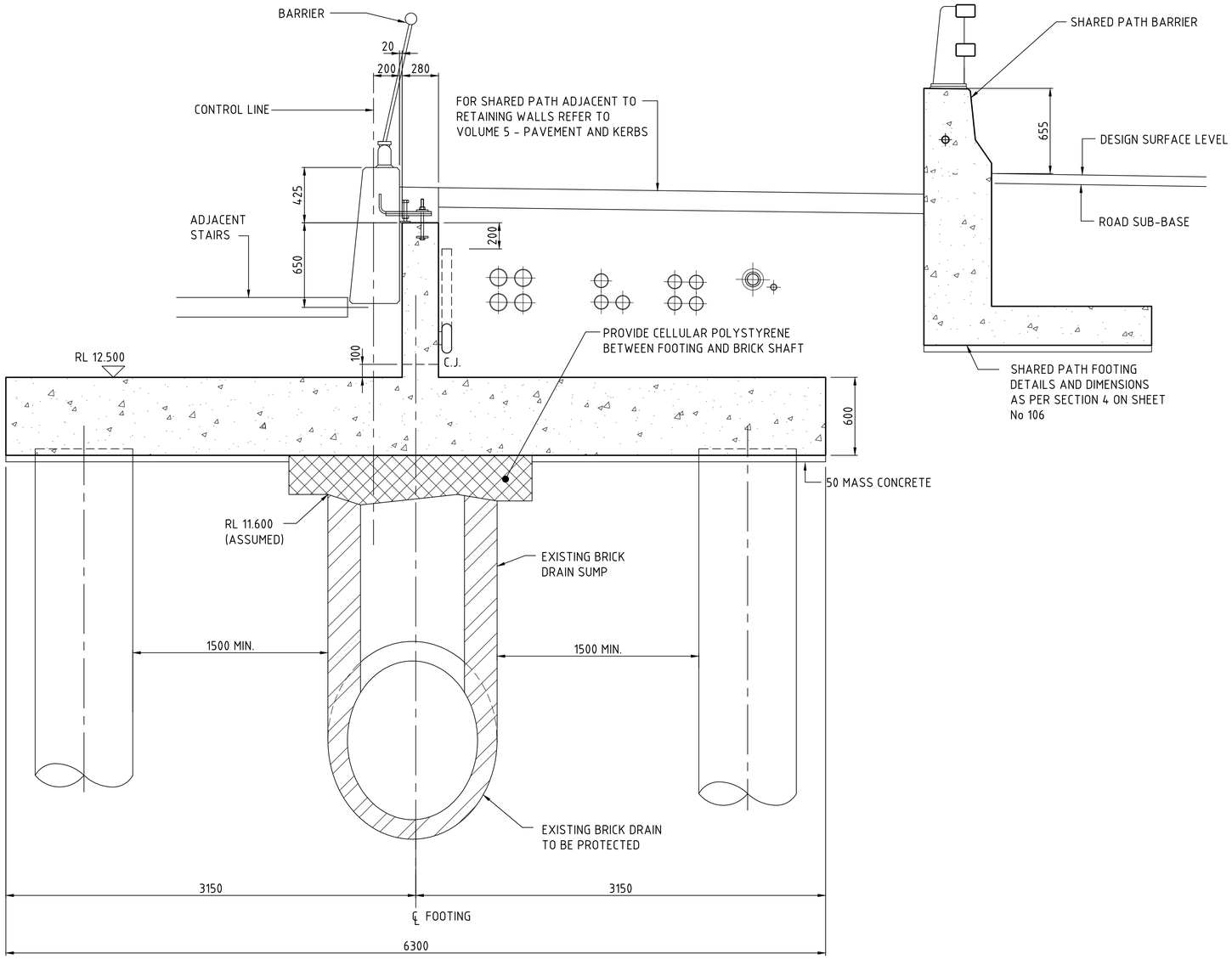
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 112	ISSUE 2

Plot Date: 09 Apr 2018, - 10:31:50 Cad File: C:\Users\shutt1a\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



WESTERN RETAINING WALL

SECTION 6/103

FOR TENDER

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 105.

Rev.	Date	Description	By	Ch'd	App'd
1	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.
0	09.03.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

RETAINING WALL SECTIONS - SHEET C

JACOBS

NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
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27 ARGYLE ST. PARRAMATTA
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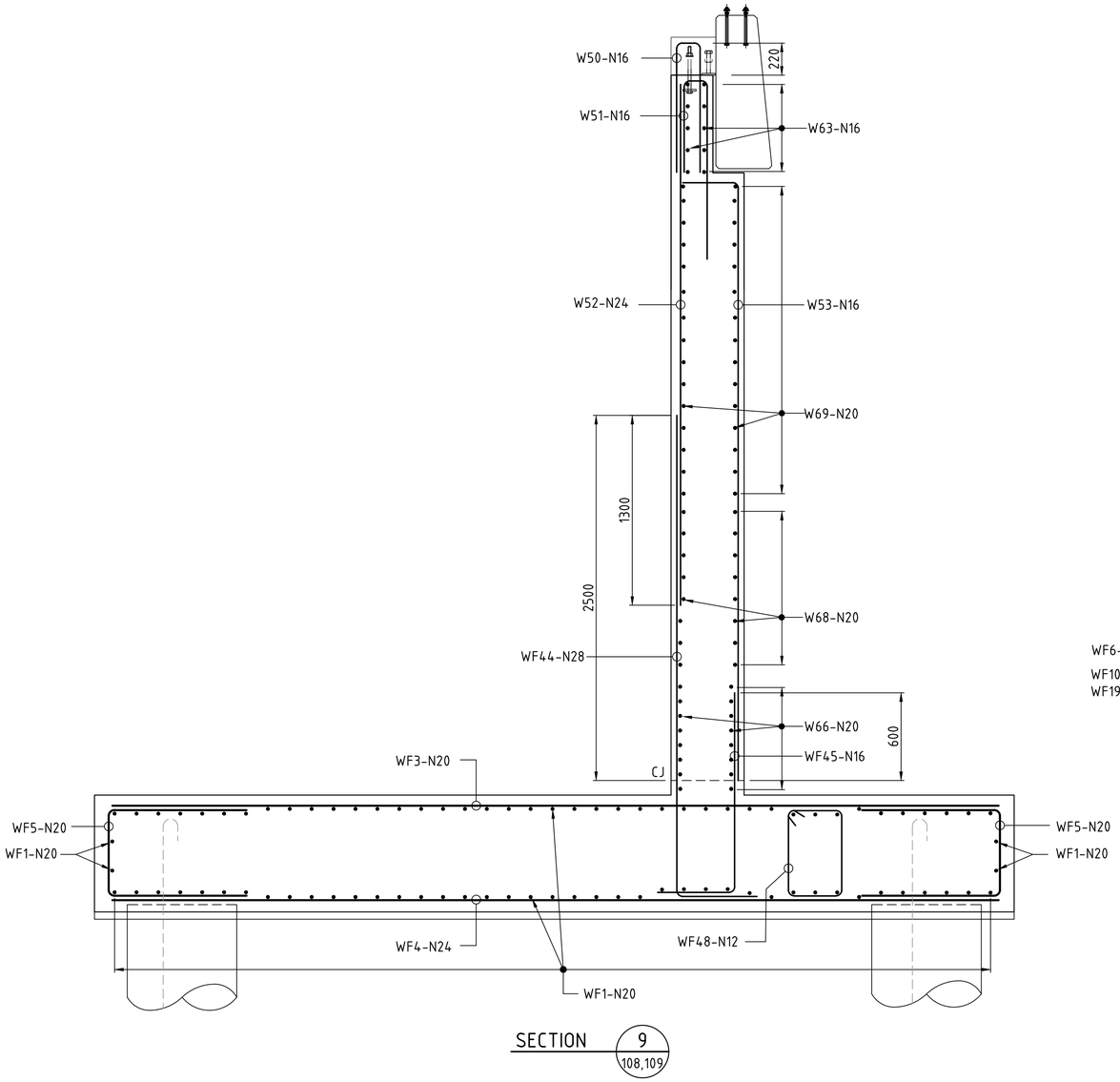
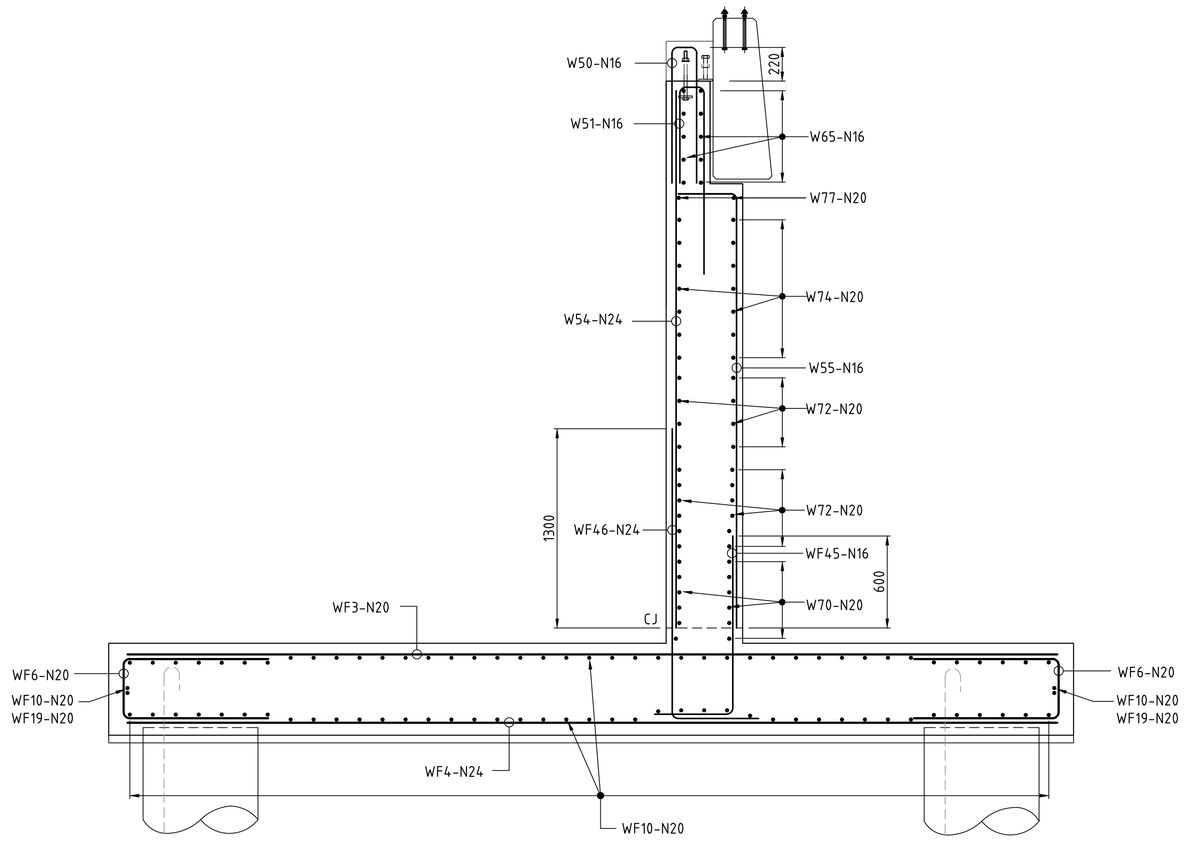
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN S.H.	J.S.	DS2012/000155
DRAWING A.S.	I.C.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 145 ISSUE 1

Plot Date: 09 Apr 2018, - 10:37:27 Cad File: C:\users\shuffa\appdata\local\project wise\rms_projects\dms0066\NB98005_ECP-DG-0102-0112.dwg



SECTION 9 108,109



SECTION 10 108,109

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 108.

FOR TENDER

Rev.	Date	Description	By	Ch'd	App'd
0	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER

AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET G

JACOBS

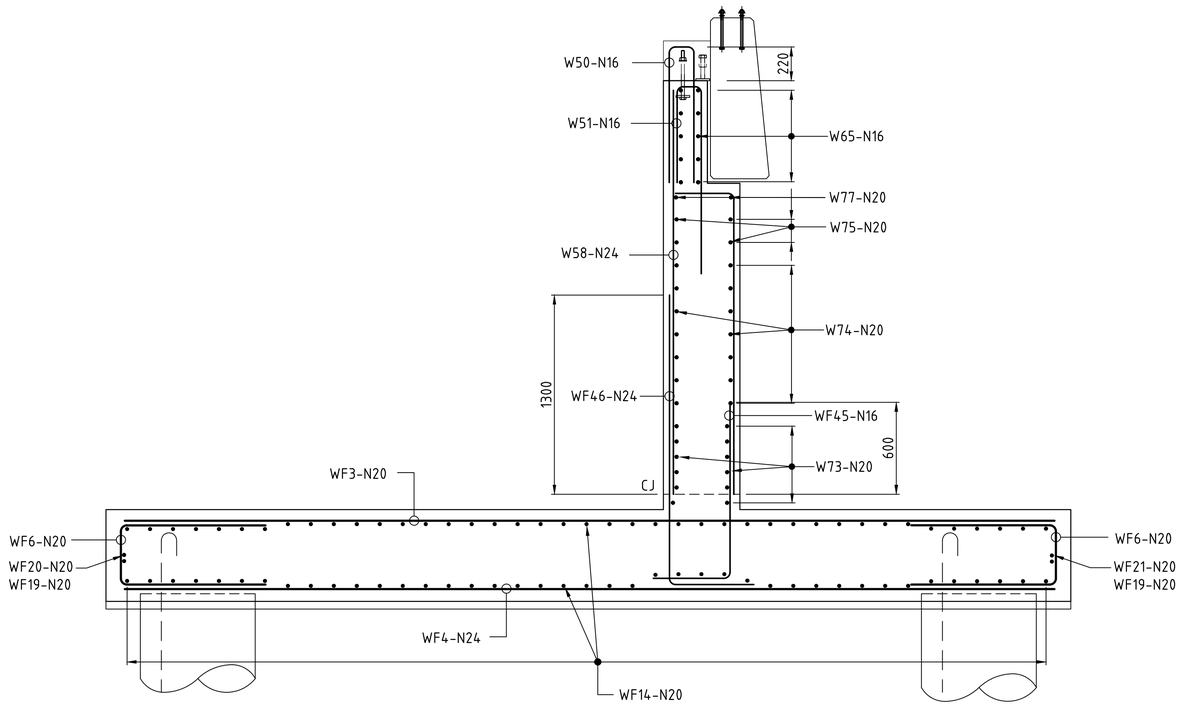
NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

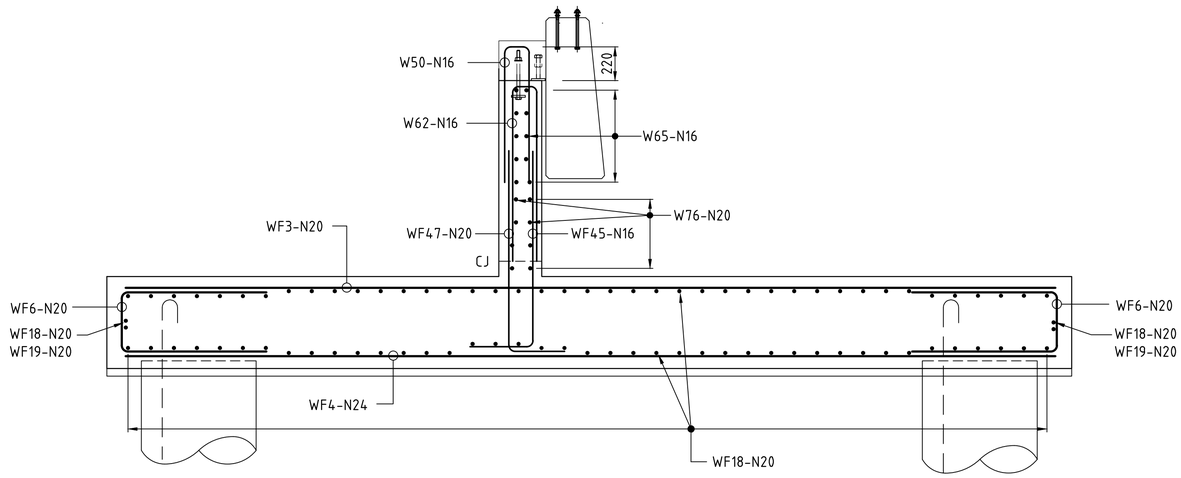
ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS
DESIGN H.N.	A.M.	DS2012/000155
DRAWING J.G.	I.T.	BRIDGE NUMBER 11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER
DIRECTOR		SHEET No. 146 ISSUE 0

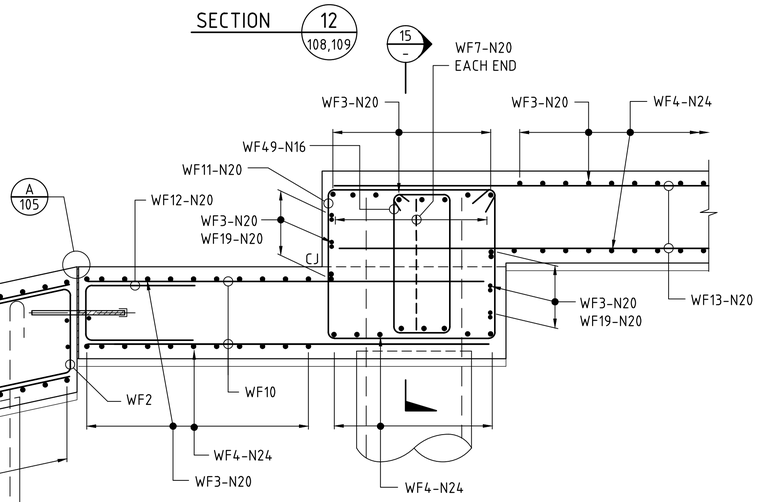
Plot Date: 09 Apr 2018, - 10:37:00 Cad File: C:\Users\shutt\AppData\Local\Projectwise\rms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg



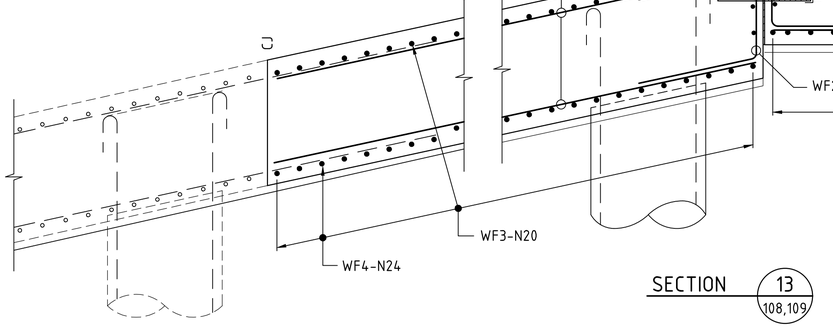
SECTION 11 (108,109)



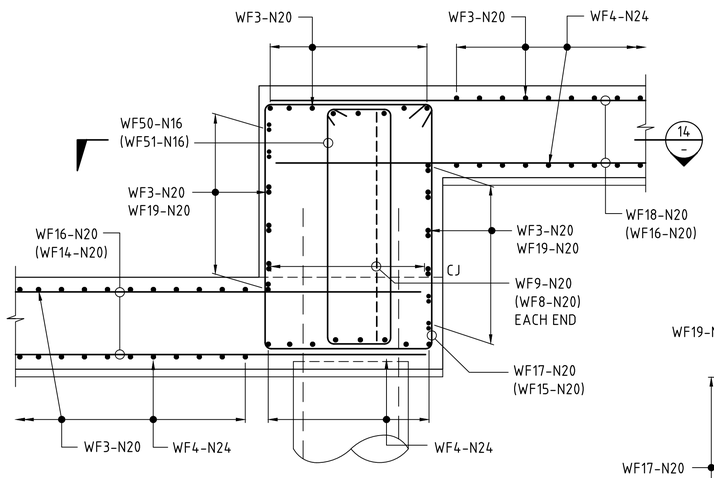
SECTION 12 (108,109)



STEP 'C' DETAIL

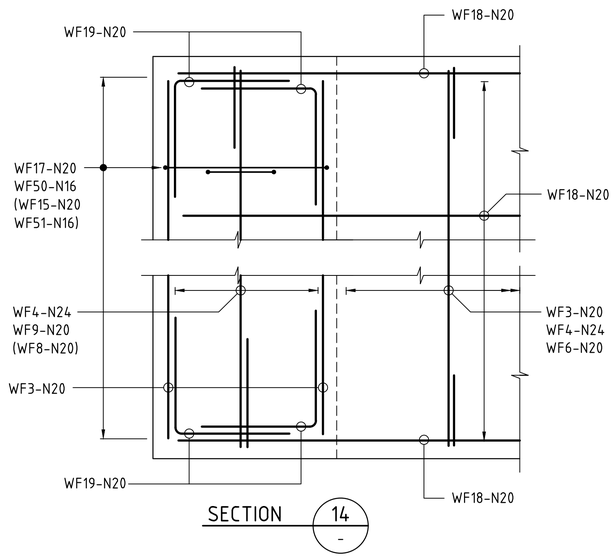


SECTION 13 (108,109)

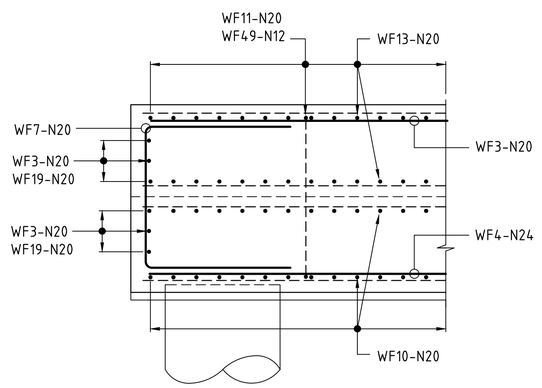


STEP 'D' AND 'E' DETAIL

STEP 'E' SHOWN, STEP 'D' SIMILAR EXCEPT WHERE SHOWN IN BRACKETS
SEE SHEET No 103 FOR LOCATION OF STEPS
FOR STEPS 'A' AND 'B' SEE SHEET No 110



SECTION 14 (-)



SECTION 15 (-)

FOR TENDER

GENERAL NOTES

SCALE 0 200 400 800 1200mm OR AS SHOWN.

FOR GENERAL NOTE SEE SHEET No 108.

Rev.	Date	Description	By	Ch'd	App'd
0	06.04.18	ISSUED FOR TENDER	A.S.	J.S.	J.S.

MAIN ROAD No 182 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER
AT WINDSOR

RETAINING WALL REINFORCEMENT - SHEET H

JACOBS — NB98005-DG-BR

Transport Roads & Maritime Services NSW GOVERNMENT

ROADS AND MARITIME SERVICES
SYDNEY REGION OFFICE
27 ARGYLE ST. PARRAMATTA
PO BOX 3035 PARRAMATTA
NSW 2124
PHONE 02 8849 2069
FACSIMILE 02 8849 2818

PREPARED	CHECKED	REGISTRATION No. OF PLANS	
DESIGN H.N.	A.M.	DS2012/000155	
DRAWING J.G.	I.T.	BRIDGE NUMBER	11386
APPROVED DESIGN QA RECORDS		ISSUE STATUS: TENDER	
DIRECTOR		SHEET No. 147	ISSUE 0

Plot Date: 09 Apr 2018, - 10:38:02 Cad File C:\Users\shutt\appdata\local\projectwise\wms_projects\dms00616\NB98005-ECP-DG-0102-0112.dwg

Appendix D - Advice from Jacobs re vibration impacts

Level 7, 177 Pacific Highway
North Sydney NSW 2060 Australia
PO Box 632 North Sydney
NSW 2059 Australia
T +61 2 9928 2100
F +61 2 9928 2500
www.jacobs.com

24 April 2018

Attention: Graham Standen
Senior Project Manager Greater Sydney Project Office
Technical and Project Services
Roads and Maritime Services
Level 9 Argyle Street Parramatta NSW 2150

Subject: Windsor Bridge Replacement Project - Preservation of brick barrel drain

Dear Graham,

We refer to the recent discovery of a historic brick barrel drain during recent archaeological investigations in Thompson Square. This has required changes to the detailed design as the location of the barrel drain would interfere with the footing configuration of the southern bridge abutment and associated western retaining wall. The main objective of the design changes was to alter the footing system of these structural elements to retain the brick barrel drain in its original location while preserving and protecting its integrity during the construction and operation phases of the proposed works.

The first step of the re-design was to develop options for an alternative structural footing system that would be sufficiently clear from the barrel drain, withstand the intended design loads and eliminate the need to amend above-surface elements previously designed. The preferred concept design of the revised footing system was then distributed for discussions with the project team, archaeologists, a material conservator(ICS) and a vibration specialist. Based on the feedback and advice received from these specialists a strategy to preserve and protect the brick barrel drain was developed. The development of this strategy considered the following key elements:

- concerns regarding risks of vibration-related damage to the brick barrel drain during piling and drilling activities. These concerns have been addressed in our memorandum titled “Barrel Drain – Potential Pilling Vibration Impacts” dated 9 March 2018 (**Attachment 1**).
- concerns in relation to the proposed construction and operation loads imposed on the brick barrel drain. These concerns have been addressed in our letter dated 23 March 2018 titled “Loads imposed on brick barrel drain” (**Attachment 2**).
- concerns associated with the long term in-situ preservation of the brick barrel drain due to:
    - Water movement (ground water movement, potential flooding)
    - Crystallisation of salts (carried by the water) and subsequent physical damage
    - Erosion and physical damage of exposed remains as a result
    - Possible plant, algae and moss growth on any exposed remains or disturbance of buried remains

  These concerns have been addressed in the advice letter prepared by International Conservation Services dated 24 April 2018 (**Attachment 3**).

We are therefore satisfied that:

- the re-design of the structural footing system and methodology to be adopted for the protection and preservation of the brick barrel drain has been adequately assessed and documented; and
- when the contractor undertakes the works in accordance with the defined methodology, the barrel drain would be adequately protected and preserved to its original condition during the construction and operation phase of the proposed works.

Yours sincerely

Bruno Dalla-Palma
Design Manager
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Bruno.Dalla-Palma@jacobs.com

Memorandum

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Subject	**Barrel Drain - Potential Piling Vibration Impacts**	**Project Name**	Windsor Bridge
Attention	Bruno Dalla-Palma	**Project Number**	IA098200
From	Graham Brown		
Date	March 9, 2018		
Copies to	John Steele		

Bruno,

I have reviewed concept design drawings of the retaining wall foundations and photographs of the unreinforced, aged masonry barrel drain that is currently located below the proposed retaining wall at the Windsor bridge site. The current drawings show several piles of diameter 750mm diameter or greater located with a 1500mm minimum horizontal distance to the barrel drain. The soil located over the barrel drain is likely to be relatively soft alluvial silt/sand, while the drain is located on top of Hawkesbury sandstone. The piles are to be bored into the sandstone rock sublayer. My understanding is that the barrel drain in non-functional, but that it is of heritage significance.

It is apparent from my review of the site photographs, drawings, vibration literature and standards relevant to this situation that there are significant risks of vibration-related damage to the barrel drain due to piling and compaction of fill associated with construction of the retaining wall. It is therefore essential to control the vibration levels at the barrel drain to minimise the risk of damage.

Prediction of construction vibration levels becomes unreliable at short source-receiver distances and so it is not possible to quantify the expected vibration levels on the drain with good accuracy. Applicable vibration standards and vibration limits for the drain are similarly imprecise, making it difficult to eliminate risks.

In order to minimise the risk of vibration related damage to the barrel drain it is recommended that:

1. The foundation of the retaining wall be designed such that the piles are spaced as far from the drain as is practically possible.

2. Specify the use of vibration minimising techniques for boring the piles (e.g. use of a small piling rig with low thrust load and reduced piling rig rotational speed, particularly when boring through rock).

3. Vibration monitoring be carried out during piling in representative soil conditions elsewhere on site to assist in identifying the lowest vibration-inducing piling techniques and maintaining control over vibrations to the greatest possible extent.

4. The first pile be bored at a location where the adjoining roof of the brick barrel drain is exposed and can be monitored by visual inspection by an archaeologist with vibration monitoring being in place.

The piling trial would then confirm the construction methodology to be employed for the remainder of the piling.

5. The use of vibratory compaction techniques over and adjacent to the barrel drain should be avoided.

6. The retaining wall foundation should not bear directly on the top of the barrel drain.

Regards,

Graham Brown
Manager – Advanced Analysis and Test
+61 (2) 9032 1262 | +61 (0) 422 045 362
graham.brown@jacobs.com

Jacobs
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North Sydney NSW 2060 AUSTRALIA
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Appendix E - Advice from Jacobs re compression impacts

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23 March 2018

Attention: Graham Standen
Senior Project Manager Greater Sydney Project Office
Technical and Project Services
Roads and Maritime Services
Level 9 Argyle Street Parramatta NSW 2150

Subject: Windsor Bridge Replacement Project - Loads imposed on brick barrel drain

Dear Graham,

I refer to recent concerns from the archaeologists in relation to the proposed loads imposed on the brick barrel drain associated with the subject project. The following response has been provided by our structural engineers:

The intention of the polystyrene being placed over the brick barrel drain when the cover is less than 500mm is to avoid concentrated loadings from the footing being applied to the barrel drain and to minimise the overall loading onto the barrel drain at different stages.

Exiting conditions:

The existing depth of fill over the brick barrel drain varies but is typically in the order of 3 metres.

Construction phase:

The loading from the wet concrete of the retaining wall footing will be transferred to the barrel drain.

The 800mm thick concrete has a density of around 2500kg/m3 compared to 1800kg/m3 for the existing fill over the brick barrel drain so it is equivalent to around 1150mm of fill.

Where there are steps in the footing and the total deep of the footing is increased, the construction would need to be staged so the lower section of the footing is cast first to support the weight of the wet concrete for the upper section of the step to control the weight on the brick barrel drain.

Operational phase:

Once the retaining wall is constructed and is operational, the weight of the wall above and the overlying soil will be supported on the footing and will bridge across to the piles which are socketed into rock on either side of the drain. The footings will deflect as it transfers these loads to the piles but the footing is stiff given its thickness and relatively short span and the polystyrene has a low modulus of elasticity and will compress under the deflection and limit further transfer of load to the brick barrel drain.

Based on our analysis results, the footing for the retaining wall will deflect approximately 3mm under the weight of the wall, the backfilling of the wall and surcharge loading from the shared path and road. A medium density polystyrene foam has a modulus of 105kPa for 10% compression which is considerably more compressible than engineered fill or stabilised sand which is why polystyrene was chosen for these locations. For example, if there is 300mm of polystyrene over the brick barrel drain, the 3mm deflection would equate to an additional pressure of 10.5kPa on the barrel drain. This is equivalent to an additional 670mm of existing fill loading. The proposed structure would therefore place an equivalent loading of just over 1.8 metres of existing fill which is less than the loading the brick barrel drain was subjected to prior to the work.

Conclusion:

We are therefore satisfied that the design of the footing for the retaining wall to bridge over the brick barrel drain and the use of the polystyrene over the areas of the brick barrel drain with less than 500mm of cover will not put detrimental loading onto the barrel drain.

Yours sincerely

Bruno Dalla-Palma
Design Manager
+61 2 9032 1213
Bruno.Dalla-Palma@jacobs.com

Appendix F - Advice from International Conservation Services

internationalconservationservices
53 Victoria Avenue
Chatswood NSW 2067
Australia
Sydney | Canberra | Melbourne
t +61 2 9417 3311
e ics@icssydney.com
w www.icssydney.com

24 April 2018

Dr MacLaren North
AAJV
3/73 Union Street
PYRMONT NSW 2009

Dear Mac

RE. WINDSOR BRIDGE PROJECT – CONSERVATION OF ARCHAEOLOGICAL REMAINS – REVISED ADVICE
ICS REF 16369a

Following on from our site visit of Friday 2nd March 2018 we understand you require advice on the in-situ preservation of a brick barrel drain uncovered as part of the Windsor Bridge Project.

Further to our preliminary advice provided on 06.03.18 and revised advice of 21.03.18, this letter details further revised advice, based on:

- our site visit of Friday 2nd March and inspection of exposed remains
- conversations with Dr MacLaren North of AAJV and Yesmina Syeda of RMS during the site visit
- Concept design drawing of bridge construction DS2012/000155 revision B provided 02.03.18
- RMS Response to ICS' preliminary advice provided 09.03.18 via email
- Additional information via email including scans of annotated drawings provided 15.03.18
- Additional information via email provided 19.03.18 including:
  - Memorandum 'Barrel Drain-Potential Piling Vibration Impacts', 9.03.18, Graham Brown, Jacobs.
  - Drawings DS2012/000155 Sheet (Issue): 4(2), 143(0), 8(3), 9(2), 10(2), 11(3), 12(3), 144(0), 103(3), 104(3), 106(3), 145(0).
  - Drawings DS2012/000289 NB98005-EEN-DG Sheet (Issue): 0211(4), 0212(4), 0311(4), 0312(4), 0313(4), 0314(4) 0320(4), 0321(4)
- Additional information via email provided 09.04.18 including:
  -Letter 'Windsor Bridge Replacement Project – Loads imposed on brick barrel drain'
- Additional information via email provided 19.04.18 including:
  - Letter from Bruno Dalla-Palma of Jacobs dated 23rd March 2018 on loads imposed on brick barrel drain

We note our advice addresses materials issues related to the in-situ preservation of the archaeological remains. We cannot comment on any of the structural issues in regards to the bridge design or preservation measures we may recommend nor on the content of the recommendations or advice regarding vibrational or structural issues.

In-situ preservation issues

The key issues identified for the long term in-situ preservation of the brick barrel drain are:

- Water movement (ground water movement, potential flooding)
- Crystallisation of salts (carried by the water) and subsequent physical damage
- Erosion and physical damage of exposed remains as a result
- Possible plant, algae and moss growth on any exposed remains or disturbance of buried remains

Proposed construction

An in-situ brick barrel drain is located between Bridge Street and Thompson Square. Tender drawings show the construction of a retaining wall for the Replacement Windsor Bridge above the brick barrel drain and the installation of piles adjacent to the drain.

Proposed protection measures (RMS/Jacobs)

Use of polystyrene

We note that "cellular polystyrene [will be provided] between footing and drain where clearance is less than 500". We understand that this product is an expanded polystyrene sheet. We note that it is proposed polystyrene will be used in 6 key locations as identified on drawing DS2012/000155 103(3). We understand from email advice from Yasmin Syeda to yourself on 09.03.18 that the use of polystyrene is proposed to minimise the transfer of load onto the barrel drain during construction (particularly the backfill of the concrete fitting). We note that where the existing soil fill is greater than 500mm this is considered sufficient depth to avoid concentrated load on the barrel drain.

We note from email advice from Yasmin Syeda to yourself on 09.03.18 that approximately 15m of the drain is considered to have soil fill of less than 500mm and these areas will be exposed to install the polystyrene.

Exposed remains and backfill

We understand from conversations during our site visit that some areas of the drain will be excavated to reveal the diameter of the drain (approx. 1400mm) and therefore approximately 700mm of the drain will be exposed above the ground level. Belinda Crichton of RMS advised via email on 09.04.18 (forwarded by yourself) that "the barrel drain has been backfilled while awaiting commencement of the bridge construction". You have advised that the remains were temporarily back filled with geotextile and on site material only.

Purpose of advice

We have previously provided urgent advice due to time constraints of the project programme. We understand that the Department of Planning and Environment (DPE) is seeking comment on the preservation of the drain in perpetuity.

Approach

Burial environments are not stable or static environments and changes are due to a range of local, regional and global factors. Guaranteed, reliable and reproducible standards and methods for the preservation of in-situ remains are not available locally or internationally, being currently an area of active research and analysis.

Two approaches in the preservation of in-situ remains are commonly used.

The first, a risk management approach (Approach 1), is to attempt to replicate the surrounding burial conditions and protect the remains from physical damage. This is based on the understanding that the burial environment is dynamic and will change due to a range of environmental factors, and that some deterioration of the remains will occur - as some deterioration would occur if the remains had not been exposed. The

primary aim of this approach is to prevent the introduction of new deterioration mechanisms through exposure or by the preventive measures employed.

The second approach is to analyse the in-situ conditions in detail, develop a reburial strategy that addresses the conditions and issues identified *at the time of assessment*, and develop and implement an ongoing monitoring program for a typical period of 5-10 years. This approach provides data to assist in the initial reburial decisions, while ongoing monitoring provides a body of data that helps develop a broader understanding of the issues, both for the site and for science of in-situ preservation. This approach is used more commonly in circumstances where ongoing maintenance and management of the site is possible or required, and more often when significant organic remains are present.

Examples of this approach with in-situ (reburial) preservation projects, with the published outcomes, include:

- Schulzgate, – installation of a 10 year monitoring program
- Tonsberg, Norway – installation of an ongoing monitoring program (2 years)
- Planarch, Netherlands – analysis and development of a monitoring program
- Bryggen, Norway – groundwater modelling and results so far of 5 years of monitoring
- Newington, England – watertable monitoring and the impact of development and environmental change assessed

It is important to note that the very nature of reburial of the remains as a preventive approach means that the remains themselves cannot be assessed or monitored. Monitoring programs are used to provide information about the conditions of the site, which are used as predictors of the condition of the remains.

Discussion

Currently neither approach can provide absolute scientific certainty of the guaranteed preservation of in-situ remains in perpetuity, as there are too many variables that cannot be accurately modelled or predicted. One way to consider the two different approaches is to weigh up the effectiveness and benefits of each. This is detailed below in a tabular form:

Preservation Risk	**Likely original conditions**	**Proposed mitigation**	**Approach 1 – Reburial**	**Approach 2 – Reburial and data monitoring and analysis**
Erosion and Physical damage	Protected by complete burial of remains. Risk of damage due erosion or development. Some damage due to erosion towards river's edge.	Protect and re-bury remains	Replicates original conditions by completely covering remains. Reburial matrix to be approved Very low risk of ongoing erosion Structural engineers and vibrational assessment to minimise risks of physical damage during construction and use. Monitoring during construction proposed.	Installation of dataloggers and monitors to provide data to assess risk of physical damage during construction and use of bridge. Short term lifespan [in-situ monitors cannot be accessed to maintain/ repair/ remove after construction]. Would require data over at least 5 years to provide meaningful information about long term preservation.

Damage by biological growth	Protected by complete burial of remains. Some risk of damage due to disturbance by deep root growth	Protect and re-bury remains[1]	Replicates original conditions by completely covering remains. Reburial matrix to be approved Very low risk of ongoing plant growth. Remains completely covered by construction & no light for photosynthesis. If there are any areas not covered by construction additional measures will be required.	Assess risk/extent of plant growth by visual assessment. In-ground monitoring could be installed to monitor disturbance by root systems at the remains. This system would have a short term lifespan [cannot be accessed to maintain/ repair/ remove after construction).
Groundwater movement	High risk of damage to do water movement – associated with proximity to the river, regular, flooding and rainfall	Protect and re-bury remains	Replicates original conditions by completely covering remains. Reburial matrix to be approved Existing high risk of damage to due water movement remains – water movement due to flooding, proximity to river and rainfall cannot be eliminated. No increase in risk of damage due to water movement predicted	Installation of dataloggers and monitors to provide data to determine and monitor water movement pathways. Additional monitors to analyse water content (pH, oxygen, conductivity, specific salts). Used to map conditions on site and monitor changes. The conditions of site are expected to be particularly dynamic and without significant base line data (data prior to disturbing the remains) it will be difficult to determine if changes observed during monitoring are natural changes in the soil conditions or if the remains are at unnatural risk. Short term lifespan [in-situ monitors cannot be accessed to maintain/ repair/ remove after construction]. Would require data over at least 5 years to provide meaningful information Limited mitigation options both post construction and regarding changing and controlling water

[1] It is understood the remains will be completely covered by the proposed construction. If any part of the area is accessible a management plan and program will be required to manage and monitor plant growth and erosion.

				content and pathways for the river and rainfall.
Salt damage	Moderate risk of damage to crystallisation of salts in-situ	Protect and re-bury remains	Replicates original conditions by completely covering remains. Reburial matrix to be approved Existing moderate risk of damage to due water movement remains. Reburial matrix designed to ensure water flows freely from remains into soil matrix and therefore crystallisation is discouraged. The presence of salts and movement through water cannot be eliminated. No significant increase in risk of damage due to salts predicted	Installation of dataloggers and monitors as outlined above to monitor water content (pH, oxygen, conductivity, specific salts). Used to map conditions on site and monitor changes. Monitoring of water content and pathways used to predict salt content and likely areas of salt deposition. Without significant base line data (data prior to disturbing the remains) it will be difficult to determine if levels observed during monitoring are natural changes in the soil conditions or if the remains are at unnatural risk. Short term lifespan [in-situ monitors cannot be accessed to maintain/ repair/ remove after construction]. Would require data over at least 5 years to provide meaningful information Limited mitigation options both post construction and regarding changing and controlling water content and pathways for the river and rainfall.

The significant question arising is whether Approach 2 (monitoring and analysis before and after reburial) will provide sufficient further reliable and interpretable information to promote the long term preservation of the remains.

On balance the further work involved, including detailed analysis of site conditions, consultation with environmental scientists, the development of a reburial strategy and a monitoring program with specialised monitoring equipment will not in our view lead to a substantially better outcome than Approach 1. However, if a risk management approach is not acceptable in this instance and further information is required, then site analysis and monitoring will be required as a next phase.

Recommendations

Accordingly the following recommendations are made:

The site of the drain is expected to be a particularly dynamic environment with a large variation in the ground water movement, and consequently variation in the soluble salts, pH and oxygen levels. This is due in part to its proximity to the river.

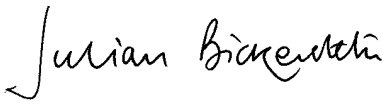
It is understand the remains will be completely covered by the construction and therefore the risks of erosion, physical damage and plant growth are removed.

In these circumstances a risk management approach to the preservation of the remains is recommended:

- That during excavation measures are taken to prevent the drain from wind, erosion and drying out. This would include prompt reburial or covering of the remains.
- That the drain is filled and reburied to prevent damage caused by water movement, salt crystallisation and erosion.
- That a separation layer such as a water permeable geotextile is used to isolate fill from unexcavated remains.
- That clean sand fill is placed over the geotextile
- That in locations where the polystyrene protection is proposed that intermediary layers of geotextile and clean sand are installed between the bricks and the polystyrene to allow water and salt movement in the long term.
- It is assumed that the entire extent of the drain will be covered by the construction. If any area of the drain may be impacted by plant growth in the future this would require separate remediation measures
- That the in-situ preservation measures are undertaken under the supervision of an experienced archaeologist or archaeological conservator.
- That all proposed materials and methods are reviewed prior to the works taking place

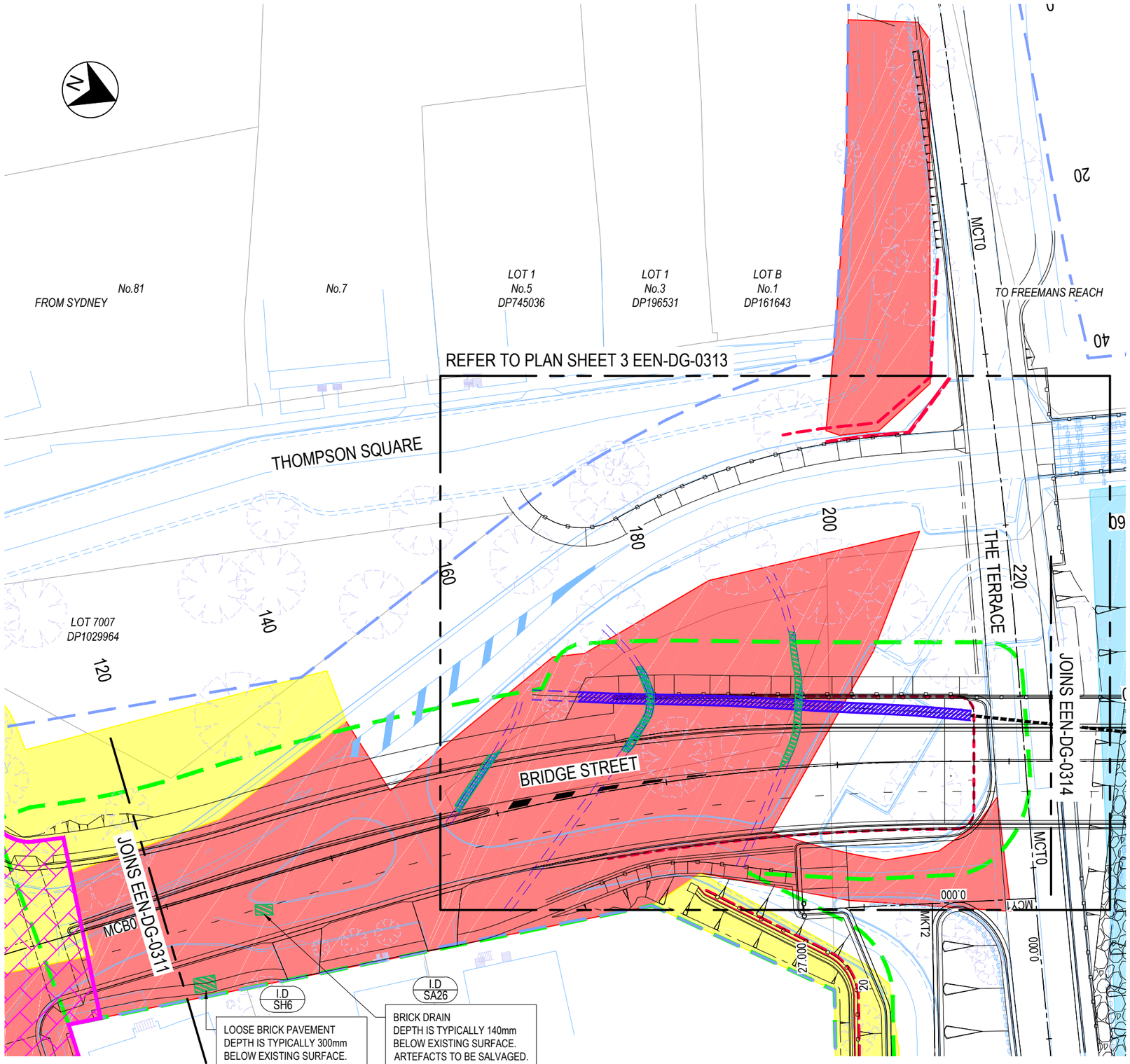
Please do not hesitate to contact either myself or Karina Acton on (02) 9417 3311 with any questions or for clarification regarding our advice.

With kind regards,



Julian Bickersteth
Managing Director
International Conservation Services

Appendix G - Advice from Jacobs re heritage management



LEGEND

PROPOSED ROADWORKS

- CONSTRUCTION WORK ZONE
- SURVEY
- Mxxx – 100 MAIN ALIGNMENT AND LOCAL ROADS CONTROL LINE, LABEL AND STATION
- RETAINING WALL

ON GOING HERITAGE MANAGEMENT ZONES

- AREA FOR ARCHAEOLOGICAL SALVAGE EXCAVATION
- MARITIME SALVAGE ZONE
- ARCHAEOLOGICAL MONITORING AND RECORDING

HISTORIC HERITAGE ITEMS

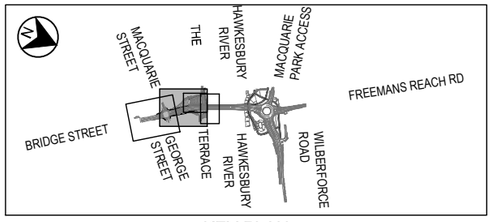
- KNOWN HISTORIC HERITAGE ITEMS (TO BE SALVAGED)
- KNOWN HISTORIC HERITAGE ITEMS (TO BE PROTECTED)
- ASSUMED PROJECTED HERITAGE ITEMS (REFER SECTIONS FOR FURTHER DETAIL)
- POSSIBLE TELFORD PAVEMENT
- MARITIME HERITAGE ITEMS (TO BE SALVAGED)
- MARITIME HERITAGE ITEMS (PRESERVE)
- I.D / XXX FEATURE IDENTIFIER FEATURE LABEL

KEY HERITAGE CONSTRAINTS

- SANDBODY BUFFER ZONE

NOTES

1. SANDBODY BUFFER ZONE APPLIES TO 4m FROM EDGE OF RETAINING WALL FORMATION ALONG REALIGNED BRIDGE STREET.
2. HEAVY PLANT PARKING AND OPERATION FOR PILING AND RETAINING WALL WORKS INCLUDING BACKFILL IS TO REMAIN WITHIN THE SANDBODY BUFFER ZONE.
3. PLANT SELECTION IS TO UNDERGO COMPACTION VIBRATION ASSESSMENT BY SUITABLE QUALIFIED ARCHAEOLOGIST PRIOR TO COMMENCING BACKFILLING OF EXISTING BRIDGE STREET ROAD.
4. ALL WORKS TO REMAIN WITHIN THE CONSTRUCTION WORK ZONE UNLESS APPROVED BY THE PRINCIPAL.
5. FOR "KNOWN HISTORIC HERITAGE ITEMS" PLEASE REFER TO DETAILED SALVAGE STRATEGY (VER 2.3) FOR SPECIFIC PROTECTION AND/OR MANAGEMENT MEASURES.



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AND PROTECTION ITEMS
PLAN SHEET 2

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BRIDGE STREET (EXISTING)

THE TERRACE

JOINS EEN-DG-0314

MCT0

BRIDGE STREET

BRICK BOX DRAIN No.2
DEPTH IS TYPICALLY 1.4m BELOW EXISTING SURFACE. ARTEFACTS TO BE SALVAGED. IN AREA OF WATERMAIN TRENCHES AND FOOTING EXCAVATION.

BRICK BOX DRAIN No.3
DEPTH IS TYPICALLY 1.9m BELOW EXISTING SURFACE. ARTEFACTS TO BE SALVAGED. IN AREA OF FOOTING EXCAVATION.

BRICK BOX DRAIN
(ASSUMED PROJECTED LOCATION)

BRICK BARREL DRAIN
(ASSUMED PROJECTED LOCATION)
TO BE PROTECTED.

BRICK BARREL DRAIN
APPROXIMATELY 1.51m HIGH x 1.22m WIDE (EXTERNAL) DEPTH VARIES FROM 1.9m TO 3.9m BELOW EXISTING SURFACE. ITEM TO BE PROTECTED.

BURIED CONCRETE STRIPS TYPICALLY 0.3m BELOW EXISTING. RECORD AND REMOVE AS REQUIRED. REFER TO BIOSIS REPORT - NOV. 2012.

BRICK SUMP ABOVE BRICK BARREL DRAIN 1300 LONG X 850 WIDE. DEPTH TO THE TOP OF SUMP IS TYPICALLY 1.6m BELOW EXISTING SURFACE. ITEM TO BE PROTECTED

BRICK SUMP ABOVE BRICK BARREL DRAIN 1300 LONG X 850 WIDE. DEPTH TO THE TOP OF SUMP IS TYPICALLY 2.0m BELOW EXISTING SURFACE. TOP 5 BRICK COURSES TO BE SALVAGED. REMAINDER OF SUMP TO BE PROTECTED.

ARCHAEOLOGICAL INVESTIGATIONS FOUND Ø225 CERAMIC PIPE TOWARD RIVER

BRICK BOX DRAIN No.1
DEPTH VARIES BETWEEN 0.5m - 1.3m BELOW EXISTING SURFACE. ARTEFACTS TO BE SALVAGED.

4 / 0321
3 / 0321
2 / 0320
1 / 0320

160
180
200
220

I.D F6
I.D F8

LEGEND

PROPOSED ROADWORKS
- CONSTRUCTION WORK ZONE
- SURVEY
- Mxxx — 100 — MAIN ALIGNMENT AND LOCAL ROADS CONTROL LINE, LABEL AND STATION
- RETAINING WALL

ON GOING HERITAGE MANAGEMENT ZONES
- AREA FOR ARCHAEOLOGICAL SALVAGE EXCAVAT
- MARITIME SALVAGE ZONE
- ARCHAEOLOGICAL MONITORING AND RECORDING

HISTORIC HERITAGE ITEMS
- KNOWN HISTORIC HERITAGE ITEMS (TO BE SALVAGED)
- KNOWN HISTORIC HERITAGE ITEMS (TO BE PROTECTED)
- ASSUMED PROJECTED HERITAGE ITEMS (REFER SECTIONS FOR FURTHER DETAIL)
- MARITIME HERITAGE ITEMS (TO BE SALVAGED)
- MARITIME HERITAGE ITEMS (PRESERVE)
- I.D XXX — FEATURE IDENTIFIER FEATURE LABEL

KEY HERITAGE CONSTRAINTS
- SANDBODY BUFFER ZONE

NOTES

1. SANDBODY BUFFER ZONE APPLIES TO 4m FROM EDGE OF RETAINI WALL FORMATION ALONG REALIGNED BRIDGE STREET.
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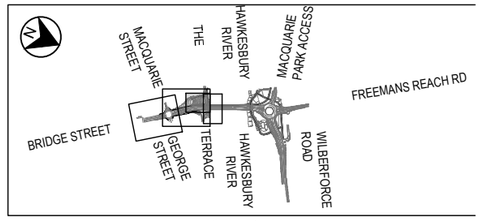

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PLAN SHEET 3

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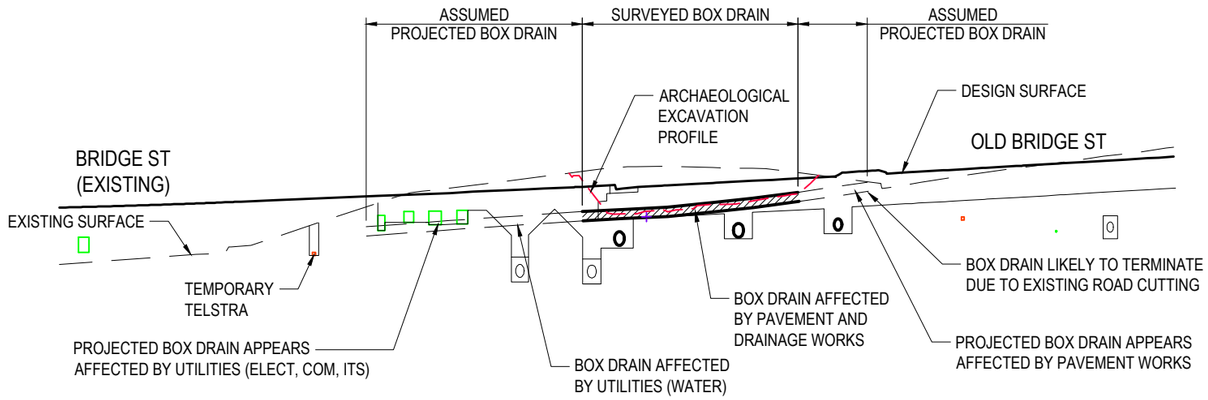

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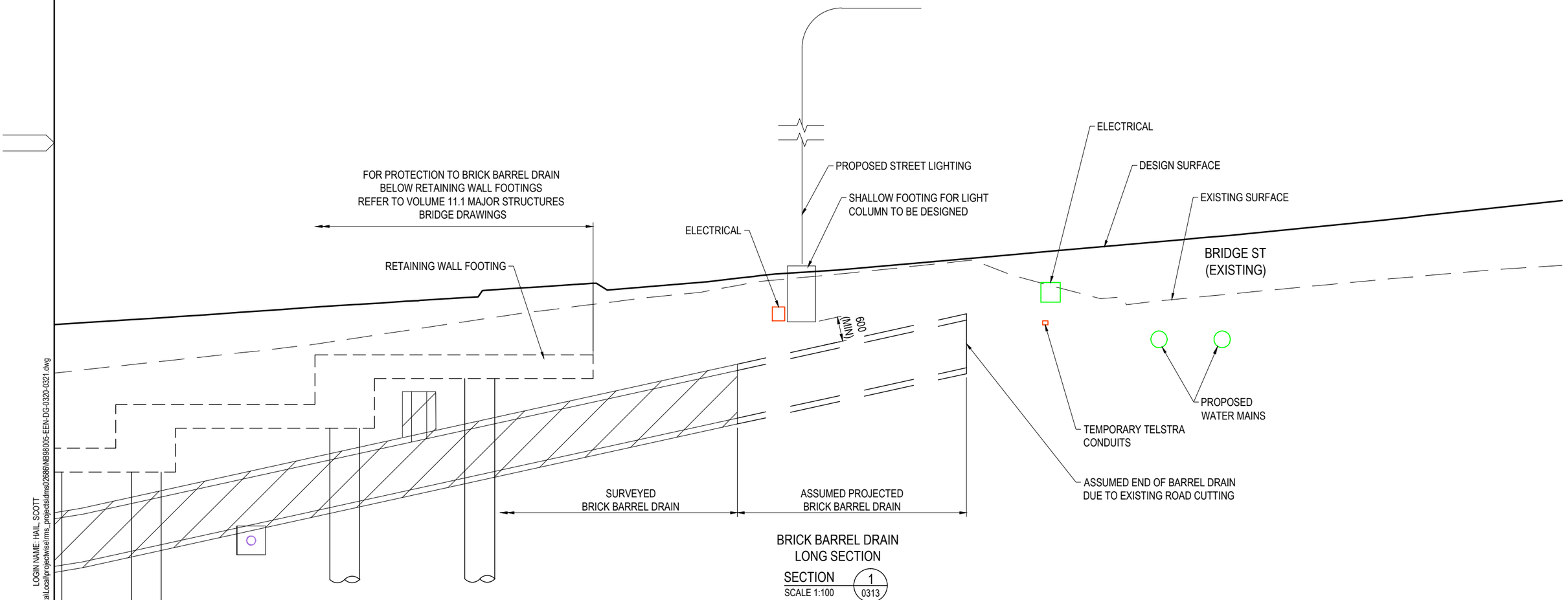

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HERITAGE MANAGEMENT
BRICK BARREL DRAIN AND BOX DRAIN
LONGITUDINAL SECTIONS

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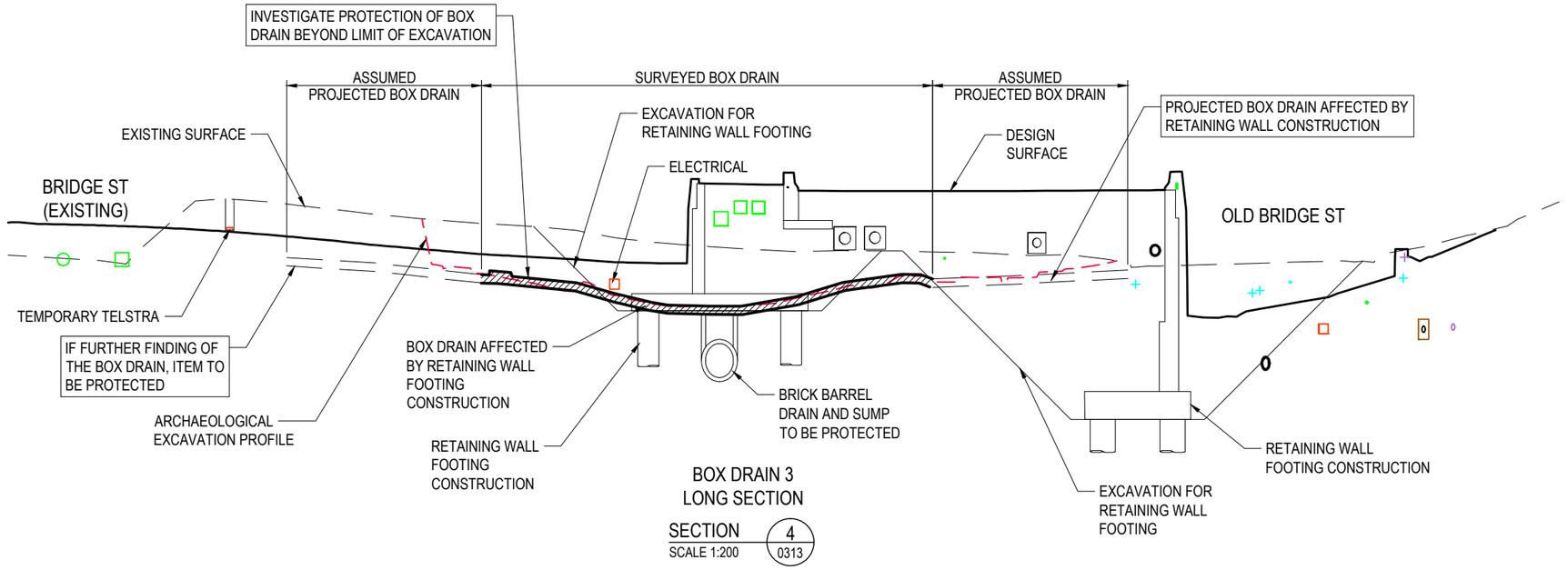

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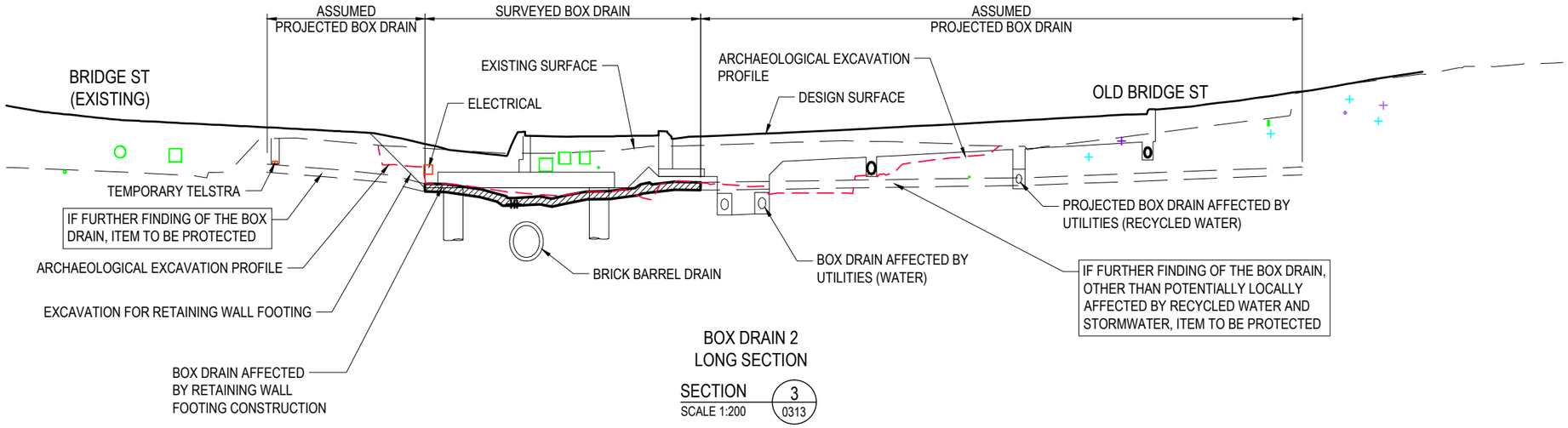

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