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| National Water Grid Authority - National Review of Wastewater Reuse Opportunities for Agriculture  Project Findings Report  National Water Grid Authority  30 March 2023 |
| 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.

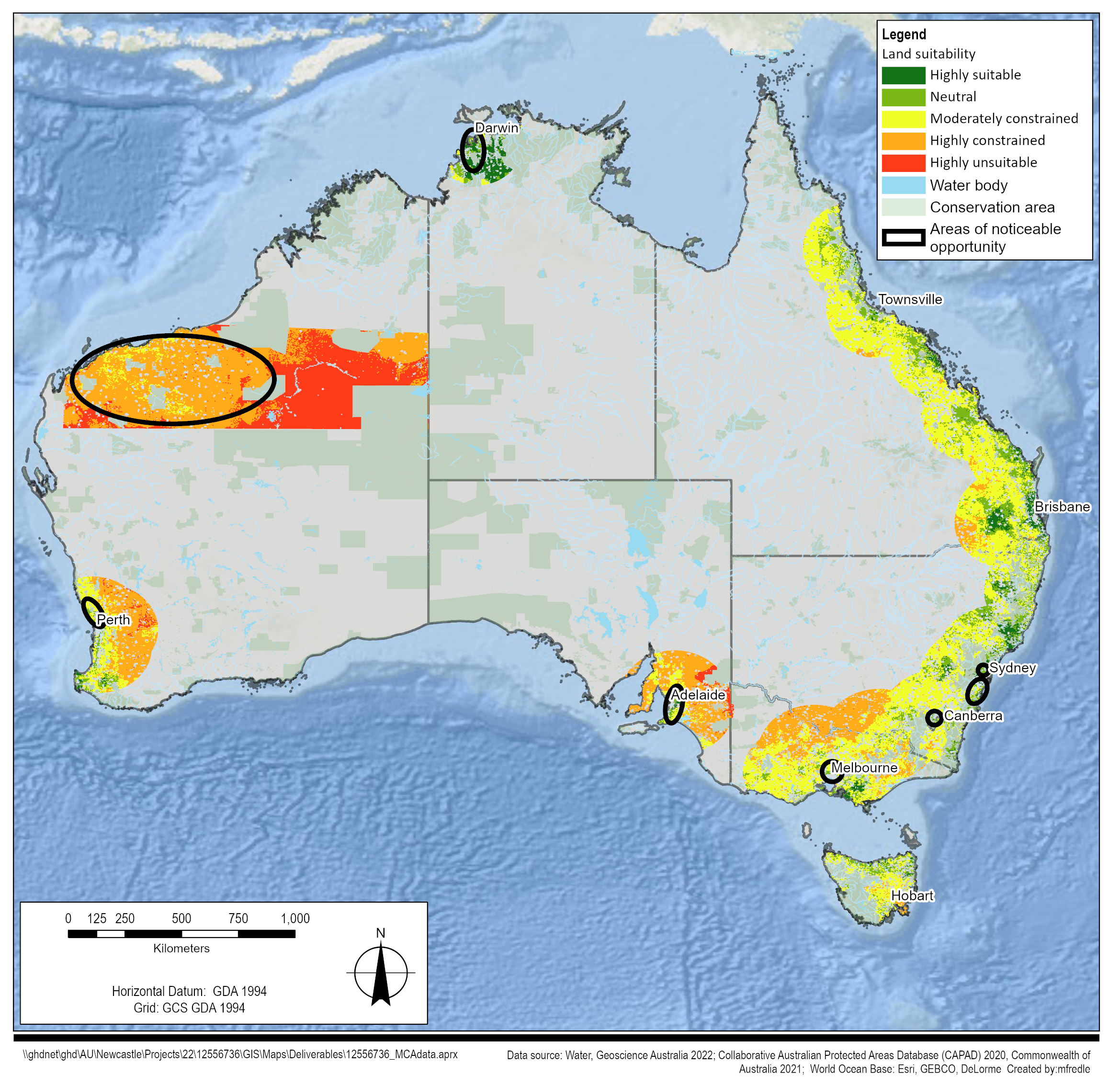


Figure E. Areas of noticeable opportunity

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 (250km2)
* North and south of Melbourne associated with proposed northern and existing eastern wastewater treatment plants (WWTPs) (140km2)
* Expansion of an existing South Australian scheme (80km2)
* Mining in northern Western Australia and expansion of existing treatment systems north of Perth (10,250km2, with the vast majority in the Pilbara region)
* Use of flow from the main Canberra treatment plant and Fyshwick WWTP (50km2)
* Southwest of Darwin from one of the main wastewater treatment plants (150km2)

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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# 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.

## 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.

## 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.

## Assumptions

Assumptions made are shown in Section 5 of this report.

## 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.

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# 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 . 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 |

## 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.

### 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.

### 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.

### 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.

## 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 . 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.

# 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.

# 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 . 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 . 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 |  |  |  |  |  |  |

# Spatial assessment process

## 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 . 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

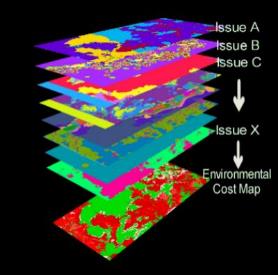


Figure . InDeGO modelling information layering process

**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)

## 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. 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 |
| 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 |

### 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.

## 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 . 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 |

## 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. Criteria scoring

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

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Figure . Sites not included in MCA

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. 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 |

## 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).

## 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.

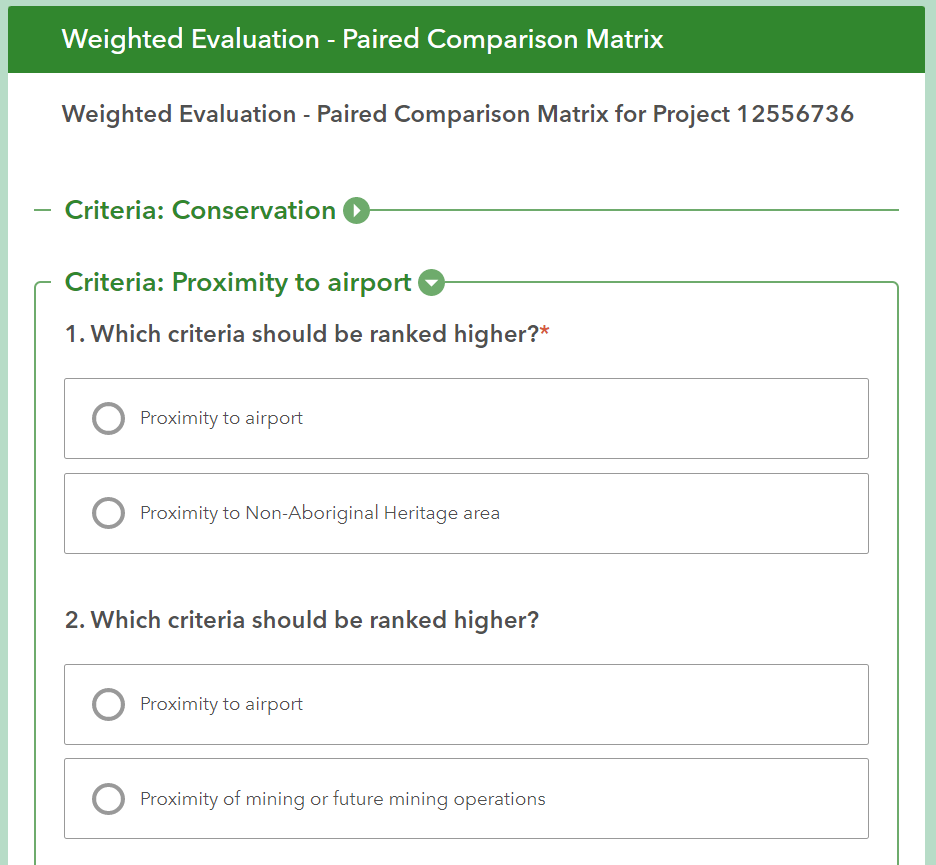


Figure . Pairwise comparison survey screenshot

Table 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.

## 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.

# 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.

## 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.

### 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.

### 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.

### 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.

### 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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Figure . MCA Results – QLD

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Figure . MCA Results – Greater Brisbane

## 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.

### 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).

### 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.

### 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.

### 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.

### 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.

### 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.

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Figure . MCA Results – NSW

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Figure . MCA Results – Sydney

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Figure . MCA Results – Newcastle and Hunter Region

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Figure . MCA Results – Wollongong

## Victoria

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

### 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.

### 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.

### 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.

### 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.

### 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.

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Figure . MCA Results – VIC

## 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.

### Suitable areas identified

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

### 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.

### 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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Figure . MCA Results – SA

## 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.

### 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.

### 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.

### 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.

### 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.

### 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.

### 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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Figure . MCA Results – Pilbara

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Figure . MCA Results – Perth

## 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.

### 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.

### 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.

### 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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Figure . MCA Results – ACT

## 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.

### 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.

### 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.

### 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.

### 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.

### 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.

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12556736\_001\_MCAResults\_TAS

Figure . MCA Results – TAS

## 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.

### 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.

### 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.

### Remaining NT

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

### 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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12556736\_001\_MCAResults\_Darwin

Figure . MCA Results – Darwin

## 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.

# 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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Figure . Areas of noticeable opportunity

# 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

1. Investigation of Current Schemes Report
2. Wastewater Treatment Requirements for Agriculture Report
3. MCA process review and initial results minutes 11Feb22
4. MCA maps- unedited
5. 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’.

1. Draft report Australia MCA map



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