PROJECT

AGRICULTURAL LAND ASSESSMENT – ‘CUDGEN CONNECTION’ 741 CUDGEN ROAD, CUDGEN NEW SOUTH WALES

PREPARED FOR

CUDGEN HEALTH PRECINCT PTY LTD
C/O PLANIT CONSULTING PTY LTD

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SYNOPSIS This report constitutes an Agricultural Land Assessment (ALA) for the proposed Cudgen Connection development located in Cudgen, New South Wales. This report details the findings of desktop and site-based investigations to determine the site's capability as agricultural land.

REVISION HISTORY

REVISION #	DATE	EDITION BY	APPROVED BY
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2	10/22	S. McGhee	P. Matthew & L.Varcoe
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SUMMARY

Planit Consulting Pty Ltd (Planit), on behalf of Cudgen Health Precinct Pty Ltd (CHP), commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare an Agricultural Land Assessment (ALA) for the proposed Cudgen Connection development located at 741 Cudgen Road, Cudgen, New South Wales. The aim of the ALA is to evaluate the suitability of the site for future agricultural use as part of a strategic land use review. It also aims to determine whether any limitations should be placed on the development of the land given:

- Tweed Shire Council's planning provisions for the protection of prime agricultural lands;
- the NSW Government's policy position to protect important agricultural land, as expressed through NSW Department of Planning, Industry and Environment; and
- any other relevant state and local planning provisions.

The proponent requested an agricultural land assessment in order to determine:

- The type and quality of soil on the site.
- The suitability of the soil for agricultural purposes.
- The capability of the site to support sustainable agricultural production having regard to its size and land use interfaces.

The results are divided into sub-sections to accurately address the requirements of the ALA. Having regard to these matters, this ALA forms expert conclusions and recommendations to ensure adverse impacts to the current and desired future land uses external to the site do not arise.

Policy framework

Primary State Policy

The Northern Rivers Farmland Protection Project 2005 (NRFPP) was prepared as a long-term Government initiative to protect agricultural land. From a strategic land use planning perspective, the NRFPP protects areas of significance from being removed or encroached upon by urban settlement and growth. At the time of the NRFPP's preparation, agriculture was the region's third largest employer and exporter and fourth highest contributor to gross regional production.

The North Coast Regional Plan 2041 (NCRP) sets out a 20-year land use planning framework, aiming to protect the environment and important farmland in the midst of strongly projected urban growth. In 2017, the (now superseded) North Coast Regional Plan 2036 augmented the State Government's approach to farmland protection, consolidating mapped State and Regionally Significant Land as 'Important Farmland'.

The NCRP 2041 acknowledges that agricultural production may not be suitable on some areas of mapped important farmland due to non-biophysical factors, and that the land may be more suitable for other uses.

Primary Local Policy

The Tweed Rural Land Strategy 2036 (Tweed RLS) was endorsed in 2020 and provides a specific strategy for the Tweed Shire, supported by a 141 Action Implementation Plan. The Tweed RLS comprises nine primary policy directions, including encouraging agricultural production and protecting agricultural land. The Tweed RLS does not claim to have reviewed the extent of mapped Important Farmland, nor does it contain an action to review the accuracy or strategic extent mapping. In comparison to the State Policy positions, the Tweed RLS draws a stronger character and visual landscape value to farming, as opposed to the soil quality driven methodology of the State Government.

Preceding and ultimately alongside the Tweed RLS, the Tweed Sustainable Agricultural Strategy identifies the need, actions and pathways to address the various challenges and opportunities facing the agricultural industry in the Tweed Shire. The Strategy is identified as a leadership action and is not considered to form a land use plan, rather it includes objectives to ensure the ongoing protection of prime agricultural land and minimise land use conflict.

Local Land Use Context

The site is located within an area commonly known as 'the Cudgen Plateau'. The area has long been farmed, to various extents, since European settlement commenced. Agricultural pursuits typically involve intensive agriculture types, such as avocado orchards and sweet potato cropping. In conjunction with active farms, several tourism-based and artisan enterprises are accommodated, such as Farm & Co and Red Earth Brewery.

The edges of the Cudgen Plateau are often adjoined by either environmental areas, forms of State infrastructure, extractive

industries or established or emerging low-density housing. The most contemporary of these land uses is the Tweed Valley Hospital, which is positioned on the north-eastern edge of land mapped as State Significant Farmland/Important Farmland.

Type and quality of soil
The soils identified on the site were **Red Ferrosols**, being soils that:

- have B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine earth fraction (<2 mm); and
- do not have clear or abrupt textural B horizons or a B2 horizon in which at least 0.3 m has vertic properties.

Red is one of the most common colour classes within this soil order, along with Brown.

The suitability of the soil for agricultural purposes
As outlined in Section 3.3, decision tables for individual hazards in the land and soil capability assessment scheme were used to identify the land suitability class. Based on the resultant soils mapping and slope analysis, the site was divided into unique mapping areas (UMA), each represented by polygons, as displayed in Appendix 1. Portions of land within the site that have similar unique soil type and landform attributes were attributed to the same UMA, which aided the land suitability assessment.

Each hazard identified through the land and soil capability assessment scheme was assigned one of the eight classes, where Class 1 represents the least hazard and Class 8 represents the greatest hazard. The final hazard assessment for the site was based on the highest hazard in that parcel of land.

The site's overall land and soil capability classes ranged from Class 3-8 with the primary determining factors including water erosion, shallow soils, rockiness and waterlogging. A portion of the site (some 2.6 hectares) was identified as Class 3 agricultural land.

The capability of the site to support sustainable agricultural production
The site's capability to support agriculture varies depending on the specific agricultural produce pursued. The site's soil depth and suitability for agricultural production also varies, with much of the land requiring rehabilitation to be commercially productive. The ALA identified the areas of the site that could practicably be used for intensive agriculture without further rehabilitation. This area of suitable land consists of approximately 2.06 ha of the total site. As

an example, typically, sweet potatoes can produce between 15 and 40 tonnes per hectare. Based on a 2.06 ha farming footprint, this may result in an initial estimate of 30 to 80 tonnes per year, excluding crop failure.

Greenhouse and controlled environment horticulture could be pursued with suitable noise mitigation and land use buffers. These formats however are decoupled from the land's soil quality and other biophysical attributes. In effect, such uses of the site would represent a departure from the soil-driven methodology which determined the extent of strategically Important Farmland areas. Accordingly, the focus of this ALA is largely confined to high-order primary production crops. Less intensive agricultural production would increase the productive area of the land, however generally results in lower yields.

As noted, the NRFPP's classification of the site as 'State Significant Farmland' was subsequently updated to 'Important Farmland' by the NCRP 2036. The current NCRP (2041) introduced Urban Growth Area Variation Principles which recognised that agricultural production may not be suitable on Important Farmland due to non-biophysical factors, and that the land may be more suitable for other uses.

Overall, the site meets the Urban Growth Area Variation Principles within the NCRP 2041 primarily due to its scale, isolation from other surrounding important farmland and large portions of the site being unsuitable for cropping, due to shallow soils and waterlogging. Such limitations are not conducive to an arable form of agriculture or estate, orchard or plantation and this is reflected in the site use to date.

Biophysical Strategic Agricultural Land

The site is mapped as Biophysical Strategic Agricultural Land, which is land with high quality soil and water resources capable of sustaining high levels of productivity. Indicative BSAL maps were introduced in 2012.

A limitation of these maps is that they were produced at a state/regional scale with varying accuracies and degrees of confidence. A site verification process has been developed under the State Environmental Planning Policy (Resources and Energy) 2021 to determine the existence of BSAL at the site of potential development. Having completed the verification process, the site is not considered BSAL because it:

- is isolated from other BSAL;

- does not meet the minimum size criteria of greater than 20 ha;
- exhibits inconsistent slopes that do not always meet the BSAL criteria of being less than or equal to 10%; and
- is not consistent with the BSAL classification's intent, which is to be based on land and soil capability classes 1, 2 or 3.

Land-use conflict mitigation

The majority of the Cudgen Plateau, including the active farm to the southwest, is currently used for small crops and other cereal and fodder crops. As such, the assessment has presumed this form of enterprise should the southern site/s be re-activated for farming.

The Tweed Development Control Plan 2008 (DCP), in Section A5 Subdivision Manual, references an 80 m buffer, inclusive of a 30 m 'biological buffer', where the spray application is not applied by aircraft. This is in line with current methods of spray application in the locale. There is no buffer distance specification for a commercial premises, however it would be prudent to include a vegetated biological buffer between any habitable building and the agricultural land. Accordingly, an 80 m residential buffer and a 60 m non-residential buffer were evaluated. In addition, an alternate site-specific buffer design, meeting the objectives of the DCP, has been assessed, which includes a reduced setback and biological buffer.

Considering applicable guidelines and having regard for the specifics of the subject land, the recommended buffer comprises two components; a 10 m wide biological buffer of vegetation; and an open space separation of 30 m provided by the roadway and its associated easement. This will give a total minimum buffer width of 40 m.

A biological buffer is a specific design for spray drift interception and consists of vegetation with fine long leaves (e.g. *Casuarina sp.)* and an additional understory using smaller shrub species with similar leaf characteristics. These types of buffers are permeable so the breeze (air) may filter through the buffer vegetation.

Contemporary development applications in the locality were assessed to provide context to the proposed buffers at the site. The TVH proposal and a residential site to the west on Cudgen Road proposed 10 m vegetated buffers from agricultural land and both proposals were subsequently approved. The buffer proposed at the site is more conservative than those other examples in the locality. Additionally, the site to the south has been assessed for potential future land use and a conservative buffer applied to avoid any potential for diminishing the rural land use rights.

We note that the Cudgen Connection Concept presently facilitates both the DCP buffer, as well as the site-specific recommended buffer through generous setbacks. Whilst future applications for the site will ultimately determine the setback and biological buffer treatment, it is clear that impact on current or future agricultural activities in the locality are able to be mitigated.

Development impact assessment

A development impact assessment, although generally not included in an ALA, was completed as there was sufficient data available for an adjoining site (Tweed Valley Hospital to the west) which provides an overview of potential impacts of the surrounding agricultural land. The impact assessment for the site takes into consideration the nature of the development proposal to the west, in comparison to the proposal for the site. Both sites were similar in historical land use and land capability and proximity to the Cudgen plateau, therefore the primary production values of the land are shared.

The site has been removed from the Cudgen plateau farming collective for approximately three decades as at the date of this report. Therefore, the site it not an active contributor to the productive values of the Cudgen plateau. It is likely that extensive rehabilitation and ameliorants would be required to restore the site to the same agricultural productivity level to that of the locale. An agricultural suitability assessment has been completed (see results in Section 6), following the State of NSW and the Office of Environment and Heritage (OEH) guidelines *The land and soil capability assessment scheme*.

A review of the relevant reports for the adjacent Tweed Valley Hospital (TVH) development to the east of the site was completed, including the Land use conflict risk assessment (Tim Fitzroy, 2019), the Agricultural Impact Assessment (Agricultural Risk Consulting Group, 2018), and the Agricultural Offset Plan (Geolink, 2019). The TVH impact assessment noted that in terms of the developments impact on the value and investment in agricultural productivity of neighbouring farming land, there were no reasons why this would change should the TVH site be developed.

The Geolink agricultural offset plan outlined how the TVH development will offset the adverse agricultural impacts of the state significant farmland of Cudgen plateau. The report identified options to minimise and mitigate adverse impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level.

As with the Tweed Valley Hospital development, the impact assessment noted that in terms of the Cudgen Connection development's impact on the value and investment in agricultural productivity of neighbouring farming land, there were no reasons why this would change should the Cudgen Connection site be developed.

Similarly, given the cropping history of the neighbouring farmland appears unchanged for numerous years, any proposed change (e.g. establishment of additional agricultural infrastructure) is unlikely to affect the subject development.

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12114_004	Soil map
12114_005	UMA map
12114_006	Land and Soil Capability Class
12114_007	Current and potential land uses
12114_008	Agricultural buffers
12114_009 to 019	Historical aerial images

1 Introduction

Planit Consulting Pty Ltd (Planit), on behalf of Cudgen Health Precinct Pty Ltd (CHP), commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare an Agricultural Land Assessment (ALA) for the proposed Cudgen Connection development located at 741 Cudgen Road, Cudgen, New South Wales ('the site').

1.1 Scope of this report

The proposed development comprises facilities for health care, community space and recreational use, hospitality and residential uses as part of 'a health and education precinct'. The aim of the ALA is to evaluate the suitability of the site for future agricultural use as part of a strategic land use review. It also aims to determine whether any limitations should be placed on the development of the land given relevant state and local planning provisions including:

- Tweed Shire Council's (TSC) planning requirements; and
- NSW Department of Planning and Environment (DPE) and the NSW Department of Primary Industries (DPI) planning provisions for the protection of prime agricultural lands; and
- NSW Department of Primary Industries protection of important agricultural land.

1.2 Objectives

The proponents required an agricultural land assessment to determine:

- The type and quality of soil on the site.
- The suitability of the soil for agricultural purposes.
- The capability of the site to support sustainable agricultural production having regard to its size and land use interfaces.

The assessment described in this report aims to adequately evaluate the suitability of the site for future agricultural use.

1.3 Policy framework

This ALA considered the following relevant guidelines and documents:

- State Environmental Planning Policy (Primary Production) 2021.
- Tweed Local Environmental Plans (2000 and 2014).
- The National Committee on Soil and Terrain 2009 'Australian Soil and Land Survey Field Handbook (3rd Edition)' CSIRO Publishing Collingwood Victoria.
- NSW Office of Environment and Heritage 'The land and soil capability assessment scheme, Second approximation'.
- North Coast Regional Plan 2041.
- Northern Rivers Farmland Protection Project, Final Recommendations 2005.
- Learmonth, R., Whitehead, R., Boyd, B. and Fletcher S.2007, 'Living and Working in Rural Areas: A handbook for managing land use conflict issues on the North Coast'. State of NSW (Department of Primary Industries), Wollongbar NSW.
- NSW Department of Primary Industries 2011 'Land Use Conflict Risk Assessment Guide - Resource Planning and Development unit Primefact 1134', State of NSW.

The Northern Rivers Farmland Protection Project 2005 (NRFPP) was prepared as a long-term Government initiative to protect agricultural land. From a strategic land use planning perspective, the NRFPP protects areas of significance from being removed or encroached upon by urban settlement and growth. At the time it was prepared, agriculture was the region's third largest employer and exporter and fourth highest contributor to gross regional production.

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consolidating mapped State and Regionally Significant Land as 'Important Farmland'.

The NCRP 2041 acknowledges that agricultural production may not be suitable on some areas of mapped important farmland due to non-biophysical factors, and that the land may be more suitable for other uses.

The Tweed Rural Land Strategy 2036 (Tweed RLS) was endorsed in 2020 and provides a specific strategy for the Tweed Shire, supported by a 141 Action Implementation Plan. The Tweed RLS comprises nine primary policy directions, including encouraging agricultural production and protecting agricultural land. The Tweed RLS does not claim to have reviewed the extent of mapped Important Farmland, not does it contain an action to review the mapping. In comparison to the State Policy, the Tweed RLS draws a stronger character and visual landscape value to farming, as opposed to the soil quality driven methodology of the State Government.

Preceding and ultimately alongside the Tweed RLS, the Tweed Sustainable Agricultural Strategy identifies the need, actions and pathways to address the various challenges and opportunities facing the agricultural industry in the Tweed Shire. The Strategy is identified as a leadership action and is not considered to form a land use plan, rather it includes objectives to ensure the ongoing protection of prime agricultural land and minimise land use conflict.

1.4 Update to the 2021 ALA

An amended version of the 2021 ALA was submitted following a pre-lodgement meeting with TSC including commentary from DPI on 24 March 2022. DPI provided correspondence on 9 March 2022 titled 'Proposed Cudgen Connection Development Pre-lodgement Meeting Advice'.

TSC provided the notes gathered during the pre-lodgement meeting held on the 24 March 2022, which incorporates the comments from DPI. This amended ALA was submitted in October 2022 and addressed those comments from TSC and DPI.

1.5 Update to the 2022 ALA

This ALA has been updated following commentary from DPI in a letter dated 30 August 2023. In the correspondence, DPI requested addition of the following information to the 2022 ALA:

- Detail on road network constraints
- Crop budget and estimated margin figures for sweet potato
- Consultation with nearby agricultural land holders; and
- An agricultural infrastructure impact assessment for the use of the site for urban purposes.

This updated ALA provides the additional information as requested by DPI and reflects changes in the applicable framework.

2 Site description

2.1 Property description and zoning

The site is described as Lot 6 DP727425 and has a total area of 5.7 ha (see Drawing 120114_001). The site is zoned as RU1 (Primary Production) under the Tweed Shire Council's (TSC) Tweed Local Environmental Plan (LEP) 2014.

2.2 Existing land uses

The majority of the site is open pasture, mostly devoid of infrastructure, with the exception of buildings in the south-east corner of the block, a shed and concrete slab along the eastern boundary and a small shed in the north-east corner. It also appears that the centre of the site has historically been cut and filled to create level pads in the lower slope of the site.

Coastal Wetlands, as mapped under the State Environmental Planning Policy (Resilience and Hazards) 2021 (SEPP 2021), and environmental features are present to the north of the site. The area is identified as a Deferred Matter under the TSC LEP and is recommended by TSC to be zoned for Environmental Protection.

To the east of the site is the new Tweed Valley Hospital (TVH) construction project.

Cudgen Road bounds the site in the south, and beyond that is open grazing lands. The Cudgen Road and Tweed Coast Road intersection is located on the south-western corner of the site, and diagonal from the site across this intersection is land currently used for small crops ,cereal and fodder crops depending on the season.

To the west of the site, across the Tweed Coast Road, the land consists of existing and emerging residential development.

2.3 Topography and local drainage

Local topographic mapping indicates that the elevation of the property is gentling rising, with relative level (RL) ranging from 2.0 to 18.0 metres Australian Height Datum (m AHD). The site's slopes are described as gently inclined (3-10%).[1]

There is a watercourse to the north of the site and a Coastal Wetland. During rainfall, discharge from the site may potentially flow to the agricultural drains (running north-south through the site) and eventually discharge into the Coastal Wetland area to the north.

2.4 Soil landscapes

Soil landscapes within the project site are described in the DPIE's 'Soil Landscapes of Central and Eastern NSW' dataset 2020.[2]

The site is within the 'Cudgen landscape' (9541cu). The landscape is described as low undulating hills and rises on Tertiary basalt plateau. The soils of the Tweed soil landscape are dominated by seep (>100 cm), well-drained Kraznozems.

2.5 Geology

A review of the 1:250,000 Geological Series SH56-3 (Warwick-Tweed Heads) indicates that the site geology lies within the Tertiary Volcanic Rocks Lismore basalt.

2.6 Vegetation

The site is characterised by open grazing lands, gentling inclined toward the south. The vegetation present on site is a mix of native and improved pastures. Syagrus romanzoffiana (Cocos palms) line the southern and western boundary to buffer the road. The agricultural drains that traverse the site contain mostly grasses.

[1] McDonald R. C., Isbell R. F., Speight J. G., Walker J. & Hopkins M. S. Australian Soil and Land Survey Field Handbook. Second Edition 1990, Inkata Press Pty Ltd.

[2] Department of Planning, Industry and Environment, 2020, Soil Landscapes of Central and Eastern NSW - v2.1, NSW Office of Environment and Heritage, Sydney.

3 Methodology

3.1 Desktop assessment

The desktop assessment comprised analysis of available soil and land data from the New South Wales eSPADE and SEED mapping databases, which included the base maps underpinning the Biophysical Strategic Agricultural Land (BSAL).

3.2 Soil sampling and classification

On 25 November 2020 a site investigation was completed to sample and characterise the site soils. Two boreholes were constructed to a depth of 1.2 m below ground level (mBGL). The soil sampling intensity adopted complied with the recommended minimum for a 'very-high' intensity survey (i.e. 1 borehole/4 hectares with 1-5% being deep borings) specified in the Australian Soil and Land Survey Handbook (1998) and under the 2009 Survey guideline.[3] Drawing No. 12114_002 shows the borehole locations across the site.

A site slope analysis was undertaken, and this is shown on Drawing No. 12114_003.

Soil logging was undertaken at each borehole location in accordance with the Australian Soil and Land Survey Field Handbook (McDonald et al 1990), with samples retained for analysis. All soils were then classified in accordance with the Australian Soil Classification Revised Edition (Isbell et all, 2002). The soil borelogs are attached as Appendix 2. The soil map for the site is shown on Drawing No. 12114_004.

Based on the resultant soils mapping and slope analysis, the site was divided into unique mapping areas (UMA), each represented by polygons.[4] These areas describe portions of land within the site that have similar unique soil type and landform attributes. The UMAs in this case aided the land suitability assessment. Drawing No. 12114_005 shows the UMA map for the site.

Finally, the site slope analysis, soil classification and UMA mapping were used to identify the land and soil capability classes. Drawing No. 12114_006 depicts these classes on the site.

3.3 Land and Soil Capability (LSC) Assessment

The NSW DPIE's scheme for land and soil capability assessment categorises land into eight classes based on its general limitations. Table 3.3.1 (on the following page) sets out the eight soil and land capability classes.

The NSW land and soil capability assessment scheme (second approximation) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate and soil type/ characteristics to derive detailed rating tables for a range of land and soil hazards. The scheme is based on an assessment of these biophysical characteristics of the land, the extent to which these will limit a particular type of land use, and the current technology that is available for management of the land.

The main hazards and limitations that are assessed include:

- water erosion (sheet, rill and gully erosion)
- wind erosion
- soil structure decline
- soil acidification
- salinity
- waterlogging
- shallow soils and rockiness and
- mass movement.

Other limitations that primarily influence agricultural productivity (rather than susceptibility to degradation) can also be a major determinant of ultimate land use. These include moisture stress limitations, fertility, slope and acid sulfate soil (ASS) risk. The classification outlines the types of land uses appropriate for a particular area and the types of land management considerations to prevent soil erosion and maintain the land's productivity. The assessment criteria are attached in Appendix 3.

[3] The National Committee on Soil and Terrain 2009 'Australian Soil and Land Survey Field Handbook (3rd Edition)' CSIRO Publishing Collingwood Victoria (note: this is an updated version of McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S., 1990, 'Australian Soil and Land Survey Field Handbook (2nd Edition)'. Inkata Press, Melbourne).

[4] A plane area bounded by a closed path.

Table 3.3.1 Soil and land capability

Usage	Class No.	Class description	Land description	Slope
Suitable for regular cultivation	1	Extremely high capability land	Land suitable for a wide variety of uses. Where soils are fertile, this is land with the highest potential for agriculture, and may be cultivated for vegetable and fruit production, cereal and other grain crops, energy crops, fodder and forage, crops, and sugar cane in specific areas. Includes 'prime agricultural land'. This land has no limitations.	<1%
	2	Very high capability land	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class 1, but increasing limitations to production due to site conditions. Includes 'prime agricultural land'. This land has slight limitations	1-3%
	3	High capability land	Sloping land suitable for cropping on a rotational basis. Generally used for the production of the same type of crops listed for Class 1, although productivity will vary depending on soil fertility. Individual yields may be the same as Classes 1 and 2, but increasing restrictions due to the erosion hazard will reduce the total yield over time. Soil erosion problems are often severe. Generally fair to good agricultural land. Land has moderate limitations.	3-10%
Suitable for grazing	4	Moderate capability land	Land not suitable for cultivation on a regular basis owing to limitations of slop gradient, soil erosion, shallowness or rockiness, climate or a combination of the factors. Comprises the better classes of grazing land ad can be cultivated for an occasional crop (fodder crop or pasture renewal). If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has moderate to high limitations for high-impact land uses.	10-20%
	5	Moderate-low capability land	Land not suitable for cultivation on a regular basis owing to considerable limitations of slope gradient, soil erosion, shallowness or rockiness, climate or a combination of the factors. Soil erosion factors are often severe. Production is generally lower than for grazing lands in Class 4. Can be cultivated for an occasional crop (fodder or pasture renewal). Not suited to the range of agricultural uses listed to Classes 1 to 3. If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has high limitations for high-impact land uses.	10-20%
	6	Low capability land	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands. If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has very high limitations for high-impact land uses.	20-33%

Usage	Class No.	Class description	Land description	Slope
Generally incapable of agricultural land use	7	Very low capability land	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is generally not recommended, but partial clearing for grazing purposes under strict management controls can be practiced on small areas of low erosion hazard. Where clearing of these lands has occurred in the past, unstable soil and terrain sites should be returned to timber cover. Land has severe limitations that restrict most land uses and generally cannot be overcome.	33-50%
	8	Extremely low capability land	Land unsuitable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks and scenic areas. Limitations are so severe that the land is incapable of sustaining any land use apart from those listed above.	>50%

3.4 Important Farmland

Farmland Mapping was developed at a subregional level to identify and protect State Significant, Regionally Significant and Significant non-contiguous farmland. The site is mapped as State Significant Farmland under the Northern Rivers Farmland Protection Project Final Recommendations (2005).

This mapping has since been superseded by the North Coast Regional Plan 2041, along with a strategy (strategy 8.1) to protect and maintain agricultural productive capacity in the region by directing urban, rural residential and other incompatible development away from important farmland. The North Coast Regional Plan 2041 maps the “Important Farmland” areas on Figure 4[5] of the Plan.

Additionally, the Urban Growth Area Variation Principles[6] from the North Coast Regional Plan 2041 provides a basis for assessing whether land may be suitable for uses other than farmland. This criteria is included in Appendix 4.

3.5 Biophysical Strategic Agricultural Land (BSAL)

BSAL is land with high quality soil and water resources capable of sustaining high levels of productivity. In 2012, indicative BSAL maps were introduced but at a state/regional scale with varying accuracies and degrees of confidence. A site verification process is required to determine if the maps are correct at a local scale.

A site verification process[7] has been developed under the State Environmental Planning Policy (Resources and Energy) 2021 to determine the presence of BSAL. The assessment flow chart is attached in Appendix 5.

3.6 Land use conflict and separation

The following two-stage approach is used to assess land use conflict and separation:

[5] Figure 4: North Coast Important Farmland, Pages 37 of the North Coast Regional Plan 2041

[6] Appendix B of the North Coast Regional Plan 2041: Important Farmland Interim Variation Criteria (page 119)

[7] Interim protocol for site verification and mapping of biophysical strategic agricultural land (2013) New South Wales Government.

- Land use conflict risk assessment (LUCRA); and
- Agricultural buffers and mitigation.

3.6.1 Land Use Conflict Risk Assessment

LUCRA is a system to identify and assess the potential for land use conflict to occur between neighbouring land uses. LUCRA helps land managers and consent authorities to assess the possibility and potential degree of future land use conflict.

In terms of the ALA, the LUCRA is a valuable tool to enable a systematic, consistent and site-specific conflict assessment approach to land use planning and development assessment. To that end the Land Use Conflict Risk Assessment Guide[8] provides the necessary tools and guidance on completing a site specific LUCRA. The risk assessment matrix is provided in Appendix 6.

3.6.2 Agricultural buffers

Appropriate separation from the surrounding land uses and existing agriculture enterprises may be required in accordance with the following:

- TSC's Development Control Plan (Subdivision Manual).
- TSC's Local Environmental Plans (2000 and 2014).
- The New South Wales Department of Primary Industries (DPI) *North Coast Living and Working in Rural Areas Handbook.*
- TSC's Tweed Development Control Plan Section A5, Subdivision Manual (2008).

In this case, the following issues potentially relevant to the site were assessed:

- noise
- traffic
- odour
- dust and
- chemical spray drift.

The Tweed LEP 2000 and 2014 determine the land zoning in the area. Based on the land zoning, and current and potential land uses, the relevant guidelines recommend appropriate buffer distance and design.

3.7 Consultation

The two nearby agricultural landholders directly affected by the proposed land use change are those immediately to the south (Lot 1 DP 593182 and Lot 13 DP868620) and to the southwest (Lot 12 DP 868288).

Consultation with the land holder to the South was previously undertaken as part of the TVH ALA and indicated no agricultural use or farming activity on the property. The landowner, Mrs. Allen, also stated they had previously completed an agricultural land assessment for their property which confirmed the soil was unsuitable for cropping.

Consultation with the landholder to the southwest was attempted, however G&S was unable to successfully contact the landholder. A property search for Lot 12 DP 868288 on the TSC DA tracker confirmed no current applications are underway for the property. Given the cropping history of this site appears unchanged for numerous years, any proposed change (e.g. establishment of additional agricultural infrastructure) is unlikely to affect the subject development.

Similarly, in terms of the proposed Cudgen Connection development's impact on the value and investment in agricultural productivity of neighbouring farming land, there are no reasons why this would change should the Cudgen Connection site be developed.

3.8 Climate change

An integral part of the agricultural land capability assessment is taking into consideration potential impacts from climate change and the predicted future capability of the land for agricultural production.

[8] Department of Primary Industries, Primefact 1134 'Land Use Conflict Risk Assessment Guide' (Oct 2011) first edition

TSC adopted its 'Climate Change Management Policy, version 1.0' in June 2020. It predicts sea levels to rise above 1990 mean levels by 0.4 m by 2050 and 0.9 m by 2100. It also anticipates an increase in the frequency and depth of tidal inundation of low lying lands and poor drainage in low lying areas. Additionally, the policy anticipates the following socio economic and environmental impacts on the Tweed Shire, specifically related to agricultural land capability:

- Increasing heat, soil erosion and drought will impact upon agricultural systems, affecting crop yield and livestock health, farm productivity and the rural economy.
- Increased flooding and tidal inundation leading to potential impacts on sugar cane production.

The '2020-2021 Interim Climate Change Action Plan' (TSC Sep 2020) outlines TSC's response to climate change. It provides a list of 20 climate adaptation actions to highlight key existing and new priorities to improve the resilience of the Tweed to the impacts of climate change.

Sea-level rise will also impact on drainage and groundwater in low-lying coastal floodplains leading to potential increase in the duration of floods, water-logging of soils and soil salination. These impacts may be exacerbated by the infiltration of saline water into coastal aquifers, reducing the quality and viability of groundwater for irrigation.[9]

[9] Climate Change in the Northern Rivers Catchment, prepared for the New South Wales Government by the CSIRO (2007).

4 Results – desktop assessment

The results are divided into sub-sections to accurately address the requirements of the ALA:

- desktop assessment
- type and quality of soil
- the suitability of the soil for agricultural purposes
- the capability of the site to support sustainable agricultural production
- land-use conflict and separation.

The desktop assessment comprised analysis of available soil and land data from NSW eSPADE and SEED mapping databases, which included the base maps underpinning the BSAL. The online mapping databases rely on information from other sources, and ground truthing is generally required to confirm the data.

4.1 Land and soil maps

Australian Soil Classification: the SEED mapping tool identifies the site soils as Ferrosols.

4.2 Land use

The land use mapping tool shows the site has been used for '*grazing modified pastures, perennial horticulture, intensive horticulture and seasonal horticulture'*.

4.3 Land and soil capability

The land and soil capability (LSC) mapping for NSW shows the site includes areas mapped as Class *3 – moderate limitations*. The land and soil capability dataset uses the second approximation of the NSW Office of Environment and Heritage *The land and soil capability assessment scheme.* Table 2 from the document specifies definitions of the mapping categories, provided below.

LSC class 3 (moderate limitations) – defined as high capability land. This land has moderate limitations and is capable of sustaining high-impact uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

4.4 Soil fertility

The SEED map, coupled with the table outlining the inherent soil fertility,[10] show that the site is mapped within the Great Soil Group *Kraznozems*, which reflects a moderately high (4) soil fertility. This coincides with the estimated inherent soil fertility mapping.

4.5 Biophysical Strategic Agricultural Land (BSAL)

The available BSAL mapping included the entire footprint of the site. The BSAL mapping coincides with the NSW state-wide land and soil mapping and is identified as a Kraznozems soil under the Australian great soil groups. The same mapping lists this soil as moderately high fertility.

4.6 Soil landscapes

The site is wholly contained within the landscape unit identified as the Cudgen landscape unit (*cu*.[11]). Landscape limitations of this landscape unit include:

- Mass movement hazard (localised)
- Water erosion hazard on cultivated land

The landscape is described as low undulating hills and rises on Tertiary basalt plateau. The soils of the Tweed soil landscape are dominated by seep (>100 cm), well-drained Kraznozems.

4.7 Important Farmland

The Northern Rivers Farmland Protection Project (NRFPP) provides the final map (Sheet 2) mapping the site as State Significant Farmland. The NRFPP mapping has since been augmented

[10] Charman, P.E.V. 1978 (ed.), *Soils of New South Wales: Their Characterisation, Classification and Conservation,* Tech. Handbook No. 1, Soil Conservation Service of NSW, Sydney.

[11] Tweed, Estuarine/Alluvial Landscapes, Soil Landscapes of the Murwillumbah-Tweed Heads, D.T. Morand 1996, pp 32-34.

by the North Coast Regional Plan 2041, along with a strategy (strategy 8.1) to protect and maintain agricultural productive capacity in the region by directing urban, rural residential and other incompatible development away from important farmland. The North Coast Regional Plan 2041 maps the "Important Farmland" areas on Figure 4[12] of the Plan.

The Urban Growth Area Variation Principles[13] (provided in Appendix 4) provides a basis for assessing whether land may be suitable for uses other than farmland. The variation criteria were used to assess the site, with further detail provided in Section 8 of this ALA.

4.8 Historical Aerial Imagery review

A review of aerial imagery (1962-2020) available through Q Imagery, Nearmap and Google Earth was used to identify the site use history. Drawings 009 to 019 show the observations of the site over the past three decades. Historical aerial imagery observations are as follows:

- August 1962: The site appears to be cropped, although unconfirmed, it is likely to have been sugar cane, given the regional occurrence of such. To the north of the site is cleared native pastures. Cudgen Road bounds the site in the south, and the east and west of the site are bound by agricultural land.
- March 1979: The site remains under cultivation, with a portion of the site having been recently harvested. The surrounding land use is much the same as the previous image, with more distinct rows and apparent cultivation. Both properties to the east and west have divided paddocks into smaller sub-sections. To the north of the site, native pastures remain, with more woody growth. A dwelling/structure has been developed in the south-west corner of the site.
- June 1987: The site remains relatively unchanged and remains under cultivation.
- July 1989: Multiple changes to the site have occurred. Principally, the site is no longer under cultivation. Tweed Coast Road has been constructed along the western site boundary. On-site infrastructure has been developed, including a long shed structure in the centre of the site and a dwelling in the site's south-east corner. Earthworks for a residential subdivision has commenced to the west of the site.
- August 1994: Additional on-site development has occurred, including the construction of additional structures along the eastern boundary. The residential subdivision to the west of the site has been completed. To the east of the site, a TAFE campus has been constructed, replacing agricultural land.
- May 2010: The intersection of Tweed Coast Road and Cudgen Road has been upgraded. Approximately 1/3 of the site has been developed into what appears to be a nursery. The centre and western portion of the site remains pasture. To the north of the site, an environmental area persists, with standing water evident across the area. Lands to the east and south remain under agricultural production.
- May 2016: The nursery operation and associated infrastructure in the south-eastern corner of the property has mostly been removed, as has the greenhouse in the centre area of the site. An area towards the lower slope in the northern section of the site has been cleared and earthworks appear to have been completed (cut and fill). A large portion of the site remains as pasture.
- April 2017: A structure has been constructed on the clearing along the northern boundary. Much of the other infrastructure of the site appears dilapidated. The majority of the site is pasture, which appears to be slashed on a regular basis.
- May 2018: The structure in the northern section of the site has been removed. Much of the other infrastructure remains in-situ. The pastures still appears to be slashed regularly.
- September 2019: The site remains relatively unchanged. However, to the east of the site, extensive earthworks have commenced in preparation for the construction of the new TVH.

[12] Figure 4: North Coast Important Farmland, Pages 37 of the North Coast Regional Plan 2041

[13] Appendix B of the North Coast Regional Plan 2041: Important Farmland Interim Variation Criteria (page 119)

- September 2023: The most recent image available for the site. The earthworks occurring to the east of the site have progressed, with roads having been constructed around the development. Very little has changed on the site, it does not appear that any slashing has occurred.

5 Results – soil type and quality

This section includes the results of the site soil sampling and land assessments to form the soil description and classification. This information was gathered from the field investigation completed on 25 November 2020.

5.1 Soil and land survey

The 25 November 2020 site investigation involved the construction of two boreholes (AG1 and AG2) using a hand auger to 1.2 mBGL to sample and characterise the site soils. Borelogs for these boreholes are included in Appendix 2. Laboratory certificates are included as Appendix 7. Drawing No 120114_002 shows the borehole locations.

Samples were retrieved from each soil profile and sent to a NATA accredited laboratory for analysis of the total soil suite. This included the analysis of pH, EC, S, P, Na, K, Ca, Mg, Al, Cl, Cu, Zn, Mn, Fe, B, NH4, NH3, organic matter, colour, texture, lime requirement, CEC, Ca/Mg ratio and % base saturation.

5.1.1 pH

pH ranged from 4.8 to 6.1. The median value for the dataset was a pH of 5.25.

5.1.2 Electrical Conductivity

The EC values ranged from 2,000 to 4,000 μS/cm with a median for the dataset of 2,500 μS/cm.

5.1.3 Nitrite and Nitrate

Most results for nitrite and nitrate were below the laboratory limit of reporting (<LOR). Results that were above the LOR ranged from 1 to 2 mg/kg.

5.1.4 Phosphorus

Results ranged from 10 to 32 mg/kg. The median result was 21 mg/kg for the dataset.

5.1.5 Potassium

Results ranged from 6 to 146 mg/kg with a median value for the dataset of 25 mg/kg. The highest potassium concentration (146 mg/kg) was AG2 topsoil (0-120). The 20th and 80th percentile range was 9 to 73 mg/kg respectively.

5.1.6 Calcium

Results ranged from 68 to 679 mg/kg whilst the median for the dataset was 280 mg/kg.

5.1.7 Magnesium

Results ranges from 26 to 336 mg/kg. The median value for the dataset was 62.50 mg/kg.

5.1.8 Sulfur

Results ranged from 50 to 237 mg/kg. Median value for the dataset was 181 mg/kg.

5.1.9 Trace elements

Iron – results ranged from 3 to 173 mg/kg with a median value of 28.5 mg/kg and concentrations generally decreasing with depth.

Copper – results ranged from 0.1 to 3.5 mg/kg. The median value for the dataset was 0.75 mg/kg.

Zinc – results ranged from 0.2 to 10.5 mg/kg. The median result for the dataset was 0.9 mg/kg.

Boron – results ranged from 0.2 to 1.2 mg/kg. The median result for the dataset was 0.3 mg/kg.

5.1.10 CEC

Results ranged from 1.47 to 6.43 meq/100g. As predicted, the CEC generally decreased with depth, with the exception of AG, which has a result of 4.69 at 500-700 depth (higher than the topsoil result of 4.32). The CEC of soils varies according to the type and percentage of clay, soil pH and the amount of organic matter.

5.1.11 Soil model data assessment

The comparison of the soil properties modelled by the NSW data sets and the actual values (tables 5.1.11.1. to 5.1.11.3 below) for the soil sample sites shows the modelled properties unreliable in determining the soil characteristics, in particular CEC, EC and pH at depth.

Table 5.1.11.1 Comparison of soil samples from sample site average cation exchange capacity (cmol/kg) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
AG1	1.67-4.32	4.69	20-30	20-30
AG2	1.87-6.43	1.47	20-30	20-30

Table 5.1.11.2 Comparison of soil samples from sample site average electrical conductivity (ds/m) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
AG1	0.02-0.04	0.02	0.2-0.3	0.2-0.3
AG2	0.02-0.04	0.03	0.2-0.3	0.2-0.3

Table 5.1.11.3 Comparison of soil samples from sample site average pH (pH units) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
AG1	5-5.4	6.1	4.5-5.0	4.5-5.0
AG2	4.8-5.8	5.1	5.0-5.5	4.5-5.0

5.1.12 Soil classification

Colour was recorded in-situ using the Munsell Soil Colour Chart.[14] Texture was collected in-situ using the Australian Land and Soil Handbook.[15] The colour and texture recorded in-situ is provided on the borelogs in Appendix 2.

AG 2 observations were made from a cutting in the slope of the hill. This allowed a more thorough assessment of the soil profile. A rock layer was observed at approximately 300-400 mBGL.

The soils identified on the site were **Red Ferrosols**. These are soils that:

- Have B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine earth fraction (<2 mm); and
- Do not have clear or abrupt textural B horizons or a B2 horizon in which at least 0.3m has vertic properties.[16]

Red is one of the most common colour classes within this soil order, along with Brown.

5.1.13 Slope analysis

A slope analysis was completed for the site and is shown in Drawing No. 12114_003. The majority of the site slope was 3-10%. The eastern boundary of the site was a slightly higher slope rating at 10-20%, with some sections in the drains reflecting a higher slope again.

Table 5 in the Australian Soil and Land Survey Field Handbook[17] provides an index to landform characterised by relief and modal slope. The relief is defined as the difference in elevation between the high and low points of a land surface. The modal slope is defined as the most common class of slope occurring in a single landform pattern.

Table 5 in the Australian Soil and Land Survey Field Handbook[18] also summarises the simple types of erosional landform pattern characterised by relief and modal slope. The modal terrain slope of the site is *Gently inclined 3-10%*. The relief is *Very low 9-30m.* These factors determine that the erosional landform pattern is *Undulating rises.*

[14] Munsell Soil Colour Charts (2015) Produced by Munsell Colour.
[15] The National Committee on Soil and Terrain, Australian Soil and Land Survey Handbook (3rd edition), CSIRO publishing.
[16] Soil material with a clayey field texture (light clay, medium clay, heavy clay) or 35% or more clay, which cracks strongly when dry and has slickensides and/or lenticular peds.
[17] Australian Soil and land Survey Field Handbook, Table 5, page 47.
[18] Ibid, page 47.

6 Results – agricultural suitability of soils

The results in this section include interpretation of the soils and landform to derive:

- Land and soil capability.
- BSAL assessment.

6.1 Unique mapping areas

As a result of the soil characterization and the slope analysis, unique mapping areas (UMAs) have been identified across the site. Each UMA then undergoes an assessment of its land and soil capability, as outlined in the following section.

The UMAs are identified in Drawing No. 12114_005.

6.2 Land and Soil Capability (LSC) assessment

The decision tables for individual hazards in the land and soil capability assessment scheme were used to identify the land suitability class (see Table 3.3.1, page 15). Each hazard is assigned one of the eight classes (Class 1 represents the least hazard and Class 8 the greatest). The final hazard assessment for the site was based on the highest hazard in that parcel of land (e.g. the land may be assessed to have no significant hazard for several limitations, but Class 8 hazard for mass movement hazard; therefore the land was Class 8 land).

A summary of the results from the assessment is provided in Table 6.2.1, with the overall suitability class for each UMA. Drawing No. 12114_006 show the soil and land capability class for the site based on the identified limitations.

Table 6.2.1 Limitations and determined suitability subclasses for the site

Limitations and suitability subclass (1 to 8)	UMA 1	UMA 2	UMA 3	UMA 4	UMA 5	UMA 6	UMA 7	UMA 8
Soil type	Ferrosol	Ferrosol	Ferrosol	Ferrosol	Ferrosol	Ferrosol	Ferrosol	Ferrosol
Area (ha)	2.06	0.85	1.08	0.514	0.29	0.59	0.11	0.17
Slope	3-10%	<1-10%	<1-20%	<1-20%	1-20%	3-20%	10-50%	3-20%
Characteristics	Majority of the site, slope generally consistent and historical land use consistent (sugar cane)	Flat area that has been cut into slope. No topsoil present, shallow soils (250mm), rock layer at 300mm BGL	Scattered with irregular landscape agricultural drains. Historically had concrete other greenhouse structures rubbish and debris concrete <30% cover	Previous location of nursery, topsoil has previously been cleared. Shallow soils 25-50 cm	Current house site, hydroponic enterprise, industrial use. Concrete layer <30% cover	Increased slope (10-20%)	Pond	Has previously been cleared, possibility of saturated soils based on vegetation occurrence.
Water erosion	3	1-3	1-4	4	3-4	3-7	4-7	2-4
Wind erosion	3	3	3	3	3	3	3	3
Soil structure decline	2	2	2	2	2	2	2	2
Soil acidification	2-3	3	3	2	2	2	3	3
Salinity hazard	2	2	2	2	2	2	2	2
Waterlogging	1	1	1	1	1	1	8	6
Shallow soils and rockiness	NA*	6	6	NA*	6	NA*	NA*	NA*
Mass movement	1	1	1	1	1	1	1	1
Overall Land Class	**3**	**6**	**6**	**4**	**6**	**7**	**8**	**6**

NA* - not applicable to the site

The land and soil classification of these parts of the landscape ranges from Class 6 (low capability) to Class 7 (very low capability). Although the land and soil capability suggests a low capability, such land in this location has the potential to be used for sugar production (with installation of suitable drainage).

6.2.1 Water erosion

Water erosion hazard refers to the likelihood of soil detachment and movement due to raindrop impact, initiation of runoff and flowing water.

In assessing the water erosion hazard for the site, a slope analysis was completed. That analysis (depicted in Drawing 12114_003) shows the majority of the site exhibits slopes of 3-10%. However, the slope within each UMA does vary, making the assessment of water erosion difficult to define. For example, UMA 1 has some areas with a slope of 10-20% (yellow) which changes the Class under the LSC assessment. In this instance, a range of the LSC class is adopted.

The slope adopted for each UMA are included in Table 6.2.1 under the UMA name and the water erosion hazard identified accordingly.

6.2.2 Wind erosion

Wind erosion hazard refers to the likelihood of soil detachment and movement under the effects of wind blowing across the soil surface. Wind erosion tends to be more prevalent in coastal areas. The major effects of wind erosion are loss of soil from the landscape and subsequent deterioration in the land's productive capacity.

The surface soil at the site falls under a *loam, clay loam or clays (all with >13% clay)*. The site exposure to prevailing winds would be considered *Intermediate situations – not low or high exposure locations*. This information combined with the high average rainfall (>500 mm annually), means the UMAs fall into Class 3 land for wind erosion.

6.2.3 Soil structure decline

Soil structure decline refers to the breakdown of the physical arrangement of soil particles and pore spaces in the soil, typically as a result of compaction and tillage. The effects of poor soil structure include low infiltration and runoff resulting in water erosion and less than optimum use of rainfall for plant growth, overall poor plant growth, poor germination and emergence of crops and poor friability of soil making them difficult and costly to till and sow.

The field texture of the site's surface soil were primarily clay (friable/ferric[19]), which means the land falls into Class 2 land for soil structure decline hazard.

6.2.4 Soil acidification

Soil acidification hazard is a major limitation in many important areas of agricultural production in NSW. As soil acidification can dramatically impact plant growth, it therefore has the potential to decrease farm productivity. This is associated with an increased potential for soil erosion and increased recharge into groundwater systems, leading to increased salinity hazard.

The buffering capacity of the surface soils in the UMAs is estimated to be high due to the soil being clay. Using the soil texture and the pH of the natural surface soil the soil acidification hazard can be determined for the upper slope and lower slope area. AG1 provides the pH range for the upper slope (5-6.1 pH) and AG2 provides the pH range for the lower slope (4.8-5.8 pH). The upper slope (UMAs 1, 4 and 5) would fall into Class 2. The lower slope (UMAs 2, 3, 6, 7, and 8) would fall into Class 3.

6.2.5 Salinity hazard

Salinity hazard is the potential for salts to be mobilised in a catchment and brought to the ground surface and waterways by changes in land use and land management. Widespread vegetation clearing, excessive irrigation inputs and other land management practices that increase recharge to groundwater are major drivers for this hazard.

Salt has a highly adverse effect on plant growth by increasing the difficultly for plants to extract water, increasing the level of toxic elements to

[19] The occurrence of friable or ferric surface soils is associated with basaltic or basic parent materials and soils of the Ferrosols group in the Australian Soil Classification or the Kraznozems Great Soils Group.

plants, and increasing sodicity levels in soils with results soil structure decline. Reduced plant growth is associated with reduced crop and pasture productivity and increase soil erosion.

Salinity hazard requires consideration of the recharge potential, discharge potential and salt stores. The site's recharge potential is considered high and the discharge potential moderate due to the high water table and a low salt store (according to Figure 7 in the assessment scheme). These factors group the site into Class 2 land for salinity hazard.

6.2.6 Waterlogging hazard

Waterlogging is a major limitation in low-lying areas of the landscape. Waterlogging can severely affect agricultural production and land use as it restricts or prevents the supply of oxygen to plant roots. The majority of agricultural crops and pasture plants will suffer, in addition to increased access difficulties for vehicles, tillage and sowing operations and stock management.

The site's slopes limit the possibility for surface water ponding across the majority of the site. There is a water body at the bottom of the slope, along the northern boundary which adjoins the northern environmental/wetland area.

The water table was not encountered during the field investigation and drilling of soil bores. For this reason, it is unlikely that the site is waterlogged for any duration through the year for the majority of the site, inclining the site as a Class 1 for waterlogging hazard. The exception to this is UMA 7, which due to it being a pond, is likely to be waterlogged permanently (Class 8) and also UMA 8, as this area appeared to be affected by waterlogging due to the proximity to the neighboring coastal wetland (Class 6).

6.2.7 Shallow soils and rockiness hazard

Shallow soils and rockiness reduces the land-use capability of soils and land. The more rock outcrop and the shallower the soils, the less volume of soil available for storing nutrients and water. The site assessment indicated no obvious surface rock outcrops, however there was a notable rock layer at approximately 0.3 mBGL within the lower slope areas, which may cause impediment to crop growth. Further assessment of the distribution of the rock layer would be required to accurately assess this hazard.

In addition to the above, a large portion of the site encompassing UMAs 2, 3 and 5 is covered by concrete, which may be considered similar to rocky outcrops in terms of hazard and therefore this hazard was assess as Class 6.

6.2.8 Mass movement hazard

Mass movement relates to the large scale movement of earth under the force of gravity. It is a function of the gravitational stress acting on the land and the resistance of the surface soil, sand or rock material to dislodgement. Certain combinations of slope, soils, landform, climate and geology are more susceptible to mass movement. Disturbance of soils in some land management actions can also increase the likelihood of mass movement.

Due to the mean annual rainfall (>500mm), mass movement would be related to steep sites. The subject land is not prone to mass movement.

7 Results – land use conflict and separation

This section presents the results addressing the land use conflict and separation issues.

7.1 Surrounding land use compatibility

Under the LEP 2014, the site is mapped as RU1 - Primary Production. The objectives of the RU1 zone are to:

- *encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *encourage diversity in primary industry enterprises and systems appropriate for the area.*
- *minimize the fragmentation and alienation of resource lands.*
- *minimize the conflict between land uses within this zone and land uses within adjoining zones.*
- *protect prime agricultural land from the economic pressure of competing land uses.*

The surrounding land uses, consistent with the land zoning include R2 (residential), RU1 (primary production), SP2 (Infrastructure), 7(l) (Tweed LEP 2000) environmental protection (SEPP Coastal Wetlands). These land zones are identified on Drawing 12114_007.

7.2 Land Use Conflict Risk Assessment

A Land Use Conflict Risk Assessment (LUCRA) was completed to accurately identify and address potential land use conflict issues and risk of occurrence. The results are provided in Table 7.2.1 (on the following page). The assessment was based on the current and potential land use permitted in the relevant land zoning.

The proposed development was assessed for its potential land use conflict with surrounding uses. To the east of the site is the under-construction Tweed Valley Hospital, which has no conflict with the proposed development on the site. To the west of the site, over the existing Tweed Coast Road, is a residential subdivision. This has no conflict with the proposed development.

To the north of the site is a mapped Coastal Wetland under the Resilience and Hazards SEPP 2021. As this land will not be used for agricultural purposes, no agricultural buffer is required to the proposed development. It may be that an ecological buffer is required, however this is deferred to an ecological assessment and is not included in the scope of this ALA.

Directly south of the site is agricultural land, used for grazing. To the south-west of the site is agricultural land, predominantly used for horticultural (sweet potatoes) and broadacre cropping. The southern boundary of the site is likely to require an agricultural buffer to mitigate the potential land use conflict between the proposed development on site and the agricultural lands to the south.

The majority of the Cudgen Plateau, including the active farm to the south-west, is currently used for small crops and other cereal and fodder crops. As such, the assessment has presumed this form of enterprise should the southern site be re-activated for farming.

Although there is no buffer distance specification for non-residential uses in the Tweed Shire Development Control Plan (DCP), such as commercial premises and medical suites, it would be prudent to include a vegetated biological buffer between any habitable building and the agricultural land. An 80 m residential buffer (including a 30m wide biological buffer) and a 60m non-residential buffer were evaluated in the absence of the commercial premises buffer specification, however an alternate buffer design, meeting the objectives of the DCP, is recommended.

Considering applicable guidelines and having regard for the specifics of the subject land, the recommended buffer comprises two components;

- a 10 m wide biological buffer of vegetation; and
- an open space separation of 30 m provided by Cudgen Road and its associated easement.

This will give a total minimum buffer width of 40m.

A biological buffer is a specific design for spray drift interception and consists of vegetation with fine long leaves (e.g. *Casuarina sp.)* and an additional understory using smaller shrub species with similar leaf characteristics. These types of buffers are permeable so the breeze (air) may filter through the buffer vegetation.

Drawing No. 12114_008 shows the site specific agricultural buffers recommended for the site.

7.2.1 Contemporary buffer review

As there is no buffer distance specification for non-residential uses in the Tweed Shire Development Control Plan (DCP), such as commercial premises and medical suites, a review of contemporary buffers in the locality was completed. This review provides additional evidence base to the site-specific land use buffer findings discussed above.

The development to the east of the site is the Tweed Valley Hospital. A LUCRA assessment was undertaken by Tim Fitzroy & Associates (Sep 2019) for the proposed TVH development. The recommendations for the development included a vegetated buffer along the southern boundary at a minimum width of 30 m, and the installation of supplementary plantings along the western and south-western boundary of the site for a minimum width of 10 m.

The report assessed the site to the west (the proposed Cudgen Connection site) under a current land use scenario, however accommodated for a buffer increase from the recommended 10 m to a 14 to 30 m vegetated buffer, with the exception of a 40 m length.

Additionally, a review of a proposed residential subdivision (DA20/0383) located west of the proposed Cudgen Connection site was completed. The development proposed is approved. A Joint Report of Land Use Conflict (LUC) Experts, prepared 15 October 2021, was provided and reviewed. A 10 m vegetated buffer from State Significant farmland to the south was proposed, including a 1.8 m high fence. The Joint Report's risk assessment identified that the installation of a vegetated buffer will effectively mitigate particulate matter and reduce the potential hazards from agricultural use.

A review of these approved buffers in the locality provides context around the proposed agricultural buffers for the Site. The proposed buffer to the south and south-west of the Site, including a 40 m buffer with a 10 m vegetated component, has been assessed in order to reduce the potential hazards from surrounding agricultural activities. On review of other contemporary buffers, the proposed buffer at the site is more conservative than those other proposed buffers in the locality. Additionally, the site to the south has been assessed for potential future land use and a conservative buffer applied to avoid any potential for diminishing the rural land use rights.

Table 7.2.1. Land use conflict risk assessment (LUCRA) for proposed development

Land Use	Hazard	Current mitigating factors	Probability	Consequence	Score	Further controls	Likelihood	Consequence	Revised score
Agricultural Land (south & south-west boundary)	Spray drift	• ~25 m separation from southern boundary to agricultural land to the south • ~75 m separation from south-west boundary to agricultural land to the south-west • Existing vegetation screen to the south and south-west (both on site and off) • Slope of site and of adjacent agricultural land • Road corridor providing separation • Notable wind direction (AM) is less than 10% N & less than 20% NE (in direction of site). Wind direction (PM) is ~22% N and ~16% NE (in direction of site)	C – Possible	Level 3 – Moderate	13	• 10 m biological buffer established along south and south-west boundary (internal) • 30 m open space buffer created by road reserves (Cudgen Road and Tweed Coast Road intersection)	C – Possible	Level 4 – Minor	8
	Noise	• Existing vegetation screen to the south and south-west • Slope of site and of adjacent agricultural land • Road corridor providing separation • Notable wind direction (AM) is less than 10% N & less than 20% NE (in direction of site). Wind direction (PM) is ~22% N and ~16% NE (in direction of site)	C – Possible	Level 5 – Negligible	4	Acceptable score achieved			
	Traffic	• Existing vegetation screen to the south and south-west • Slope of site and of adjacent agricultural land • Road corridor providing separation	C – Possible	Level 5 – Negligible	4	Acceptable score achieved			

Table 7.2.1. Land use conflict risk assessment (LUCRA) for proposed development

Land Use	Hazard	Current mitigating factors	Probability	Consequence	Score	Further controls	Likelihood	Consequence	Revised score
		• Notable wind direction (AM) is less than 10% N & less than 20% NE (in direction of site). Wind direction (PM) is ~22% N and ~16% NE (in direction of site)							
	Dust	• Existing vegetation screen to the south and south-west • Slope of site and of adjacent agricultural land • Road corridor providing separation • Notable wind direction (AM) is less than 10% N & less than 20% NE (in direction of site). Wind direction (PM) is ~22% N and ~16% NE (in direction of site)	C – Possible	Level 5 – Negligible	4	Acceptable score achieved			
	Odour	• Existing vegetation screen to the south and south-west • Slope of site and of adjacent agricultural land • Road corridor providing separation • Notable wind direction (AM) is less than 10% N & less than 20% NE (in direction of site). Wind direction (PM) is ~22% N and ~16% NE (in direction of site)	C – Possible	Level 5 – Negligible	4	Acceptable score achieved			

Notes:
1 Vegetative buffer is a specific design for spray drift interception and consists of vegetation with fine long leaves (e.g. *Casuarina sp.)* and an additional understory using smaller shrub species with similar leaf characteristics. These types of buffers are permeable so the breeze (air) may filter through the buffer vegetation. Fire breaks will be required.
2 Bureau of Meteorology Ballina Airport AWS Wind rose

8 Results – land capability

This section discusses the capability of the site to support sustainable agricultural production having regard to its size and land use interfaces.

8.1 Regional Farmland Mapping

Planning documents that outline the region's agricultural future include:

- the North Coast Regional Plan 2041; and
- the Northern Rivers Farmland Protection Project Final Recommendations 2005 (augmented by above)

The North Coast Regional Plan 2036 estimated the gross value of agriculture (2014-2015) to be $930 million. However, rapid population growth and a growing number of tourists visiting the region has resulted in a change from an economy dominated by agriculture to one now dominated by service sector industries (84%) and manufacturing and construction (12%).[20]

The Northern Rivers Farmland Protection Project mapped the site as State Significant Farmland. This framework has since been augmented by the North Coast Regional Plan 2041. The same criteria apply to lands mapped under this plan.

To the east of the site, an area also mapped as state significant farmland is currently under earthwork construction for the Tweed Valley Hospital. The site is isolated from other important farmland by the Tweed Coast Road and the Cudgen Road, both of which are high traffic roads with vehicular control restricting movement in and out of the site.

The land and soil suitability assessment indicated 47% (2.72 ha) of the site is of low capability due to shallow soils and waterlogging. Such limitations are not conducive to an arable form of agriculture or estate, orchard or plantation agriculture.

The remainder of the site is not practicable for agricultural production due to its small size in addition to its separation from other farming land. In addition, this land is not practicable for tree crops because of the noise component of the land use conflict assessment. Many tree crops require night operations as part of the crop management program.

Appendix B of the North Coast Regional Plan 2041 outlines criteria to identify land that may be suitable for uses other than farmland. The following subsections outline the findings of this agricultural land assessment in terms of these criteria.

8.1.1 Land use conflict

The variation must be appropriately separated from incompatible land uses, including agricultural activities, sewerage treatment plants, waste facilities and productive resource lands.

The Important Farmland map[21] covers a large land area and the scale of the online mapping does not accurately depict the site mapped as Important Farmland. In this instance, the Final Map 2005[22] provides a more detailed view of the site. Assuming that the same land area mapped as State and Regionally significant in the Final Map 2005 is classified as Important Farmland, then the land to the east, south and west is also Important Farmland. However, the land to the east is currently being developed for the TVH, land to the south is isolated by Cudgen Road and Tweed Coast Road, and land to the west is residential development.

The land and soil capability (determined in Section 6 of this report) identifies the site as ranging from Class 3 to 8 land. The best quality land identified as Class 3 land is defined as generally fair to good agricultural land with moderate limitations with a detailed definition included in Table 3.3.1.

[20] NSW Department of Planning, *Far North Coast Regional Strategy 2006 to 2031,* (2006) (superseded by the North Coast Regional Plan 2036).

[21] Figure 9, North Coast Regional Plan 2036.

[22] Final Map 2005, Northern Rivers Farmland Protection Project.

Site limitations, such as noise restraints and site accessibility, in conjunction with the soil quality, will determine the practicability of agricultural production at the site.

Overall, in terms of agricultural capability, as determined through this agricultural land assessment, the site meets the criteria of land that may be suitable for uses other than farmland identified in Appendix B of the North Coast Regional Plan 2041.

Where feasible, the agricultural assessment aims to propose measures that will mitigate any risk associated with agricultural activities and surrounding land use conflict.

8.1.2 Important farmland

The planning area is contiguous with existing zoned urban land and the need and justification is supported by a sound evidence base addressing agricultural capability and sustainability and is either for:

- A minor adjustment to 'round off an urban boundary', or
- If demonstrated through a Department approved local strategy that no other suitable alternate land is available, and if for housing, that substantial movement has been made toward achieving required infill targets within existing urban growth area boundaries.

Land use conflict, assessed in Section 7 of this report, identified agricultural buffers and separation components that can be implemented to mitigate the likelihood of conflict with current or future adjacent agricultural activities.

Agricultural land is located to the south and south west of the site. Whilst land to the south of the site is not actively cultivated at present, to uphold strategic intent expressed through the applicable planning framework (lead by the North Coast Regional Plan 2041 and its important farmland mapping) additional land use conflict assessment has been pursued to ensure the subject site supports active farmland to the south west and does not reduce or limit the agricultural opportunity of dormant farmland to the south.

The majority of the Cudgen Plateau, including the active farm to the southwest, is currently used for small crops and other cereal and fodder crops. As such, the assessment has presumed this form of enterprise should the southern site be re-activated for farming.

Although there is no buffer distance specification for non-residential purposes in the Tweed Shire Development Control Plan (DCP), it would be prudent to include a vegetated biological buffer between any habitable building and the agricultural land. An 80 m residential buffer and a 60 m non-residential buffer, both inclusive of a 30m biological buffer, was employed as a precautionary approach, and its suitability evaluated. Post review of the subject sites context, an alternate, site-specific buffer design, meeting the objectives of the DCP, is recommended.

Considering applicable guidelines and having regard for the specifics of the subject land, the recommended buffer to farmland (south and southwest) comprises two components; a 10 m wide biological buffer of vegetation; and an open space separation of 30 m provided by Cudgen Road and its associated easement. This will give a total minimum buffer width of 40m.

This recommended buffer to development is depicted on Drawing No. 12114_009.

8.1.3 Infrastructure

The variation needs to consider the use of committed and planned major transport, water and sewerage infrastructure, and have no cost to the government. The variation should only be permitted if adequate and cost effective infrastructure can be provided to match the expected population.

This is a specialist assessment outside the scope of an agricultural assessment.

With regards to agricultural infrastructure, the Project will have a negligible impact on local and regional agricultural infrastructure. There will be negligible impacts on the road network that

connects the agricultural industry to services, suppliers and markets. Additionally, there is no agricultural infrastructure in the vicinity of the site as the site is not currently being used for agricultural purposes and has not been cropped since prior to 1989.

The Project will have a negligible impact on the viability of local and regional agricultural services. Potential impacts to the supply and viability of agricultural support services in the Cudgen area resulting from the proposed development would therefore be minimal. Changes would predominantly be driven by other surrounding commercial enterprises such as the TVH site and the Kingscliff TAFE as they are far exceeding the scale of the anticipated reduction in agricultural land use as a result of the proposed development.

Therefore, the Project will not negatively impact any existing agricultural enterprise or it's associated productivity of land outside of the Study Area.

8.1.4 Environment and heritage

The variation should avoid, minimise and appropriately manage and protect any areas of high environmental value and water quality sensitivity, riparian land or of Aboriginal and non-Aboriginal heritage.

Coastal Wetland is identified to the north of the site, as mapped under the SEPP (Resilience and Hazards) 2021, depicted in Drawing No. 12114_007.

The development of this site poses design issues for the protection of the wetlands which are within the normal and standard approaches to water quality and water quantity management procedures used by the development industry. Such assessment is beyond the scope of an agricultural assessment.

Although the environment and heritage assessment is beyond the scope of this assessment, it is noteworthy that the site has been historically used for farming purposes and that the land is extensively disturbed.

8.1.5 Avoiding risk

Risks associated with physically constrained land are identified and avoided, including:

- *Flood-prone*
- *Bushfire-prone*
- *Highly erodible*
- *Severe slope*
- *Acid sulfate soils*

The site has little to no consequence associated with the identified risks, as far as assessed under this agricultural land assessment. The site is mapped as bush fire prone land (category 3 vegetation). A portion of the site to the north is mapped under the Tweed LEP 2014 as a flood prone area, most likely associated with the mapped coastal wetland in the vicinity. However, given the sloping and elevated nature, the majority of the site is not mapped as affected by flood.

Under the Tweed LEP 2014, the site is mapped as Class 5 Acid Sulfate Soils. However, pursuant to an acid sulfate soil assessment, this cannot be confirmed, and is beyond the scope of this agricultural assessment.

8.1.6 Coastal strip

Only minor and contiguous variations to urban growth areas will be considered within the coastal strip due to its environmental sensitivity and the range of land uses competing for this limited area.

As indicated in Figure 23 of the NCRP 2041, the site is within the Coastal Strip. The total area of the site within the Coastal Strip is smaller in area when compared to the neighbouring approved TVH site also within the Coastal Strip. Therefore, the proposed development would be considered a minor variation in comparison to existing approved variations for surrounding properties.

8.2 Biophysical Strategic Agricultural Land (BSAL)

The portion of the site mapped as BSAL is isolated from other BSAL. This is because:

- the mapped BSAL east of the site is the location for the TVH (currently under construction) and is unequivocally removed from agricultural production;
- the land to the south is isolated by the Cudgen Road, soon to be upgraded by the TVH developers;
- the land diagonal the site is isolated by the intersection of Tweed Coast Road and Cudgen Road, also planned for upgrade under the Tweed Road Development Strategy – four-laning of Tweed Coast Road;
- the land to the west is not BSAL; and
- the land to the north is not entirely BSAL, as it is partially mapped as Coastal Wetlands under State Environmental Planning Policy (Resilience and Hazard) 2021 and identified for Environmental Protection under Tweed Shire Council land use planning framework.

As the remaining area of mapped BSAL is less than 6 ha, it does not fulfil the minimum size criterion of 20 ha. This isolation is caused by Cudgen Road and Tweed Coast Road, with high traffic volumes that create accessibility issues to the site.

Cudgen Road is a two-lane rural road connecting Kingscliff to the east with Cudgen and Tweed Valley Way to the west. Cudgen Road mainly carries commuter and school traffic movements.

Tweed Coast Road is classified as a regional road under the jurisdiction of Tweed Shire Council and predominantly carries commuter traffic, with a “tidal flow” pattern (northbound in the morning, southbound in the afternoon).

Although it is understood that some rural properties have approvals to operate tractors and machinery on Tweed Coast Road and Cudgen Road, current developments in the vicinity of the project site will increase traffic flow in the area.

The Kings Forest development site is currently underway and is located to the south of the site. The Kings Forest development relies significantly on Tweed Coast Road as the main traffic route between Kings Forest and the Pacific Highway.

Additionally, the Tweed Valley Hospital and the Kingscliff TAFE are in close proximity to the site and rely on access from Cudgen Road.

Due to the large number of traffic movements projected and already occurring on these roads, the traverse of heavy and slow agricultural machinery will pose a traffic hazard. The exit from the site is constrained to eastward towards Kingscliff along Cudgen Road and entry is only from the western approach. This characteristic of the site fragments it from surrounding agricultural land and poses an impediment to its integration with other farming lots in the vicinity.

The traffic regulations result in a prohibition on turning around to access farm land across Cudgen Road (from the site) or farm land to the west of the site until the roundabout at the intersection of Cudgen Road, Turnock Street and McPhail Avenue some 750m to the east.

The slope identified across the site is inconsistent and does not always meet the BSAL criteria for being less than or equal to 10%. The slope is the first criteria of the BSAL verification process, therefore the site falls out of the BSAL classification at the first criteria, as identified on the BSAL flow chart in Appendix 5.

The estimated inherent soil fertility on the site is moderately high, however the land and soil capability assessment determined the site to be between 3-8 Class land. This is primarily due to shallow soils, rockiness and waterlogging. This is not consistent with the intent of the BSAL classification to be based on land and soil capability classes 1, 2 or 3.

9 Practicability of agricultural land

The use of this land for farming purposes is impracticable. This is due to:

- The area of land suitable for farming being too small (ha). The site has an area of 5.7 hectares (ha) of which 2.06 ha is useable for arable purposes.
- The agricultural use of this land will lead to a land use conflict between the agricultural user and the adjacent urban areas
- The site is separated from the adjacent farming land by roads that severely restrict vehicles from crossing the road, projected to intensify in the future as road upgrades are completed.

In addition, TSC is implementing the *Tweed Road Development Strategy – four-laning Tweed Coast Road.* Design has begun of the four-laning of Tweed Coast Road from Morton Street at Chinderah to Grand Parade at Casuarina and the Cudgen Road intersection upgrades will be undertaken in due course.

The separation distances required from the surrounding sensitive receptors limit the usable land size of the site. The noise constraints limit the feasibility of the site to be used for avocado/macadamia orchards or the like.[23]

9.1 Primary production potential

The site has an area of 5.7 ha, of which 2.06 ha is useable for arable agricultural production. The remainder of the site land has been subject to cut and fill operations and further disturbance from the previous land uses on the site. These disturbed areas are degraded to such an extent that the rehabilitation is in itself not available. This is because the soil has been either removed or the soil profile cut to a point where the rehabilitation may result in degradation of the remaining materials.

The remaining 2.06 ha of land that is suitable for agricultural is limited to small crops such as horticultural product systems based on sweet potato, tomato and the like. Orchards such as avocado or macadamia are not feasible. The area available is too small for broad acre farming.

9.1.1 Small crops – Horticultural uses

The surrounding agricultural land is primary used for the production of sweet potato in the Cudgen Plateau. This horticultural crop requires well drained sandy loams with a pH of 6.0[24], therefore requiring the addition of 2.88t/ha of agricultural lime in some areas (based off a pH increase of 0.1/240kg/ha). Specialised machinery would be required for bed forming, planting, cutting collection, spraying, and harvesting. These tasks can be completed manually, but is slow, labour intensive, costly, and may further increase the gap between actual yields and obtainable yields.

Estimated nutrient loss from crop removal (kg/ha)[28] is as follows:

- 100kg Nitrogen (N)
- 90kg Phosphorus (P)
- 200kg Potassium (K)
- 200kg Calcium (Ca)

These nutrients will need to be replaced seasonally to sustainably produce agricultural products at the site.

The locality is known for its fruit orchards, small crops and other cereal and fodder crops. Should these intensive agriculture types be pursued, being an ‘agent of change’, the inclusion of land use conflict buffers are considered necessary to protect existing adjoining land uses. These land use buffers reduce the productive area of land to approximately 2.06 ha. Typically, sweet potatoes can produce between 15 and 40 tonnes per hectare. Based on a 2.06 ha farming footprint, this may result in an initial estimate of 30 to 80 tonnes per year, excluding crop failure. Based on the Cudgen Agricultural Capacity Report prepared by Pinnacle Agriculture, estimated crop budget and

[23] Noise Guide for Local Government NSW EPA 2007.

[24] Sweet Potato Production Guide, M. Traynor, 2005.

margin figure for sweet potatoes is $36,402.00 and $34,998 respectively based on an expected production of 63 tonnes of sweet potato. [25]

However, it is not practicable to initiate a sweet potato operation in isolation due to the set-up costs. The use of the land is dependent on amalgamation or integration of the land with other farming units in the vicinity. The surrounding non-rural developments and the traffic accessibility restrictions suggest the agricultural use of the site is improbable.

9.1.2 Share farming

'Share farming' is where a farmer with land and fixed equipment (the Landowner) enters into an arrangement with another farmer (the Operator) who contributes labour and machinery. Share farming is a viable option that may off-set the limitations of the land size for a sole producer. Adding the land to a share farming portfolio may create value to a larger operation.

The share farming scenario is unlikely for this site because of the lack of infrastructure required for farming (such as water sources) and the logistics of gaining access to the site from the public roads adjacent to it. Surrounded by development, there is no off-road connection (such as adjacent farming land) that affords site access to farm machinery. Future road upgrades that surround the site's western and southern boundaries are likely and will further exacerbate the access issue.

9.1.3 Alternate agricultural production

In acknowledgment of the identification of the subject site as strategically important farmland, the focus of the assessment is largely confined to high-order primary production crops, such as small crops and other cereal and fodder crops, being the traditional and current prevailing pursuits, as well as high value tree crops such as avocado and macadamia orchards.

Greenhouse and controlled environment horticulture could have been pursued, however have not been specifically reviewed as part of this assessment as these formats generally occur without agricultural land assessment as they are decoupled from site soil quality and other biophysical attributes of the land. Greenhouses and hydroponics operate in a close circuit, controlled environment, which does not rely on the inputs from site soil or environment. Therefore, these forms of agriculture can be located at most sites, without consideration of the capability of the land itself. Limitations such as noise mitigation and agricultural buffers are likely to still apply to greenhouses and controlled environment horticulture.

[25] Pinnacle Agriculture (undated) Cudgen Agricultural Capacity report Production Potential section (unpaginated)r

10 Development impact assessment

A development impact assessment, although generally not included in an agricultural land assessment, has been completed as there is sufficient data available for an adjoining site (the TVH site to the east) which provides an overview of potential impacts of the surrounding agricultural land. Additionally, data from the Australian Bureau of Statistics provides an overview of the production values of the Tweed Shire.

The impact assessment for the site takes into consideration the nature of the TVH development, in comparison to the proposal for the site. Both sites were similar in historical land use and land capability and proximity to the Cudgen plateau, therefore the primary production values of the land are shared.

The main difference in historical land use was the duration of time that the land on which the TVH has been developed was actively farmed. On review of available aerial imagery that the TVH site was actively cultivated up until late 2018. In contrast, the proposed Cudgen Connection site ceased active farming between 1987 and 1989.

10.1 Value of agricultural production

Data sourced from the 2015-16 Agricultural Census, run by the Australian Bureau of Statistics, shows the gross value of agricultural commodities in broad categories, measured across two Agricultural Census periods for the Tweed Shire. The figures provided in Appendix 9 show the states commodities dollar value and percentage production statistics. The highest monetary value commodity in the Tweed is *Other broadacre crops*, specifically sugar cane, which also represents the highest value for Tweed Shire as a percentage of New South Wales.

The Cudgen Plateau, an area defined as a cap of basalt soil from the eroded Mt Warning caldera, primarily grows sweet potatoes, with a typical return in the order of 55 to 65 tonnes a hectare in a productive environment. Although sweet potatoes are not specified in the ABS data, it can be assumed that they are included within the potatoes category, which account for 0.5% of Tweed Shires commodities.

Employment within the Agricultural, Forestry and Fishing industry accounts for 3% within the Tweed Shire. Section 8.4.1 provides information on the likely employment at the site in the plausible agricultural endeavour and footprint. The Site has however been removed from the Cudgen plateau farming collective for approximately three decades as at the date of this report (November 2023). Therefore, the site it not an active contributor to the productive values of the Cudgen plateau. It is likely that extensive site rehabilitation and ameliorants would be required to restore the site to the same agricultural productivity level to that of the locale.

An agricultural suitability assessment has been completed (in Section 6), following the State of NSW and the Office of Environment and Heritage (OEH) guidelines *The land and soil capability assessment scheme*.[26] The land and soil capability classes range from Class 3 to 8 across the site. The Class 3 (2.06 ha) land is likely to be suitable for agricultural production, although further investigation will delineate the extend of remediation required to restore the productivity. Large portions of the site land have been extensively disturbed, and in sections the topsoil has been removed.

10.2 Site context – Tweed Valley Hospital Agricultural Impact Assessment

Agricultural Risk Consulting Group (ARC Group) completed an agricultural impact assessment for the neighbouring TVH site (to the east of the site),

[26] The land and soil capability assessment scheme, second approximation, Office of Environment and Heritage, State of NSW, October 2012.

dated 16 October 2018. The report notes that the removal of the TVH site as farmland does not cause any significant fragmentation of, or have any impact on, other Cudgen Plateau state significant farmland. This can also be said for the proposed Cudgen Connection site, as the road junction of Cudgen Road and Tweed Coast Road has already isolated the parcel of land from surrounding agricultural land. In addition, the development of the TVH site and environmental sensitivities to the north has removed any possible connectivity that the proposed Cudgen Connection site offered.

The TVH impact assessment also notes that in terms of value and investment in agricultural productivity of neighbouring farming land, ARC Group could not identify any reason why this may change from the current values in terms of productivity.

The report provides land use categories and areas within the Cudgen Plateau state significant farmland. The total area of farming land in the Cudgen Plateau state significant farmland is 476.15 ha and the total area within the Cudgen Plateau state significant farmland is 580.3 ha.[27] The total arable area on the proposed Cudgen Connection site that is Class 3 land and suitable for potential horticultural production, following extensive agricultural restoration and soil ameliorants is 2.06 ha (UMA1). This area is approximately 0.4% of all farming land in the Cudgen Plateau and 0.3% of the total area within the Cudgen Plateau state significant farming area.

The report also covered statistics for growing crops such as sweet potatoes and the loss of such land being replaced by land identified as “Potentially under-utilised” land on the Cudgen Plateau.

The TVH site has been assessed to not cause any significant impact on the Cudgen Plateau state significant farmland if removed as agricultural land.

As the TVH site offered more arable land than the proposed Cudgen Connection site and as no contradictory evidence has been identified in this assessment, a similar conclusion can be drawn when assessing the loss of the subject site from the Cudgen Plateau state significant farmland.

Overall, the report makes similar observations to those associated with the proposed Cudgen Connection site,

10.3 Site context – Tweed Valley Hospital Agricultural Offset Plan

An agricultural offset plan was prepared by Geolink in September 2019. The plan outlines how the development will offset the adverse agricultural impacts of the state significant farmland of Cudgen plateau by identifying options to minimise and mitigate adverse impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level.

The report identified the potential for site contamination as a limiting factor for topsoil reuse, and further site investigations would be required to delineate potential contaminated soils.

[27] Section 3.6 TVH Agricultural Impact, Agricultural Risk Consulting Group, October 2018

12 Conclusions

An Agricultural Land Assessment was completed to assess the suitability of the proposed Cudgen Connection development site at 741 Cudgen Road, Cudgen, New South Wales for future agricultural use. The ALA was part of a strategic land use review that also determined whether any limitations should be placed on the development of the land given:

- Tweed Shire Council's planning provisions for the protection of prime agricultural lands;
- NSW Government's policy position to protect important agricultural land, as expressed through NSW Department of Planning, Industry and Environment; and
- any other relevant state and local planning provisions.

The ALA determined the:

- type and quality of soil on the site;
- soils' suitability for agricultural purposes; and
- capability of the site to support sustainable agricultural production having regard to its size and land use interfaces.

The results were divided into sub-sections to accurately address the ALA requirements and support expert conclusions and recommendations to ensure no adverse impacts to the current and desired future land uses external to the site.

A review of relevant policies identified that the Northern Rivers Farmland Protection Project 2005 was a long-term Government initiative to protect agricultural land. It protects areas of significance from being removed or encroached upon by urban settlement and growth. At the time of its preparation, agriculture was the region's third largest employer and exporter and fourth highest contributor to gross regional production.

In 2017, the (now superseded) North Coast Regional Plan 2036 augmented the State Government's approach to farmland protection, consolidating mapped State and Regionally Significant Land as 'Important Farmland'. The North Coast Regional Plan 2041 acknowledges that agricultural production may not be suitable on some areas of mapped important farmland due to non-biophysical factors, and that the land may be more suitable for other uses.

The Tweed Rural Land Strategy 2036 (endorsed in 2020) provided a specific strategy for the Tweed Shire, supported by a 141 Action Implementation Plan. It comprised nine primary policy directions, including encouraging agricultural production and protecting agricultural land. The Tweed RLS did not claim to have reviewed the extent of mapped Important Farmland, nor did it contain an action to review the accuracy or strategic extent mapping. The Tweed RLS placed greater emphasis on the character and visual landscape values of farming, with less emphasis on the soil quality driven methodology of the State Government.

Preceding and ultimately alongside the Tweed RLS, the Tweed Sustainable Agricultural Strategy identified the need, actions and pathways to address the various challenges and opportunities facing the agricultural industry in the Tweed Shire. The Strategy is identified as a leadership action and not a land use plan. Rather, it aims include the ongoing protection of prime agricultural land and land use conflict minimisation.

The site is located within an area commonly known as 'the Cudgen Plateau', an area with a long history of farming. Agricultural pursuits typically involve intensive agriculture types, such as avocado orchards and sweet potato cropping. In conjunction with active farms, several tourism-based and artisan enterprises have established.

The edges of the Cudgen Plateau are often adjoined by either environmental areas, forms of State infrastructure, extractive industries or established or emerging low-density housing. The most contemporary of these land uses is the Tweed Valley Hospital, which is positioned on the north-eastern edge of land mapped as State Significant Farmland/Important Farmland.

The site soils were identified as **Red Ferrosols**, being soils that:

- have B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine earth fraction (<2 mm); and
- do not have clear or abrupt textural B horizons or a B2 horizon in which at least 0.3 m has vertic properties.

As outlined in Section 3.3, decision tables for individual hazards in the land and soil capability assessment scheme were used to identify the land suitability class. Based on the resultant soils mapping and slope analysis, the site was divided into unique mapping areas (UMA), each represented by polygons, as displayed in Appendix 1. Portions of land within the site that have similar unique soil type and landform attributes were attributed to the same UMA, which aided the land suitability assessment.

Each hazard identified through the land and soil capability assessment scheme was assigned one of the eight classes, where Class 1 represents the least hazard and Class 8 represents the greatest hazard. The final hazard assessment for the site was based on the highest hazard in that parcel of land.

The overall land and soil capability class ranged from Class 3-8 across the site. The primary factors in determining this Class include water erosion, shallow soils and rockiness and waterlogging. A portion of the site (approximately 2.6 hectares) was identified as Class 3 agricultural land.

The site's capability to support agriculture varies depending on the specific agricultural produce pursued. The site's soil depth and suitability for agricultural production also varies, with much of the land requiring rehabilitation to be commercially productive.

The ALA identified the areas of the site that could practicably be used for intensive agriculture without further rehabilitation. This area of suitable land consists of approximately 2.06 ha of the total site. As an example, typically, sweet potatoes can produce between 15 and 40 tonnes per hectare. Based on a 2.06 ha farming footprint, this may result in an initial estimate of 30 to 80 tonnes per year, excluding crop failure.

Greenhouse and controlled environment horticulture could be pursued with suitable noise mitigation and land use buffers. These formats however are decoupled from site soil quality and other biophysical attributes of the land. Accordingly, pursuit of greenhouse or controlled environment horticulture is considered converse to the soil-driven methodology which determined the extent of strategically Important Farmland areas. Accordingly, the focus of this ALA is largely confined to high-order primary production crops.

Less intensive agricultural production would increase the productive area of the land, however generally results in lower yields.

As detailed previously, the NRFPP identifies the site as State Significant Farmland, which was then contemporised and updated to Important Farmland through the NCRP 2036.

The current NCRP (2041) introduced the Urban Growth Area Variation Principles where agricultural production may not be suitable on Important Farmland due to non-biophysical factors, and that the land may be more suitable for other uses.

Overall, the site meets the Urban Growth Area Variation Principles within the NCRP 2041. This is primarily due to the site's isolation from other surrounding important farmland along with a large portion of the site's unsuitability due to shallow soils and waterlogging. Such limitations are not conducive to an arable form of agriculture or estate, orchard or plantation.

The site is mapped as Biophysical Strategic Agricultural Land (BSAL). BSAL is land with high quality soil and water resources capable of sustaining high levels of productivity. Indicative BSAL maps were introduced in 2012. The limitations of these maps are at a state/regional scale with varying accuracies and degrees of confidence. A site verification process has been developed under the State Environmental Planning Policy (Resources and Energy) 2021 to

determine the existence of BSAL at the site of potential development. Based on the verification process, the site is not BSAL because it:

- is isolated from other BSAL;
- not meet the minimum size criteria of greater than 20 ha;
- exhibits slopes that do not consistently meet the BSAL criteria (i.e. ≤ 10%); and
- not consistent with the BSAL classification's intent, which is to be based on land and soil capability classes 1, 2 or 3.

The majority of the Cudgen Plateau, including the active farm to the southwest, is currently used for small crops and other cereal and fodder crops. As such, the assessment has presumed this form of enterprise should the southern site/s be re-activated for farming.

The Tweed Development Control Plan 2008 (DCP), through Section A5 Subdivision Manual, references an 80m buffer, inclusive of a 30m 'biological buffer', where the spray application is not applied by aircraft. Further, there is no buffer distance specification for a commercial premises, however, it would be prudent to include a vegetated biological buffer between any habitable building and the agricultural land. Accordingly, an 80 m residential buffer and a 60 m non-residential buffer were evaluated. In addition, an alternate site-specific buffer design, meeting the objectives of the DCP, has been assessed, which includes a reduced setback and biological buffer.

Considering applicable guidelines and having regard for the specifics of the subject land, the recommended buffer comprises two components; a 10 m wide biological buffer of vegetation; and an open space separation of 30 m provided by the roadway and its associated easement. This will give a total minimum buffer width of 40m.

A biological buffer is a specific design for spray drift interception and consists of vegetation with fine long leaves (e.g. *Casuarina sp.)* and an additional understory using smaller shrub species with similar leaf characteristics. These types of buffers are permeable so the breeze (air) may filter through the buffer vegetation.

Contemporary Development Applications in the locality were assessed to provide context to the proposed buffers at the site. The TVH proposal and a residential site to the west on Cudgen Road proposed 10 m vegetated buffers from agricultural land and both proposals were subsequently approved. On review of other contemporary buffers, the proposed buffer at the site is more conservative than those other proposed buffers in the locality. Additionally, the site to the south has been assessed for potential future land use and a conservative buffer applied to avoid any potential for diminishing the rural land use rights.

We note that the Cudgen Connection Concept presently facilitates both the DCP buffer, as well as the site-specific recommended buffer through generous setbacks. Whilst future applications for the site will ultimately determine the setback and biological buffer treatment, it is clear that impact on current or future agricultural activities in the locality are able to be mitigated.

A development impact assessment, although generally not included in an agricultural land assessment, has been completed as there is sufficient data available for an adjoining site (Tweed Valley Hospital to the east) which provides an overview of potential impacts of the surrounding agricultural land. The impact assessment for the site takes into consideration the nature of the development proposal to the west, in comparison to the proposal for the site. Both sites were similar in historical land use and land capability and proximity to the Cudgen plateau, therefore the primary production values of the land are shared.

The site has been removed from the Cudgen plateau farming collective for approximately three decades as at the date of this report. Therefore, the site is not an active contributor to the productive values of the Cudgen plateau. It is likely that extensive rehabilitation and ameliorants would be required to restore the site to the same agricultural productivity level to that of the locale.

An agricultural suitability assessment has been completed (see results in Section 6), following the State of NSW and the Office of Environment and Heritage (OEH) guidelines *The land and soil capability assessment scheme*.

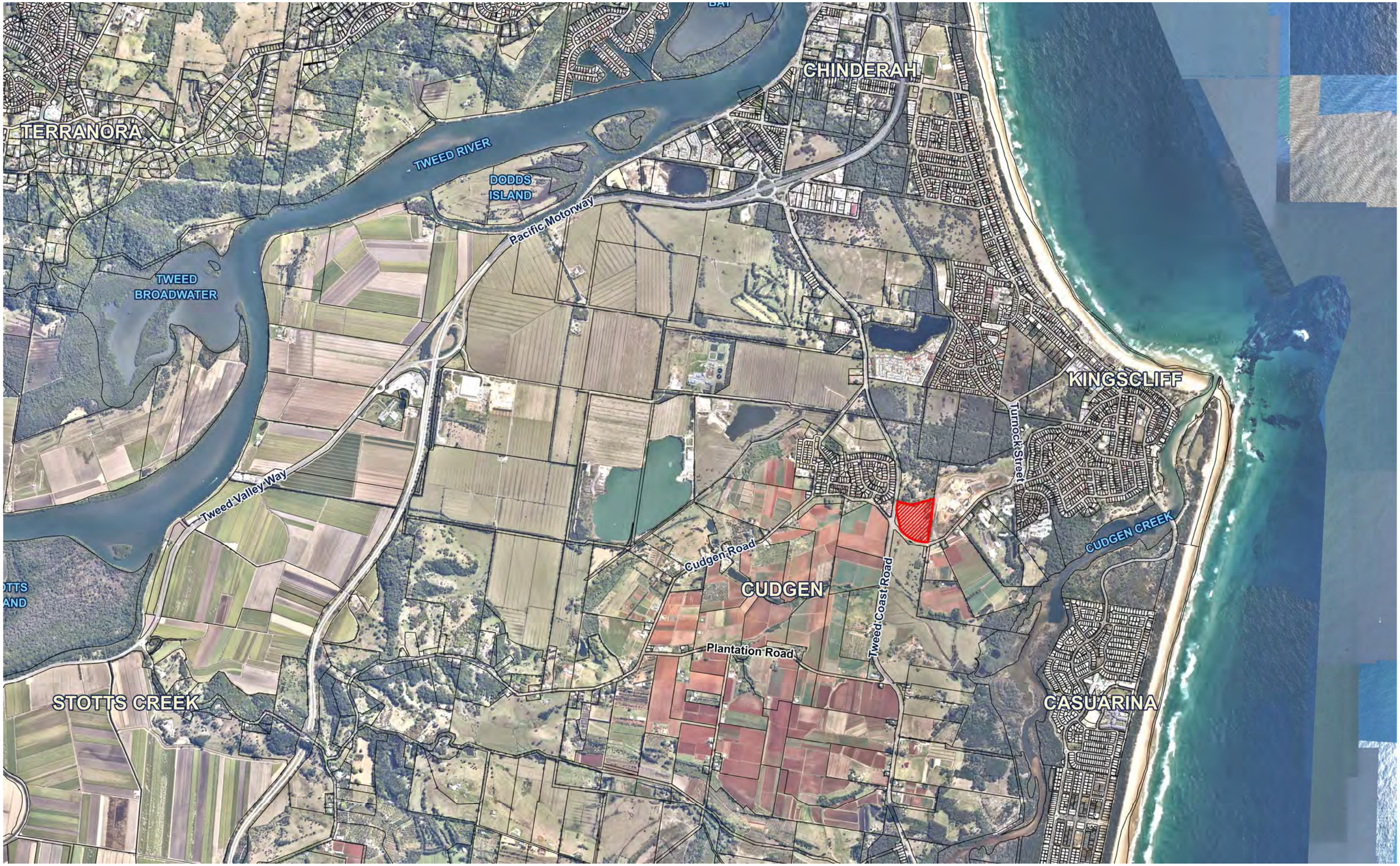
A review of the relevant reports for the adjacent Tweed Valley Hospital (TVH) development to the east of the site was completed, including the Land use conflict risk assessment (Tim Fitzroy, 2019), the Agricultural Impact Assessment (Agricultural Risk Consulting Group, 2018), and the Agricultural Offset Plan (Geolink, 2019). The TVH impact assessment noted that in terms of the hospital development's impact on the value and investment in agricultural productivity of neighbouring farming land, there were no reasons why this would change should the TVH site be developed.

The Geolink agricultural offset plan outlined how the TVH development will offset the adverse agricultural impacts of the state significant farmland of Cudgen plateau. The report identified options to minimise and mitigate adverse impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level.

As with the Tweed Valley Hospital development, the impact assessment noted that in terms of the Cudgen Connection development's impact on the value and investment in agricultural productivity of neighbouring farming land, there were no reasons why this would change should the Cudgen Connection site be developed.

Similarly, given the cropping history of the neighbouring farmland appears unchanged for numerous years, any proposed change (e.g. establishment of additional agricultural infrastructure) is unlikely to affect the subject development.

13 Appendix 1 – Drawing package



ORIENTATION

SCALE

250 500 750 1000 1250
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- Cadastral boundaries
- Site boundary

SOURCES

Image: Nearmap image dated 14 September 2020

PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
SITE LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:25 000@A3	8/07/2022	AJF/SWP	SAM	12114	001	-

GILBERT SUTHERLAND

ORIENTATION

SCALE

20 40 60 80 100
metres

ROBINA
PO Box 4115 Robina QLD4230
Email robina@access.gs
07 5578 9944
www.access.gs

LEGEND

- Cadastral boundaries
- Site boundary
- Contours (1m interval)
- Borehole locations

SOURCES

Image: Nearmap image dated 14 September 2020.

Contours: derived from 1m LiDAR for Tweed Heads dated September 2013, Foundation Spatial Data Framework, ANZLIC.

PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
BOREHOLE LOCATIONS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:2 000@A3	8/07/2022	AJF/SWP	SAM	12114	002	-

GILBERT SUTHERLAND

ORIENTATION

SCALE

20 40 60 80 100
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- Cadastral boundaries
- Site boundary
- Contours (1m interval)

SLOPE CLASS

- < 1 %
- 1 - 3 %
- 3 - 10 %
- 10 - 20 %
- 20 - 33 %
- 33 - 50 %
- > 50 %

SOURCES

Image: Nearmap image dated 14 September 2020.

Contours & slope: derived from 1m LiDAR for Tweed Heads dated September 2013, Foundation Spatial Data Framework, ANZLIC.

PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
SLOPE ANALYSIS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:2 000@A3	8/07/2022	AJF/SWP	SAM	12114	003	-

GILBERT SUTHERLAND

ORIENTATION

SCALE

20 40 60 80 100
metres

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LEGEND

- Cadastral boundaries
- Site boundary
- Contours (1m interval)

SOIL TYPES
- Ferrosol

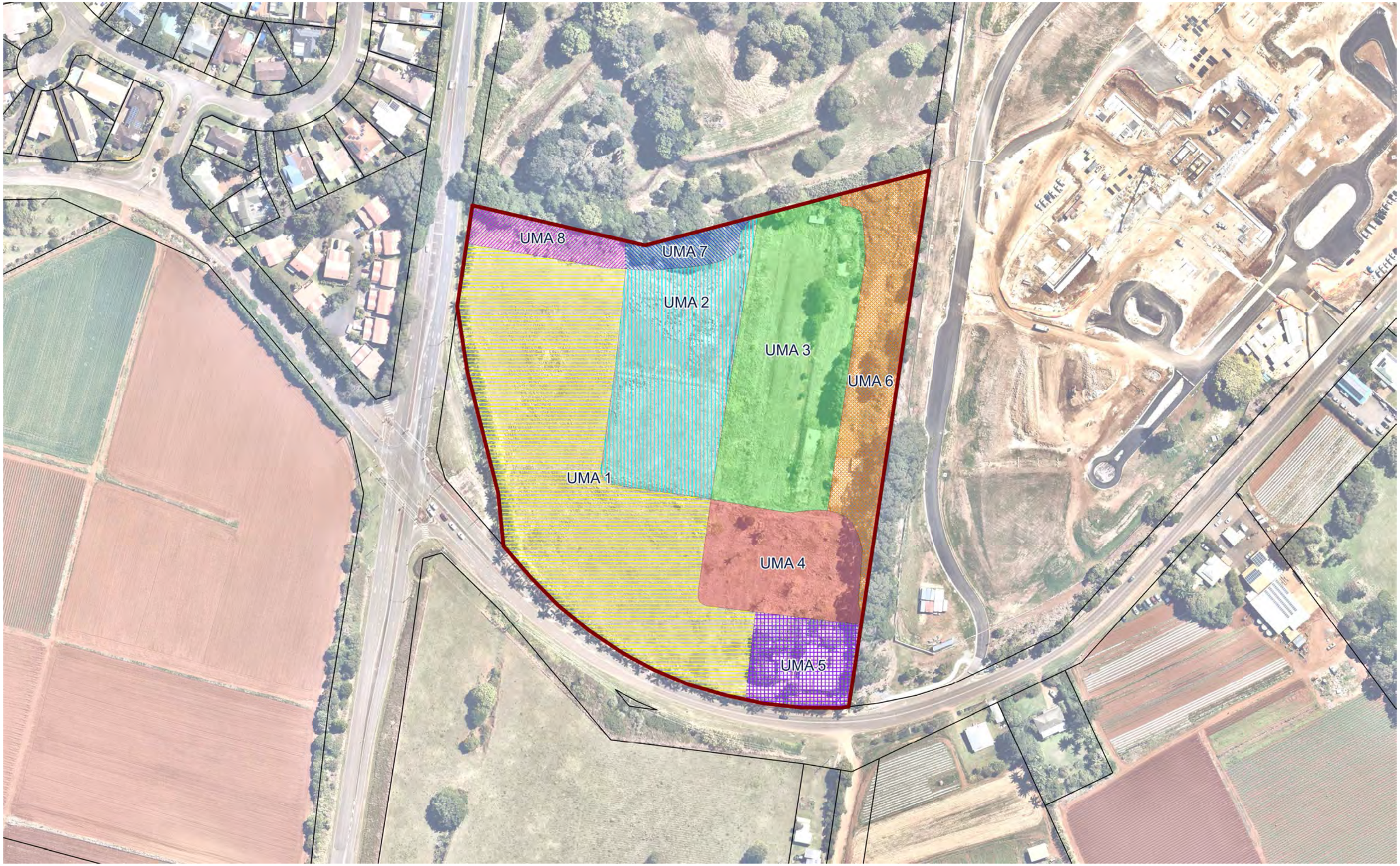
SOURCES

Image: Nearmap image dated 14 September 2020.

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	SOIL TYPES

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:2 000@A3	8/07/2022	AJF/SWP	SAM	12114	004	-

GILBERT SUTHERLAND



ORIENTATION

SCALE

20 40 60 80 100
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

Cadastral boundaries

Site boundary

UNIQUE MAPPING AREAS

UMA 1
UMA 2
UMA 3
UMA 4
UMA 5
UMA 6
UMA 7
UMA 8

SOURCES

Image: Nearmap image dated 14 September 2020.

PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
UNIQUE MAPPING AREAS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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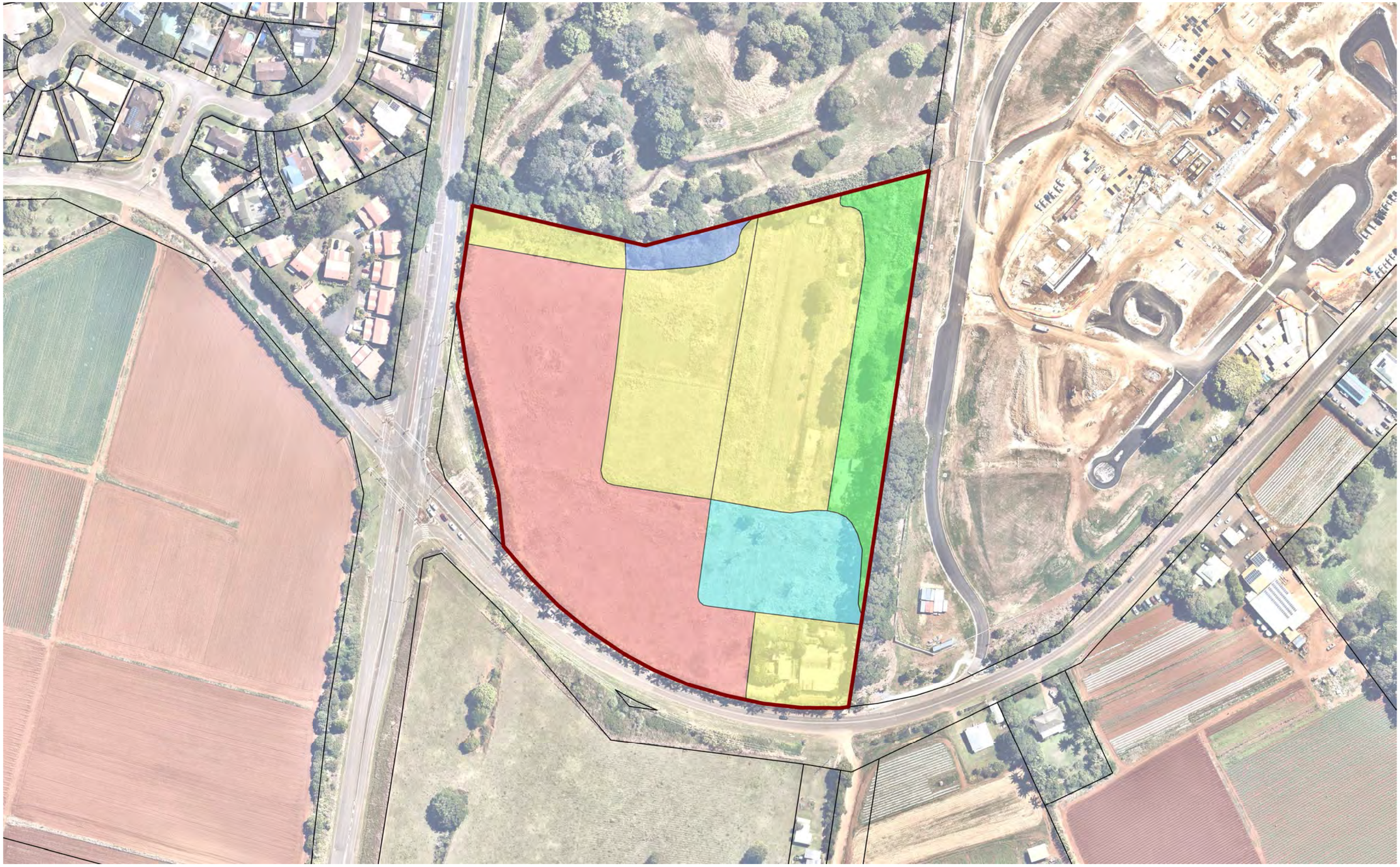
GILBERT SUTHERLAND



ORIENTATION

SCALE

20 40 60 80 100
metres

ROBINA
PO Box 4115 Robina QLD4230
Email robina@access.gs
07 5578 9944
www.access.gs

LEGEND

- Cadastral boundaries
- Site boundary

LAND AND SOIL CAPABILITY CLASS

- Class 3
- Class 4
- Class 6
- Class 7
- Class 8

SOURCES

Image: Nearmap image dated 14 September 2020.

PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
LAND AND SOIL CAPABILITY CLASS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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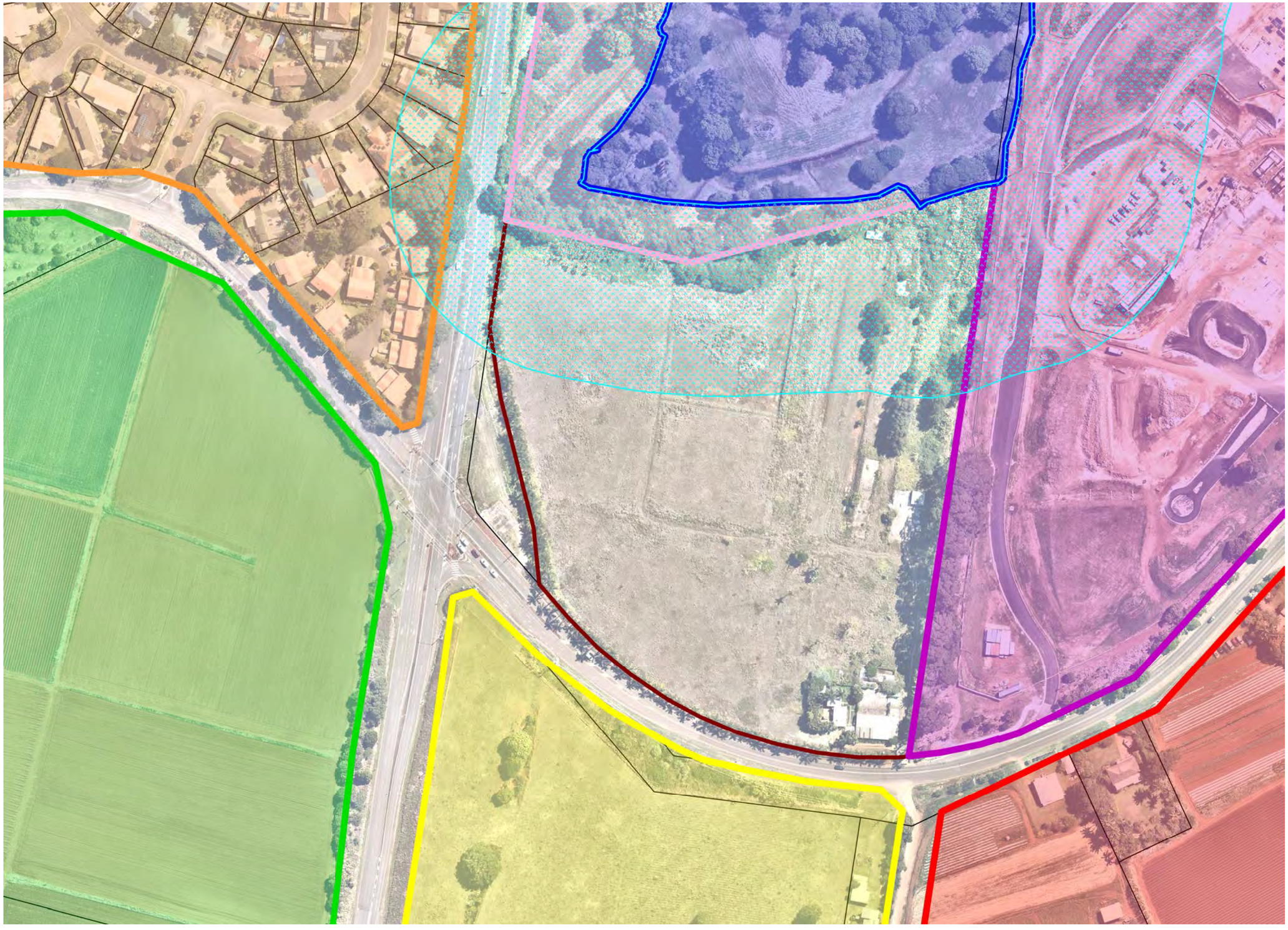
GILBERT SUTHERLAND



ORIENTATION

SCALE

20 40 60 80 100
metres

ROBINA
PO Box 4115 Robina QLD4230
Email robina@access.gs
07 5578 9944
www.access.gs

LEGEND

Cadastral boundaries

Site boundary

SOURCES

Image: Nearmap image dated 14 September 2020.

Coastal Wetlands: Stayte Environmental Planning Policy (Coastal Managment) 2018

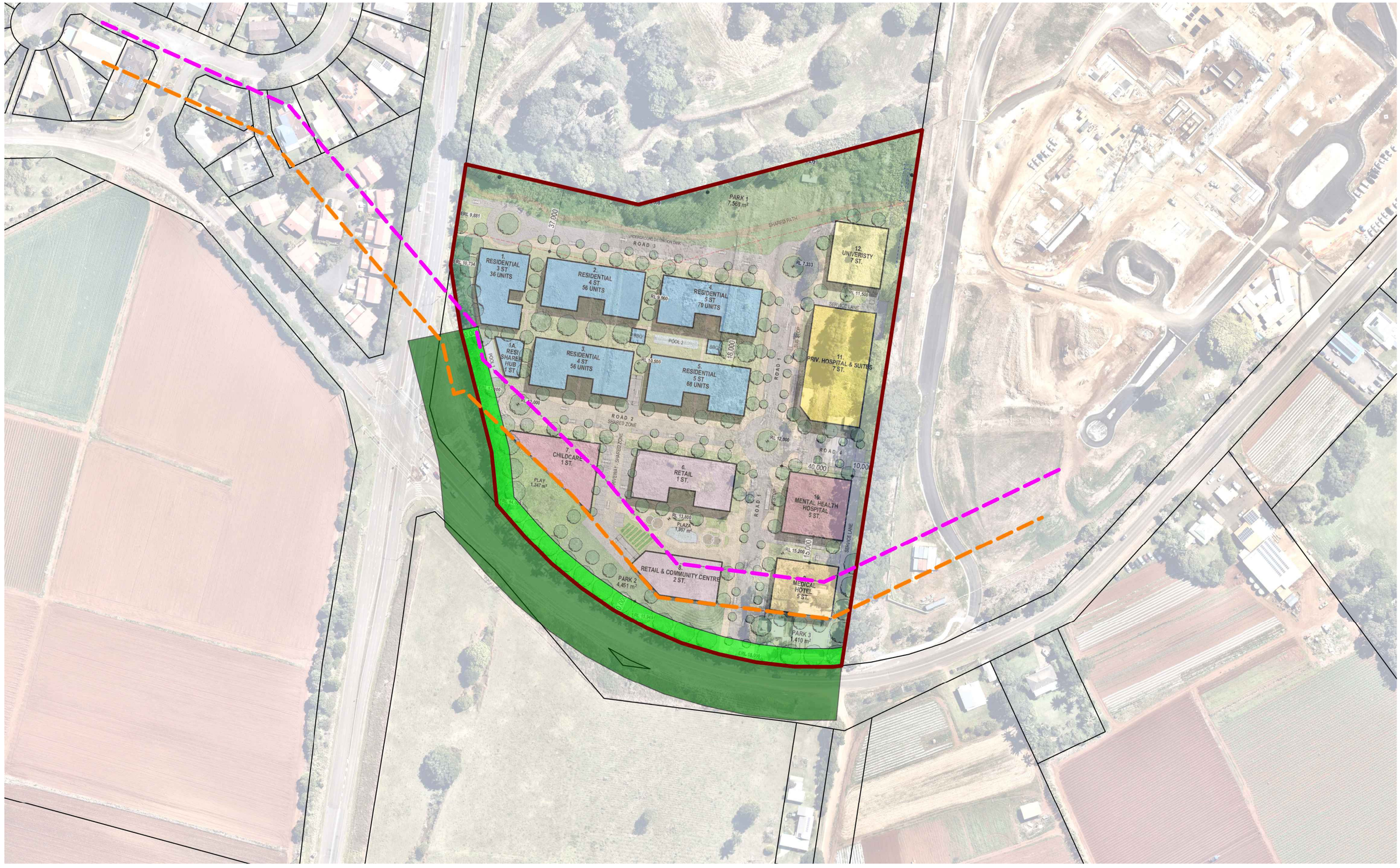
PROJECT
CUDGEN CONNECTION

CLIENT
CUDGEN HEALTH PRECINCT PTY LTD

DRAWING
CURRENT AND POTENTIAL LAND USE

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:2 000@A3	8/07/2022	AJF/SWP	SAM	12114	007	-

GILBERT SUTHERLAND



ORIENTATION

SCALE

0 20 40 60 80 100 metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

- Cadastral boundaries
- Site boundary

PROPOSED AGRICULTURAL BUFFERS
- 10 m biological buffer
- 30 m open space buffer

DCP SECTION A5 - RECOMMENDED BUFFER
- 80 m buffer from southern agricultural land to residential use
- 60 m buffer from southern agricultural land to non-residential use

SOURCES

Image: Nearmap image dated 14 September 2020.

Layout: Detailed Masterplan, Cudgen Connection.

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	AGRICULTURAL BUFFERS TO DEVELOPMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:2 000@A3	23/11/2023	AJF/SWP	GLH	12114	008	C

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

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LEGEND

Site Boundary

SOURCES

Image: Q-Imagery, Image dated August 1962

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - AUGUST 1962

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	009	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

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LEGEND

Site Boundary

SOURCES

Image: Q-Imagery, Image dated March 1979

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - MARCH 1979

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	010	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

Site Boundary

SOURCES

Image: Q-Imagery, Image dated 27.06.1987

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - JUNE 1987

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	011	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944

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LEGEND

Site Boundary

SOURCES

Image: Q-Imagery, Image dated 7.07.1989

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - JULY 1989

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	012	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

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LEGEND

Site Boundary

SOURCES

Image: Q-Imagery, Image dated 22.08.1994

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - AUGUST 1994

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	013	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

Site Boundary

SOURCES

Image: Nearmap, Image dated 6.05.2010

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - MAY 2010

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	014	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

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LEGEND

Site Boundary

SOURCES

Image: Nearmap, Image dated 18.05.2016

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - MAY 2016

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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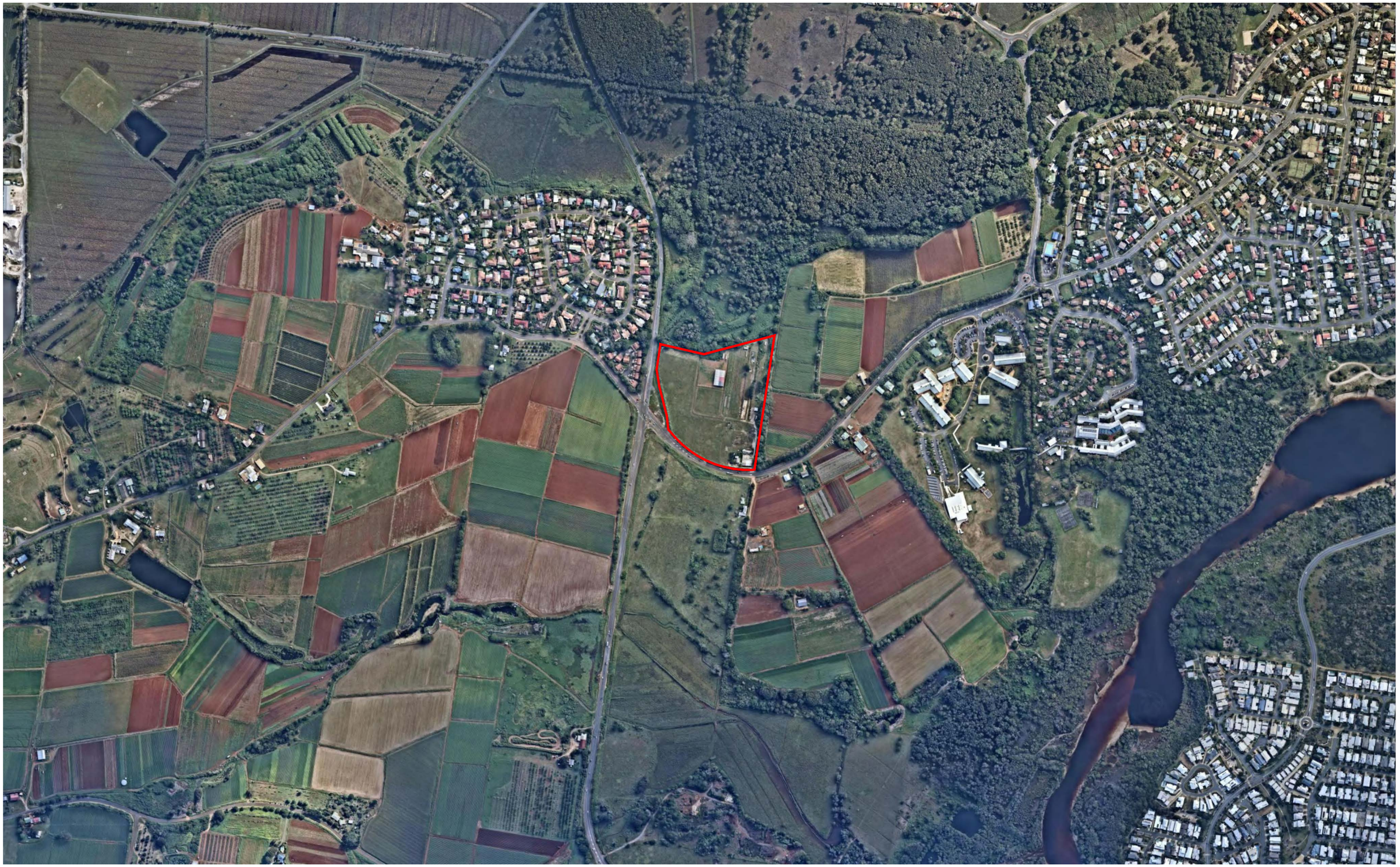
GILBERT SUTHERLAND



ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944

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LEGEND

Site Boundary

SOURCES

Image: Nearmap, Image dated 24.04.2017

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - APRIL 2017

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	016	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

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LEGEND

Site Boundary

SOURCES

Image: Nearmap, Image dated 10.05.2018

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - MAY 2018

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	017	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

Site Boundary

SOURCES

Image: Nearmap, Image dated 9.09.2019

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - SEPTEMBER 2019

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	018	-

GILBERT SUTHERLAND

ORIENTATION

SCALE 1:8000

100 200 300 400 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

Site Boundary

SOURCES

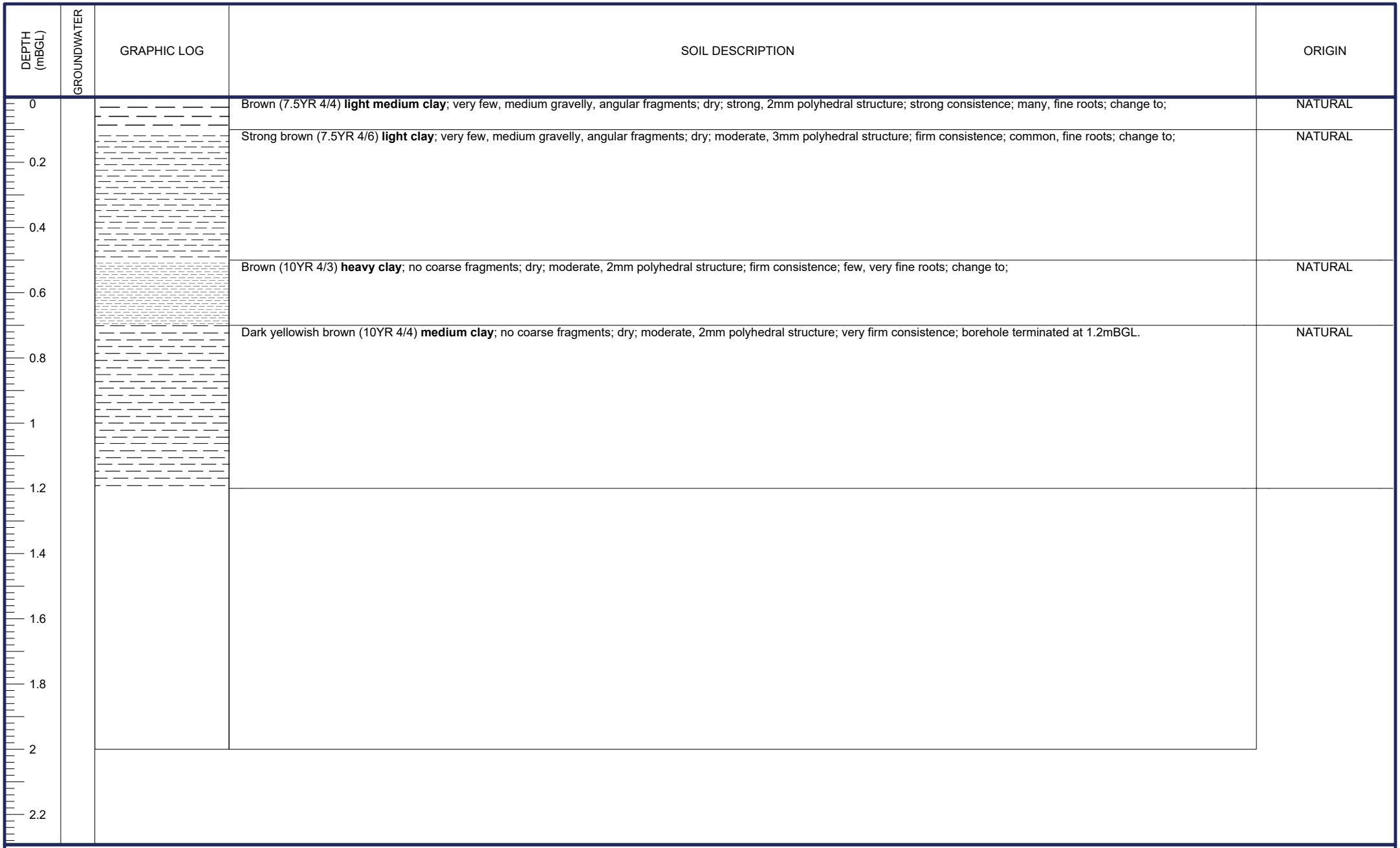
Image: Nearmap, Image dated 14.09.2020

PROJECT	CLIENT	DRAWING
CUDGEN CONNECTION	CUDGEN HEALTH PRECINCT PTY LTD	HISTORICAL IMAGERY - SEPTEMBER 2020

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:8 000@A3	8/07/2022	SWP	SAM	12114	019	-

GILBERT SUTHERLAND

14 Appendix 2 – Soil borelogs



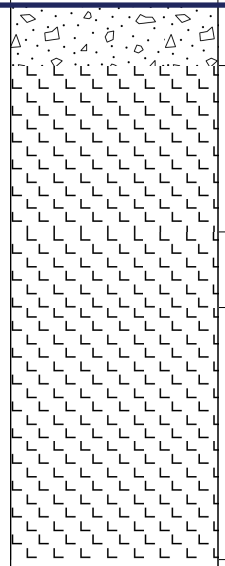
DEPTH (mBGL)	GROUNDWATER	GRAPHIC LOG	SOIL DESCRIPTION	ORIGIN
0			Brown (7.5YR 4/4) **light medium clay**; very few, medium gravelly, angular fragments; dry; strong, 2mm polyhedral structure; strong consistence; many, fine roots; change to;	NATURAL
0.2			Strong brown (7.5YR 4/6) **light clay**; very few, medium gravelly, angular fragments; dry; moderate, 3mm polyhedral structure; firm consistence; common, fine roots; change to;	NATURAL
0.4				
0.6			Brown (10YR 4/3) **heavy clay**; no coarse fragments; dry; moderate, 2mm polyhedral structure; firm consistence; few, very fine roots; change to;	NATURAL
0.8			Dark yellowish brown (10YR 4/4) **medium clay**; no coarse fragments; dry; moderate, 2mm polyhedral structure; very firm consistence; borehole terminated at 1.2mBGL.	NATURAL
1				
1.2				
1.4				
1.6				
1.8				
2				
2.2				

BOREHOLE

AG1

CLIENT	CUDGEN CONNECTION	**PROJECT No.**	12114	**TOTAL DEPTH**	1.2mBGL	**DRILL DATE**	5-Nov-20
PROJECT	IRBS PTY LTD	**SURFACE RL**	Not surveyed	**DRILLED BY**	G+S	**EASTING**	555228
LOCATION	CUDGEN, NSW	**DRILL METHOD**	HAND AUGER	**LOGGED BY**	SAM	**NORTHING**	6873151

GILBERT SUTHERLAND

DEPTH (mBGL)	GROUNDWATER	GRAPHIC LOG	SOIL DESCRIPTION	ORIGIN
0			Dark yellowish brown (10YR 3/6) **sandy clay loam**; few, medium gravelly, angular tabular fragments; dry; strong, 3mm polyhedral structure; strong consistence; many, medium roots; change to;	NATURAL
0.2			Dark yellowish brown (10YR 4/6) **clay loam**; few, cobbly, subangular tabular fragments; dry; moderate, 3mm polyhedral structure; firm consistence; common, fine roots; change to;	NATURAL
0.4			Dark yellowish brown (10YR 4/4) **clay loam**; very few, medium gravelly, subangular tabular fragments; dry; moderate, 2mm polyhedral structure; firm consistence; common, fine roots; change to;	NATURAL
0.6			Dark yellowish brown (10YR 4/6) **clay loam**; very few, medium gravelly, subangular tabular fragments; dry; moderate, 2mm polyhedral structure; very firm consistence; common, very fine roots; borehole terminated at 1.1mBGL.	NATURAL
0.8				
1				
1.2				
1.4				
1.6				
1.8				
2				
2.2				

BOREHOLE

AG2

CLIENT	CUDGEN CONNECTION	**PROJECT No.**	12114	**TOTAL DEPTH**	1.1mBGL	**DRILL DATE**	25-Nov-20
PROJECT	IRBS PTY LTD	**SURFACE RL**	Not surveyed	**DRILLED BY**	G+S	**EASTING**	555213
LOCATION	CUDGEN, NSW	**DRILL METHOD**	HAND AUGER	**LOGGED BY**	SAM	**NORTHING**	6873295

GILBERT SUTHERLAND

15 Appendix 3 – Land and soil capability criteria

5 Decision tables for individual hazards

5.1 Introduction

The decision tables in the LSC assessment scheme are an essential part of the scheme and are partly based on those in the *Native Vegetation Regulation 2005 environmental outcomes assessment methodology* (DECCW 2011). They use landscape, soils and climate data on the various hazards or limitations to allocate a tract of land to an LSC class for each hazard or limitation. The logic tables for each hazard or limitation are outlined below. The operation of the logic tables requires several sources of data and these are outlined below.

Each hazard is assigned one of eight LSC classes where Class 1 represents the least hazard and Class 8 represents the greatest hazard. Each hazard is assessed individually and in this way a profile of hazards is developed for the parcel of land being assessed. The final hazard assessment for a parcel of land is based on the highest hazard in that parcel of land (see Figure 4). For example, a parcel of land may be assessed to have no significant hazard for several limitations but a Class 8 hazard for mass movement hazard; this land will be Class 8 land.

5.2 Base information

Various base information is required to commence assessment of LSC. Some of the base information, such as climate and slope, feeds into other hazard assessments, while other base information, such as that on landform features and existing erosion, is sufficient to identify the capability immediately. The data required to determine the LSC class of a parcel of land is summarised in Table 3.

5.3 Water erosion hazard

Water erosion hazard refers to the likelihood of soil detachment and movement under the effects of raindrop impact, initiation of runoff, and flowing water (Geeves et al. 2007).

The amount of water erosion is controlled by:

- the slope gradient and slope length, which control the erosive power of water flowing down the slope
- the erodibility of the soil, which can be assessed on the detachability and transportability of the soil
- the amount of vegetation cover on the landscape, as this can intercept raindrop impact and attenuate the effects of rainfall erosivity
- the condition of the soil, whether in a loose, tilled or settled coherent condition: soils in a loose, tilled condition are more easily detached and transported.

While the coast has the most intense rainfall, usually it is the cropping areas in the north-west of the State (Namoi and Border rivers) that have the highest water erosion hazard. These lands have the combination of relatively intense rainfall, highly erodible soil (easily detached and transported) and the common occurrence of cropping, meaning that there is the potential for the soil to have a low surface cover for significant periods of the year. Soils in a loose, tilled condition are highly susceptible to water erosion.

5.3.1 Effects of water erosion

The major effects of water erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the landscape and its capacity to deliver ecosystem functions
- movement of soil materials and associated nutrients and chemicals into waterways and storages, with consequent reductions in water quality and the storage capacity of reservoirs
- damage to infrastructure caused by both erosion and deposition of soil materials.

Table 3. Data requirements for determining LSC classes

	Water erosion	Wind erosion	Soil structure decline	Soil acidification	Salinity	Water-logging	Shallow soils and rock	Mass movement
NSW Division	✓							
Sand dune or mobile sand body	✓							
Slope %	✓							✓
Scree or talus slope								✓
Footslope or drainage plain receiving high run-on	✓							
Gully erosion or sodic dispersible subsoils	✓							
Annual rainfall		✓		✓				✓
Wind erosive power		✓						
Exposure to wind		✓						
Surface soil texture		✓	✓	✓				
Surface soil texture modifier			✓					
Great Soil Group				✓				
pH of surface soil				✓				
Surface soil modifier				✓				
Parent material				✓				
Recharge potential of landscape					✓			
Discharge potential of landscape					✓			
Salt store of landscape					✓			
Waterlogging duration						✓		
Return period of waterlogging						✓		
Rocky outcrop							✓	
Soil depth							✓	
Presence of existing mass movement								✓

5.3.2 Assessment of water erosion hazard

The rule set for water erosion hazard is in Table 4. These rules are based on slope classes in the original rural land capability scheme (Emery 1986) and these were based on more than 20 years' field experience of the SCS throughout NSW.

The Western Division is distinguished from the Eastern and Central divisions because of its drier climate, resulting in less protective groundcover.

The data required to complete this assessment may be derived from topographic maps, digital elevation models, direct field measurement with a clinometer or from existing soil-landscape maps.

The influence of specific localised issues such as highly erodible soils, potential for crusting or hardsetting topsoils, shallow texture contrast soils and long slope length have not been directly addressed in this version of the scheme.

5.3.3 Effects of water erosion

The major effects of water erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the landscape and its capacity to deliver ecosystem functions
- movement of soil materials and associated nutrients and chemicals into waterways and storages, with consequent reductions in water quality and the storage capacity of reservoirs
- damage to infrastructure caused by both erosion and deposition of soil materials.

Table 4. Slope class for each LSC class used to determine water erosion hazard

NSW division	Slope class (%) for each LSC class							
	Class 1	Class 2	Class 3	Class 4 [1]	Class 5 [2]	Class 6	Class 7	Class 8
Eastern and Central divisions	<1	1 to <3	3 to <10 or 1 to <3 with slopes >500 m length	10 to <20	10 to <20	20 to <33	33 – <50	>50
Western Division [3]	<1	1 to <3 or <1 for hardsetting red soils	1–3	3–5	3–5	5–33	33–50	>50

Sand bodies are classified as Class 1 for water erosion hazard.

[1] No gully erosion or sodic/dispersible soils are present.

[2] Gully erosion and/or sodic/dispersible subsoils are present.

[3] Western CMA provided advice on the slope classes.

5.4 Wind erosion hazard

Wind erosion hazard refers to the likelihood for soil detachment and movement under the effects of wind blowing across the soil surface (Leys 2007; Leys and McTainsh 2007). Wind erosion hazard tends to be the highest in coastal areas and on the inland plains.

Wind can detach and transport soil particles over a range of distances. Three major transport processes occur in wind erosion:

- creep, as the soil particles (>0.5 mm) roll and bump along the unstable surface as result of the impact of other fast moving particles
- saltation, where particles are transported short distances in a series of bounces – particles in the size range 0.1–0.5 mm are detached and transported this way; this is the material that often builds up along fences and other barriers with active wind erosion
- suspension, whereby soil particles are suspended in the air and transported large distances (hundreds or thousands of kilometres); this is the material seen in dust storms and particles in the size range <0.1 mm are transported this way.

The wind erosion hazard is dependent on the:

- wind erosive power or wind erosivity, which is influenced by overall wind patterns but also by the potential for local modifications by landform, trees and buildings
- exposure of the land to wind, taking into account local variation in wind power. Areas exposed to long wind fetches tend to be subjected to higher wind erosive power. In some landforms the wind flow is channelled and accelerated, increasing the wind erosive power, such as between hills or across saddles. Elevated areas of the landscape will likely have higher exposure than valley floors, while some landforms have naturally high exposure, for example beach fronts, sand dunes on plains, and the crests of ridgelines.
- detachability and transportability of the soil particles to wind. Generally, sandy soils are more erodible than clayey soils. While sand particles are more readily detached by wind they tend to travel only short distances under the process of saltation. It is the clay and silt particles in the sandy soils or aggregated clays that travel long distances and create the familiar dust storm clouds associated with severe wind erosion.

5.4.1 Effects of wind erosion

The major effects of wind erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the land and in the capacity of the land to perform ecosystem functions. There is a disproportionate loss of nutrients and organic carbon from soils affected by wind erosion as the finer and more nutrient-rich fractions are winnowed out by wind erosion.
- movement of soil materials at close range (saltation) onto fences, roads and buildings that can result in infrastructure damage, or at least the need to remove the deposited soil material at considerable cost.
- movement of suspended soil materials at some distance from the original site. This material is moved as dust clouds that can adversely affect visibility, deposit dust and lead to air quality and infrastructure problems.

5.4.2 Assessment of wind erosion hazard

The LSC assessment scheme uses the following factors:

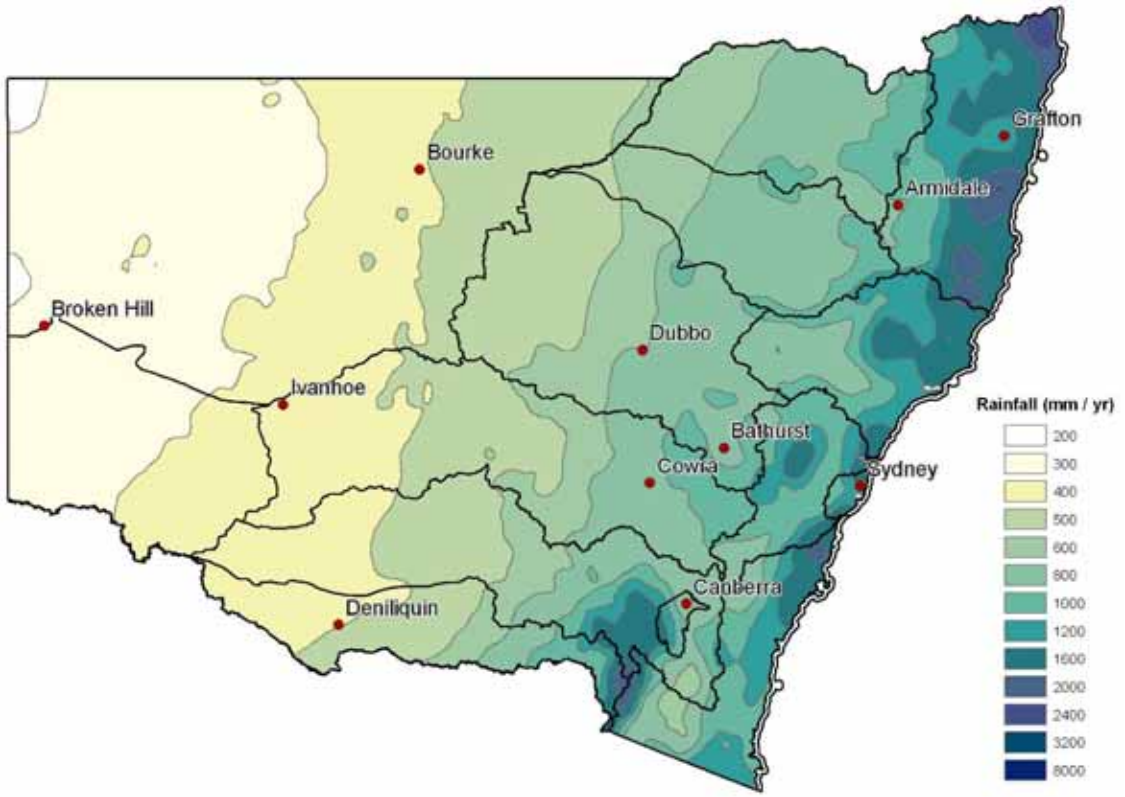
- the average rainfall which determines the capacity of the land to maintain surface cover and keep the soil wet. The wind erosion hazard increases as the average annual rainfall declines (Figure 5).
- the wind erosive power or wind erosivity based on overall wind patterns. Figure 6 is a map of the wind erosive power for NSW.
- the exposure of the tract of land to wind, taking into account local variations in wind power. For example, at the local scale, the landform might channel the prevailing wind into some areas (Table 5).
- the soil erodibility to wind. This is largely determined by the texture of the soil as this determines the detachability and transportability of the soil particles (Table 5).

In assessing the wind erosion hazard, the assumption is made of land management associated with low surface cover. This is consistent with the objective of identifying the land management practices that can be imposed on the landscape without causing long-term degradation. The LSC class for different annual rainfall regimes is shown in Table 6.

Table 5. Factors in assessing wind erosion hazard

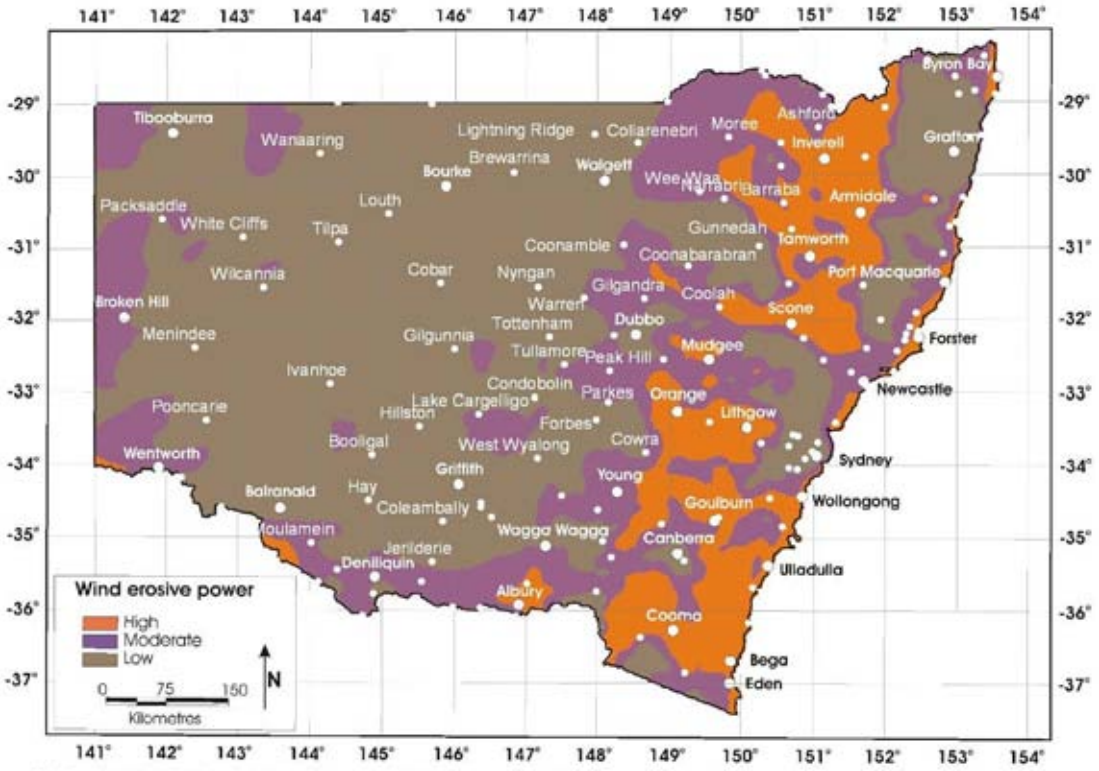
Class	Factor		
	Surface soil texture	**Site exposure to prevailing winds**	**Wind erosive power***
Low	Loams, clay loams or clays (all with >13% clay)	Sheltered locations in valleys or in the lee of hills	Low
Moderate	Fine sandy loams or sandy loams (all with 6–13% clay); also includes organic peats	Intermediate situations – not low or high exposure locations	Moderate
High	Loamy sands or loose sands (all with <6% clay).	Hilltops, cols or saddles, open plains or exposed coastal locations	High

* See Figure 6.



Based on data provided by Australian Bureau of Meteorology.

Figure 5. Average annual rainfall in NSW



Source: NSW Department of Trade and Investment (undated).

Figure 6. Wind erosive power in NSW

Table 6. LSC class for wind erosion hazard

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Low	Low	Low	1	2	3	6
		Moderate	1	2	3	6
		High	2	3	4	7
	Moderate	Low	1	2	3	6
		Moderate	2	3	4	6
		High	3	4	5	7
	High	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	7
Moderate	Low	Low	2	3	4	7
		Moderate	3	4	5	7
		High	4	5	6	8
	Moderate	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	8
	High	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
High	Low	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
	Moderate	Low	4	5	6	8
		Moderate	5	6	7	8
		High	6	7	8	8
	High	Low	5	6	7	8
		Moderate	6	7	8	8
		High	7 (8*)	8	8	8

* Mobile sand bodies such as coastal beaches, foredunes and blowouts are Class 8.

5.5 Soil structure decline hazard

Soil structure decline refers to the breakdown of the physical arrangement of soil particles and pore spaces in the soil, typically as a result of compaction and tillage. It results in the loss of pore space, fissures and tunnels that allow movement and exchange of air, water, nutrients and penetration of plant roots. It is a hazard for all agricultural systems. Organic matter decline is also often associated with soil structure decline. The approach taken here is that soil structure decline is a sufficiently severe soil degradation problem that it should be assessed as an identifiable hazard, especially in the case of sodic surface soils and some other very hardsetting surface soils high in silt and fine sand.

This assessment concentrates on the surface characteristics as described in Lawrie et al. (2002, 2007) who identified that good soil structure is dependent on soil organic matter in the soils with less clay (sandy loams to loams), whereas the level of sodium becomes more important in soils with more clay (clay loams, light clays and heavy clays) where it leads to clay dispersion. Kay (1990) identified that soil structure is dynamic, and that an assessment of soil structural decline hazard requires an estimation of the current soil structural condition, a prediction of the stability of the structural condition and the capacity of the soil to redevelop soil structure should it become degraded (its resilience). This assessment takes some account of the dynamic nature of soil structure.

The stability of soil structure is very dependent on organic matter in soils with less clay and is more affected by sodium as the amount of sodium increases. The resilience of the soil structure is dependent on the capacity of the soil to shrink and swell, and the capacity of the soil to support plant growth.

5.5.1 Effects of soil structure decline

The major effects of poor soil structure are:

- low infiltration and runoff resulting in water erosion and less than optimum use of rainfall for plant growth
- overall poor plant growth
- poor germination and emergence of crops
- poor friability of soils making them difficult and costly to till and to sow.

5.5.2 Assessment of soil structure decline hazard

The LSC classification assesses the soil structure decline hazard using the nature of the surface soils. The nature of the surface soils is assessed using the following criteria:

- surface soil texture
- degree of sodicity
- degree of self-mulching.

These criteria enable an estimate of the likely structural condition, stability and resilience to be made. The features are estimated by observation in the field using standard procedures as defined in Lawrie et al. (2007) and Murphy et al. (2012). Subsoil character may be incorporated into the assessment in future versions of the scheme.

The soil structure decline hazard is assessed using a combination of Tables 7 and 8. The main assessment is provided in Table 7 and uses the texture, sodicity, degree of self-mulching, amount of organic matter and the presence of iron stabilised peds from basalt-type parent materials. Table 8 provides some guidelines on evaluating the degree of self-mulching and sodicity of clay surface soils.

Soil structure decline in many instances can be more easily overcome by a range of management practices than some of the other hazards; therefore, its effect on the LSC class is generally less than hazards such as water and wind erosion.

Table 7. LSC class for soil structural decline hazard

Field texture (surface soils)	Modifier	Outcome – surface soil type	LSC class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable clay loam surface soil – includes dark, friable clay loam soils	1
	High levels of silt and very fine sand (>60%)	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic clay loam surface soil	4
	Moderately sodic	Moderately sodic clay loam surface soil	6
Clay	Friable/ferric[1]	Friable clay surface soil	2
	Strongly self-mulching	Strongly self-mulching surface soil	1
	Weakly self-mulching	Weakly self-mulching surface soil	3
	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
	Strongly sodic	Strongly sodic surface soil	7
Highly organic soils	Mineral soils with high organic matter[2]	Mineral soils with high organic matter	-[2]
	Organosol/peat soils[3]	Organic/peat soils	7

[1] The occurrence of friable or ferric surface soils is associated with (a) basaltic or basic parent materials and soils of the Ferrosols groups in the Australian Soil Classification or the Krasnozems and Euchrozem Great Soil Groups, and (b) the dark loam surface soils of the Chernozems and Prairie Soils on alluvial flats.

[2] Loosely defined here as soils with over 8% organic carbon. These soils revert to the LSC class determined by the mineral component of the soils.

[3] Organosols have organic material layers over 0.4 m thick with minimum organic carbon of 12% if sands or 18% if clays (Isbell 2002).

Table 8. Guidelines for evaluating some surface soil properties of clays

Sodicity/size of soil structural units	Character of surface soil
Very low exchangeable sodium (<3%), high exchangeable calcium, strongly swelling clays (smectitic) as in Vertosols (GSG Black Earths) Peds/aggregates 2–5 mm in an air dry condition	Strongly self-mulching surface soil
Low exchangeable sodium (3–5%), moderate exchangeable calcium, moderately swelling clays (illitic, interstratified, kaolinitic) as in many Dermosols and fertile Chromosols (GSG, Krasnozems, Euchrozems and others) Peds/aggregates 5–10 mm in an air dry condition	Weakly self-mulching surface soil
Moderate levels of exchangeable sodium (5–8%), often moderately low exchangeable calcium relative to exchangeable magnesium (ratio <2:1) Peds/aggregates 10–20 mm in an air dry condition	Mildly sodic surface soils
High levels of exchangeable sodium (8–15%), often low exchangeable calcium relative to exchangeable magnesium (ratio <1:1) Peds/aggregates 20–50 mm in an air dry condition	Moderately sodic surface soils
Very high levels of exchangeable sodium (>15%), often very low exchangeable calcium relative to exchangeable magnesium (ratio <0.5:1) Peds/aggregates >50 mm in an air dry condition	Strongly sodic surface soils

5.6 Soil acidification hazard

Soil acidification hazard is a major limitation in many important areas of agricultural production in NSW. Soils vary considerably in their natural acidity status and in their buffering capacity to resist changes in pH. The climate imposes an acidification potential on the soil by providing a leaching regime than can drive acidifying processes, especially nitrate leaching, but also by increasing plant growth and the plant-related acidifying processes such as nitrogen fixation. Land management practices also vary considerably in their acidification potential. The removal of agricultural produce as grain, vegetable mass or meat adds to the acidification pressure on the soil (Fenton and Helyar 2007; Fenton et al. 1996).

5.6.1 Effects of soil acidification

Soil acidification impacts on plant growth by:

- direct impact on biological and plant growth systems
- increased presence of some toxic elements, including aluminium at pH_{CaCl} levels below 4
- reduction in availability of some plant nutrients.

The resulting poor plant growth means:

- less farm productivity
- increased potential for soil erosion
- increased recharge into groundwater systems leading to increased salinity hazard
- reduced biodiversity.

5.6.2 Assessment of acidification hazard

Buffering capacity is estimated using Table 9, but Tables 10 and 11 may be used if a Great Soil Group classification is not available. The LSC class for soil acidification hazard is estimated using Table 12.

Table 9. Estimating buffering capacity based on Great Soil Group

Great Soil Group	Buffering capacity of surface soil	Great Soil Group	Buffering capacity of surface soil
Acid Peats	VL	Non-calcic Brown soils	M
Alluvial Soils – Light sandy textured (Sands to Sandy Loams)	L	Peaty Podzols	L
Alluvial Soils – Medium textured (Loams clay loams)	M	Podzols	VL
Alpine Humus soils	M	Prairie Soils	H
Black Earths	VH	Red and Brown Hardpan Soils	H
Brown Earths	M	Red-brown Earths	M
Brown Podzolic Soils	M	Red Earths – less fertile (granites and metasediments)	L
Calcareous Red Earths	H	Red Earths – more fertile (volcanics, granodiorites) or highly structured	M
Calcareous Sands	M	Red Podzolic Soils – less fertile (granites and metasediments)	L
Chernozems	H	Red Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M
Chocolate soils	M	Rendzinas	H
Desert Loams	M	Siliceous Sands	VL
Earthy Sands	VL	Solodic soils	L
Euchrozems	H	Solonchaks	H
Gleyed Podzolic Soils	L	Solonetz	M
Grey-brown and Red Calcareous Soils	H	Solonized Brown Soils	M
Grey-brown Podzolic soils	L	Solonized Solonetz	L
Grey, Brown and Red Clays	VH	Soloths	L
Humic Gleys	L	Terra Rossa Soils	M
Humus Podzols	L	Wiesenboden	H
Krasnozems	M	Xanthozems	M
Lateritic Podzolic Soils	L	Yellow Earths	L
Lithosols	VL	Yellow Podzolic Soils – less fertile (granites and metasediments)	L
Neutral to Alkaline Peats	M	Yellow Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M

Table 10. Estimating buffering capacity based on surface soil texture

Surface soil texture	Buffering capacity of surface soil
Sands and sandy loams – no calcium carbonate	VL
Sands and sandy loams – with calcium carbonate	M
Fine sandy loams – no calcium carbonate	L
Fine sandy loams – with calcium carbonate	M
Loams and clay loams – no calcium carbonate	M
Loams and clay loams – with calcium carbonate	H
Dark loams and clay loams (e.g. topsoils in Chernozems and Prairie Soils)	H
Clays – no calcium carbonate	H
Clays – with calcium carbonate	VH
Clays – with high shrink–swell	VH

Table 11. Estimating buffering capacity based on geology

Nature of parent material	Buffering capacity of surface soil
Highly weathered shales and metamorphic rocks, quartzose sandstones – highly siliceous	VL
Siliceous granites, sandstones	VL to L
Intermediate parent materials – granodiorites, less weathered shales and metamorphic rocks, andesites	M
Intermediate to basic rocks and parent materials – basalts, some andesites, gabbros, dolerites	H
Basic to ultrabasic rocks and parent materials – highly mafic or carbonates present, e.g. limestones	VH
Alluvium with high levels of carbonates and clays	H
Alluvium – sandy light textured	L
Alluvium – medium textured	M

Table 12. LSC class for soil acidification hazard

Texture/ buffering capacity	pH of the natural surface soil				
	<4.0 ($CaCl_2$) <4.7 (water)	4.0–4.7 ($CaCl_2$) 4.7–5.5 (water)	4.7–6.0 ($CaCl_2$) 5.5–6.7 (water)	6.0–7.5 ($CaCl_2$) 6.7–8.0 (water)	>7.5 ($CaCl_2$) >8.0 (water)
Mean annual rainfall <550 mm					
Very low	6*	5	4	3	n/a
Low	5	5	3	3	n/a
Moderate	5	4	3	2	1
High	4	3	2	1	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 550–700 mm					
Very low	6*	5	5	4	n/a
Low	5	5	4	3	n/a
Moderate	5	4	3	3	1
High	n/a	n/a	2	2	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 700–900 mm					
Very low	6*	5	5	4	n/a
Low	6*	5	4	4	n/a
Moderate	5	4	3	3	2
High	n/a	n/a	2	2	1
Very high	n/a	n/a	2	1	1
Mean annual rainfall >900 mm or irrigation					
Very low	6*	5	5*	4	n/a
Low	6*	4	4	3*	n/a
Moderate	5	4	3	3	2
High	5	3	2	2	1
Very high	5	3	2	1	1

Based on natural pH status, buffering capacity and climate
* These lands usually have very low fertility.

5.7 Salinity hazard

Salinity hazard is the potential for salts to be mobilised in a catchment and brought to the ground surface and waterways by changes in land use and land management. Widespread vegetation clearing, excessive irrigation inputs and other land management practices that increase recharge to groundwater are major drivers for this hazard.

5.7.1 Effects of salinity

Salinity is a major land degradation problem in NSW. Mobilisation of salts can have the effect of:

- saline outbreaks and scalding on the ground surface
- increased salinity concentration in streams
- increased salt loads leaving the catchment and being transported downstream.

Salt has a highly adverse effect on plant growth by:

- making it difficult for plants to extract water
- increasing the level of toxic elements to plants
- increasing sodicity levels in soils with resulting soil structure decline, crusting and other problems.

Reduced plant growth is associated with reduced crop and pasture productivity, and increased soil erosion.

5.7.2 Assessment of salinity hazard

The LSC classes for salinity hazard provide a simple initial evaluation of salinity hazard. A more detailed assessment of the salinity hazard can be achieved using the Hydrogeological Landscapes framework (Jenkins et al. 2010; Wilford et al. 2010). That system has been developed by OEH and the NSW Department of Primary Industries and is being progressively applied at a range of scales across NSW.

The LSC assessment for salinity hazard is based on the methodology in the environmental outcomes assessment methodology for the Native Vegetation Regulation (DNR 2005; DECCW 2011) and requires the following three inputs.

Recharge potential is the potential for water from rainfall, irrigation or streams to infiltrate past the plant root zone into the underlying groundwater system. This can occur over a whole landscape, or a component of the landscape, where water readily infiltrates soil, sediment or rock. Typically recharge areas have permeable, shallow and/or stony soils and fractured and/or weathered rock.

Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Under natural conditions it relates to the climate, land use and hydrological characteristics of the catchment. It is exacerbated by land-use practices that disturb the vegetation cover or soil surface.

The value assigned for recharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.

Discharge potential is the potential for groundwater to flow from the saturated zone to the land surface. It is a function of position in the landscape, depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration. Discharge may occur as leakage to streams, evaporation from shallow water tables, or as springs and wet areas where water tables intersect the land surface or where narrow breaks occur in low permeability layers above confined aquifers. Typical discharge areas are low in the landscape and have high water tables, or higher in the landscape if sub-surface barriers impede groundwater flow.

Discharge potential is highest when recharge rates are greater than the amount of water that leaves the groundwater system through base flow and evapotranspiration.

The value assigned for discharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.

Salt stores are high for many soils, regolith materials and rock types. This will depend on weathering characteristics, geological structures, rock and soil type, depth of the various materials and salt flux. It is possible to have areas of low salt store and still have a salinity hazard due to evaporative concentration of salts at the soil surface.

Conversely, areas of high salt store can have a lower hazard due to low rainfall. For example, in areas of low rainfall and low slope, salinity hazard can be low. Figure 7 provides a broad indication of salt stores throughout NSW. This map is generalised and local information should be used where available.

These three inputs are combined to provide a simple assessment of salinity hazard as described in Table 13. For localised assessments, it is important to calibrate the LSC estimates to local conditions and to validate against known areas of salinity, as reported in soil-landscape and hydrogeological landscape reports and other available sources. Consideration should be given to factors not used in the simplified LSC ranking, including salt mobility, local climate, soil buffering capacity and position in the landscape.

Table 13. LSC class for salinity hazard

Recharge potential	Discharge potential	Salt store	LSC class
Low	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	1
		Moderate	4
		High	4
	High	Low	1
		Moderate	4
		High	5
Moderate	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	2
		Moderate	5
		High	6
	High	Low	1 (3) *
		Moderate	6
		High	6
High	Low	Low	1
		Moderate	4
		High	5
	Moderate	Low	3 (2) *
		Moderate	4
		High	7
	High	Low	2 (3) *
		Moderate	6
		High	7

* The values in brackets are more accurate and should be used in preference to the original rating.

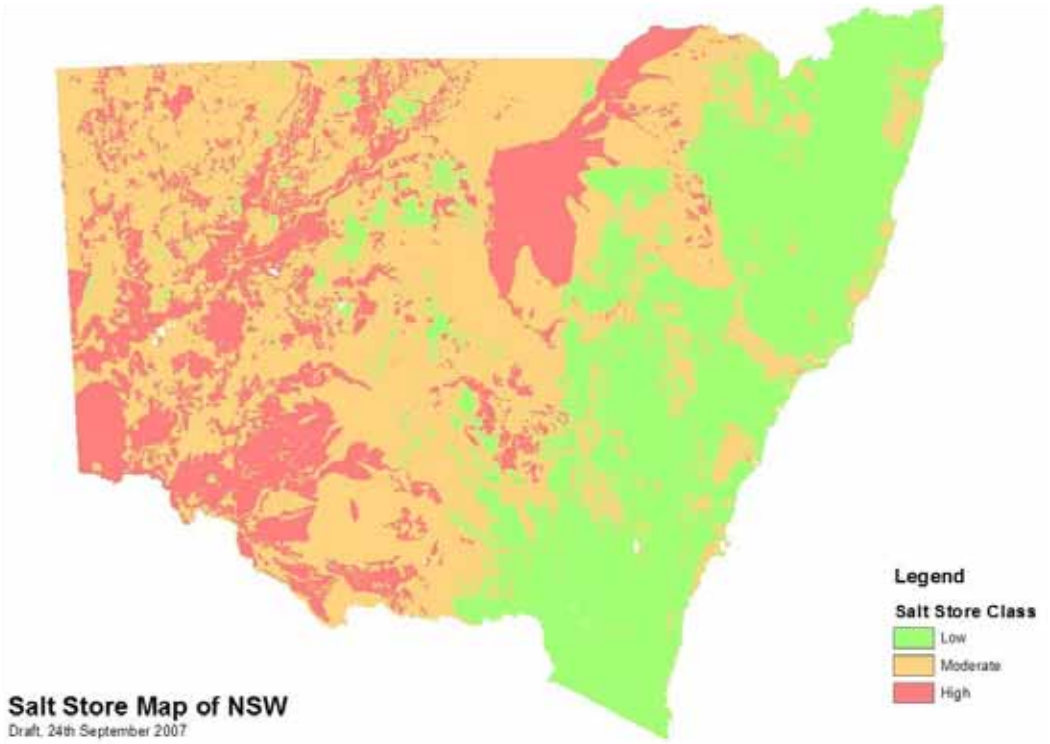


Figure 7. Salt store map

5.8 Waterlogging hazard

Waterlogging of soils is a major limitation in some generally low-lying areas of the landscape. Soils vary considerably in their natural drainage depending on the climate, their position in the landscape and their textural characteristics. Soils may be wet or waterlogged, for short periods, for long periods of several months, particularly in the wetter winter season, or even most of the year.

5.8.1 Effects of waterlogging

Waterlogging can severely affect agricultural production and land use. It restricts or prevents the supply of oxygen to plant roots, thus it can severely impact on plant health and survival. Plants and crops have differing abilities to tolerate waterlogged conditions. For example, rice and cotton require these conditions; however, most agricultural crop and pasture plants will suffer. Waterlogging also inhibits vehicular access, tillage and sowing operations and stock management.

5.8.2 Assessment of waterlogging hazard

Waterlogging hazard assessment is largely based on the drainage classes in NCST (2009). Table 14 is used to assess waterlogging hazard. It relies on information contained in soil landscape reports and other natural resource products or knowledge from local soil and land practitioners to determine the waterlogging duration and return period.

Table 14. LSC class for waterlogging hazard

Typical waterlogging duration (months)	Return period	Typical soil drainage*	LSC class**
0	every year	rapidly drained and well drained	1
0–0.25	every year	moderately well drained	2
0.25–2	every year	imperfectly drained	3
2–3	every 2 to 3 years	imperfectly drained	4
2–3	every year	imperfectly drained	5
>3	every year	poorly drained	6
Almost permanently	every year	very poorly drained	8

* NCST (2009, p.202–4)
** Based on slope position, climate and length of time soils are wet.

5.9 Shallow soils and rockiness hazard

5.9.1 Effects of shallow soils and rockiness

Shallow soils and rockiness reduce the land-use capability of soils and land. The more rock outcrop and the shallower the soils, the less volume of soil available for storing nutrients and water. Rock outcrop impedes access by vehicles and farm machinery and restricts potential for tillage and sowing of crops.

5.9.2 Assessment of shallow soils and rockiness hazard

The criteria used by the LSC classification to assess shallow soils and rockiness hazard are:

- estimated percentage exposure of rocky outcrops
- average soil depth.

The relationship between the criteria in determining the LSC class is shown in Table 15.

5.10 Mass movement hazard

Mass movement relates to the large scale movement of earth under the force of gravity. It is a function of the gravitational stress acting on the land surface and the resistance of the surface soil, sand or rock materials to dislodgement (Hicks 2007). In general the hazard for mass movement increases with an increase in slope and an increase in rainfall when more water is available to saturate and reduce the strength of the soil. Certain combinations of slope, soils, landform, climate and geology are more susceptible to mass movement. Disturbance of soils in some land management actions (for example cutting of batters into slopes) can also increase the likelihood of mass movement.

5.10.1 Effects of mass movement

Mass movement is a serious threat to many land uses. The most serious consequences are damage to or destruction of buildings and other infrastructure, and injury or loss of life of people or livestock.

5.10.2 Assessment of mass movement hazard

The criteria used in the LSC classification to assess mass movement hazard are:

- existing evidence of mass movement
- slope class
- average annual rainfall.

The relationship between the criteria in determining the LSC class is shown in Table 16.

In some circumstances land that has been classified as Class 7 or 8 because of mass movement hazard may be used for limited agricultural land uses.

Table 15. LSC class for shallow soils and rockiness hazard

Rocky outcrop (% coverage)*	Soil depth (cm)	LSC class**
Nil	>100	1
<30 (localised*)	>100	2
	75– <100	3
	50– <75	4
	25– <50	6
	0– <25	7
30–50 (widespread*)	>100	4
	75–100	5
	25–75	6
	<25	7
50–70 (widespread*)	>100	6
	50–100	6
	25– <50	7
	<25	7
>70	n/a	8

* Rock outcrop limitation from soil landscape report.
** Based on rocky outcrop and soil depth

Table 16. LSC class for mass movement hazard

Mean annual rainfall (mm)	Mass movement present	Slope class (%)	LSC class
<500	No	n/a	1
	Yes	n/a	8
>500	No	n/a	1
	Yes	<20	6
		>20–50	7
		>50 or any scree or talus slope	8

Note that scree or talus slopes go automatically into Class 8.

16 Appendix 4 – Urban growth area variation principles

APPENDIX B:

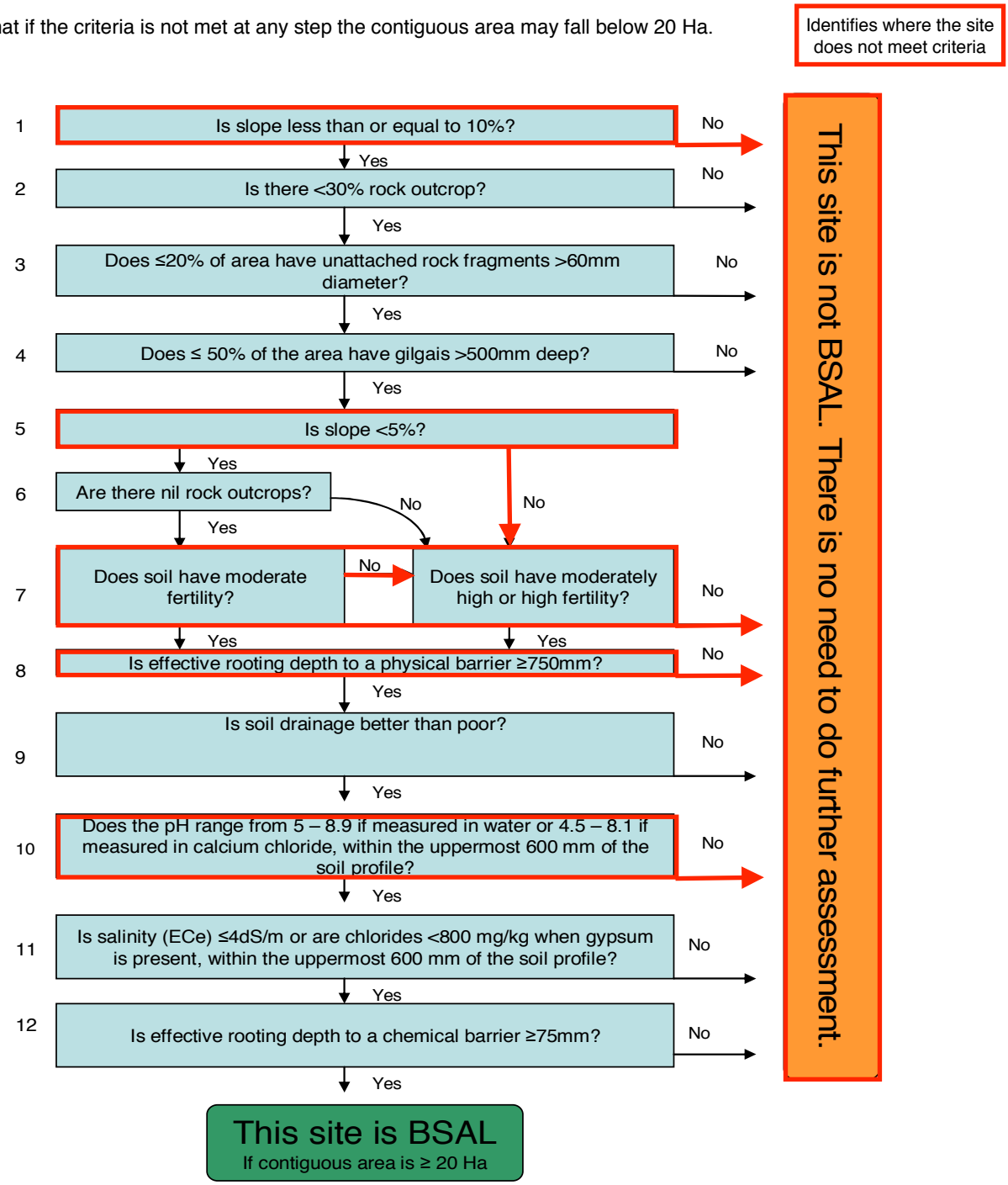
Urban Growth Area Variation Principles

Urban Growth Area Variation Principles	
Policy	The variation needs to be consistent with the objectives and outcomes in the *North Coast Regional Plan 2041* and should consider the intent of any applicable Section 9.1 Direction, State Environmental Planning Policy and local growth management strategy.
Infrastructure	The variation needs to consider the use of committed and planned major transport, water and sewerage infrastructure, and have no cost to government. The variation should only be permitted if adequate and cost effective infrastructure can be provided to match the expected population.
Environmental and heritage	The variation should avoid, minimise and appropriately manage and protect any areas of high environmental value and water quality sensitivity, riparian land or of Aboriginal and non-Aboriginal heritage.
Avoiding Risk	Risks associated with physically constrained land are identified and avoided, including: • flood prone • bushfire-prone • highly erodible • severe slope, and • acid sulfate soils.
Coastal Strip	Only minor and contiguous variations to urban growth areas will be considered within the coastal strip due to its environmental sensitivity and the range of land uses competing for this limited area.
Land Use Conflict	The variation must be appropriately separated from incompatible land uses, including agricultural activities, sewerage treatment plants, waste facilities and productive resource lands.
Important Farmland	The planning area is contiguous with existing zoned urban land and the need and justification is supported by a sound evidence base addressing agricultural capability and sustainability and is either for: • a minor adjustment to 'round off an urban boundary', or • if demonstrated through a Department approved local strategy that no other suitable alternate land is available, and if for housing, that substantial movement has been made toward achieving required infill targets within existing urban growth area boundaries.

18 Appendix 5 – BSAL decision flow chart

Figure 2: Flow chart for site assessment of BSAL

Note: that if the criteria is not met at any step the contiguous area may fall below 20 Ha.



6.1. Slope (Steps 1 and 5 in Figure 2)

Slope is the upward or downward incline of the land surface, measured in per cent. BSAL soils must have a slope of less than or equal to 10 per cent.

Slope can be an impediment to farming as erosion potential rapidly increases once slope increases beyond 10 per cent. Increased slope is also an impediment to the safe operation of machinery. It is a useful criterion for clearly identifying lands that are not BSAL.

19 Appendix 6 – Risk Assessment

Table A1 Risk Ranking Matrix

PROBABILITY	A	B	C	D	E
Consequence					
1	25	24	22	19	15
2	23	21	18	14	10
3	20	17	13	9	6
4	16	12	8	5	3
5	11	7	4	2	1

Table A2 Probability Table – to score the likelihood of the consequence occurring

Level	Descriptor	Description
A	Almost certain	Common of repeating occurrence
B	Likely	Known to occur, or 'it has happened'
C	Possible	Could occur, or 'I've heard of it happening'
D	Unlikely	Could possible occur in some circumstances, but not likely to occur
E	Rare	Practically impossible

Table A3 Measure of consequence

Level 1	Descriptor: Severe
Description	• Severe and/or permanent damage to the environment • Irreversible • Severe impact on the community • Neighbours are in prolonged dispute and legal action involved
Example/implication	• Harm or death to animals, fish, birds or plants • Long term damage to soil or water • Odours so offensive some people are evacuated or leave voluntarily • Many public complaints and serious damage to Council's reputation • Contravenes Protection of the Environment & Operations Act and conditions of Council's licences and permits. Prosecution under the POEO Act almost certain
Level 2	Descriptor: Major
Description	• Serious and/or long-term impact to the environment • Long-term management implications • Serious impact on the community • Neighbours are in serious dispute
Example/implication	• Water, soil or air impacted, possibly in the long term • Harm to animals, fish or birds or plants • Public complaints. Neighbour disputes occur. Impacts pass quickly • Contravenes the conditions of Council's licences, permits and the POEO Act • Likely prosecution

Level 3	Descriptor: Moderate
Description	• Moderate and/or medium-term impact to the environment and community • Some ongoing management implications • Neighbour disputes occur
Example/implication	• Water, soil or air known to be affected, probably in the short term • No serious harm to animals, fish, birds or plants • Public largely unaware and few complaints to Council • May contravene the conditions of Council's Licences and the POEO Act • Unlikely to result in prosecution
Level 4	Descriptor: Minor
Description	• Minor and/or short-term impact to the environment and community • Can be effectively managed as part of normal operations • Infrequent disputes between neighbours
Example/implication	• Theoretically could affect the environment or people but no impacts noticed • No complaints to Council • Does not affect the legal compliance status of Council
Level 5	Descriptor: Negligible
Description	• Very minor impact to the environment and community • Can be effectively managed as part of normal operations • Neighbour disputes unlikely
Example/implication	• No measurable or identifiable impact on the environment • No measurable impact on the community or impact is generally acceptable

20 Appendix 7 – Laboratory certificates

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG2 LOWER SLOPE 0-120

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542A / SCK2882

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	5.8
pH [1:5 CaCl2]	4.6
Organic Matter (%)	15.9
CEC (meq/100g)	6.43
EC [1:5 H2O] (dS/m)	0.02
NO3-N (ppm)	2.0
NH4/N (ppm)	< 1.0
Phosphorus [Olsen] (ppm)	20
Potassium[Am. Acet.] (meq/100g)	0.37
Calcium[Am. Acet.] (meq/100g)	2.85
Magnesium[Am. Acet.] (meq/100g)	2.80
Sulphur [MCP] (ppm)	50
Boron[CaCl2] (ppm)	1.2
Copper [DTPA] (ppm)	3.5
Iron [DTPA] (ppm)	173
Manganese [DTPA] (ppm)	45.7
Zinc [DTPA] (ppm)	10.5
Sodium[Am. Acet.] (meq/100g)	0.1
Aluminium[KCl] (meq/100g)	0.29
Chloride (ppm)	9
Ca base saturation (%)	44.2

ASPAC CERTIFIED

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Quality Checked: per Rob Cirocco (Lab Manager) – RC

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Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542A / SCK2882

Crop NO CROP STATED

Analysis	Result
K base saturation (%)	5.8
Mg base saturation (%)	43.5
Na base saturation (%)	1.9
Al base saturation (%)	4.60
Ca:Mg Ratio	1.0
Texture	LOAM
Colour	BROWN
Aluminium (ppm)	26.0
Sodium (ppm)	28.0
Calcium (ppm)	569.0
Magnesium (ppm)	336.0
Potassium (ppm)	146.0
Lime Requirement (t/ha)	< 0.50

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

Please Note

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Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA

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Sample No B120542A / SCK2882

Crop NO CROP STATED

Phosyn Analytical Pty Ltd - Lab Methods

Soil Analysis - *Analysis performed on samples dried at 40°C and ground to <2mm*	Method Code
Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

1. ASPAC certified tests are demonstrated and highlighted with an asterisk (*); 2. NATA accredited tests are demonstrated and highlighted with a hat (^)

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Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG2 LOWER SLOPE 120-450

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542B / SCK2883

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	4.8
pH [1:5 CaCl2]	4.2
Organic Matter (%)	12.7
CEC (meq/100g)	1.87
EC [1:5 H2O] (dS/m)	0.04
NO3-N (ppm)	< 1.0
NH4/N (ppm)	< 1.0
Phosphorus [Olsen] (ppm)	18
Potassium[Am. Acet.] (meq/100g)	0.08
Calcium[Am. Acet.] (meq/100g)	0.34
Magnesium[Am. Acet.] (meq/100g)	0.24
Sulphur [MCP] (ppm)	230
Boron[CaCl2] (ppm)	0.3
Copper [DTPA] (ppm)	0.9
Iron [DTPA] (ppm)	34
Manganese [DTPA] (ppm)	4.8
Zinc [DTPA] (ppm)	0.7
Sodium[Am. Acet.] (meq/100g)	< 0.1
Aluminium[KCl] (meq/100g)	1.17
Chloride (ppm)	12
Ca base saturation (%)	18.2

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Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542B / SCK2883

Crop NO CROP STATED

Analysis	Result
K base saturation (%)	4.4
Mg base saturation (%)	13.0
Na base saturation (%)	1.9
Al base saturation (%)	62.60
Ca:Mg Ratio	1.4
Texture	LOAM
Colour	BROWN
Aluminium (ppm)	105.0
Sodium (ppm)	< 18.4
Calcium (ppm)	68.0
Magnesium (ppm)	29.0
Potassium (ppm)	32.0
Lime Requirement (t/ha)	1.40

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

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Sample No B120542B / SCK2883

Crop NO CROP STATED

Phosyn Analytical Pty Ltd - Lab Methods

Soil Analysis - *Analysis performed on samples dried at 40°C and ground to <2mm*	Method Code
Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

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QLD

Sample Ref AG2 LOWER SLOPE 450-600

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542C / SCK2884

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	5.1
pH [1:5 CaCl2]	4.3
Organic Matter (%)	11.7
CEC (meq/100g)	1.47
EC [1:5 H2O] (dS/m)	0.03
NO3-N (ppm)	< 1.0
NH4/N (ppm)	1.0
Phosphorus [Olsen] (ppm)	23
Potassium[Am. Acet.] (meq/100g)	0.05
Calcium[Am. Acet.] (meq/100g)	0.71
Magnesium[Am. Acet.] (meq/100g)	0.34
Sulphur [MCP] (ppm)	237
Boron[CaCl2] (ppm)	0.5
Copper [DTPA] (ppm)	0.6
Iron [DTPA] (ppm)	23
Manganese [DTPA] (ppm)	11.5
Zinc [DTPA] (ppm)	1.1
Sodium[Am. Acet.] (meq/100g)	0.1
Aluminium[KCl] (meq/100g)	0.29
Chloride (ppm)	14
Ca base saturation (%)	48.4

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Sample No B120542C / SCK2884

Crop NO CROP STATED

Analysis	Result
K base saturation (%)	3.2
Mg base saturation (%)	23.0
Na base saturation (%)	5.5
Al base saturation (%)	20.00
Ca:Mg Ratio	2.1
Texture	LOAM
Colour	BROWN
Aluminium (ppm)	26.0
Sodium (ppm)	19.0
Calcium (ppm)	142.0
Magnesium (ppm)	41.0
Potassium (ppm)	18.0
Lime Requirement (t/ha)	< 0.50

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

Please Note

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Sample No B120542C / SCK2884

Crop NO CROP STATED

Phosyn Analytical Pty Ltd - Lab Methods

Soil Analysis - *Analysis performed on samples dried at 40°C and ground to <2mm*	Method Code
Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

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Email: phosynanalytical@phosyn.com.au

Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG1 UPPER SLOPE 0-100

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542D / SCK2885

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	5.4
pH [1:5 CaCl2]	4.4
Organic Matter (%)	13.9
CEC (meq/100g)	4.32
EC [1:5 H2O] (dS/m)	0.04
NO3-N (ppm)	< 1.0
NH4/N (ppm)	1.0
Phosphorus [Olsen] (ppm)	32
Potassium[Am. Acet.] (meq/100g)	0.19
Calcium[Am. Acet.] (meq/100g)	2.09
Magnesium[Am. Acet.] (meq/100g)	1.43
Sulphur [MCP] (ppm)	50
Boron[CaCl2] (ppm)	0.3
Copper [DTPA] (ppm)	1.3
Iron [DTPA] (ppm)	53
Manganese [DTPA] (ppm)	17.8
Zinc [DTPA] (ppm)	2.3
Sodium[Am. Acet.] (meq/100g)	< 0.1
Aluminium[KCl] (meq/100g)	0.54
Chloride (ppm)	21
Ca base saturation (%)	48.3

ASPAC CERTIFIED

Accredited for compliance with ISO/IEC 17025 – Testing
NATA ACCREDITED FOR TECHNICAL COMPETENCE

Quality Checked: per Rob Cirocco (Lab Manager) – RC

Date Printed : 01/12/2020

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

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QLD

Sample Ref AG1 UPPER SLOPE 0-100

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542D / SCK2885

Crop NO CROP STATED

Analysis	Result
K base saturation (%)	4.3
Mg base saturation (%)	33.0
Na base saturation (%)	1.8
Al base saturation (%)	12.60
Ca:Mg Ratio	1.5
Texture	LOAM
Colour	BROWN
Aluminium (ppm)	49.0
Sodium (ppm)	< 18.4
Calcium (ppm)	418.0
Magnesium (ppm)	171.0
Potassium (ppm)	73.0
Lime Requirement (t/ha)	< 0.50

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA

Sample Ref AG1 UPPER SLOPE 0-100

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542D / SCK2885

Crop NO CROP STATED

Phosyn Analytical Pty Ltd - Lab Methods

Soil Analysis - *Analysis performed on samples dried at 40°C and ground to <2mm*	Method Code
Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

1. ASPAC certified tests are demonstrated and highlighted with an asterisk (*); 2. NATA accredited tests are demonstrated and highlighted with a hat (^)

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG1 UPPER SLOPE 100-500

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542E / SCK2886

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	5.0
pH [1:5 CaCl2]	4.3
Organic Matter (%)	10.2
CEC (meq/100g)	1.67
EC [1:5 H2O] (dS/m)	0.02
NO3-N (ppm)	< 1.0
NH4/N (ppm)	< 1.0
Phosphorus [Olsen] (ppm)	22
Potassium[Am. Acet.] (meq/100g)	0.02
Calcium[Am. Acet.] (meq/100g)	0.62
Magnesium[Am. Acet.] (meq/100g)	0.22
Sulphur [MCP] (ppm)	219
Boron[CaCl2] (ppm)	0.2
Copper [DTPA] (ppm)	0.3
Iron [DTPA] (ppm)	16
Manganese [DTPA] (ppm)	1.4
Zinc [DTPA] (ppm)	0.3
Sodium[Am. Acet.] (meq/100g)	< 0.1
Aluminium[KCl] (meq/100g)	0.77
Chloride (ppm)	8
Ca base saturation (%)	37.1

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Analysis Results (SOIL)

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Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG1 UPPER SLOPE 100-500

Date Received 26/11/2020 (Date Issued: 01/12/2020) (Date Sampled: 25/11/2020)

Sample No B120542E / SCK2886

Crop NO CROP STATED

Analysis	Result
K base saturation (%)	1.4
Mg base saturation (%)	13.2
Na base saturation (%)	2.2
Al base saturation (%)	46.20
Ca:Mg Ratio	2.8
Texture	LOAM
Colour	BROWN
Aluminium (ppm)	70.0
Sodium (ppm)	< 18.4
Calcium (ppm)	124.0
Magnesium (ppm)	26.0
Potassium (ppm)	9.0
Lime Requirement (t/ha)	0.90

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

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Sample No B120542E / SCK2886

Crop NO CROP STATED

Phosyn Analytical Pty Ltd - Lab Methods

Soil Analysis - *Analysis performed on samples dried at 40°C and ground to <2mm*	Method Code
Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

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Analysis Results (SOIL)

Customer GILBERT & SUTHERLAND

Distributor GILBERT & SUTHERLAND PTY LTD - ROBINA
SUITE 12 /140 ROBINA
ROBINA
QLD

Sample Ref AG1 UPPER SLOPE 500-700

Date Received 26/11/2020 (Date Issued: 01/12/2020)

Sample No B120542F / SCK2887

Crop NO CROP STATED

Analysis	Result
pH [1:5 H2O]	6.1
pH [1:5 CaCl2]	5.7
Organic Matter (%)	5.3
CEC (meq/100g)	4.69
EC [1:5 H2O] (dS/m)	0.02
NO3-N (ppm)	< 1.0
NH4/N (ppm)	< 1.0
Phosphorus [Olsen] (ppm)	10
Potassium[Am. Acet.] (meq/100g)	0.01
Calcium[Am. Acet.] (meq/100g)	3.39
Magnesium[Am. Acet.] (meq/100g)	0.70
Sulphur [MCP] (ppm)	143
Boron[CaCl2] (ppm)	0.2
Copper [DTPA] (ppm)	0.1
Iron [DTPA] (ppm)	3
Manganese [DTPA] (ppm)	0.3
Zinc [DTPA] (ppm)	0.2
Sodium[Am. Acet.] (meq/100g)	0.1
Aluminium[KCl] (meq/100g)	0.49
Chloride (ppm)	12
Ca base saturation (%)	72.3
K base saturation (%)	0.3

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Sample Ref AG1 UPPER SLOPE 500-700

Date Received 26/11/2020 (Date Issued: 01/12/2020)

Sample No B120542F / SCK2887

Crop NO CROP STATED

Analysis	Result
Mg base saturation (%)	14.9
Na base saturation (%)	2.1
Al base saturation (%)	10.40
Ca:Mg Ratio	4.9
Texture	SILTY LOAM
Colour	GREY BROWN
Aluminium (ppm)	44.0
Sodium (ppm)	22.0
Calcium (ppm)	679.0
Magnesium (ppm)	84.0
Potassium (ppm)	6.0
Lime Requirement (t/ha)	< 0.50

Additional Comments

Soil analyses performed and reported on samples dried at 40°C and sieved to <2mm; Plant tissue analyses performed and reported on samples dried at 70°C and ground (NB/ Fruit, Fruitlet & Tuber reported on fresh weight basis)

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Sample No B120542F / SCK2887

Crop NO CROP STATED

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Ammonium-N	03-S04
Boron (CaCl2) *^	03-S08
CEC (Cation Exchange Capacity) ^	03-S06
Chloride ^	03-S04
Colour and Texture	03-S15
Phosphorus BSES *^	03-S12
Phosphorus Colwell *^	03-S13
Phosphorus Olsen *^	03-S11
PBI unadjusted *^	03-S14
EC (1:5 H2O) ^	03-S02
Exchangeable Aluminium (1M KCl)	03-S10
Exchangeable Calcium (1M Ammonium Acetate) *^	03-S06
Exchangeable Magnesium (1M Ammonium Acetate) *^	03-S06
Exchangeable Potassium (1M Ammonium Acetate) *^	03-S06
Exchangeable Sodium (1M Ammonium Acetate) *^	03-S06
Extractable Copper (DTPA) *^	03-S07
Extractable Iron (DTPA) *^	03-S07
Extractable Manganese (DTPA) *^	03-S07
Extractable Zinc (DTPA) *^	03-S07
Extractable Sulphur (MCP) *^	03-S09
Nitrate-N *^	03-S04
Organic Matter *	03-S01
pH (1:5 CaCl2) *^	03-S03
pH (1:5 H2O) *^	03-S02
Total N ^	03-S16

Plant Analsyis - *Analysis performed on plant tissue dried at 70°C and ground*	Method Code
Aluminium *^	03-P01
Boron *^	03-P01
Calcium *^	03-P01
Cobalt	03-P01
Copper	03-P01
Iron	03-P01
Magnesium *^	03-P01
Manganese	03-P01
Molybdenum	03-P01
Nitrogen *^	03-P02
Phosphorus *^	03-P01
Potassium *^	03-P01
Sodium	03-P01
Sulphur ^	03-P02
Zinc *	03-P01
Chloride	03-S04
Nitrate-N *	03-S04

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CERTIFIED

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Date Printed : 01/12/2020

21 Appendix 8 – Wind rose - Bureau of Meteorology

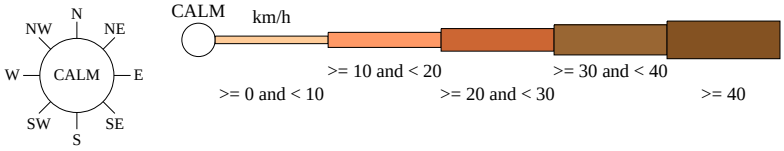
Rose of Wind direction versus Wind speed in km/h (01 Oct 1987 to 10 Aug 2021)

Custom times selected, refer to attached note for details

COOLANGATTA

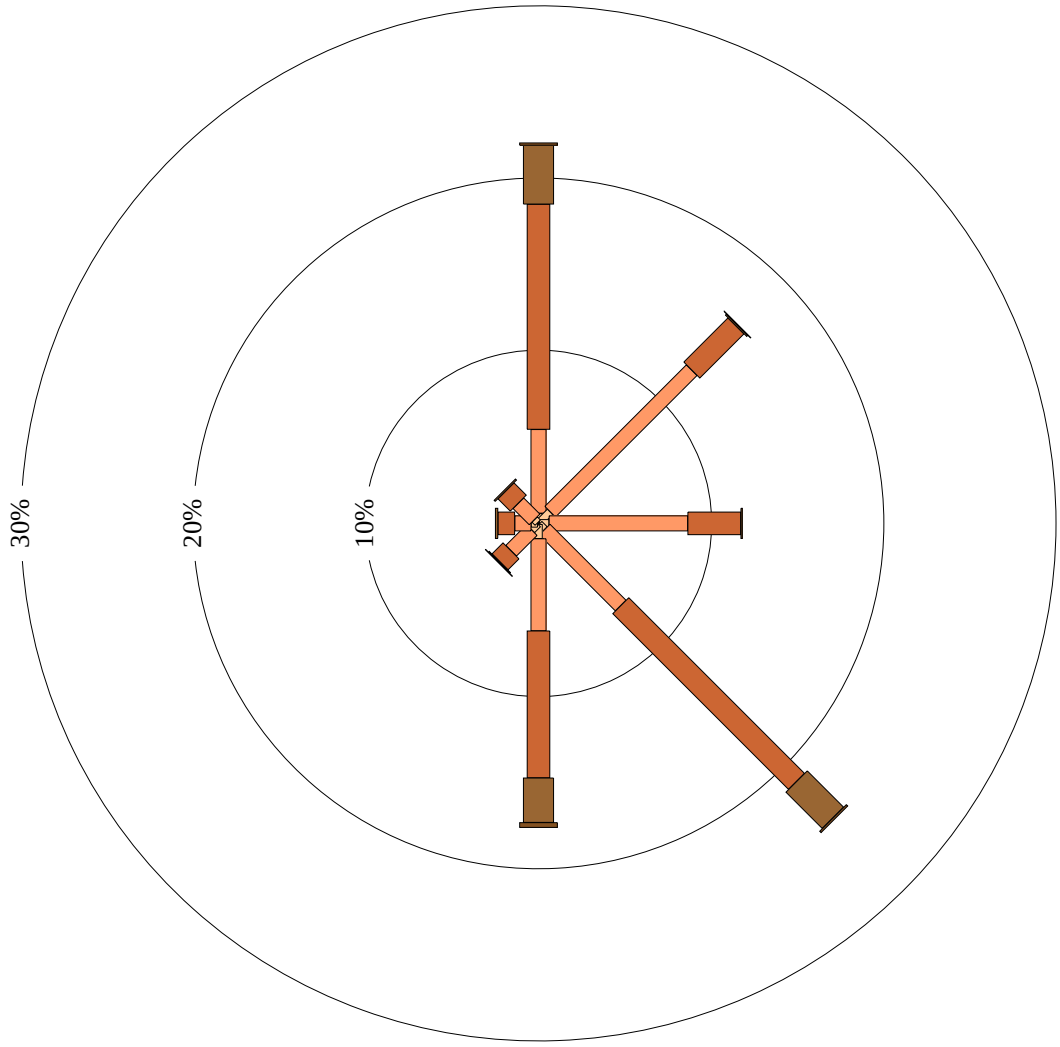
Site No: 040717 • Opened Jan 1982 • Still Open • Latitude: -28.1681° • Longitude: 153.5053° • Elevation 4m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
12153 Total Observations

Calm *



Rose of Wind direction versus Wind speed in km/h (01 Oct 1987 to 10 Aug 2021)

Custom times selected, refer to attached note for details

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Site No: 040717 • Opened Jan 1982 • Still Open • Latitude: -28.1681° • Longitude: 153.5053° • Elevation 4m

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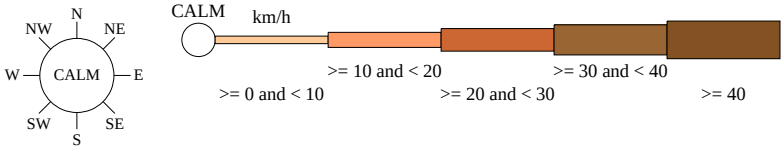
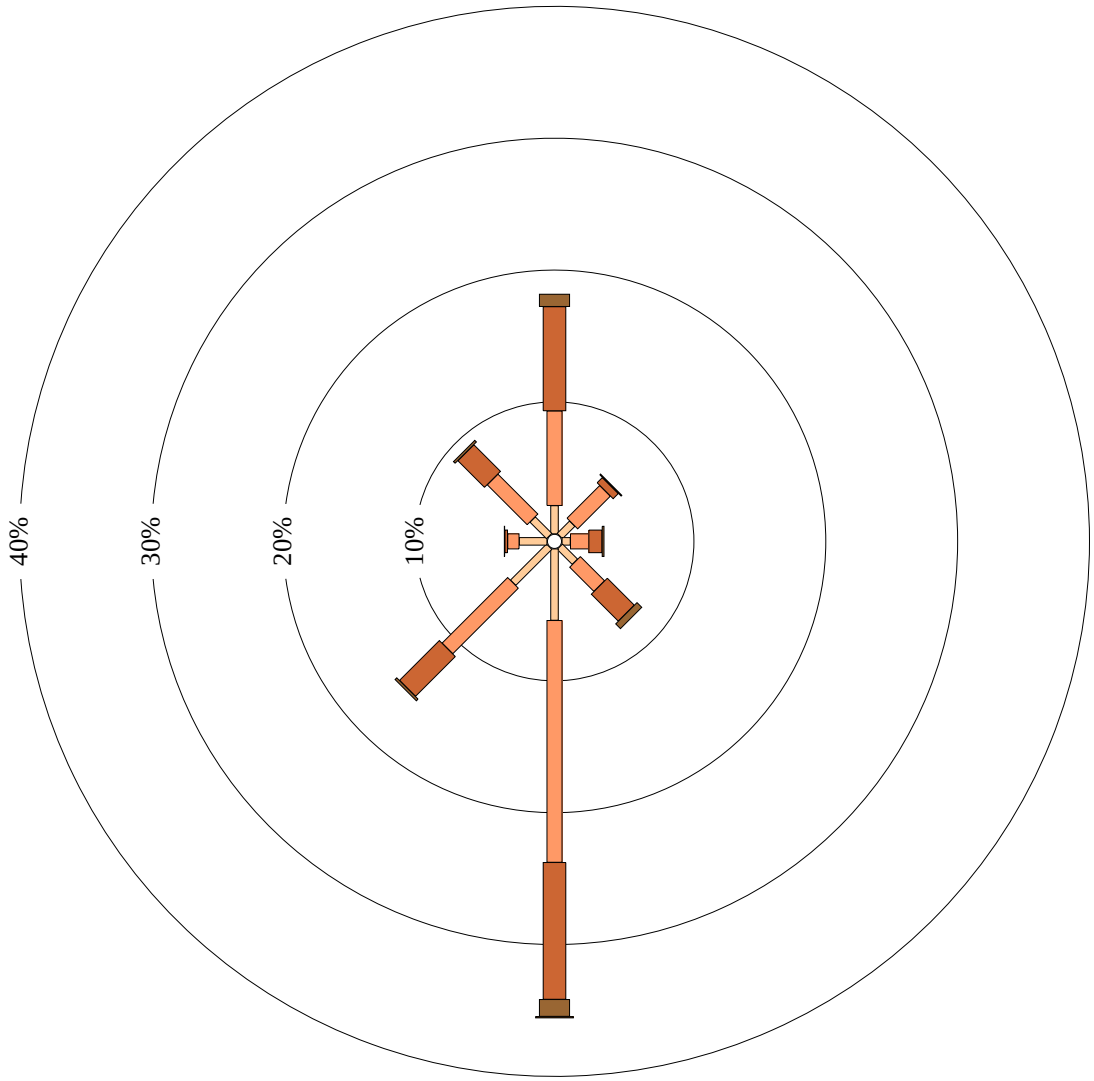
Other important info about this analysis is available in the accompanying notes.

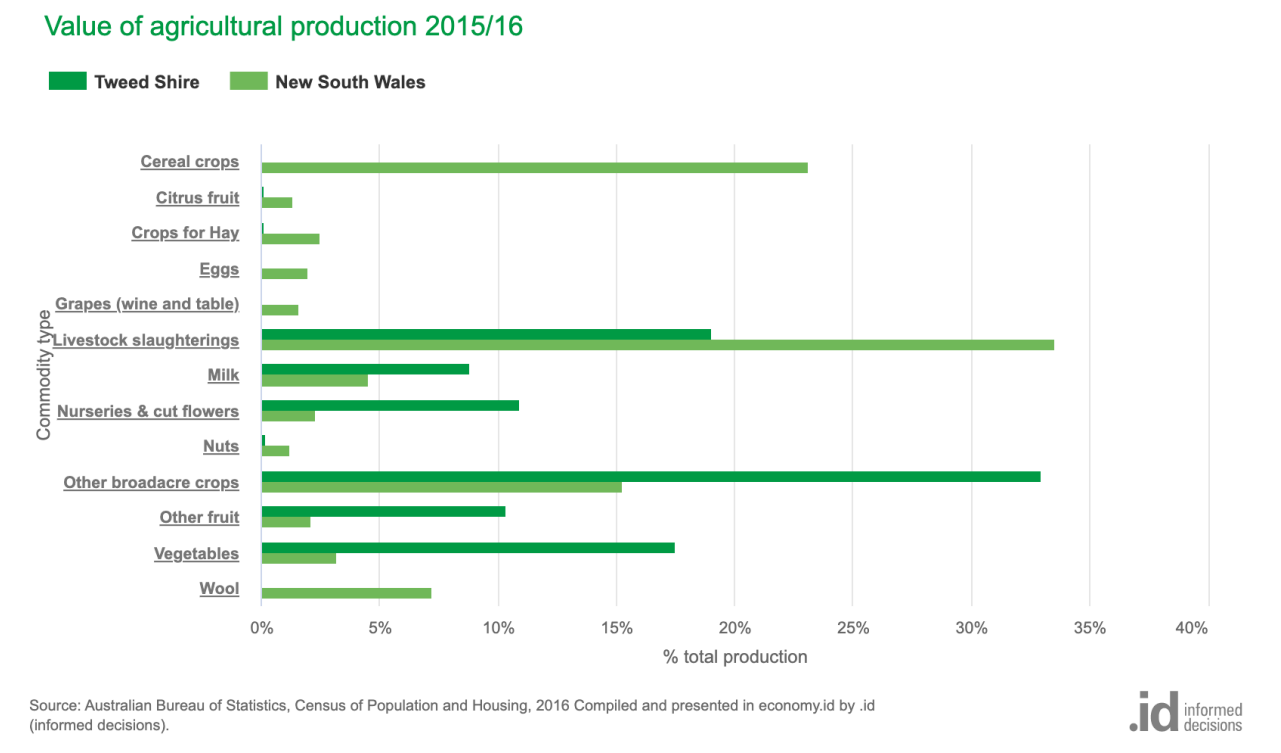


9 am
12123 Total Observations

Calm 3%



23 Appendix 9 – Australian Bureau of Statistics Agricultural Census 2015-16 statistics



Value of agricultural production Tweed Shire	2015/16			
Commodity (Click rows to view sub-categories)	$	%.	New South Wales %	Tweed Shire as a % of New South Wales
Other broadacre crops	13,469,383	33.0	15.3	0.7
Livestock slaughterings	7,769,214	19.0	33.6	0.2
Vegetables	7,138,766	17.5	3.2	1.7
Nurseries & cut flowers	4,453,632	10.9	2.3	1.5
Other fruit	4,239,393	10.4	2.1	1.5
Milk	3,591,243	8.8	4.5	0.6
Nuts	88,251	0.2	1.2	0.1
Crops for Hay	40,024	0.1	2.5	0.0
Citrus fruit	39,547	0.1	1.4	0.0
Eggs	9,334	0.0	2.0	0.0
Wool	2,446	0.0	7.2	0.0
Cereal crops	636	0.0	23.1	--
Grapes (wine and table)	382	0.0	1.6	0.0
Agriculture - Total Value	40,842,251	100.0	100.0	0.3

Source: Australian Bureau of Statistics, Value of Agricultural Commodities Produced, Australia, 2015-16. Cat. No. 7503.0Please refer to specific data notes for more information