Appendix G

Geotechnical Working Paper

New Grafton Correctional Centre SSDA 7413

INFRASTRUCTURE NSW

New Grafton Correctional Centre

Infrastructure New South Wales

Geotechnical Working Paper

Final | V05

1 August 2016

New Grafton Correctional Centre

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Document history and status

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Final revised	01/08/2016	Client Review	Rachel Vazey	Steve Rosin	Rachel Vazey

Contents

Terms and acronyms used in this document

Acronym	Definition
AASS	Actual Acid Sulfate Soils
AHD	Australian height datum
ASS	Acid sulphate soils
CBR	California Bearing Ratio
CSNSW	Correctional Services New South Wales
DPE	Department of Planning and Environment
EIS	Environmental Impact Statement
GBH	Geotechnical bore log
GPS	Global positioning system
INSW	Infrastructure New South Wales
LGA	Local government area
mAHD	Metres above Australian Height Datum
MMDD	Modified Maximum Dry Density
MBGL	Metres below ground level
NATA	National Association of Testing Authorities
NGCC	New Grafton Correctional Centre
NSW	New South Wales
PAD	Potential archaeological deposit
PASS	Potential acid sulphate soils
Project	Comprises the New Grafton Correctional Centre which will provide up to 1,700 new prison beds, within a maximum and minimum security correctional centre with relevant support services and facilities
Project Site	Comprised of two properties Lot 26 DP 751376 and Lot 1 DP 1190399 and is located at 313 Avenue Road, Lavadia
Proposal	Comprises the concept proposal and the Stage 1 works development application
PSD	Particle Size Distribution
SANC	Acid Neutralising Capacity
SCR	Potential Sulfidic Acidity
SEARS	Secretary Environment Assessment Requirements
SRD SEPP	*State Environmental Planning Policy [State and Regional Development] 2011*
SNAS	Retained Acidity
SPOCAS Suite method	Suspension Peroxide Oxidation Combined Acidity and Sulphate Suite method is a self-contained acid base accounting test. It provides a measurement of the maximum oxidisable sulfur, Titratable Actual Acidity (TAA) and Titratable Peroxide Acidity (TPA) and the potential Acid Neutralising Capacity (ANC) present in the soil sample
SSD	State Significant Development
STAA	Existing Acidity (Actual Acidity)
TSS	Total Suspended Solids

Executive Summary

Infrastructure NSW (INSW) on behalf of Corrective Services NSW (CSNSW), a division of the Department of Justice, is seeking approval under Division 4.1, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the concept proposal and Stage 1 Development Application (DA) for the New Grafton Correctional Centre (the Project). The Project will be located on a 195 ha site (the Project Site), approximately 12.5 kilometres (km) south-east of Grafton in the Clarence Valley local government area. The concept proposal and the Stage 1 works application comprise the Proposal.

This Geotechnical Working Paper has been prepared to support the preparation of the EIS required under Division 4.1, Part 4 of the EP&A Act. Geotechnical investigations for this working paper involved the review of available background information and the excavation and geotechnical logging of 15 test pits across the site. In addition to this a range of soil samples were submitted for laboratory tests to assess the geotechnical properties of the site soils.

The site is underlain generally by stiff high plasticity clayey soils to depths ranging between about 0.75 to 2.75 metres below the surface (Unit 1 and 2). These overburden soils are in turn underlain by siltstones and sandstone bedrock of the Grafton Formation. The upper zone of this bedrock is comprised of weathered low strength bedrock extending to depths ranging between 5.75 and 7.75 metres (Unit 3a) below the surface. Below this the quality of the rock mass tends to improve grading to slightly weathered to fresh (Unit 3b), medium to high strength bedrock. The groundwater table is anticipated at depths ranging between five and greater than 15 metres below the surface.

An investigation was undertaken in relation to the potential for the occurrence of acid sulfate soil at the site. The history of the formation of the site soils does not lead to an anticipation of such soils occurring at the site. This is because the site soils do not contain sulphides, and are non-estuarine in origin. However, site investigations revealed another actual acid hazard identified which required further field and laboratory investigation to quantify the risk of acid generation associated with the exposure of the site soils. Appropriate soil management plans may need to be developed depending on the results of further investigations which will need to be completed prior to construction starting.

The general geotechnical conditions of the Project Site do not represents any particular constraint on the Project and general founding conditions for building structures should generally be considered favourable given the shallow depth to bedrock and the generally stiff near surface soils encountered at the site. However given the nature of the gently undulating site topography and the requirement for the Project to result in large levelled building platform areas, extensive cut and fill earthworks areas are expected to be required for the Project. This would likely be required to balance earth works and avoid importation of site fill materials for the platforms. In view of such requirements and depending on the depth of excavations, consideration would have to be given to the ability to appropriately excavate the subsurface materials to the required depth. In particular if it is required to excavate well below the surface into the underlying medium to high strength unit 3b bedrock, heavy ripping machinery maybe required with associated significant noise and air quality impacts during the works.

There are also a range of other geotechnical related conditions that need to be considered in the design and construction of the Project as listed below.

- The occurrence of the surface high plasticity clay reactive soils (Unit 2) that are prone to shrink-swell movement as a result of seasonable moisture changes which will require careful consideration for the design of building structures founded directly on such soils.
- These high plasticity soils result in low California Bearing Ratio (CBR) values and would likely require special treatment such as lime stabilisation for subgrade treatment for design of building platforms and roads for the Project.
- The site soils are dispersive in nature and will require special treatment when used in fill batters and slope cuts to avoid soil erosion problems.
- Special consideration will be required for the engineering design of fill platforms given the likely poor strength of excavated materials for re-use as general fill for building platforms due to the highly reactive nature of the upper clayey soils and the slaking properties of the underlying weathered unit 3a bedrock.

This working paper fulfils the first part of the Secretary's Environmental Assessment Requirement (SEAR) Works Item 4 - General in which a Geotechnical and Structural Report is to be prepared for the Project. The second part of this SEAR requests that an Acid Sulfate Soils Management Plan be prepared, if required. The

results of testing completed for this working paper and the understanding of the history of the formation of acid sulfate soils do not indicate the typical formation of acid sulfate soils. This is because the soils do not contain sulphides, and are non-estuarine in origin. However, based on the test results there is some other acid soil generation hazard which would require further field and laboratory investigation to quantify the risk. It is recommended that additional sampling be completed prior to construction occurring in the exact location of the footprint of the Project and to the depths that excavation is required in accordance with the Roads and Traffic Authority (2005) *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze.* Test material would be subject to a full range of analyses and if the results indicate that acid sulphate material is present, an Acid Sulfate Material Management Plan would be prepared prior to construction activities commencing.

1. Introduction

1.1 Background

Infrastructure NSW (INSW) on behalf of Corrective Services NSW, a division of the Department of Justice, is seeking approval under Division 4.1, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A) for the concept proposal and Stage 1 Development Application (the Proposal) for the New Grafton Correctional Centre (NGCC) (the Project).

The Project satisfies the criteria of Schedule 1 of *State Environmental Planning Policy (State and Regional Development) 2011* as the capital investment value of the correctional centre exceeds $30 million. As such, the Project is declared to be a State Significant Development (SSD) under Division 4.1, Part 4 of the EP&A Act and the Minister for Planning is the consent authority for the application. The Secretaryøs Environmental Assessment Requirements (SEARs) for the Proposal were issued by the Department of Planning and Environment (DPE) on 21 December 2015.

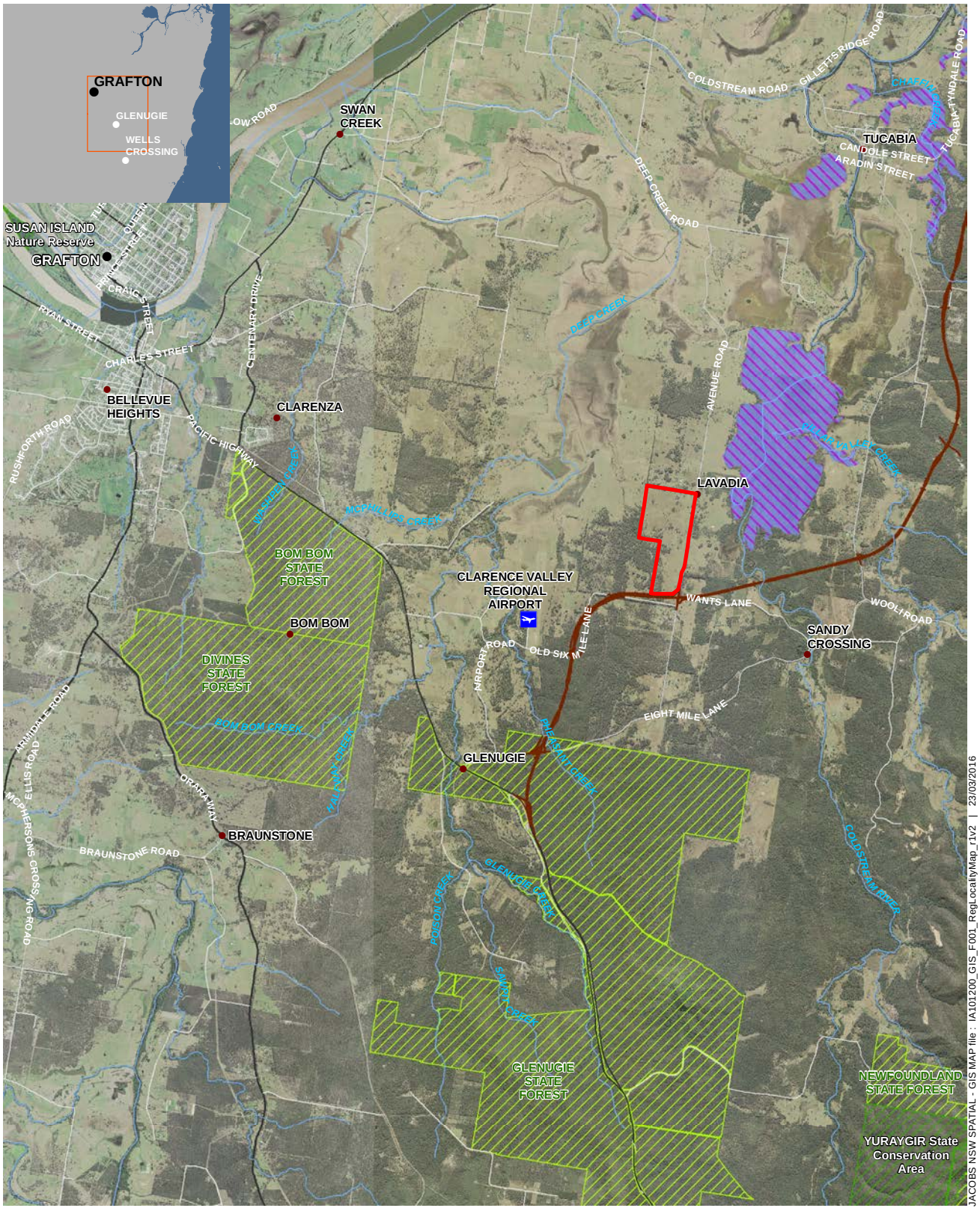
1.2 Locality

The Project is located approximately 12.5 kilometres southeast of Grafton; refer to **Table 1-1**; within the Clarence Valley Local Government Area (LGA) at 313 Avenue Road, Lavadia (the Project Site).The Project Site is zoned RU2 ï Rural Landscape under the *Clarence Valley Local Environmental Plan 2011.* Development for the purpose of a correctional centre is permissible with consent within the RU2 Rural Landscape zone.

The Project Site includes two properties comprised of Lot 26 DP 751376 and Lot 1 DP 1190399 and is 195 hectares in size; refer to **Table 1-2**. The site has historically been used for cattle grazing. In July 2015, development consent for a dwelling house in the southeast corner of Lot 1 DP 1190399 was granted by Clarence Valley Council (the Council) and construction of the house is complete. The Project Site is bounded by Avenue Road (also recognised as Golden Mile Road) to the east, and Old Six Mile Lane to the south. Avenue Road connects to the Pacific Highway via Eight Mile Lane to the south and Old Six Mile Lane connects to the Pacific Highway to the west.

1.3 Project description

The New Grafton Correctional Centre (NGCC) requires a staged development application that sets out a concept proposal for a new correctional centre at Grafton that provides maximum and minimum security facilities and includes a total of 1,700 beds. The concept proposal includes a maximum built form height of 12 metres (approximately three storeys) gross floor area of approximately 100,000 square metres. The staged development application also seeks concurrent Stage 1 approval for site clearance and preparatory works. The concept proposal and the Stage 1 works application comprise the Proposal. **Table 1-1** provides a summary of the Proposaløs key components and features.



Legend

- The Project
- Grafton Bypass (proposed)
- SEPP 14 Wetlands
- National Park Reserves
- State Forests

0 2 4 Km

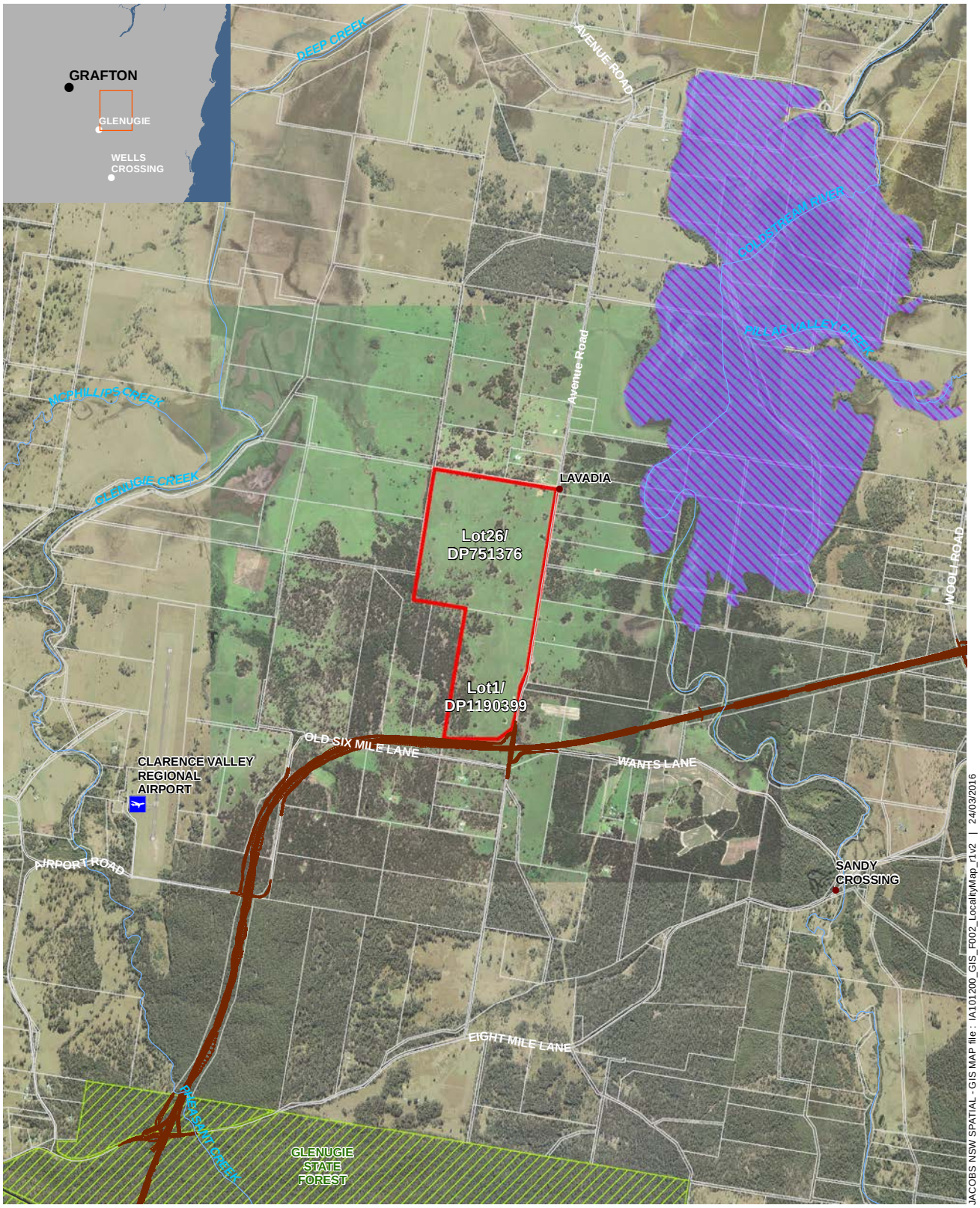
1:125,000 @ A4

N

Data sources

Jacobs 2015
LPI 2015
NSW DPE 2015
RMS 2013 (W2B Alliance)

Figure 1-1 | Regional Locality



Legend

- The Project
- Grafton Bypass (proposed)
- SEPP 14 Wetlands
- State Forests

0 1 2 Km

1:50,000 @ A4

N

Data sources

Jacobs 2015
LPI 2015
NSW DPE 2015
RMS 2013 (W2B Alliance)

Figure 1-2 | The Project

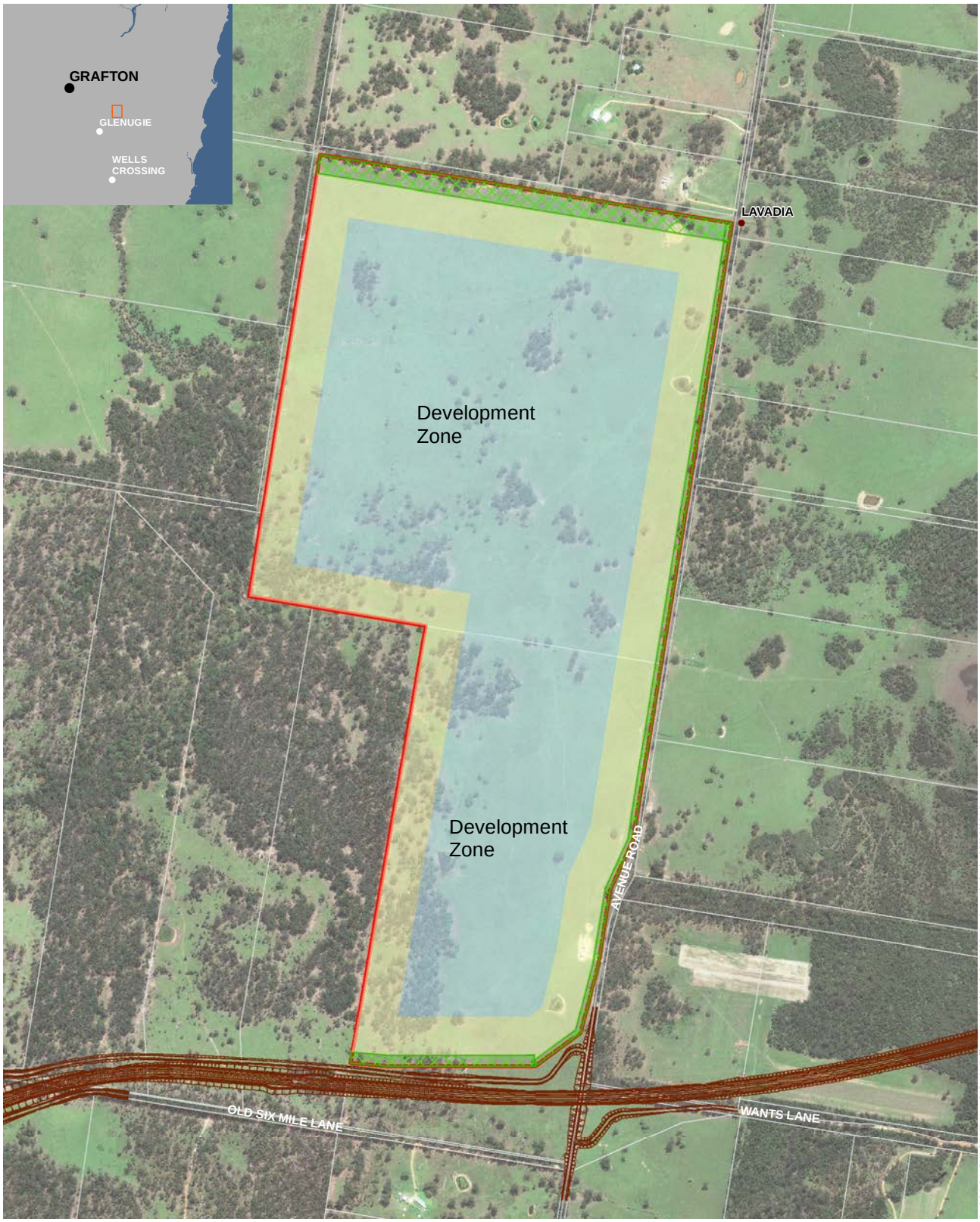
Table 1-3 Key Project Components

Stage	Description
Development summary	The staged SSD application seeks approval for: • A concept proposal for the New Grafton Correctional Centre. • First stage site clearance and preparatory works for the Project. Together referred to at the Proposal.
Project Concept Proposal	The NGCC includes a maximum and minimum security correctional centre of 1,700 beds comprised of: • A maximum security section of 1,300 beds that will include: – 1000 beds for male inmates. – 300 beds for female inmates. • A minimum security section that will include: – 400 bed residential accommodation for male inmates. The building envelope including the configuration, location and number of building structures required for the Project would not be determined until the detailed design is complete as part of the Stage 2 works. Consequently, the stage 2 construction works for the Project could occur anywhere within the development zone shown in Figure 1-3. The total footprint around both the maximum and minimum correctional centres, including the carpark, is around 45 hectares. Features of the Project include the following: • The concept proposal includes a maximum built form height of 12 metres (approximately three storeys). • The gross floor area will be approximately 100,000 square metres. • A six metre high fence or wall will be constructed around the perimeter of the facility, with light and security camera poles up to 10 metres in height. • Store buildings, small ancillary facilities and a central energy plant will be located outside the perimeter walls / fences. • Internal access into and out of the correctional centre from Avenue Road will be provided. • Car parking for approximately 500 car spaces. • Other associated facilities include recreational oval, special accommodation units, health facilities, education and programs areas, administration, workshops, staff amenities, visitor facilities and utilities. • A 100-metre wide Asset Protection Zone (APZ) zone would be cleared around the correctional centre and associated facilities and car parking area in accordance with the Rural Fires Act 1997 and requirements of the Planning for Bush Fire Protection (PBP; NSW Rural Fire Service [RFS], 2006). • A vegetation buffer outside the APZ would be provided along the northern, eastern and southern boundaries of the Project Site. The buffer would be 50 metres wide along the northern property boundary, 15 metres wide to the east along Avenue Road and 30 metres wide along the southern property boundary. • Fire access roads on the inside and the outside of the perimeter fence of the facility will be constructed to ensure safe operational access for emergency services personnel responding to a bushfire event. • Water, wastewater, power and communication utilities within the Project Site. • Landscaping of ground cover and /or shrubbery in areas to be defined.

Stage	Description
Stage 1 Site Clearance and Preparatory Works	Stage 1 (early works), includes preparatory work within the cadastral boundaries of Lot 26 DP 751376 and Lot 1 DP 1190399. This would involve: • Vegetation clearance and biodiversity management activities. • Construction of access roads including fire access roads to the extent required to conduct Stage 1 works. • Construction of auxiliary facilities such as construction compound, construction staff parking facilities and stockpiles sites. • Temporary provision of water, power and communication services within the site to the extent required to conduct Stage 1 works. • Demolition of the existing house and sheds. • Bulk excavation and site stabilisation works. • Landscaping.
Value	The capital investment value for the Project is in excess of $30 million.
Project Site	• Located at 313 Avenue Road, Lavadia. • Lot 26 DP 751376. • Lot 1 DP 1190399. • Project Site is195 hectares (ha) in size.

Future works regarding the design, construction and servicing of the Project will be based on the final design and layout of the facilities and will be the subject of future staged development application(s).

The construction activities associated with the Stage 1 site clearance and preparatory works is estimated to take approximately 6 to 12 months and provide up to 50 full time equivalent positions.



Legend

- The Project
- Landscaping zone
- Asset Protection Zone
- Development Zone
- Grafton Bypass (proposed)

0 250 500 Metres

1:15,000 @ A4

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Data sources

Jacobs 2015
LPI 2015
NSW DPE 2015
RMS 2013 (W2B Alliance)

Figure 1-3 | The Project

1.4 Project objectives

The objectives of the Project are to:

1) Be a safe and secure correctional centre.
2) Be a humane and ethically managed centre.
3) Help reduce the risk of re-offending through (among other things) preparing inmates for reintegration into the community on release from the CSNSW network.
4) Manage resources effectively and efficiently, enhancing value for money.
5) Utilise effective governance arrangements.
6) Produce strong economic and social benefits to the local Grafton region, the northern NSW region and the broader NSW community.
7) Be a valuable physical asset for the duration of the Operating Phase and beyond.
8) Be operated in such a way as to keep pace with best correctional practice over the term of its operational life.
9) Be operated so that it links with the broader management strategies and operational needs of the CSNSW network.

1.5 Legislative Requirements

SEARs relevant to this working paper and where they have been addressed are summarised in **Table 1-1**.

Table 1-5 SEARs relevant to this specialist working paper

SEARs	Cross reference
SEARS – Early Works Item 4 General In addition, the EIS must include the following: • Geotechnical and Structural Report. • Acid Sulfate Soils Management Plan (if required).	The first item is addressed through completion of this working paper.

1.6 Report structure

This Geotechnical Working Paper will be used to support the preparation of the EIS required under Part 4.1 of the EP&A Act. The structure of the report is summarised in **Table 1-6**.

Table 1-6 Report structure

Section reference	Section heading	Description
Executive summary	Executive summary	Concise summary of this technical paper and the key findings
1	Introduction • Background • Locality • Proposal description • Proposal objectives • Legislative requirements • Report structure	Description of the project relevant to potential impacts on geotechnical aspects of the project. Provides an overview of the study objectives and structure of the paper.
2	Regional Topography and Geology	Describes the regional topography and geology of the area in the context of understanding site geotechnical conditions.

Section reference	Section heading	Description
3	Results of Background Review	Presents the results of previous geotechnical investigation results from various stages of the Roads and Maritime Services Pacific Highway Upgrade and review of other relevant information such as background groundwater data and seismicity for the area.
4	Site Geotechnical Investigations.	Describes the scope of the field investigations and laboratory testing program for the project.
5	Site Geotechnical Conditions	Describes the site topography and the subsurface geotechnical and ground water conditions.
6	Geotechnical Laboratory Testing	Describes the results of the geotechnical laboratory testing program.
7	Preliminary Assessment of Acid Sulphate Soil Potential	Provides the results of the testing of the Project Site and recommends appropriate soil management strategies and/or further investigations.
8	Soil and groundwater aggressitivity	Provides an assessment of the aggressitivity of the subsurface conditions for design of concrete and steel piles.
9	Overall Geotechnical Assessment	This section provides an overall geotechnical evaluation of site conditions with regard to the proposed development in terms of the properties of the site soils, cut and fill earthworks, excavatability of materials, foundations for structures, and road pavements.

2. Regional topography and geology

2.1 General topography and drainage

The regional topography is strongly determined by the geology and drainage pattern of the area. The area of the Project Site is typified by a gently undulating topography underlain by Grafton Formation rocks which are less resistant to weathering compared to other rocks in the region. The ground elevations in the general area typical range between 10-40 mAHD (metres above Australian Height Datum).

Within a few kilometres of the site, directly to the north-east, the topography merges with a local low lying swampy area (Colletts Swamp) which forms part of the northerly flowing tributary to the Coldstream River drainage network.

Further to the east of the site the gentle topography merges with a regional north/south trending ridge called the Pillar Range, located some nine kilometres to the east underlain by resistant Kangaroo Sandstones with an elevation range of between 100-200 mAHD.

The topography to the west and north-west merges with the low lying area of the Clarence River Flood Plain. To the south of the site the topography becomes slightly more rugged. In the south a singular volcanic remnant plug referred to as the Glenugie Peak forms a prominent feature in the landscape and is located about nine kilometres to the south of the Project Site and reaches an elevation of 316 mAHD.

The topography of the Project Site is gently undulating with natural depressions occurring throughout. A small ridge runs through the Project Site in a north to south direction; refer to **Figure 2-1**. The slope of Lot 26 DP 751376 (northern portion) of the Project Site typically head down gradient drainage channels located along the east (towards Avenue Road) and to west (towards adjacent properties). Within Lot 1 DP 1190399 (southern portion) of the Project Site, the slope is typically in the direction of east and west towards drainage features located in the north west and south east of the Project Site.

Consistent with the topography of the Project Site, the surrounding topography is gently undulating, sloping towards drainage channels which feed into Glenugie Creek located to the west and north west and towards the Coldstream River located to the east, refer to **Table 1-2**.

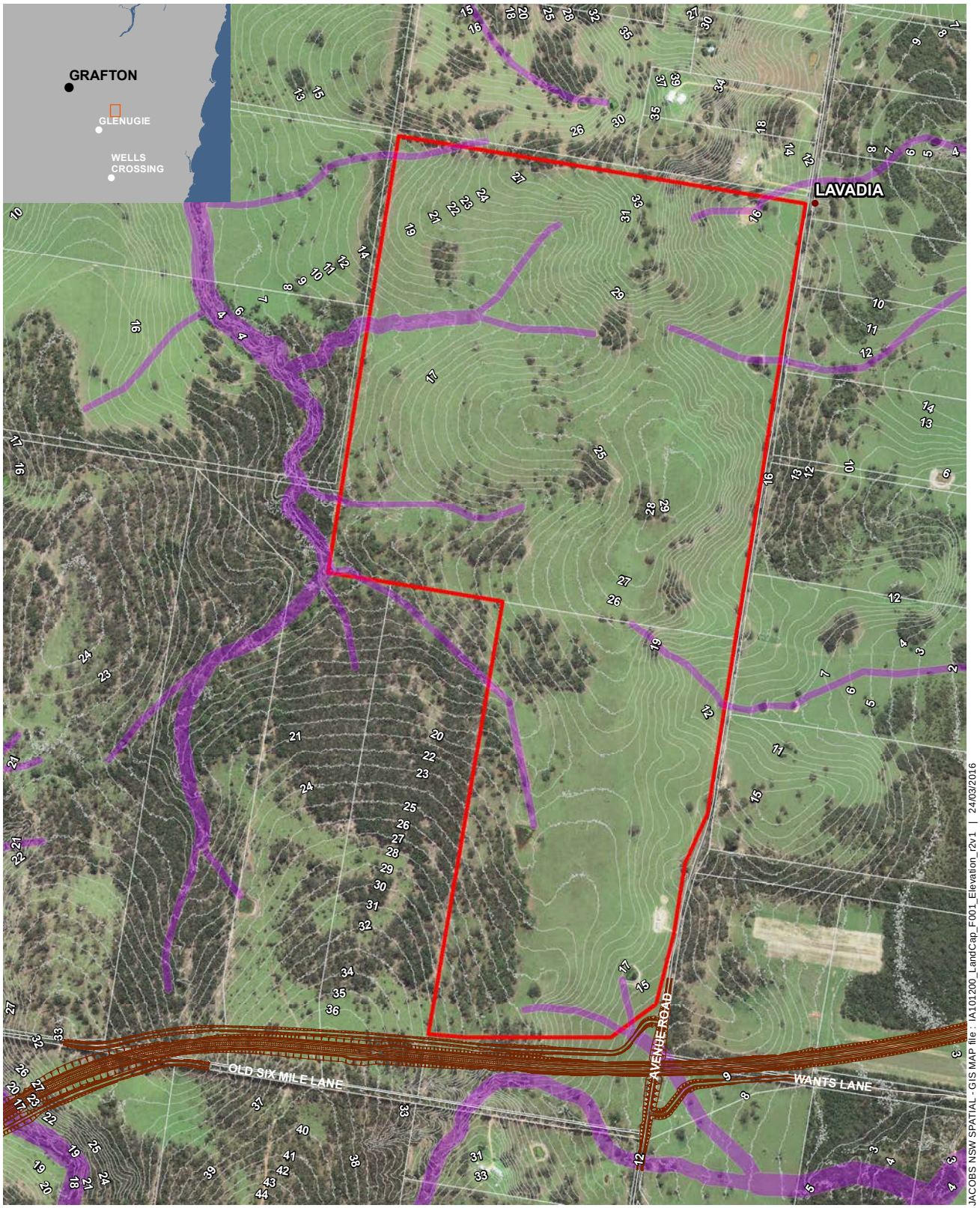
The predominant surface water features surrounding the site are the Coldstream River and associated wetlands (approximately 600 metres to the east) and Glenugie Creek (approximately 1.5 kilometres to the west/north west). On-site there are multiple tributaries heading off-site which feed into the Coldstream River to the east and Glenugie Creek to the west (refer to **Table 1-2**.). These drainage channels appear to form a natural low point in the topography. There are four artificially constructed dams within the Project Site which have been located at natural depression to capture overland flows. A constructed storm water drain that runs adjacent to Avenue Road, east of the Project Site is also present.

The majority of rain falling onto the site would fall onto unsealed (cleared and vegetated) surfaces, and is expected to infiltrate into sub-soils and run off into the natural drainage channels heading off-site to the east and west as well as to the four artificially constructed dams present within the Project Site . Rain falling onto surrounding areas is expected to infiltrate into sub-soils, fall onto unsealed (cleared and vegetated) surfaces or run off across sealed surfaces (Avenue Road to the east) into formalised storm water drains.

2.2 General geology

The regional geological map of the area is presented in **Table 2-2** with the local scale geology presented in **Table 2-3**.

The regional geology of the area comprises sedimentary rocks of the Clarence ï Moreton sedimentary basin which spans from the Middle Triassic at the base to late Jurassic (between 230-141 million years ago (Ma)). These rocks represent an extensive onï shore 3000-4000 metre thick sedimentary basin in north-east NSW and south-east Queensland. This sequence is underlain in parts by Palaeozoic basement rocks of the New England Fold Belt.



Legend

- The Project
- Grafton Bypass (proposed)
- 1m contours
- Riparian zone (strahler order)

0 250 500 Metres

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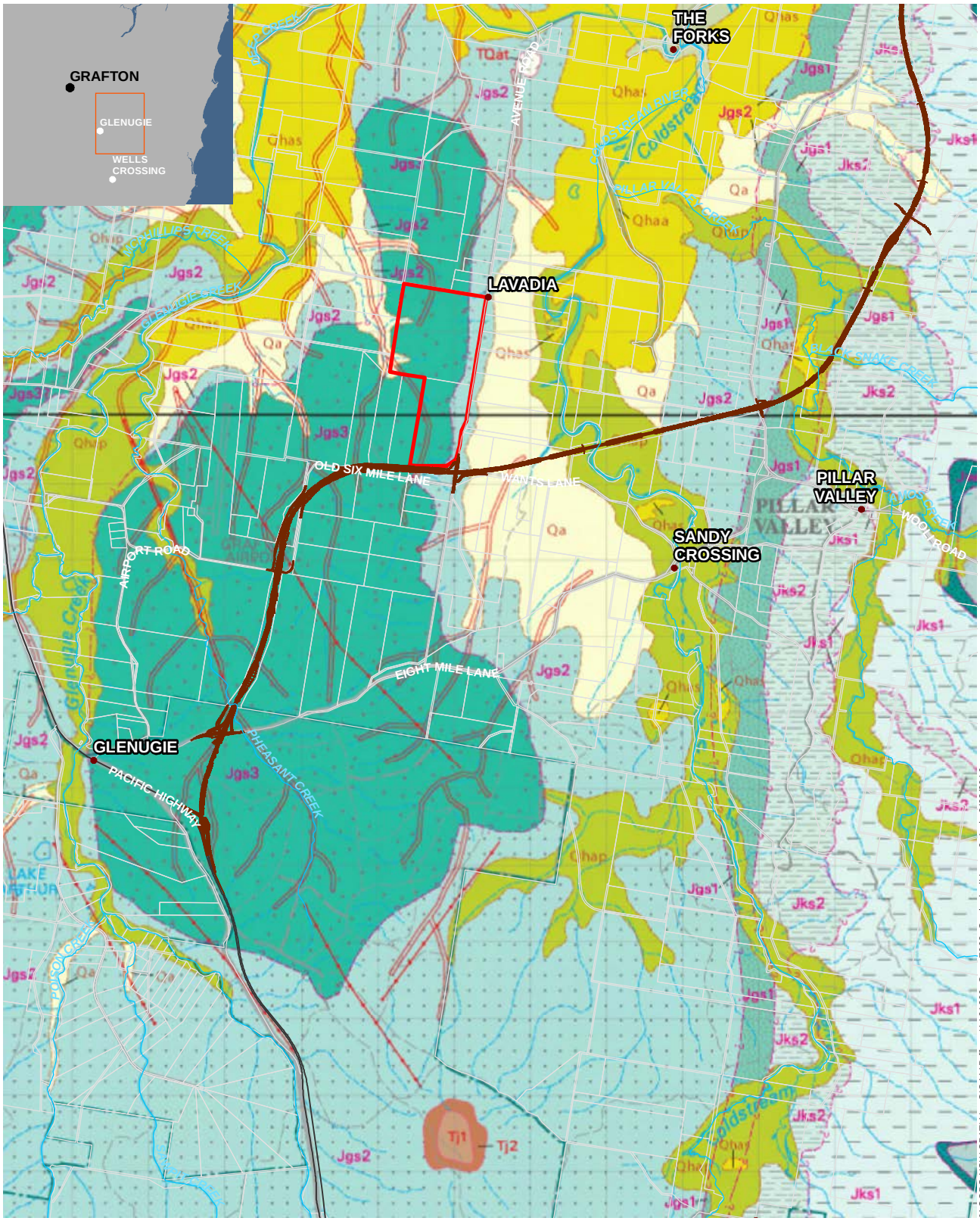
Data sources
Jacobs 2015
LPI 2015
RMS 2013 (W2B Alliance)

Figure 2-1 | Elevation and drainage features



JACOBS NSW SPATIAL - GIS MAP file : IA101200_Geo_F003_GeologicalMaps_r2v1 | 2/08/2016

Legend

- The Project
- Grafton Bypass (proposed)

Qa: Undifferentiated alluvial and colluvial deposits
Qhas: Backswamp, freshwater swamp
Qhaa: Alluvial palaeochannels and swales
Qhap: Floodplain
Jgs1: Grafton Formation
Jgs3 Grafton Formation
TQat: Residual alluvial terrace

0 1 2 Km
1:75,000 @ A4

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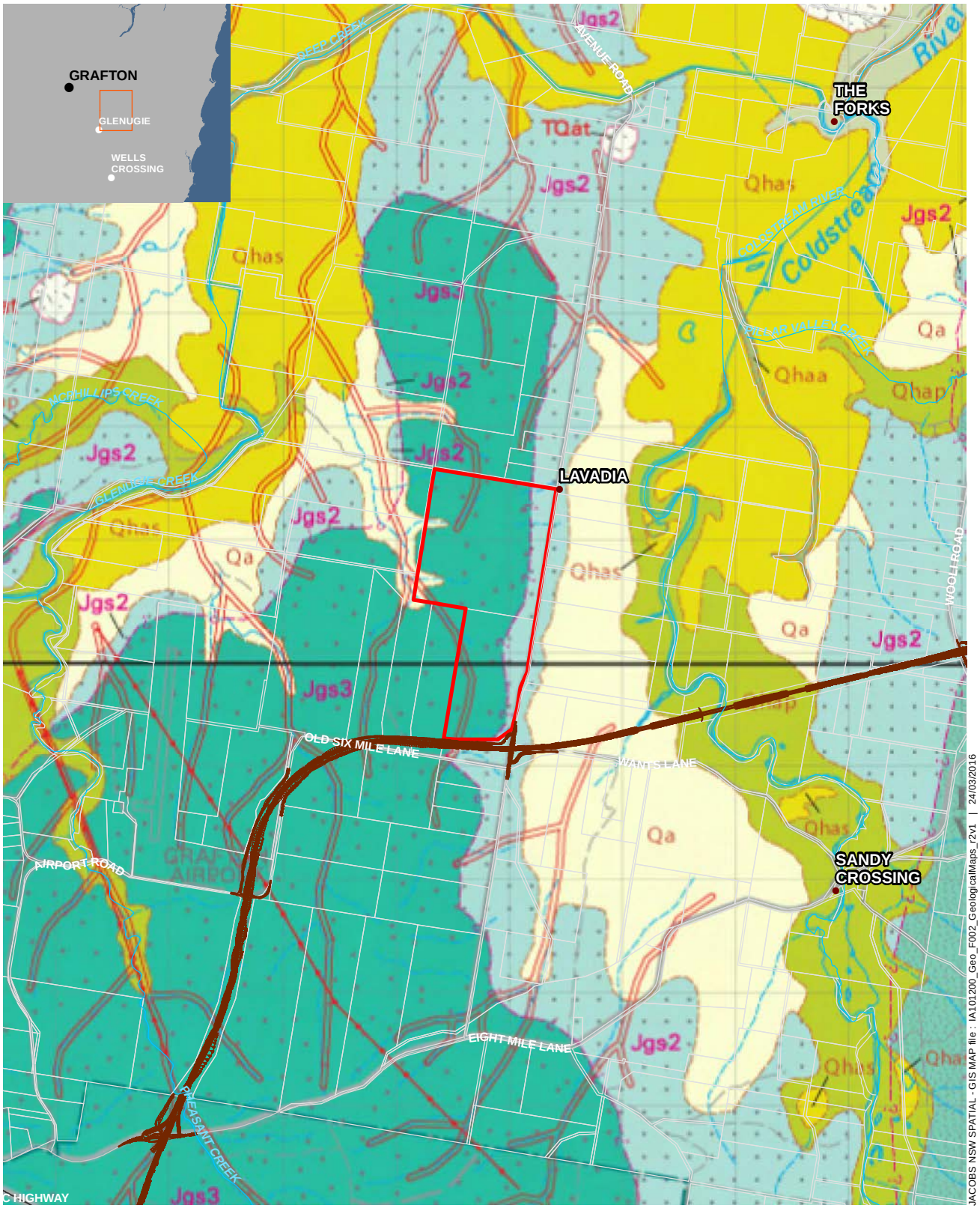
Data sources

Jacobs 2015
LPI 2015
RMS 2013 (W2B Alliance)
DRE, NSW

Figure 2-1 | Geological mapsheets - Bare Point regional scale geological sheet



Legend

The Project

Grafton Bypass (proposed)

Qa: Undifferentiated alluvial and colluvial deposits
Qhas: Backswamp, freshwater swamp
Qhaa: Alluvial palaeochannels and swales
Qhap: Floodplain
Jgs1: Grafton Formation
Jgs3 Grafton Formation
TQat: Residual alluvial terrace

0 1 2 Km

1:50,000 @ A4

N

Data sources

Jacobs 2015
LPI 2015
RMS 2013 (W2B Alliance)
DRE, NSW

Figure 2-3 | Geological mapsheets - Bare Point local scale geological sheet

Minor Tertiary Volcanics (60 Ma.) occur in the area with an example being the Glenugie Peak (Tj1, refer to **Figure 2-1**). The most recent formations comprise unconsolidated Quaternary sediments deposited on the Clarence River flood plains and estuary and other low lying areas. A summary of the stratigraphy is shown in **Plate 2-1**.

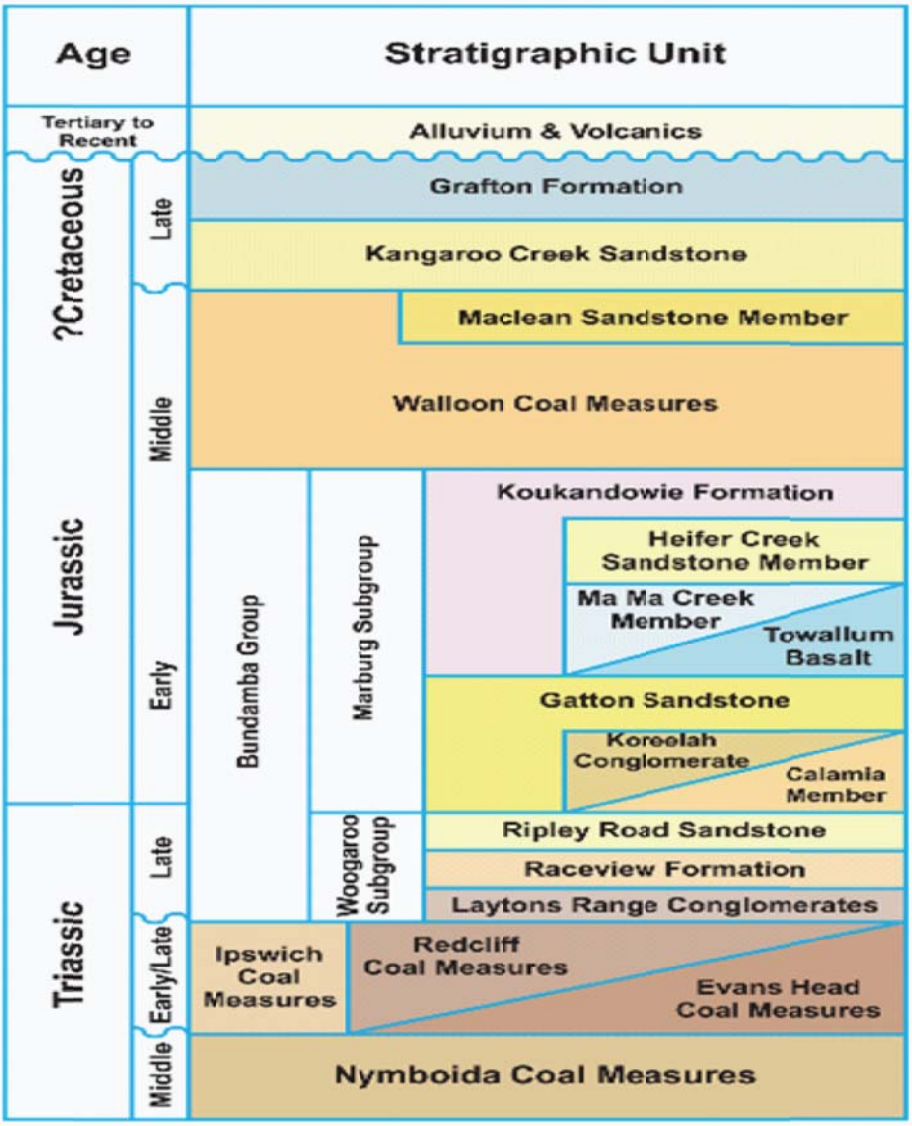


Plate 2-1 – Summary of stratigraphy in the Clarence-Moreton Basin (Metgasco, 2007)

The Project Site is underlain by a gently dipping Grafton Formation sedimentary sequence which consists of dark grey-green sandstone; fine to coarse grained and thinly to thickly bedded, siltstones and also shale and minor coal. The Grafton Formation typically forms low, rounded undulating hills due to their reduced resistance to weathering.

In the area unconsolidated Quaternary sediments occur within the Colletts swamp directly to the north east of the Project Site in the vicinity of Lavadia. Moreover, according to the geological map a limited thickness of quaternary sediments appears to occur along the site boundary in the north western part of the site associated with a tributary to the Clarence River.

3. Results of background review

3.1 Geotechnical investigations

A review of relevant previous geotechnical investigations for various stages of the Pacific Highway Upgrade Program was undertaken for the purposes of this assessment, as the alignment for the Pacific Highway Upgrade is located directly south of the site boundary and similar geotechnical conditions underlain by Grafton Formation rocks are expected at the Project Site. The Pacific Highway Upgrade investigations had been completed for Roads and Maritime Services (RMS), who granted permission for INSW to access this information for the purposes of this assessment. The location of relevant test pits and boreholes associated with these past studies are presented in **Table 3-1** (regional scale) and **Table 3-2** (local scale). Copies of the relevant test pit and borehole logs are provided in **Appendix A**. The main stages of investigation that were reviewed included:

- **2009 Investigations**: Coffey Geotechnics, *Pacific Highway Upgrade Project, Wells Crossing to Iluka Road: Geotechnical Investigation Report* January 2009 undertaken for Sinclair Knight Metz Pty Ltd. The relevant investigations cover the Test Pits GTP88 and GTP90-GTP92, and Boreholes GBH181, 182, 184 and 185).
- **2012 Investigations**: Coffey Geotechnics, *HW10 Pacific Highway Upgrade Project: Section 3 (Glenugie to Tyndale).* The relevant investigations cover the Test Pits TP1049 and TP1053, and Boreholes BH1023-BH1025, which are associated with the bridge crossing along Wants Lane.

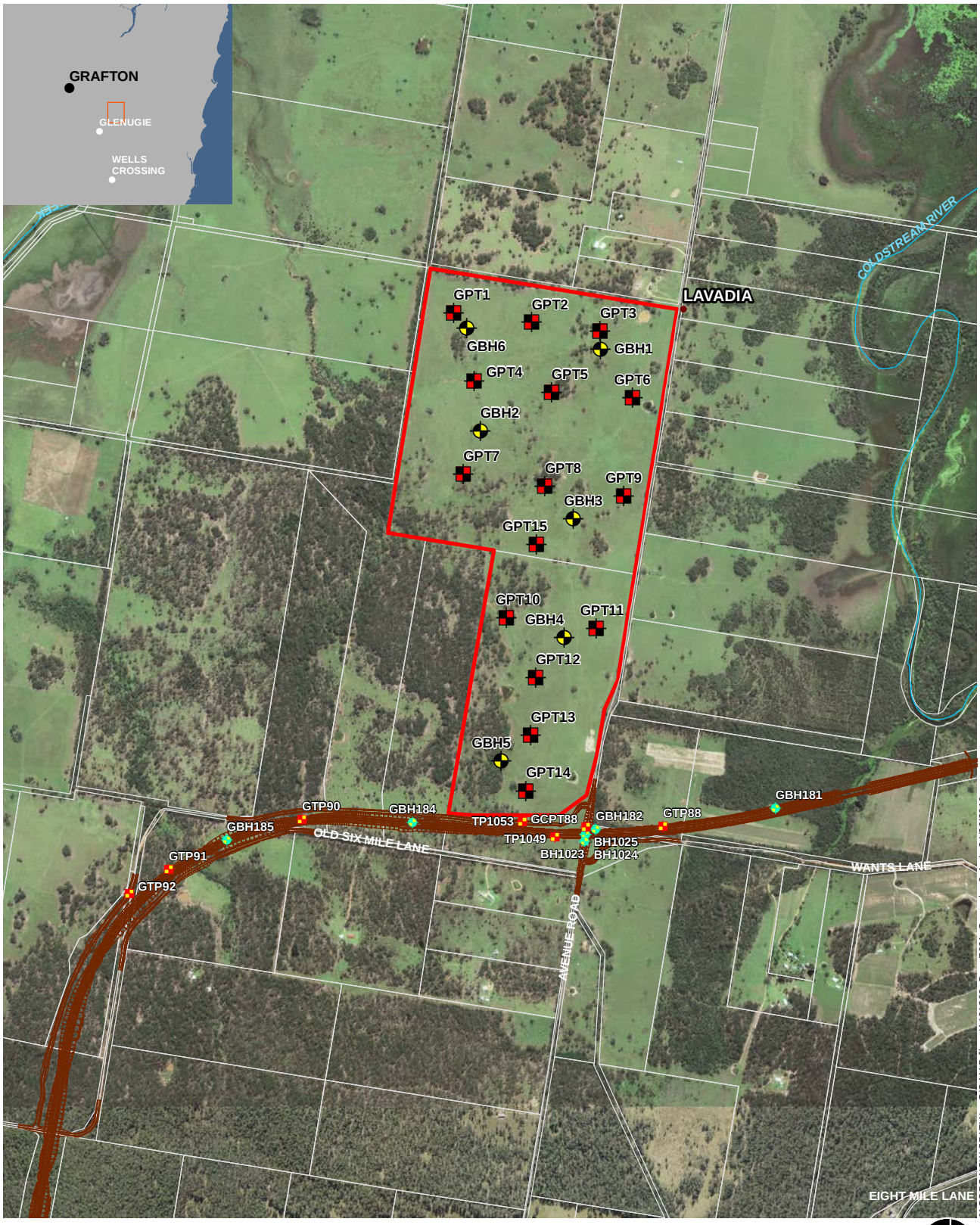
A review of this available background information shows a general uniformity in the soil profile throughout the area immediately to the south of the site along the Pacific Highway Upgrade alignment. Typically the soil profile comprises of a thin silty clay topsoil layer underlain by a grey brown mottled orange, stiff to very stiff/hard high plasticity silty clay extending to typical depths ranging between 1.5 metres to 3 metres below the surface. These soils are expected to be of transported origin (colluvial), grading with depth to residual soils (*in situ* weathering products of the underlying bedrock). These soils are in turn underlain by weathered low to very low strength, fractured to highly fractured siltstones and sandstones. At typical depths of about 8 metres below the surface the quality of the rock tends to improved where medium to high strength slightly weathered rockmass is typically encountered to the final depth of drilling in most boreholes at a depth of about 15 metres below the surface.

The only anomaly to this typical profile was the profile encountered at borehole GBH184 (surface elevation of 36.3mAHD) just south-west of the site boundary, along a ridge line. At this location stiff to hard high plasticity silty clays were encountered to a depth of 9.36 metres below the surface, and were in turn underlain by weathered to fresh sandstone for a few metres to a borehole termination depth of 11.64 metres. The increase in overburden soils at this site may be related to the occurrence of a relic deeply weathered soil profile developed from a previous climatic condition which to a large extent has been eroded away in the region.

A specific review has been carried out for boreholes GHB1023-1025 drilled for the proposed overbridge structure for the Avenue Road crossing of the proposed Pacific Highway upgrade which is located directly south of the Project Site. For these holes high plasticity silty clay soils were encountered to a depth ranging between 1.5 metres to 3.8 metres below the surface, and are expected to be of mainly colluvial soil origin. Toward the base of each hole, a gravelly silty clay layer was encountered interpreted to be of residual soil origin. The underlying bedrock comprised of interlaminated carbonaceous siltstones and sandstones.

3.2 Laboratory test results

A review of selected laboratory tests undertaken for the bridge pile foundations for the Avenue Road overpass crossing of the Pacific Highway from the 2012 investigations for the Pacific Highway upgrade project is provided in **Table 3-3** below.



Legend

- The Project
- Grafton Bypass (proposed)

Jacobs investigations

- GBH1 - GBH6 (Proposed Boreholes)
- GPT1 - GPT15 (Completed Test Pit Feb 2016)

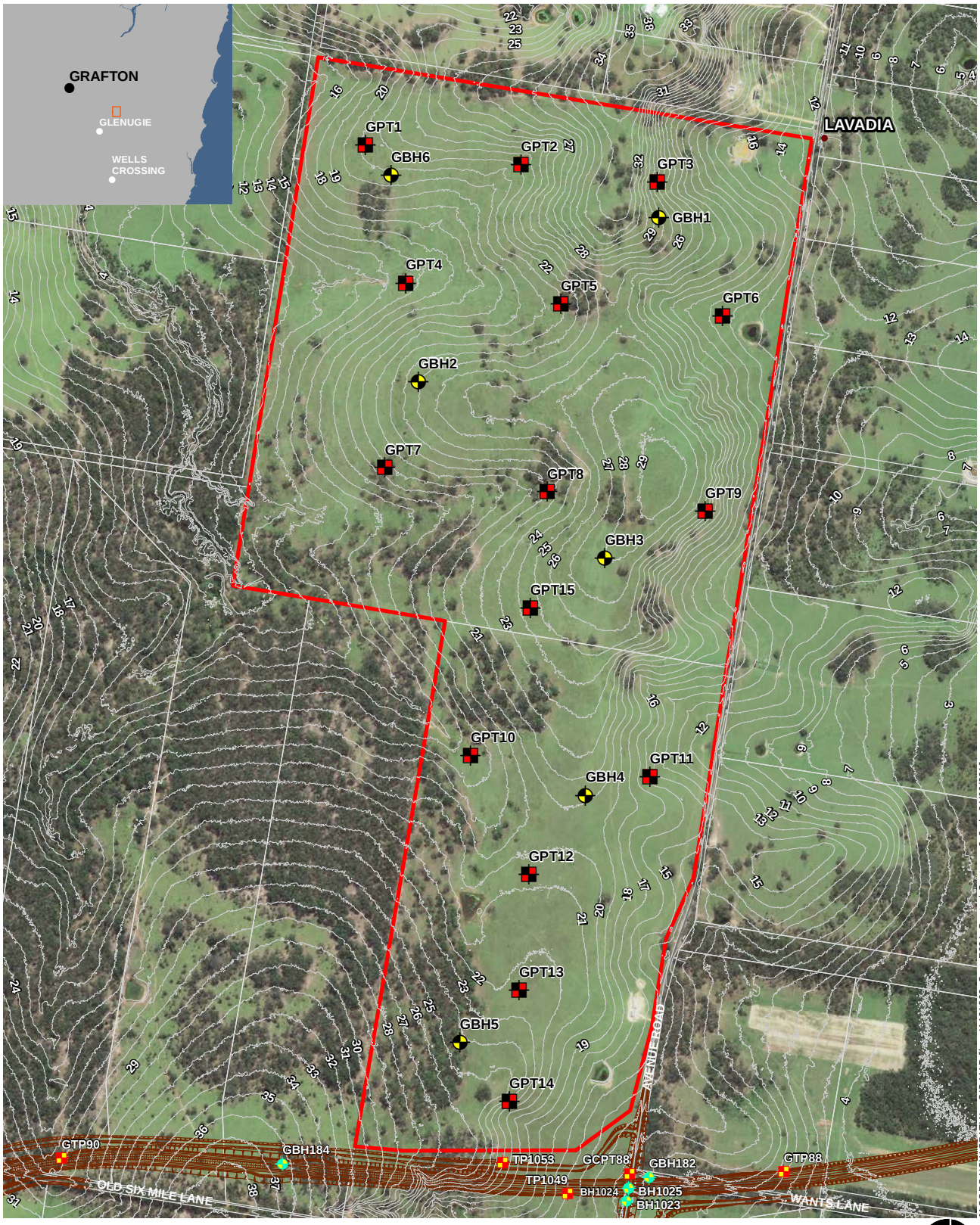
Previous drilling for Pacific Highway upgrades

- Borehole
- Test Pit

Data sources

Jacobs 2015
LPI 2015
RMS 2013 (W2B Alliance)

Figure 3-1 | Previous and current geotechnical investigations - Regional scale



Legend

- The Project
- Grafton Bypass (proposed)

Jacobs investigations

- GBH1 - GBH6 (Proposed Boreholes)
- GPT1 - GPT15 (Completed Test Pit Feb 2016)

Previous drilling for Pacific Highway upgrades

- Borehole
- Test Pit

0 250 500 Metres

1:12,500 @ A4

N

Data sources

Jacobs 2015
LPI 2015
RMS 2013 (W2B Alliance)

Figure 3-2 | Previous and current geotechnical investigations - Local scale

Table 3-3 Summary Soil Test Results for the Avenue Road Overpass of the Pacific Highway Investigations

Borehole / Test Pit No.	Depth range (m)	Field Moisture Content (%)	Soil Type	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	pH	Conductivity (µS/cm)	Chloride (mg/kg)	Sulphate (mg/kg)	Exposure classification
BH1023	2.5-2.95	21.0	Sandy clay with high plasticity				5.5	450	930	<10	Non ï aggressive
BH1024	1.0-1.45	19.0	Clay with high plasticity	60	11	49					
BH1024	1.0-1.45	16.0	Clay with high plasticity				5.1	340	960	31	Mild
BH1024	2.5-2.66	14.4	Clay with high plasticity	54	22	32					
BH1024	2.50-2.6	16.0	Clay with high plasticity				5.4	440	820	19	Non ï aggressive
BH1025	1.0-1.45	18.0	Clay with high plasticity				5.3	210	400	20	Mild

These investigations confirm the high plasticity (CH) clays encountered at the site. With reference to AS2159 - 2009 Australian Standard. Piling Design and Installation (Table 6.4.2), the results of chemical tests suggest that the exposure classification for concrete piles is expected to be ñmildò to ñon-aggressiveò

3.3 Groundwater

A review of the NSW Office of Water database was undertaken to identify any relevant information related to the presence and abstraction of groundwater in the area. No specific previous groundwater data was found within the Project Site and only limited information was found within a few kilometres of the Project Site.

Water bores drilled immediately to the south and west of the site within the Grafton Formation bedrock, extending typically to depths of 20-25 metres below the surface produced low yields, which is not surprising given the expected generally low permeability of the rockmass. No data was available on groundwater levels and these holes were assumed to be abandoned. A single borehole drilled a few kilometres to the west of the site, just east of the Bom Bom State Forest (GW307543) and within the general area of the Glenugie Creek flood plain, also encountered bedrock at shallow depths but with measurable yields and a water table about 6 metres below the surface.

Within BH1023 at the site of the Avenue Road overpass crossing of the Pacific Highway , a static water level was encountered at depth of 2.8 metres below the surface (8.9 mAHD) measured on 15 August 2012.

No other groundwater information was available in the area associated with the Pacific Highway upgrade project.

3.4 Seismicity

A review of seismic events from the Geoscience Australia website (records commence from 1955) indicates that there has been no earthquake within a 50 kilometre radius of the site of the recorded 60 year period.

Reference to *Australia Standard AS 1170-2007 (Structural design actions Part 4: Earthquake actions in Australia)* indicates that the earthquake hazard factor (Z) is 0.05. The earthquake hazard factor is equivalent to an earthquake acceleration coefficient with an annual probability of exceedance in 1/500 (i.e. a 10% probability of exceedance in 50 years.

3.5 Mineral resources

Reviews of a number of databases managed by the NSW Department of Industry Resources and Energy were undertaken to identify any relevant information related to coal, mineral and petroleum titles or tenures, including title / tenure applications. These databases include:

- Geoscientific Data Warehouse
- MinView
- NSW Titles Viewer.

A review of the Geoscientific Data Warehouse was undertaken to identify any existing mineral resources in the vicinity of the site area. A borehole used for coal seam gas exploration operated by Metgasco Ltd was identified near Avenue Road directly south of Old Six Mile Lane. The borehole is permanently sealed and is not anticipated to impact the Project.

A review of the MinView database was undertaken to identify any coal, mineral or petroleum titles, including title applications. No applications or current titles relating to coal, minerals or petroleum were found within or in proximity to the site area. A number of open file petroleum boreholes were located in the Grafton and Pillar Valley area, the closest was the Metgasco borehole identified in the Geoscientific Data Warehouse search. Historical minerals exploration licences dated between 1970 and 1979 were the most recent found to cover the site area and are no longer current.

A review of the NSW Titles Viewer was undertaken to identify any relevant tenures, specifically related to current tenures or applications for mineral, coal or petroleum tenures. No applications or current tenures were found within or in proximity to the site area.