National Water Grid Authority - National Review of Wastewater Reuse Opportunities for Agriculture

Project Findings Report

National Water Grid Authority

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→ **The Power of Commitment**

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Executive summary

Around Australia, many towns and cities reuse their wastewater (effluent) for agriculture, however there is still a large volume being sent into rivers or direct to the ocean, particularly from large coastal cities. The National Water Grid Authority (NWGA) engaged GHD Pty Ltd (GHD) to assess the potential locations and opportunities for beneficial reuse of wastewater for agricultural purposes throughout Australia.

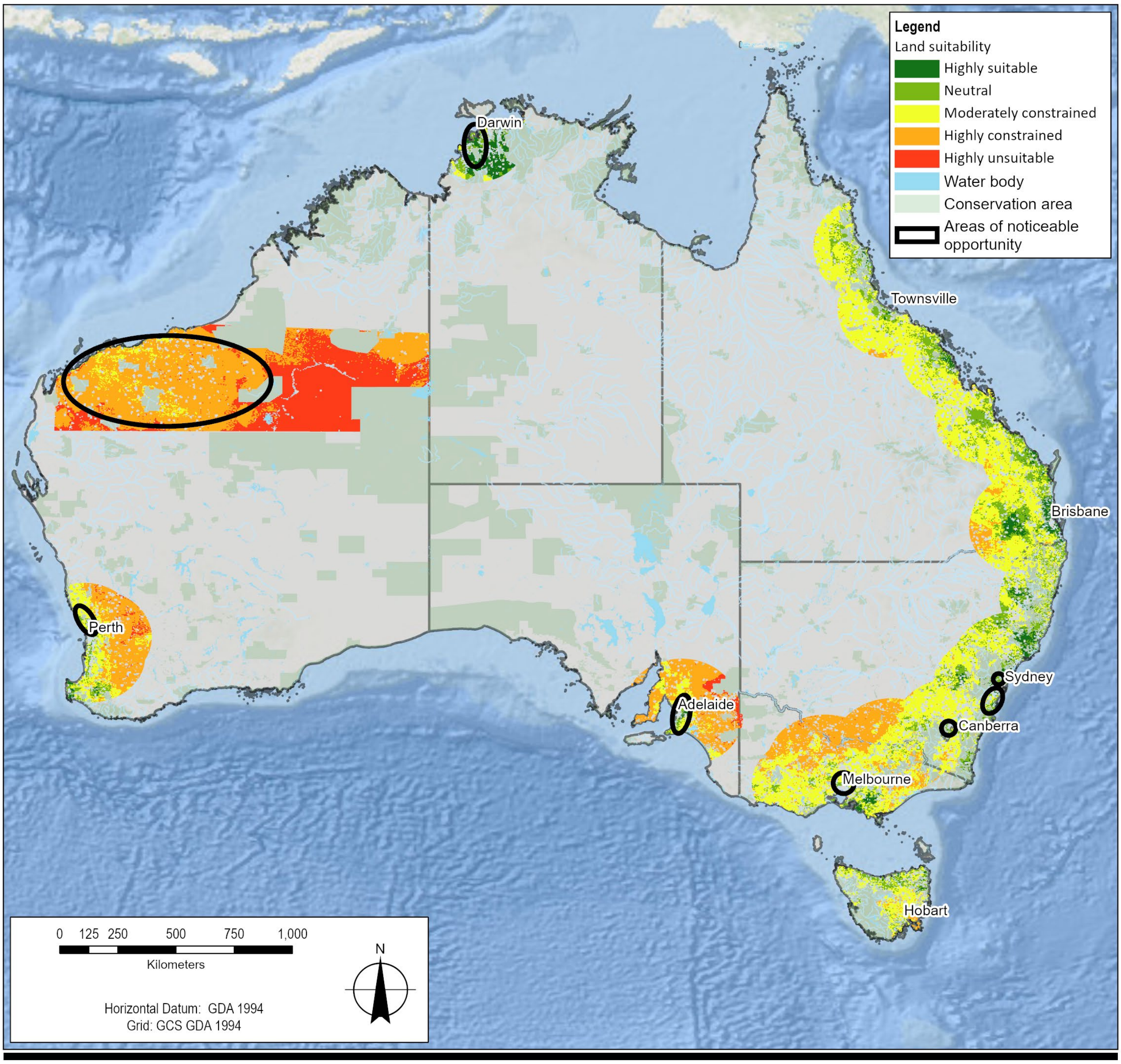
A review of existing and conceptual wastewater reuse schemes within each state and territory was undertaken to determine the common factors that contribute to a project's feasibility. It was determined that economic viability and legislative ease are the primary factors that promote the viability of such a scheme, with the lack of sufficient wastewater supply and appropriate location being the primary factors identified for wastewater reuse scheme proposals that are unsuccessful.

To identify potential site locations, a GHD-unique spatial analysis process known as Infrastructure Development Geospatial Options (InDeGO) was used to analyse the relative importance of multiple factors and how they affect the potential for wastewater reuse. Only national data layers, checked for completeness across all states and territories, were used in the spatial analysis. The result of the InDeGO process for this analysis is a national map that highlights locations throughout Australia where the feasibility for such schemes is more favourable than other areas.

Large areas of Australia were excluded from the InDeGO process because they were identified as 'unfit for agriculture'. This included, for example, areas with unfavourable land or soil qualities. Other no-go criteria included conservation or heritage areas. From this analysis, Australia is primarily 'dotted' with non-viable (or no-go) areas, with large portions of central Australia and most of Tasmania being excluded.

Factors influencing potential agricultural development from wastewater reuse were examined by the project team to ensure major site-specific factors were considered. Data from major factors was categorised from 'highly suitable' to 'highly unsuitable' by defined scoring categories relevant to each factor. More than twenty mapping data layers with national coverage were used to define these factors. Additionally, due to the scale of the investigation and that this study was aimed at large-scale agricultural development potential, only wastewater from treatment plants servicing populations of greater than 50,000, or substantial mining wastewater opportunities, were considered. From here, a distance radius of 200km was applied to represent likely cost-effective transport limits (both for wastewater supply and transfer to end markets in the supply chain). In the Pilbara region however, this proximity rule was not applied as the significantly larger mining wastewater volumes available would mean that larger transport distances may be feasible.

Application of the criteria and wastewater volume rule in the InDeGO process resulted in the map shown on Figure E.1, noting that areas range from highly suitable in dark green to highly unsuitable in red.



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Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021; World Ocean Base: Esri, GEBCO, DeLorme Created by:mfredle

Figure E.1 Areas of noticeable opportunity

The areas of noticeable opportunity are as follows (noting that existing treated wastewater schemes in Queensland and the viable locations in Tasmania use the majority of available wastewater volume), with likely maximum available areas in each general location, shown in brackets:

– Large schemes to northwest and south of the Sydney Water Corporation (SWC) area of operations (250km^2)
– North and south of Melbourne associated with proposed northern and existing eastern wastewater treatment plants (WWTPs) (140km^2)
– Expansion of an existing South Australian scheme (80km^2)
– Mining in northern Western Australia and expansion of existing treatment systems north of Perth (10,250km^2, with the vast majority in the Pilbara region)
– Use of flow from the main Canberra treatment plant and Fyshwick WWTP (50km^2)
– Southwest of Darwin from one of the main wastewater treatment plants (150km^2)

Note that the likely maximum available areas shown above will exceed the available treated wastewater volumes that are likely to be cost-effective to transfer to those areas. However, the identified areas listed above are likely to reduce further following more detailed investigations and discussions with local authorities.

A sensitivity analysis on the InDeGO process was then undertaken to test robustness of the findings and the tolerance of the overall process to small changes in the weightings applied to the various factors, including whether there were significant changes to the "highly suitable" areas that had been identified. Six different sensitivity analysis scenarios were undertaken as follows:

1. Adoption of a suite of weightings as discussed/suggested by project partners (and not averaging against the ones the GHD team members provided)
2. Applying equal weighting to all factors
3. Greater importance on sites being further away from conservation areas
4. Moving the ranking of relevant soils layers to be most important
5. Applying a lesser weighting to land use factors
6. A random set of weightings, generated using a 'random selection' function in InDeGO

Having calculated the InDeGo results for each of the above scenarios, the change in the overall favourability score (as a representative of over 410,000 grid cells across Australia) was compared against the initial analysis for greatest increase, greatest decrease and change in national average. All but one of the six alternative weighting scenarios yielded results within 2% of the current analysis, on either a national average or specific location (model grid cell) basis. This difference is considered to be within the order of accuracy of the study and the input data. Scenario 2 was the only alternative weighting scenario tested that yielded a greater difference (where the maximum difference of just over 8% in some specific locations). However, application of equal weightings for all factors is unrealistic (for example, this would consider that land slope is as important as proximity to a wastewater supply source) and was therefore discounted.

This sensitivity analysis provided greater confidence in the robustness of the process to understand the difference in results from an extreme weighting scenario.

Based on the findings listed above, it is recommended that the eight locations identified above are investigated in greater detail to explore their viability for potential reuse of treated wastewater. Further investigations should include including treatment water quality requirements (i.e. the greater wastewater processing required for the selected agricultural end use), local soil mapping analysis/testing and refinement of potentially suitable agricultural development types.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.4 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

Around Australia, many towns and cities reuse their wastewater (effluent) for agriculture. However, a lot of wastewater is still being sent into rivers or the ocean, especially from large coastal cities. Also, expansion of agriculture is often restricted by inadequate water supply. Moreover, increasing population and contested demands for water use with other economic activities present significant threats to our reliance on current agriculture practices.

Reuse of wastewater for agriculture provides a solution for sustaining and expanding agriculture productions. Only 3% of irrigation is sourced from recycled water currently, which mainly consists of small local schemes. Large scale reuse schemes, such as the Western Corridor scheme in Queensland, are significantly more efficient and financially viable and are worth exploring. This study investigates opportunities for reuse of wastewater, which would otherwise be released to the environment, for enhancing our agriculture practices.

1.1 Project background

The National Water Grid Authority (NWGA) has engaged GHD Pty Ltd (GHD) to assess viability of reuse of wastewater for agriculture throughout Australia.

1.2 Objectives

The purpose of this study is to review current wastewater schemes, and apply the findings to spatial analysis of relevant data (information) layers with corresponding relative weightings to determine wastewater reuse opportunities throughout Australia.

1.3 Assumptions

Assumptions made are shown in Section 5 of this report.

1.4 Scope and limitations

The scope of this report is to:

- Summarise principles/common aspects of viable schemes and challenges for expansion of existing schemes.
- Present an outline of the spatial assessment process for the analysis of potential opportunity, including data/information inputs and weightings.
- Present spatial analysis findings and GHD recommendations for opportunity for wastewater reuse.
- Outline differences between state and territory wastewater guidelines and the resulting impacts to potential feasibility for new wastewater reuse opportunities in each jurisdiction.

This report has been prepared by GHD for NWGA and may only be used and relied on by the NWGA for the purpose as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other NWGA arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Principles of viable schemes

An investigation of some current schemes is detailed in the report attached in Appendix A. Our comparison between existing and conceptual schemes showed that economic viability and legislative ease are the most prevalent factors that contribute to the feasibility of a wastewater reuse project.

A summary of the current schemes which were reviewed, and proposed extensions/augmentations to existing scheme(s) that are either deemed not viable or are under further investigation, are outlined in Table 2.1.

Table 2.1 Review of current schemes summary

State/Territory	Reviewed Schemes and Areas of Potential Opportunity	Scheme Status
Western Australia	The Hamersley Agricultural Scheme	Existing
	The Pilbara Hinterland Agricultural Development Initiative	Proposed
	Kimberly to Perth pipeline/canal study	Proposed
	Confidential assessments of areas south of Perth	Proposed
	Collie Water Supply Scheme	Proposed
	Assessments around Perth	Proposed
South Australia	The Bolivar Market Gardens Virginia irrigation scheme	Existing
	Other Schemes: mines and minor (<22,000 population) WWTP reuse	Existing
Northern Territory		
Queensland	Water for Lockyer study	Proposed
	Great Whitsunday Alliance	Proposed
	Bulk water security strategy	Existing
	The Nuwater project	Existing/Proposed
	The Western Corridor project	Existing
	Bradfield Scheme	Proposed
Australian Capital Territory	Northern Canberra Water Reuse Scheme	Existing (non-operational)
Victoria	Greater Melbourne	Existing
	Several smaller projects outside Greater Melbourne	Existing
New South Wales	Existing regional agricultural reuse schemes	Existing
	Hunter Water	Existing/Proposed
	Sydney Water	Existing
Tasmania	Hobart area	Existing/Proposed
	Launceston area	Existing
	Some very small schemes in regional Tasmania	Existing

2.1 Economic viability

Economic viability reflects improving economic value in use of wastewater in agriculture through cost effective designs, considering the factors outlined in the following subsections.

2.1.1 Wastewater supply/demand

Adequate and constant supply of wastewater are key to feasibility and cost effectiveness of a wastewater reuse scheme. In addition, seasonal variations in demand (i.e. winter or high rainfall periods) need to be catered for with adequate allowances for any unanticipated future variations. Availability of sufficient land that is suitable for agriculture use is also key for maximising the cost effectiveness of a wastewater reuse scheme.

Effects of climate change are also likely to affect the viability of a wastewater reuse scheme. Extreme weather events, such as increased rainfall, can reduce the demand on a wastewater scheme, while droughts can pose additional stresses on the schemes too.

2.1.2 Capital and transport costs

Capital cost of infrastructure is a critical factor when assessing the economic viability of a wastewater scheme. The cost analyses need to consider the trade-offs between capital costs and capacity when arriving at optimal solutions. In addition, transport costs between the treatment plants and agriculture land also need to be accounted for, which can be highly reliant on remoteness. For example, in the case of Western Australia outlined in Appendix A, delivery via super tankers rather than pipelines or channels was more economically viable due to remoteness.

2.1.3 Water quality and environmental impacts

Wastewater treatment costs can vary significantly based on water quality requirements (at source, as well as for end users), leading to government interventions in policy and/or funding. Offset costs associated with environmental impacts due to treatment, conveyance and/or application of wastewater also need to be accounted for in line with the relevant regulations, with special consideration for any disturbances of environmentally sensitive areas.

2.2 Legislative ease

In the absence of an overarching regulatory framework or body for recycled water usage in Australia, each state and territory adopt their respective frameworks that regulate recycled wastewater usage. Federal Government's *Australian Guidelines for Water Recycling 2006* is referred to by many states and territories as the basis or scientific guide for their respective guidelines, but only NSW and SA adopt the national guidelines as their primary wastewater reuse legislation.

The guidelines between states and territories often vary in application processes and other requirements such as documentation required for establishing wastewater reuse schemes. Some similarities can be found in areas such as water quality thresholds and subsequent uses of recycled water, with the guidelines generally appearing to be moving towards on-land disposal as the preferred option for all new plants.

Refer to Table 2.2 below for state and territory regulatory summaries, noting that the Northern Territory does not have specific legislations due to current lack of demand for these schemes.

Table 2.2 State/Territory recycled water legislation comparison

State	Government agency responsible	Regulatory requirements	New recycled water project requirements
QLD	Queensland Health	Low - regulations around chemical contents and treatment levels for various uses, but are only guides, rather than strict requirements. Only requirement is that recycled water does not present a "public health risk".	Applications to Department of Natural Resources, Mines and Energy who assess in conjunction with Queensland Health.
NSW	NSW Health	High - all water authorities require adherence to the Australian Guidelines for Water Recycling 2009.	Any new water supply and water recycling schemes must obtain ministerial approval. The NSW Department of Planning and Environment will also play a role in assessing the appropriateness of the proposal.
VIC	Environment Protection Authority (EPA)	High - EPA has a set of guidelines that must be complied with by the various water authorities.	Application to EPA which is assessed using its technical, environmental and governance framework.
SA	SA Department of Health	Low - uses the Australian Guidelines for Water Recycling (AGWR) 2009 for scientific guidance. Limited SA specific guidelines are given.	SA Department of Health and EPA jointly consider applications using the AGWR as an assessment framework.
WA	WA Health	High - WA has developed a set of guidelines around composition, usage and treatment. Requirements around monitoring of infrastructure and water quality also mandated.	All new schemes must be approved by the states' Chief Health Officer.
TAS	TasWater	High - EPA has a set of guidelines that must be complied with by the various water authorities.	EPA is responsible for assessing new schemes.

Further state and territory specific legislative requirements are discussed in Appendix A and Appendix B.

3. Challenges for expansion

Challenges faced during expansion of existing wastewater reuse schemes were determined, based on overview of the existing and unsuccessful wastewater scheme proposals in the *Investigation of Current Schemes* report. They were found to be in alignment with principles/common themes of viability listed in Section 2 of this report. A summary of the challenges for expansion are as follows:

– Lack of wastewater supply to cater for natural seasonal demand variances, in particular, during droughts when demand increases.
– Low reliance on wastewater due to competition from lower cost options (e.g. local bore water or rainwater storage in dams during consistent rainfall periods).
– High infrastructure and transport costs associated with expansion, in particular, for advanced treatment for higher-end agricultural use.
– Lack of suitability, proximity to wastewater treatment locations and favourable land characteristics.
– Topographic/landform constraints requiring pumping to agricultural land (over high elevation areas along pipelines) and therefore consuming large amounts of pumping energy and costs.

4. Water quality requirements

Water quality requirements associated with use of effluent (treated municipal wastewater) for agriculture depend on a number of factors. These include agriculture use (cropping, grazing etc), risks of people being exposed to wastewater (and potential associated health impacts), impacts on soils and any legal requirements of the states or territories where the schemes will be built.

The report enclosed in Appendix B investigates these requirements further, based on which the following observations are made:

– Water classification and treatment requirements differ greatly between each state and territory, as do terminologies. The only uniform quality measure between states and territories is the measure of E. coli, which differs depending on the reuse applications. For comparison of reuse applications, see Table 4.1 for proposed water classifications defined by E. coli.
– Uses permitted for different water classifications differ greatly between each state and territory, refer to Table 4.2 below for details.
– Many states and territories defer to the national guidelines for hazard impact assessment and soil and nutrient loading guidelines, while most states and territories have agricultural guidelines.
– Most states and territories have specific guidelines for human exposure controls and site selection, noting that they differ in stringency but are similar in intent.
– Based on our review of the approvals process in each state and territory (and the collective experience of GHD process engineers who have gone through these processes), Queensland and South Australia are viewed as lower strictness of the approvals process, with all other states and territories considered to be significantly higher. Refer to Table 4.2 for regulatory strictness comparison.

Table 4.1 Proposed water classifications for reuse comparison

New Classification	A+	A	B	C	D	E	F	G	Z
E. coli (cfu/100ml)	0	<1	<10	<100	<1,000	<10,000	<100,000	No Requirements	Other Requirements

Table 4.2 Uses comparison by state/territory

Class	NSW	VI	WA	QLD	ACT	TAS	SA	NT
A+								Irrigation, fodder and pasture, dust suppression, indirect/processed crops
A			Raw crops, urban unrestricted access, urban use					
B	Municipal (non-restricted access), direct crops		Urban irrigation (restricted access), firefighting, ornamental water features, industrial with potential human exposure, dust suppression		Irrigation (uncontrolled access), dairy pasture and fodder, non-potable urban use, aquaculture (human food chain)	Indirect potable source recharge, non-potable urban use, direct human contact crop irrigation, aquaculture		
C	Livestock drinking water (dairy without withholding period)	Dairy pasture and fodder, industrial processes	Nonedible crops, irrigation with enhanced restricted access, subsurface irrigation			Non-potable irrigation with restricted access, pasture and fodder (without withholding period)		
D	Municipal (restricted access), indirect/processed crops, pasture and fodder (with withholding period)	Non-potable urban use, indirect/processed crops, grazing/fodder, industrial processes (no potential human exposure)			Irrigation (restricted access), pasture and fodder, horticulture, indirect/processed crops	Indirect/processed crops, pasture and fodder (with withholding period),		
E	Non-food crops				Ornamental waterbodies (restricted access), aquaculture (non-human food chain)	Non-human food chain crops and aquaculture, industrial processes		
F								
G			Woodlots, subsurface irrigation					
Z		Public irrigation, raw crops, firefighting, urban gardening						

5. Spatial assessment process

5.1 Outline of InDeGO process

GHD used a method known as Infrastructure Development Geospatial Options (InDeGO), which combines multi-criteria analysis (MCA) with geographical information system (GIS) technology. InDeGO was used to conduct a quantitative assessment and evaluation of complex physical, infrastructure, social and environmental issues that are associated with determining appropriate locations for infrastructure development.

The InDeGO methodology includes the following fundamental advantages of MCA:

- Involves an integrated and systematic, multidisciplinary approach
- Applies a rational method of decision analysis
- Provides a robust, transparent and repeatable quantitative assessment
- Permits the development of alternative scenarios (or geographically defined alternatives)
- Time and cost effective
- Flexible enough to allow regional and site-specific analysis

An InDeGO assessment of a region of interest (or area) produces a map highlighting the area suitability, based on constraints and opportunities in relation to the criteria selected for the study. Options that are most suitable against the selection criteria can then be considered in more detail through the integration of additional spatial data/information relating to those locations.

The steps involved in the InDeGO process and shown in the figure below.

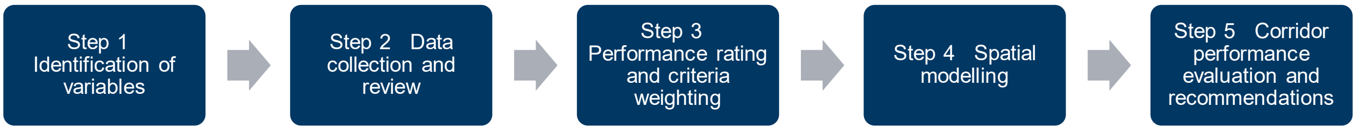


Figure 5.1 InDeGO process flowchart

Step 1 – Identification of variables

- Likely built environment constraints (e.g. mineral resources or existing infrastructure)
- Natural environment constraints (e.g. vegetation, slope and drainage)
- Social issue constraints (e.g. native title, land use and visual sensitivity)
- Siting opportunities
- Issue/aspect driven
- Not data/information driven at this stage

Step 2 – Data/information collation and review

Care is required at this stage to obtain representative coverage. The criteria for inclusion of information layers includes:

- Representation of the primary assessment criteria, in terms of both constraints and opportunities
- Balanced representation across primary aspects
- A consistent level of geographic coverage across the study extent
- Accuracy and currency

Step 3 – Performance rating and criteria weighting

Criteria rating/scoring as seen in Table 5.3 is driven by:

- Legislative requirements
- Environmental values and sensitivities, and the need to protect ecosystems and species
- Socio-economic values and sensitivities
- Engineering performance and associated cost

Review ratings/scorings and apply weights through pair-wise comparison:

- Every input must be weighted before further analysis
- Weights have to be out of 100, spread across all inputs (i.e. % influence) and are representative of the relative influence of the particular criteria
- These weights are driven by project objectives and agreed upon during a collaborative workshop or detailed individual survey

Step 4 – Spatial modelling

After the MCA process review and initial results workshop, GHD:

- Conducted an internal workshop to evaluate engineering aspects
- Integrated scored and weighted constraints (and opportunities) using GIS methods to develop an overall suitability model
- Performed an analysis of transfer pipeline distance options to identify corridors that most efficiently and effectively connect a source point (wastewater plant) to end user (agricultural opportunity site) through the model
- Provided visual outputs to illustrate the results

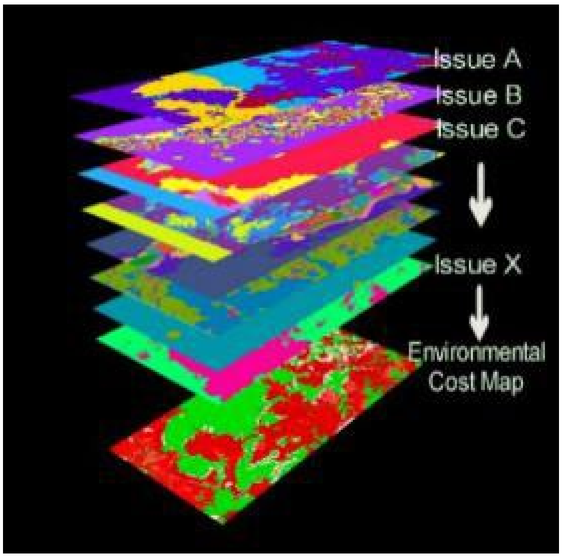


Figure 5.2 InDeGO modelling information layering process

Step 5 – Performance Evaluation and Recommendations

After spatial modelling, GHD:

- Performed analysis of opportunity options against the study performance criteria
- Provided visual outputs to illustrate the results
- Delivered a report providing a detailed overview of the methodology, results and recommendations (this report)

5.2 Information used

The information used was limited to Federal Government information layers only. This is sufficient for a high-level options assessment, but a detailed options assessment (for areas with potential) would require large-scale, detailed information layers that are available through state or local government organizations or other studies.

The information layers used in the study can be found in Table 5.1, categorised into land suitability (LS), supply suitability (SA) and supply chain measure (SCM).

The broad experiences of the combined (GHD and NWGA) project team was key for an accurate investigation. These included technical knowledge on wastewater treatment and reuse, managing agriculture practices and planning land use, as well as hands-on experience in monitoring the moisture in the soil, managing wastewater and planning harvests.

Table 5.1 Spatial layers

Criteria	Category	Description	Data source	Data currency (year)
Conservation	LS	Proximity to current conservation sites as to preserve environmental areas from schemes construction and agricultural activity.	Department of Agriculture, Water and the Environment	2020
Non-aboriginal heritage	LS	Proximity to existing or potential non-aboriginal (non-first nations people) heritage area as to reduce impact and protect sites from schemes construction and agricultural activity.	Department of Agriculture, Water and the Environment	2020
Mine plan/operation	LS	Measure of proximity to current or future mining locations for potential sources of wastewater.	Bioregional Assessment Program	2019
Slope %	LS	The average slope of areas with a 300 m radius to estimate difficulties for agricultural feasibility.	Geoscience Australia	2019
Proximity to existing and surplus mining	SA	Measure of proximity to existing potential sources of wastewater for reduced transport distances thereby increasing scheme cost effectiveness.	Geoscience Australia	2021
Land use	LS	Differentiation and ranking of current land use designations for suitability for agricultural use.	Department of Agriculture, Water and the Environment	2020
Precipitation	LS	The annual rainfall for an area used to identify regions of increase rainfall where wastewater will be least beneficial due to abundance of ground and surface water.	Bureau of Meteorology	2010
Water quality	SA	Measure of the treatment quality of source wastewater to contribute to determining plant viability for opportune areas and cost estimations for further water treatment.	Geoscience Australia	2012
Wastewater produced - 2021	SA	A GHD study to determine the wastewater produced by each LGA Australia wide. Used to determine wastewater source availability to determine scale of agricultural opportunity within transportation range.	GHD	2021
Heat stress	LS	The effects of excessive temperatures on the productivity of plants causing wilting, plant water loss and reduction or stopping fruit production.	Bureau of Meteorology	2019
Frost	LS	Measure of the effects cold damage from temperature or hoarfrost have on agricultural potential such as crop yield.	Bureau of Meteorology	2005
Moisture availability (0-1m depth)	LS	The minimum potential percentage of moisture availability within irrigated crop soils to a depth of 1 m. Used as a representation of the soils inability to retain moisture resulting in larger water requirements and potential impacting crop yield for shallow root plants.	CSIRO	2014
Moisture availability, (1-1.5 m depth)	LS	The minimum potential percentage of moisture availability within irrigated crop soils at depths 1-1.5 m. Used as a representation of the soils inability to retain moisture resulting in larger water requirements and potential impacting crop yield for deep root plants such as woodlots and trees.	CSIRO	2014

Criteria	Category	Description	Data source	Data currency (year)
Nutrient balance (soil pH)	LS	The soil pH measured to a depth of 0.3 m and calculated from the presence of calcium chloride extract. This will help identify areas with larger ranges of viable agricultural species.	CSIRO	2013
Soil depth	LS	A measure of available soil for use of agriculture. This will help define viable crop species as increased depths widen ranges of viable species. Additionally increased depths can provide more nutrition and water to plants and to increase yield and economic value.	CSIRO	2013
Evapotranspiration	LS	Sum of evaporation from the land surface plus transpiration from plants (7-day ET). Increased evapotranspiration will reduce available water in topsoil potentially leading to soil surface hardening, increased irrigation runoff and increase difficulty of agricultural processes.	Bureau of Meteorology	1990
Airport proximate	LS	The proximity to airports due to imposed buffer regions to constrain the presence of birds and provide safer flying condition.	Geoscience Australia	2012
Acid sulfates	LS	The likelihood of acid sulphate presence in soil. Increased concentrations result in generation of sulfuric acid become poisonous to plants, preventing growth or killing the plant.	CSIRO	2011
Radioactivity	LS	Land identified as having existed or potential radioactivity due to the danger of contamination from radiation and introduction to the human food chain.	Bioregional Assessment Program	2019
Water demand	SCM	Annual water market demand by current agriculture type 2005–06 to 2018–19.	Australian Bureau of Statistics	2019

5.2.1 Information unused

A number of information layers were not included in the analysis, as they were found to overlap. In these cases, the layers were assessed by inspection and the information layers with the largest area was used. It was considered appropriate to remove these overlapping datasets from the model to avoid double counting and improve accuracy of the assessment.

Not all available information was suitable for a successful assessment. Two information layers were considered in step 1 of the InDeGO process, but were removed in step 2 for the reasons described below.

Soil Type: This input of the LS category was initially included to account for the soil properties such as air, water and mineral contents supporting the plant growth. However, this information layer was later removed to avoid any bias, as it was similar to other information layers that also included such as soil properties.

Soil Sodicity: Sodicity is the measure of sodium ions in soil, which is unsuitable for plant growth in high concentrations. Sodicity was inconsistent with other information layers, and also, the national and state/territory information layers were inconsistent. This information layer was therefore removed to avoid inaccuracies. It will be included when assessing potentially viable locations at later project investigation stages. A brief discussion on soil sodicity based on publicly available state-based mapping is included in Appendix E.

5.3 Non-suitable areas (no-go)

Any areas which were unsuitable for agriculture, too costly, too difficult to access or dangerous were classified as non-suitable. Refer to table below for this list.

Figure 5.3 shows a map of the no-go areas across Australia from the InDeGO process, based on the factors corresponding to no-go conditions outlined in Figure 5.3.

Table 5.2 Non-suitable criteria and conditions

Criteria	No go condition	Notes	Examples
Conservation areas	All conservation sites	Land designated as conservation are unable to be used for agriculture	National parks, state forests, Darwin Harbour (NT), Great barrier reef (QLD), Victoria Falls (VIC)
Non-Aboriginal heritage	All listed non-indigenous sites	Land designated as non-aboriginal heritage are unable to be used for agriculture	Harbour Bridge (NSW), Queen Victoria Markets (VIC), Snowy Mt Scheme (NSW)
Slope	>25%	Locations of increased slopes effect construction and result in agricultural difficulties such as high runoffs and minimal infiltration	Snowy Mountains, Victorian Alps, Great Dividing Range
Land use type	Nature conservation, water	Land designated as nature conservation sites and waterbodies are unusable for agriculture	Lake Eyre (SA), Great Barrier Reef (QLD)
Moisture availability, irrigated crops (0-1 soil depth)	<3% moisture	Minimal soil ability to retain water increases difficulty of agriculture viability	Sandy soils (coasts of south-West Australia and southern Queensland)
Moisture availability, irrigated crops (1-1.5 m soil depth)	<3% moisture	Minimal soil ability to retain water increases difficulty of agriculture viability	Sandy soils (coastal plains, South-West Australian and Southern Queensland coasts)
Airport proximity	<3 km from airport	Airport ban on new agricultural developments within 3 km to minimise the presence of birds and promote clearer skies	Sydney Airport (Mascot-NSW), Darwin Airport (Easton-NT)
Acid sulfate in soils	High probability of occurrence	Presence of acid sulphate causes decline in water and soil quality	Mangrove and saltmarsh areas
Radioactivity	Any area with radioactivity	Land identified as radioactive from current or previous uses of radiation	Radioactive waste disposal sites, land used for radiation testing and experimentation

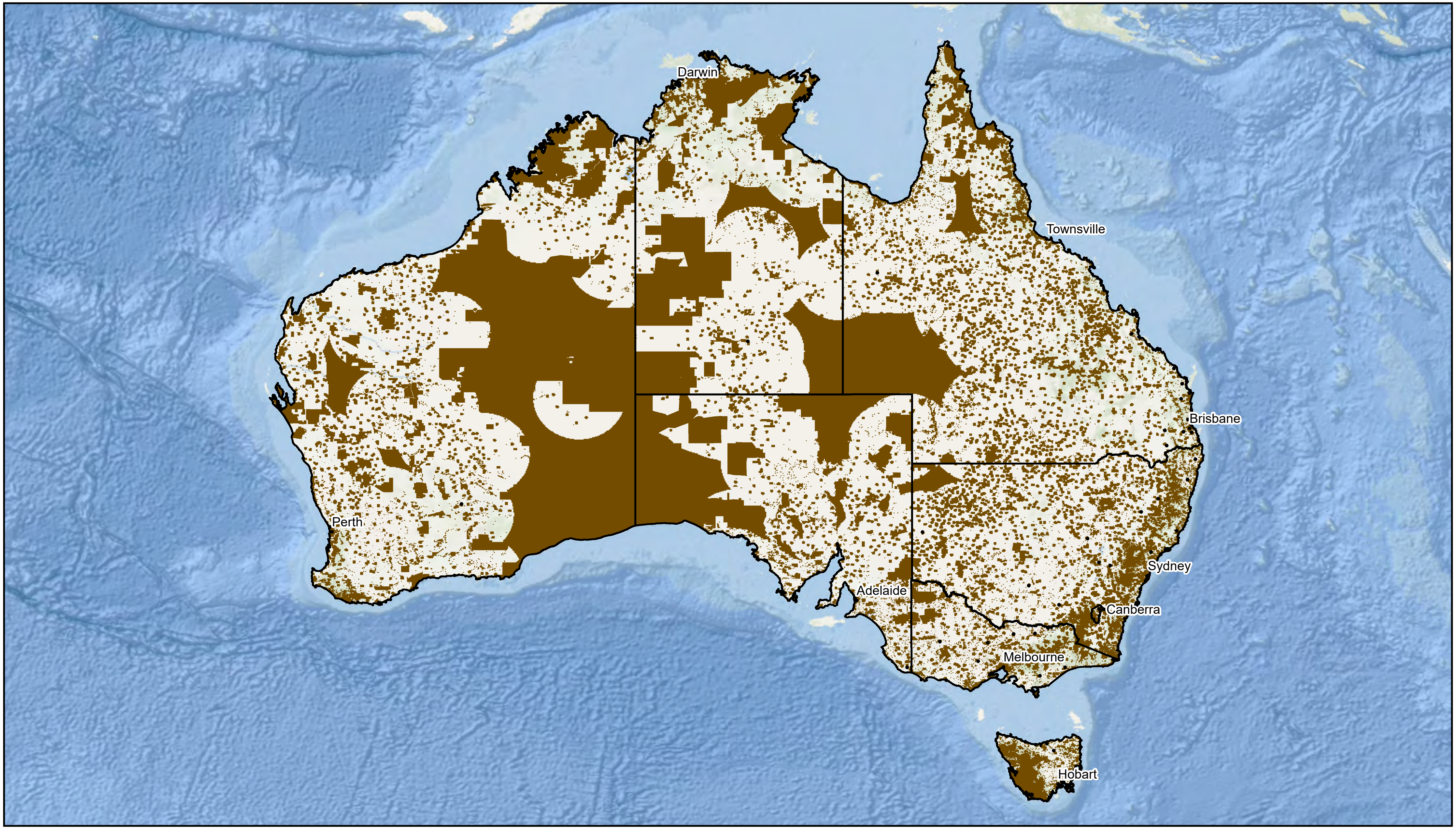
5.4 Suitability categories for each information layer

The scorings and weightings assigned to the assessment inputs show the preferences of the project team during the MCA process. They have a direct and significant influence on the outcomes of the assessment.

The criteria scoring and corresponding performances for the InDeGO assessment are outlined in Table 5.3 below.

Table 5.3 Criteria scoring

Performance	Highly suitable	Neutral	Moderately constrained	Highly constrained	Highly unsuitable	No Go
Score	1	10	20	40	100	9999



Legend

No-go sites

Paper Size ISO A4

0 250 500 750 1,000

Kilometres

Horizontal Datum: WGS 1984
Grid: GCS WGS 1984

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GHD

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Non-Viable Areas for InDeGO Process

Project No. **12556736**
Revision No. **1**
Date **21-Jun-22**

FIGURE 5.3

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Print date: 22 Jun 2022 - 17:06

Data source: Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021; World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue. Created by: mfredle

An initial set of suitability criteria was developed by the GHD team to meet the requirements of the study. These criteria were reviewed in a stakeholder meeting where the scorings and weightings were assigned. The criteria and corresponding performance constraints are outlined in Table 5.1, considering all criteria outlined in Table 5.1, and defined in line with the performance categories provided in Table 2.2.

Table 5.4 Suitability criteria

Criteria	Highly Suitable	Neutral	Moderately constrained	Highly constrained	Highly unsuitable
Mine plan/operation		<20 km	20-30 km	40-60 km	>60 km
Slope %	0-2%	2-5%	5-10%	10-15%	15-25%
Land use	Dryland cropping; Dryland horticulture; Land in transition; Irrigated pastures; Irrigated cropping	Other minimal use; Grazing modified pastures; Mining and waste; Irrigated horticulture; Intensive horticulture and animal production; Rural residential and farm infrastructure		Grazing native vegetation; Plantation forests	Managed resource protection; Production native forests; Urban intensive uses
Precipitation	600-800 mm	800-100 mm	>1000 mm		
Water quality	Mine surplus water, tertiary treated		Secondary treated		Primary treated
Wastewater produced - 2021	>30 GL	20-30 GL	10-20 GL	5-10 GL	<5 GL
Heat stress	Low heat stress (<5 40+°C days)	Moderate heat stress (5-20 40+°C days)	Severe heat stress (>20 40+°C days)		
Frost	No Frost	Occasional frost (<2 days)	Regular light frosts (≥2 days)		
Moisture availability (0-1 m depth)	>25%	20-25%	15-20%	10-15%	3-10%
Moisture availability (1-1.5 m depth)	>25%	20-25%	15-20%	10-15%	3-10%
Nutrient balance (soil pH)	4.8-6.9	7.0	4-4.8; 7.1-7.5	>7.5; <4	
Soil depth	Very deep (>1.5m)	Deep (1.0 - 1.5m)	Moderate (0.5 - 1.0 m)	Shallow (0.25 - 0.5 m)	Very shallow (<0.25 m)
Evapotranspiration	1300 mm	900-1300 mm	600-900 mm	300-600 mm	<300 mm
Airport proximity	>13 km				3-13 km
Acid sulfates	Extremely low probability of occurrence		Low probability of occurrence		
Water demand	>30,000 GL/yr	20-30,000 GL/yr	10-20,000 GL/yr	5-10,000 GL/yr	<5,000 GL/yr

5.5 Wastewater proximity

For urbanised areas, only the wastewater sources with a population of 50,000 or greater were considered, with a buffer of 200 km surrounding the location only included. These thresholds were used as indicative economic viability values for this high-level study (based on GHD experience from assessing viable schemes in the past), given that economic viability is complex and needs to be considered further for any sites identified from this study.

Even though the Pilbara region has a population less than 50,000, it was considered with a buffer of approximately 500 km, due to the significantly larger supply volumes available here (thus making longer supply pipeline systems potentially more economically viable).

5.6 Pairwise weighting

Pairwise comparisons are used to compare two objects or categories to determine which is preferred. Pairwise comparisons between each pair of criteria are used to decide the order of importance from the most valued/preferred to the least. During GIS modelling, the scorings of the criteria were adjusted by their relative importance. This method was used across all information when deciding the suitability of an area.

Local and national experiences of the GHD team in a range of infrastructure projects, agricultural economics, wastewater systems and reuse schemes were essential for this study. Additionally, staff from NWGA were invited to complete the pairwise comparison.

Wastewater infrastructure and environmental factors were key when deciding the suitability of locations. Social criteria were also considered but financial factors were not considered. Ease of access to wastewater sources, together with appropriate maximum distances were considered as described in Section 5.5, as an initial assessment on likely economic viability instead.

See Figure 5.4 for an example of the pairwise comparison process.

The order of importance based on pairwise comparison of the information layers is outlined in Table 5.5.

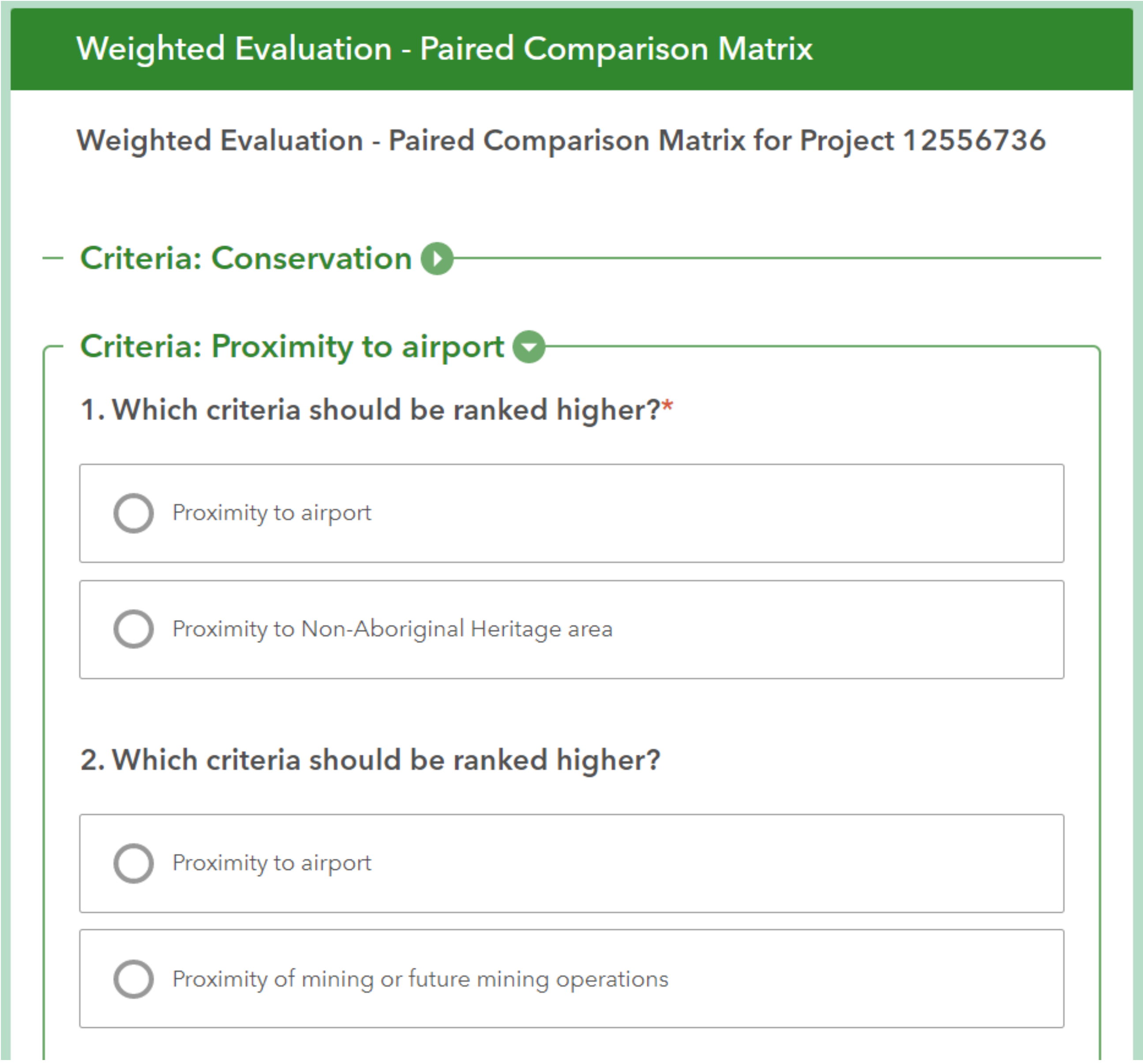


Figure 5.4 Pairwise comparison survey screenshot

Table 5.5 Pairwise weighting

Criteria	Raw score	Weight (%)	Rank
Conservation	5	2	18
Non-aboriginal heritage	1	1	20
Mine plan/operation	6	3	16
Slope %	9.5	5	12
Proximity to existing WWTP and surplus mining	15	7	4
Land use	17	8	1
Precipitation	10.5	5	10
Water quality	12.5	6	9
Wastewater produces - 2021	16	8	2
Heat stress	10	5	11
Frost	6.5	3	15
Moisture availability, irrigated crops (0-1 soil depth)	15	7	4
Moisture availability, irrigated crops (1.5 m soil depth)**	15	7	4
Nutrient balance (soil pH)	8	4	14
Soil depth	13	6	8
Evapotranspiration	14.5	7	7
Airport proximity	3.5	2	19
Acid sulfates	6	3	16
Radioactivity	9	4	13
Water demand	16	8	2
Sum	209	100%	

**Note – This layer was removed after the pairwise process, as it was overestimating results toward moisture availability and that it generally only covers deep soil crops such as wood lotting.

5.7 MCA limitations

MCA is a powerful tool for assessing study areas, however, there are some limitations to this approach, including:

– Not considering all factors that determine the suitability of a water reuse scheme in different areas
– Lack of information at a suitable size showing the needs of specific sites
– Inaccuracies of the information

The study was based on a high-level assessment, and further detailed analysis will be required to understand any specific details. The MCA could be improved by including more specific information of the areas if available. In addition, field investigations can be used to verify and validate the MCA outcomes.

6. Assessment results

Our assessment included all wastewater treatment plants from the national database, and considered only the larger schemes with a minimum connected population of 50,000. A draft assessment without this threshold is shown in Appendix F for comparison.

The outcomes of the assessment for each state and territory are shown below.

6.1 Queensland

The results for Queensland and the surrounding areas of NSW and NT are shown on Figure 6.1. The suitable areas of QLD were limited to the east coast (identified as moderately constrained). The other areas of Queensland that were more than 230 km from the coastline were identified as unsuitable.

6.1.1 Suitable areas identified

No highly suitable areas were identified within QLD. The areas with most opportunities for schemes included the greater Brisbane area and Townsville.

6.1.2 Greater Brisbane

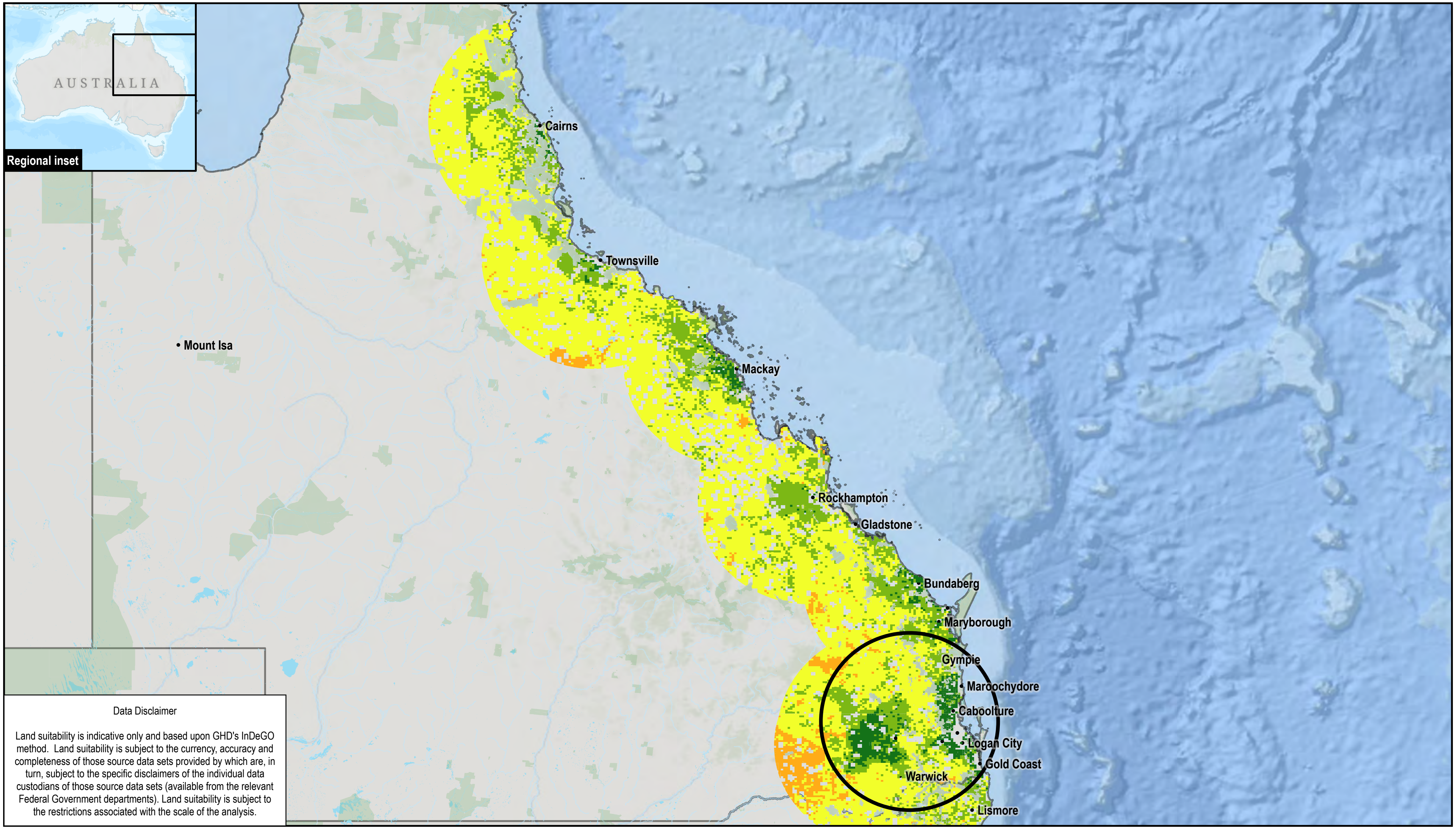
The greater Brisbane area covers QLD-NSW border to the south, Toowoomba to the west and Maroochydore to the north, with a scattering of neutral areas. The greater Brisbane area is already a part of the Western Corridor Recycled Water Scheme (WCRWS) which is facing issues related to reliable supply.

6.1.3 Townsville

The Townsville area consisted of some neutral land, due to its proximity to the Townsville WWTP and land suitability. The Cleveland Bay Recycled Water Treatment Facility in Townsville, once upgraded in 2023, will provide recycled water, and it is therefore unlikely to require additional wastewater recycling schemes in this area.

6.1.4 Conclusions

QLD had no highly suitable areas but consisted of some neutral areas in greater Brisbane and near Townsville. Any improvements to the WCRWS are likely to be aimed at improving the supply issues of this scheme instead of for agriculture use. The neutral areas (and perhaps some of the moderately constrained areas) of Townsville could be considered for future wastewater reuse schemes following economic assessments but are a lower priority due to smaller overall size.



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 74 148 222 296

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

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Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - QLD

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Revision No.	1
Date	20-Jun-22

FIGURE 6.1

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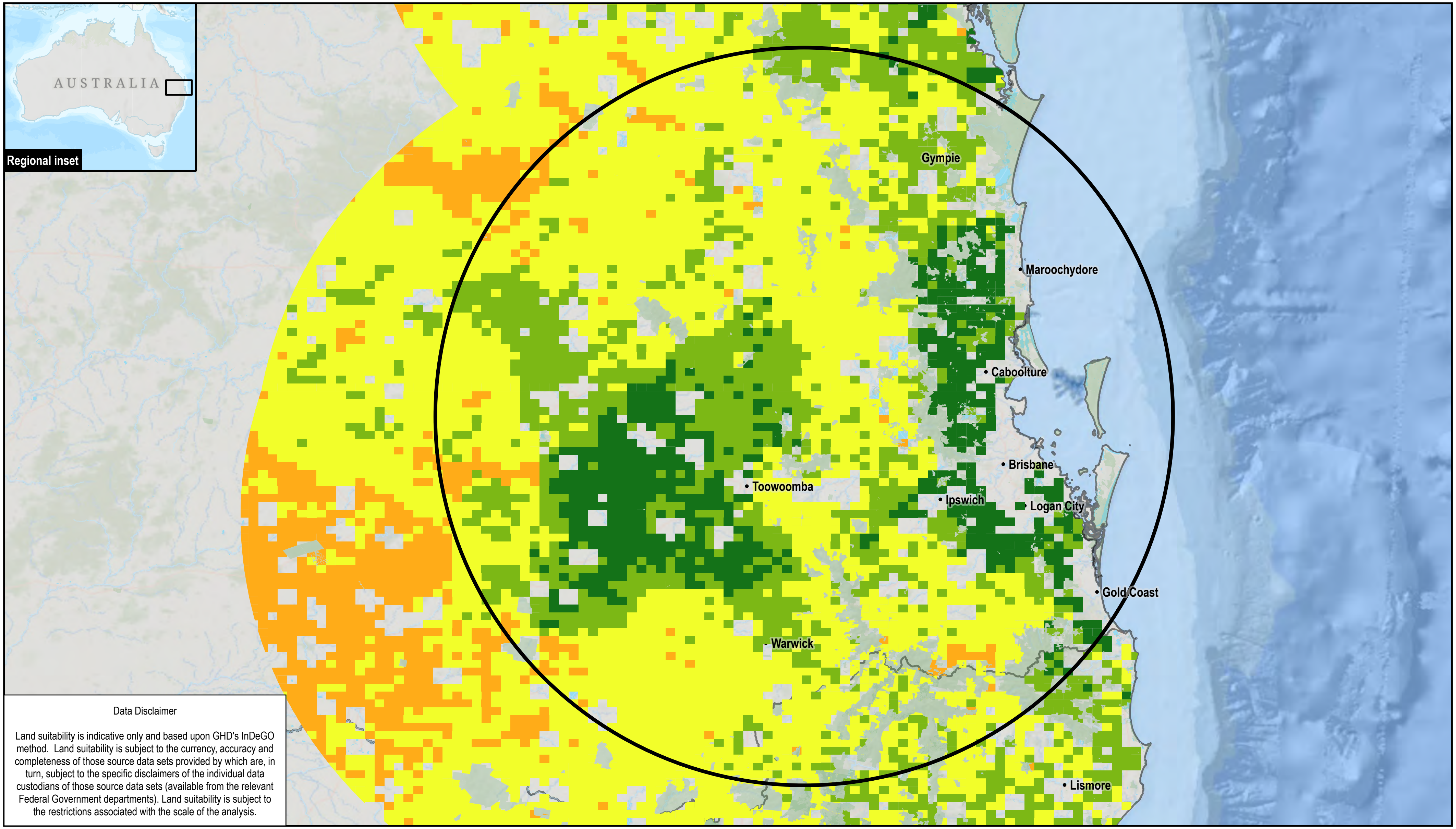
Print date: 20 Jun 2022 - 13:59

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



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Legend

Land suitability
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- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 18 36 54 72

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

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National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Greater Brisbane, QLD

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.2

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Print date: 20 Jun 2022 - 14:01

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.2 New South Wales

The results for New South Wales and the surrounding areas of VIC and the ACT are shown on Figure 6.3. Similar to QLD, the suitable areas of NSW were limited to the east coast.

6.2.1 Suitable areas identified

No highly suitable areas were identified within NSW. The areas of most opportunities (neutral suitability) included northwest of Sydney (Figure 6.4), north of Newcastle, the Hunter Region (Figure 6.5) and Wollongong (Figure 6.6).

6.2.2 Northwest of Sydney

There are many medium-sized WWTPs in the west and southwest of Sydney that are tertiary treated and discharged into waterways (except oceans). Sydney Water plants currently discharge over 6.3 GL/day (Sydney Water Website, 2022) and only 3% is reused. This water could be used for agriculture in the northwest of Sydney, although current agriculture land is largely being transformed into residential/commercial/industrial use, making it likely unviable.

6.2.3 North of Newcastle

The areas to the north of Newcastle, up to the extent of Taree, consisted of neutral land 'dotted' with moderately constrained and some highly constrained land. Most existing agriculture lands have river extraction irrigation licences, although any new agriculture developments could be restricted to wastewater reuse supplemented by rainwater storage tanks or river extraction.

6.2.4 Hunter Region

The agriculture land surrounding Cessnock is already using private wastewater reuse schemes and river water irrigation schemes. Although there were plans to convert more land to agriculture use once the power plants around Singleton were closed down, this may require significant land remediation.

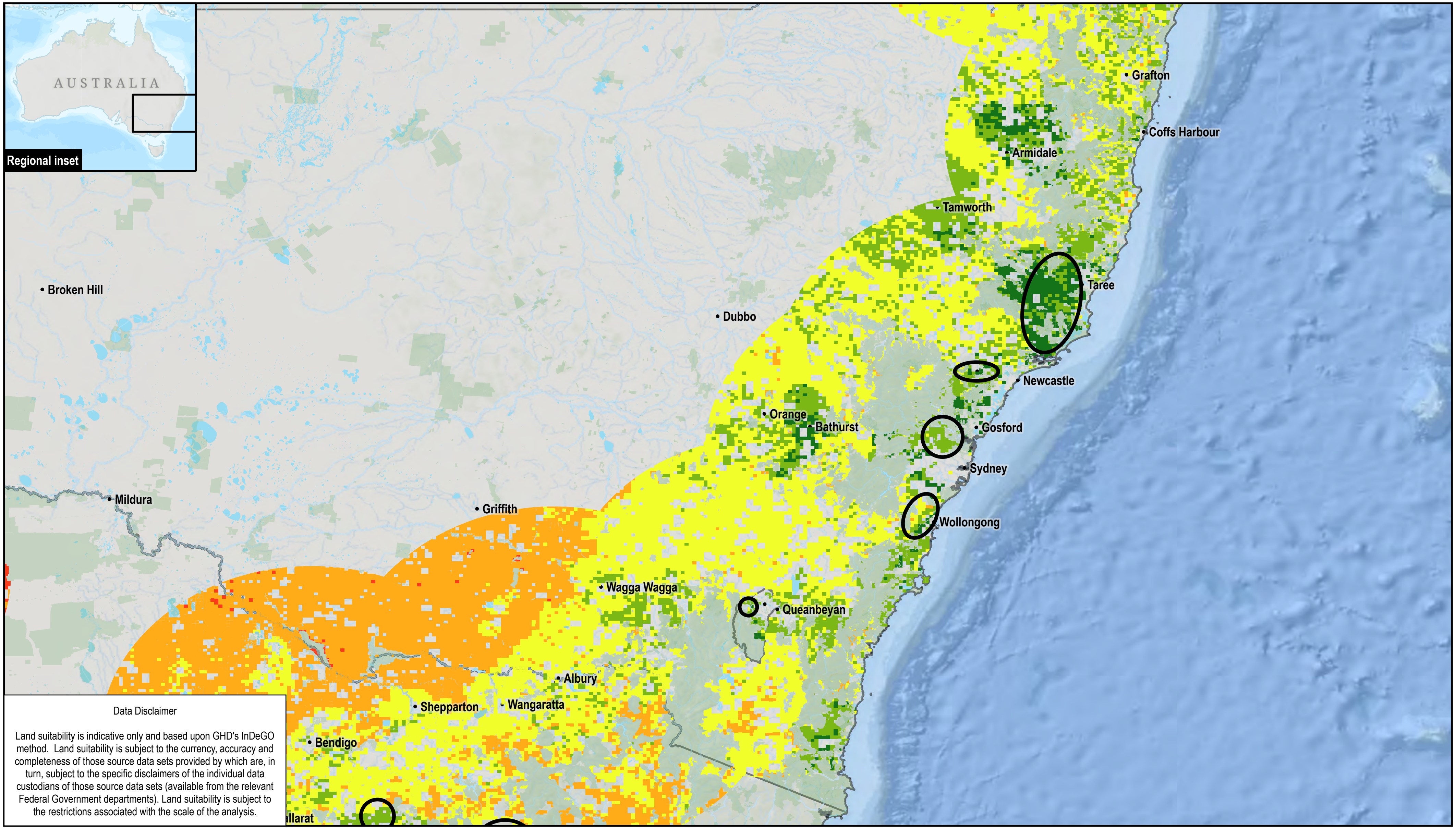
6.2.5 Wollongong

The Wollongong region consisted of large areas identified as being of neutral suitability. The Wollongong WWTP is discharging 320 ML/day of tertiary treated water to an ocean outfall. It may be feasible to reuse of this discharge (and possibly the discharge from Sydney WWTPs depending on proximity) for agriculture in the Wollongong area.

6.2.6 Conclusions

The opportunities and constraints for reuse of wastewater in areas of NSW with neutral suitability are as follows:

- Northwest of Sydney – the WWTPs in the west and southwest of Sydney could support agriculture in the northwest of Sydney, but the agriculture land is being transformed into other uses, making it unviable.
- North of Newcastle – consists of largest area of neutral suitability. Any new agriculture developments could be restricted to wastewater reuse supplemented by rainwater or river extraction (lower priority).
- Hunter Region – more land around Singleton could be converted to agriculture use, but significant land remediation requirements need to be considered (lower priority).
- Wollongong – consists of areas of neutral suitability. Feasibility of reuse of discharge from Wollongong (and possibly the Sydney WWTPs) for agriculture could be assessed.



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 45 90 135 180

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - NSW

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.3

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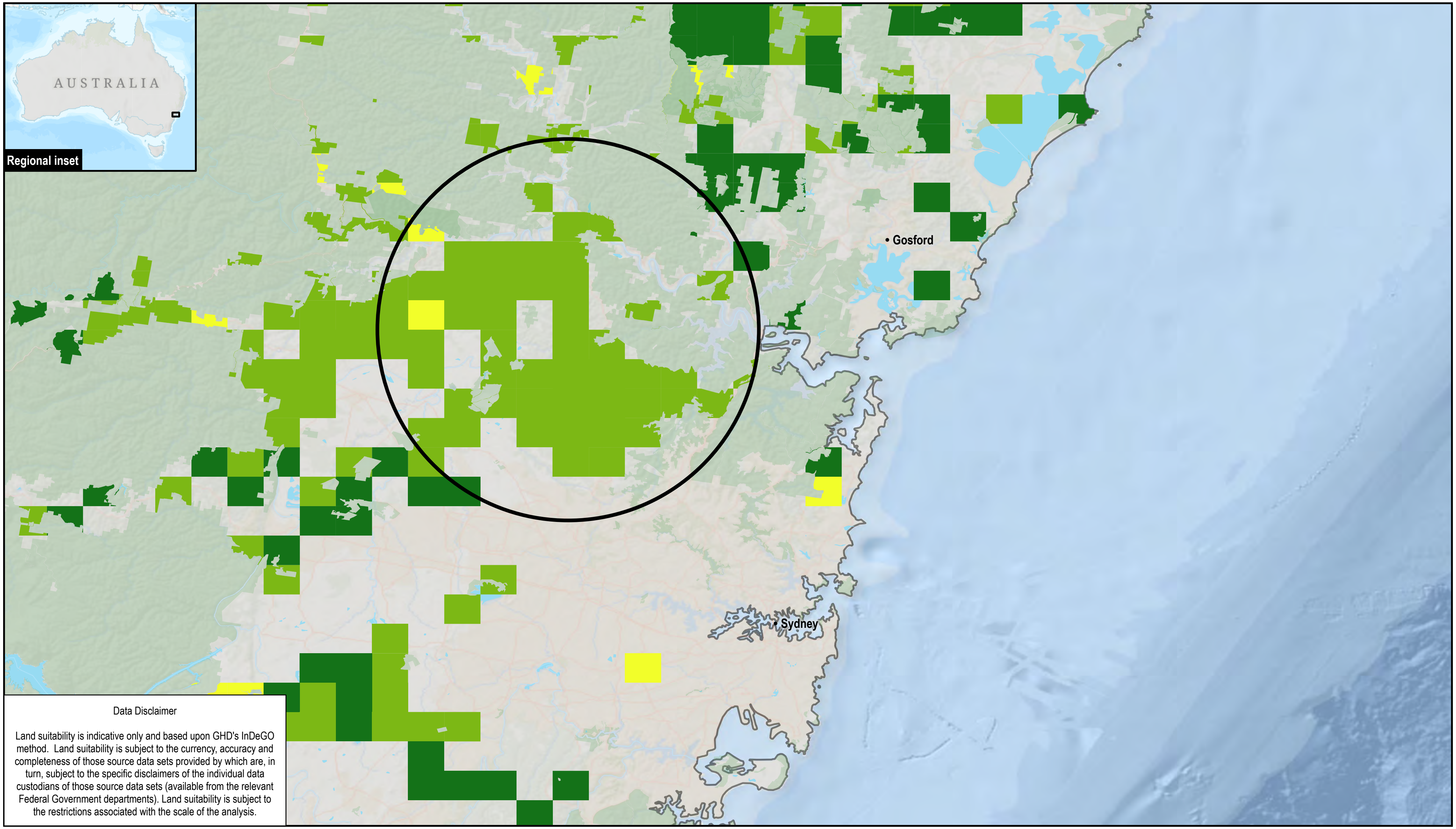
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 4.75 9.5 14.25 19

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

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National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Sydney, NSW

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.4

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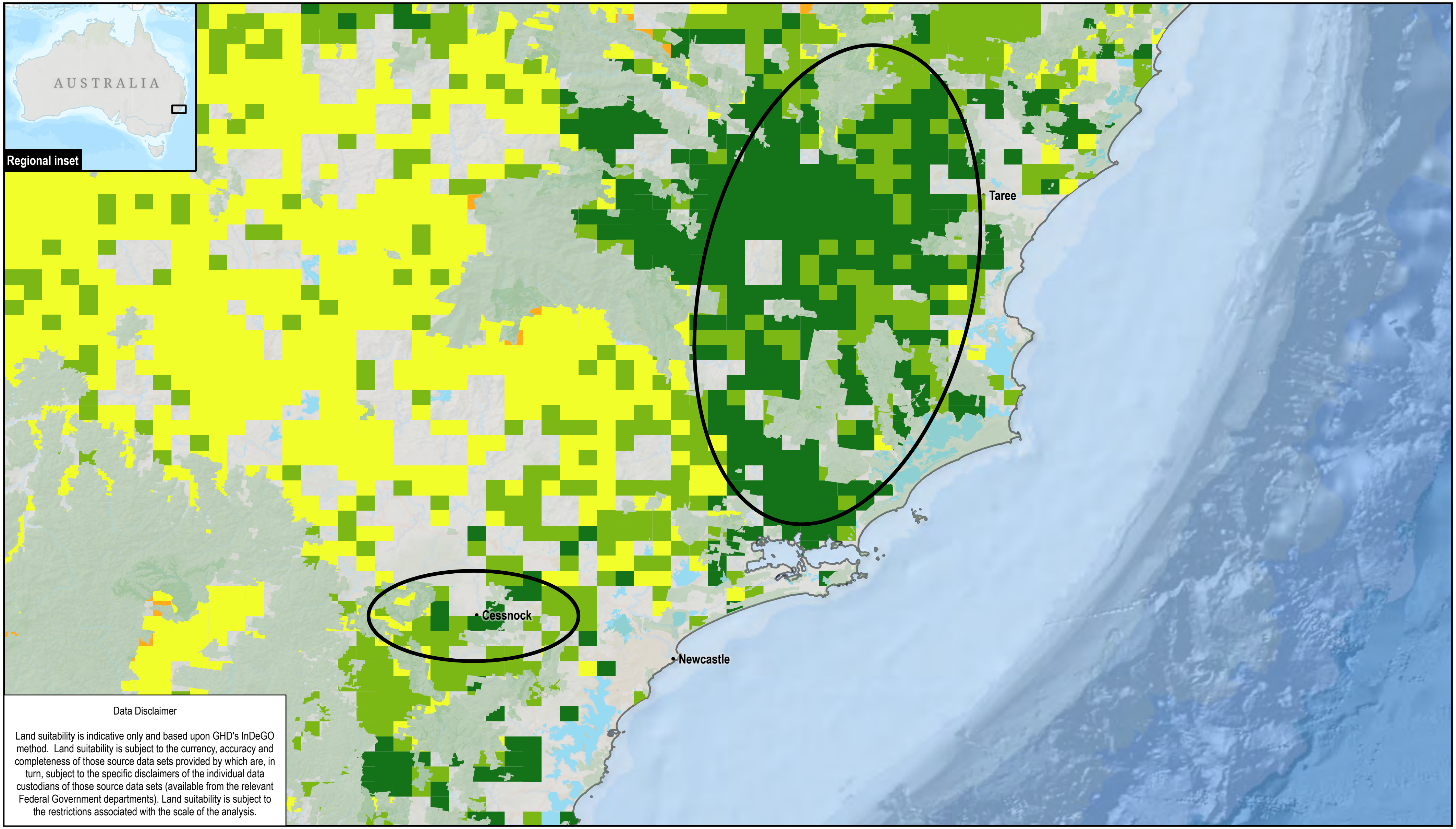
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 9.25 18.5 27.75 37

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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Wastewater Reuse Opportunities for Agriculture Suitability Map - Newcastle and Hunter Region

Project No.	**12556736**
Revision No.	**1**
Date	**20-Jun-22**

FIGURE 6.5

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
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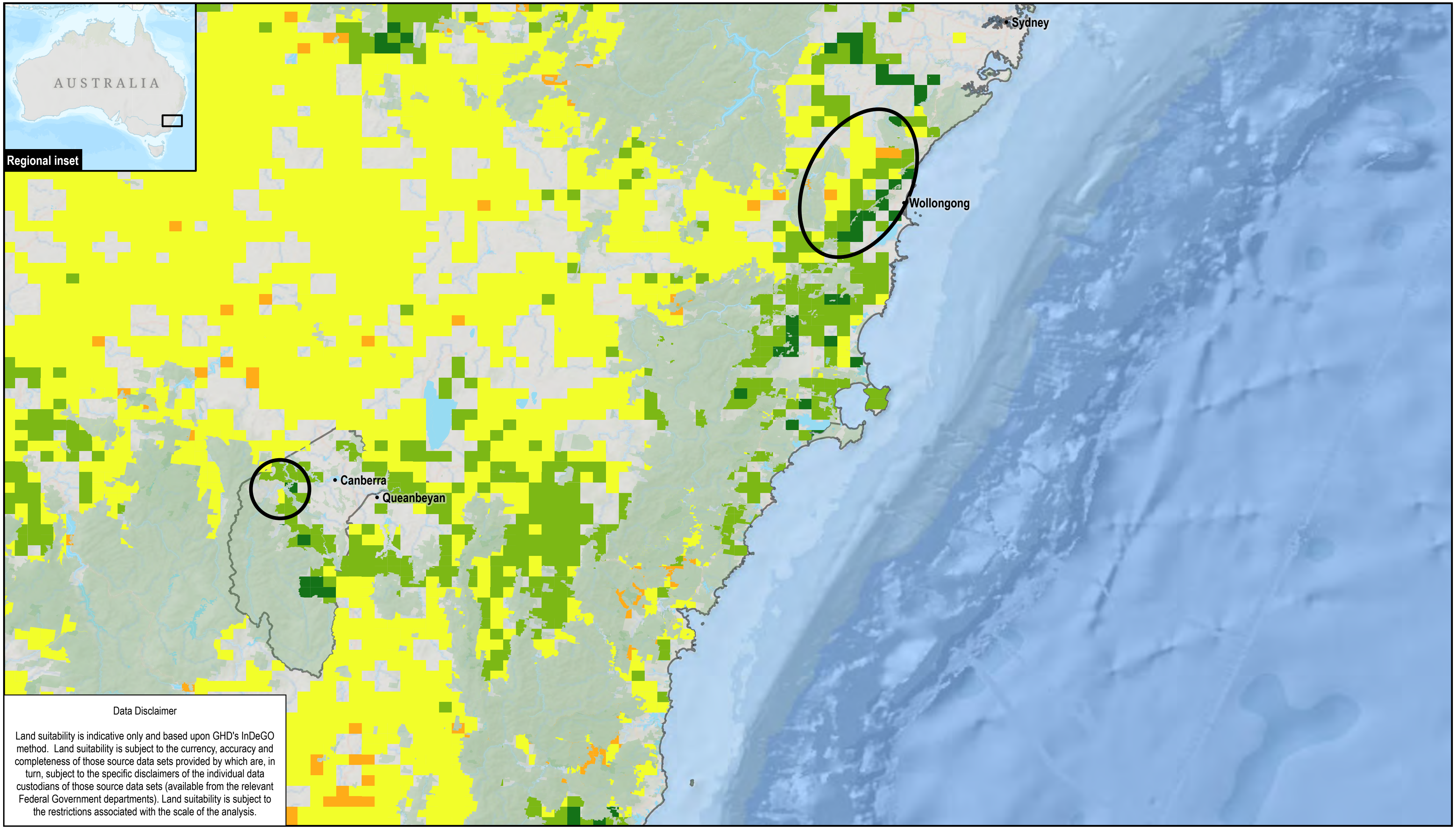

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Legend

Land suitability
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- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 13 26 39 52

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Wollongong, NSW

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.6

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.3 Victoria

The results for Victoria and the bordering areas of NSW are shown on Figure 6.7.

6.3.1 Suitable areas identified

No highly suitable areas were identified within Victoria. Small areas of neutral land were identified in south Melbourne and northwest of Traralgon. The area to the north of Melbourne is currently identified as moderately constrained and highly unsuitable.

6.3.2 Southeast Melbourne

40% of Melbourne’s total wastewater volume (330 ML/day) is tertiary treated at Melbourne’s eastern WWTP. It supplies 5 GL/year (8.2 ML/day) to Melbourne’s eastern irrigation scheme and the remainder is discharged to the ocean via an outfall. The pipeline to the outfall passes close to the areas identified as neutral in southeast Melbourne, which presents an opportunity to use the remaining discharge in these areas.

6.3.3 Northwest Traralgon

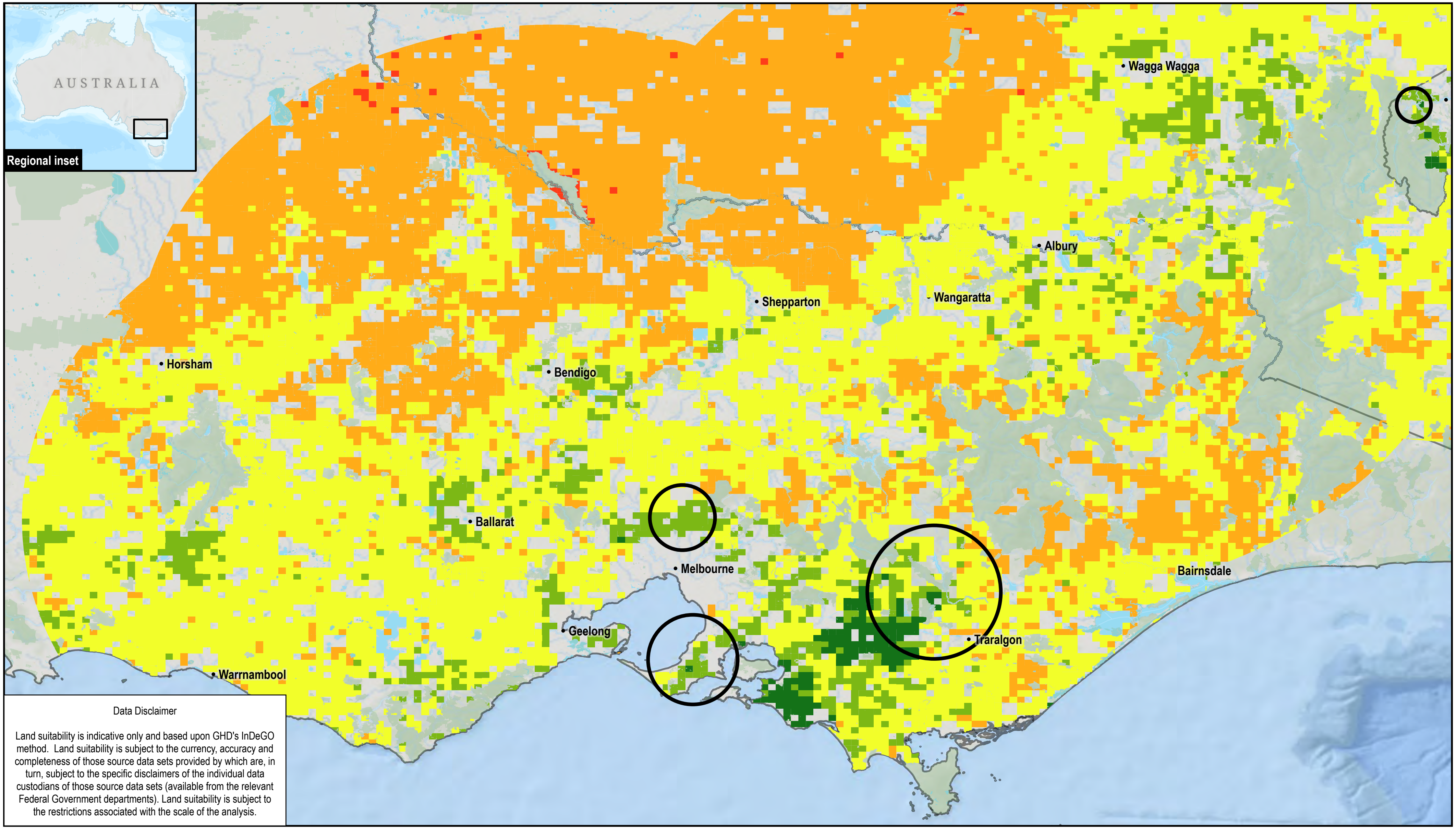
A small area of neutral suitability land was identified to the northwest of Traralgon. The most likely wastewater source for this area was likely to be from the Traralgon area but requires further assessment. The large amounts of water available from Melbourne’s eastern WWTP is unlikely to be economically viable considering having to transport a distance of approximately 130 km.

6.3.4 North of Melbourne

A future WWTP with a discharge of 5.5 ML/day is proposed in north of Melbourne to service the increasing population, but it was not considered as it was not yet in operation. This may be used for the moderately constrained area identified, however requires further investigation.

6.3.5 Conclusions

The viability of use of the remaining tertiary treated wastewater from Melbourne’s eastern WWTP on the neutral land in southeast Melbourne would require further consideration. The remaining areas of northwest Traralgon and north of Melbourne would also require further investigations to determine any potential.



Legend

Land suitability
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- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 23 46 69 92

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

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National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - VIC

Project No.	12556736
Revision No.	1
Date	20-Jun-22

FIGURE 6.7

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.4 South Australia

The results for South Australia and the bordering areas of Victoria are shown on Figure 6.8. The wastewater is sourced from Adelaide, and therefore, the only potentially viable areas are contained in the general proximity to the city. The areas are generally highly unsuitable due to the close proximity to Adelaide. Some areas of neutral and highly constrained were identified in Gawler.

6.4.1 Suitable areas identified

No highly suitable areas were identified within SA. Some areas of neutral suitability were identified around Adelaide and Gawler.

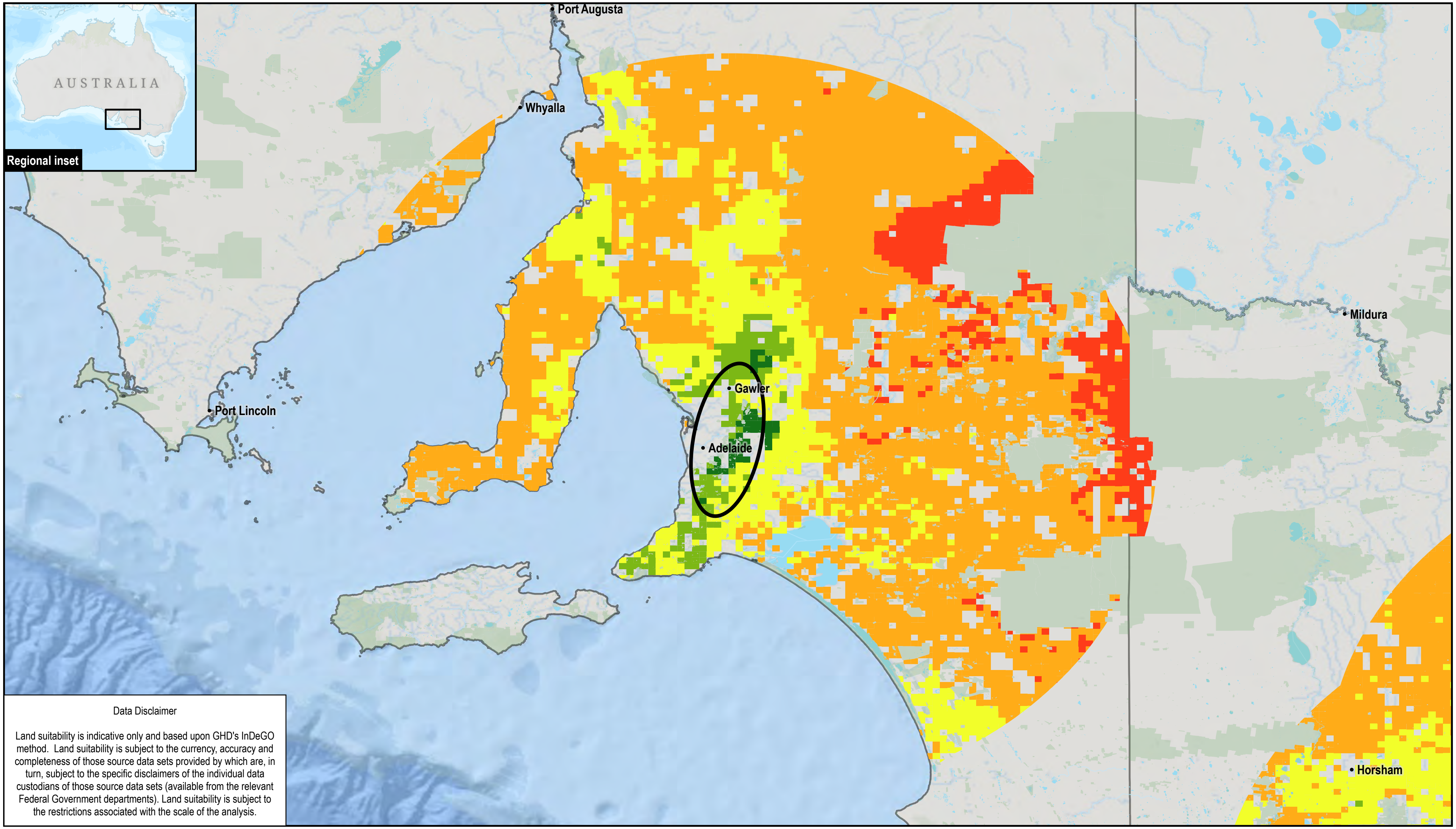
6.4.2 Wastewater reuse in SA

There are three major wastewater treatment plants at Bolivar, Glenelg and Christies Beach in Adelaide. They treat over 250 ML/d of sewage. There are 20 other WWTPs outside the Adelaide metropolitan area but are all very small comparatively.

Bolivar WWTP is located to the north of the CBD and serves about 70-75% of Adelaide's population. It generates about 30% of the wastewater in Adelaide, of which 100% is reused over the summer months, but much less over the winter months due to lack of storage. Glenelg and Christies Beach WWTPs provide significant municipal reuse of wastewater, for instance, to vineyards, orchards and water companies. Some of the larger towns with high water reuse for agriculture include Mount Barker with a 22,000 Equivalent Population (EP) and Murray Bridge (20,000 EP), and some smaller towns include Millicent (5,000 EP), Nangwarry and Mt Burr (500 EP each). There are also several treatment systems with no reuse, such as Olympic Dam Village and Port Broughton.

6.4.3 Conclusion

South Australia has very limited potential for reuse of wastewater. Based on our assessment of the individual schemes, the Bolivar WWTP Virginia market gardens scheme to the north was identified as a scheme with potential for expansion.



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 24 48 72 96

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - SA

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.8

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.5 Western Australia

The results for northern and southern regions of Western Australia are shown on Figure 6.9 and Figure 6.10. The maps are limited to the potentially viable areas due to the large scale of WA. The high-quality natural water from the Pilbara region and the urbanised areas near Perth were the only large-scale water sources considered.

6.5.1 Suitable areas identified

No highly suitable areas were identified within WA. Numerous neutral areas were dotted along the southwest coast of WA, mainly to the north of Perth and south of Bunbury.

6.5.2 Wastewater treatment plants in WA

There are 113 wastewater treatment plants across the state. Approximately 80% of the wastewater collected across WA is treated in the three large wastewater treatment plants in Woodman Point, Beenyup (Craigie) and Subiaco, and discharged to the ocean. In addition, there are currently five small coastal plants discharging treated wastewater to an aquifer.

6.5.3 North of Perth

The closest potential opportunity for wastewater reuse for agriculture was identified at the west coast to the north of Perth. The area was identified as neutral suitability and also a mix of moderately constrained and highly unsuitable. It may be viable to transport the discharge to these areas from the one or more WWTPs in metropolitan Perth.

6.5.4 South of Bunbury

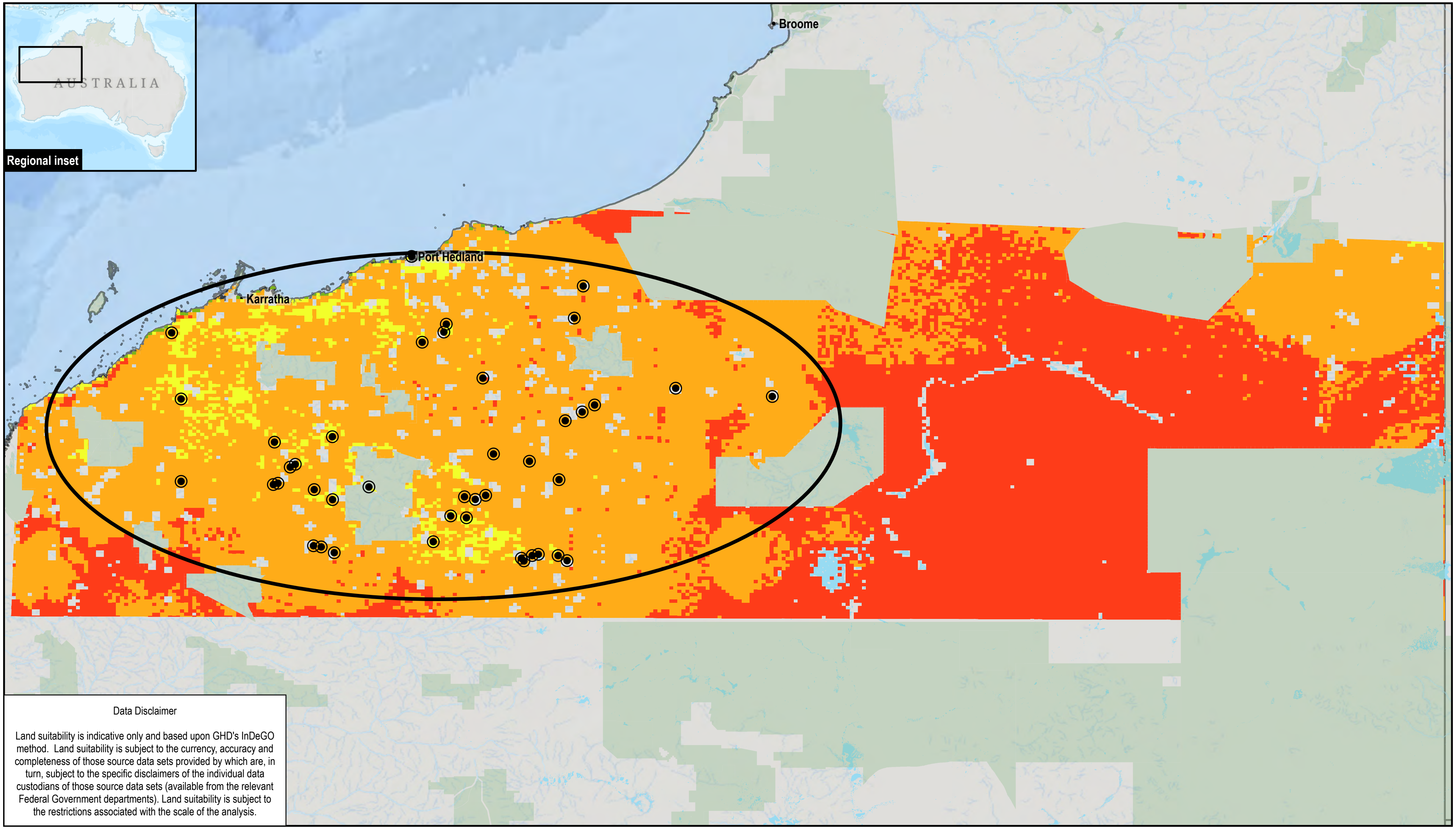
South of Bunbury also contained large areas of neutral suitability. Cost-effectiveness is likely to be the critical factor for determining the viability of transporting the discharge to these areas. Some minor WWTPs at Bunbury and other locations could also potentially supply wastewater to the area, but viability will rely on the cost-effectiveness.

6.5.5 Pilbara

The Pilbara has the potential for large-scale agriculture development due to the increasing surplus of water from mining dewatering (200 GL in 2020). Transport was identified as the primary constraint during the assessment of previous schemes, as shown in Appendix A. Transportation of large quantities over large distances is not only costly but also creates uncertainties on availability of discharge. Also, land availability was limited, and measures to improve agricultural potential would need to be investigated. In previous studies (*Growing the Pilbara (DPIRD, 2017)*) it was noted that mine dewatering was best suited as augmentation of other sources for irrigation, rather than as a standalone resource, due to challenges such as variability in supply and the ability to capture, transmit and store the water.

6.5.6 Conclusions

WA's potential for reuse of wastewater for agriculture is limited to the areas to the north of Perth which can use wastewater from one or more of the city's major WWTPs. The other potential areas would need further investigation to determine feasibility and economic viability.



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity
- Operational mines

Paper Size ISO A4

0 43 86 129 172

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

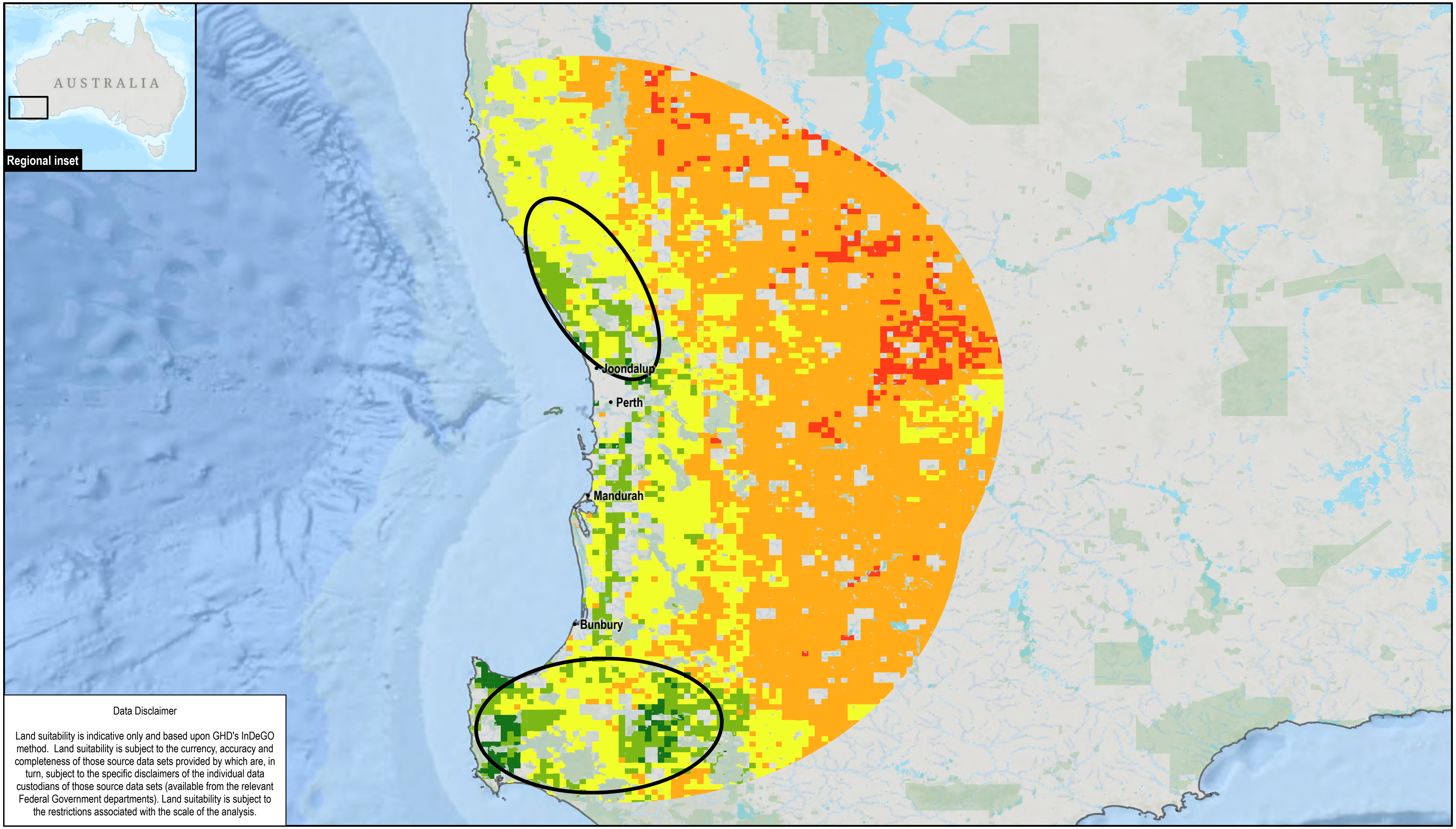
Wastewater Reuse Opportunities for Agriculture Suitability Map - Pilbara region

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.9

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:01

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Legend

Land suitability

- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 26 52 78 104

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Perth, WA

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.10

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.6 Australian Capital Territory

The results for Australian Capital Territory and the surrounding areas of NSW are shown on Figure 6.11. Areas of neutral suitability that are highly constrained were found within the ACT, whereas the areas of NSW within 100 km were neutral and highly unsuitable.

6.6.1 Suitable areas identified

No highly suitable areas were identified within the ACT. The Lower Molonglo Water Quality Control Centre (LMWQCC) to the northwest of the territory was identified as the most potential area, and also other neutral locations to the east of the territory. Although, they were unlikely to be large enough for desired agricultural growth.

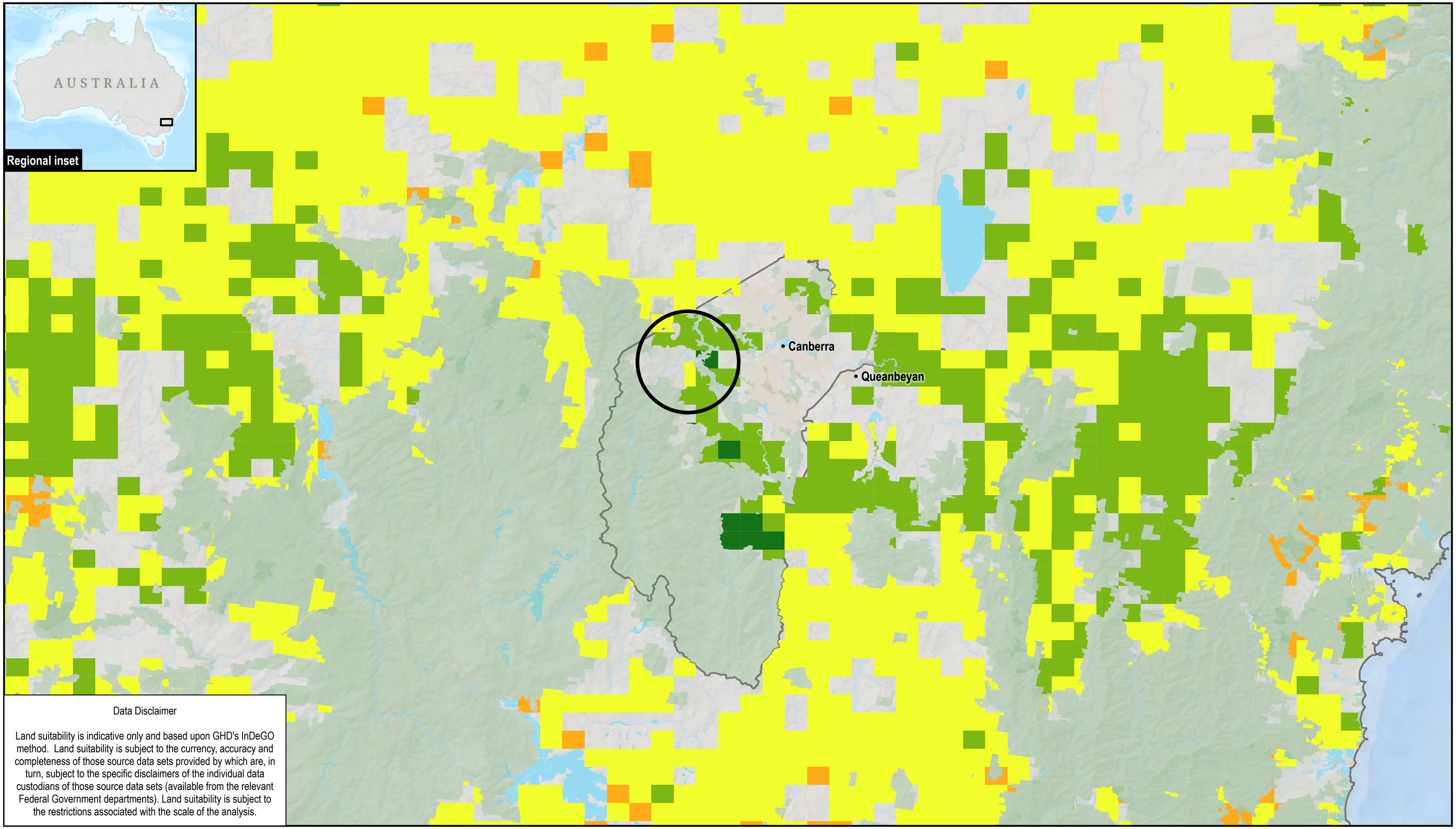
6.6.2 Larger wastewater treatment facilities

All wastewater from Canberra is treated at LMWQCC and discharged to the Lower Molonglo River which flows into the Murrumbidgee River. It treats 80-90 ML/d of Class D effluent flow, where only 10 ML/d is being recycled. ACT’s Class D classified water is allowed for irrigation (with restricted human access), and for use in pasture, fodder, horticulture, indirect/processed crops and for other uses of classes lower than D. The Fyshwick WWTP services a much smaller population to the east of Canberra. This plant already services an open space irrigation system which has a remaining asset life of 20 years, and discharges to the LMWQCC during high flows.

Given this location is in the Murray-Darling Basin, the flows discharged from this plant to the environment may be difficult to assign to on-land use and may impact economic viability of this scheme. This needs to be considered for further studies.

6.6.3 Conclusion

There is a significant opportunity to reuse the remainder of the treated wastewater from LMWQCC for agriculture as well as wastewater from the Fyshwick WWTP for smaller agriculture opportunities. Upgrading the LMWQCC would also expand the potential agriculture uses significantly.



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 7.7 15.4 23.1 30.8

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - ACT

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.11

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.7 Tasmania

The results for Tasmania are shown on Figure 6.12. Tasmania has neutral and highly unsuitable land, and large portions of the southwest were identified as no-go areas.

6.7.1 Suitable areas identified

No highly suitable areas were identified within TAS, however there are sites where there are opportunities for further investigation. The highest potential neutral lands were identified scattered throughout, as well as near west Hobart, Launceston and along the north coast.

6.7.2 Hobart

The three primary reuse schemes in Hobart (Clarence, Brighton and Penna) contribute 67% to the state's total effluent reuse. Construction projects for recycled water irrigation schemes have been approved in Greater Hobart and Bicheno, in collaboration with the NWGA. Typical uses for irrigation of treated effluent include pasture, sports fields and golf courses. In addition, the recent EPA guideline changes require all discharge to be ceased and redirected to additional reuse sites by July 2022. The small areas of neutral suitability identified near Hobart have the potential to develop agriculture using this treated effluent. Opportunities for neutral areas to the west of Hobart would need to be investigated further, also considering cost-effectiveness of recycled water projects.

6.7.3 Launceston

A number of areas round Launceston are already supplied by TasWater irrigation schemes from small individual WWTPs. Only a small proportion of treated effluent is recycled and additional opportunities may exist in this area for recycled water irrigation. The Launceston wastewater/stormwater system that currently has no reuse and services a maximum of 50,000 EP would require costly treatment.

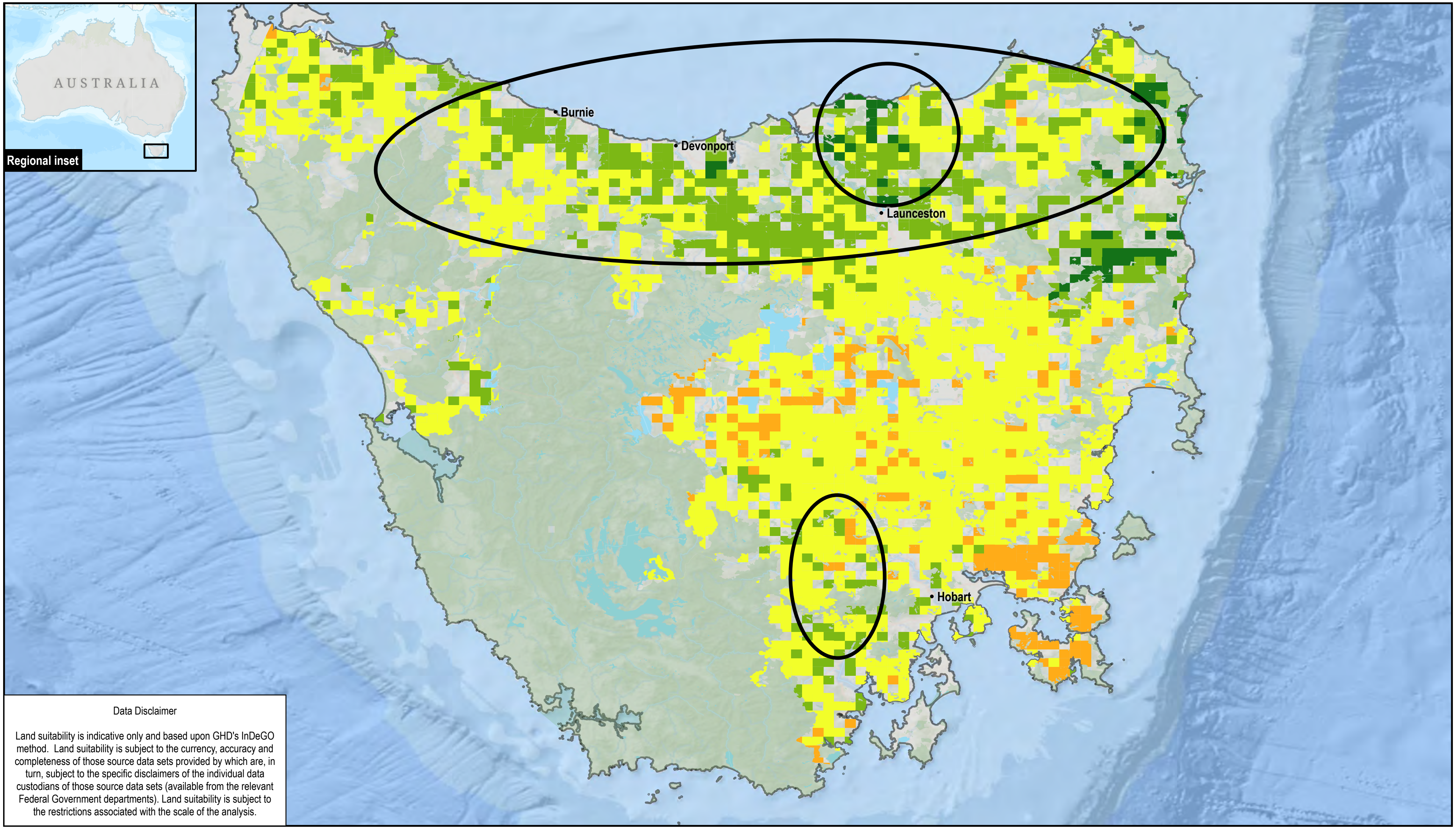
6.7.4 North coast

77 WWTPs are scattered throughout Tasmania. 12% of the state's effluent discharge was reused in 2019-20. 36 WWTPs contributed to the reuse schemes, but only 10 WWTPs provided 100% reuse. There is an opportunity to use the remaining discharge in areas of neutral suitability along the higher density WWTP areas, mainly along the north coast.

6.7.5 Conclusion

Tasmania's drinking and wastewater services are governed by a single state-wide body, and the state is therefore uniquely positioned to coordinate multiple WWTPs for effluent reuse. The opportunities for wastewater reuse (lower priority though due to very small comparative volume compared to other states and territories) are as follows:

– Hobart - the changes to EPA guidelines requiring all discharge to be redirected to reuse sites by July 2022 creates an opportunity to increase reuse of wastewater, including the neutral areas around Hobart.
– Launceston - there may be reduced opportunity in the surrounding areas due to existing schemes from small WWTPs. Any reuse of wastewater from central Launceston catchment will also need unique treatment for hydrocarbons which could be costly.
– North coast - Some of the other WWTPs not in the proximity of Hobart or Launceston already have private irrigation agreements or discharge to local waterways. There are also opportunities to use the remaining discharge in areas of neutral suitability along the north coast.



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 16 32 48 64

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - TAS

Project No.	12556736
Revision No.	1
Date	20-Jun-22

FIGURE 6.12

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Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.8 Northern Territory

The results for Northern Territory are shown on Figure 6.13. Darwin was the only viable area identified in the study, and therefore, the NT map focuses on this region.

6.8.1 Suitable areas identified

NT, unlike the other states and territories, contains highly suitable areas grouped within 70 km southwest of Darwin. The remaining areas are identified as predominantly neutral with minimal highly unsuitable land.

6.8.2 Southwest Darwin

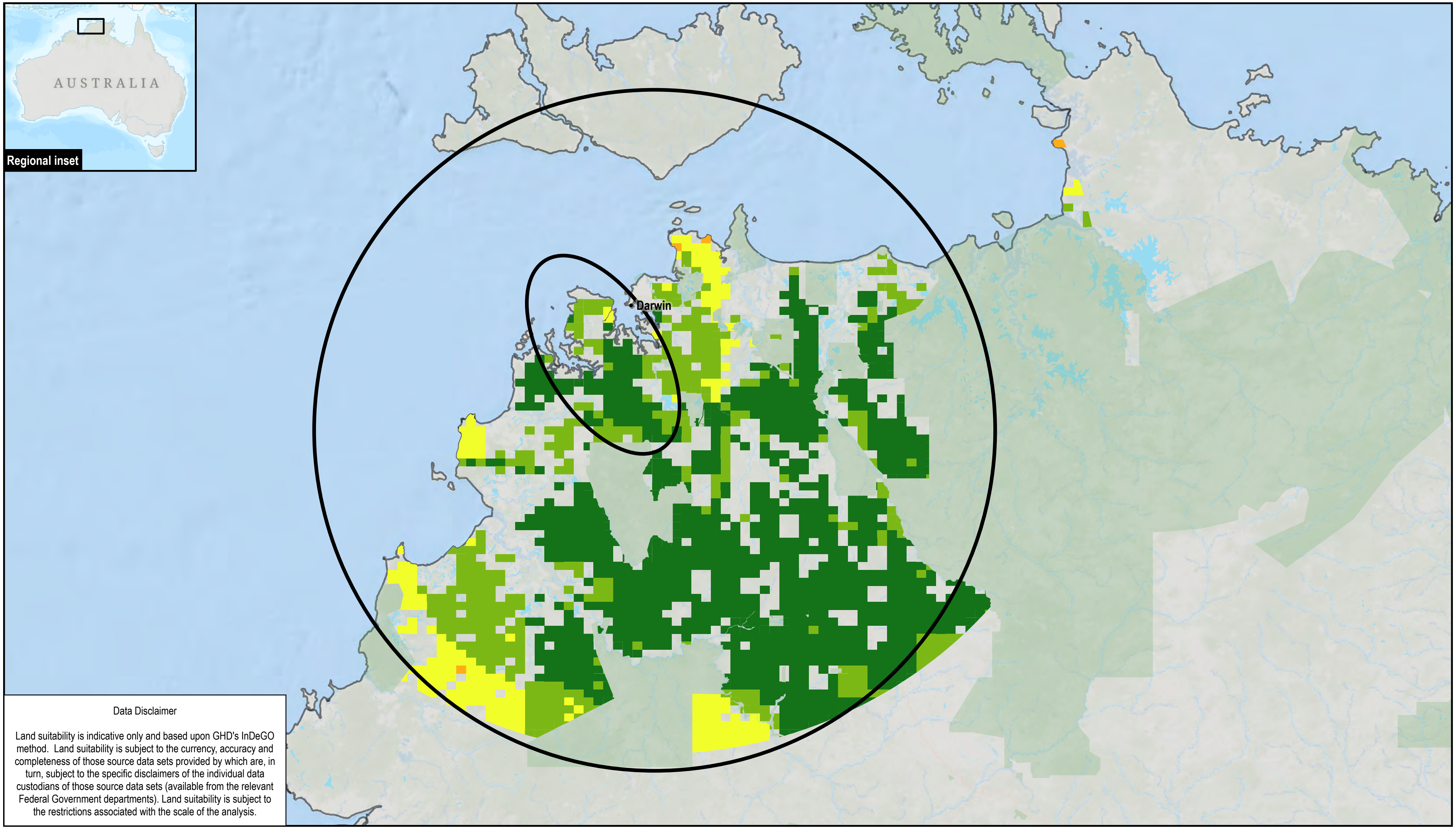
The highly suitable areas across the Darwin Harbour are located to the southwest of Darwin. The treated wastewater from the Leanyer-Sanderson WWTP (15 ML/d) currently either evaporates or is discharged to Buffalo Creek. No reuse currently exists except during the dry season when small amounts are pumped to the Northlakes Reuse Plant.

6.8.3 Remaining NT

Localised WWTPs could be used for the remaining neutral areas identified in the NT based on economic viability.

6.8.4 Conclusion

There is a opportunity to use the highly suitable areas to the southwest of Darwin by maximising the discharge from the Leanyer-Sanderson WWTP. Smaller schemes currently not reusing wastewater would also need to be investigated.



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- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 18 36 54 72

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Darwin, NT

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.13

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Print date: 20 Jun 2022 - 14:01

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle

6.9 Sensitivity analysis

A sensitivity analysis on the InDeGO process was then undertaken to test robustness of the findings and the tolerance of the overall process to small changes in the weightings applied to the various factors, including whether there were significant changes to the highly suitable areas that had been identified.

Six different sensitivity analysis scenarios were undertaken as follows:

1. Adoption of a suite of weightings as discussed/suggested by project partners (and not averaging against the ones the GHD team members provided)
2. Applying equal weighting to all factors
3. Greater importance on sites being further away from conservation areas
4. Moving the ranking of relevant soils layers to be most important
5. Applying a lesser weighting to land use factors
6. A random set of weightings, generated using a ‘random selection’ function in InDeGO

Having calculated the InDeGo results for each of the above scenarios, the change in the overall favourability score (as a representative of over 410,000 grid cells across Australia) was compared against the initial analysis for greatest increase, greatest decrease and change in national average. All but one of the six alternative weighting scenarios yielded results within 2% of the current analysis, on either a national average or specific location (model grid cell) basis. This difference is considered to be within the order of accuracy of the study and the input data.

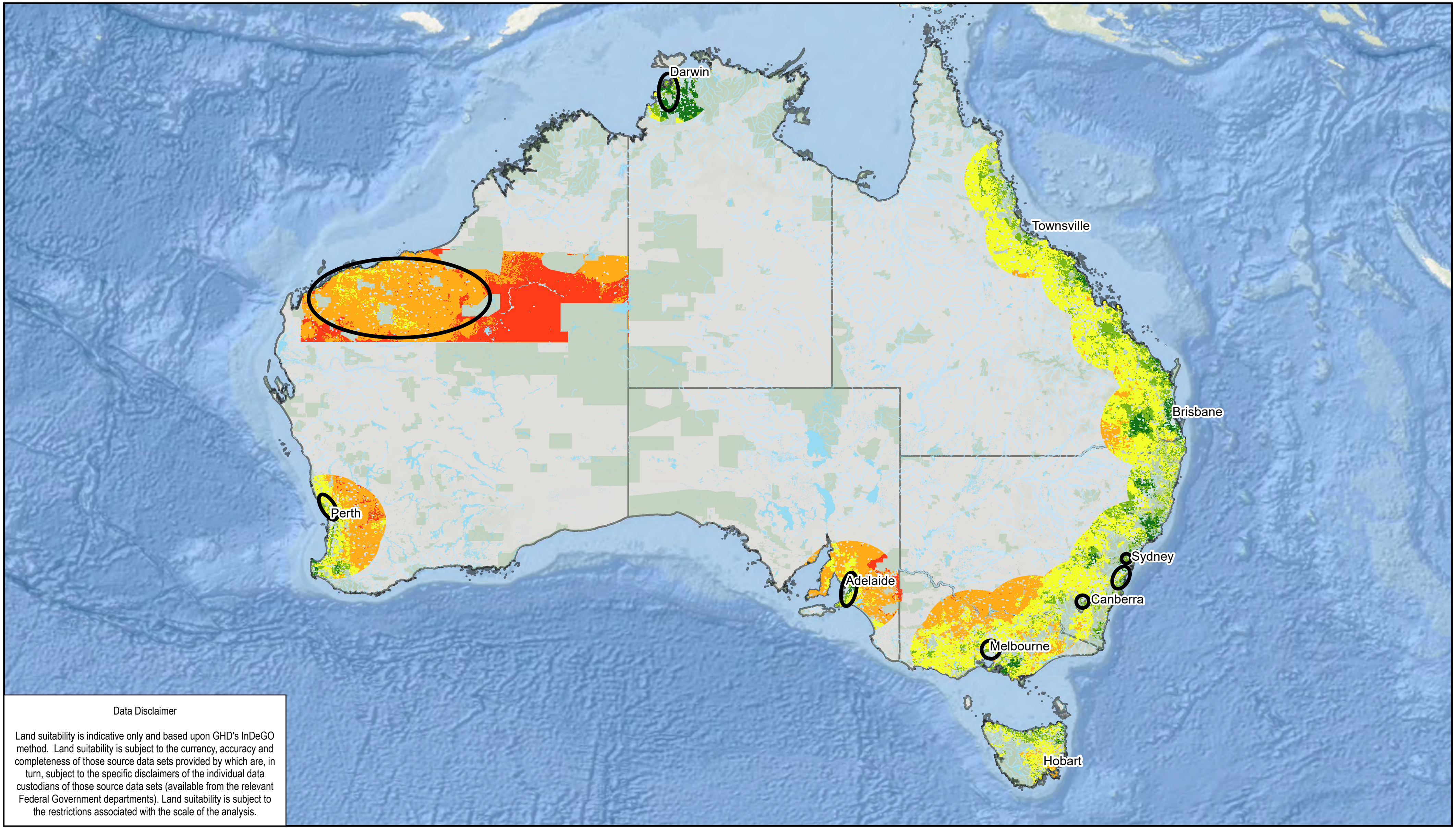
Scenario 2 was the only alternative weighting scenario tested that yielded a greater difference (where the maximum difference of just over 8% in some specific locations). However, application of equal weightings for all factors is unrealistic (for example, this would consider that land slope is as important as proximity to a wastewater supply source) and was therefore discounted.

This sensitivity analysis provided greater confidence in the robustness of the process to understand the difference in results from an extreme weighting scenario.

7. Conclusions

Large scale wastewater reuse opportunities will come primarily from the major capital cities due to the large volumes of treated wastewater. It can be concluded that the areas of noticeable opportunities are as follows:

- New South Wales – Opportunities to supply treated wastewater to neutral areas in northwest of Sydney whilst considering transformations in agriculture land. Additionally, there could be opportunities to distribute the tertiary treated water from the Wollongong WWTP (and possibly the Sydney WWTPs) to the surrounding neutral areas based on economic viability.
- Victoria – Opportunities to use the large volumes of tertiary treated wastewater from Melbourne's eastern WWTP and the area of north Melbourne.
- South Australian – Opportunities for expansion of the existing South Australian schemes to meet available wastewater volumes.
- Western Australia – Opportunities for use of increasing surplus of water from mining dewatering in the Pilbara region and expansion of existing systems to the north of Perth.
- Australian Capital Territory – Opportunities to reuse the remainder of the treated wastewater from LMWQCC for agriculture as well as wastewater from the Fyshwick WWTP for smaller agriculture opportunities.
- Northern Territory – Opportunities to maximise the discharge from the Leanyer-Sanderson WWTP to supply wastewater to the highly suitable areas.



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 250 500 750 1,000

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map

Project No. **12556736**
Revision No. **1**
Date **21-Jun-22**

FIGURE 7.1

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Print date: 21 Jun 2022 - 10:08

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021; World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue. Created by: mfredle

8. Recommendations

The areas of noticeable opportunities listed on the section above were identified through high-level analyses and require further investigations as follows:

– New South Wales – Supply of treated wastewater to northwest and south of SWC area of operations could be explored.
– Victoria – Use of large volumes of tertiary treated wastewater in north and south of Melbourne from proposed northern and existing eastern WWTPs could be explored.
– South Australian – Expansion of an existing South Australian scheme could be explored.
– Western Australia – Use of increasing surplus of water from mining dewatering in northern Western Australia and expansion of existing treatment systems north of Perth could be explored.
– Australian Capital Territory – Use of flow from the main Canberra treatment plant and Fyshwick WWTP could be explored.
– Northern Territory – Maximising the discharge to southwest of Darwin from one of the main wastewater treatment plants could be explored.

It is recommended that these identified options are investigated further in greater detail to assess feasibility for wastewater reuse.

Water quality requirements, local soil mapping analysis/testing, local government/utility specific requirements and the suitable types of agriculture are also critical considerations.

Appendices

Appendix A

Investigation of Current Schemes Report

-

Investigation of Current Schemes

National Review of Wastewater Reuse opportunities for Agriculture

Department of Infrastructure | Transport | Regional Development and Communications

10 January 2022

→ **The Power of Commitment**

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Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	L Sharpe B Rogers C West I Lun	N Malcolm		N Malcolm		10/01/2022

Executive summary

The National Water Grid Authority (NWGA) has engaged GHD Pty Ltd (GHD) to assess where opportunities exist for beneficial use of wastewater for agricultural purposes throughout Australia.

While municipal wastewater appears to be an abundant resource with very low existing reuse in eastern capitals such as Sydney, Melbourne and Canberra, cheaper/simpler alternatives, the additional cost of treatment to produce crops for human consumption, the distance of suitable agricultural land and the somewhat protracted/complex approvals processes are apparent barriers to additional reuse uptake for agriculture. The large volume of surplus mine water of generally good quality that appears well suited to reuse is generally undermined by the distance of this resource from areas viable for agriculture. Further limiting current uptake of wastewater reuse, Australian farmers also maintain significant power over water access, pricing, usage and maintenance.

A review of current schemes (and those not yet deemed viable) in each state and territory of Australia, along with challenges for expansion, was undertaken to understand common principles for viability. These are as follows:

- There is an underlying environmental or political driver for the project, given that most are not financially viable without subsidy or acceptance of an operating cost deficit. This is not necessarily the case for viable mining water schemes in northern WA (i.e. they are financially viable) where very large volumes of high quality surplus water are in relatively close proximity to large areas of agricultural land to make a cost-effective proposition.
- Soils are generally suitable for agriculture with minimal adjustment and in close proximity to the wastewater source.
- Located in areas with typically lower average annual rainfall and greater annual rainfall variability, so that other water supply options are comparatively more costly or less reliable.
- In some cases, an existing, large storage is available to buffer supply and demand variability.
- Favourable and less complex approvals pathways assist.

Based on the interim findings listed in the section above, it is concluded that:

- The spatial analysis to be undertaken in the next phase of this project (that will exclude areas noted as No-Go areas) should be used as a first pass to allocate weightings and scoring ranges for available various spatial layers.
- Non-spatial considerations such as political drivers, legislative ease and the non-spatial elements of economic viability can then be applied (potentially through a multi-criteria analysis process) to compare the most favourable options that come from the spatial analysis to filter/rank options prior to further assessment.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.3 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

Agricultural water usage in Australia is managed by disparate and regionalised authorities. Water policy and management is the domain of the states, and within the states, the authority is divided further by region. The size, resources, and political power of these various organisations is varied. Despite efforts to centralise and simplify water management, Australian farmers maintain significant power over water access, usage and maintenance. The consequence is that farmers typically pay below cost price for water, may access more than they are technically entitled to and/or benefit from subsidisation.

Furthermore, there are few mechanisms to observe the true level of water used for farming purposes across the country. The challenge therefore for any new water policy is to confront these prevailing realities. It can either attempt to undo them or, it can exist within the existing framework. In short, it will face resistance if it undermines the existing power balance and/or alters the price. While municipal wastewater appears to be an abundant resource with very low existing reuse in eastern capitals such as Sydney, Melbourne and Canberra, cheaper/simpler alternatives, the additional cost of treatment to produce crops for human consumption, the distance of suitable agricultural land and the somewhat protracted/complex approvals processes are apparent barriers to additional reuse uptake for agriculture. The large volume of surplus mine water of generally good quality that appears well suited to reuse is generally undermined by the distance of this resource from areas viable for agriculture.

This report will look at the regional differences in agriculture water management. It will explore the different schemes (both viable and not yet deemed viable) and authority mechanisms in place. An examination of the various regulator's legislation and guidelines around recycled water is also present. Understanding these will be vital for success for any scheme that will utilise recycled water/wastewater.

1.1 Project background

The National Water Grid Authority (NWGA) has engaged GHD Pty Ltd (GHD) to assess where opportunities exist for beneficial use of wastewater for agricultural purposes throughout Australia.

1.2 Purpose of this report

The purpose of this report is to draw insights from a review of current wastewater reuse schemes for agriculture around Australia to distil key principles for viable schemes and identify challenges for expansion of existing schemes.

These principles and their relative importance will then inform the project team on the key data layers required for the spatial analysis to be undertaken in the next phase of the project to identify NO-GO areas and then weighting and scoring layers to allow comparison of suitable agriculture areas for wastewater reuse.

1.3 Scope and limitations

The scope of this report is to:

– Present a review of current wastewater reuse schemes and schemes deemed not yet viable from each state and territory in Australia. Both municipal wastewater and mine water reuse are in scope.
– Identify principles of viable schemes from this review (or conversely, the barriers to schemes being viable). Within this is both economic viability and legislative ease.
– Identify challenges for expansion of existing schemes.
– Present interim findings to support the spatial analysis in the next phase of this project. This will start to form views on what spatial parameters are key when weighted against each other for the comparison of viable wastewater reuse for agriculture.

This report has been prepared by GHD for Department of Infrastructure | Transport | Regional Development and Communications and may only be used and relied on by Department of Infrastructure | Transport | Regional Development and Communications for the purpose agreed between GHD and Department of Infrastructure | Transport | Regional Development and Communications as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Department of Infrastructure | Transport | Regional Development and Communications arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Review of current schemes

A review of existing wastewater irrigation schemes that have been successful was undertaken to determine key attributes that contribute to their success (and what attributes were missing for schemes not yet deemed viable).

The schemes reviewed are those that, to our knowledge (at the time of writing of this report), current state/territory effluent or mining surplus reuse schemes, either in operation or only considered and not constructed, on both large and individual scale are as per the following subsections. We have also included large-scale bulk water studies where some learnings are relevant to this project.

2.1 Western Australia

2.1.1 The Hamersley Agricultural Scheme

The Hamersley Agricultural Project (HAP) has been in operation for approximately 10 years. The project was driven by the need to dispose of up to 80 ML/d of surplus water from dewatering activities at the Marandoo and Nammuldi iron ore mines. The environmental regulator required that an alternative use be identified for this surplus to avoid long-term discharge to ephemeral creek systems.

The total area under irrigation is approximately 2,500 ha and the primary crops grown are Rhodes grass and oats, some Lucerne trials have also been undertaken. The schemes are ongoing and will continue for the life of the mining operations.

The challenges with agricultural operations linked directly to mining operations is that the system is in effect supply driven, the mine needs to dispose of the water throughout the year. As a result, the only way to manage the consequences of a constant volume is to expand and contract the number of pivots in operation in response to climatic conditions. This results in a sub optimal agricultural outcome, the agricultural scheme in effect remains a surplus water disposal system.

Figure 2.1 The Hamersley Agricultural Project and Marandoo mine near Tom Price, Pilbara Region Western Australia

2.1.2 The Pilbara Hinterland Agricultural Development Initiative (PHADI)

The HAP demonstrated that irrigated agriculture was possible in the Pilbara. As a result GHD were commissioned by the Department of Agriculture WA (DAFWA) to undertake a study in 2013 to investigate the viability of surplus water for mining in the Pilbara region in Northern WA.

Location and capacity

The locations of area surplus dewater and the available annual volume as of the 2013 investigation include (see image below for locations):

- Oakover River – 28 GL
- West Pilbara – 10 GL
- Central Pilbara – 74 GL
- East Pilbara – 11 GL

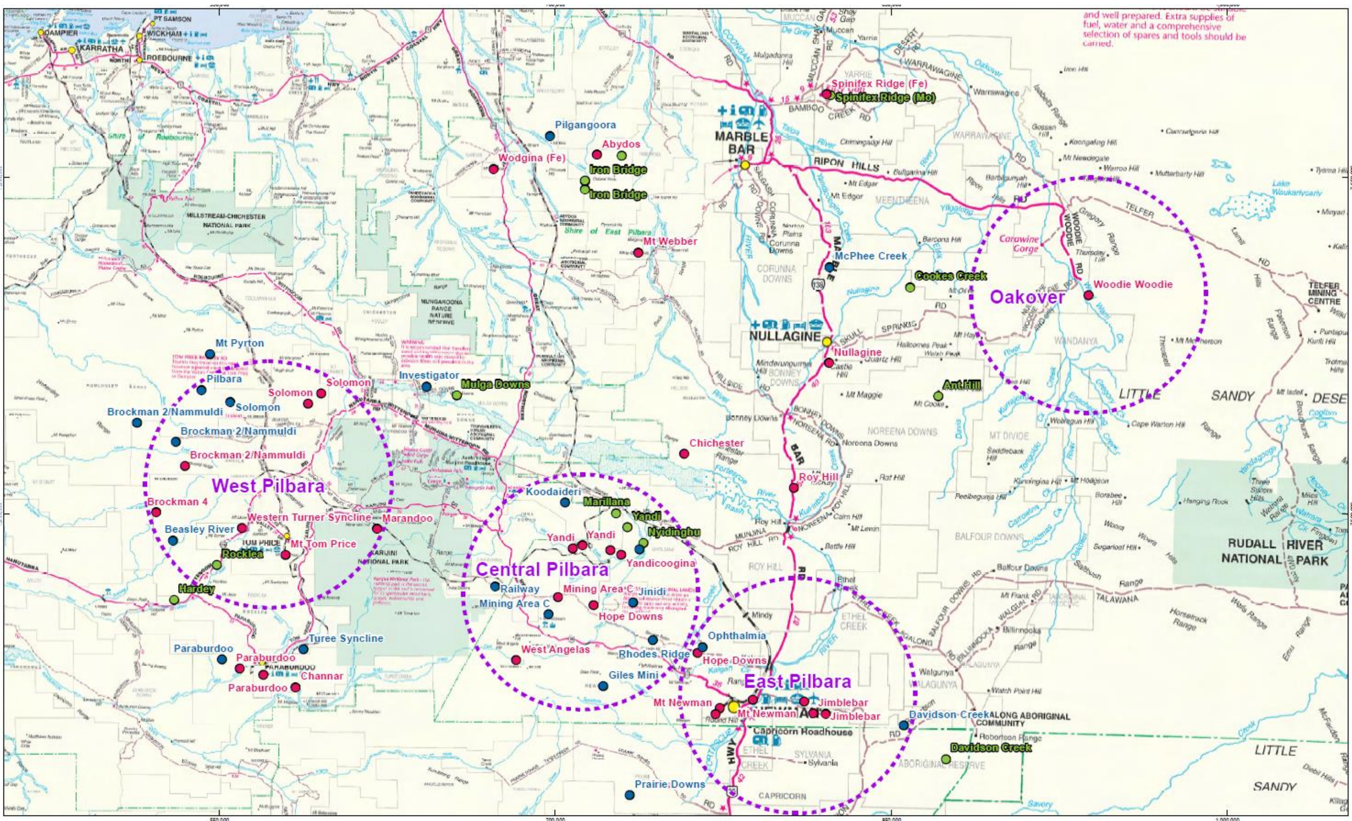

Figure 2.2 PHADI wastewater locations

Since 2013 these surplus volumes have increased to the point whereas of 2020 the annual surplus volume available is approaching 200 GL from across the region, the majority of which is from mine dewatering. The challenge with this origin is that each mining operation has a finite life, so understanding the long-term surplus availability is highly dependent on the mine plan of the various operating companies across the Pilbara. Regardless of this fact, the volumes will be significant for many years to come.

Feedwater type

Surplus water from mine dewatering.

End User

Irrigation for agriculture, none (discharge to creeks).

Constraints

– Ability and willingness of mining companies to provide dewatering sources is constrained by:
  - Schedules of production strategies being highly confidential.
  - Market uncertainties relating to predicting demand and supply.
  - Uncertainty around the balance between above and below water table and future dewatering plans.
– Majority of pastoral leases are held by mining companies who have no appetite to move into complex agriculture.
– Current WA legislation:
  - The Mining Act (WA) 1978. The act is silent on water other than a mining operation can take water for mining purposes, no explicit provision is made that allows for dewatering.
  - The Rights in Water and Irrigation Act (WA) 1913, unless a mining company is a licenced water service provider then water cannot be sold by a mining company to a third party (the HAP got over this legislative issue as Hamersley station lease and Marandoo mine are both owned by Rio Tinto, therefore water was not being sold).
– Remoteness and lack of state owned infrastructure.
– The local economy is dominated by mining which has limited use for water leading to surplus water having no economic value.

Conclusions/recommendations

Three areas of potential development were identified in the 2013 study for further consideration.

Area 1 (Precinct 5): 60 000 ha located on the Marillana Creek Plains on Juna Downs Station. This area is located within the Central Pilbara dewatering zone and has several mines within the 30 km supply catchment that can contribute to irrigation in this area.

Area 2 (Precinct 9): 250 000 ha has been identified to have potentially viable soils which is located east of the Marble Bar Road on Ethel Creek Station. Access to the area would be convenient and the close proximate to Newman would be opportune for the development of supporting services. Additionally, the area is remote from existing and planned mining operations (as of 2013) and related services which would facilitate ease of agricultural operations. The 30 km supply catchment intersect the East Pilbara dewatering zone with the surrounding mines report large dewatering surpluses which are deployed for aquifers recharge and supply augmentation to Newman and surrounding mining operations.

Area 3 (Precinct 10): 250 000 ha located on unallocated Crown land east of Oakover River and north of the Rudall River National Park, this area lays adjacent to Warrawagine and Wandanya Stations. No existing or planned mining operations or related services are within this area that could create barriers to agricultural development. The 30 km catchment contains only one mine (Consolidated Mineral’s Woodie Woodie) which is known to produce significant dewatering surpluses. Coupled with some relatively high yield bores along Ripon Hills Road have indicated that the detrital aquifer system may be suitable to augmentation for irrigation water supply.

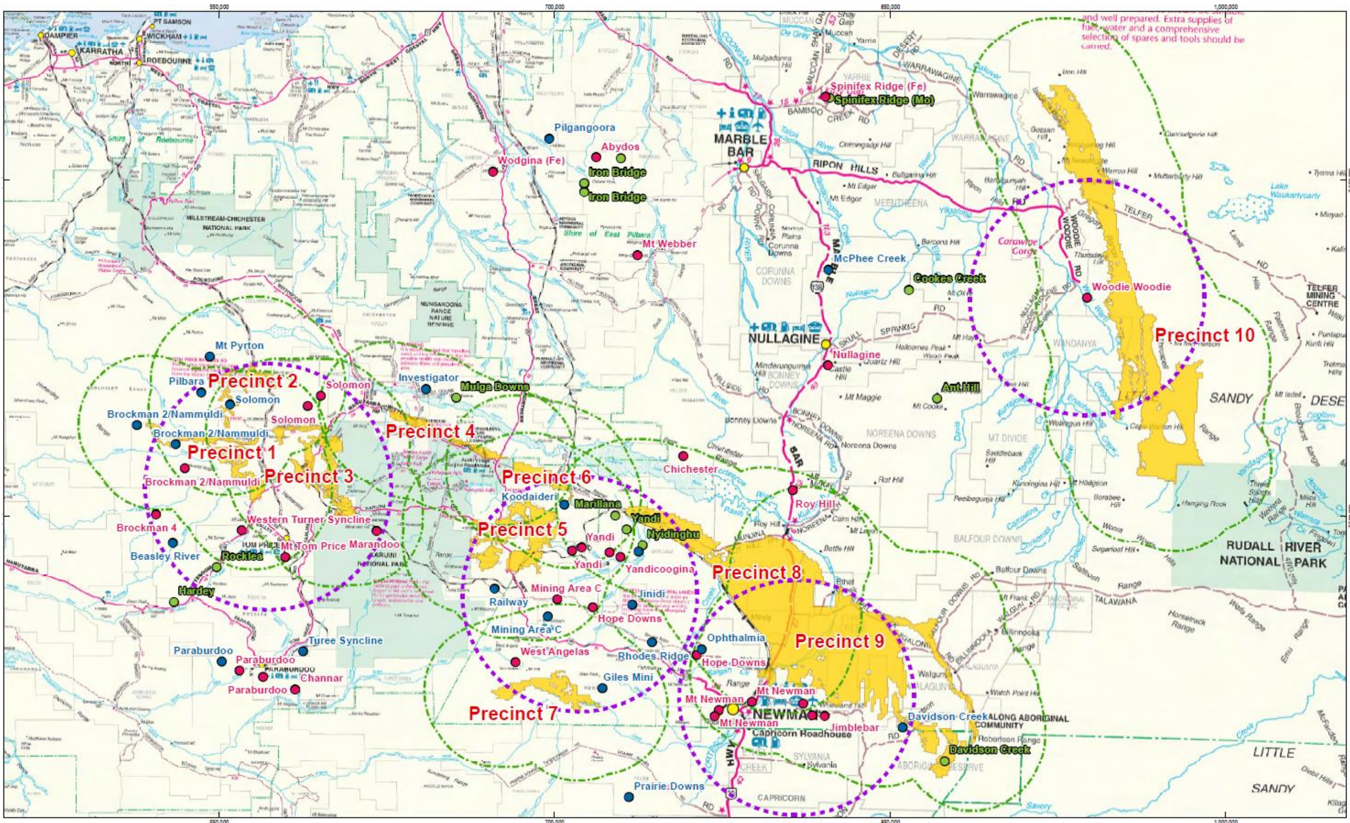

Figure 2.3 PHADI precinct identification

Current status

These developments have not proceeded due to the constraints highlighted and costs of effectively starting from a zero base rendering the projects unviable.

There are ongoing consortia that continue to try to realise the potential of both the land and abundant good quality water but progress is very slow.

2.1.3 Kimberly to Perth pipeline/canal study

An investigation into the viability of varying scheme to supply Perth and the region on route with water supplied from the Kimberly Area, specifically the Fitzroy and Ord Rivers. The researched means of transport included canal system, pipeline, ocean tanker and ocean waterbag to deliver 200 GL/yr.

Location and Capacity

Fitzroy and Ord rivers – capacity unspecified but in excess of 200 GL/yr.

Feedwater

River waters from the Fitzroy.

End User

Integrated Water Supply Scheme (IWSS) region, irrigation for agriculture enroute to Perth, supply for towns and communities enroute to Perth.

Constraints

– Unknown environmental impacts due to limited knowledge of the Kimberly hydrology and ecology.
– Indigenous communities unsupportive of the project.
– Highly variable stream flow from source, in turn requiring off-stream storage or a dam for reliability.
– Not economically viable, primarily due to the distance and the costs associated with construction and operation.

Conclusions/recommendations

The analysis found the most cost-effective means to supply water from the Kimberly to Perth was via super tankers, which was five times the cost of desalination.

The canal transport method was the most expensive and risk-prone option with regards to delivering reliable water supply with the largest environmental impact. The risk of operating a over such distance is the unknown, predominantly the extreme cyclonic conditions that occasionally occur over a significant distance of the canal's length.

The consideration of a pipeline option whilst proven viable with the least risk exposure and greater certainty to water quality, the primary concern was the high energy requirements associated with pumping.

Any commitment to a scheme was recommended to first need substantial environmental and hydrological research to understand the natural systems to outline detailed impacts and help determine feasibility.

2.1.4 Confidential assessments of areas south of Perth

Investigation to initiate a major project to provide climate resilience, capacity and growth opportunities for the region south of Perth.

Location and capacity

Woodman Point WWTP – 60 GL/yr.

Gordon Road WWTP – unspecified.

Feedwater

Primary treated wastewater.

End User

Agriculture and horticulture.

Constraints

– Water from the Gordon Road WWTP is dependent upon availability after the City of Mandurah has accessed it for parks, gardens and similar other uses.
– Increase of surrounding demands from expanding mining, industry, agricultural and urban development.
– Reduced rainfall and streamflow in the area.

Conclusions/recommendations

The treated wastewater from both WWTPs is regarded as non-climate dependent, with the water from Woodman Point having the opportunity of enhancing water security in the study area.

2.1.5 Collie Water Supply Scheme

The Myalup–Wellington project was an industry-led initiative, proposed by Collie Water, to reduce salinity in Wellington Dam, the major water resource in WA's South West with a capacity of 185 gigalitres (GL).

The aim of the project was to substantially increase agricultural production capacity, create jobs and allow economic uplift in the region.

The proposal involved diverting the highest salinity water flowing into the Wellington reservoir from the Collie River East branch into a nearby mine void. Water would then be extracted from the mine void desalinated and piped to the Water Corporation Harris Dam to provide a long-term solution to declining drinking water supplies for Collie and Great Southern Towns.

Extraction of this saline water from the upper catchment of the Collie River, east of Collie will quickly improve the water quality of the river and in turn this will significantly improve water quality of Wellington Dam within a few years.

The ultimate aim of the project was to help diversify Western Australia's regional economy through irrigated agriculture. Currently, less than 20% of the available hectares of the Collie River, Harvey and Waroona districts are irrigated.

The scheme also incorporates new gravity powered delivery system of water to irrigators via a new weir. Another opportunity will be the replacement of the old open irrigation channels with a new pressurised pipe network to reduce water losses and improve supply to irrigators.

Whilst the scheme attracted significant interest and represents an innovative and logical solution to a long standing problem the project has never progressed beyond concept stage due to an inability to secure funding and cooperation between the various parties.

Conclusions/recommendations

The scheme is technically feasible however, the only way it is likely to succeed is with strong government intervention and ownership compelling the various parties to engage with the process.

2.1.6 Assessments around Perth

A 2019 study to identify and assess opportunities for alternative water sources for the Perth-Peel region to meet predicted projects of 2050 demands.

Location and capacity

Wastewater availability predictions for 2050.

– Northwest – 38 GL/yr
– Northeast – 21 GL/yr
– Central – 20 GL/yr
– Southeast – 22 GL/yr
– Peel – 14 GL/yr
– Other – 7 GL/yr

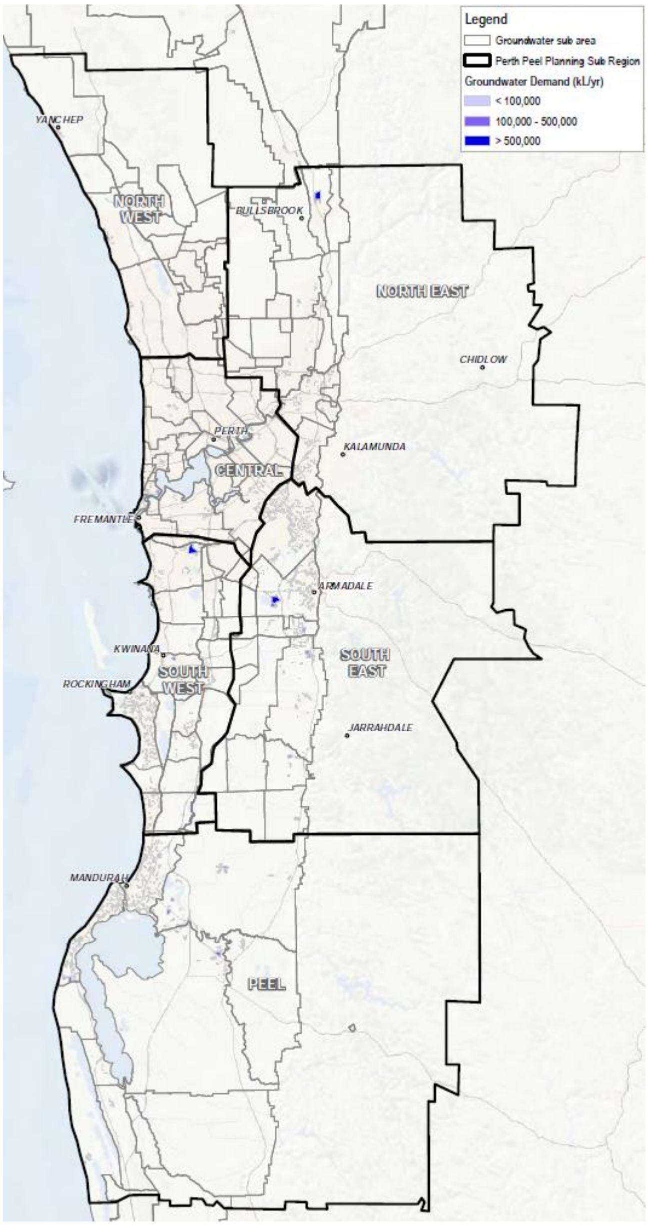

Figure 2.4 ***Perth area WWTP locations***

Feedwater

Treated wastewater from surrounding WWTPs.

End user

Industry, agriculture and aquifer recharge.

Constraints

- Increase of surrounding demands from expanding industry, agricultural and urban development
- Reduction in current groundwater availability
- Proximity to WWTP

Conclusions/recommendations

WWTP wastewater are a potential source of large wastewater reuse. Areas within 5 km of existing or planned WWTP are considered prospective, 5-10 km considered constrained and 10+ km unlikely to be economically viable.

Conceptual water supply schemes are needed to determine the feasibility of this opportunity.

2.2 South Australia

2.2.1 The Bolivar Market Gardens Virginia irrigation scheme

The Bolivar Market Gardens Virginia Irrigation scheme or the Northern Adelaide Irrigation Scheme (NAIS) through increased access to water resource is to promote growth in the agricultural industry. This is to ensure long-term viability of the Northern Adelaide plains horticultural industry, to transform the area into a leader of intensive, high tech food production and provide growth of social and economic futures of its communities.

The existing Virginia Pipeline Scheme currently delivers approximately 17 GL/a from an available 19.5 GL/a, and with NAIS will deliver an additional 8 GL/a with a higher rate available during the wetter months. This additional water will be sourced from the increased use of the Bolivar WWTP.

Figure 2.5 *Scheme locality map*

Feedwater

– Effluent from Bolivar WWTP - up to 20 GL/yr.

End user

– Advanced horticulture and high-tech food production to a new area north of the Gawler River.

Constraints

– Limited current storage.

Conclusions/recommendations

Additional water storage options are recommended as currently due to limited storage, excess discharge is via an ocean outfall into Gulf St Vincent during winter when demand is low. This outfall in the past has affected the health of sea grass meadows which are a major source of fish within the gulf.

During summer there is 100% reuse from the WWTP, therefore increased storage will not only be beneficial for a continued decreased in the amount of ocean discharge and therefore prevent further environmental damage, it will also provide security and additional supply during peak summer periods, thus promoting additional yield and growth. Two methods are currently being explored for viable storage methods, these include:

– Below ground storage in local aquifers (likely the T2 aquifer) recharged through the managed aquifer recharge process.
– Above ground storage, possibly consisting of lagoons or other reservoir methods.

2.2.2 Other schemes

No wastewater is currently sourced from mines in South Australia as mines like those at Roxby Downs/Olympic Dam do not generate a surplus.

Almost all smaller scale schemes throughout South Australia have 100% local reuse. These include:

– Mount Baker: 22,000 EP, current reuse is to a mine for process water and agriculture which is expected to grow post mine closure.
– Murray Bridge: 22,000 EP, potential for reuse from the WWTP to adjacent farms.

Other towns of 15,000-20,000 EP located along the coast (Port Pirie and Whyalla) have limited reuse due to salinity, lack of demand or a combination of both.

Smaller towns of 5,000 EP have near 100% effluent use by nearby agricultural areas.

2.3 Northern Territory

Currently, to our knowledge, no large-scale wastewater irrigation schemes are in operation in the Northern Territory (NT), due to soil sustainability concerns and climate extremes.

Constraints

As noted in NT government's agriculture department advice for food crops (https://nt.gov.au/industry/agriculture/food-crops-plants-and-quarantine/resource-management-for-growers), the constraints to the establishment of schemes appear to be:

– Differing environmental and rainfall environments affecting agriculture such as NT's biggest horticultural export mangoes.
– Extreme potential agricultural water uses during hotter periods.
– Dependency on water supply sources and infrastructure as evapotranspiration may exceed rainfall up to 10 months of the year.
– Indigenous disagreement with use of valued ground and surface water sources.
– Lack of suitable storage sites.
– Gaps in knowledge of risks to water quality.

Conclusions/recommendations

A number of organisations have noted gaps in risks to water quality. Investigation into the following areas should be prioritised before commitment to agricultural development:

– Fine scale monitoring of pesticides and plant nutrient contamination in water bodies.
– Movement paths of pesticides and plant nutrients through soil to ground water.

2.4 Queensland

2.4.1 Water for Lockyer study

A strategic business case has been prepared to identify the preferred option for the supply of additional water to the highly fertile and productive agricultural area of Lockyer Valley (and the Somerset Regional Council area located 90 km west of Brisbane), which have significant growth and economic potential. This area, which is ranked within the top 10 fertile areas in the world and grows a very diverse commercial range of fruits and vegetables, has the limiting factor of water supply preventing economic and agricultural development. The current primary water sources (mainly groundwater with some surface water) are fully allocated and unreliable which is impacting productivity and growth of the area.

Location and capacity

Area in Lockyer Valley and Somerset Regional Council within 200 km of the Western Corridor Recycled Water Scheme (WCRWS) – desired capacity unspecified

Feedwater

Recycled water.

End user

Irrigation for agriculture and as required for urban water security.

Constraints

– Increase of surrounding demands from expanding agriculture
– Competition with other cost-effective schemes

Conclusions/recommendations

From the multiple combinations considered in the report, the options that included the WCRWS connection consistently had high capital costs and the greatest negative Net Present Value. As a result, the largest additional water supply of 50 ML was achievable however still had medium reliability.

Other options that didn't include wastewater were recommended from this study.

2.4.2 Great Whitsunday Alliance

The Great Whitsunday Alliance (GW3), consisting of three regional councils, being Mackay, Isaac and Whitsunday, with a combined population of 172,500, is located North of the Tropic of Capricorn and form the heart of the Whitsunday Islands area. The GW3 in an investigation in this region to understand the effects of water reliability on economic development, identify water infrastructure and opportunities to provide a catalyst for economic development and finally enhance current knowledge underpinning water infrastructure planning. Currently groundwater is the primary water source, with large supplement volumes from dams and weirs, transported via the supply schemes of Bowen Broken, Proserpine, Pioneer, Eton and Burdekin Haughton.

Location and capacity

Potential recycled water sources:

– Arrow Energy's Bowen Gas project – 5-10 GL/yr
– Mine affected water (onsite storage) – 186 GL as of 30 June 2020

Feedwater

Coal seam gas (CSG) water.

End User

– Construction and dust suppression
– Raw water storage of mines for additional uses
– Irrigation for agriculture

Constraints

– Uncertainty of reliability, as historically CSG water production forecasts have been inaccurate
– Variability of mine affected water volumes
– Water quality and environmental conditions
– Review of CSG license agreements

Conclusions/recommendations

As mine-affected water is largely dependent on rainfall, this as a source has a high degree of risk from a reliability perspective. On the contrary, during wet conditions water volumes can build beyond on-site storage capacity.

Due to the unreliability of wastewater production from CSG, Arrow Energy for example are noted to be unlikely to guarantee given volume of water supply, therefore commercial agreements are likely to seek guaranteed water to be taken as build-up of water will eventually impact production. These types of agreements can then lead to approvals being needed to discharge surplus water to a new location and can be time consuming and/or cost prohibitive.

Mining companies have expressed a desire and begun to move away from surface water supply, to reduce environmental impacts. Willingness has been shown to invest in storage facilities and reuse infrastructure.

Investigation into a potential centralised mine water reuse scheme has been proposed to overcome supply/demand variability, with a network of distribution pipelines to join disparate supplies into a central grid system. Management of this grid would provide greater supply reliability than isolated mines and could further be bolstered by addition of surface water in times of drought.

In this study, other options that didn't include wastewater were also investigated.

2.4.3 Bulk water security strategy

Currently in its fifth annual release, the Queensland Bulk Water Opportunity Statement (QBWOS) is a strategy for the QLD government to investigate better use of existing bulk water infrastructure and effective investment into new infrastructure. Specifically, demand management, optimal use of existing supplies and future bulk supply options as to all facilitate growth and economic development for regional communities. This strategy also provides the framework and policies to enable efficient and effective delivery of bulk water supply options in response to current and emerging conditions.

Location and capacity

Recycled water – unspecified.

CSG water – 1,700 GL (proposed lifetime of all current CSG projects).

Feedwater

– Sewage, greywater and storm water
– Water from QLD CSG mines

End user

Unspecified but various types e.g. power generation, agriculture.

Constraints

– Water treatment and quality appropriate for intended use
– Varying quality with typically high salinity from CSG water
– Strict environmental requirements

Conclusions/recommendations

The study identifies recycled water from sewage, greywater and storm water systems, as well as CSG water, as possible supply options to diversify supply to meet demand, however, does not investigate feasibility or constraints to utilise this resource.

Water from CSG commonly has commonly high salt content so any water sourced from CSG mining will require some degree of desalination or treatment to make usable. Bulk water infrastructure such as dams can have direct impact on the water downstream by altering the natural volume of flowing water, chemical composition and lead to land-use changes which can have further impacts. New bulk water storages and sources are recommended to have an in-depth environmental analysis, as to determine impacts that can occur and the extent of the impact as to protect waterways, including but not limited to, the Great Barrier Reef.

2.4.4 The Nuwater project

NuWater is an irrigation plan to utilise recycled water and existing infrastructure from the WCRWS (specifically from the outfall into Moreton Bay) to meet agricultural demand in the Lockyer Valley and Darling Downs during non-bulk water shortages. During periods of bulk water shortages, irrigation would be interrupted to allow the use of the WCRWS for the emergency supplementation of potable water supplies through Wivenhoe Dam.

Funding from the Australian Government National Water Infrastructure Development Fund has allowed a feasibility study and preliminary business case to test the feasibility of possible options.

Location and capacity

Nominal capacity – 232 ML/d.

Current capacity – 180 ML/d.

Feedwater

Treated wastewater from six urban STPs (Luggage Point, Gibson Island, Oxley, Wacol, Goodna and Bundamba).

End User

Irrigation for agriculture.

Constraints

Significant energy requirements.

Conclusions/recommendations

Alternative combinations of recycled water delivery options, pump stations and WTP were investigated for feasibility. Ultimately the business case found the most favourable combination, from an economic, financial and commercial analysis, included:

– Class B/C water with the WCRWS pipeline
– Four new booster pump stations located at Heathwood, Lowood, Gatton and Toowoomba Range
– New transfer pipeline from Lowood to Gatton and on to the Darling Downs
– In the Lockyer Valley, new class A+ recycled WTP, 4 GL recycled water storage and a distribution network
– New Darling Downs distribution network for recycled water delivery
– Power supply upgrades

2.4.5 The Western Corridor project

The Western Corridor project is a scheme which recommissioned existing AWTPs to supply water to the South-Eastern region's power stations with the emergency capability to discharge into Lake Wivenhoe (main storage dam for Brisbane). During periods of drought and water shortages, the WCRWS would supplement drinking water supplies and provide security during bulk water shortages by discharging to the Wivenhoe Dam that would be treated again at Wivenhoe WTP and distributed within South-East Queensland.

Location and capacity

Nominal capacity – 232 ML/d

Current capacity – 180 ML/d:

– Bundamba – 60 ML/d
– Gibson Island – 50 ML/d (100 ML/d capacity)
– Luggage Point – 70 ML/d

Feedwater

Treated wastewater from six urban STPs (Luggage Point, Gibson Island, Oxley, Wacol, Goodna and Bundamba).

End user

– Swanbank and Tarong Power Stations
– Lake Wivenhoe (when levels drop below 40%)

Constraints

Providing enough flow from the source STPs in times of drought to meet demand is difficult.

Conclusions/recommendations

Unspecified.

2.4.6 Bradfield Scheme

The Bradfield scheme proposal is an inter-catchment water diversion scheme located in Northern QLD to move water inland to Central Western QLD to expand regional agriculture. Originally devised in 1938 by Dr John Bradfield, variations have been analysed in detail with technical feasibility being confirmed however none as yet have been found commercially viable.

GHD recently conducted a study into the optimistic feasibility and economic value of historic and modern Bradfield Schemes.

Location and capacity

East-draining Upper Tully, Herbert, Burdekin and Flinders catchments – 3,305 GL/yr.

Feedwater

River water from Tully, Herbert and Burdekin Rivers.

End user

Westerly draining Flinders catchment, Northern Murray-Darling Basin (MDB).

Constraints

– Community concerns due to the benefit of one basin at the expense of another.
– Long approval, construction and agricultural development time (11+ years) before economic benefit is seen.
– Incompatible infrastructure with contemporary indigenous values and development objectives.

- High risk economic unfeasibility as minimal price variability for crops causes growing costs to exceed revenue.
- Reduced scheme yield over lifetime due to strong climate data indicating reducing rainfall in feedwater catchments.
- Common dam and tunnel infrastructure cost overruns likely.
- Required changes and negotiations to the existing water plan with current stakeholders.

Conclusions/recommendations

Infrastructure costs were too great for solely crop revenue calculated to repay a maximum of 51% of the scheme's costs over its lifetime. The maximum transferable water quantity being less than half as that proposed by Bradfield with original storage capacities and streamflow greatly overestimated than determined through the study.

Due to the financial costs and ecological impacts of the Bradfield-style schemes, it is recommended that investigation into smaller resource developments situated in proximity to the location of where the water is captured as to mitigate constraints of larger scale alternatives.

The opportunity to support other industries and to cost recoup via generating hydro-electric power along the water supply route is limited.

With decreasing rainfall throughout the lifetime of the scheme due to climate change, the yield of the scheme reduces and economical viability becomes progressively worse due to reduced farmland area and increase water transport costs.

2.5 ACT

GHD is aware of the old Northern Canberra Water Reuse Scheme (that irrigates parks and gardens) that has not been in use for some time and are not aware of any plans by Icon Water to restart the system. GHD is aware the Lower Molonglo Water Quality Control Centre (LMWQCC) discharges into the Murrumbidgee River via the licenced discharge point into the Molonglo River, however, GHD is not aware of any current schemes to reuse this discharge. This plant has a 90 ML/d average day discharge.

2.6 Victoria

2.6.1 Greater Melbourne

Assessment by GHD of the economic feasibility of strategic options for large scale use of alternative water sources (including stormwater, recycled water and rainwater) across Greater Melbourne over the next 50 years.

The primary STPs of Melbourne include the Eastern and Western STPs, which together treat 90% of Melbourne's wastewater. An additional future STP in the Northern region has been identified as an option however currently no identified discharge pathway has been confirmed. This represents a possible agricultural use opportunity for land to the north of Greater Melbourne.

The Eastern STP (ESTP) treats approximately 40% of Melbourne's wastewater. Currently the ESTP supplies 5 GL/yr to the Eastern Irrigation scheme which supplies an advanced tertiary treatment plant that supplies class A water to the Cranbourne/Clyde areas for agricultural irrigation.

Additional uses for this treated wastewater have been the focus of recent investigations into the feasibility of a new pipe network from the ESTP by extension from the Eastern Irrigation Schemes to fill the abandoned open pit mines or encourage economic and agricultural growth in the 'Bunyip Food Bowl', however, was determined to be non-economical.

The discharge from the ESTP is via ocean outfall at Boags Rocks, Gunnamatta. The areas directly adjacent to the existing pipe network have not been able to determine a cost-effective arrangement to tap into this treated water source. Further investigation into schemes surrounding this area is recommended.

The Western STP (WSTP) treats approximately 50% of Melbourne's wastewater. The water in this region has a high salt content that would require reduction (i.e. costly reverse osmosis treatment) for agriculture use. Coupling this with the cost of required infrastructure to transport the treated water to agricultural regions to the north has currently determined this scheme to be economically unviable.

Location and capacity

Eastern STP – 80 GL/yr.

Western STP – 100 GL/yr.

Northern STP (future) – 2 GL/yr.

Estimated by 2070:

Total wastewater – 700 GL/yr.

Urban stormwater runoff – 750 GL/yr.

Feedwater

STP's listed above plus stormwater considered also.

End user

Currently limited agricultural use from Eastern STP only.

Constraints

– Non economically viable due to characteristics unique to differing wastewater sources.

Conclusions/recommendations

The two key sources of alternative water to supply on a large scale are storm and wastewater, both of which have quite different characteristics as potential water sources.

Whilst there is substantial volume available annually from stormwater, its occurrence over short periods for high volumes makes its use in supply to large networks difficult to utilise without constructing very significant storages. The difficulty of upstream harvesting to protect downstream tributaries and storage cost and location requirements are also major factors.

A single citywide network is unlikely to be feasible though localised, opportunities which build off existing schemes may be recommended to be investigated further.

Greater reuse in the Bunyip Food Bowl from the ESTP and for agricultural land to the north of the future NSTP appear to be the most viable uses of wastewater for agriculture.

2.6.2 Several smaller projects outside Greater Melbourne

2.6.2.1 Gippsland water factory

Gippsland Water Factory is a WWTP treats 35 ML/d of high-quality water with 8 ML/d being sold to the Australian Paper's Maryvale Mill for industrial processes with the remaining used for some irrigation, to supply services to 48,000 domestic customers and distribution along the regional outfall sewer. It comprises of two WWTPs that share common infrastructure and has feed wastewater from nine towns around central Gippsland and wastewater from the Maryvale Mill.

2.6.2.2 Barwon Water – Geelong, Golden Plains, Bellarine and Coast System

The Barwon Water service system for Geelong and neighbouring regions is the largest Barwon water system servicing 90% of their customers (323,000 population). This network consists of eight reclamation WWTP with the largest being the Northern WTP providing 2 GL/yr of Class A recycled water. Three of the WWTP has 100% reuse either onsite or for irrigation of nearby golf courses, recreation reserves or farmland. Portions of the remaining WWTP are used for irrigation or discharged into the Bass Strait under EPA discharge license.

Opportunity has been identified to investigate viability an indicative volume of up to 15 GL/yr of recycled water use for agriculture, industry, to support the environment/recreation and potential for indirect potable reuse.

2.6.2.3 Barwon Water – Colac System

The second largest system for Barwon Water servicing a 14,000 population, consists of only one STP located on the North-East of town and treats 1,450 ML/yr from residential, commercial and industrial sources to Class C. Less than 5% is reused onsite, leaving 1,300 ML/yr available that currently is discharged to Lake Colac. Further works to the STP are proposed to progressively increase capacity of the plant to manage changes and future growth in local industry.

To note Lake Colac largely dried out during the millennium drought and as recently as the 2015/16 summer, discharges from the Colac WTP are a major source of water for the lake during dry periods.

2.7 NSW

2.7.1 Existing agricultural reuse schemes in regional areas

There are several wastewater reuse for agriculture schemes in the larger population centres (>50,000 people) in regional NSW as follows:

– **Coffs Harbour**. A reclaimed water systems has been supplying to commercial customers (many in agriculture such as blueberry farms) since the early 1990's, with zero charge to customers. Council has resolved that as from 1 July 2021, charges will be levied, with a financial rebate program to be established to reward commercial users who are able to demonstrate a high degree of efficiency in their use of Recycled Water. Charges will be 20 cents per kilolitre (kL) up to the allocated volume per customer (with modest incremental increases stated for the next three financial years), and then $2/kL above that.

– **Tamworth**. The Tamworth Regional Council effluent reuse farm (with the operating contract currently being renewed) is able to source 80% of the flows from the Westdale Wastewater treatment plant (8km away) and stored on-site in a 1,500 ML dam. The majority of the 3-4 GL annual volume available is used at the farm in an average rainfall year for cropping (crop options currently considered include lucerne, corn, wheat, barley and canola). The property covers 600 ha and is irrigated by 13 centre pivots and is serviced by a pump station and five pumps capable of pumping 45 ML/d. Council is currently investing in a further two centre pivots for the farm to increase the total irrigated area to 685 ha.

– **Dubbo**. While Dubbo has a wastewater-connected population closer to 33,000 people, GHD has been involved for many years with the operation of the Greengrove Effluent Reuse Scheme that receives most of the high quality treated effluent flows from the plant (as well as another private landholding). Annual volume available for irrigation is in the order of 3 GL, with around 1 GL of storage at the plant holding volume well during wet weather to maximise reuse. The scheme has the capacity to irrigate up to 16 ML/d and is designed to accommodate Dubbo's reclaimed water reuse needs for many years. The scheme consists of 208 ha of efficient irrigation comprising of 6 centre pivots.

– **Wagga Wagga**. The Wagga Wagga City Council region is supplied its potable water from Riverina Water County Council. From the regions three STPs that service its 63,500 residents (to reduce potable water costs and sewage discharge to the Murrumbidgee River) recycled water is used for irrigation of sports grounds, cemetery lawns and non-food agricultural crop irrigation to a capacity of around 23 ML/d.

– **Central Coast**. The majority of the effluent from the eight STP's in the Central Coast area (servicing a population of around 345,000 people) is secondary treated and discharged to ocean via outfalls. A small percentage is tertiary treated and delivered to golf courses, parks and ovals, with none identified for agriculture.

– **Shoalhaven**. The population of 165,000 is serviced by thirteen WWTP with discharges varying between dune exfiltration, ocean outfalls and direct connection to local agricultural irrigation and sporting fields. Eight of these WWTPs connect into the regions Reclaimed Effluent Management Scheme (REMS) where in 2019/2020 recorded a re-use of 1,870 ML to over 600 ha of land for uses of dairy farming, golf courses and sporting grounds.

2.7.2 Hunter Water

Hunter Water provides water and wastewater services to a population of 600,000 in the Lower Hunter Valley region. There are currently 15 recycled water schemes linked to their system which produce a total of around six billion litres of recycled water each year. This equates to only around 10% of all wastewater generated by Hunter Water. Only a small proportion of this is for agriculture, with the majority of that reused going to golf courses, industrial users of third-pipe residential systems.

Some of the opportunities they are currently investigating are:

– Irrigation schemes in Newcastle, Lake Macquarie and Cessnock for public open spaces

– Dual reticulation schemes for new residential developments

– New and expanded industrial recycling schemes

Schemes to supply recycled water to the power stations further up the Hunter Valley have been suggested in the past but our understanding is that none have proceeded to detailed design.

2.7.3 Sydney Water

Sydney Water operate 14 water recycling plants, with the majority as tertiary treatment and a few as advanced tertiary treatment. Only two of these are used for agriculture that includes the Picton Wastewater Scheme and the Gerringong - Gerroa Sewerage Reuse Scheme.

The **Picton Wastewater Scheme** was commissioned by Sydney Water in early 2000. The Scheme currently services approximately 18,000 people living on the south-western outskirts of Sydney. The Scheme originally involved the collection, transfer, treatment and recycling of wastewater for the three townships of Picton, Thirlmere and Tahmoor. In 2014, two additional towns, Bargo and Buxton, were connected to the system. Recently, Ingham’s Turkey Processing Plant was also connected to the Picton Wastewater System under a licensed Trade Waste Agreement. Currently, about 2.3 ML of wastewater is processed by the Picton WRP daily. Amplification of the Scheme to accommodate growth and the connection of additional areas commenced in 2014 and was completed in 2017.

Wastewater is treated to secondary and tertiary levels at the WRP and stored separately in two farm dams. The secondary treated recycled water is stored in the Eastern Dam and used for irrigation on the Farm to grow fodder crops. When the Scheme was commissioned, it was expected that during dry weather, 100% of the secondary treated wastewater would be used for irrigation. Tertiary treated recycled water is stored in the Western Dam and can also be used for irrigation, or discharged to Stonequarry Creek during wet weather (precautionary discharges).

GHD has operated and managed the Picton Farm on behalf of Sydney Water since 2001. The use of recycled water at the farm is based on moisture deficit irrigation, whereby the volume of irrigation is regulated based on weather and soil conditions, so that the volume of recycled water applied never exceeds the capacity of the soil to absorb it. Through this approach, both surface runoff and deep percolation of wastewater are prevented. Both pivot irrigation (40 ha) and solid set sprinklers (80 ha) are used at the farm with 300 ML of storage available on site. The scheme produces high quality fodder (hay and silage) for local dairies and other livestock enterprises and reuses 100% of the biosolids generated on site.

The **Gerringong - Gerroa Sewerage Reuse Scheme** on the south-coast of NSW (approximately 120 km south of Sydney) was commissioned in 2002, and designed to meet the local community’s needs for an estimated population of up to 11,000 people with a daily capacity of 2.2 ML. The scheme consists of a treatment plant, 50 kilometres of pipelines and 12 pumping stations and is designed to reuse 80% or more of the treated effluent for irrigation at a local dairy farm. There are also occasional discharges into adjacent sand dunes and into a nearby natural wetland in extreme wet weather conditions.

2.8 Tasmania

Tasmania differs from other states and territories as drinking and wastewater services are provided by a single state-wide utility, Tasmanian Water and Sewage Corporation Pty Ltd (TasWater).

According to REPORT ON THE STATE OF THE TASMANIAN WATER AND SEWERAGE INDUSTRY 2019-20 (Tasmanian Economic Regulator, 2021), thirty-six of TasWater’s 77 Level 2 STPs discharged a proportion of their outflows to effluent reuse or land irrigation schemes in 2019-20. Ten STPs achieved full reuse in 2019-20, and an additional eight STPs succeeded in discharging 95 per cent or more of their total discharged flow to reuse. The total portion of reuse recycled water and the other discharges volumes and locations can be seen below.

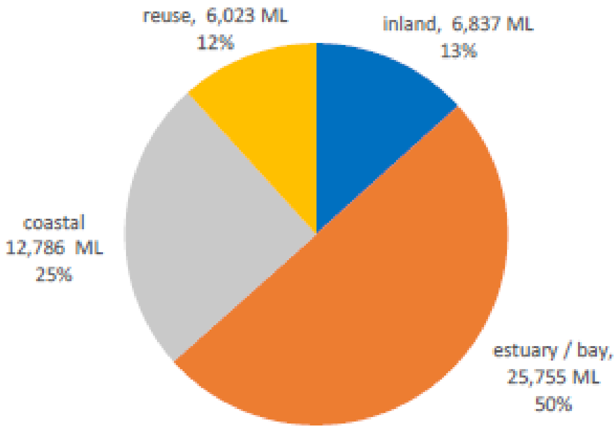

Figure 2.6 Tasmanian sewage discharges (ML/year; percentage of flow)

2.8.1 Hobart area

STPs in the outer-Eastern Greater Hobart area are either regularly or periodically discharging into waterways which impact the Pittwater (the water body between the mouth of coal river and entrance to Fredrick Henry Bay). EPA guideline changes have created a deadline of July 2022 to cease all discharge to Pittwater.

The three existing reuse schemes (Clarence, Brighton and Penna) represent 67% of the state's recycled effluent. The two larger schemes (Clarence and Penna) which discharge into the Pittwater have some current reuse for sporting grounds, however none are used for agriculture.

Location and capacity

Eastern Hobart STPs (Penna Scheme in Coal River area) – possible 408 ML/yr.

Clarence Recycled Water scheme (also known as the Coal River Valley Recycled Water Scheme) – 2,600 ML/yr.

Feedwater

Sorell and Midway Point STPs.

End user

Agriculture.

Constraints

– Competition with other cost-effective schemes (existing or new)
– More supply will likely result in intensification of agriculture, as opposed to new opportunities
– Mismatch between supply and demand
– Increase compliance costs for increased treatment due to regulatory requirements
– Variable product quality and costing between schemes

Conclusions/recommendations

The constraints as stated above have been identified by TasWater due to business and asset changes, possible solution to these constraints have been noted and include additional storage construction, connection between schemes, upgrade of schemes and pricing changes.

There is opportunity for intensification/expansion of schemes for additional reuse and greater agricultural output similarly to the grant for minor expansion of the Penna Scheme to allow for 100% reuse. It is noted there is future opportunities to connect the Penna and Clarence Schemes for operational flexibility.

2.8.2 Launceston area

Many of the areas that could be used to expand or intensify agriculture that surround Launceston are already supplied by the TasWater irrigation schemes or by very small individual STPs. Launceston itself has a combined wastewater/stormwater system to the STP with no current reuse.

Location and capacity

Various STPs – capacity unclear but well below 50,000 EP.

Feedwater

Small STPs outside Launceston.

End user

Agriculture.

Constraints

– Competition with other cost-effective schemes (existing or new)
– Combined sewer/stormwater in Launceston decreases feasibility (costly to treat for hydrocarbons)
– More supply will increase deification as opposed to new opportunities

Conclusions/recommendations

Limited opportunities.

2.8.3 Very small schemes in regional Tasmania

Of the 77 STP throughout Tasmanian, those not in high density areas of Hobart or Launceston are scattered either along the East Coast or along the central Midland Highway. Reuse of recycled water is via local irrigation or outfalls into local waterways or the Tasman Sea.

Location and capacity

Various STPs - capacity unclear but well below 50,000 EP (likely to be all below 2,000 EP).

Feedwater

Local urban wastewater.

End user

Agriculture.

Constraints

– Competition with other cost-effective schemes (existing or new)
– Combined sewer/stormwater in Launceston decreases feasibility
– More supply will increase densification as opposed to new opportunities

Conclusions/recommendations

Unspecified.

3. Principles of viable schemes

From our review of the existing schemes operating and studies for schemes that have not yet been deemed viable (as shown in Section 2, the number of currently non-viable schemes are the majority), we have gained a greater understanding of the principles that need to be prevalent for specific schemes to be viable. Discussion of each of these principles is shown in the subsections below.

3.1 Economic viability

3.1.1 Principles

The objective of the schemes are to find opportunities to use wastewater in agriculture where it is found to offer net economic benefits to the community . It is important to ensure the schemes are aligned with government's initiatives in integrated water cycle management, circular economy and relevant water initiatives such as the National Water Initiatives. This will be achieved by promoting cost effectiveness in the schemes, resulting in:

– Better match of demand and supply
– Increased use of wastewater as a water supply option
– Ensure quality of wastewater used is at standard set out by the authority and/or regulators
– Promoting private investment in water recycling

The principles for assessment of economic viability will need to consider the following constraints identified in the above schemes:

3.1.1.1 Demand

– Demand for wastewater: it is driven the price of access to the water in comparison to alternative sources of water, assessed risk, and the expected financial returns from the use of that water. An increase of demand driven by expansion in the nearby industry (possibly driven by government policy or initiatives), or agricultural and urban development, or reduction in surface water availability; or weather conditions, or storage limitation.
– Requirement for disposal of a suitable quality wastewater supply: if the wastewater is supplied from a nearby mine's dewatering process, the supply will depend on mine production strategy, including the asset life. It also depends on market conditions which drive production of the mine.

3.1.1.2 Supply

– Water supply sources: A sustainable water supply will have less requirements for ongoing accessibility of ground and surface water, particularly in areas with more variable rainfall due to climate change. The quality of the wastewater supplies (and any required investment in capital works for treatment infrastructure) is a major factor. Sustainability of mining surplus water (mainly in Northern WA, given that most large mines in other states run a water balance or deficit) is also dependant on the operational life of the mine.
– Availability of suitable land: From the No-Go spatial assessment workshop held on 21 December 2021 (Refer to minutes in Appendix A), it was agreed that areas with high slope, inappropriate land use designation, national or state environmental protection, poor soil conditions (pH outside acceptable range, desert areas, acidification potential etc) would be considered inappropriate for new agricultural development or installation of conveyance structures for potential schemes. This eliminates over half of the land in Australia from consideration. The comparison of less constrained land that is further from supply sources against more constrained land in closer proximity will need to be assessed spatially in each case by weighting key project feasibility factors to further narrow down the remaining land to identify the most suitable. Extreme wind/cyclone areas impact the feasibility of using traditional irrigation methods for agriculture but will not be noted as No-Go areas instead, these will be identified as least preferred in spatial mapping.

3.1.1.3 Costs

– Capital costs: Storage and delivery systems capital costs can be significant. Trade-off between larger capital costs and greater capacity leading to greater reliability will need to be analysed. Also, consideration must be given to operating and maintaining the delivery systems.
– Cost of transportation: It depends on distance from a treatment plant and locational remoteness. It was demonstrated in one extreme case study that the most cost-effective way of delivering water is via super tanker.
– Cost of treatment/production: costs can vary widely depending on quality of the source water and the quality required for the recycled products.
– Cost of energy: Should wastewater be transported via pipes (greater infiltration and evaporation losses in channels suggests that pipelines are the most effective conveyance structure), required pumping energy usage is potentially one of the key operating costs.
– Environmental costs: offsetting costs for disturbance of environmentally sensitive areas for treatment, conveyance and/or agricultural footprint of schemes can be substantial.
– Government intervention: Many of the schemes require government intervention (funding, policy or both) to be viable.

3.1.1.4 Legislation and regulations

– Legislation barriers: complication resulting from the rights in Water and Irrigation (WA) restricted mining company to sell water to a third party unless it is registered as a water service provider.
– Level of treatment requirements: EPA requirements.
– Preference for on-land disposal: This approach is increasing with most EPA’s around Australia.

The principles for an economically viable scheme should include the following elements:

– Encouraging the adoption of least cost practice, taking into consideration of associated risks and practicality.
– Including incentives for promoting the use of wastewater in agriculture.
– Minimising seasonality impact on water source supply and demand.
– Promoting the use of innovation whereby it improves efficiency and effectiveness of the integrated water cycle management.
– Provision of transparency of regulation and governance of the scheme, plus simpler legislative pathways for scheme development.

3.1.2 Assessment

To promote the use of wastewater in agriculture, it is critical to ensure the wastewater scheme will result in optimising net economic benefits to the end users as well as to the wider community. A framework for assessing economic viability of a scheme is to evaluate the total economic value of using the wastewater in agriculture. This relates to:

– Financial: all relevant infrastructure which facilitates the use of wastewater
– Economics: impact on the end users
– Social: impact on the immediate community and wider economics
– Environment: impact on environment

Considerations will be given to:

– Costs: Direct and indirect costs (including transportation); environmental costs; reticulation costs
– Benefits: Avoidable direct and indirect costs; water savings; benefits to the community

Cost benefit analysis is the common approach of measuring economic viability of a project. A well-defined base case is to reflect the current situation in which the proposed project does not progress. It is required to identify costs and benefits incurred in the current situation. The base case is used to test the proposed project net incremental economic impact over the life of the project (assessment period).

Regulations and financial assistance from government aim to promote efficiency, cost minimisation, high level of service in the provision of wastewater in agriculture, and risk mitigation. The level of assistance will depend on the outcomes of the economic viability assessment. The three likely outcomes will be:

– Financially viable but not economic or social or environmentally viable: this will require government intervention and/or regulations to minimise the negative impact of the using wastewater in agriculture.
– Financially not viable but economic or social or environmentally viable: this will require government subsidy or taxation incentive to encourage use of wastewater in agriculture under the scheme.
– All elements (financial + economic + social + environmental) of the scheme are proven viable: this will require minimal assistance from government or regulations.

This project could consider each region in terms of a State or Territory, agricultural region or by local government level (but will not get down to the farm level based on materiality thresholds for the project on this national scale). Examples of the expected costs and benefits can be provided in case studies to give some context to the scale of the expected impacts. Below is a framework for understanding economic viability using the cost benefit assessment method. Depending on the available data, the assessment may be qualitative and/or quantitative but should be viewed from the perspective of the net economic welfare outcome for the Australian community.

This assessment has not compared the proposed allocation of wastewater project to other uses for wastewater or the funding that might be required, which is typically required for a full cost benefit analysis.

The base case for the use of wastewater to supply agricultural producers for this project is developed by understanding key values for each region being assessed as per the following subsections.

3.1.2.1 Agricultural production base case:

– Water supply:
  - Quantity of water per year per hectare or other metric to understand the total volume demanded and the match to actual supply. Many agricultural water supply contracts allow for high/low water flows where the actual water supplied can vary from the contracted volume.
  - Quality of water – across Australia the water quality for agriculture can vary significantly and the regulations controlling the quality is different for different products and locations. The current water supply quality measure is also different in each region.
  - Reliability of agriculture water supply is highly volatile and can greatly impact on the output of the business.
  - Cost of production of water inputs to each quantity of agricultural good produced or by hectare.
  - Cost of water delivery from source to agricultural use location.
– Agricultural output:
  - Quantity of the agricultural product demand and supply will assist in understanding the gap that might exist and will provide an estimate of the base case of the total value of production for each region.
  - Quality of agricultural output can vary for regions, products and other factors that might be impacted by access to the wastewater.
  - Value of the current agricultural output separated into financial and economic values:
    – Financial value of costs and benefits are focused on per farm or per type of product to understand the capacity to pay and the possible flow to economic impacts:
      - Cost of production of the farm output and if available the cost of water inputs to each quantity of agricultural good produced.
      - Revenue from agricultural production compared to the costs of production to understand the approximate net financial outcome. Typically, agriculture will have highly seasonal changes to financial outcomes, therefore an average over time or seasonally adjusted financial outcome is likely required.
    – Economic outcomes from current economic activity are important to understand as this assessment is likely to find government funding of project would be required to support wastewater use and the economic benefit to the community is the justification for this investment. Economic outcomes are separated into direct and indirect, tangible and intangible:

- Direct outcome examples – local employment, purchase of local products, increased food supply security, transport, export value, environmental impacts, social impacts, financial and commercial impacts.
- Indirect outcome examples – reduced social problems in regional areas due to supporting employment in the regional townships through the purchase of local goods and services to support agricultural activity, agricultural banking/finance, city commodity trading, ports support.
- Wider Economic Benefits (WEBs) – care is needed when considering the WEBs as the relationship to the activity can be difficult to measure or prove but can include increased property values, secondary and tertiary business activity flowing from agriculture activity.

3.1.2.2 Wastewater production base case

Wastewater production base case is measured separately at this point to understand the net economic change of this part of the project. Considerations include:

– Quality of the wastewater that is disposed of into the environment as this will enable a comparison for the required quality of water in the project case.

– Quantity of water produced per period (day/month/year).

– Cost of wastewater treatment and disposal:

  - Financial – the best cost estimate would be the long-run marginal cost but typically an average cost per megalitre is used or specific costs of capital expenditure and operational and maintenance costs can be used to understand the per unit costs. Any revenue from current sales of the wastewater will also be important.
  - Economic – the treatment of wastewater before dumping provides health, social, environmental and avoided costs benefit that need to be understood to some extent to compare against the project case. Wastewater not treated (stormwater) can have economic costs that might want to be considered if these waters are to be used as part of the project case.

Using additional wastewater option - understanding the incremental change to the economic costs and benefits for the proposed project case will need to review the base case measures to estimate the change expected over the life of the project. In addition to the already estimated costs and benefits there is likely a range of others to be considered that apply specifically to the proposed options, including:

– Costs of any additional works required to treat or distribute the wastewater to the agricultural producers for use will need to be estimated over the life of the project and compared to the base case to understand the net outcome for the community. Examples of economic impacts include:

  - Treatment of wastewater to a higher standard than already treated, will need to consider:
    – Financial costs – can be measured as an average cost of production or calculated using the estimated capital, operating and maintenance costs to achieve the water quality and quantity levels required.
    – Economic costs – environmental, regulatory management activity (pricing, quality).
  - Distribution of the water from the wastewater treatment facility to the agricultural producer is important to understand and can be a significant portion of the costs. Each user of the water will have different costs as they are physically separated, and the distribution infrastructure needs to connect all users. There might be some cross over where the current water distribution infrastructure is used and therefore, there is no or little additional costs.
    – Financial costs – can be measured as an average cost of delivery or calculated using the estimated capital, operating and maintenance costs to achieve the water quality and quantity levels required.
    – Economic costs – environmental, regulatory management activity (pricing, quality).

– Benefits of the proposed options for use of wastewater on agricultural products in addition to the changes in the base case would include:

  - Reduced environmental cost of dumping.

- Reduced need for other water treatment facility – if a desalination plant is required to treat the water the current water treatment plant might be stopped and there will be savings from not running and renewing the old facility. Although the water authority might need to still recover the financial capital used to build the original facility even if not being used. Economic regulatory approval might be required to agree on the way these assets are treated in the pricing program.
- Quality increase – water quality improvement might have environmental benefits and or might be more usable for higher quality and value agricultural goods.
- Quantity increase – direct quantity increases can assist in improved output and assist with environmental flows.
- Certainty increase – assists with sustaining current crops, reducing seasonal volatility, enables different types of products and reduced need for government support during droughts.
- Agricultural production increase – comparing the base case to the quantity, quality, and value of the output due to the added water.
  - Could switch to higher value production – new or better supply of water might enable some agricultural producers to change production to a higher value product which improves economic outcomes.

A key measure of the economic viability is the net agricultural financial output given the change in water price. However, the economic costs and benefits are in addition to the net financial output. If the financial net outcome is found to be negative, there might be a case for the government to intervene in the market and provide some fiscal support to realise the economic welfare improvements for the community.

If government subsidy is required additional economic impacts are required to be tested, including:

– Deadweight loss (DWL) is the loss of economic efficiency in terms of utility for consumers/producers such that optimal or allocative efficiency is not achieved.
– Redirection of resources (capital, labour) away from higher value activity towards agricultural production.
– Taxation burden – distortions in the economy due to the tax and subsidy.
– Regulatory management of pricing, quantity and quality could distort market activity.

3.2 Legislative ease

This section will discuss the regulations around Australia. There is no overarching regulatory framework for recycled water usage in Australia as regulation is disparate and localised with each regulator having a different framework for the use of recycled water. The Federal Government’s Australian Guidelines for Water Recycling 2006 is mentioned in the regulatory frameworks of states, but only as a guide or touchstone, rather than a robust piece of legislation.

The frameworks are principally concerned with the treatment and subsequent uses of recycled water and in providing chemical thresholds for these applications. They provide regulations around how water is treated, monitoring, safety and what levels of quality are required for the different possible uses. For instance, water used in irrigating crops must be of a higher quality than recycled water used for watering public spaces and parks in each of the states.

Whilst the legislation is different across the country, as noted above, there are overarching focuses across the regulatory landscape with the regulator in each state moving towards or requiring on-land disposal as the preferred option for all new plants. The treatment requirements across the areas appear very similar or the same in many cases. It is worth noting however, that the states do have processes and systems for establishing new recycled water. These include application processes and requirements. Refer to the table below for a summary, noting that the Northern Territory does not have specific legislation due to lack of demand for these systems as noted in Section 2.3.

Table 3.1 Recycled Water Legislation

State	Government agency responsible	Regulatory strictness	New recycled water project requirements
QLD	Queensland Health	Low - regulations around chemical contents and treatment levels for various uses, but are only guides, rather than strict requirements. Only requirement is that recycled water does not present a "public health risk".	Applications to Department of Natural Resources, Mines and Energy who assess in conjunction with Queensland Health.
NSW	NSW Health	High - all water authorities require adherence to the Australian Guidelines for Water Recycling 2006.	Any new water supply and water recycling schemes must obtain ministerial approval. The Department of Planning, Industry and Environment will also play a role in assessing the appropriateness of the proposal.
VIC	EPA	High - EPA has a set of guidelines that must be complied with by the various water authorities.	Application to EPA which is assess using its technical, environmental and governance framework.
SA	SA Department of Health	Low - uses the Australian Guidelines for Water Recycling (AGWR) 2009 for scientific guidance. This is not however a mandatory provision and is not a prescribed code.	SA Department of Health and EPA jointly consider applications using the AGWR as an assessment framework.
WA	WA Health	High - WA has developed a set of guidelines around composition, usage and treatment. Requirements around monitoring of infrastructure and water quality also mandated.	All new schemes must be approved by the states' Chief Health Officer.
TAS	TasWater	High - EPA has a set of guidelines that must be complied with by the various water authorities.	EPA is responsible for assessing new schemes.

3.2.1 Queensland

In Queensland, recycled water is regulated differently depending on how the recycled water is used. Queensland Health is the primary regulator under the Public Health Act 2005 for recycled water. The main uses are for municipal open space irrigation, the irrigation of pasture and fodder crops, the irrigation of highly-processed food crops and non-food crops, and dust suppression.

The state recognises two types of recycled water vis-à-vis public safety. These are "low-exposure" and "high-exposure". The distinction is mainly around how much people and animals may voluntarily or inadvertently consume/ingest/be exposed to the recycled water. "Low-exposure" recycled water is water that is used in irrigation of public open spaces such as parks and play fields, pastures, heavily processed food crops (like sugar cane), non-food crops like cotton and construction/industrial sites. "High-exposure" recycled water refers to drinking water, dual pipe schemes (toilet flushing, laundry and irrigating lawns or gardens) and irrigation of minimally processed food crops.

Queensland Health has created guidelines for the five classes of recycled water that are used in the state. These guidelines are supposed to ensure that all recycled water used in the state is "fit-for-use". Whilst there are some guidelines for chemical contents in recycled water, these are not actually legally binding. Essentially, so long as humans and animals do not become ill/impaired in some way after exposure to the water, it is "fit-for-use".

3.2.2 NSW

NSW Health is the chief authority for recycled water in the state. The various water authorities have their own rules and regulations around recycled water production and use. It appears as though all the water authorities in the state (that currently operate recycling schemes) use the Australian Guidelines for Water Recycling 2006. This document informs the state's regulation of production and use of recycled water, including guidelines around chemical composition requirements.

It is of note that in NSW, any new water supply and water recycling schemes must obtain ministerial approval. The Department of Planning, Industry and Environment will also play a role in assessing the appropriateness of the proposal. The proposal must include information around the following points:

- A risk assessment for the overall scheme
- Information about the recycled water sources, treatment process and end uses
- A summary of the validation and verification monitoring results
- Operational procedures
- Strategies for incident and emergency response
- A training and awareness plan
- Strategies for operational reporting and auditing
- A communications strategy for stakeholder engagement
- End user agreements (ensuring that all supplier and user responsibilities and obligations are identified)

Approval times for new schemes in NSW are typically in excess of 18 months, with anecdotal evidence suggesting that some local water utilities are not pursuing new schemes due to this timeframe and costs/resources required to gain approval.

3.2.3 Victoria

In Victoria, the EPA is responsible for setting the recycled water use and quality guidelines. These guidelines include a framework of operations for recycled water users and producers as well as another set of technical parameters, specifying the biological health and safety requirements. There are various types of recycled water usage that are defined in the guidelines. Each has a slightly different level of safety and operational scrutiny required. For instance, there is a limit of salt (salinity) in recycled water used for crop irrigation, as well as guidelines around other materials such as nitrates, phosphorus and potassium. The guidelines also include robust compliance requirements. These include monitoring and reporting regulation.

The state's guidelines also include considerations of soil health and of agricultural machinery and equipment. For instance, it has requirements around recycled water quality and contents for irrigation purposes to ensure that the soil is not ruined by the water and that the irrigation system is likewise not destroyed by the water (this can occur for instance due to high salinity). EPA also takes applications for new recycled water projects and assess these against a framework it has established.

3.2.4 SA

SA Department of Health is the core regulating body. They have produced a guidelines document. The Guidelines adopt the Australian Guidelines for Water Recycling (AGWR) 2009 for scientific guidance. They do not contain mandatory provisions and are not a prescribed code. Indeed, whilst the guidelines outline recycled water practices around treatment, transportation and chemical makeup, they are not a set of requirements, only suggested best practice. This is similar to the regulations in Queensland.

AGWR's guidelines focus on treatment, transport, chemical composition and uses. For instance, the guidelines prohibit the use of recycled water for watering pigs due to the potential for adverse reactions in humans if pork from pigs fed recycled water is consumed. It has outlines chemical compositions required for different use types. For instance, as one would imagine, water used on crops with minimal processing requires higher quality than water used for irrigation of public parks and playing fields. The guidelines also outline how prospective producers can apply to develop recycled water facilities. This is done through the state's EPA and Department of Health.

3.2.5 WA

WA Health is the main authority body for recycled water usage in the state. There is a robust and developed set of regulations around recycled water use. These are the Guidelines for the Non-potable Uses of Recycled Water in Western Australia. The regulator has requirements around treatment and water quality. WA also has mandatory monitoring of treatment and storage facilitates as well as water quality. WA Health oversees these compliance measures. Like other states, the guidelines also delineate various use types and required level of quality for various applications.

The health department will review applications for new recycled water projects. Ultimately, these will be approved (or not) by the state's Chief Health Officer.

In dealing with surplus water from miming operations in WA, the regulator is concerned about the continuous discharge of water into ephemeral creeks and rivers. This permanent discharge has the effect of dramatically altering the receiving environment, which once dewatering is completed, effectively collapses with the source of water being removed. To combat this state of affairs, the Department of Water released the 'Pilbara water in mining guideline' in September 2009 which set out a hierarchy of use for surplus water as follows in descending order of preference:

- Efficient on-site use, including mitigation of any impacts.
- Used for fit-for-purpose activities (such as processing and dust suppression).
- Transferred to meet other demand, including other proponents in the area, agriculture and public water supply, as approved by the department.
- Injection back into the aquifer at designated sites determined by the proponent and agreed by the department.
- Controlled release to the environment where the dewater release is allowed to flow (either through a pipe or overland) into a designated water course or wetland determined by the proponent and agreed by the department.

3.2.6 Tasmania

TasWater is the peak authority in the state for recycled water. The EPA is also involved in the management and monitoring of recycled water. It also is responsible for approving new recycled water projects in the state. To implement a new recycled water scheme in Tasmania a Development Proposal and Environmental Management Plan (DPEMP) is prepared to ensure that recycled water use is sustainable and will not impose negative outcomes on either the environment or public health.

Recycled water facilitates have a set of requirements they must adhere to. These regulations include parameters around how water is treated, stored and around its quality. Once again, like other states, different applications of recycled water require different levels of quality.

4. Challenges for expansion

From our review of the existing schemes operating where expansion is being considered, we have gained a greater understanding of the challenges faced. Many of these challenges are the exact opposite of the principles of viable schemes listed in Section 3. A summary of the challenges for expansion are as follows:

- Providing additional wastewater supply to a system (like in the case of the WCRWS) during times of drought when agricultural demand is higher.
- Competing with lower cost source options (i.e. storage of rainfall in onsite dams in areas with more consistent rainfall).
- Costs associated with addition of advanced treatment required for higher-end agricultural use.
- Suitable areas for agriculture (based on soils, proximity to end market supply chain, land zoning etc) being in close proximity to existing systems.
- Natural topography constraints. Expansion of cities to their topographic boundaries means pumping to large agricultural areas over high elevation areas requires a large amount of pumping energy and cost).

5. Interim findings

From the schemes identified in our review that have been made viable, a few common principles exist as follows:

– There is an underlying environmental or political driver for the project, given that most are not financially viable without subsidy or acceptance of an operating cost deficit. This is not necessarily the case for viable mining water schemes in northern WA (i.e. they are financially viable) where very large volumes of high quality surplus water are in relatively close proximity to large areas of agricultural land to make a cost-effective proposition.
– Soils are generally suitable for agriculture with minimal adjustment and in close proximity to the wastewater source
– Located in areas with typically lower average annual rainfall and greater annual rainfall variability, so that other water supply options are comparatively more costly or less reliable
– In some cases, an existing, large storage is available to buffer supply and demand variability
– Favourable and less complex approvals pathways assist

Other factors (represented by the other data layers to be used in the spatial analysis in the next phase of the project, refer to Appendix A) generally have less bearing than those nominated above and will be weighted accordingly.

6. Conclusion

Based on the interim findings listed in the section above, it is concluded that:

– The spatial analysis to be undertaken in the next phase of this project (that will exclude areas noted as No-Go areas) should be used as a first pass to allocate weightings and scoring ranges for available various spatial layers.

– Non-spatial considerations such as political drivers, legislative ease and the non-spatial elements of economic viability can then be applied (potentially through a multi-criteria analysis process) to compare the most favourable options that come from the spatial analysis to filter/rank options prior to further assessment.

Appendix A

No-Go Workshop Minutes 21Dec21

Minutes

23 December 2021

Project name	NWGA National Review of Wastewater Reuse opportunities for Agriculture	**From**	Christina West
Subject	No-Go Workshop	**Tel**	02 6113 3397
Date / Time	21 December 11:00 am – 1:00 pm	**Project no.**	12556736
Attendees	Stuart Jamieson Sheena Dunne Nathan Malcolm Luke Sharpe Molly Fredle Andrew Foddy Paul Dellow Ryan Brotchie Bob Kinnell	**Apologies**	John Goodrich
Objective	Establish and agree on no-go agriculture (and connecting 'conveyance structures') areas for data layers to be used for the assessment. We will touch on supply side also to inform process.	**Copy to**	All invitees

Minutes	Action	To be actioned by
Introductions	– All GHD on call introduced themselves	-
Objective	– NM noted that at the end of this workshop, we want to identify the areas that are no-go for agriculture and conveyance structures (e.g. pipeline or channels)	-
Data list and tables	– MF presented list that has been prepared based on existing data sets planned to use. – Most are from Federal Government agencies and have national coverage. – One set is produced by GHD and can be used. – MF ran through the specifics of the data lists available. – **All to provide opinion on list of data presented (see first attachment).** – Conservation and heritage sites – shape files, so shows areas. – Slope – high level of data. – Wastewater treatment plants are points on the map. – Landuse – similar to conservation area focused shape files. – Precipitation – detailed areas, can adjust scale as needed. – Bureau of statistics is smallest (by LGA). – Wastewater by LGA by GHD. – CSIRO soil – shape files. – BoM – shape file. – pH soil – very fine and can broaden. – Others similar.	ALL

Minutes	Action	To be actioned by
	– Bureau of statistics limiting scale but can utilise other data at smaller scale e.g. wastewater data by GHD. – Not a lot of gaps identified at this stage, comfortable with the coverage achieved at this stage. – Road network – easy to follow a public road for conveyance structures than negotiate with landholders. – SD – bring together as single data set? NM noted that we will bring together in one map. – Will utilise to exclude areas for agricultural reuse. Will have lots of layers overlapping and use colours to show good vs not good areas.	
Viable scheme principles	– Research undertaken in each state/territory. – NT – none known to knowledge due to climate extremes and distance to end markets. – All areas will be covered on project map, even no-go areas. – SA – extensive area – Bolivar Markets / Northern Adelaide irrigation scheme. Currently taking flow from existing plants, considering expansion. Source Point Materiality thresholds – if under 50,000 people/20,000 connections either already doing small reuse or no scope due to low flows. – Mining – apart from WA mining operations generally water deficit unless near coast. Mines generally seeking surplus water from elsewhere. BK noted that materiality threshold for mining will need to be defined. – ACT – Canberra LMWQCC doesn't currently reuse water so there may be scope in the vicinity. Will likely be cross-border issues to manage. – TAS – Tas Water large number of treatment plants, 77 have secondary treatment, 10 with full reuse and others with 90% reuse. Hobart scheme potential for expansion. Large number of small treatment plants in Hobart to Launceston corridor. EPA drives local small reuse. – NSW – whole bunch of schemes being adopted where there are large populations e.g. Coffs Harbour replacing bananas with blueberries, Tamworth has recently been retendered and requirements in brief around the scheme, Dubbo prefer and gave allocation to industries in town, Gerringong/Gerroa and Picton all owned by Sydney Water, treatment plant alongside agriculture area, only fodder crops. Guidelines being refreshed to use on food crops. Shoalhaven REMS to golf course, sports ground, dairy. Central Coast most to ocean outfall. Hunter Water public space irrigation, dual pipe to subdivisions, only 10% reused. Sydney Water only 2 reuse – Picton and South Coast, others to green space irrigation. Comes down to approvals and preference to have land adjacent use. There is pressure for inland plants to not discharge to inland waterways. – VIC – 90% wastewater to two large treatment plants – western to Port Phillip Bay, Eastern outfall to Gunnamatta/Boag's Rocks. As proportion of total water generated ~20% currently reused. Western – water quality highly saline need desalination. Eastern treatment plant some existing small scale so opportunity for new pipeline through Cardinia, Packenham and Bunyip food bowl. ~80 GL/y excess. Yarra Valley Water building Northern treatment plant without disposal strategy. Currently reuse schemes don't stack up on pure economics but individual opportunities are being pursued, larger schemes need a broader policy driver. – QLD – Lockyer study strategic business case, hasn't yet stacked up but still in progress. Currently considering groundwater but may consider connection to Western Corridor scheme. Large bulk water strategy, reuse plus coal seam gas. New water project irrigation scheme options for future expansion of agricultural areas in northern areas. Cotton feasibility studies in north Queensland and north WA. Trying to get water inland rather than discharging to coast. – WA – Pilbara, Hammersley agriculture project up to 80 ML/d surplus water. Grass, oats, lucerne. This is a success story. About 10 years ago working for agriculture department GL/y scale >100 GL/y across 4 areas. Not yet come to fruition. Identified options but not viable economically yet. Salinity an issue where groundwater previously relied on and salinity increasing.	

Minutes	Action	To be actioned by
	– RB noted that in Vic and possibly elsewhere, likely increased regulation of environmental discharge. E.g. USA ocean outfall banned. Currently of concern to Melbourne Water. Doesn't currently have deep ocean outfall so economics would favour reuse potentially.	
No-go areas	– MF showed map of no-go areas: • Land use (Purple) – environmental conservation, mining, urban, water body • Protection areas (Green) – state and territory protected areas • Soil acidification (Orange) • Soil pH (Blue) – <5.5 and >7.5 • Desert sub-regions (Yellow) • Slope – anything >25% would be no-go. Generally agreed by all. – Discussion on areas: • Land use – break up subset layers, as mining may not be excluded. • PD – soil pH. Sites we manage we currently apply fertiliser to balance. Soil sampling undertaken regularly. OK on small scale but not on a large scale. NM noted that GHD may be able to tighten range. • Slope – will need to consider appropriateness with proximity to treatment plants etc. • Protected areas – national parks and state parks and crown land. • MF broke down the land use layer to its components. • Looked at the definitions under managed resource protection and other minimal use. MF showed the definition – could go to a lower level. Items under 1.2 as no go. **Items under '1.3 Other minimal use' consider if no-go.** • Mining area reviewed, indicatively no-go. • Heat map output example showed for a plant in Queensland. The more green, the more suitable the site. • Desert sub-regions – came from bioregion data set from Geoscience Australia. Multiple areas in Australia. Extracted any considered desert. BK noted the area could be larger e.g. Nullarbor Plain. **Noted area in Queensland to be checked.** • Soil acidification study – review soil quality and extracted what is considered poor soil. No very poor identified. Exclude very poor as no go and use grading on poor areas. Poor likely to be viable for the uses being discussed. SJ noted CSIRO have done Acid Sulphate Soil work and could consider this as a no-go data set. **Consider ASS in exclusion. Exclude very poor, graduation on poor and then increase positive on good and very good.** • Soil pH – lucerne 6.5 – 7.5 at a site GHD operates. Querying the dataset as it is showing low pH in areas already known to be used for agriculture e.g. south of Perth. **MF to review and investigate accuracy.** – **Add radiation layer as no-go layer.**	MF MF MF MF MF
Changes and scoring	– Economic viability and legislative ease are two key drivers. Following items are all generally a subset of economics. – Water pricing mechanisms. – Proximity of end use to source. – Suitability of agricultural sites. – Climatic consideration. – Rainfall and precipitation. – Environmental drivers e.g. EPA pushing change. – Additional treatment cost e.g. only secondary treatment. – Salinity.	

Minutes	Action	To be actioned by
Next steps	– Currently preparing draft reports – Workshop minutes – Environmental values being reviewed – Weighting and scorings to be devised including materiality threshold and minimum agriculture area – Note may need to apply a different rule for mining surplus water in WA – Aim to issue draft report by end of this week	
Recap and meeting close	– CW reviewed the recorded actions – NM thanked everyone for their time	

Attachments: Data source list

Screen shots of presented material

Initial list

Criteria	Description	Source	Data coverage
Conservation		Department of Agriculture, Water and the Environment	National
Non-Aboriginal Heritage		Department of Agriculture, Water and the Environment	National
Slope	Suitability for construction	Geoscience Australia	National
Existing waste water treatment plants		Geoscience Australia	National
Land Use		Department of Agriculture, Water and the Environment	National
Precipitation		Bureau of Meteorology	National
Water demand	Water Market Demand by agriculture type 2005–06 to 2018–19	Australian Bureau of Statistics	National
Wastewater produced - 2021	Wastewater produced by LGA (Megalitre) - GHD study	GHD	National per LGA
Soil Atlas	Type of soils	CSIRO	National
Heat stress		Bureau of Meteorology	National
Frost		Bureau of Meteorology	National
Moisture availability, irrigated crops		CSIRO	National
Nutrient balance, (Nr) Soil pH	Ideal agriculture pH for soil = 5.5 to 7.5, with a pH of 6.0 to 6.5	CSIRO	National
Soil depth		CSIRO	National
Terrestial ecoregion	Australia's landscapes	Department of Agriculture, Water and the Environment	National
Soil acidification grade	In 2011, a study in soil acidification and land resource assessment was convened to provide an assessment of the state and trends of soil acidification across Australia.	CSIRO	National
Population	From latest census	Australian Bureau of Statistics	National
National Heritage List National and States and Territories Gross Value of Agricultural Production	From latest census	Australian Bureau of Statistics	National
Road Network		Department for Infrastructure and Transport	National
Radiation		Geoscience Australia	National

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→ The Power of Commitment

Appendix B

Wastewater Treatment Requirements for Agriculture Report

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Wastewater Treatment Requirements for Agriculture

Department of Infrastructure Transport Regional Development and Communications

4 April 2022

→ The Power of Commitment

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			Name	Signature	Name	Signature	Date
S4	0	R. Dorse L. Sharpe	N. Malcolm	N. Malcolm	N. Malcolm	N. Malcolm	04/04/22

Executive summary

The National Water Grid Authority (NWGA) has engaged GHD Pty Ltd (GHD) to investigate the potential locations and opportunities for wastewater reuse schemes for agriculture. This report is to supplement the aforementioned investigation to provide NWGA with a summary of all state and territory guidelines surrounding wastewater treatment, reuse, approval processes and other related information.

Water guidelines whether sourced from surface waterbodies, groundwater or from effluent have unique and specific guidelines surrounding the treatment, use restrictions and other requirements between states and territories. Similarly, the legislative bodies responsible for these water guidelines are unique to each state and territory.

The summary of these varying guidelines from each state and territory in Australia, along with national guidelines was undertaken to understand the similarities and differences. The following summary and comparison results are as follows:

- National guidelines are not mandatory or legislative, only being legal within a state or territory if those guidelines are adopted. It is common for states and territory's use the national guidelines as scientific basis for their respective guidelines except for NSW and subsequently SA which adopt the national guidelines.
- Uses of recycled water appear similar across the regulatory bodies though potential treatment or specific water qualities can vary.
- Little uniformity exists between application processes and other requirements such as documentation for the establishment of a wastewater reuse scheme.
- Current wastewater reuse opportunities exist in NSW, ACT and VIC with current treatment qualities having some application use without additional treatment.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.2 and the assumptions and qualifications contained throughout the Report.

Contents

Table index

Figure index

1. Introduction

1.1 Purpose of this report

The purpose of this report is to provide insight into the existing standards and guidelines each state and territory in Australia has regarding wastewater reuse for agriculture, to help identifying potentially feasible wastewater schemes and to outline application and documentation processes.

1.2 Scope and limitations

The scope of this report is to:

– Present summaries of wastewater reuse for agriculture guidelines for each state and territory in Australia.
– Identify categories for national guideline comparison.
– Present opportunities for wastewater reuse, outlining current water qualities and potential uses.

This report has been prepared by GHD for Department of Infrastructure Transport Regional Development and Communications and may only be used and relied on by Department of Infrastructure Transport Regional Development and Communications for the purpose agreed between GHD and Department of Infrastructure Transport Regional Development and Communications as set out in this report.

GHD otherwise disclaims responsibility to any person other than Department of Infrastructure Transport Regional Development and Communications arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

2. National Guidelines

The National Guidelines have been produced by the Environment Protection and Heritage Council, Natural Resources Management Ministerial Council and the Australian Health Ministers Conference to provide guidance on best practices for water recycling. The National Guidelines provide a risk assessment framework that is applicable to the recycling of water from wastewater treatment plants, greywater and raw sewage sources. The National Guidelines are not mandatory but are designed to provide an authoritative reference that can be used to support beneficial and sustainable water recycling practises. The National Guidelines are intended to be used by anyone involved in the collection, treatment, distribution, supply, use and regulation of recycled water schemes.

Except NSW and SA, all other states/territories use the Federal Government's *Australian Guidelines for Water Recycling 2006* not as mandatory legislation but only as reference and scientific basis to which their relative guidelines are made. For an outline of the national guidelines please see Section 3.1 or Overview of the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (2006) report.

3. State/Territory Wastewater Guidelines

The following categories have been summarised from the state and territory guidelines to outline requirements and processes for wastewater reuse for agriculture. The category descriptions can be seen below.

Water classification and treatment: the categorisation of water quality and/or treatment requirements for different potential uses of recycled water.

Hazard impact: the potential level of impact varying chemical and bacterial quantities have on the growth and development on crops.

Soil and nutrient loading: similar to hazard impacts, this outlines the levels of severity that varying chemical and bacterial qualities have on soils which can lead to reduced agricultural production.

Agricultural specific guidelines: guidelines specifically relating to wastewater reuse for irrigation for crops, livestock water sources, livestock fodder irrigation etc.

Procedure and approval processes: a summary of the primary approval processes and documentation. To note this does not include every step to the establishment of a wastewater reuse scheme. Further knowledge should be sought from the appropriate regulatory bodies as per the summaries in Table 4.5.

Human exposure controls: procedures and control measures required to prevent human exposure and ensure safety during the use of recycled wastewater.

Site selection: site characteristics recommended for consideration when comparing and selecting locations for agricultural with wastewater reuse.

3.1 New South Wales

EPA NSW provides guidelines around the use of effluent for irrigation in "Use of Effluent by Irrigation" and also adopts National Guidelines for Water Recycling (NGWR) released through the National Water Quality Management Strategy, which focuses on human health risk assessment and management. (Policies, Guidelines and Programs (nsw.gov.au)).

The national guidelines state:

"The risk management approach outlined here incorporates the concept of identifying and producing recycled water of a quality that is 'fit-for-purpose'. To be consistent with this approach, these guidelines do not include a classification system for recycled water. A principal reason for this decision is that classification systems can limit flexibility. For example, uses such as dual reticulation, municipal irrigation with unrestricted access and irrigation of salad crops are often grouped together under a heading of (relatively) high exposure uses. However, using a risk assessment approach as shown in Chapter 3, the pathogen removal requirements are different for each of these three ends uses. Including them under a single classification (eg Class A) could be misleading."

In NSW, the risk management approach to water quality objectives can be determined on a case-by-case basis depending on the log reductions required for specific end uses.

3.1.3 Water classification and treatment

Water treatment classification is based on the log reductions of given pathogen and organisms. These classifications and their log reduction values can be seen below.

NGWR discusses preventative measures to protect the public and achieve performance targets with the use of recycled water. Hazard concentrations can be reduced using various treatment processes, either singly or in combination. Table 3.1 summarises indicative removals of microbial hazards that can be achieved using identified treatment processes. The achievable ranges of pathogen reduction are relatively broad because effectiveness will be influenced by design features. Whenever treatment options are selected, performance claims need validation. This can be achieved using published data or by testing for specific pathogens or suitable indicators.

Water NSW (one of the many water providers in NSW) defines tertiary treatment as "highly advanced systems that use air and biological processes as well as membranes and UV filtration". Whilst the national guidelines do not specifically outline the requirements for tertiary treatment, the additional processes can be assumed to be a possible component to tertiary treatment and the specific inclusion of one process over another should be determined by a case-by-case basis.

Table 3.1 NSW treatment classifications and log reduction value

	Log Reduction Value Range							
Treatment	**E.coli**	**Bacterial pathogen**	**Viruses**	**Phage**	**Giardia**	**Cryptosporidium**	**Clostridium perfringens**	**Helminths**
Primary	0-0.5	0-0.5	0-0.1	NA	0.5-1.0	0-0.5	0-0.5	0-2.0
Secondary	1.0-3.0	1.0-3.0	0.5-2.0	0.5-2.5	0.5-1.5	1.5-2.5	0.5-1.0	0-2.0
Tertiary:								
Membrane filtration	4.5->6.0	3.5->6.0	2.5->6.0	3->6.0	>6.0	>6.0	>6.0	>6.0
Reverse osmosis	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0
Lagoon storage	1.0-5.0	1.0-5.0	1.0-4.0	1.0-4.0	3.0-4.0	1.0-3.5	NA	1.5->3.0
Chlorination	2.0-6.0	2.0-6.0	1.0-3.0	0-0.25	0.5-1.5	0-0.5	1.0-2.0	0-1.0
UV light	2.0->4.0	2.0->4.0	>1.0	3.0-6.0	>3.0	>3.0	NA	NA
Wetlands – surface flow	1.5-2.5	1	NA	1.5-2.0	0.5-1.5	0.5-1.0	1.5	0-2.0
Wetlands – subsurface flow	0.5-3.0	1.0-3.0	NA	1.5-2.0	1.5-2.0	0.5-1.0	1.0-3.0	NA

Note: If a process is not included in the above tables, then it will need to be verified to determine the achieved LRV.

Whilst the above log reductions are used as guidelines, NSW does define types of reuses by the treatment level required, the end effluent qualities and log reductions for differing activities. Frequency of monitoring is also recommended in these guidelines. Table 2 and notes have been taken from the NGWR.

Table 3.2 NSW municipal sewage effluent guidelines for treatment and disinfection

Type of Reuse	Treatment Level	Effluent quality	Monitoring frequency
Urban (non-potable)			
Municipal: uncontrolled public access	Tertiary Pathogen reduction[5]	pH 6.5-8.5[7] <=2 NTU[9] 1mg/L CI2 residual [10] or equivalent level of disinfection Thermotolerant coliforms[3] <10 cfu/100mL[4]	Weekly Continuous Daily Weekly
Municipal: controlled public access	Secondary Pathogen reduction[5]	Thermotolerant coliforms[3] <1,000 cfu/100mL[4]	Weekly

Type of Reuse	Treatment Level	Effluent quality	Monitoring frequency
Agriculture			
Food production: food crop in direct contact with effluent	Tertiary Pathogen reduction[5]	pH 6.5-8.5[7] <=2 NTU[9] 1mg/L Cl2 residual [10] or equivalent level of disinfection Thermotolerant coliforms[3] <10 cfu/100mL[4] <1 intestinal nematode egg or lava /L[6]	Weekly Continuous Daily Weekly
Food production: cooked/processed food or raw food not in direct contact with effluent	Secondary Pathogen reduction[5]	pH 6.5-8.5[7] Thermotolerant coliforms[3] <1,000 cfu/100mL[4]	Weekly Weekly
Food production: pasture and fodder and for dairy animals (with withholding period)		pH: 6.5-8.5[7] E coli <1,000 cfu/100mL[4] BOD <20 mg/L SS <30 mg/L E.coli <100 per 100mL	Weekly Weekly No specified Not specified Not specified
Food production: dairy animals (without withholding period), drinking water and washdown for dairies.		pH 6.5-8.5[7] Thermotolerant coliforms[3] <100 cfu/100mL[4] BOD <20 mg/L SS <30 mg/L E.coli <100 per 100mL	Weekly Weekly No specified Not specified Not specified
Non-food crop: silviculture, turf and cotton etc		pH 6.5-8.5[7] Thermotolerant coliforms[3] <10,000 cfu/100mL[4]	Weekly Weekly
Livestock drinking water	Secondary treatment with helminth reduction Or Primary treatment with >50 day detention and disinfection	BOD <20 mg/L SS <30 mg/L E.coli <100 per 100mL	Not specified

Table 3.2 Notes:

DEC/local council will adopt the criteria set in any updated national guidelines except where NSW Health provides different requirements particular to NSW or local conditions.

Consistent with the national guidelines, it should be noted that in some cases, the Department of Environment and Conservation/local council or NSW Health may adopt more stringent requirements than those outlined in the national document, e.g. It is possible that NSW Health may apply the national guideline values as maximum levels rather than median levels.

Intensive animal industries should check for specific animal health protection measures.

SS = suspended solids

NTU = nephelometric turbidity unit

CFU = colony-forming units

1. Effluent quality refers to its quality following treatment appropriate for a particular application and prior to mixing with receiving waters. The guideline levels apply to the treated effluent feeding into the reticulation system, after the point of treatment and disinfection. The effluent should not degrade in quality while it is being stored or while travelling through a reticulation system. Chlorine may need to be added as a primary or secondary disinfectant to allow for a residual disinfection.
2. Monitoring demonstrates effluent water quality at the point of supply rather than at the treatment plant. In most cases this will be the point of entry to the reticulation system or other suitable representative sampling location.
3. Thermotolerant coliforms includes E coli if not stated.
4. Median value. Refer to statistical treatment of data in ARMCANZ, ANZECC & NHMRC (2000) or future updates.

5. Pathogen reduction beyond secondary treatment may be accomplished by disinfection (e.g. chlorine) or by detention (e.g. ponds or lagoons). Systems using detention only do not provide reduction of thermotolerant coliform counts to <10 per 100 mL and are unsuitable as the sole means of pathogen reduction for high contact uses.
6. Disinfection systems refer to chlorination, ultraviolet irradiation or other disinfection systems. Monitoring requirements may include checking chlorine residual or operational checking of UV equipment. Monitoring frequency for pond and lagoon systems will be site-specific and dependent on factors such as detention time.
7. 90% compliance for samples.
8. Helminths controls include measures such as removal by treatment, veterinary inspection, cattle husbandry and/or a withholding period prior to grazing. For pasture and fodder applications, other options may be used to control helminth infection in grazing animals if they are acceptable to the NSW Department of Primary Industries.
9. Limit met prior to disinfection. 24 hour mean value. 5 NTU maximum value not to be exceeded.
10. Total Chlorine Residual after a minimum contact time of 30 minutes.
11. In NSW, NSW Health specifies that for raw food crops separated from contact with effluent by peel, the level of treatment should be the higher category of 'Raw food crops in direct contact with effluent.'

Similar to Table 3.2, the following are the log reduction requirements for varying uses of recycled water.

Table 3.3 NSW log reductions for recycled and treated sewage

Activity	Cryptosporidium	Rotavirus	Campylobacteria
Commercial food crop	4.8	6.1	5.0
Dual Reticulation:			
Garden irrigation	4.4	5.8	4.6
Garden food crops	4.0	5.3	4.2
Total internal use (no garden use)	4.9	6.3	5.1
Municipal irrigation	3.7	5.2	4.0
Dual reticulation and municipal irrigation	5.0	6.4	5.1
Fire fighting	5.1	6.5	5.4

3.1.4 Hazard impact

The NSW guidelines do not outline hazards to plants, see section below for reference.

3.1.5 Soil and nutrient loading

Table 3.4 Classification of effluent constituents harmful to the environment

	Strength (average concentration mg/L)[1]		
Constituent	Low	Medium	High
Total Nitrogen	<50	50-100	>100
Total Phosphorous	<10	10-20	>20
BOD	<40	40-1,500	>1,500
Total Dissolved Solids (TDS)	<600	600-1,00	>1,000-2,500
Other pollutants (metals, pesticides)	Effluent with more than 5x the ANZEX and ARMCANZ long-term water quality trigger values for irrigation waters must be considered high strength and will require examination to soil is not contaminated.		
Grease and oil	Effluent more than 1,500 mg/L must be considered high and irrigation rates and practices managed to ensure soil and vegetation is not damaged.		

1. Average concentrations established from a minimum of 12 representative samples, collected at regular intervals over a year.

3.1.6 Agricultural Guidelines

Irrigation

Table 3.5 NSW municipal sewage effluent irrigation controls

Type of Reuse	Irrigation controls
Urban (non-potable)	
Municipal: uncontrolled public access	Application rates limited to protect groundwater quality Salinity should be considered for irrigation
Municipal: controlled public access	Irrigation during times of no public access Application rates limited to protect groundwater quality Salinity should be considered for irrigation Withholding period nominally 4 hours or until irrigated area is dry
Agriculture	
Food production: food crop in direct contact with effluent	Application rates limited to protect groundwater quality Salinity should be considered for irrigation Minimum if 25 days ponding or equivalent treatment
Food production: cooked/processed food or raw food not in direct contact with effluent	Application rates limited to protect groundwater quality Salinity should be considered for irrigation Dropped crops not to be harvested from the ground Crops must be cooked (>70°C for 2 minutes) or peeled before consumption
Food production: pasture and fodder and for dairy animals (with withholding period)	Application rates limited to protect groundwater quality Withholding period nominally 4 hours for irrigated pasture. Drying or ensiling fodder Helminth controls
Food production: dairy animals (without withholding period), drinking water and washdown for dairies.	Application rates limited to protect groundwater quality No withholding periods Helminth controls
Non-food crop: silviculture, turf and cotton etc	Application rates limited to protect groundwater quality Restricted public access Withholding period nominally 4 hours or until irrigated area is dry

Livestock

While not a risk to livestock health, the use of recycled water in dairy operations can potentially contaminate milk and pose a risk to human health. Pasteurisation of milk will effectively kill bacterial pathogens but may be inadequate for inactivating the viral and protozoan pathogens present in human faeces.

Table 3.6 NSW livestock controls

Type of use	Livestock controls
Livestock drinking water	Recycled water not to be consumed by cattle <12 months of age if water source contains animal waste
Dairy shed wash down	Recycled water not to be used for wash down of milking machinery
Pasture or fodder crop irrigation (limited holding period)	Exclude lactating dairy cattle from pastures for 4 hours or until pasture is dry Fodder dried or ensiled (not for human consumption)
Pasture or fodder crop irrigation (limited holding period)	Exclude grazing animals for 5 days after irrigation Fodder dried or ensiled (not for human consumption

3.1.7 Procedures and approval process

Under Section 60 of the Local Government Act 1993, utilities are required to obtain Ministerial approval for water supply and sewerage works including water recycling schemes. See the guidance document below for assistance in preparation of a recycled water management plan.

NSW Guidance for Recycled Water Management Systems

3.1.8 Human exposure controls

Crops typically have exposure controls based on if the public are in the vicinity of the irrigation area. See Table 3.7 for outline of the levels or public exposure control.

Table 3.7 Public exposure controls for crops

Control Type	Control Description
Standard	No access and drip or subsurface irrigation No access during irrigation and if spray irrigation, min 25m buffer zone
Advanced	No access and drip irrigation No access during irrigation and if spray irrigation, min 25 m buffer zone, or Extended buffer zone to min 90 m

The onsite human exposure controls are heavily based on the treatment of the recycled water being used.

Table 3.8 Onsite control for designated used of recycled water from treated sewage

Specific use	Onsite preventative measures
Municipal use:	
Open spaces, sporting grounds, golf courses etc or unrestricted access and application	No specific measures
With restricted access and application	Restricted public access during irrigation and one of the following: – No access after irrigation until dry (1-4 hours) – Min 25 m buffer zone – Spray drift control
With enhanced restrictions on access on access and application	Restricted public access during irrigation and combination of: – No access after irrigation until dry (1-4 hours) – Min 25 m buffer zone – Spray drift control
Landscape irrigation:	
Trees, shrubs, public gardens	Combination of: – Micro-spray – Drip irrigation – No public access
Non-food crops:	
Trees, turf, woodlots, flowers	Advanced public exposure controls
Food crops:	
Consumed raw or unprocessed	No requirements
Within limited or no ground contact and eaten raw (e.g. tomatoes, capsicum)	No harvesting of wet or dropped produce Pathogen reduction between harvesting and sale Standard public exposure controls

Specific use	Onsite preventative measures
Crops with ground contact with skins removed for consumption (e.g. watermelon)	If spray irrigation, minimum 2 days between final irrigation and harvest Pathogen reduction between harvesting and sale Standard public exposure controls
Above ground crops with subsurface irrigation	Pathogen reduction between harvesting and sale Standard public exposure controls
Crops with no ground contact and skin removed before consumption (e.g. citrus, nuts)	No harvesting of wet or dropped produce If spray irrigation, minimum 2 days between final irrigation and harvest Pathogen reduction between harvesting and sale Standard public exposure controls
Crops no ground contact and heavily processed (e.g. grapes for wine, cereals)	Pathogen reduction between harvesting and sale Advanced public exposure controls
Crops cooked/processed before consumption (e.g. potatoes, beetroot)	Pathogen reduction between harvesting and sale Advanced public exposure controls
Crops with no ground contact and skin removed before consumption (e.g. citrus, nuts)	No spray irrigation No harvesting of wet or dropped produce Pathogen reduction between harvesting and sale Advanced public exposure controls
Raised crops (e.g. apples, apricots, grapes)	Drip irrigation No harvesting of wet or dropped produce Pathogen reduction between harvesting and sale Advanced public exposure controls
Agriculture:	
Livestock drinking water	Recycled water not to be consumed by cattle <12 months of age if water source contains animal waste
Dairy shed wash down	Recycled water not to be used for wash down of milking machinery
Pasture or fodder crop irrigation (limited holding period)	Fodder dried or ensiled (not for human consumption) Standard public exposure controls
Pasture or fodder crop irrigation (limited holding period)	Fodder dried or ensiled (not for human consumption Standard public exposure controls

NSW does specify recommend buffer distances depended on the water resource and the strength of the effluent from contaminants as identified in Table 3.9.

Table 3.9 Recommended buffer distances for water resources

	Separation distance	
Sensitive Area	**Low strength effluent**	**Medium high strength effluent**
Natural waterbodies	50 m	50 m
Other waterbodies	Site-specific	Site-specific
Domestic well	Site-specific	250 m
Town water supply bores	Site-specific	1000 m
Spray irrigation	50 m	50 m
Other	Site-specific	250 m

3.1.9 Site selection

NSW guidelines does not outline characteristics for consideration when selecting agricultural sites.

3.2 Victoria

3.2.1 Water classification and treatment

In Victoria the classes of recycled water are split into three types based on the water quality at the end of treatment as described in Table 3.10. Uses not permitted by any class of recycled water are as follows:

– Drinking
– Cooking or other kitchen purposes
– Bathing and showering
– Filling domestic swimming pools and spas
– Children's water toys

Table 3.10 Classes of recycled water and corresponding standards and allowable uses

Class	Water Quality	Treatment Processes	Uses
A	Microbiological log reduction targets (see Table 3.11 example) Turbidity <2 NTU <10/5 mg/L BOD / SS pH 6 - 9	Processes should be designed to achieve the required Log Reduction	Irrigation for public areas e.g. parks and sporting fields Agricultural: raw consumed food Domestic gardening Toilet flushing Firefighting and fire protection systems
B	< 100 E. coli org/100 mL <20/30 mg/L BOD / SS pH 6 - 9	Secondary and pathogen (including helminth reduction for cattle grazing) reduction4	Agriculture e.g. dairy cattle grazing Industry e.g. washdown water
C	< 1,000 E. coli org/100 mL <20/30 mg/L BOD / SS pH 6 - 9	Secondary and pathogen reduction (including helminth reduction for cattle grazing use schemes)	Urban (non-potable) Agriculture: cooked/processed foods, grazing/fodder for livestock Industry: systems with not potential worker exposure

Water quality specification and concentrations if not stated in Table 3.10 need to be considered in regard to plants being irrigated and the tolerances specific plants have. Standard concentrations and level of impact on plants can be seen in Table 3.12.

For Class A recycled water schemes in Victoria, pathogens need to be reduced by a minimum log reduction value as outlined in Guidelines for validating treatment processes for pathogen reduction: Supporting class A recycled water schemes in Victoria (DH Victoria, 2013). See the log reduction example values in Table 3.11 for dual pipe schemes.

Table 3.11 Class A recycled water pathogen log reduction targets for dual pipe schemes

Group	Total log reduction value objective
Bacteria	6
Viruses	7
Protozoa	6

3.2.2 Hazard impact

Table 3.12 Victoria General hazard consideration concentrations and plant impacts

		Impact				
Hazard	**Units**	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Electrical Conductivity (EC)	dS/m	<0.65	0.65 - <1.3	1.3 - <2.9	2.9 - <5.2	>=5.2
TDS	mg/L	0 - <390	390 - <780	780 - <1739	1740 - <3120	>=3120
Sodium	mg/L	0 - 115	116 - 230	231 - 460	>460	
Chlorine	mg/L	0 - <175	176 - <350	350 - <700	>700	
Residual chlorine	mg/L	0 - <1	1 - <5	5 - <10	>=10	
Boron	mg/L	<0.5	0.5 - 1.0	1.0 - 2	2.0 - 4.0	>=4.0

3.2.3 Soil and nutrient loading

Table 3.13 Victoria nutrient hazards

	Units	**Insignificant**	**Minor**	**Moderate**	**Major**	**Extreme**
Phosphorous	mg/l		<5		>10	
Annual irrigation application rates	ML/ha/yr		<3		>6	
Sodium	mg/l	<115	115 - <230	230 - <460	>=460	
Chlorine	mg/l	<175	175 - <350	350 - <700	>700	
Electrical Conductivity	dS/m	<0.65	0.65 - <1.3	1.3 - <2.9	2.9 - <5.2	>5.2
TDS	mg/l	<390	390 - <780	780 - <1740	1740 - <3120	>3120
Boron	mg/l	<0.5	0.5 - 1	1.0 - 2.0	2.0 - 4.0	>4.0

The sodium and chlorine hazardous concentrations are for recycled water in direct contact with the produce through sprinklers. Whilst this will not be the same for each irrigation method it is a good guideline for other irrigation methods.

Where potential impact on drinking water sources (including underground rainwater tanks, bore water supplies, waterways and reservoirs) from recycled water schemes, buffer distances need to be agreed upon with the drink water supplier. Recommendation buffer distances for class C water quality can be seen below and should be used as a guide for other classes of water.

Table 3.14 Recommended buffer distances for class C recycled waters

Irrigation type	**Surface waters**
Flood/high pressure spray	100 m
Low pressure spray	50 m
Trickle or subsurface	30 m

As mentioned above the buffer distances needs to be agreed upon with the drink water supplier on a case-by-case basis. Potential factors for considerations to increase or decrease of the buffer zone distances can be seen below.

Table 3.15 Considerations for changing buffer distance recommendations to surface waters

Buffer distance	Possible considerations
Increase	– Class A or B water – Surface water is seasonal or a drainage channel – Best practice measures implemented preventing contaminated run-off leaving site – Site is particularly favourable (e.g. elevated or well vegetated between recycling site and surface water)
Decrease	– Surface water is highly sensitive (e.g. heritage rivers, Ramsar sites) – Surface water is used in potable water supplies – Site is unfavourable (e.g. steep slopes, impermeable sites)

3.2.4 Agricultural Guidelines

3.2.4.1 Livestock

Stock grazed on pasture irrigated with water, or supplied with drinking water, from waterways downstream of a recycled water scheme may require individual identification, enhanced meat inspection and monitoring in accordance with the *Livestock Diseases Control Act 1994* and the *Meat Industry Act 1993* if the water has not been adequately treated for helminths.

A requirement for helminth control is a key component of the *Livestock Disease Control Act 1994*. This specifies that in order for recycled water to be suitable for use on cattle grazing land, and not be classified as sewage, treatment processes must be specifically designed and managed to reduce pathogens (particularly helminths) to acceptable levels. This is to prevent helminth infections in cattle ('beef measles' or *Cysticercus bovis*) caused by the helminth *Taenia saginata*, a human tapeworm in cattle which can impact meat quality.

Table 3.16 Livestock application requirements for recycled water

Recycled water from sources NOT containing human faeces	Recycled water from sources containing human faeces
– No restriction to grazing of pigs or fodder uses – Helminth removal for recycled water sources not required – All other eleventh guidelines in Victorian guideline for water recycling (2021) apply	– 25-day detention in treatment lagoons or storage facility where all recycled water is detained from last inflow into storage – Approved method of infiltration – Not exposed to pigs directly – Used to grow produce pigs may be exposed to

Supplying pigs with recycled water sourced from wastewater that contains human faecal matter is prohibited. Pigs or cattle can access land that has been irrigated with recycled water (that contained human faeces) that has not had adequately helminth removal if two years have passed since last recycled water application. If within 2 years a veterinary office must be consulted prior to grazing.

3.2.5 Procedures and approval process

Class A recycled water schemes producing more than 5,000 L/day or Class B or C recycled water schemes producing more than 1 ML/day required formal approval and will be accessed in accordance with Victorian Guideline for Water Recycling 2021.

Recycled water schemes in Victoria require approval from EPA. All applications and enquires related to recycled water schemes should be made through EPA.

There are four main stages of managing a water recycling scheme:

1. Approval of development and construction
2. Commencing operation
3. Routine, ongoing operation
4. Periodic review, maintenance and renewal

EPA provides approval for recycled water schemes which is required for the first and second stages of the scheme to the point of the scheme being ready to operate. Other government agencies may be involved in the approval process either in an advisory and/or endorsement capacity, such as Chief Veterinary Officer. The scheme manager is responsible for the other stages including ongoing review.

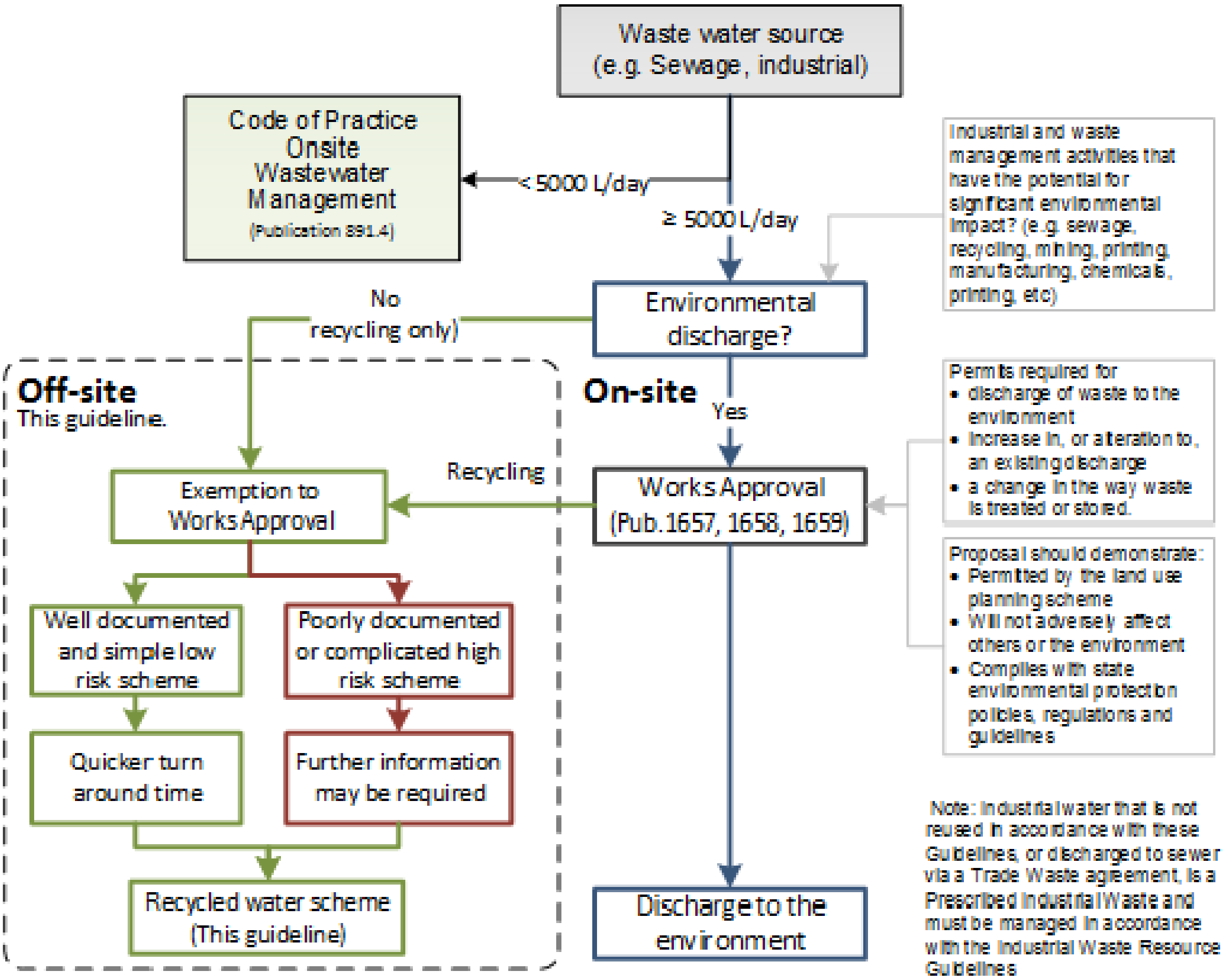

Figure 3.1 Overview of requirements for developing a recycled water scheme

Health and environmental management plan

A health and environmental management plan (HEMP) is essential for sustainable and safe water recycling. The HEMP is necessary for exemption from EPA works approval and licensing provisions and establishing the recycled water scheme.

The recycled water HEMP is required to:

1. Initially establish and validate the scheme
2. In conjunction with the user site management plan (if applicable), guide operational and sustainability verification of the scheme

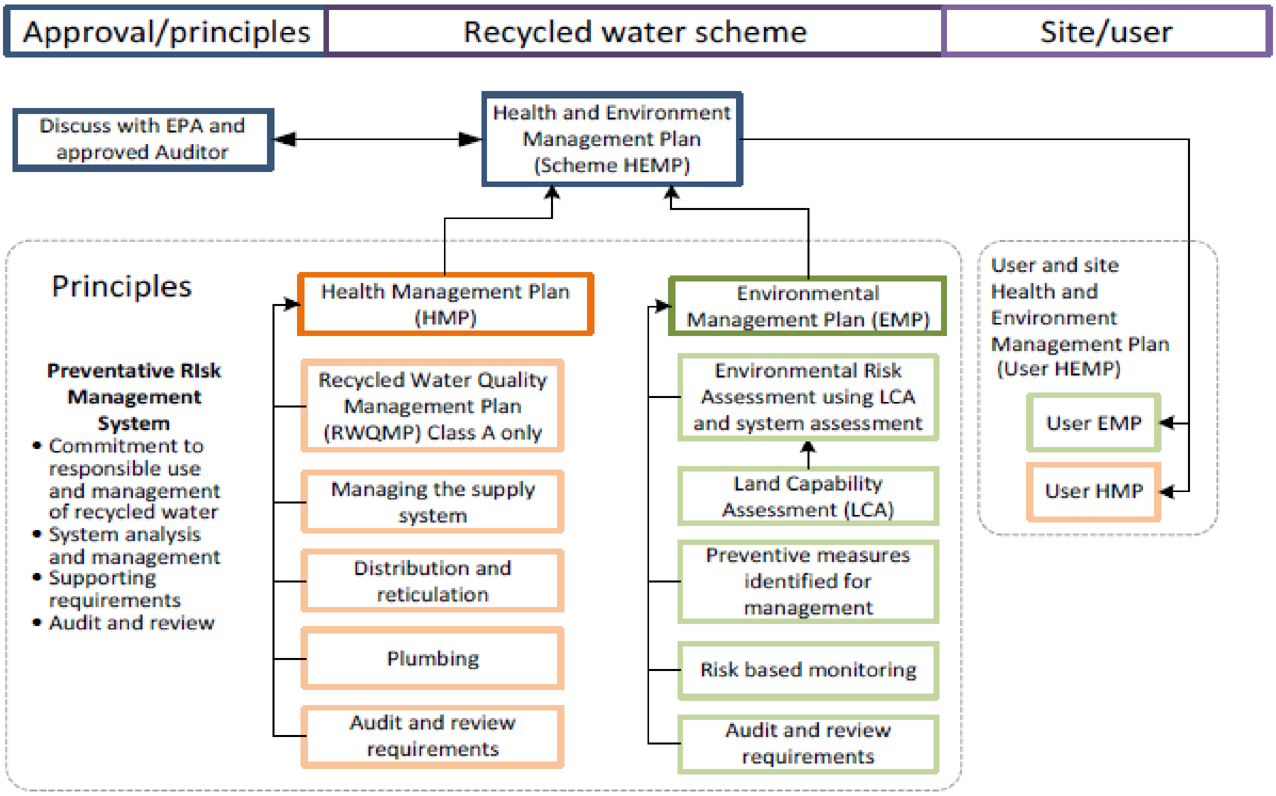

Figure 3.2 HEMP overview for recycled water schemes

Recycled water quality management plan

A recycled water quality management plan (RWQMP) is required for class A or fit-for-purpose recycled water schemes (schemes supplying water for the range of acceptable high value uses listed for class A, in that have a high potential for direct human contact with recycled water).

The RWQMP needs to consider design, operation, maintenance and inspection of the treatment system and set out the source water, product water and distribution water monitoring program.

The focus of the RWQMP is on ensuring the treatment plant will produce water that meets the required microbial criteria for the selected reuse, and that the water quality is not compromised downstream of the treatment process. Therefore, the RWQMP should extend from the catchment of the system (including system inputs), through to the end of the treatment process. Where the supplier manages storage, the storage should also be included in the RWQMP.

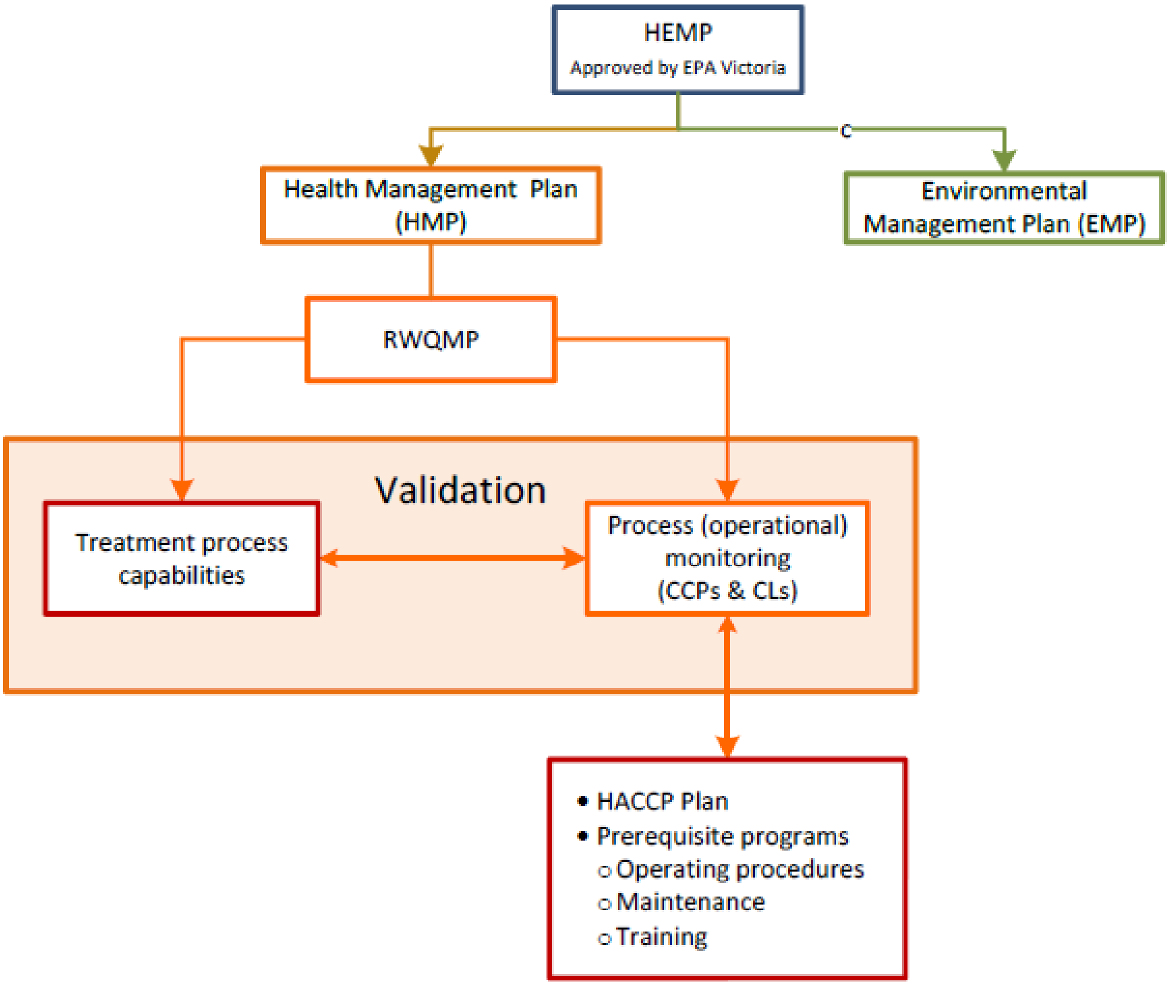

Figure 3.3 Elements of RWQMP

Others

Other documentation of note that must be completed include:

– Water balance
– Nutrient balance

3.2.6 Human exposure controls

When class A recycled water is used, no specific access restrictions (other than pig prohibition) are recommended. Sensible stock restriction controls should be employed to protect soils from stock traffic and compaction when wet.

For lower quality recycled water (class B and C), restrictions on public/workers access, stock access and limits on irrigation times may be required. These limitations will depend on the stock exposure potential and the quality of recycled water used.

For irrigation, spray drift is recommended to not occur beyond boundaries of reuse due to potential contamination of non-target produce and ingestion of aerosols by the public. Buffer distances for spray irrigation in proximity to sensitive development (residential areas, public parks, schools and shops) suggested below:

– Class A: 0 m, given no spray or water movement off-site
– Class B: 50 m
– Class C: 100 m

3.2.7 Site selection

Victoria relies on the national Guidelines for wastewater irrigation to outline considerations for site selection. Specific characteristics stated by the Victorian guidelines that should be considered can be seen in the table below.

Table 3.17 Victoria site selection considerations

	Guideline notes
Soil	Highly permeable (e.g. high sand/gravel content) or low infiltration (heavy clay soils) are not suitable for irrigation. While these soil types make a site less suitable, recycled water can still be applied providing associated risks are managed.
Slope	<10% slope is preferred for irrigation, the greater the slope, the more restraints on the design of the irrigation system and the more site management controls are required.
Surface and groundwater	Surface water sources in proximity should be assessed and protected to avoid impacts from surface run-off from or into stormwater systems. Any surface drainage from the site irrigation should be retained on site. Movement offsite should consider impacts to other relevant environmental segments such as surface and ground waters.
Climate drainage	A hydrogeological assessment of the proposed irrigation scheme should be undertaken and completed in accordance with the principles outlined in Hydrogeological assessment (groundwater quality) guidelines. Consideration for the effect of the plant/crop production system and the effects of climate and recycled water on groundwater quality. Where an assessment indicates that irrigation is likely to result in surface waterlogging, root zone salinity and/or groundwater contamination, advice should be sought from an agronomist to determine if these risks can be managed adequately through site-specific controls.
Rainfall	Average annual evapotranspiration rates should substantially exceed rainfall to maximise recycled water reuse. Drier climates, such as those in the northwest of Victoria, are the most suitable. In areas with high rainfall, irrigation with recycled water is possible provided there is a distinct prolonged dry season, together with adequate available land for storage and irrigation.

3.3 Western Australia

3.3.1 Water classification and treatment

The classification of recycled water in Western Australia (WA) is dependent on the end users or final application and the level of risk associated. End uses have been split into 4 levels of 'Exposure Risk' with varying quality objectives as seen in Table 3.18 with the differing log reduction targets of pathogens for varying uses in Table 3.19.

Table 3.18 WA recycled water treatment and monitoring levels

Exposure Risk	Potential End Users	Parameters	Compliance Value	Influent Monitoring	Effluent Monitoring
High	Multi-unit dwellings: internal and external surface irrigation Agricultural irrigation: unprocessed foods Urban irrigation with unrestricted access	E. Coli	<1 MPN or cfu/100mL	Weekly	Weekly
		BOD	<10mg/L	Not required	Weekly
		SS	<10mg/L	Not required	Weekly
		pH	6.5 - 8.5	Continuous or weekly	Continuous
		Turbidity	<2 NTU (95%ile) <5 NTU (maximum)	Continuous or weekly	Continuous

Exposure Risk	Potential End Users	Parameters	Compliance Value	Influent Monitoring	Effluent Monitoring
	Communal use: flushing toilets and designed cold tap washing machines	Disinfection	Cl: 0.2 – 2.0 mg/L UV UVT >75% UV intensity: drop <25% at 254nm UV does: 40 – 70 ml/cm^2 Ozone	NA	Continuous
		Coliphages	<1 pfu/100mL	Fortnightly	Weekly
		Clostridia	<1 pfu/100mL	Fortnightly	Weekly
Medium	Urban irrigation with some restricted access and application Fire fighting Fountains and water features Industrial use with potential human exposure Dust suppression	E.Coli	<10 MPN or cfu/100mL	Weekly	Weekly
		BOD	<20 mg/L	Not required	Weekly
		SS	<30 mg/L	Not required	Weekly
		pH	6.5 - 8.5	Continuous or weekly	Continuous
		Turbidity	<5 NTU (95%ile)	Continuous or weekly	Continuous
		Disinfection	Cl: 0.2 – 2.0 mg/L UV UVT >75% UV intensity: drop <25% at 254nm UV does: 40 – 70 ml/cm^2	NA	Continuous
Low	Communal sub-surface irrigation Urban irrigation with enhanced restricted access and application Agricultural irrigation: non-edible crops	E.Coli	<100 MPN or cfu/100mL	Weekly	Weekly
		BOD	<20 mg/L	Not required	Weekly
		SS	<30 mg/L	Not required	Weekly
		pH	6.5 – 8.5	Continuous or weekly	Continuous or daily
		Disinfection	Cl: 0.2 – 2.0 mg/L	NA	Continuous or daily
Extra Low	Woodlots Sub-surface irrigation (non-food crops)	No treatment or monitoring requirements			

Table 3.19 Log reduction targets for designated recycled water uses

End uses	Log reduction targets		
	Virus	Protozoa	Bacteria
Third pipe reticulation with indoor and outdoor use	6.5	5.0	5.0
Third pip reticulation with indoor or outdoor use only	6.0	4.5	5.0
Municipal use with unrestricted access and application	5.0	3.5	4.0
Municipal use with restricted access and application	5.0	3.5	4.0
Municipal use with enhanced restrictions for access and application	5.0	3.5	4.0
Commercial food crops consumed raw or unprocessed	6.0	5.0	5.0
Non-food crops	5.0	3.5	4.0

3.3.1.1 Industrial and commercial use

Due to the variety of inputs and the occupational health and safety considerations required, the use of recycled water for industrial or commercial purposes currently requires approval on a project-by-project basis. The Victorian government current has plans to release a technical code (water recycling for industrial purposes) in the future to provide further guidance.

3.3.2 Hazard impact

It is indicated that it is necessary to consult detailed tolerance tables to determine plants yield susceptibility to varying concentrations to different hazards. The general impact of common hazards as outlined in the WA guidelines can be seen below in Table 3.20.

Table 3.20 WA General hazard consideration concentrations and plant impacts

Hazard	Units	Impact		
		Insignificant	Moderate	Major
Electrical Conductivity (EC)	mS/m	<75	75 - 300	>300
Sodium	Adj. SAR	<3	3 - 9	>9
Chlorine	Me/L	<4	4 - 10	>10
Boron	mg/1	<0.75	0.75 – 2.0	>2.0

3.3.3 Soil and nutrient loading

A vulnerable parameter as according to the Department of Water Nutrient and Irrigation Management Plan (NIMP) is the total allowable nitrogen (TN) and phosphorous (TP) application rates for recycled water as outlined in Table 3.21. To calculate the minimum area required for irrigation of wastewater to prevent the maximum nutrient loading of phosphorous and nitrogen as stated in Table 3.21 see the set of equations below.

Total Daily Flow = Number of people x Hydraulic load (L/day)

TP in effluent (kg/year) = (No of people x Hydraulic load (L/day) x TP (effluent/day) * 360) ÷ 1000000

TN in effluent (kg/year) = (No of people x Hydraulic load x TN in (effluent/day) * 360) ÷ 1000000

Area required (Ha) = TP in effluent (kg/year) ÷ Total TP allowed (Ha) (from Table 3.21)

Area required (Ha) = TN in effluent (kg/year) ÷ Total TN allowed (Ha) (from Table 3.21)

Table 3.21 Nutrient application criteria to control eutrophication risk

Vulnerability Category	Description	Total nutrient application allowed kg/ha/year	
		Nitrogen	Phosphorous
A	Coarse grain soil and translucent waters	140	10
B	Coarse grained soil and turbid or dark coloured waters	180	20
C	Fine grained soil and translucent waters	300	20
D	Coarse grained sol and turbid or dark coloured waters	480	120

3.3.4 Agricultural Guidelines

3.3.4.1 Irrigation

An extensive number of recommendations in regard to waster reuse for irrigation is outlined in *Irrigation with Nutrient-Rich Wastewater (2008)*. A small example of recommendations can be seen below. Interest in developing a scheme or checking an existing scheme should seek more information from that document:

– Spray drift should be minimised due to risks associated with human exposure, where spray irrigation is used buffer zones should be established.
– Irrigation systems should be installed and operated without surface runoff and to ensure ponding does not occur as can lead to mosquito and greater risk to human exposure.
– Irrigation pipes should be drainable and flushable to remove obstructions.
– For schemes subject to algae blooms, a blue-green algae emergency response plan should be developed.
– A mosquito management program must be implemented if a mosquito breeding risk is identified.
– Wastewater should not be applied to land that is permanently or seasonally flooded or waterlogged, instead be used at sites sufficiently high in the landscape to allow for effective filter zones and sediment control systems.
– Wastewater irrigation should not occur within recharge zones of natural wetlands.
– A minimum of 2 m vertical separation between the irrigated surface and the end of the wet-season water table should be ensured to maintain aerobic soils.

3.3.5 Procedures and approval process

Western Australia's *Guideline for the approval of non-drinking water systems in Western Australia* is an excellent document which simplifies and clarifies the approval process for the use of non-drinking water. Whilst it does focus on urban development for land developer and local governments, it is a good comparison and should be used as a guide implementation of recycled water for agriculture purposes.

The approval process for recycling water schemes sourced from sewage, municipal or industrial wastewater can be summarised into five primary steps:

1. If schemes >5000 L/day of treated effluent:
   - Yes: follow approval process in Guideline for the approval of non-drinking water systems in Western Australia.
   - No: approval not required. Follow requirements in Code of Practice for the reuse of greywater in Western Australia.
2. Is there a sewage treatment plant installed?
   - Yes: complete the application for approval of a recycled water scheme and a draft Recycled Water Quality Management Plan (RWQMP).
   - No: In addition to the recycling application form and the draft RWQMP you will need to apply to install a wastewater system.
3. Assessment and in principle approval:
   - Conditions to install recycled treatment plant (if not already installed).
   - Validate and verify samples to demonstrate treatment plant is achieving required water standards.
   - Any RWQMP sections that need addressing.
4. Post plant commission:
   - Results of validation
   - Verification of sampling program
   - Completed RWQMP
5. Final approval: after all submissions are to the satisfaction of the Department of Health.

3.3.5.1 Additional processes

Whilst the general approval process is outlined above, specific consideration is thought to be significant, those specific considerations include:

Environmental release

If recycled water can be used for environmental uses, provided it meets all site-specific environmental standards can be used for environmental purposes. The corresponding DEC regional office should be contacted for those schemes seeking approval for environmental benefits.

Mosquito management

In Western Australia, mosquitoes can be serious pests as well as potential vectors of disease-causing viruses and parasites. Ross River virus disease and Barmah Forest virus disease (Delivering a Healthy WA 57) occur state-wide in environmentally driven cycles and the rare, but potentially fatal Murray Valley encephalitis, occurs in the northern half of the State.

It is essential that the implementation of recycled water use does not enhance mosquito breeding and the transmission of disease. The water provider must implement a mosquito management program if mosquito breeding risk is identified as an issue through the health risk assessment.

3.3.6 Human exposure controls

Wherever water is being used for non-potable applications, erect prominent warning signs indicating, in English and any other primary languages predominately spoken in the area:

– "Recycled Water – Do Not Drink"

All recycled water detention basins and storage areas should also be clearly sign- posted. The wording of these signs should state:

– "WARNING – RECYCLED WATER – DO NOT DRINK OR SWIM"

These signs must incorporate the following requirements:

– A minimum size of 20 cm x 30 cm on a white background with black lettering of at least 20 mm in height.
– Contain the recommended International Public Information – Drinking Water Symbol with the Prohibition Overlay in RED.
– In compliance with AS1319 – 1994 Safety Signs for the Occupational Environment.
– Number of signs and size of wording should be determined on the basis of the visual distance from the observer.

All requirements for signage can be seen in *Warning Signs for Non-potable Water Schemes*.

3.3.7 Site selection

The criteria for site selection will be dependent on the proposed end use of the recycled water but there are some criteria common to all recycled water treatment processes.

In selecting a suitable site for the construction of a recycled water scheme, particular attention should be paid to:

– Land use conflicts:
  - Planning consideration (e.g. odour/noise control) if in proximate to residential premises
  - Recycled water and public drinking water sources conflict or specific environmental requirements
– Proximately to end-use:
  - Preferably sufficiently closer to end user where possible

3.4 Queensland

3.4.1 Water classification and treatment

The classes of recycled water described for Queensland (QLD) are based on recommendations contained in the draft national guidelines.

Table 3.22 QLD recycled water classes

Class	Factor	Sampling Frequency	Factor quality and log reduction requirement	Annual Value (found in 95% of a 12 month period)
A+	Chlorine residual	Daily	<0.2 mg/L – <0.5 mg/L	<=0.5 mg/L
	Clostridium perfringens	Weekly	<= 10 cfu/100mL – <1 cfu/100mL And 5 log	<1 cfu/100mL
	E. coli	Weekly	<= 10 cfu/100mL And 5 log	<1 cfu/100mL
	F-RNA bacteriophages	Weekly	<= 10 pfu/100mL And 6.5 log	<1 pfu/100mL
	Somatic coliphages	Weekly	<= 10 pfu/100mL Or 6.5 log	<1 pfu/100mL
	Turbidity	Daily	<= 5 NTU	<2 NTU
A	E. coli	Weekly	<= 100 cfu/100mL	<10 cfu/100mL
B	E. coli	Weekly	<= 1,000 cfu/100mL	<100 cfu/100mL
C	E. coli	Weekly	<= 10,000 cfu/100mL	<1,000 cfu/100mL
D	E. coli	Weekly	<= 100,000 cfu/100mL	<10,000 cfu/100mL

Drinking water

Queensland does have provisions for recycled water to augment the supply of drinking water. The requirements for which are extensive including concentrations of microorganisms to have a nil concentration and over 100 chemical compounds associated maximum concentrations which need to be monitored. The list of these microorganisms and the chemical compounds can be seen in *Public health regulations 2005 (18AD and 3B)*.

3.4.2 Hazard impact

Queensland does not outline chemicals hazardous to plant throughout the various guidelines.

3.4.3 Soil and nutrient loading

Similar to the section above, Queensland does not outline chemicals to be considered during reuse throughout the various guidelines.

3.4.4 Agricultural Guidelines

3.4.4.1 Irrigation

The table below outlines the crop types and minimum allowable recycled water class based on the irrigation method.

Table 3.23 QLD irrigation standards for minimally processed crops

Crop Type	Example Crop	Irrigation Method	Minimum Water Class
Root crops	Carrots, beetroot and onions	Spray, drip, flood, furrow or subsurface	A
Crops grown on or near the ground if normally eaten with skin removed	Pumpkin	Spray	B
		Subsurface, drip, flood or furrow	C
Rockmelons		Subsurface, drip, flood or furrow	A+
Crops grown on or near the ground, other than crops normally eaten with skin removed	Broccoli, cabbage and tomato	Spray, flood and furrow	A+
		Drip	A
		Subsurface	C
Crops grown away from ground, normally eaten with skin removed	Avocado, banana and mango	Spray	B
		Subsurface, drip, flood or furrow	C
Crops grown away from ground, other than crops normally eaten with skin removed	Apple, olive and peach	Spray	A+
		Drip, flood and furrow	B
		Subsurface	C
Crops grown in hydroponic conditions	Herb, lettuce and seed sprouts	Hydroponic	A+

If a recycled water provider fails to meet the minimum class, the provider should contact the nearest Queensland Health Public Health Unit to discuss any measures that may been to be implemented to ensure public health.

3.4.4.2 Livestock

All classes of recycled water can be used for beef and dairy cattle given the following controls are required:

– Exclude lactating dairy cattle during irrigation and until pasture is dry
– Fodder must be allowed to dry before being supplied as feed

3.4.5 Procedures and approval process

The Supply (Safety and Reliability) Act 2008 (the Act) includes provisions relating to recycled water. The primary aim of the recycled water provisions is to protect public health and, for certain schemes known as critical recycled water schemes, to ensure continuity of operation to meet the essential water supply needs of the community or industry.

The Act requires that a recycled water provider must have either of the following before supplying recycled water unless they are covered by a transitional period:

– A recycled water management plan (RWMP) approved by the regulator, or
– An exemption from preparation of a RWMP granted by the regulator (refer to Recycled water management plan exemption guidelines)

Other varying requirements are dependent on characteristics of the recycling scheme such as inclusion of a sewage treatment plant and the differing requirements for common, local, state and Commonwealth which is well summarised in *Queensland water recycling guidelines 2005.* The guide also provides a developmental chart for the development of a recycled water scheme that can be seen below.

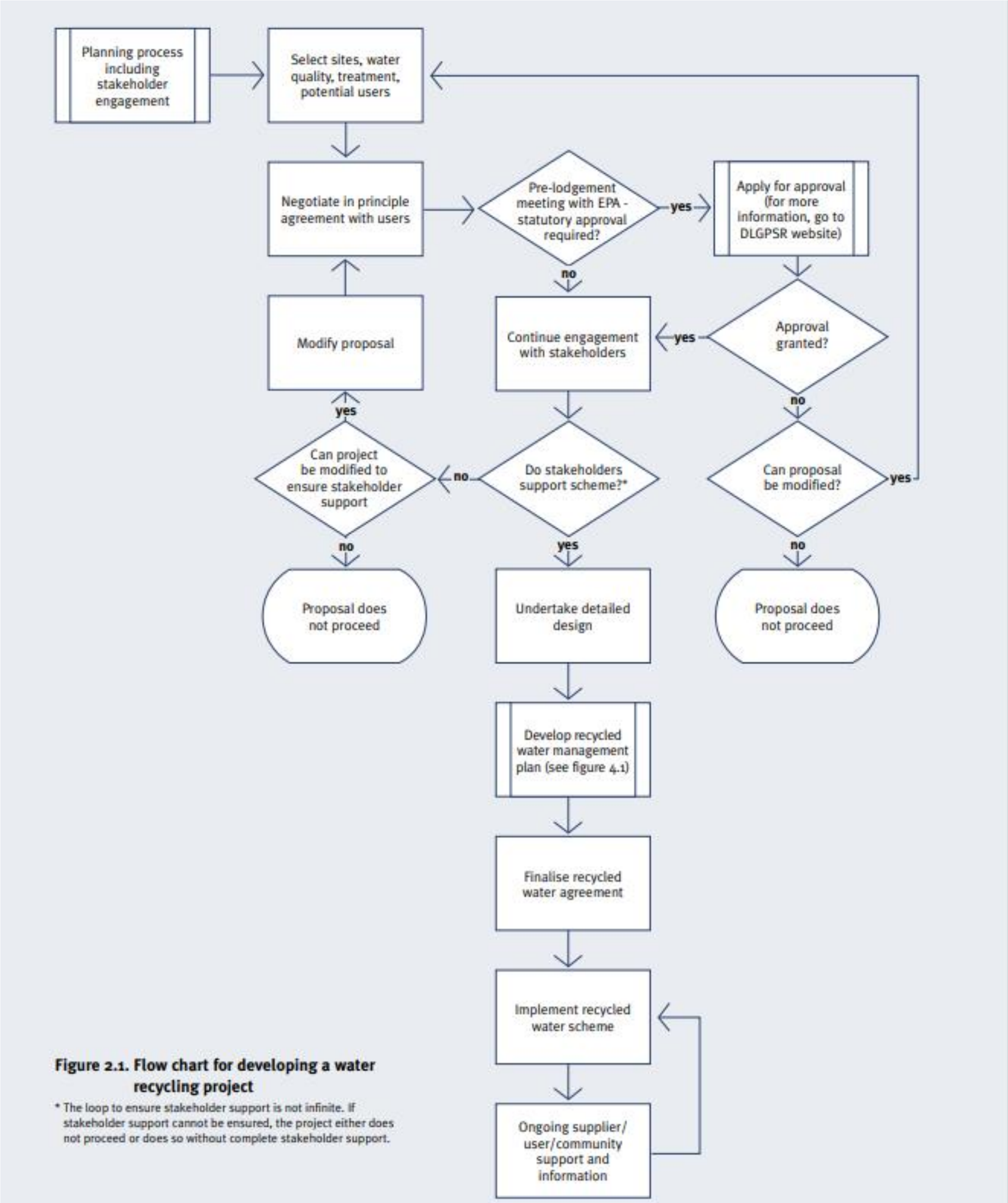

Figure 3.4 Recycled water development chart

3.4.5.1 Other procedures

Across northern Australia in particular, mosquito are carriers of diseases. Therefore, it is essential that the implementation of recycled water does not enhance mosquito breeding and the transmission of disease. The Local Government Association of Queensland has produced a *Mosquito Management Code of Practice (LGAQ 2002)* that contains detailed advice on mosquito control in Queensland.

3.4.6 Human exposure controls

Certain controls must be employed for every use of recycled water. For all classes of recycled water other than purified recycled water (water at the standard to replenish drinking water supplies) are not considered suitable for human consumption. Minimum onsite controls for places recycled water is used must include:

- All plumbing compliances to prevent cross connects with drinking pipes.
- Prominent warning signs at public access points to indicated recycled water non-suitability for consumption or human exposure.
- Precautions to ensure no contamination of water used as supply for drinking (e.g. dams or bore).
- No runoff or ponding of recycled water.
- No overspray.

Other controls are required for differing recycled water classes in different irrigation uses, this is outlined in Table 3.24.

Table 3.24 QLD site controls for recycled water irrigation

Municipal open spaces (parks and sports fields)	Golf courses	Pastures and fodder crops for beef and dairy cattle	Highly process food and non food crops
Class A+:			
Minimum on-site controls	Minimum on-site controls	Minimum onsite controls Exclude lactating dairy cattle during irrigation and until pasture is dry Fodder must be allowed to dry before being supplied as feed	Minimum onsite controls
Class A:			
Minimum on-site controls Spray drift control	Minimum on-site controls Spray drift control	Minimum onsite controls Exclude lactating dairy cattle during irrigation and until pasture is dry Fodder must be allowed to dry before being supplied as feed If members of public may be in vicinity of irrigation area: Spray drift control	Minimum onsite controls If members of public may be in vicinity of irrigation area: Spray drift control or drip irrigation
Class B:			
Minimum on-site controls Restricted access during irrigation and 4 hours after or until dry Spray drift control or buffer zone of min 25 m	Minimum on-site controls Restricted access during irrigation Spray drift control or buffer zone of min 25 m	Minimum onsite controls Exclude lactating dairy cattle during irrigation and until pasture is dry Fodder must be allowed to dry before being supplied as feed If members of public may be in vicinity of irrigation area: Restricted access Spray drift control or buffer zone of min 25 m	Minimum onsite controls If members of public may be in vicinity of irrigation area: Restricted access and one of the following: – Spray drift control – Drip irrigation – A buffer zone of min 25 m

Municipal open spaces (parks and sports fields)	Golf courses	Pastures and fodder crops for beef and dairy cattle	Highly process food and non food crops
Class C:			
Minimum on-site controls Restricted access during irrigation and 4 hours after or until dry Spray drift control Buffer zone of min 25 m	Minimum on-site controls Restricted access during irrigation Spray drift control Buffer zone of min 25 m	Minimum onsite controls Exclude lactating dairy cattle during irrigation and until pasture is dry Fodder must be allowed to dry before being supplied as feed If members of public may be in vicinity of irrigation area: Restricted access, a spray drift control and buffer zone of min 25 Restricted access and extended buffer zone of min 50 m	Minimum onsite controls Crops must be allowed to dry before harvesting If members of public may be in vicinity of irrigation area: Restricted access and one of the following: – Spray drift control – Drip irrigation – A buffer zone of min 25 m Or – Restricted access and an extended buffer zone of min 50 m
Class D:			
NA	NA	NA	Used for non-food crops only Minimum onsite controls If members of public may be in vicinity of irrigation area: No public access and drip irrigation Restricted access, spray drift control and a buffer zone of min 50 m

3.4.7 Site selection

The Queensland guidelines do not recommend favourable or impactful characteristics to consider in agricultural site selection.

3.5 Australian Capital Territory

3.5.1 Water classification and treatment

The Australian Capital Territory outlines its water quality and treatment requirements based off the end user application of reuse purpose. The following are the ACT specific treatment, quality and monitoring requirements.

Table 3.25 ACT water treatment requirements

Type of reuse	Level of treatment	Water quality	Monitoring
Municipal irrigation, ornamental public access – uncontrolled public access	Secondary Pathogen reduction by disinfection, ponding or filtration	pH 6.5-8	Weekly
		Thermotolerant coliforms <10 cfu/100mL	Weekly
		>1 mg/L chlorine residue	Daily
Municipal irrigation – controlled public access	Secondary and Pathogen reduction by disinfection, ponding or filtration	Thermotolerant coliforms <1,000 cfu/100mL	Monthly
Pasture and fodder for dairy cattle		pH 6.5-8	Weekly
		Thermotolerant coliforms <10 cfu/100ml	Weekly
Pasture and fodder	Secondary	Thermotolerant coliforms <1,000 cfu/100mL	Monthly
Horticulture			

Type of reuse	Level of treatment	Water quality	Monitoring
Residential: garden watering, toilet flushing, car washing	Secondary Pathogen reduction Filtration	Thermotolerant coliforms <10 cfu/100ml	Weekly
		>1 mg/L chlorine residue	Daily
		pH 6.5-8	Weekly
Silviculture, turf and non-food crop	Secondary	No quality requirement	NA
Food crops not in direct contact with water or is cooked/processed	Secondary and pathogen reduction	T coliforms < 1,000 cfu/100ml	Monthly
		pH 6.5-8	Monthly
Ornamental waterbodies – restricted access	Secondary	Thermotolerant coliforms <10,000 cfu/100mL	Monthly
Aquaculture – nonhuman food chain	Secondary maturation ponds (5-day retention)	Thermotolerant coliforms <10,000 cfu/100mL	Weekly
		TDS <1000 mg/L	Not specified
Aquaculture – human food chain	Secondary Pathogen reduction Filtration	T coliforms <10 cfu/100mL	Weekly
		>=1 mg/L chlorine residue	Daily
		pH 6.5-8	Weekly

3.5.2 Hazard impact

The Australian Capital Territory does not outline chemicals to be considerate of during irrigation throughout the various guidelines.

3.5.3 Soil and nutrient loading

Besides the chlorine residual and heavy metal/restricted substances, all standards require initial and periodic monitoring. Chlorine residual monitoring is required if there is potential to discharge to receiving waterways and heavy metal/restricted substances if effluent is derived from industrial estates. The recommended maximum concentrations can be seen below.

Table 3.26 Environmental consideration for wastewater reuse

Parameter	Effluent standard
Nutrient levels	Dependent on plant requirements Nitrate <10mg/L for humans, <30mg/L for animals
TDS	500 mg/L
EC	800 µs/cm
Sodium absorption ratio	<6
Biochemical oxygen demand	Organic load: <=40kg/ha/day
Acidity	6.5-8.5
Chlorine residual	<0.5 mg/L where runoff is likely to enter receiving waters
Heavy metals/restricted substances	See Table 3.27

Table 3.27 Heavy metal/restricted substances total concentrations

Element	Total Concentration (mg/L)	Element	Total Concentration (mg/L)
Aluminium	5.00	Arsenic	0.10
Beryllium	0.10	Cadmium	0.01
Chromium	0.10	Cobalt	0.05
Copper	0.20	Iron	1.00

Element	Total Concentration (mg/L)	Element	Total Concentration (mg/L)
Lead	0.20	Lithium	2.50
Manganese	0.20	Nickel	0.20
Molybdenum	0.01	Zinc	2.00
Selenium	0.02		

3.5.4 Agricultural Guidelines

3.5.4.1 Irrigation

Systems are recommended where practical and where costs and inflexibility of the system is considered, to minimise human contact such as through sub-surface irrigation, particularly where there is uncontrolled public access. Additionally, any irrigation is to be done with care as to prevent surface flow or seepage into neighbouring properties.

Where above ground irrigation is adopted, sprinklers which produce coarse droplets and not a fine mist should be used to minimise the risk of aerosol dispersion by wind.

3.5.5 Procedures and approval process

If the proposal or installation of a wastewater reuse scheme with a capacity of >3 ML/yr or in circumstances where environmental risk is concerned, it is required to hold one of the following:

- Environmental agreement with the environmental management authority
- Current environmental authorisation for activity

The following information should be provided in the circumstances where an assessment of the environment and health impacts of a wastewater irrigation system is required:

- A detailed description of the treatment process including a layout plan design capacity.
- Performance specification including the quantity, rate and quality of the effluent produced.
  - Information on effluent quality should include thermotolerant coliforms, total phosphorus, total nitrogen, sodium absorption ratio, acidity (pH), total dissolved solids, turbidity and biological oxygen demand.
- A preliminary description of the health and environmental impacts of the proposed system.
- Details of safeguards and controls that are required under this guideline.
- A description of the irrigation system.
  - The following should be included in the irrigation system decryptions: proposed or existing land use, area, topography, drainage patterns including proximity to waterbodies, depth to groundwater, soil permeability and public access.
- A water balance for the irrigation site including rainfall and evapotranspiration.
- A nutrient balance for the irrigation site.
- Storage provision for periods of wet weather when the soil is saturated.
- Details of performance monitoring regime.
- Any other information required to assess the proposal as necessary.

3.5.6 Human exposure controls

For the types of uses as stated in Table 3.25 the only controls related to human exposure was for silviculture, turf and non-food crops which has been noted to have restricted public access and withholding for 4 hours.

For effluent, which is not suitable for public access, spray irrigation systems should be surrounded by vegetative buffer zones and should not be sited in proximity to dwellings, public roads and parks. In general, the following buffer zones are recommended if irrigation at night is not feasible:

– Aerosols: 50 m
– Low rising sprays: 20 m

3.5.7 Site selection

The following factors are those that the ACT guidelines recommend being taken into account in determining the suitability of a site and the irrigation system. Additional notes for the outlined factors can be seen in Table 3.28.

– Proposed or existing land use
– Site features:
  - Topography
  - Drainage characteristics
  - Proximity to dwellings and waterbodies
  - Depth to groundwater
  - Soil permeability
  - Vegetation
  - Public access
– Water balance for site
– Storage provisions for periods of wet weather when the soil is saturated
– Nutrient balance assessment
– Appropriate design, installation and maintaining requirements for such systems

Table 3.28 Site selection additional notes

Factors	Notes
Topography	Slopes <=15% are acceptable for pasture irrigation provided runoff and erosion are strictly controlled Steep slopes recommended for plants such as trees and vines which use trickle irrigation
Proximately to ground water	Should be least 500 m from any surface water which is used as a domestic supply Distance from natural watercourses will depend on the quality of the effluent, slope and permeability of the site
Groundwater	Where agronomically viable, trickle systems are recommended as they provide more protection to groundwater that other irrigation systems Irrigation should be based on a moisture deficit
Soil	Ideally medium grained, moderately permeable and well structured Clay, sandy and gravely soils may be difficult to manage due to the extreme low and high infiltration rates Soil depths in excess of 1.5 m throughout the site are preferred, lesser depths may be effective for shallow rooted pastures
Water balance	Runoff from the catchment above the irrigation area may need to be diverted to reduce discharge from the site Good irrigation practice requires well defined rest periods within the program to provide an opportunity for the applied water to be evapotranspiration, and for soil micro-organisms to break down the organic matter contained in the effluent Effluent should not be applied if soil moisture conditions are such that surface runoff or ponding is likely to occur. Irrigation of effluent should only be carried out under dry weather conditions

Factors	Notes
Storage	Monthly precipitation and evaporation data should be analysed to determine how often there may need to be a temporary reduction or cessation of effluent irrigation and the resultant storage requirements The site planned for storage lagoons should be carefully investigated and adequately designed to prevent seepage losses and maintain adequate freeboard Storage is not required where sewer mining is on a demand basis with the option of diverting the effluent to the sewer system during periods when irrigation is not required

3.6 Tasmania

3.6.1 Water classification

The below tables show the Tasmanian mandatory effluent treatment and qualities requirements. The processes involved with each treatment level can be seen in Figure 3.5 or for further treatment outlines see *Guidelines for the preparation of a development proposal and environmental management plan for irrigation of treated wastewater on land.*

Table 3.29 TAS Water classification and treatment requirements

Class	Mandatory treatment requirements	Mandatory effluent quality	Monitoring
A	Advanced treatment with disinfection	<10 thermotolerant coliforms /100ml pH 5.5-8.0 BOD <10mg/l Nutrient, toxicant and salinity controls	pH – weekly BOD – Weekly SS – weekly Disinfection – daily Turbidity and chlorine – continuous Coliforms – daily Viruses and parasites – twice yearly Nutrient, toxicant and salinity – regularly
B	Secondary treatment with disinfection	<1,000 (<100 in special circumstances) thermotolerant coliforms/100ml pH 5.5-8.0 BOD <50mg/l Nutrient, toxicant and salinity controls	pH – weekly BOD – Weekly SS – weekly Disinfection – daily Turbidity – continuous (in high-rate processes) Coliforms – weekly Viruses and parasites – twice yearly Nutrient, toxicant and salinity – regularly Monthly monitoring for reuse schemes <1 ML/day
C	Secondary treatment	<10,000 thermotolerant coliforms /100ml pH 5.5-8.0 BOD <80mg/l Nutrient, toxicant and salinity controls	pH – monthly BOD – monthly SS – monthly Disinfection – daily (except for 30 day maturation ponds) Coliforms – weekly Viruses and parasites – twice yearly Nutrient, toxicant and salinity – regularly Quarterly monitoring for reuse schemes <1 ML/day

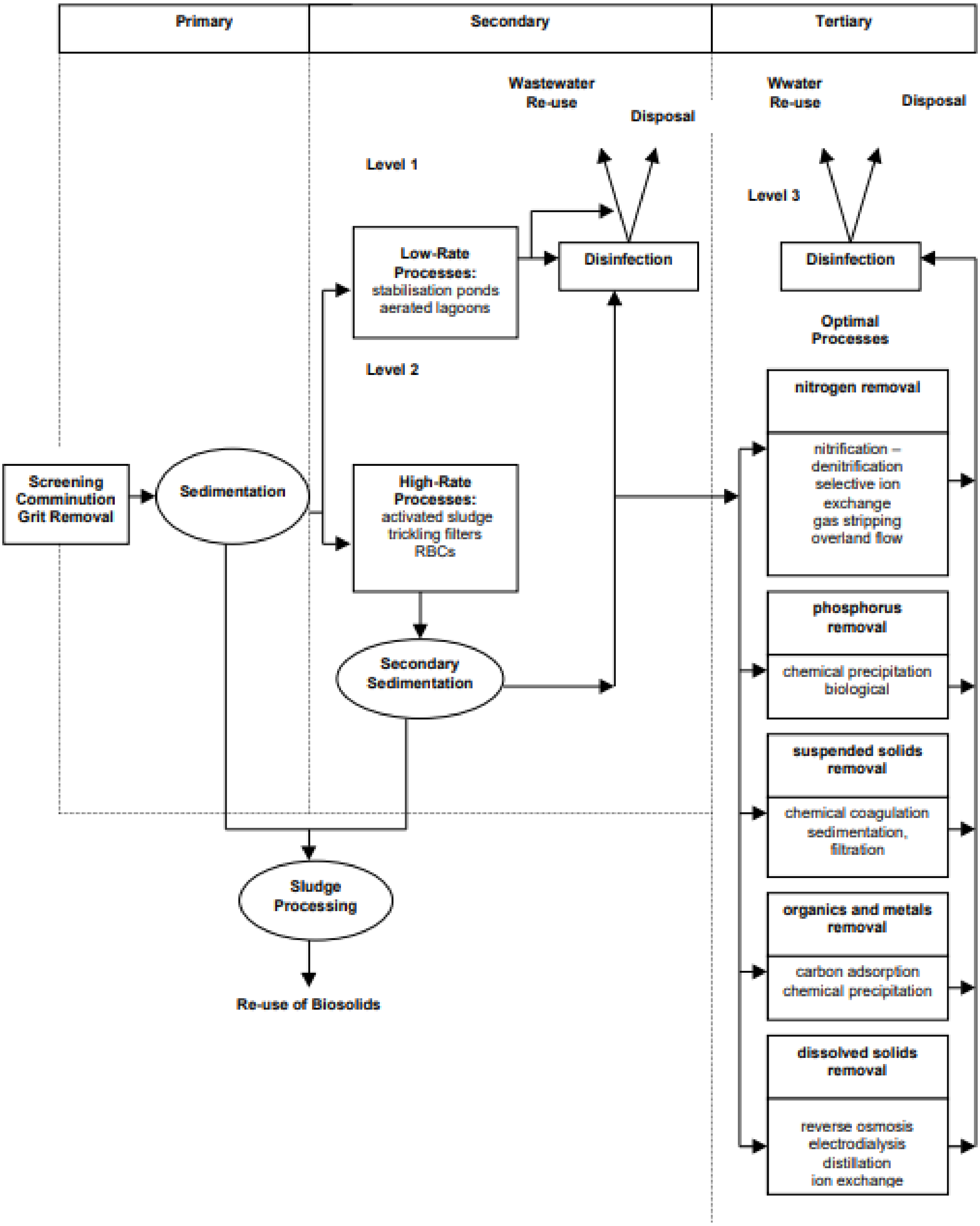

Figure 3.5 Typical processes in differing levels of treatment

Table 3.30 Water class specific management requirements

Class	Management requirements	Potential use
A	Municipal uses may include irrigation of open spaces, sports grounds, parks, dust suppression and land rehabilitation areas. The system must be managed to prevent drift control. No spray drift must be decreed beyond the boundaries of the irrigation area.	Indirect potable groundwater recharge by spreading Indirect potable groundwater recharge by injection Non-potable municipal irrigation (uncontrolled access) Urban non-potable (general household use) Fire and water protection systems Agricultural: Direct contact of reclaimed water with crops consumed raw Stream augmentation and groundwater recharge Urban use (garden watering and toilets) Aquaculture (human food chain) Other uses subject to approval
B	The system must be managed to prevent spray drift. No spray drift must be detected beyond the boundaries of the irrigation area Dropped crops not to be harvested from the ground Crops contacted by effluent must be cooked (>70°C for 2 minutes), commercially processed, or peeled before consumption Restricted public access. Withholding period of nominally 4 hours or until irrigated area is dry Withholding period 5 days for grazing animals	Crops to be consumed raw but not in direct contact with reclaimed water or crops sold to consumers cooked or processed Pasture and fodder (no pigs or poultry) for grazing animals withholding period applies – 5 day for dairy, 4 hour for non-dairy for grazing animals withholding period applies – 5 day for dairy, 4 hour for non-dairy Non-potable municipal irrigation with controlled access <100 thermotolerant coliforms applies for pastures and fodder crops (dairy and non-dairy) without withholding period
C	The system must be managed to prevent spray drift. No spray drift must be detected beyond the boundaries of the irrigation area Restricted public access Withholding period of nominally 4 hours or until irrigated area is dry No human food chain crops	Agriculture (non-human food chain e.g. forestry, cotton) Industrial processes (closed system) Non-human food chain aquaculture

The wastewater sources identified as unacceptable for reuse in the Tasmanian guidelines include:

– Radioactive materials with a half-life greater than a few days
– Pharmacologically active compounds
– Non-biodegradable organic compounds
– Wastes containing elevated levels of total dissolved salts
– Wastes containing high concentrations of metals
– Petrochemical and mining industries output

Potable re-use

Whilst Tasmanian guidelines state that wastewater for drinking or other related domestic purposes or resulting in bodily contact, contact recreational application (e.g. filling swimming pools), whilst possible is not envisaged and therefore not outlined in the guidelines for wastewater due to the high treatment and disinfection standards required.

3.6.2 Hazard impact

The Tasmanian wastewater reuse and agricultural guidelines do not outline plant hazards, it is recommended to use soil loading guidelines below for reference.

3.6.3 Soil and nutrient loading

Table 3.31 indicates the maximum allowable concentrations of trace elements and metals in irrigation waters for long term use. The concentration of heavy metals in plant tissues is considered unlikely to be a problem using irrigation waters containing metals below these listed recommended levels.

Table 3.31 Recommended max concentration for metal in irrigation waters

Element	Suggested soil CCL (kg/ha)	LTV over 100 yrs (mg/L)	STV over 20 yrs (mg/L)
Aluminium	ND	5	20
Arsenic	20	0.1	2
Beryllium	ND	0.1	0.5
Boron	ND	0.5	<0.5-15
Cadmium	2	0.01	0.05
Chromium	ND	0.1	1
Cobalt	ND	0.05	0.1
Copper	140	0.2	5
Fluoride	ND	1	2
Iron	ND	0.2	10
Lead	260	5	20
Lithium	ND	2.5	2.5
Manganese	ND	0.2	10
Mercury	2	0.002	0.002
Molybdenum	ND	0.01	0.05
Nickel	85	0.2	2
Selenium	10	0.02	0.05
Uranium	ND	0.01	0.1
Vanadium	ND	0.1	0.5
Zinc	300	2	5

ND = not determined, insufficient back data to calculate CCL

CCL = cumulative contaminant loading limit, maximum contaminant above which site specific risk assessment is required if contaminant addition is planned

LTV = long term trigger, is the maximum concentration of contaminant in irrigation water which can be tolerated given 100 years of irrigation

STV = short term trigger value, is the maximum concentration of contaminant that can be tolerated over 20 years assuming same annual irrigation loading assumptions as LTV

– Other environmental factors and effects are outlined and discussed in *Environmental guidelines for the use of recycled water in Tasmania (2002)*

3.6.4 Agricultural Guidelines

To ensure that foods for human consumption produced using treated wastewater are safe to eat, the principal requirements as outlined in the Food Act 1998 need to be adhered.

In Tasmania, food safety is governed by several pieces of legislation, including the Food Act 1998. This Act is administered by the Department of Health and Human Services and by local government officers. Importantly the Act requires that all food intended for human consumption must be safe to eat - regardless of whether it is primary food production or retail and whether it is produced conventionally or with treated wastewater.

In most cases where re-claimed wastewater is used, food safety is assured by separating the edible portion of the crop from the wastewater. This may be achieved in several ways, for example by the use of drip-fed irrigation directed at the root zone of fruit trees, thereby avoiding contact with the edible portion. However, it is also necessary to ensure that wind-fall fruit and other fruit that contacts treated wastewater is not harvested for human consumption as it may be contaminated.

Other agricultural management requirements for both livestock, crops and irrigation can be seen in Table 3.30.

3.6.4.1 Irrigation

The Tasmanian guidelines understand that for irrigation, specifically salinity (measured in EC) is important and therefore should be considered when determining suitability for wastewater irrigation. The following outlines classes based off the TDS content as shown below and potential uses for water of respective salinity. The amount of wastewater applied should not exceed the requirements of the plants growing on the site. To be sustainable, irrigation should cease in winter to allow leaching and to avoid possible build-up of salt and nutrients.

Table 3.32 Irrigation classes

Salinity Class	TDS (mg/L)	EC (dS/m)	Uses/notes
1	0-175	0-0.3	Most crops on most soils, all methods of water application, little likelihood of salinity problems developing, some leach required.
2	175-500	0.3-0.8	Used if a moderate amount of leaching occurs, plants with moderate salt tolerance.
3	500-1500	0.8-2.3	Shouldn’t be used on soils with restricted drainage. Salinity control may be required, salt tolerance of the plants to be irrigated must be considered.
4	1500-3500	2.3-5.5	Soils must be permeable and drainage adequate, Water applied in excess to provide considerable leaching, salt-tolerant crops should be selected.
5	>3500	>5.5	Not suitable for irrigation except on permeable well drained soils under good management, restrict to salt-tolerant crops, or for occasional emergency use.

3.6.5 Procedures and approval process

The Wastewater Reuse Coordinating Group (WRCG) is the body which facilitates a comprehensive assessment process. Recommendations of the WRCG will be implemented as appropriate by the Environment Division through the permit conditions for wastewater treatment plants. Other proposals linked to wastewater reuse, such as those from industrial premises, will be assessed by the Environment Division and/or the Environmental Management & Pollution Control Board with input from other agencies as appropriate. The WRCG examines issues including suitability of the effluent for re-use, suitability of the site, protection of groundwater quality, and other specific management issues. Where necessary, the WRCG may require additional information or data to be presented within a Development Proposal and Environmental Management Plan (DPEMP) for the proposed scheme. The final DPEMP document will form the basis for regulating the re-use activity’s operation.

Proposals and environmental management plans should follow the *Guidelines for the preparation of a development proposal and environmental management plan for irrigation of treated wastewater on land*. Other checklist for chemical, nutrient, permits and records can be seen in the same document and can be an effective tool in checking the viability of a wastewater reuse scheme.

3.6.6 Human exposure controls

Below is an overview of the restriction requirements for public access for the three classes of treated wastewater as outlined in the Tasmanian guidelines.

Table 3.33 Public access restriction requirements for water classes

Class	Public access management requirements
A	No restricted access
B	Limited restrictions apply
C	Access restricted

Signages

Warning signs with both a pictorial signage and words indicating that reclaimed water is being used should be placed in strategic positions. Two-tone colouring should be used with black picture and text and red symbol. The number of signs and size of wording should be determined on the basis of the visual distance from the observer (for example, 100 mm wide sign at a distance of 3 m, AS 1319 Safety signs for the occupational environment).

Security

All waste treatment facilities, pumps, valves and controls should be locked, fenced or enclosed as necessary to prevent unauthorised access or interference. Storage lagoons are required to be fenced when on publicly accessible land, such as a golf course. For agricultural storages, a fence is only required in the absence of a property boundary fence.

Buffer distances

Buffer distances can be used for a variety of purposes. The following table shows the Tasmanian minimum buffer distances for varying types of wastewater reuse. For uses not identified below, human risk potential and desired outcome for buffer zones need to be considered to determine suitable minimum buffer distances.

Table 3.34 TAS standard minimum buffer distances

Type of use	Minimum buffer to nearest road of dwelling (m)	Reasoning for buffer
Storage lagoons/holding dams	250	Odour
High pressure irrigation	100	Spray drift
Pivot irrigation	Dependent on technology	Spray drift
Wastewater transfer and irrigation pumps	50	Noise
Flood irrigation	50	Odour and runoff
Drip irrigation	20	Odour and runoff
Surface waters	Dependent on dilution and movement of water	Water quality protection

3.6.7 Site selection

The Tasmanian guidelines note that selection of the most suitable site for a reuse scheme should be evaluated through a scoping analysis, with considerations to the factors listed below. Whilst many of these factors are dynamic, interrelated and may change over time, the evaluation is important to determine the critical factors that determine the limit of effluent usable.

Table 3.35 Site selection consideration

Category	Factors
Critical Distances	Within practical distance from source and away from sensitive developments Capacity for future expansion
Climate	Sufficient yearly evaporation demand Prevailing winds
Local landscape	Site topography Geological feature on site impeding cropping or uncontrolled water movement Risk of erosion
Known cultural heritage	Protection of heritage features
Soils suitable for irrigation	Soil type
Water movement	Susceptibility to unwanted flooding Location from defined watercourses
Offsite effects	Potential adverse effects on surrounding areas e.g. wetlands, sensitive flora or fauna, surface waters

3.7 South Australia

The South Australian recycled water guidelines primarily adopt the Australian guidelines for water recycling 2009 for scientific guidance similarly to the NSW guidelines.

Very limited SA specific guidance is given to the water quality classes and other guidelines such as for agricultural application. A summary of the SA specific guidelines is outlined below. It is recommended to use the Australian guidelines (see Section 3.1 New South Wales) as a basis and seek clarification regarding treatment requirements from the Environment Protection Authority (EPA) and the Department fo Health and Ageing (DHA).

3.7.1 Water classification and treatment

The South Australian guidelines do not outline water treatment requirements, instead as mentioned above, adopts the Australian guidelines.

However, Appendix E of the 2012 guidelines provides an indication of treatment processes and effluent quality classification for reclaimed water in South Australia (which was based around the 1999 SA Reclaimed Water guidelines and used as a reference).

Table 3.36 SA Reclaimed Water Quality Guidelines

Class	Use	Microbiological Criteria [a]	Other Criteria (mean)	Typical Treatment Process Train
A	Residential non-potable Municipal use/public access Unrestricted crop irrigation	< 10	Turbidity $\leq$ 2 NTU	Full secondary plus tertiary filtration plus disinfection
B	Municipal use/restricted access Restricted crop irrigation Irrigation of pasture/fodder Firefighting	<100	BOD < 20 mg/L SS < 30 mg/L (not including algae)	Full secondary plus disinfection
C	Municipal use/restricted access Restricted crop irrigation Irrigation of pasture/fodder	<1,000	BOD < 20 mg/L SS < 30 mg/L (not including algae)	Primary sedimentation plus lagooning or full secondary
D	Restricted crop irrigation Irrigation for turf production Silviculture	<10,000	Chemical content to match use	Primary sedimentation plus lagooning or full secondary

a Thermo coliform (or E Coli) per 100 mL (median).

3.7.2 Hazard impact

Due to the use of the Australian guidelines, no guidance is given to the impact of chemicals on agriculture. However, some general indication is adopted form the previous guidelines (refer to Section 3.7.3 and 3.7.4 below).

3.7.3 Soil and nutrient loading

Similarly, to the section above, no information is provided for concentrations of chemicals to consider soil nutrient loadings. However, regulatory authorities note that effluent application to land should be in in accordance with crop requirements for nutrients and tolerance levels to any toxic contaminants. The volume of water applied should not exceed that used by the crop or lost via evaporation or deep drainage to prevent waterlogging within the rootzones (1999 SA Reclaimed water guidelines).

3.7.4 Agricultural Guidelines

The South Australian guidelines do not provide specific recommendations for wastewater reuse for agricultural purposes. However, the 1999 guidelines note the requirement for monitoring of a range of parameters to ascertain suitability of land (based on intended usage) to receive treated effluent, and this is part of the procedures outlined in Section 3.7.5 below.

3.7.5 Procedures and approval process

The EPA is South Australia's primary environmental regulator. Operators of reuse schemes may have either:

– Environmental Improvement Plans to improve the performance of wastewater treatment plants, or
– Wastewater Irrigation Management Plans (also known as Environment Management Plans) to guide the reuse of treated wastewater

Proponents are required to provide information as requested by the regulating body. The regulating body will provide guidance and advice on the information required. The level and degree of this information will be commensurate with the source of water, intended uses and size and complexity of the scheme.

Applications for recycled water use are assessed for management of risk including prevention, treatment, use restrictions and on-site controls. Such measures should be detailed in a Risk Management Plan.

Other legal requirements are discussed further in *South Australian Recycling Water Guidelines, Appendix A*.

The following are the overviews of the South Australian approvial processes for the varying sources of wastewater. All sources are advised to contact the DHA for guidance.

Treated sewage or mixed sources

The approval process for treated sewage or mixed sources reuse systems in South Australia is shown in the figure below.

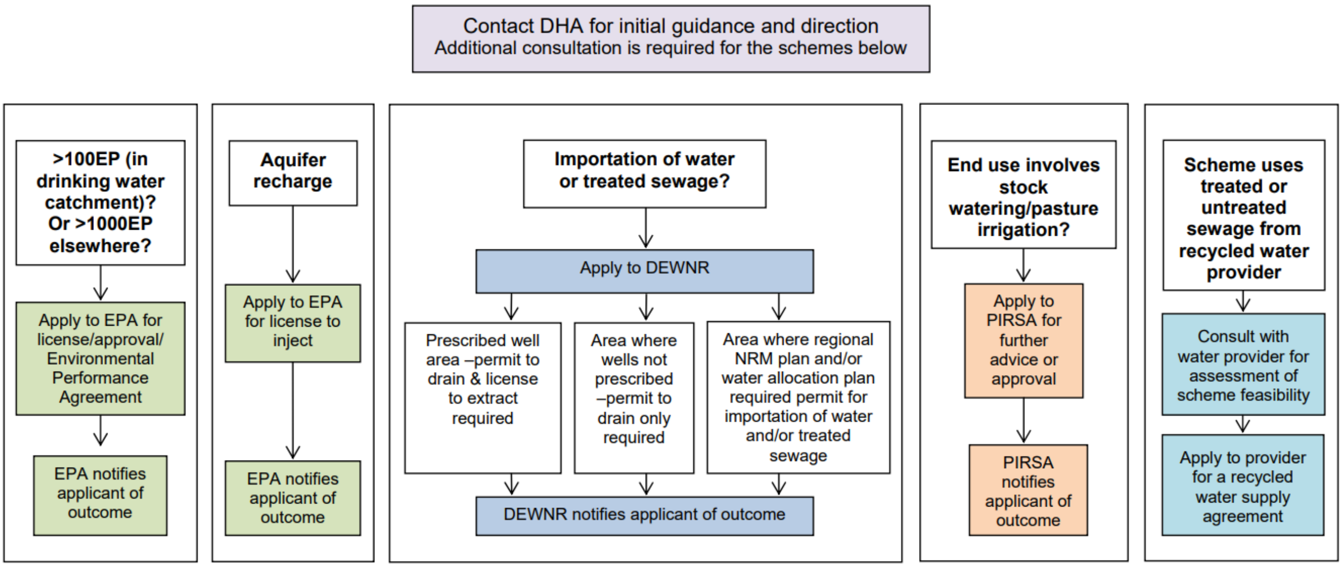

Figure 3.6 Treated sewage or other sources approval process overview

Greywater

The approval process for greywater reuse systems in South Australia is shown in the figure below.

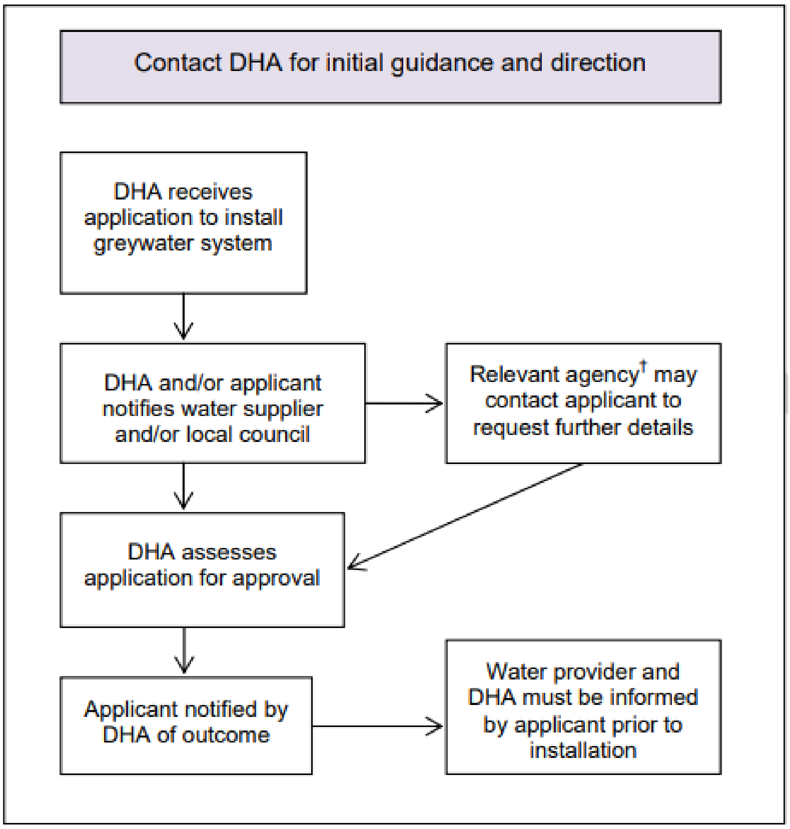

Figure 3.7 Greywater approval process overview

Stormwater

The approval process for stormwater reuse systems in South Australia is shown in the figure below.

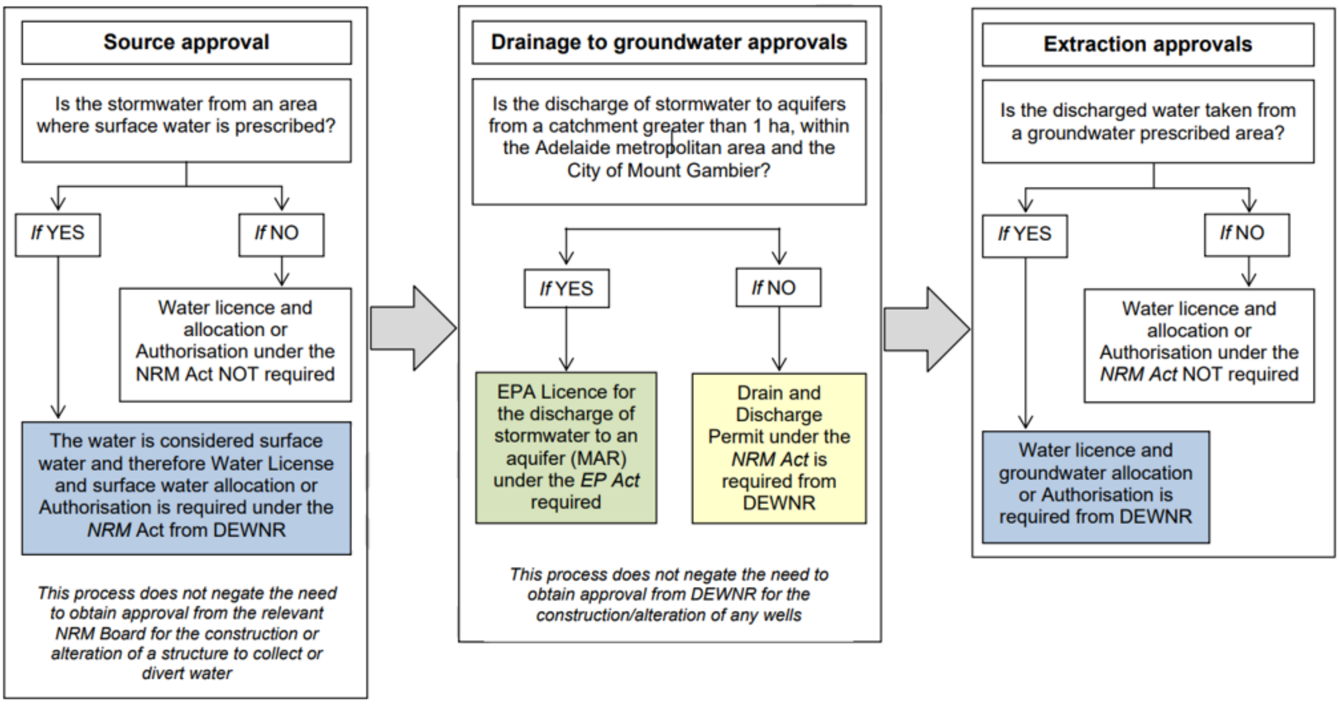

Figure 3.8 Stormwater approval process overview

3.7.6 Human exposure controls

The South Australian guidelines do not specifically outline human protective measures for the use of recycled wastewater in the main guideline sections, However Appendix E of the guidelines indicates the following.

Table 3.37 Public access restriction requirements for reclaimed water classifications

Class	Public access management requirements
A	No restricted access
B	Limited restrictions apply
C	Further restricyions apply
D	Access restricted

3.7.7 Site selection

The table blow shows hazard controls to be considered in South Australia when selecting sites for a reuse scheme.

Table 3.38 Hazard recommendations

Features	Minor	Moderate	Major
Slope:			
Flood irrigation	<1%	1-3%	>3%
Sprinkler, tanker	<6%	6-12%	>12%
Trickle, micro spray	<10%	10-20%	>20%
Flooding	Non-rare	Occasional	Frequent
Distance to water source (m)	>200	100-200	50-100

Features	Minor	Moderate	Major
Landform	Hill crests, convex slopes and plains	Concave slopes, foot slopes	Drainage plains, incised channels
Surface rock	Nil	0-5%	>5%
Hydraulic conductivity (mm/hr): Topsoil Subsoil to 1 m	 20-80 20-80	 5-20 1-20	 <5 <1
Depth to water table (m)	>3	0.5-1	<0.5
Depth to bedrock (m)	>1	0.5-1	<0.5
Available water holding capacity (mm/hr)	>200	<200	
Salinity or EC (dS/m)	<2	2-8	<8
P sorption capacity (mg P/kg)	>1000	200-1000	<200
pH (in $CaCl_2$)	4 - 9	3 - 4	<3 or >9
ESP	0-5	5-10	>10
CEC (cmol(+)/kg) (average 0-40 cm)	>15	<15	

3.8 Northern Territory

3.8.1 Water classification and treatment

Previously the Northern Territory's approach to setting wastewater requirements was similar to other states and territories, by defining mandatory quality requirements in the finished water. The current approach is via a risked based assessment as in the Australian guidelines and following the recommended log reductions required as based on the end use. The log reduction values for common end uses as identified by the Northern Territory guidelines are seen below and should be used as a guide in conjunction with Table 3.1 for high exposure schemes.

Table 3.39 Common uses and log reductions

Use	Protozoa	Viruses	Bacteria
Commercial food crops	4.8	6.1	5.0
Dual reticulation	5.0	6.4	5.1
Fire fighting	5.1	6.5	5.3
Municipal reuse	3.7	5.2	4.0
Non-food crops	3.7	5.2	4.0

For the risk-based assessment, reuse schemes are classified into two categories as identified below.

Table 3.40 Common uses for varying exposure risks

Risk level	Common uses
Low risk	Irrigation of open spaces, pastures, fodder crops, heavily processed food crops, dust suppression
High risk	Augment supply of drinking water via a source supply, development by way of dual reticulation, irrigate minimally processed food crops

Recycled water providers must monitor for a range of parameters in accordance with the Public and Environmental Health Regulations. For a public health perspective, the key quality parameter to measure is E. coli on a recommended weekly basis. Below is the measure of E. coli and the associated class.

Table 3.41 E. coli classifications for low exposure

Class	E.coli Quality (cfu/mL)
A+	0
A	>10
B	<100
C	<1000
D	<10000

3.8.2 Hazard impact

The Northern Territory does not outline chemical hazardous to plant throughout the various guidelines.

3.8.3 Soil and nutrient loading

The Northern Territory does not outline chemicals that should be considered due to excessive soil loading throughout the various guidelines.

3.8.4 Agricultural Guidelines

The Northern Territory does not outline agricultural specific requirements throughout the various guidelines.

3.8.5 Procedures and approval process

Low exposure

Although there is no regulatory requirement for proponents of low exposure recycled water schemes to have a recycled water management system (RWMS), having an appropriate RWMS can be a useful way of demonstrating compliance with this section.

High exposure

Department of Health (DoH) requires the proponent develop, submit and implement a Recycled Water Management Systems addressing the 12 elements of the AGWR. The purpose of developing a RWMS is to ensure risks are systematically identified and appropriately managed and is extensively outline in the *Code of practice for water recycling.*

3.8.6 Human exposure controls

End-users of any recycled water scheme must ensure that they comply with any restrictions on use, as well as any on-site control requirements set out in a recycled water user agreement. No recommendations are given to potential controls to be included in recycled water user agreements.

3.8.7 Site selection

The Northern Territory does not outline site characteristics for consideration throughout the various guidelines.

4. Comparison of State/Territory Guidelines

4.1 Water classification, treatment and uses

Through comparison of the differing classification of quality and water treatment requirements between varying states and territories, the only uniform quality measure throughout is the measure of E. coli. The next table below outlines the new classification system used to compare state/territory classifications which is based on the presence of E. coli due to E. coli providing an indication of the level of disease-causing microorganisms that may be present in the recycled water. To note NSW, ACT and SA do not classify wastewater treatment by a measure of the presences of chemicals and bacteria (as per blank columns in second table below).

Table 4.1 New water classification for comparison

New Classification	A+	A	B	C	D	E	F	G	Z
E. coli (cfu/100ml)	0	<1	<10	<100	<1000	<10000	<100000	No Requirement	Other Requirement

Table 4.2 State and territory water class comparison

Class	NSW	VIC	WA	QLD	ACT	TAS	SA	NT
A+								A+
A			High Exposure					
B			Medium Exposure	A+		A		A
C		B	Low Exposure	A		B[2]		B
D		C		B		B		C
E				C		C		D
F				D				
G								
Z		A[1]						

Note:

1. Victorian water class A is based on log reductions.
2. Tasmanian class B water is predominately <10000 cfu/100ml, in special circumstances does the quality requirement change to <100

To compare the mandatory treatment levels between states, the standard levels of treatment have been used with the annotation of + to indicate additional treatment level requirements. The Water NSW descriptions of the levels of treatment can be seen below:

– Tertiary (T): “highly advanced systems that use air and biological processes as well as membranes and UV disinfection to treat wastewater to a very high standard”
– Secondary (S): “more advanced treatment using air and biological processes to decompose the solids and chlorine to disinfect the liquid”
– Primary (P): “minimal treatment involving flotation and settlement to separate solids and liquids, and disposal of the clarified but still contaminated effluent”

Due to the varying mandatory treatment levels and corresponding quality requirements, the mandatory treatment comparison for each state is based on:

– the lowest presence of E. coli a treatment level has for any corresponding quality requirement (e.g. NSW notes direct contact with food production has a mandatory treatment of S and E. coli quality of <10, similarly no food crop production also has mandatory treatment S though an E. coli quality of <10000, therefore S treatment will be denoted for quality of <1000).
– if a quality of E. coli is noted to have more than one possible treatment level, the higher quality treatment is used for comparison (e.g. NSW notes livestock water to be treated either by P+ or S to a E. coli quality of <100, therefore S treatment will be compared).

To note WA, QLD, SA and NT do not outline levels of treatment in their respective guidelines. Refer to the table below for a treatment comparison or each state and territory, and the table after that for a comparison of permissible uses by water classification.

Table 4.3 Treatment comparison

Class	NSW	VIC	WA	QLD	ACT	TAS	SA	NT
A+								
A								
B	T				S+	T		
C	S	S+				S+		
D	S	S+			S	S+		
E	S				S	S		
F								
G					S			
Z		Equivalent log reduction						

Table 4.4 Uses comparison

Class	NSW	VIC	WA	QLD	ACT	TAS	SA	NT
A+								Irrigation, fodder and pasture, dust suppression, indirect/processed crops
A			Raw crops, urban unrestricted access, urban use					
B	Municipal (non-restricted access), direct crops		Urban irrigation (restricted access, firefighting, ornamental water features, industrial with potential human exposure, dust suppression		Irrigation (uncontrolled access), dairy pasture and fodder, non-potable urban use, aquaculture (human food chain)	Indirect potable source recharge, non-potable urban use, direct human contact crop irrigation, aquaculture		
C	Livestock drinking water (dairy without withholding period)	Dairy pasture and fodder, industrial processes	Nonedible crops, irrigation with enhanced restricted access, subsurface irrigation			Non-potable irrigation with restricted access, pasture and fodder (without withholding period)		
D	Municipal (restricted access), indirect/processed crops, pasture and fodder (with withholding period)	Non-potable urban use, indirect/processed crops, grazing/fodder, industrial processes (no potential human exposure)			Irrigation (restricted access), pasture and fodder, horticulture, indirect/processed crops	Indirect/processed crops, pasture and fodder (with withholding period),		
E	Non-food crops				Ornamental waterbodies (restricted access), aquaculture (non-human food chain)	Non-human food chain crops and aquaculture, industrial processes		
F								
G			Woodlots, subsurface irrigation					
Z		Public irrigation, raw crops, firefighting, urban gardening						

4.2 Approval processes comparison

The following table shows a summary comparing the relative restrictiveness of the varying regulatory bodies in each state and territory with the corresponding schemes' requirements e.g. documentation.

Table 4.5 Approval and regulatory body comparison

State	Government agency responsible	Regulatory requirements/strictness	New recycled water project requirements
QLD	Queensland Health	Low - regulations around chemical contents and treatment levels for various uses, but are only guides, rather than strict requirements. Only requirement is that recycled water does not present a "public health risk".	Applications to Department of Natural Resources, Mines and Energy who assess in conjunction with Queensland Health.
NSW	NSW Health	High - all water authorities require adherence to the Australian Guidelines for Water Recycling 2006.	Any new water supply and water recycling schemes must obtain ministerial approval. The Department of Planning and Environment will also play a role in assessing the appropriateness of the proposal.
VIC	EPA	High - EPA has a set of guidelines that must be complied with by the various water authorities.	Application to EPA which is assessed using its technical, environmental and governance framework.
SA	SA Department of Health	Low - uses the Australian Guidelines for Water Recycling (AGWR) 2009 for scientific guidance. Limited SA specific guidelines are given.	SA Department of Health and EPA jointly consider applications using the AGWR as an assessment framework.
WA	WA Health	High - WA has developed a set of guidelines around composition, usage and treatment. Requirements around monitoring of infrastructure and water quality also mandated.	All new schemes must be approved by the states' Chief Health Officer.
TAS	TasWater	High - EPA has a set of guidelines that must be complied with by the various water authorities.	EPA is responsible for assessing new schemes.

5. Opportunities for reuse

Opportunities for reuse from larger plants (greater than 50,000 EP capacity) has commenced.

An initial investigation has been conducted on the opportunities that may exist for treatment plants without current recycled water schemes in place, or with extra capacity. These identified opportunity's locations include the Hunter Water (NSW) wastewater treatment works (WWTW) network which has 21 treatment plants with varying extra capacities.

The Sydney Water plants discharge over 6.3 GL/day of flow (Sydney Water website, 2022) and are generally categorised as follows:

– Less than 3% currently reused.
– Large flows (over 53%) with primary treatment only for ocean discharge like Bondi, Malabar and North Head and very limited site-based reuse.
– A few smaller ocean discharge plants with secondary treatment make up a bit over 5% of flow total.
– Cronulla and Wollongong plant have 436 and 320 ML/d capacities respectively (~12%) and tertiary treatment with ocean discharge.
– Western Sydney plants that discharge to freshwater rivers and creeks:
  - Have tertiary treatment
  - 15 plants make up the remaining 30% of flow, with reuse from some of the smaller ones only
  - Three plants in North-Western Sydney total almost 550 ML/d
  - Three plants near Penrith total over 810 ML/d

Additionally, the ACT's largest water and wastewater treatment plant, Lower Molonglo Water Quality Control Centre (LMWQCC) owned and operated by Icon Water, supplies recycled water off-site to a local golf course with capacity for further use. The effluent qualities from both opportunities have been included in the following sections.

Melbourne (Victoria) also has a future opportunity as a new greenfield STP to the north of the city is in planning with potential for a recycled water scheme but without a nominated discharge strategy. Effluent data for this could be estimated by assessing the water quality at the other Melbourne Plants and assessing differing STP inputs. This assessment of the potential effluent quality has not yet been undertaken and requires further investigation.

5.1 Hunter Water WWTW effluent quality

Hunter Water's pollution monitoring results for the end of year Environmental Protection Licence review for 2020/2021 have been assessed. The minimum and maximum yearly values of selected WWTWs (in western part of their area of operations and without an existing/contracted reuse scheme in place for the majority of the flow) are shown below, comparison of classes adopted in Section 3 are applied to understand the water quality level the effluent is currently at.

Table 5.1 Hunter water effluent quality comparison

Effluent location	Daily flow (ML/d)	Total phosphorus (mg/L)	Suspended solids (mg/L)	Ammonia (mg/L) depending on the season	Total chlorine (mg/L)	Faecal coliforms (cfu/ 100 mL)	pH	Comparison class
Farley	7.2	<0.05 - 0.81	<1 - 20	<0.05 - 2.48		<17 - 600	7.32 - 7.94	C – D
Kurri Kurri	4	0.027 - 1.49	<1 - 12	<0.05 - 0.64		<2 - 33	7.16 - 7.98	B – C
Morpeth	10	0.16 - 1.9	<1 - 46	<0.05 - 0.72		<17 - 830	7.13 - 8.01	C – D

From the comparison classes, the mean quality is approx. class C. From the NSW guidelines the current quality is sufficed for use in agriculture (e.g. livestock drinking water and indirect/processed crops).

5.2 Lower Molonglo Water Quality Control Centre

Looking at the Lower Molonglo Water Quality Control Centre (LMWQCC) effluent discharge quality the level places it as a comparison class level D (<1000 cfu/100mL) as described in Section 4.1.

Table 5.2 Lower Molonglo quality

Total Dissolved Solids (mg /L)	Total phosphorus (mg/L)	Total nitrogen average daily load limit kg/day	Suspended solids (mg/L)	Ammonia (mg/L) depending on the season	Total chlorine (mg/L)	Thermotolerant coliforms/ 100 mL
550	0.4	2100	10	1.6−7.4	0.2	200

The ACT classification for the comparative class D water allows for irrigation (with restricted human access), use in pasture and fodder, horticulture and indirect/processed crops and other uses for water of class lower than D as evident in Table 4.4.

Due to the treatment location near the North-Western border of the ACT, potential reuse could cross state borders if a NSW opportunity was better. Whilst NSW does have similar uses for comparative class D water such as use with indirect/processed crops, the uses are not identical and establishing the end use of a scheme will be a critical step in a cross-state scheme.

6. References

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→ The Power of Commitment

Appendix C

MCA process review and initial results minutes 11Feb22

-

Minutes

22 February 2022

Project name	NWGA - National Review of Wastewater Reuse opportunities for Agriculture	**From**	Luke Sharpe
Subject	MCA process review and initial results	**Tel**	+61 2 49107763
Date / Time	11 February 13:00 – 15:00	**Project no.**	12556736
Attendees	John Goodrich Stuart Jamieson Luke Sharpe Molly Fredle Nathan Malcolm Paul Dellow Ryan Brotchie Bob Kinnell	**Apologies**	Andrew Foddy Sheena Dunne
Objective	Gaining agreement on the no-go's, layers used, categories/weighting and way forward for identifying opportunities	**Copy to**	All invitees

Minutes	**Action**	**To be actioned by**
Acknowledgement of Country	– CW gave an acknowledgement of country	
Objective and review	– Objective of session 'Gaining agreement on the no-go's, layers used, categories/weighting and way forward for identifying opportunities' – NM gave overview by state/territory – NT low/no opportunity – WA some opportunity in mining areas near Pilbara and south of Perth – Tas – nothing large – Qld – western corridor but struggling to get water in drought, small towns already have schemes – NSW, ACT – more opportunity – Vic – opportunities in future Northern Melbourne plant	Noted
Layers previously discussed	– MF showed no-go criteria e.g. conservation, non-Aboriginal heritage, slope >25%, proximity to wastewater treatment plants/surplus mining > 200 km, land use type, moisture availability <3%, airports, acid sulfate soils high probability. – MF showed constraints criteria (including no-go criteria and items considered as constraints). – NM noted the criteria shown are national layers. There are state based layers that are of interest but we have only used national ones. – JG asked to clarify Wastewater produced 2021. This is the data for how much wastewater produced in 2021 in each LGA across Australia, including future projections.	Noted

Minutes	Action	To be actioned by
	– MF advised that the lower a number, the more suitable a location will be for the project (highly suitable 1, neutral 10 through to highly unsuitable and no-go 999). – Conservation and non-Aboriginal heritage layers – further away from a conservation area or site is more suitable. – Mining – 60 km+ is highly unsuitable – can use the wastewater. – Slope – flatter is highly suitable. Considered elevation within median 300 m as the layer was too detailed to consider the average slope across the area. 300 m can be adjusted. – Existing wastewater treatment – unsuitable if >150 km away. Using as a pseudo economic indicator. – Land use – data provided by DAWE. All of Australia is given a land use classification. NM noted that in the report there will be discussion/explanation of the grouping of the land use. JG – suggest wet tropics would be included in highly unsuitable. – Precipitation – low annual rainfall is highly suitable. Wastewater as main water supply used as pseudo economic criterion, as with rainfall available they are likely to use that as a primary source (approach agreed). – Water quality – tertiary most suitable, primary not suitable as not useable for agriculture. – Wastewater produced by LGA – information from a previous GHD study. More wastewater produced is highly suitable. – Heat stress – low heat stress is suitable. Data is from Bureau of Meteorology (BoM). – Frost – highly suitable is frost free. Data is from BoM. – Moisture availability – showing separation between deeper for wood lotting and standard agriculture. – Nutrient balance – 5-7 is best for agriculture however data shows lower pH in the existing agricultural areas, so modified from first workshop. – Soil depth – deeper soil enables agricultural activity and is therefore more suitable. – Evapotranspiration – if plants hold on to water it is more suitable. Data is from BoM. – Airports – no-go in 3 km as to keep immediate skies clear of birds, <13 km there are still restrictions, some agricultural permitted. – Acid sulphate soils – avoid ASS – extremely low probability is considered highly suitable. – Radioactivity – considered as a no-go area. – SJ queried the level of accuracy in pH data. MF advised data has two decimal places. Unlikely to be many sites in the neutral zone.	
Layer weightings	– MF reviewed the pairwise comparison process. – Each criterion is considered against each other criterion. A survey was done internally to give diversity of views from the team (7 respondents). – NM clarified that all criteria are compared to all other criteria individually. – SJ noted that moisture availability combined has a high weighting. GHD to consider if this is skewing the data and whether sensitivity analysis is needed for this (near 50% weighting in 4 criteria overall but could be considered as doubling up a few of the criteria are similar). – JG land use and evapotranspiration. NM noted land use has set out what areas can be used and therefore the areas already dedicated to agriculture are likely to have high evapotranspiration so may be double counting. Consider for sensitivity analysis.	GHD to action as noted.
InDeGO process	– MF presented on the InDeGO process. – This is a methodology that GHD has produced where socio-economic analysis to visualise areas most suitable for the infrastructure project. – GHD has used this for site and route selection. – Final deliverable for this project will be a map of Australia showing the suitability of areas for agricultural wastewater reuse.	

Minutes	Action	To be actioned by
	– Clients receive data and can add these into the client version of the web map.	
Initial mapping results	– MF showed mapping results using the above method and criteria. – MF noted that GHD don't have all results for all criteria for today, only around half of results are available. Initial results included these layers: wastewater plants, land use, precipitation, wastewater produced, frost, airports and evapotranspiration. - On the map displayed dark green was highly suitable, red as highly unsuitable. JG noted these areas coincided with urban areas and that great artesian basin was only suitable. Noted this could be affected by distance rule. – MF noted grid sizing and band colours can be adjusted. RB noted more differentiated at higher results. JG noted this will help target most suitable areas. GHD to revise. – RB and JG suggest highly urban areas should be no go. NM noted GHD action to remove highly urban areas, maybe through land use layer. – SJ noted large highly suitable areas in NT. NM noted additional layers may eliminate some of these areas.	GHD to action as noted.
Sensitivity analysis	– RB suggests looking at land suitability criteria only (17 layers) and exclude supply side (3 layers).	GHD to action as noted.
Actions and next steps	– GHD to prepare PDF of areas changed resulting from the meeting and each state, PDFs to be include, for each state (2 halves for WA), 200 km around each capital, major wastewater sources and Pilbara region. Around 12-15 maps in all. – Provide PDFs for comment by the end of next week (originally 18th Feb but will now be 23rd Feb based on model run times – email to follow tomorrow with revised program to meet agreed project end date). – Send through revised weighting for each criterion. – Provide pairwise criteria comparison survey to NWGA for input (17Feb22). – Add visual pinpoint for large dams, wastewater treatment plants, major towns/cities. – Investigate Daly River area (NT) that is currently showing highly unsuitable. Seems to be land use layer. GHD to investigate and see if all categories are suitably scored. – NM advised project is still on time. NM will advise if sensitivity analysis process will impact this following today's discussion. GHD to confirm if any delays.	GHD to action as noted.

Appendix D

MCA maps- unedited

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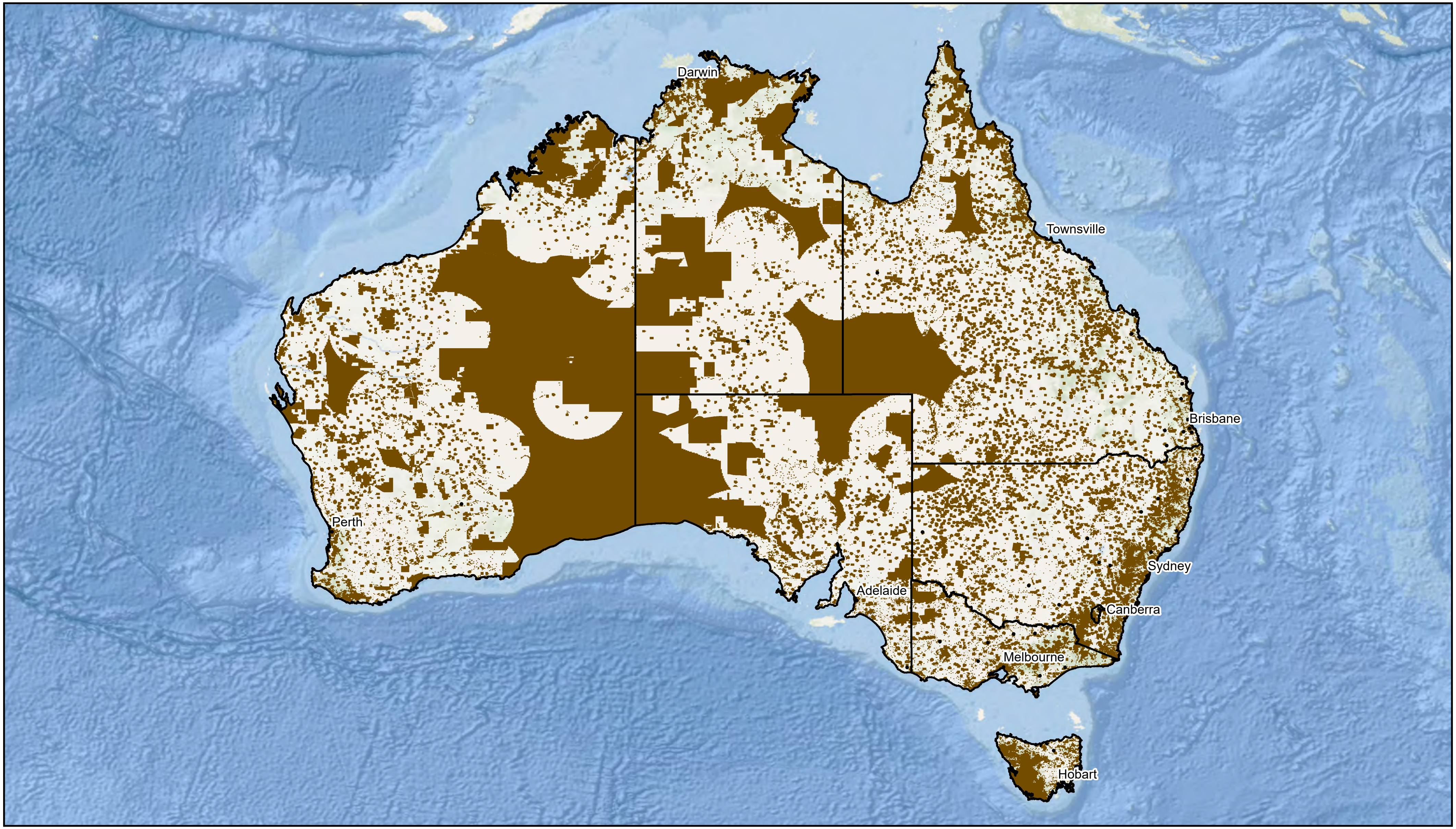

Legend

No-go sites

Paper Size ISO A4

0 250 500 750 1,000

Kilometres

N

Horizontal Datum: WGS 1984
Grid: GCS WGS 1984

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Non-Viable Areas for InDeGO Process

Project No. **12556736**
Revision No. **1**
Date **21-Jun-22**

FIGURE 5.3

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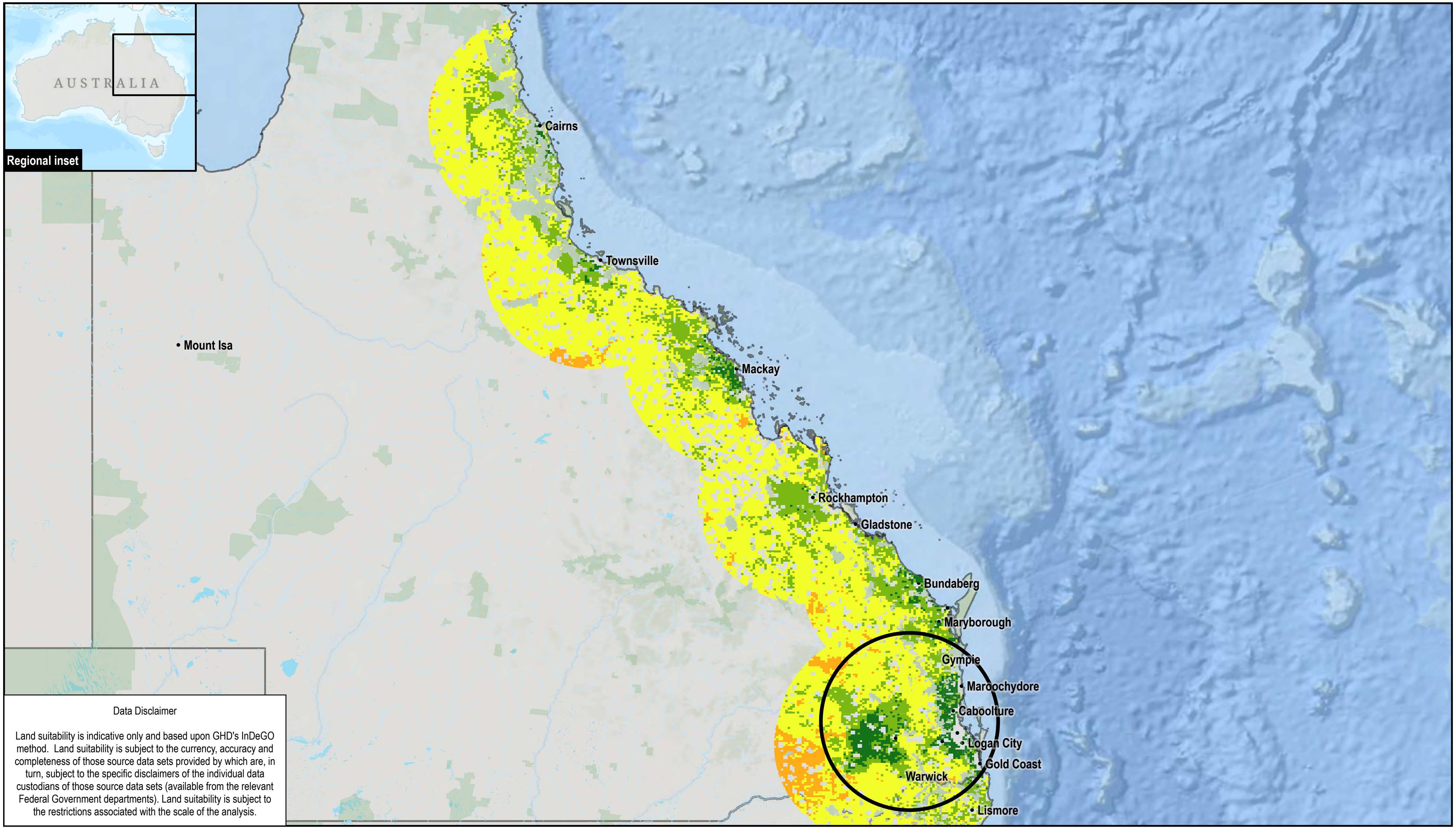

Data Disclaimer

Land suitability is indicative only and based upon GHD's InDeGO method. Land suitability is subject to the currency, accuracy and completeness of those source data sets provided by which are, in turn, subject to the specific disclaimers of the individual data custodians of those source data sets (available from the relevant Federal Government departments). Land suitability is subject to the restrictions associated with the scale of the analysis.

Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 74 148 222 296

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - QLD

Project No.	12556736
Revision No.	1
Date	20-Jun-22

FIGURE 6.1

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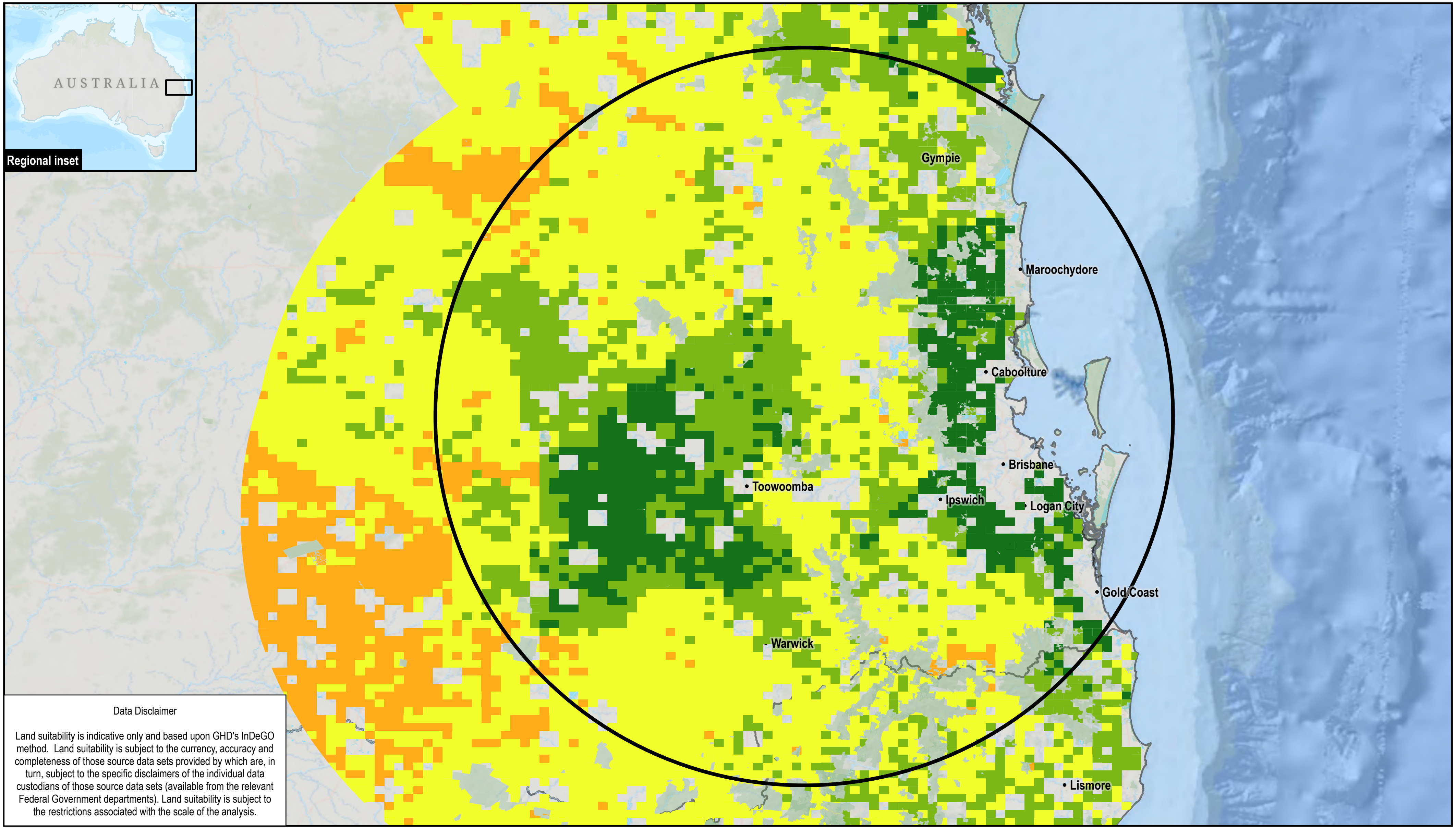
Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 18 36 54 72

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Greater Brisbane, QLD

Project No.	**12556736**
Revision No.	**1**
Date	**20-Jun-22**

FIGURE 6.2

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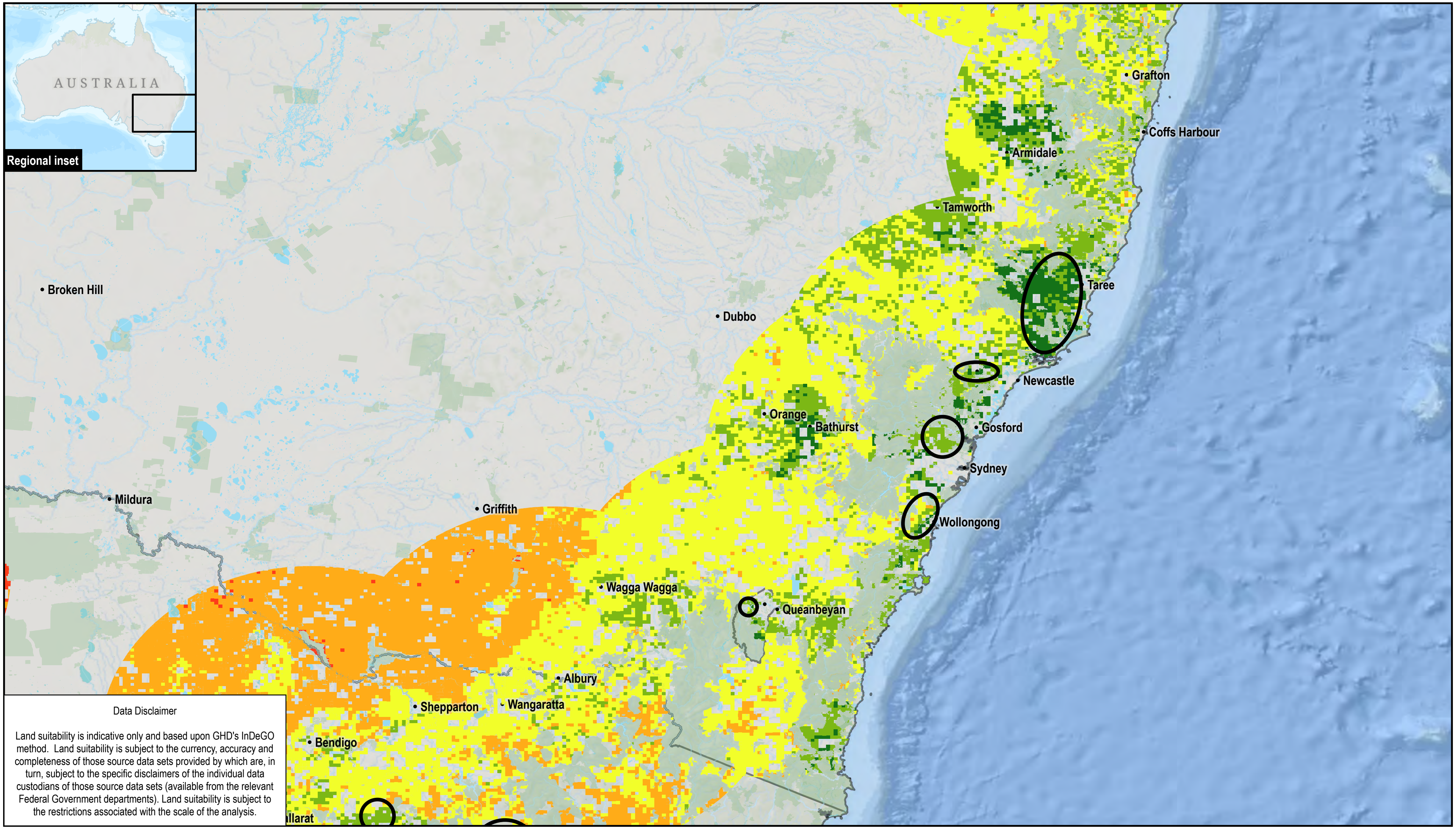
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

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Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - NSW

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.3

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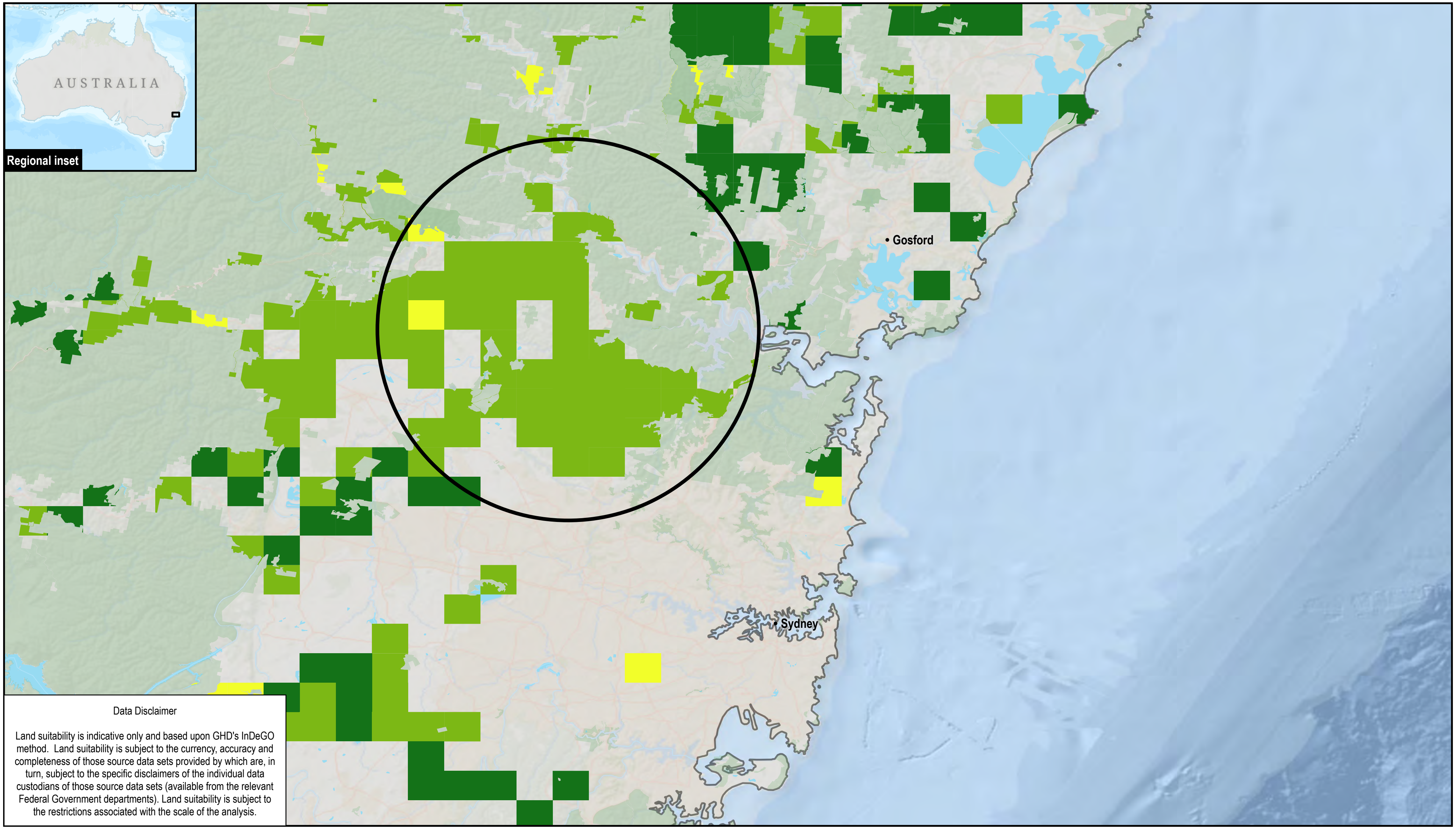
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

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Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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GHD

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Sydney, NSW

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.4

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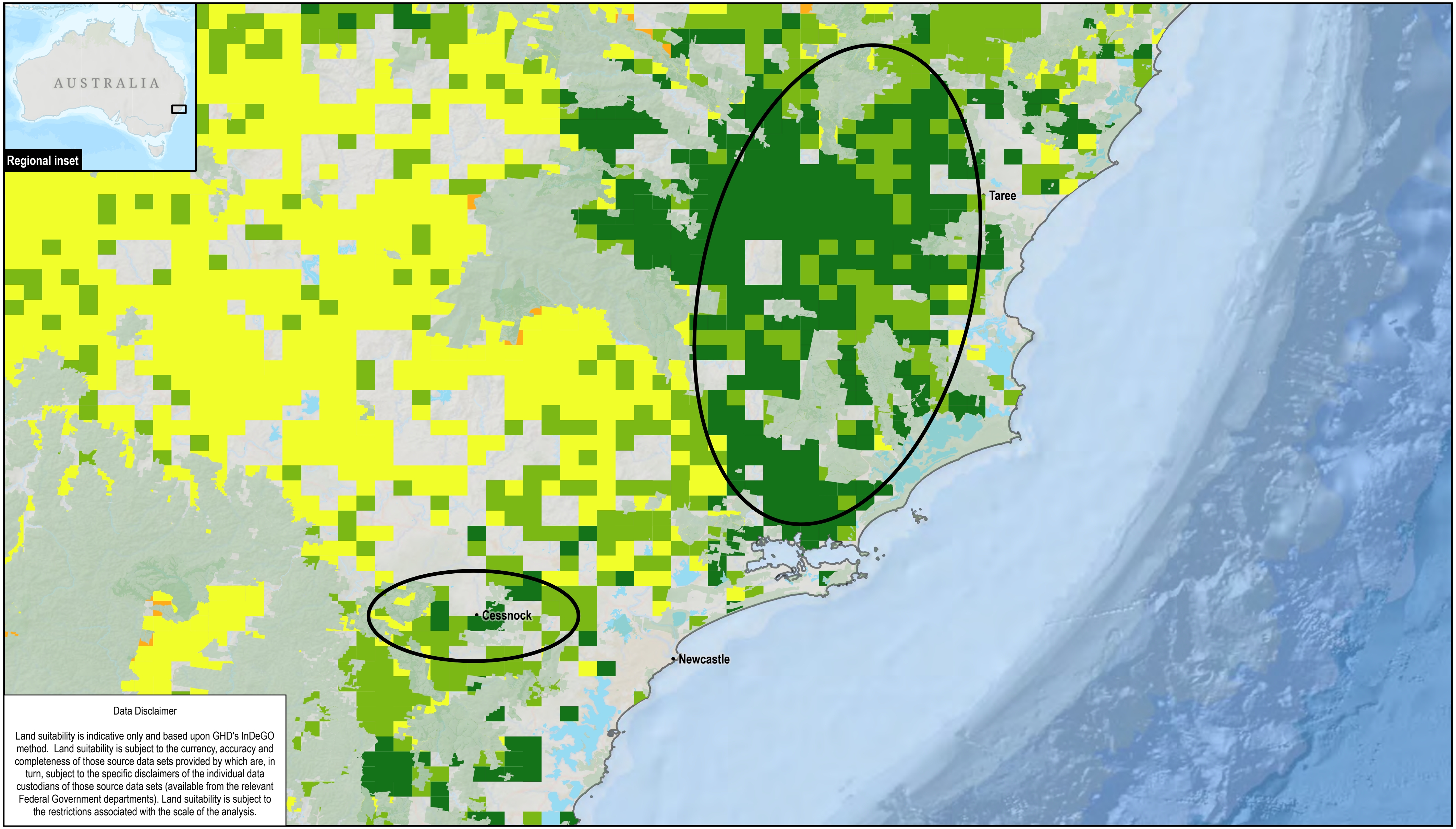
World Hillshade: Esri, USGS. Created by: mfredle



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Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable
- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 9.25 18.5 27.75 37

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Wastewater Reuse Opportunities for Agriculture Suitability Map - Newcastle and Hunter Region

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.5

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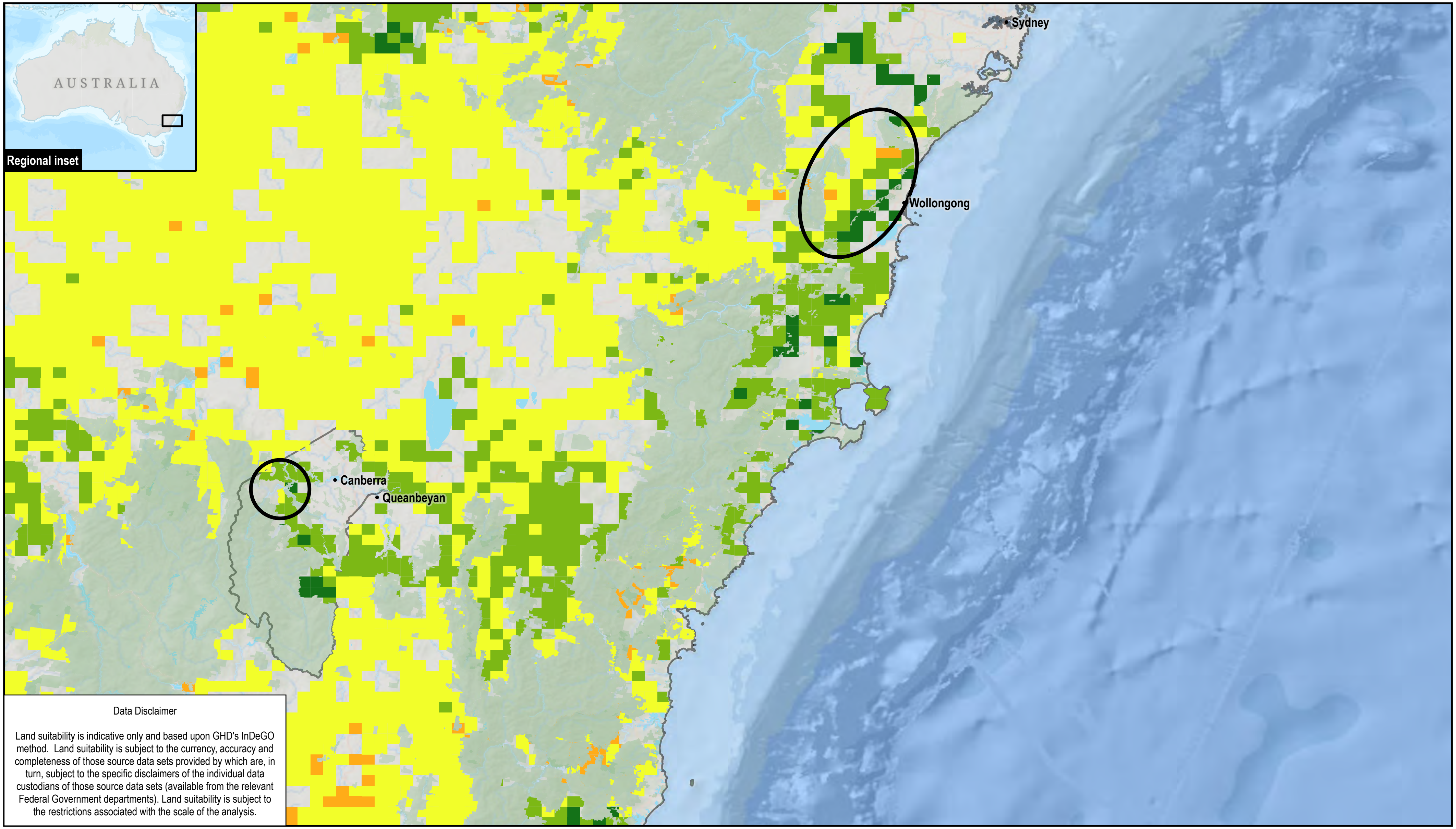
Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

Land suitability is indicative only and based upon GHD's InDeGO method. Land suitability is subject to the currency, accuracy and completeness of those source data sets provided by which are, in turn, subject to the specific disclaimers of the individual data custodians of those source data sets (available from the relevant Federal Government departments). Land suitability is subject to the restrictions associated with the scale of the analysis.

Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 13 26 39 52

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater
Reuse opportunities for Agriculture

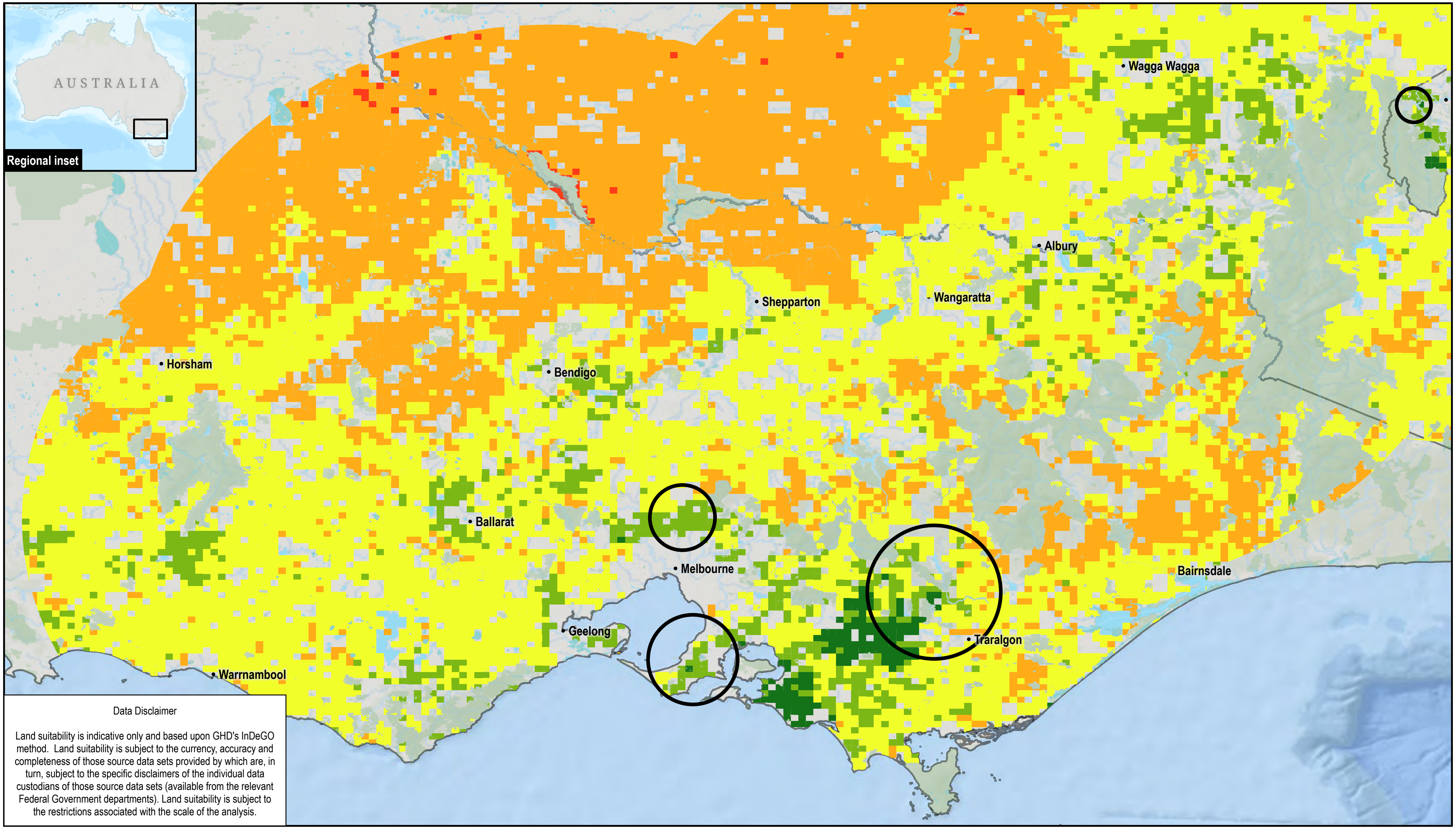
Wastewater Reuse Opportunities for Agriculture Suitability Map - Wollongong, NSW

Project No. 12556736
Revision No. 1
Date 20-Jun-22

FIGURE 6.6

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 23 46 69 92

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

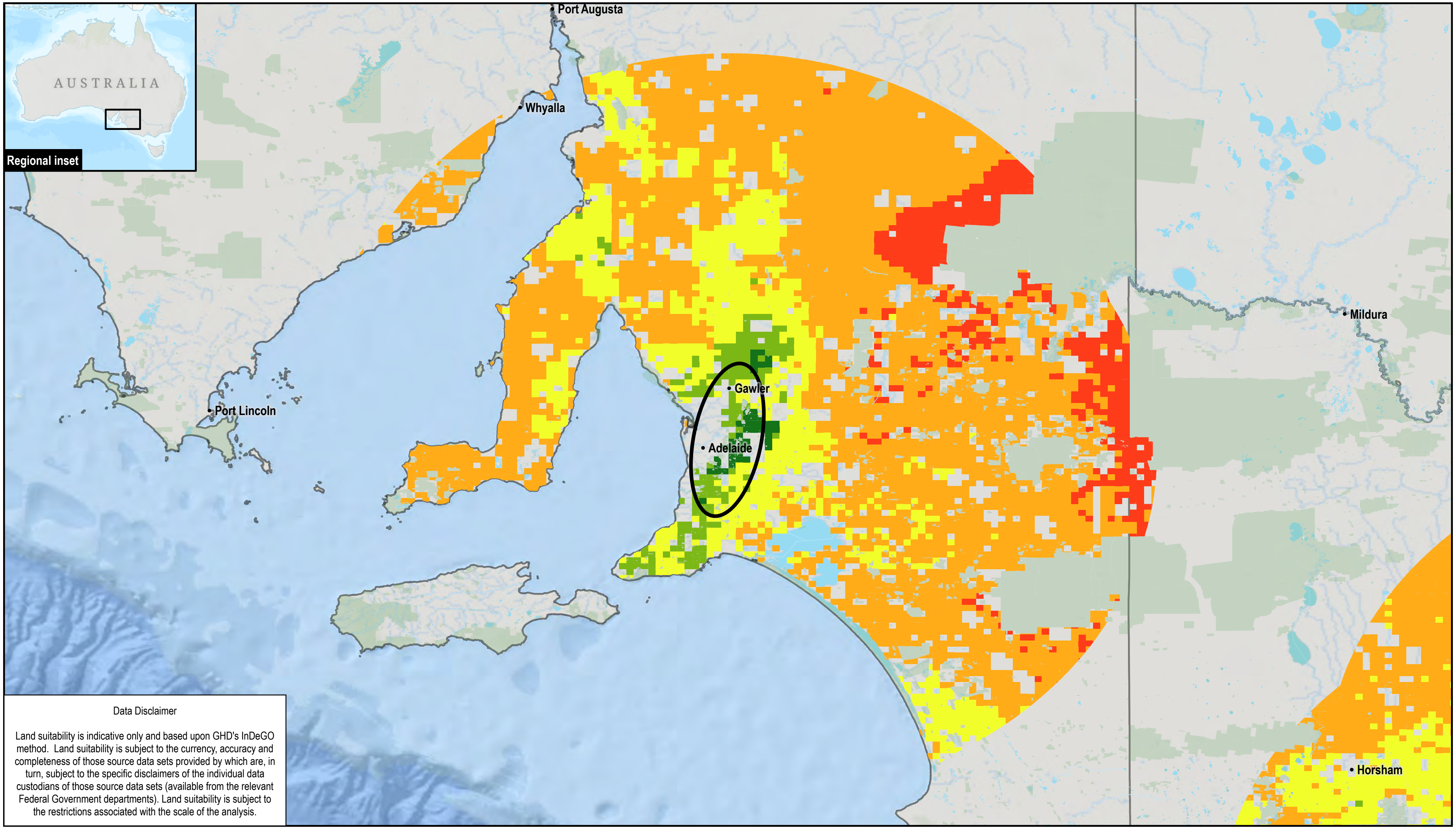
Wastewater Reuse Opportunities for Agriculture Suitability Map - VIC

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.7

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 24 48 72 96

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

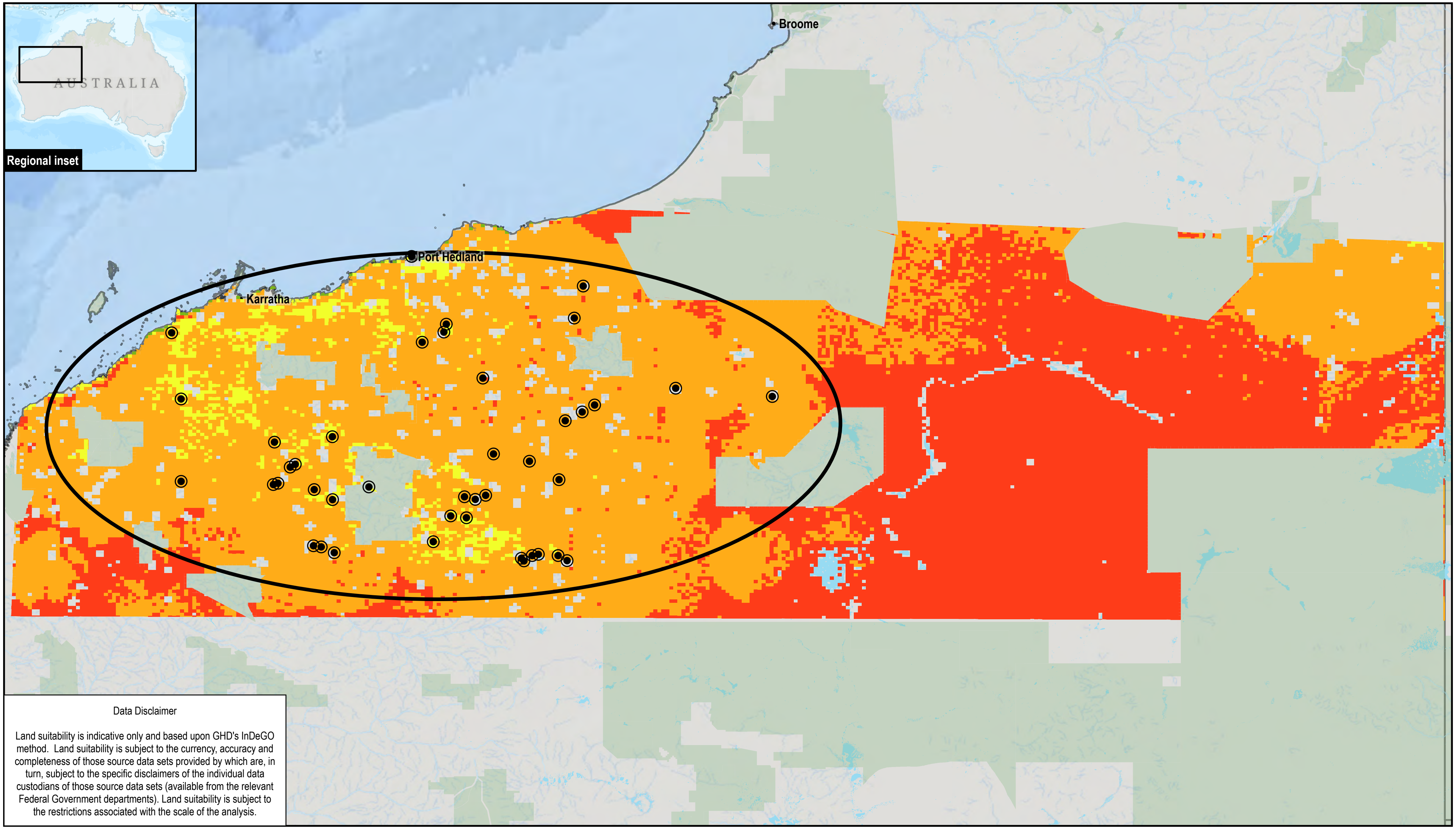
Wastewater Reuse Opportunities for Agriculture Suitability Map - SA

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.8

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity
- Operational mines

Paper Size ISO A4

0 43 86 129 172

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

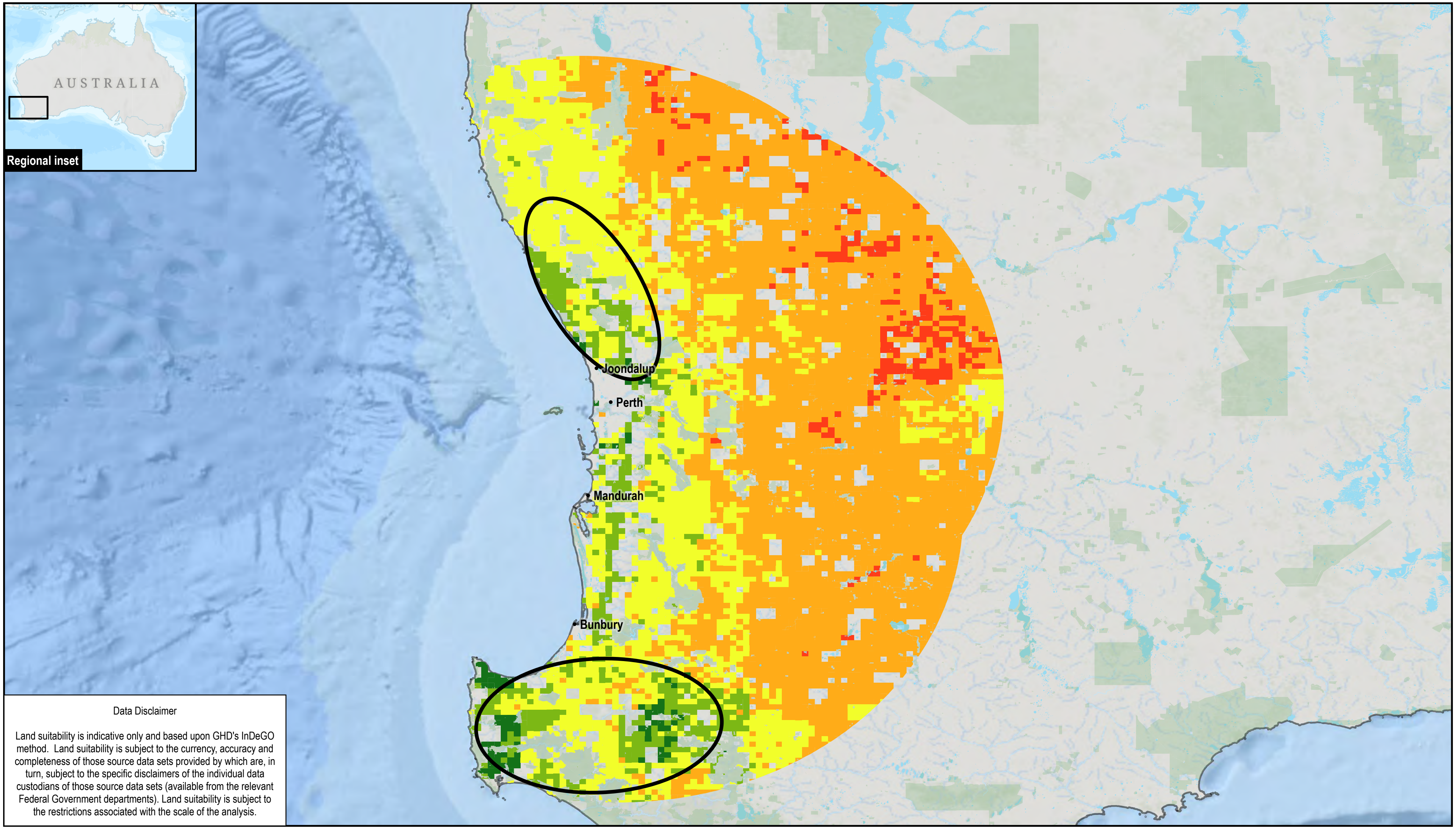
Wastewater Reuse Opportunities for Agriculture Suitability Map - Pilbara region

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.9

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:01

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



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Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 26 52 78 104

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

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National Review of Wastewater Reuse opportunities for Agriculture

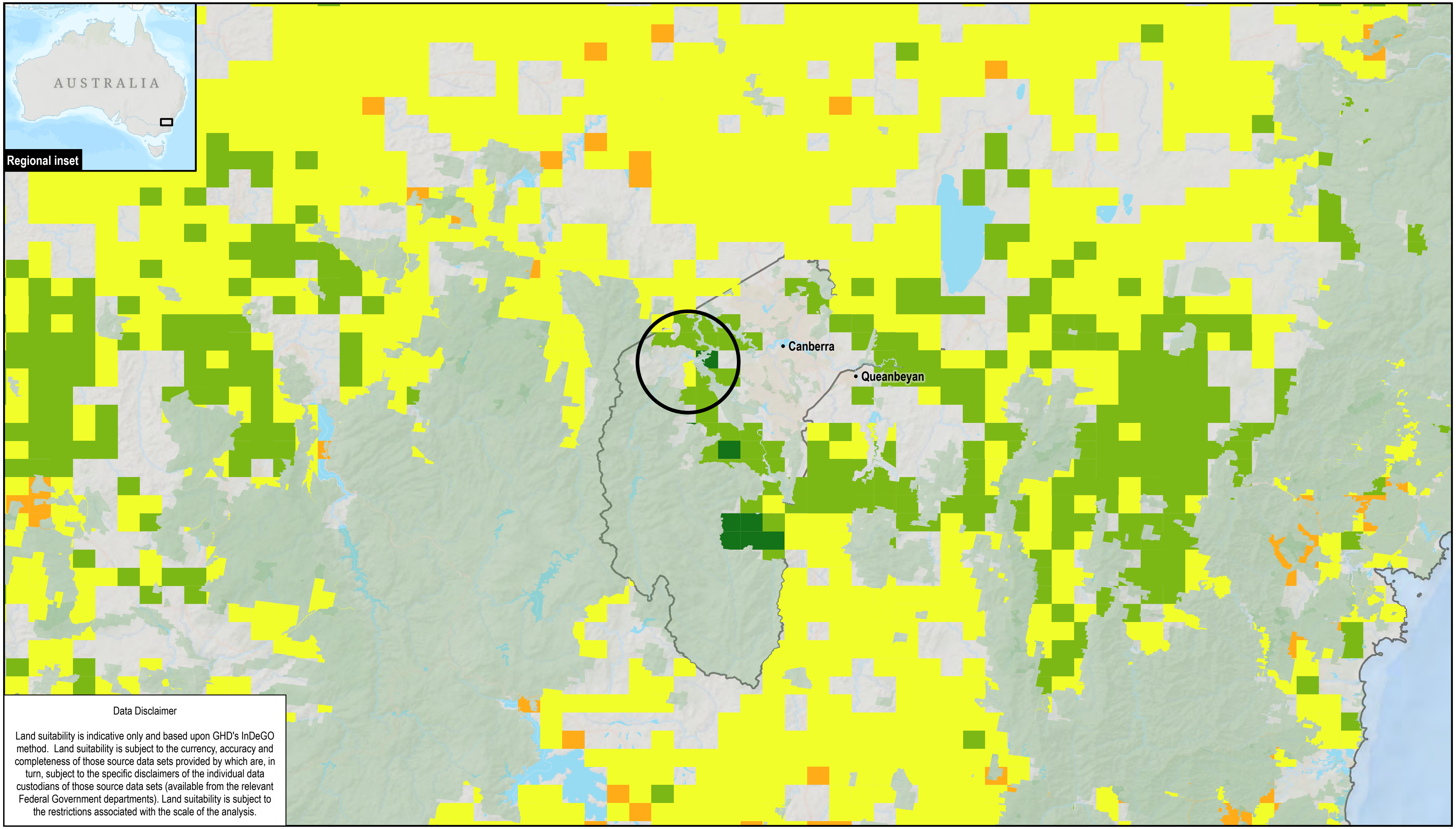
Wastewater Reuse Opportunities for Agriculture Suitability Map - Perth, WA

Project No.	**12556736**
Revision No.	**1**
Date	**20-Jun-22**

FIGURE 6.10

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

Land suitability is indicative only and based upon GHD's InDeGO method. Land suitability is subject to the currency, accuracy and completeness of those source data sets provided by which are, in turn, subject to the specific disclaimers of the individual data custodians of those source data sets (available from the relevant Federal Government departments). Land suitability is subject to the restrictions associated with the scale of the analysis.

Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 7.7 15.4 23.1 30.8

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

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National Review of Wastewater Reuse opportunities for Agriculture

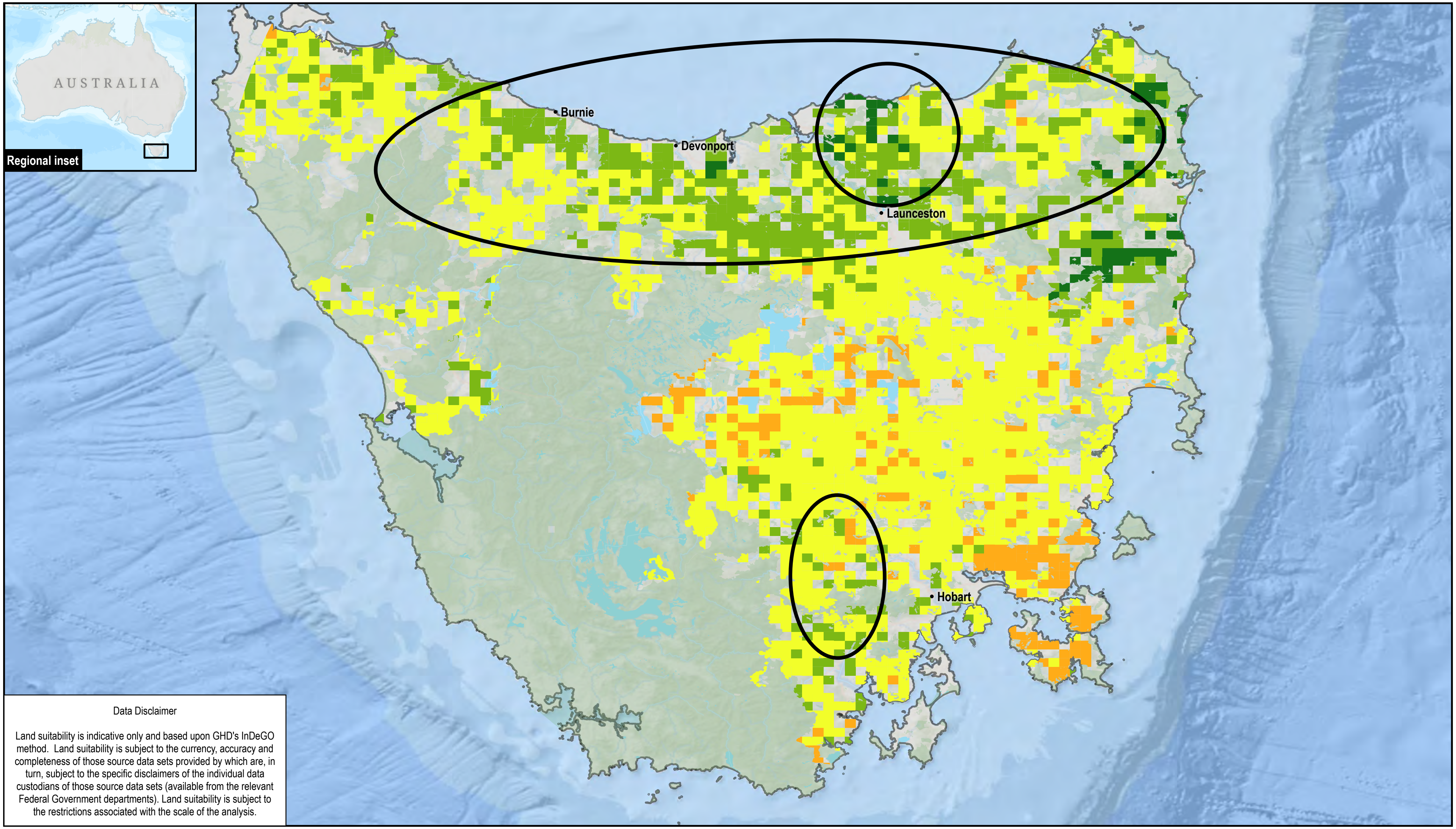
Wastewater Reuse Opportunities for Agriculture Suitability Map - ACT

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.11

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

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Legend

Land suitability

- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 16 32 48 64

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

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National Review of Wastewater Reuse opportunities for Agriculture

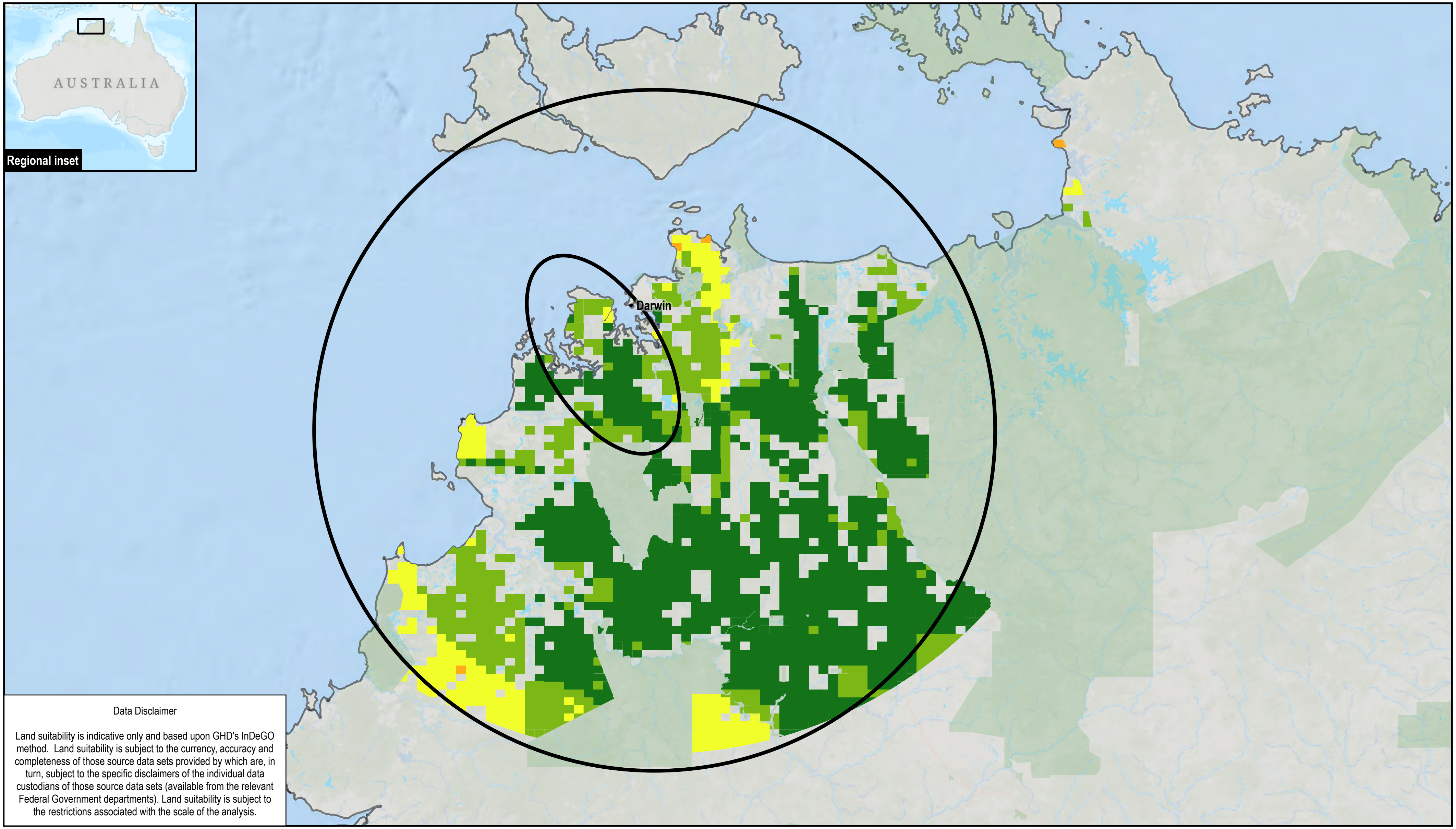
Wastewater Reuse Opportunities for Agriculture Suitability Map - TAS

Project No.	**12556736**
Revision No.	**1**
Date	**20-Jun-22**

FIGURE 6.12

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:00

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Data Disclaimer

Land suitability is indicative only and based upon GHD's InDeGO method. Land suitability is subject to the currency, accuracy and completeness of those source data sets provided by which are, in turn, subject to the specific disclaimers of the individual data custodians of those source data sets (available from the relevant Federal Government departments). Land suitability is subject to the restrictions associated with the scale of the analysis.

Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable
- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 18 36 54 72

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

GHD

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National Review of Wastewater Reuse opportunities for Agriculture

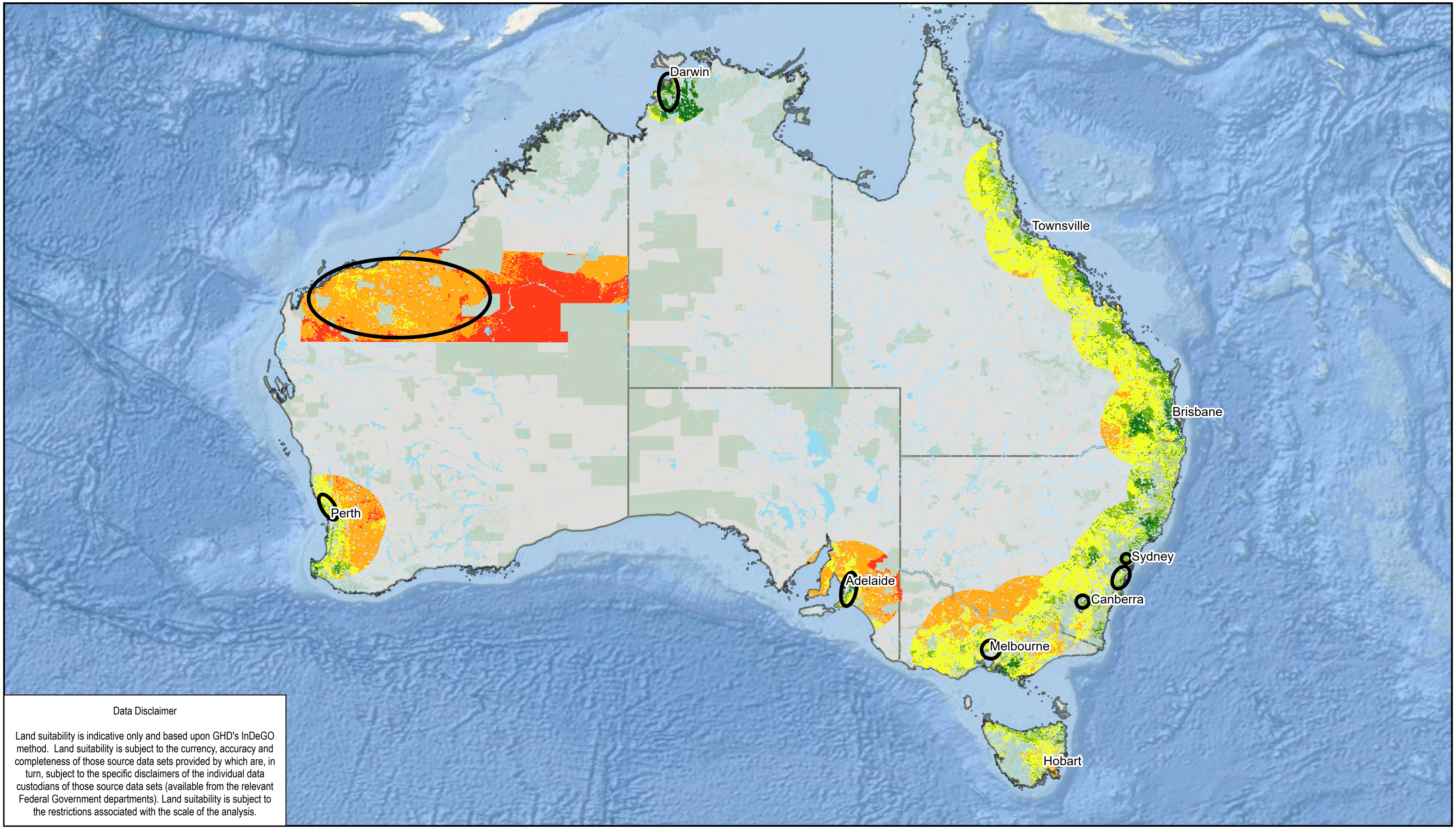
Wastewater Reuse Opportunities for Agriculture Suitability Map - Darwin, NT

Project No. **12556736**
Revision No. **1**
Date **20-Jun-22**

FIGURE 6.13

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 20 Jun 2022 - 14:01

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021 World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue
World Topographic Map: Esri, FAO, NOAA, USGS
World Hillshade: Esri, USGS. Created by: mfredle



Legend

Land suitability
- Highly suitable
- Neutral
- Moderately constrained
- Highly constrained
- Highly unsuitable

- Water body
- Conservation area
- Areas of noticeable opportunity

Paper Size ISO A4

0 250 500 750 1,000

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

NWGA
National Review of Wastewater Reuse opportunities for Agriculture

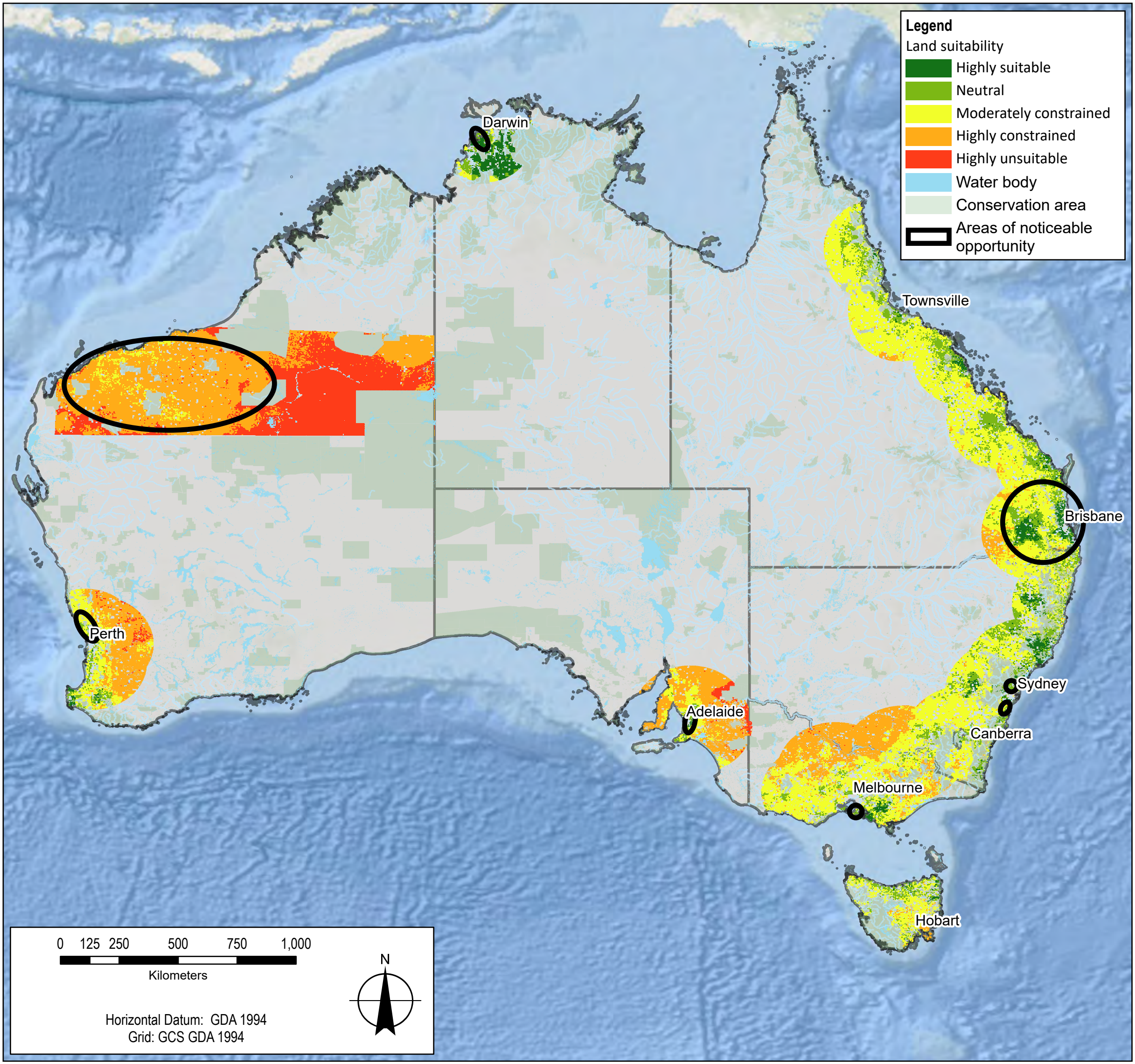
Wastewater Reuse Opportunities for Agriculture Suitability Map

Project No. **12556736**
Revision No. **1**
Date **21-Jun-22**

FIGURE 7.1

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 21 Jun 2022 - 10:08

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021; World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue. Created by: mfredle



\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx

Data source: Water, Geoscience Australia 2022; Collaborative Australian Protected Areas Database (CAPAD) 2020, Commonwealth of Australia 2021; World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue Created by:mfredle

Appendix E

Sodicity

Sodicity

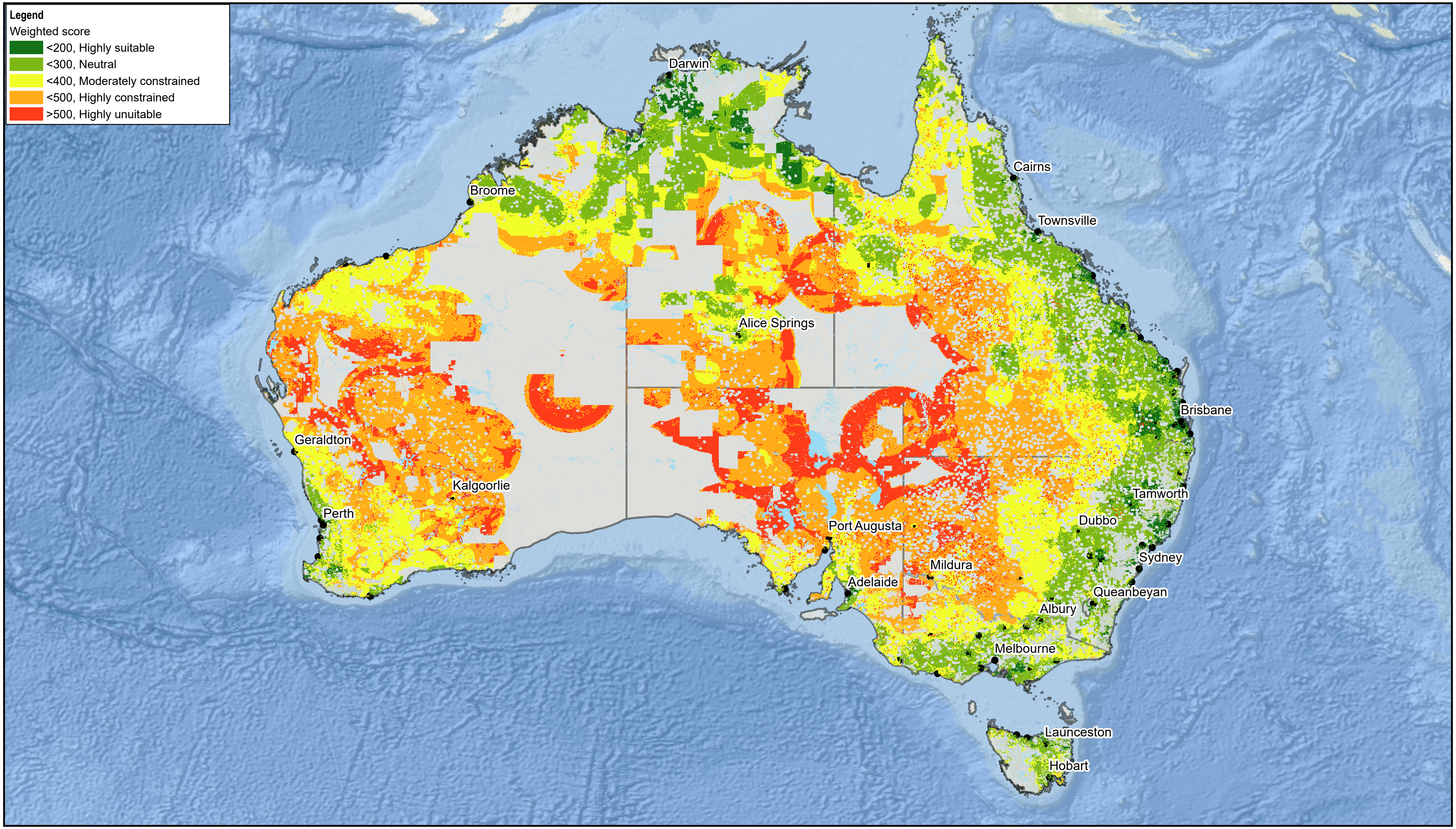
There are various site-specific factors that need to be further reviewed for each of the recommended investigation areas. Soil sodicity can be discussed further based on state-based mapping publicly available, as follows:

– NSW – Based on the *Current knowledge of distribution of sodic soils and sodic soil profiles in NSW* (Department of Land and Water Conservation, 2003), there is a mix of 'sodic soil profiles', 'localised significant sodicity' and 'minor to no sodicity' areas.
– Victoria:
  - Based on the *Victorian Sodic Soils Provisional Map* (Agriculture Research Division of Department of Environment and Primary Industries, 2014), it indicated the areas north of greater Melbourne are partially Calcarosols and Sodosols.
  - Calcarosols have a gradual increase in its clay content with depth when compared to other soil types like Sodosols. Calcarosols are dependent on the soil texture as to their importance to the land. Heavier textured Calcarosols are 'more fertile and less erodible, but more prone to salting and to hardsetting when overcultivated' (State of Victoria (Agriculture Victoria) website, 2019).
  - Sodosols are soils which 'display a strong texture contrast between surface horizons and subsoil horizons which are sodic'. They are 'further differentiated based on subsoil characteristics such as level of sodicity and presence of carbonate (lime)' (State of Victoria (Agriculture Victoria) website, 2019). Sodosols appear to have greater challenges than Calcarosols for agriculture but many of these factors can be overcome with soil improvement techniques and better management, albeit at a higher cost.
– South Australian – Based on *Sodium Toxicity Depth to Toxic Layer Map* (SA Department of Environment and Water, 2018), there are some areas where the potentially toxic soil layer is 25-50cm below ground, with most of the area at 50-100 cm.
– Western Australia:
  - Pilbara Region – Specific studies for the Pilbara region are the only source of information found given that sodic soil studies in Western Australia are generally concentrated around existing agricultural areas. The Pilbara region is generally considered to be free of sodic soils.
  - Around Perth – Dispersive soils are common in the agricultural areas of Western Australia. According to Department of Primary Industries and Regional Development's Agriculture and Food (website, 2022) 'Soils with more than about 18% sodic clay are susceptible to dispersion when wet. Sodic duplex soils are particularly susceptible to waterlogging because they are commonly on broad, flat landscapes with poor drainage. These soils are difficult to manage and have several constraints to crop and pasture growth'. They experience the issues defined above for Sodosols but are able to be overcome, albeit at a higher cost than non-sodic soil areas.
– Australian Capital Territory – Based on the *Current knowledge of distribution of sodic soils and sodic soil profiles in NSW* (Department of Land and Water Conservation, 2003), there is a mix of mapped 'sodic soil profiles', 'localised significant sodicity' and 'minor to no sodicity' areas, while noting that agriculture existing in many of these areas for specific crops.
– Northern Territory – Based on the *Supporting sustainable development – risks and impacts of plant industries on soil conditions* (NT Department of Resources, 2011), there is a mix of varying soil types a respective plant industry, only 'Hydrosols (poorly-drained duplex clay soils on floodplains)' are noted as 'dispersive due to possible sodicity'.

Appendix F

Draft report Australia MCA map

-



DRAFT

Paper Size ISO A4

0 180 360 540 720

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

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NWGA
National Review of Wastewater Reuse opportunities for Agriculture

Project No. 12556736
Revision No. B
Date 2/03/2022

MCA Results - Australia

FIGURE 1

\\ghdnet\ghd\AU\Newcastle\Projects\22\12556736\GIS\Maps\Deliverables\12556736_MCAdata.aprx
Print date: 02 Mar 2022 - 13:16

Data source: World Ocean Base: Esri, GEBCO, DeLorme, NaturalVue. Created by: mfredle

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The Power of Commitment