Landfill Post-Closure Plan

Upper Gascoyne Waste Management Facility Development

Prepared for Shire of Upper Gascoyne

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Table of Contents

1 Introduction 5

1.1 Background 5

1.2 Report Objectives 5

2 Site Description 6

2.1 Site Location and Access 6

2.2 Zoning, Surrounding Land Use and Sensitive Receptors 6

2.3 Native Title 6

3 Environmental Attributes 8

3.1 Climate 8

3.1.1 Rainfall 8

3.1.2 Temperature 8

3.1.3 Pan Evaporation 9

3.1.4 Humidity 9

3.1.5 Wind 10

3.2 Topography 10

3.3 Geology 11

3.3.1 Soil Testing 11

3.4 Hydrology 11

3.5 Hydrogeology 11

3.6 Bushfire Prone Areas 12

4 Social Attributes 13

4.1 Aboriginal Heritage 13

4.2 European Heritage 13

4.3 Mining Tenements 13

5 Legislative Context 14

5.1 Environmental Protection (Rural Landfill) Regulations 2002 (WA) 14

5.2 Victorian EPA BPEM Guidelines 14

6 Historic, Current and Proposed Landfill Operations 15

6.1 Filling History 15

6.2 Current Activities 15

6.3 Need for Expansion 15

6.4 Future Activities 16

6.5 Waste Data and Projections 16

6.5.1 Putrescible Waste ... 16
6.5.2 Inert Waste ... 17
6.5.3 Stockpile Material ... 17

7 Rehabilitation Design ... 19
7.1 Current Landfill Profiles ... 19
7.2 Proposed Landfill Development ... 19
7.2.1 Putrescible Landfill ... 19
7.2.2 Inert Landfill ... 19
7.2.3 Landfill Design ... 19
7.3 Final Fill Profile ... 20
7.4 Rehabilitation Profile ... 20
7.4.1 Design Considerations ... 20
7.4.2 Cap Design ... 21
7.4.3 Final Restoration Profile ... 21
7.5 Void Space Modelling ... 22
7.6 Material Balance ... 23
7.7 Phasing of the Capping Works ... 24
7.8 Temporary Capping System ... 24
7.9 Asbestos Disposal ... 24

8 Surface Water Management ... 26
8.1 Key Infrastructure ... 26
8.1.1 Perimeter Swales ... 26
8.1.2 Surface Water Pond ... 27
8.2 Surface Water Modelling ... 27
8.2.1 Catchment Areas ... 27
8.3 Surface Water Infrastructure Design ... 28
8.3.1 Swale System ... 28
8.3.2 Surface Water Pond ... 28
8.3.3 Surface Water Bund ... 28

9 Post-Closure Management and Monitoring ... 30
9.1 Landfill Gas ... 30
9.2 Landfill Leachate ... 30
9.3 Surface Water ... 30
9.4 Groundwater ... 31
9.5 Topography ... 31

9.6 Vegetation ... 31
9.7 Monitoring Program ... 31

Tables

Table 2-1: Site Details ... 6
Table 3-1: Rainfall Overview in Millimetres (1973-2023) ... 8
Table 3-2: Maximum and Minimum Temperatures at Gascoyne Junction (1973-2023) ... 9
Table 3-3: Pan Evaporation Average Data for the Site in Millimetres (1973-2023) ... 9
Table 3-4: Morning and Afternoon Relative Humidity at Gascoyne Junction (006022) ... 9
Table 6-1: Generation Estimate ... 17
Table 6-2: Landfill Annual Fill Rate ... 17
Table 7-1: Estimated Landfill Lifespans and Void Space ... 22
Table 7-2: Approximate Material Balance Calculations for the Sites ... 23
Table 8-1: Objectives and Associated Design Features of the Surface Water Management System ... 26
Table 8-2: Summary of Catchment Areas ... 27
Table 8-3: Proposed Swale Design ... 28
Table 8-4: Summary of Surface Water Pond Design Criteria ... 28
Table 9-2: Post-Closure Management & Monitoring Program ... 31

Appendices

APPENDIX A Figures
APPENDIX B Drawings
APPENDIX C Waste Projections and Void Space Modelling
APPENDIX D Surface Water Modelling

1 Introduction

1.1 Background

The Shire of Upper Gascoyne (the Shire) operates the Gascoyne Waste Management Facility (the Site), located on Vested Crown Land on Wansborough Road, 1 kilometre (km) south of Gascoyne Junction, in the Gascoyne region. The existing Site is reaching operational capacity and requires expansion to maintain operations. As part of the expansion the existing facility will need to be closed and remediated.

The existing Site is registered with the Department of Water and Environmental Regulation (DWER) and is subject to the *Western Australian Environmental Protection Rural Landfill Regulations 2002* (Rural Landfill Regulations).

The Shire has appointed Talis Consultants Pty Ltd (Talis) to draft a Landfill Post-Closure Plan (LPCP) that outlines the current and future landfill development for both the currently operating and future landfill facilities, including surface water management and post-closure monitoring requirements.

1.2 Report Objectives

This LPCP will provide the Shire with clear direction on the closure and rehabilitation of their landfills in accordance with the Rural Landfill Regulations. As Western Australia has no landfill guidelines, the LPCP will also be guided by the Victorian Environment Protection Agency (EPA) *Best Practice Environmental Management 'Siting, Design, Operation and Rehabilitation of Landfills', 2015* (BPEM Guidelines), in order to determine appropriate landfill development and rehabilitation requirements as well as management of environmental impacts to ensure safe and stable closure.

The key objectives of the LPCP are to provide the closed landfills:

1. A final restoration profile in accordance with the Rural Landfill Regulations;
2. An estimate of remaining void space and lifespan calculations;
3. An estimate of the volume of material available/required for restoration;
4. Detail relating to the post-closure use of the Site; and
5. The post-closure monitoring requirements and period to ensure suitable protection of the environment.

2 Site Description

The following sub-sections provide an overview of the key aspects of the Site, including the location, surrounding land uses, and environmental attributes.

2.1 Site Location and Access

The Site is located approximately 170km east of Carnarvon, and 1,050km north of Perth. The Site is approximately 1km from Gascoyne Junction town and is accessed through Wansborough Road. The existing Site covers an area of 29,000 square metres (m^2) and is on vested crown land. The existing Site boundary is outlined in Drawing W-101, found in Appendix B.

A summary of the Site details is provided in Table 2-1.

Table 2-1: Site Details

Detail	Description
Land Description	Lot 561 on Plan 72451
Street Address	Wansborough Road, Upper Gascoyne
Primary Interest Holder	Shire of Upper Gascoyne
Registration Number	R2338/2012/1

A locality plan of the Site is provided in Figure 1, in Appendix A.

2.2 Zoning, Surrounding Land Use and Sensitive Receptors

The Site is located within the Shire of Upper Gascoyne. The existing Site is located at Lot 561 on Deposited Plan 72451 and is subject to Class ‘C’ Crown Reserve 52428, set aside for the purpose of ‘Waste Disposal Site’. Land adjacent to the existing Site is Unallocated Crown Land (UCL) PIN 11240241.

The Department of Planning, Lands and Heritage (DPLH) has recommended excising a portion of the UCL to the east and south of the existing Site and adding it to Reserve 52428. The Shire is currently in the process of acquiring this portion of UCL, of which 161,000m^2 has been allocated for expansion of the waste management facility.

The planning scheme of the Site and surrounding area is outlined in Figure 2, in Appendix A. The Site boundary is outlined in Drawing W-101, found in Appendix B.

2.3 Native Title

Under Australian Law, Native Title is a form of land title that recognizes the unique connections Aboriginal groups have to the land. Native Title exists where Aboriginal people have maintained a traditional connection to their land and waters, since sovereignty, and where acts of government have not removed it. Under the Native Title Act 1993 a Native Title determination confirms the rights and interests of Indigenous people to land and waters according to their traditional laws and customs. This determination grants the Native Title holders certain rights over the land, which can influence how the land is used and developed.

A review of the National Native Titles Tribunal *National Native Title Register* indicates that non-exclusive Native Title rights and interests are shown to exist over the Site (UCL PIN 11240241), as per the Gnulli, Gnulli #2 and Gnulli #3 - Yinggarda, Baiyungu and Thalanyji People Determination.

As part of acquiring the UCL, the Shire is required to enter into an Indigenous Land Use Agreement (ILUA) with the Registered Native Title Body Corporation, the Yinggarda Aboriginal Corporation. This process is ongoing.

3 Environmental Attributes

The following section outlines the key environmental attributes of the Site, that are particularly relevant to the expended Site's design, including climate, topography, geology, hydrogeology (groundwater), hydrology (surface water) and other key attributes.

3.1 Climate

The Site experiences a moderate arid tropical climate, with very hot summers and warm winters. According to the Gascoyne Development Commission, the region receives approximately 320 days of sunshine each year. During the warmer months from December through to March, there is frequent cyclonic activity and tropical lows drawing in from the northwest coast.

The closest Bureau of Meteorology (BOM) weather station with long-term data is Gascoyne Junction (Station 006022), approximately 1km west of the Site. The prevailing wind information was sourced from this weather station. However, the data for temperature, rainfall and pan evaporation data had limited quality. Therefore, these parameters have been sourced using the Scientific Information for Land Owners (SILO), a database of Australian climate data from 1889 to the present day that is hosted by the Queensland Department of Environment and Science (DES). It provides daily meteorological datasets for a range of climate variables in ready-to-use formats suitable for biophysical modelling, research, and climate applications. The datasets are constructed from observational data obtained from BOM, using mathematical interpolation techniques to infill gaps in time series and construct spatial grids. The spatial grid selected (Latitude: -25.05, Longitude: 115.2) encompasses the Site in its entirety.

Climate data is discussed in further detail in the following sections.

3.1.1 Rainfall

Being in a tropical-arid zone, rainfall is seasonal with higher rainfall generally in the months of December to March due to cyclonic activity, meaning rainfall volumes vary greatly. Table 3-1 presents a summary of SILO's rainfall records for the past 50 years, from 1973 to 2023.

Table 3-1: Rainfall Overview in Millimetres (1973-2023)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	18	36	29	19	22	28	24	12	4	4	5	8	**210**
90th Percentile	0	88	9	46	24	22	30	13	0	42	108	0	**381**
Highest	16	293	18	1	134	25	36	5	2	15	3	0	**547**

The mean annual rainfall for the Site is calculated as 210 millimetres (mm) with the highest recorded annual rainfall at 547mm, which occurred in 2021.

3.1.2 Temperature

Table 3-2 presents a summary of SILO's maximum and minimum temperature records for the past 50 years, from 1973 to 2023.

Table 3-2: Maximum and Minimum Temperatures at Gascoyne Junction (1973-2023)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Maximum Temperature (°C)	40	39	37	33	28	24	23	25	28	32	34	38	**32**
Mean Minimum Temperature (°C)	24	25	23	19	14	11	10	11	13	16	19	22	**17**

The highest average maximum temperature is 40°C in January, whilst the lowest average minimum temperature is 10°C in July.

3.1.3 Pan Evaporation

The approximate average daily pan evaporation rates for the Site are based on the calculated monthly rates from SILO. Table 3-3 outlines the average pan evaporation data, from 1973 to 2023.

Table 3-3: Pan Evaporation Average Data for the Site in Millimetres (1973-2023)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly (mm)	367	308	296	212	156	113	118	154	211	285	323	366	**2,909**
Daily (mm)	12	10	10	7	5	4	4	5	7	9	10	12	

The daily average pan evaporation ranges from 3mm to 12mm and monthly from 113mm to 367mm. The average total annual pan evaporation for the Site is calculated as 2,909mm. This is a significant potential evaporation rate that is approximately five times the wettest rainfall year experienced at Site.

3.1.4 Humidity

BOM data suggests that the Site experiences a relatively low humidity year-round due to the Site's semi-arid climate. Table 3-4 shows the morning, afternoon and calculated average humidity at Gascoyne Junction (006022) from 1940 to 2010.

Table 3-4: Morning and Afternoon Relative Humidity at Gascoyne Junction (006022)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean 9am Relative Humidity (%)	42	46	45	51	58	68	67	58	49	43	40	40	**51**
Mean 3pm Relative Humidity (%)	20	24	24	29	34	42	40	33	25	21	20	18	**28**

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Humidity (%)	31	35	35	40	46	55	54	46	37	32	30	29	**40**

As can be seen from the data in the table, the Site experiences a relatively low humidity in the summer months, with the highest mean humidity occurring during June, and the lowest occurring during December.

3.1.5 Wind

Wind speed is measured as the average speed of the wind measured over a ten-minute interval before the time of observation and is measured ten metres above the ground. Diagram 3-1 indicates that winds are predominantly easterly in the morning (9am), and easterly or westerly direction in the afternoon (3pm). Wind speed generally increases in the afternoon, with average speeds rarely above 30km/h.

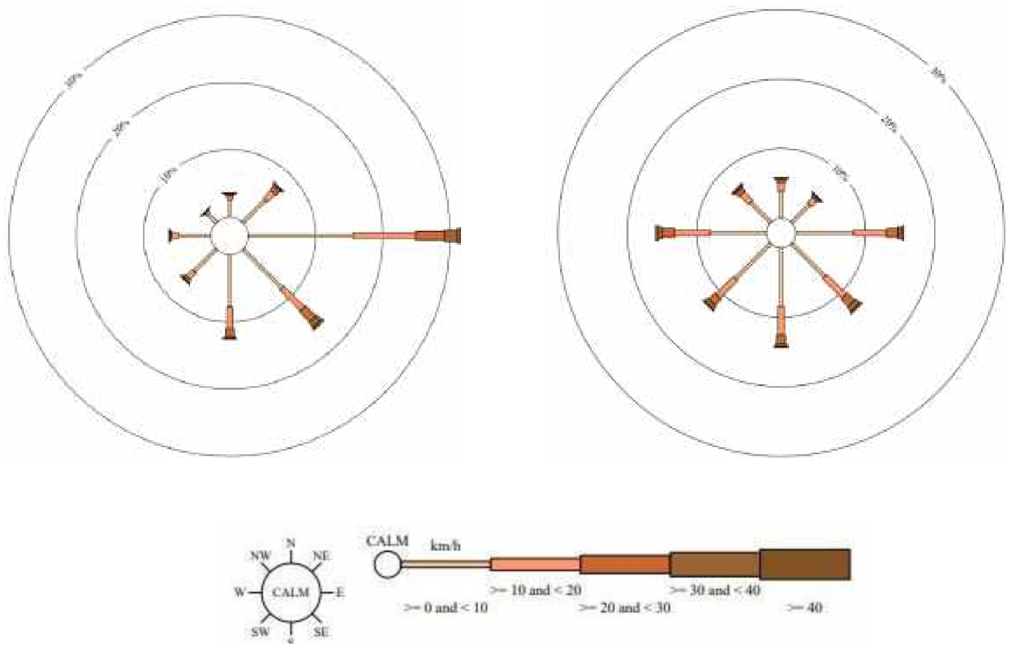

Diagram 3-1: Average Wind Rose Data for 9am (left) and 3pm (right)

3.2 Topography

Topography at the expanded Site is relatively flat, with natural ground elevations ranging from 139mAHD in the north to northwest of the Site to 146mAHD in the south of the Site. There are two raised landforms in the southern portion of the expanded Site that reach heights of 144.5mAHD and 146mAHD, with the lowest point within the expanded Site being towards the north at 141.5mAHD.

The general topography of the Site is shown in Figure 4, presented in Appendix A, with further details provided in Drawing W-100 in Appendix B.

3.3 Geology

The Gascoyne region is predominantly wide alluvial valleys that form the drainage basins for the surrounding rivers. The area is characterised by extensive alluvial plains, and low sedimentary ranges with red dune belts. Much of the region is covered by a large sedimentary basin known as the Carnarvon Basin.

The surface geology of the Site is shown in Figure 4, presented in Appendix A.

3.3.1 Soil Testing

Following consultation with the DWER, the Shire was advised that soil characterisation testing should be undertaken to ensure the ground is suitable for unlined trenches and evaporation ponds. Soil testing was carried out on four samples from the Site at Western Geotechnical and Laboratory Services, a NATA accredited laboratory in Perth, Western Australia.

Testing determined that soil is predominately Silty SAND (SM) up to a depth of 3.0m, followed by Sandy CLAY (CL) to the maximum of investigated depth of 4.0m. Samples were combined and remoulded to 95%MMDD and tested for falling head permeability, with a surcharge of 3kPa. Combined Samples 1 & 2 were retrieved from between 0-2mbgl and recorded a permeability of $2x10^{-8}$m/s. Combined Sample 3 & 4 were retrieved between 2-4mbgl and recorded a permeability of $1x10^{-8}$m/s. This shows that permeability is generally low and appears to slightly decrease with depth, indicating that the ground is suitable for the construction of unlined trenches and evaporation ponds.

3.4 Hydrology

Surface water systems in the region are generally ephemeral. Mapping indicates that there is a minor watercourse that runs along the western boundary of the existing Site which is a tributary of the Gascoyne River. The Gascoyne River a potable water zone. Gascoyne River is a delta system that only flows every 2-3 years and is located approximately 1.5km to the north of the Site. Figure 5, shown in Appendix A, show the surface water bodies surrounding the Site.

Discussions with Shire representatives and observations of vegetation growth at the Site may indicate the presence of three additional ephemeral watercourses that direct flow through the Site to the Gascoyne River. Drawing W-400 in Appendix B outlines the additional water courses within the Site.

Disaster mapping indicates that both the existing and expanded Site are located entirely within 1-in-100 Annual Exceedance Probability (AEP) Floodplain Development Control Area. However, the Local Planning Scheme (LPS) identifies that the Gascoyne River Floodplain does not extend to the existing and expanded Sites. Additionally, anecdotal evidence from the Shire confirmed that during a 1-in-100-year flood event, which occurred in 2010, the water levels were true to the Gascoyne River Floodplain boundaries outlined in the LPS.

Disaster mapping of the Site is shown in Figure 7, presented in Appendix A.

3.5 Hydrogeology

The Site is located within the Gascoyne Proclaimed Groundwater Area, as defined under the Rights in Water and Irrigation Act 1914 (RIWI Act). Under section 26D of the Act any construction or alteration of non-artesian wells must be conducted under a licence.

The Gascoyne Junction Water Reserve is located 740m north of the Site and is classified by the DWER as a Priority 1 protected area. Activities in Priority 1 protected areas are highly restricted to avoid water quality risks. The Gascoyne River is located within the Gascoyne Junction Water Reserve and tributaries of the Gascoyne River are located at the Site.

The groundwater level is estimated to be greater than 4 meters below ground level (mbgl), based on previous excavations at the Site and the relative lower elevation of the surrounding area. Additionally, the Gascoyne Junction GJ 1/22 Bore Completion Report shows that the groundwater elevation within GJ 1/22 Bore, located on Gregory St approximately 1km from the Site, is 20.9mbgl.

The hydrogeology mapping of the Site is shown in Figure 6, presented in Appendix A.

3.6 Bushfire Prone Areas

Disaster mapping from Landgate indicates that the Site is within a Bushfire Prone Area, shown in Figure 7, presented in Appendix A.

4 Social Attributes

4.1 Aboriginal Heritage

A search of the DPLH's Aboriginal Heritage Places dataset identified that the Site has no known Aboriginal Cultural Heritage within its boundaries. The following Registered Sites are in proximity to the Site:

- DPLH39200: Gascoyne and Lyons River is located 460m north of the Site;
- DPLH15913: Deep Creek – Gascoyne Junction is located 3km to the northeast of the Site;
- DPLH8853: NATGAS209 is located 2km to the northwest of the Site; and
- DPLH8854: NATGAS210 is located 2km to the northwest of the Site.

It is possible that items or areas of cultural significance may occur at the Site. It is recommended that the relevant traditional owner groups, the Yinggarda Aboriginal Corporation, are engaged in discussions regarding the development and the preferred method to proceed. At this stage, it is anticipated that this will not prohibit the development of the Site.

The Aboriginal heritage aspects for the Site and surrounding areas are shown in Figure 9 in Appendix A.

4.2 European Heritage

A search of the Heritage Council WA – Local Heritage Survey dataset identified no known European or post-colonial heritage values within the Site.

4.3 Mining Tenements

A review of the Department of Mines, Industry Regulation and Safety (DMIRS) mining tenement data indicated that the Site is not located within any category of mining tenement. The nearest exploration mining tenement is located 1.5km to the northeast of the Site.

5 Legislative Context

5.1 Environmental Protection (Rural Landfill) Regulations 2002 (WA)

The Site is registered as a Category 89 Prescribed Premises under Part V of the *Environment Protection Act, 1986* (EP Act).

The Rural Landfill Regulations apply to Category 89 Prescribed Premises in Schedule 1 Part 2 of the *Environmental Protection Regulations 1987*, for putrescible landfill sites that accepts between 20 and 5,000 tonnes of waste per year.

These regulations outline requirements for the tipping area, covering and containing of waste, the control of surface water runoff, dust suppression, separation distances, disposing of asbestos and clinical waste, and a post-closure rehabilitation plan.

The post-closure rehabilitation plan must provide information on the following:

- Options for use of the Site after landfilling has ceased, including specifying a preferred option;
- Conceptual design of the required infrastructure for the preferred post-closure option;
- Estimated final contours for the Site, including allowance for settlement;
- Capping materials to be used at the Site;
- Proposed stormwater management system for the Site;
- Measures for environmental protection and monitoring at the Site; and
- The estimated period for which the Site will require monitoring.

These regulations have been adopted for the Site, with consideration given to the requirements in the conceptual designs presented in this LPCP.

5.2 Victorian EPA BPEM Guidelines

The BPEM Guidelines outline specific landfilling requirements and practices, particularly with regard to the design of a final landfill profile and specifics of surface water management. In the absence of West Australian landfill guidelines, these guidelines have been used to generally guide the specification of the following aspects of this LPCP:

- Final landform profiles;
- Final capping system, including materials; and
- Proposed surface water management systems.

6 Historic, Current and Proposed Landfill Operations

The following sections provide an overview of the current and future activities at the Site.

6.1 Filling History

Landfilling activities at the Site are estimated to have commenced in the late 1990s. Landfilling has previously occurred in trenches or pits in the existing Site. No waste has been disposed of above ground level. The northern portion of the existing Site has been used for the burial of commercial waste, with disposal still occurring in the northeast of the existing Site. MSW is currently being disposed of in the eastern portion of the Site. Along the north of the eastern boundary of the existing Site there is an unknown historic disposal area, to the south of this is a historic septic waste disposal area.

Former landfill areas have been filled to 500-1,000mm below ground level, then closed and capped by the Shire using approximately 1,000-1,500mm of clean fill.

6.2 Current Activities

The existing landfill is a Class II putrescible landfill operating as a Category 89 prescribed premises and can accept up to a combined total of 5,000 tonnes per annum of waste. The Site currently accepts kerbside and commercial waste and has a designated area for the stockpiling of recyclable materials. Materials accepted on Site include:

- Municipal Solid Waste (MSW);
- Commercial and Industrial (C&I) waste;
- Construction and Demolition (C&D) waste;
- Scrap metal; and
- Green waste.

The main component of the Site is the refuse disposal area, which includes active landfill cells for current waste disposal which is accessed by members of the community in addition to household rubbish collection trucks. The existing Site has closed cells that are no longer receiving waste and a historic septic waste disposal area which is no longer in use.

The Site is unmanned and there are no restrictions on community access, with weekly inspections being carried out to monitor conditions.

6.3 Need for Expansion

The existing Site is nearing its capacity, and identifying suitable areas for expansion has become increasingly difficult due to incomplete Site records. The construction of new landfill trenches is further complicated by the site's limited footprint and the absence of accurate historical data, leading to excavation of buried waste during construction.

Additionally, the residential footprint of Upper Gascoyne is projected to increase in the coming years due to commitments to build homes and commercial properties in the town from the Department of Biodiversity, Conservation and Attractions (DBCA) and multiple mining companies.

6.4 Future Activities

The Shire is planning to expand the existing Site boundary and construct a new putrescible landfill, inert landfill and a Community Recycling Centre CRC. This expanded facility will cater to municipal and commercial waste streams in the region.

The CRC has a number of dedicated single-material storage areas which include the following:

- Scrap metal stockpile area;
- Greenwaste stockpile area;
- White goods/bulky item stockpile area;
- C&D stockpile area;
- Treated pallets/timber stockpile areas;
- Battery and waste oil storage shed/s;
- Road base/aggregate stockpile area.

Drawing W-101 available in Appendix B provides an overview of the current Site layout, including the expanded Site boundary.

6.5 Waste Data and Projections

6.5.1 Putrescible Waste

Historic putrescible waste acceptance volumes have not been collected at the Site as there is no weighbridge and the low waste acceptance volume does not require waste volumes to be reported to the DWER. Waste generation is often closely linked with population, and the growth rate in a population can be used as a substitute for the growth rate in waste generation. This approach can be used to generate estimated landfill tonnages and average annual growth from Australian Bureau of Statistics (ABS) census data.

A representative from the Shire has indicated that the Site currently serves 40 people, and the Shire anticipates an additional 8 houses to be constructed within the town between 2024 and 2039. It is assumed that each household will have an average of 4 residents, this increases the number of people the Site services to 72 people by 2040.

The per capita waste generation rate was calculated by using the current population and an estimated annual waste acceptance tonnage of 80 tonnes was provided by a Shire Representative. This generation rate was used to calculate the volume taken up to dispose of this waste, referred to as airspace. To calculate airspace consumption a waste compaction factor and volume of cover soil used must be calculated. The waste compaction factor was estimated to be 0.35 tonnes per cubic metre (t/m^3) based on the availability of plant equipment on Site which can compact waste. The volume of cover soils used has been estimated to be 50% of the total void, this is based on the volume of waste accepted and the frequency that waste must be covered as outlined in the WA Rural Landfill Guidelines.

Table 6-1 outlines the values used to calculate the airspace consumption rate.

Table 6-1: Generation Estimate

Aspect	Value
Estimated Waste Generation per Capita	2 Tonnes/year
Waste Compaction Factor	0.35 Tonnes/m^3
Cover Soil	50%
Airspace Consumption per Capita (including cover soils)	11.43 m^3/year

The airspace consumption rate per capita, as presented in Table 6-1, was then applied to the projected future population for the Shire to determine an annual landfill airspace consumption rate. The annual airspace consumption rate is presented in Table 6-2.

Table 6-2: Landfill Annual Fill Rate

Year	Estimated Population	Airspace Consumption Rate (m^3/year)
2025	42	475
2030	51	578
2035	62	703
2040	72	823
2045	72	823
2050	72	823
2055	72	823
Total (2025-2055)		**22,683**

The detailed waste generation modelling is presented in Appendix C.

6.5.2 Inert Waste

As discussed in Section 6.5.1 historic waste volumes have not been recorded at the Site. Due to the unknown nature of acceptance of inert waste the proposed inert landfill has been sized based on historic landfill sizing at the Site. This is assumed to be sufficient as sizing is based on a 25-year acceptance period at the Site. It is also assumed that due to the inclusion of a CRC the volume of waste disposed of in the inert landfill will reduce compared to past operations.

6.5.3 Stockpile Material

The purpose of the CRC is to facilitate the temporary storage of these materials received from domestic customers prior to their collection by material recyclers. The total area of the drop-off is 8,110m^2, and has been sized to allow for higher volumes of stockpiled materials to be stored to make collection more viable.

The Site will include a Recycling Drop-off Area within the CRC for recyclables and bulk waste, including scrap metal, greenwaste, white goods, treated pallets and timer, and materials laydown. The acceptance volume of these materials is unknown but the drop-off areas have been sized to allow for a larger volume of materials be stockpiled, due to the remoteness of the area it is assumed that collection of materials will be more viable if volumes are higher.

7 Rehabilitation Design

The existing and future landfill developments, filling history, void space, filling rate and phasing of capping works at both the Site are discussed in the following sub-sections.

7.1 Current Landfill Profiles

As no filling has occurred above ground the Site currently has a relatively flat profile with some minor landform located in the eastern portion of the existing Site, that are approximately 1m higher than surrounding ground level.

The current landfill area at the Site is shown in Drawing W-100, available in Appendix B.

7.2 Proposed Landfill Development

Future development at the Site will be guided by the Rural Landfill Regulations. The following sections discuss the proposed development of landfill operations at the Site.

7.2.1 Putrescible Landfill

The putrescible landfill will be situated within the expanded Site, southeast of the existing Site. The putrescible landfill will consist of landfill trenches, utilising below ground operations to continue to maximise void space and gain suitable soil material. Landfill trenches have been sized to provide sufficient capacity for waste disposal for approximately 2-3 years. It is estimated that 15 trenches will be required to meet the demand of a 30-year landfill operational capacity.

The putrescible landfill development will provide a total capacity of approximately 45,780m^3. It is proposed that trenches are developed from north to south, with filling occurring from the eastern to the western end of each trench. The development and rehabilitation of these landfill trenches will be undertaken in a staged manner in line with the needs of the Site and the amount of waste received. Excavated materials can be used for operations and future rehabilitation works as required.

7.2.2 Inert Landfill

The inert landfill development area will be located within the expanded Site, situated to the north of the putrescible landfill facility and will consist of below ground landfill operations to continue maximising void space and gaining suitable soil material. The inert landfill has been sized to provide capacity for inert landfill disposal for approximately 30 years.

The inert landfill development will provide a total capacity of approximately 12,530m^3. It is proposed that filling occurs from southeast to northwest. The development and rehabilitation of the inert landfill can happen as a single event or progressively, as required by the Shire. Excavated materials can be used for operations and future rehabilitation works as required.

7.2.3 Landfill Design

The landfill trenches will be excavated to 3.5mbgl and waste will be filled to 0.5mbgl. The 3.5m excavation depth has been set based on existing operations at the Site, and to maintain compliance with the groundwater separation distances, estimated to be 4m from the base of landfill excavations. The base of the landfill will be prepared to ensure it is suitable for operations, with the surface graded and if necessary compacted, to create a stable and trafficable area for vehicle access.

For landfill void space modelling and material balance calculations outlined in Sections 7.5 and 7.6, respectively, it has been assumed that a 3.5mbgl excavation is possible across the entire extent of each landfill facility.

7.3 Final Fill Profile

It is proposed to cap both landfill sites in an approach that will comply with the objectives set out in the Rural Landfill Regulations and BPEM Guidelines. To guide these works, key objectives adopted for the final waste profile, onto which the capping system will be installed, include the following:

- Final fill profile and slopes that:
  - Ensure the long-term stability and integrity of the capping material and containment layer;
  - Promote natural surface water run-off;
  - Provide an aesthetically acceptable landform; and
  - Minimise long-term maintenance requirements.

Drawings W-106 and W-107 show the typical final fill profiles for the putrescible and inert landfill facilities that is in general compliance with the Rural Landfill Regulations. The final fill profiles for each facility maintain an approximate 0.5m below the existing ground levels and provides a smooth surface for the installation of a capping system.

7.4 Rehabilitation Profile

7.4.1 Design Considerations

The landfill capping system design must consider site uses after landfilling operations have ceased at each site. Following the landfill closure, the Site will continue to be used as a community drop-off area and material storage area, landfilled areas will be rehabilitated.

As the Rural Landfill Regulations do not provide specific details on rehabilitation design, a landfill capping system designed to comply with the BPEM Guidelines is proposed. In accordance with BEPM Guidelines, the design of the final capping for the landfill shall:

- Design and construction of the best cap practicable to prevent pollution of groundwater;
- Minimising seepage through the landfill cap by encouraging shedding of surface water;
- Progressive rehabilitation;
- Minimise infiltration of surface water into the waste;
- Provide a long-term, stable barrier between waste and the environment to protect human health and the environment; and
- Provide land suitable for its intended after use.

In addition, the following Site attributes influenced the proposed capping design for both landfill areas:

- The groundwater table is estimated to be greater than 4m below the base of the proposed landfill excavation areas;

- Very low annual waste inputs;
- The Shire is in an arid tropical climate with very hot summers, warm winters, and an average rainfall of 210mm.

7.4.2 Cap Design

In order to meet the design considerations discussed in Section 7.4.1, the proposed capping system for the landfill facilities at the Site is as follows, in order of construction, from bottom to top:

- 500mm Regulating Layer;
- 500mm Low Permeability Soil Layer; and
- 500mm of Revegetation Layer.

The layers will mostly consist of site-won material from the excavation works from the development of the landfill facilities. An additional capping layer of 200mm of green waste mulch can placed by the Shire, if available. This will promote the growth of the vegetation on the surface of the capping system, which will help minimise erosion.

The elements of this capping system are discussed in further detail in the following sub-sections, with the design shown in Drawings W-106 and W-107, available in Appendix B.

7.4.2.1 *Regulating Layer*

The preferred design approach for the capping system is the utilisation of a 500mm thick regulating bedding layer, consisting of site-won material to provide a smooth firm subgrade for installation of the Low Permeability Soil Layer. The material for the regulating layer may be sourced from existing stockpiles of excavated soils created during the development of the Site, or from construction of the surface water pond. The landfill's temporary capping as described in Section 7.8 may form part of the regulating layer.

7.4.2.2 *Low Permeability Soil Layer*

The 500mm thick Low Permeability Soil Layer will be formed from in-situ clayey material won from the excavation works landfill development, or from the development of the surface water pond. It is recommended that the material be compacted in layers not exceeding 300mm to construct the low permeability layer and reduce infiltration through the cap.

7.4.2.3 *Restoration Layer*

The 500mm Revegetation Layer will mostly consist of site-won material from the excavation works during the landfill development, or from construction of the surface water pond. Due to the low-risk nature of the landfill facilities, it is anticipated that wind-blown seed will be adequate for establishing a vegetation layer, however this may be supplemented with tube stock planting or application of a seed mix in areas where natural vegetation is taking longer to establish. The application of grass/seed mix, where undertaken, should be based on species native to the region.

7.4.3 Final Restoration Profile

Drawings W-106 and W-107 show the final restoration profile for the putrescible and inert landfill facilities, based on its proposed final fill profiles and capping system design. The profile for the putrescible landfill has a maximum height of 143.5mAHD, which is approximately 1m above existing ground levels, while the inert landfill has a maximum height of 144.4mAHD, which is approximately 1.4m above existing ground levels.

The proposed final restoration profiles at each site provide the following key outcomes:

- The encapsulation of all waste disposed across the landfill Site;
- Facilitate the conventional rehabilitation of each Site through compliance with the Rural Landfill Regulations;
- The development of a best practice landfill profile and side slopes which will:
  - Promote the natural flow of surface water off the landfill, minimising pooling and infiltration;
  - Facilitate the development of a typical perimeter drain, where relevant, to cater for surface water across the capped landfill;
  - Ensure the long-term stability and integrity of the capping system and environmental control systems (surface water management);
  - Minimise the long-term maintenance requirements of the capping system;
  - Provide an aesthetically acceptable landform long-term and support further post-closure land uses; and
  - Facilitate phased capping.

7.5 Void Space Modelling

Void space modelling ensures that a landfill can cater for future long-term waste management demands, and the results can be used to project key capital works over the various financial years going forward and ensure continued operations to cater for the communities' disposal requirements.

Void Space Modelling has been undertaken to determine the required filling capacity for the proposed landfills using the calculated landfill sizing outlined in Sections 7.2.1 and 7.2.2. This will allow the Shire to understand the required footprint for a variety of landfill trench lifespans and provide the ability to plan the construction of additional trenches over the Site's lifespan.

For the purposes of this modelling, the density of putrescible waste after placement is assumed to be 0.35t/m^3 and the cover material requirements to be 50% of the total available void space volume. Based on a rectangular, 8m wide, 84m long and 3.5m deep trench, with a 1:10 access ramp, the void space and lifespans for the landfill trenches are presented in Table 7-1.

The density of inert waste is assumed to be 1t/m^3 and there are no cover material requirements. Assuming the Inert Landfill is 56m wide, 95m long and 3.5m deep, with a 6m wide, 1:10 (V:H) access ramp, the void space and lifespans for the landfill is presented in Table 7-1.

Table 7-1: Estimated Landfill Lifespans and Void Space

Facility	Landfill Lifespan	Total Void Space (m^3)	Net Void Space (ex. Cover Soils) (m^3)
Putrescible Landfill (per Trench)	2 years	1,526	763

Facility	Landfill Lifespan	Total Void Space (m^3)	Net Void Space (ex. Cover Soils) (m^3)
Total Putrescible Landfill (15 Trenches)	30 years	22,890	11,445
Inert Landfill Cell	30 years	12,530	12,530
Total	**30**	**24,738**	**36,946**

Waste modelling undertaken shows that an estimated 39,606m^3 of void space will be required over the approximately 30-year lifespan of the Site to cater for both putrescible and inert landfilling practices.

It is recommended that Shire staff monitor the volume of waste disposed in the landfills and maintain a record of this. This input waste volume should be reviewed annually in conjunction with the void space consumption within each landfill to determine landfill compaction and consumption rates and to monitor the required landfill void and siting.

The detailed void space modelling is presented in Appendix C.

7.6 Material Balance

A Material Balance is the calculation of the volume of materials required to carry out engineering works, daily cover activities, and landfill restoration works and comparing these quantities to the volume of material which can be retrieved from site. The balance of material requirements against supply over the life of each landfill should be considered during the conceptual design stage to ensure that the design optimises available fill to meet these requirements. If a Material Balance is not achieved over a landfill's lifespan, the deficient material will need to be imported at additional cost.

Calculations have been undertaken to determine the material required throughout the life of the waste management facility for:

- Landfill construction;
- Daily cover material, which is assumed as 50% of the total landfill void; and
- Surface water pond construction.

Table 7-2 shows the approximate material balance for the Site, based on the construction of 3.5m deep excavations and the rehabilitation designs presented in W-104, presented in Appendix B.

Table 7-2: Approximate Material Balance Calculations for the Sites

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Net Balance
Putrescible Landfill (per Trench)	+1,526	-763	-1,008	-245
Total Putrescible Landfill (15 Trenches)	+22,890	-11,445	-15,120	-3,675

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Net Balance
Inert Landfill	+12,530	0	-9,393	+3,137
Surface Water Pond	+1,877	0	0	+1,877
Total	**+37,297**	**-11,445**	**-24,513**	**+1,339**

As shown in Table 7-2, the Site can theoretically achieve a material balance, with the excess soils to be used for the surface water and safety bunds around an active trench.

It should be noted that the total Material Balance requirement is sensitive to the amount of cover soils used during operations and will therefore be monitored by the Shire to ensure that sufficient soils are stockpiled at the Site.

7.7 Phasing of the Capping Works

To improve environmental outcomes for any rural landfill, it is typically recommended that capping should be undertaken progressively on an as needed basis, as filling rates and Shire budgets allow.

As described in Section 7.5, the total remaining void space is estimated to be 36,946m^3, which is anticipated to provide up to 30 years of landfill lifespan. The putrescible landfill trenches each have an approximate lifespan of two years. It is recommended that closure occurs once filling no longer occurs in that trench. Ideally, capping works should be scheduled within six months of completion of tipping operations where possible and should align with the development of the next trench so that excavation materials can be used for capping works.

The inert Landfill capping works are proposed to occur as a single event when the landfill at the Site is no longer operation, however, can be progressively capped if required.

7.8 Temporary Capping System

Temporary capping works may be required as an interim protective measure until the permanent capping works commence. The temporary cap will need to be consistently maintained, particularly after extreme rainfall events, which could result in scouring and erosion. The temporary capping system should consist of 500mm of low permeability soil layer at a minimum and should be formed such that surface water run-off is diverted away from the landfill. This temporary capping layer should be scraped back in the event of further waste placement or may be used as the Regulating Layer for the foundation of the capping system described in Section 7.4.2.

7.9 Asbestos Disposal

Asbestos is not expected to be accepted at the Site under normal operations. In the event asbestos needs to be accepted, arrangements must be made with the Shire at least two weeks in advance, to allow for the construction of the monocell. Asbestos will only be accepted by appointment, and each load must be declared for inspection by Site staff to determine whether it meets the acceptance criteria. The Shire will only accept double-wrapped domestic quantities of non-friable asbestos-containing materials (i.e., under 10m^2 in size).

Soils excavated during the cell's construction will be used to cap the cell with a 1m layer of restoration soils. The restoration profile of the capped monocell will be shaped to encourage surface water runoff and reduce water percolation into the cell.

These activities will be undertaken in accordance with Regulation 16 of the Rural Landfill Regulations, which includes:

- Ensuring that all asbestos waste is disposed of under the Shire's personal supervision, or under the personal supervision of a nominated representative;
- Ensuring that asbestos wastes are covered as soon as practicable following deposition with clean fill soils to a minimum depth of one metre; and
- Maintaining a register and site plan showing where asbestos has been disposed, and the details of its disposal.

The location of the proposed Asbestos Monocell is shown in Drawing W-101, with typical details of the proposed monocell shown in Drawing W-107, available in Appendix B.

8 Surface Water Management

Environmental risks associated with leachate and surface water at the Site will be managed through the development of a Surface Water Management System (SWMS), which will be designed to meet two key objectives including minimising leachate generation and proactively managing surface water. These objectives and the design features incorporated to achieve them are shown in Table 8-1.

Table 8-1: Objectives and Associated Design Features of the Surface Water Management System

Objective	Design Feature
Minimise Leachate Generation	Implement a Site-specific capping and surface water management system over the landfill.
	Develop a perimeter drainage system that: • Maintains connectivity with the capping system; and • Includes strategically located discharge points away from the waste mass.
	Locate long-term surface water discharge points.
Proactively Manage Surface Water	Incorporate measures into the capping system to direct surface water from the landfill cap to the discharge points.
	Ensure the SWMS is appropriately sized to manage a 1-in-20-year Annual Exceedance Probability (AEP) storm event.
	Establish controlled discharge points for surface water.

The design for the final capping system at the Site incorporates surface water management infrastructure to prevent the infiltration of surface water into the waste mass and thereby preventing the production of leachate over time.

The Site only accepts non-putrescible wastes and is considered to have a very low environmental risk profile. For these reasons, a formal SWMS at the Site is proposed, with runoff from the capping system following the boundary of the Site and draining into a surface water pond.

8.1 Key Infrastructure

The following sections discuss the proposed key infrastructure at the Site.

8.1.1 Perimeter Swales

Perimeter swales will run around the boundary of each landfill area and will be used solely to collect surface water that sheds from the landfill's restoration profile following permanent capping works. These drains will connect to a surface water attenuation pond, which is discussed further in Section 8.1.2. These drains will be clean earth channels which will be constructed progressively as the landfill is developed and capped.

8.1.2 Surface Water Pond

A surface water attenuation pond will be constructed in the northeast corner of the expanded Site, at the lowest level to allow for surface water to drain via gravity from the remainder of the Site. The pond will be constructed with a 250mm compacted subgrade layer using onsite soil material.

8.2 Surface Water Modelling

The SWMS has been designed to contain and control surface water runoff from a 24-hour, 1-in-20-year AEP storm event, at a minimum, with contingency for a larger 24-hour, 1-in-50-year AEP storm event. The proposed surface water management infrastructure consists of perimeter swales and a surface water pond. To determine the appropriate design for this infrastructure, modelling was undertaken using a Microsoft Excel surface water pond and drainage swale sizing algorithm based on local climate data including rainfall depth and intensity.

8.2.1 Catchment Areas

The catchment area covers the development areas across the Site. This catchment was based on topographical data, the design of the landfill areas and other supporting infrastructure. The following sections discuss the design criteria for the catchment.

8.2.1.1 *Runoff Coefficient*

Based on the geology of the Site, the surface soils are considered to be sand and sandy silts. The landfill capping will be constructed with Site-won soils which will have a grade of approximately 5%. Using the Queensland Urban Drainage Manual[1], the runoff coefficient for graded clay soils at a gradient of 0-10% is 0.5, and this value was used for modelling purposes.

8.2.1.2 *Catchment Design Summary*

Table 8-2 summarises the design details of the catchment areas considered for the SWMS.

Table 8-2: Summary of Catchment Areas

Catchment	Area (ha)	Runoff Coefficient
Catchment A	22,647	0.5
Catchment B	10,930	0.5
Catchment C	17,535	0.5
Catchment D	34,220	0.5
Total	**85,332**	**0.5**

The catchment areas identified in Table 8-2 are utilised to calculate the required capacity of the new surface water pond and assisted in determining the recommended geometry of swale system to transfer surface water run-off to the surface water pond.

[1] Queensland Urban Drainage Manual. 4th Edition. Institute of Public Works Engineering Australasia, Queensland.

8.3 Surface Water Infrastructure Design

The following sections describe the modelling results and the finalised design characteristics of the key infrastructure proposed for the SWMS at the Site.

8.3.1 Swale System

The swales should have a general trapezoidal design shown in Figure 8-1.

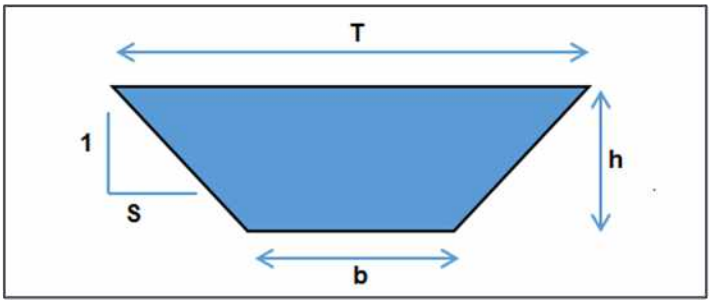

Figure 8-1: Swale Geometry

To simplify the swale system, one swale design is proposed for implementation throughout the site, which is presented in Table 8-3, with the dimensions corresponding to the swale shown in Figure 8-1.

Table 8-3: Proposed Swale Design

Design	S	b (m)	T (m)	h (m)
A	3	1	7	1

8.3.2 Surface Water Pond

Table 8-4 outlines the key design criteria for the proposed surface water pond, which is illustrated in Drawings W-103 provided in Appendix B.

Table 8-4: Summary of Surface Water Pond Design Criteria

Approx. Dimensions [LxWxh] (m)	Side Slopes (V:H)	Surface Area (m^2)	Operational Pond Capacity* (m^3)	Required Capacity (m^3)
				1:20, 24hr
60 x 70 x 2.5	1:2.5	8,100	6,579	5,905

The pond has been designed to handle a 1-in-20-year, 24-hour storm event during regular operation, with contingency for a 1-in-50-year, 24-hour storm event. This pond is an improvement from the Site's current informal SWMS and provides significant attenuation before the surface water runoff overflows offsite. Calculations for the sizing of the surface water ponds and conveyance network are presented in Appendix D.

8.3.3 Surface Water Bund

A surface water bund shall be installed to protect the landfill facilities from external floodwaters. The continuous bund shall be neatly formed from suitable excavated material. The surface water bund will continuous along the western edge of the Site, as shown in Drawing W-101, presented in Appendix B.

The surface water bund is proposed to be 1m high, and 8m wide with 1:4 (H:V) slopes, and will be constructed of non-dispersive site-won soils.

9 Post-Closure Management and Monitoring

The BPEM Guidelines state that the typical period for aftercare for a putrescible landfill is approximately 30 years. The following areas have been considered in planning for the aftercare period:

- Maintenance of landfill cap, in particular to:
  - Prevent/control erosion
  - Restore depressions, seal and monitor cracks in the cap caused by settlement
  - Restore/maintain vegetation
- Environmental monitoring of:
  - Groundwater
  - Surface water
  - Landfill gas (if any)
  - Landfill leachate (if any)
  - Topography (i.e. settlement).

The environmental management measures that will be employed, and associated monitoring works, are described in the following sections.

9.1 Landfill Gas

The low levels of putrescible waste acceptance and a very dry climate at the Site indicates that any landfill gas generation will be limited. The proposed landfill capping system should be adequate in controlling the landfill gas, which will oxidise as it permeates through the landfill's soil cap. The lack of sensitive receptors near the Site also lowers the environmental and human health risks.

Therefore, no landfill gas management or monitoring infrastructure is considered warranted for the Site.

9.2 Landfill Leachate

The implementation of the capping system at the Site will significantly reduce water infiltration and leachate generation, which in turn will reduce the amount of leachate permeating into the groundwater, reducing any environmental impacts. Therefore, it is recommended that the capping of the landfill is undertaken within 6 months of final fill levels being achieved.

No standalone monitoring of landfill leachate is recommended, as the Site accepts a small annual quantity of putrescible waste and climate conditions are arid, with low annual average rainfall and low relative humidity year-round as discussed in Section 3.1.

9.3 Surface Water

A visual inspection of the SWMS should be conducted annually or after heavy rainfall events to ensure that it is operating effectively. This inspection should be continued during the first five years following the rehabilitation of the landfill. After this time, further monitoring may not be required if results indicate that the SWMS is effective.

In the even that there is damage to the SWMS infrastructure, capping system or indication of contamination, samples should be taken at the discharge points to the surface water pond and tested for evidence of leachate or other contaminants. Where the results indicate the presence of contaminants, the source of the contamination should be identified, and action taken to remedy any failures in the system. This may require sampling of the individual channels of the SWMS to assist in the identification of the source.

9.4 Groundwater

Groundwater may be impacted by leachate percolating through in-situ ground and may also cause landfill inundation if the separation distance is inadequate. The regional depth to groundwater is understood to be well in excess of the 3m requirement of the WA Rural Landfill Regulations, however it recommended that the Shire consider groundwater bores be installed to confirm the depth to groundwater in the immediate vicinity of the Site. In addition, groundwater bores can be used to monitor the groundwater quality at the Site.

Groundwater monitoring and sampling is recommended to identify any changes to its characteristics in the event a leak/seepage occurs from waste activities onsite and to ensure a sufficient response time if leachate extraction is required.

9.5 Topography

Following rehabilitation, inspections of the integrity of the capping system should be conducted twice annually and following severe weather events. It is critical for the proposed topsoil layer remains in place and it may be necessary to reinstate displaced restoration soils. If an inspection highlights any damage to the capping system, from erosion or settlement, then works should be undertaken to repair the capping system in line with the designs presented in Section 7.4.2 as soon as possible to mitigate further damage.

9.6 Vegetation

Vegetation growth should be encouraged; however, it is noted that the undisturbed areas at the Site and surrounding areas exhibit a very low volume of vegetation growth. Rehabilitated areas should be visually monitored following the revegetation of landfilled areas to ensure areas reflect the characteristics of undisturbed land. Monitoring for weeds should also be undertaken, with weed control measures implemented biannually. Establishment of vegetation is critical in the years following capping as vegetation assist in reducing erosion and maintain the integrity of the capping system.

9.7 Monitoring Program

The proposed Post-Closure Management and Monitoring Program at the Site is presented in Table 9-1.

Table 9-1: Post-Closure Management & Monitoring Program

Aspect	Monitoring Method	Frequency	Duration
Landfill Gas	No post-closure management or monitoring recommended		
Landfill Leachate	No post-closure management or monitoring recommended		

Aspect	Monitoring Method	Frequency	Duration
Surface Water	Visual Inspection	Annually	During operation and the following 5 years post-closure
	Visual Inspection	Following heavy rainfall events	As required
	Sampling at surface water evaporation pond	As indicated by visual inspection	During operation and the following 5 years post-closure
Topography	Visual Inspection	Biannually*	First 2 years following closure
		Every 2 years	Following 13 years
		Every 5 years	Following 15 years
Vegetation	Visual Inspection	Biannually	First 2 years following closure
		Every 2 years	Following 13 years
		Every 5 years	Following 15 years

* Following extreme weather events, it is recommended to undertake an inspection of the restoration soils and monitor the formation of any rills or gullies

APPENDIX A
Figures

Figure 1: Locality Plan

Figure 2: Zoning

Figure 3: Sensitive Receptors

Figure 4: Topography & Geology

Figure 5: Hydrology

Figure 6: Hydrogeology

Figure 7: Disaster Mapping

Figure 8: Threatened & Priority Flora, Fauna and Ecological Communities

Figure 9: Heritage

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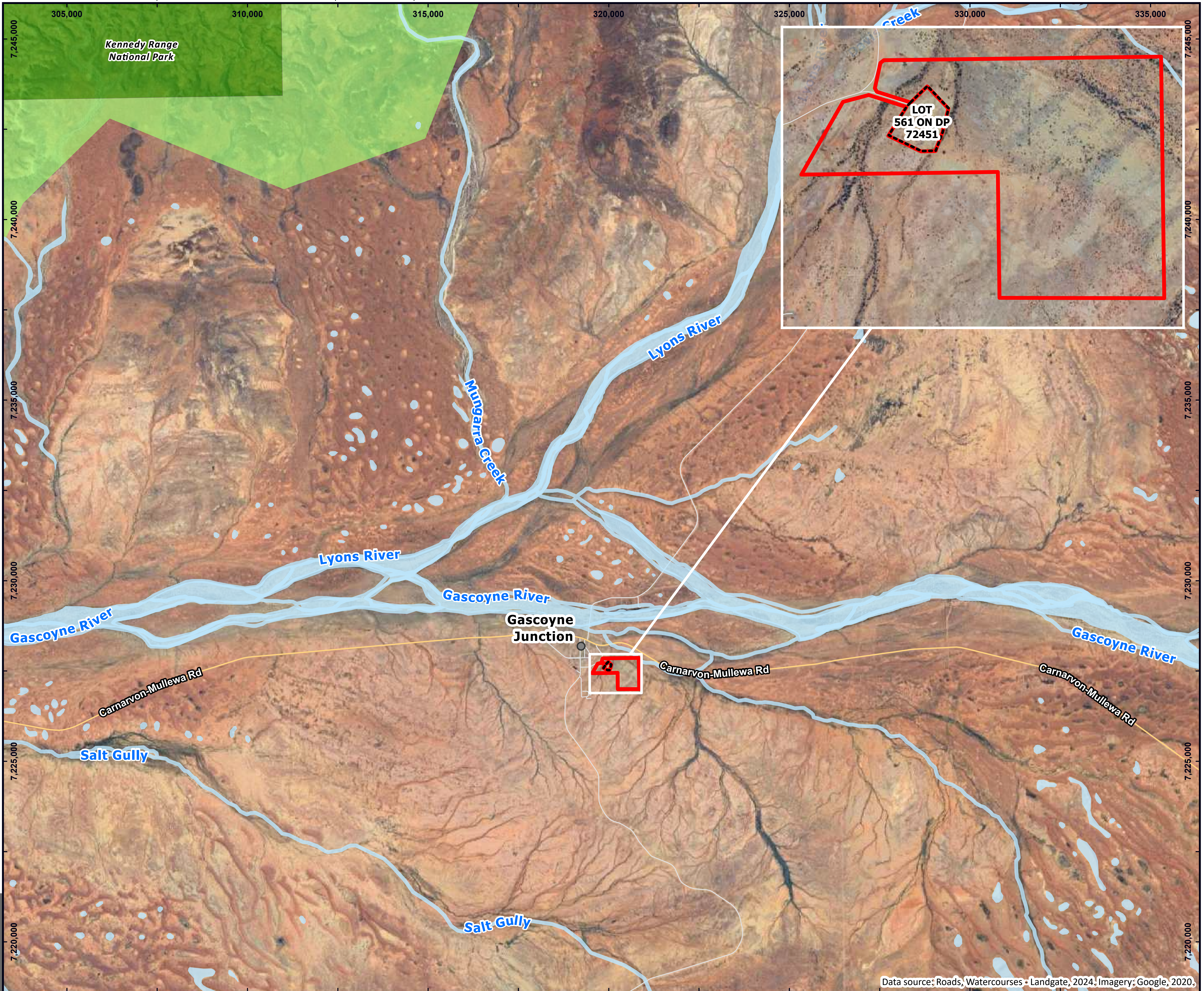

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451
- Watercourses

Legislated Lands and Waters

- National Park
- UCL - Section 33(2)

Western Australian Roads

- Main Road
- Minor Road

LOCALITY

LOCALITY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 1 2 3 4 km

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:100,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 01

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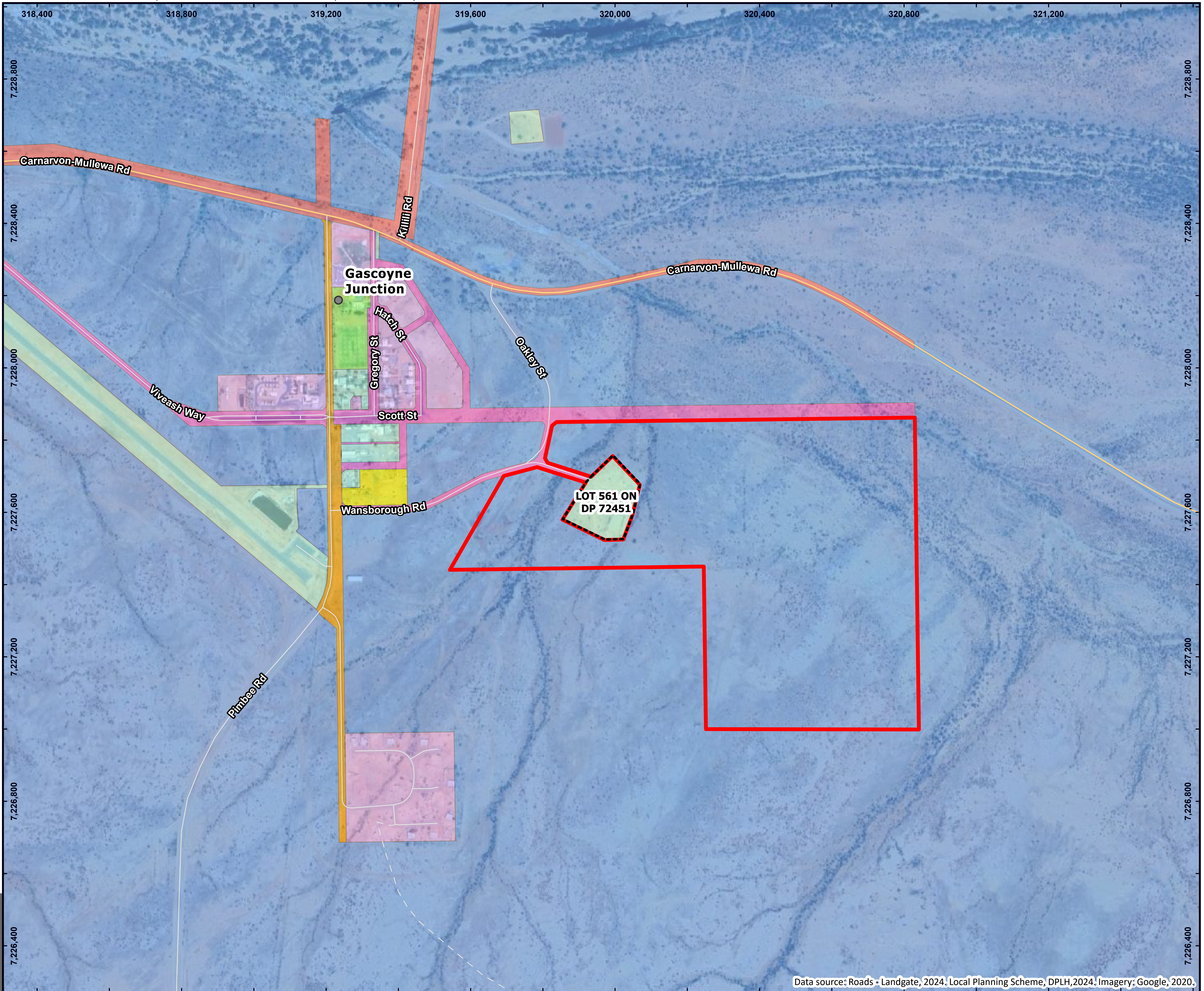


LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

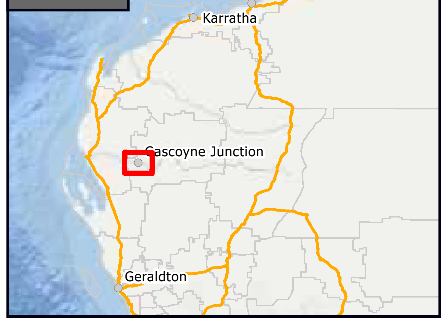
Local Planning Scheme

- Light industry
- Local distributor road
- Local road
- Primary distributor road
- Public open space
- Public purposes
- Rural
- Rural townsite

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



ZONING

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 02

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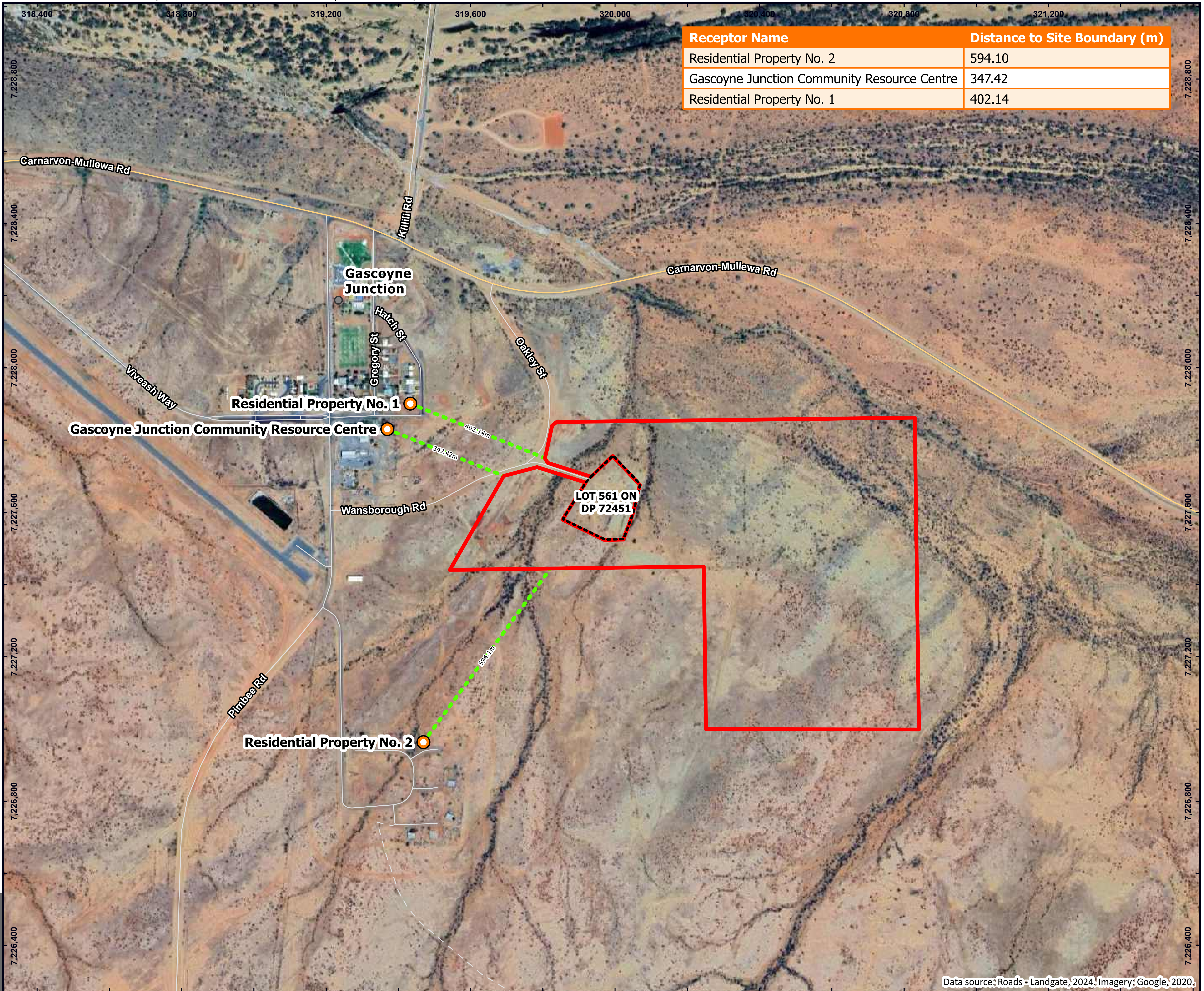


Receptor Name	Distance to Site Boundary (m)
Residential Property No. 2	594.10
Gascoyne Junction Community Resource Centre	347.42
Residential Property No. 1	402.14

LEGEND

Proposed Boundary Expansion

Lot 561 on Plan 72451

Separation Distances

Sensitive Receptors

Separation Distances

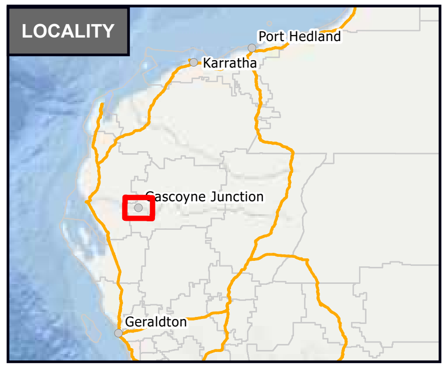
Western Australian Roads

Main Road

Minor Road

Other

LOCALITY



0 200 400 600 800 1,000 km

SENSITIVE RECEPTORS

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 03

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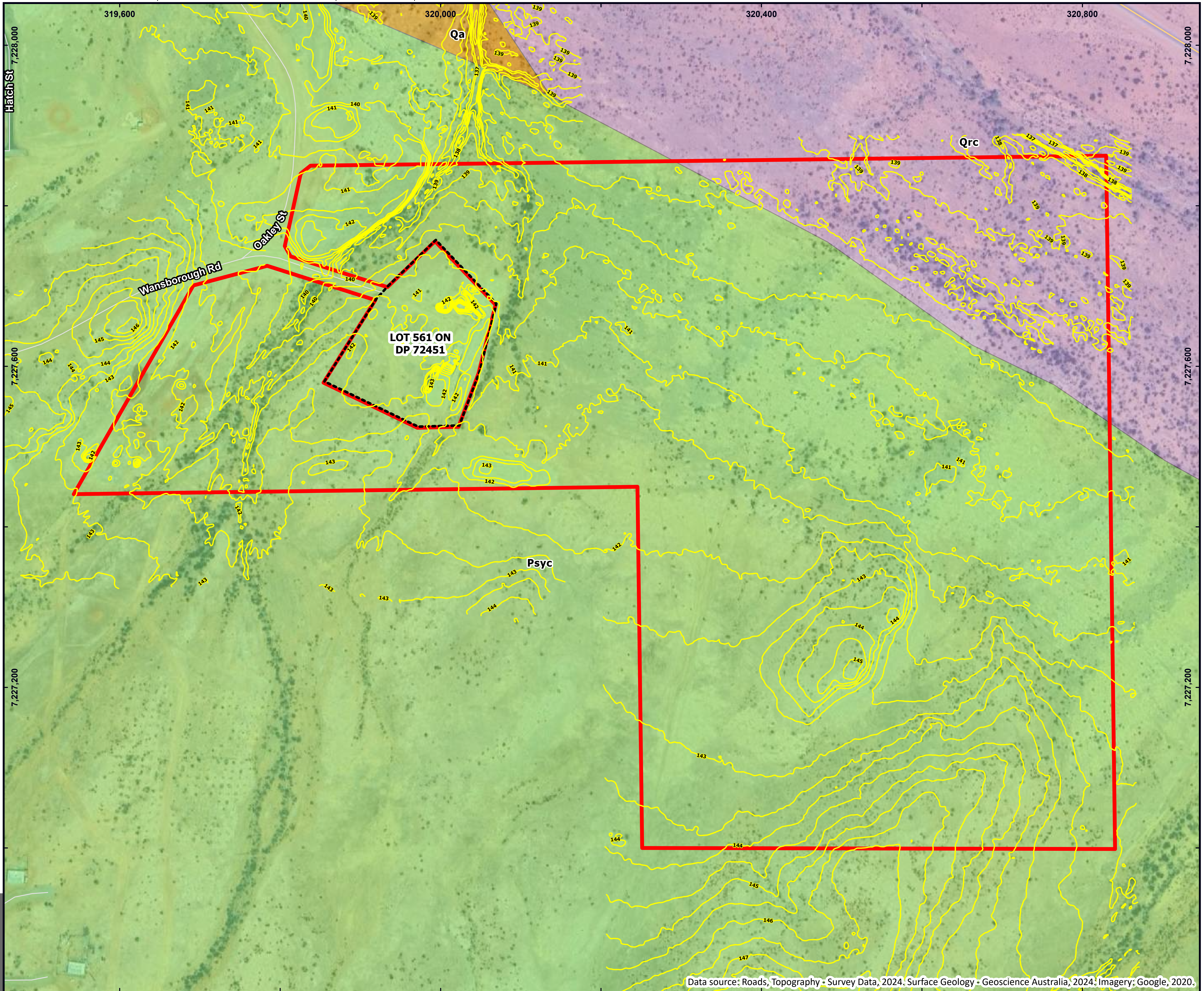

LEGEND

Proposed Boundary Expansion

Lot 561 on Plan 72451

0.5m Contours (m AHD)

Surface Geology (GA)

Psyc: Quartz wacke, siltstone, carbonaceous siltstone and shale, locally fossiliferous.

Qa: Channel and flood plain alluvium; gravel, sand, silt, clay; may be locally calcreted

Qrc: Colluvium and/or residual deposits, sheetwash, talus, scree; boulder, gravel, sand; may include minor alluvial or sand plain deposits, local calcrete and reworked laterite

Western Australian Roads

Main Road

Minor Road

LOCALITY

TOPOGRAPHY & GEOLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 50 100 150 200 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:4,500

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 04

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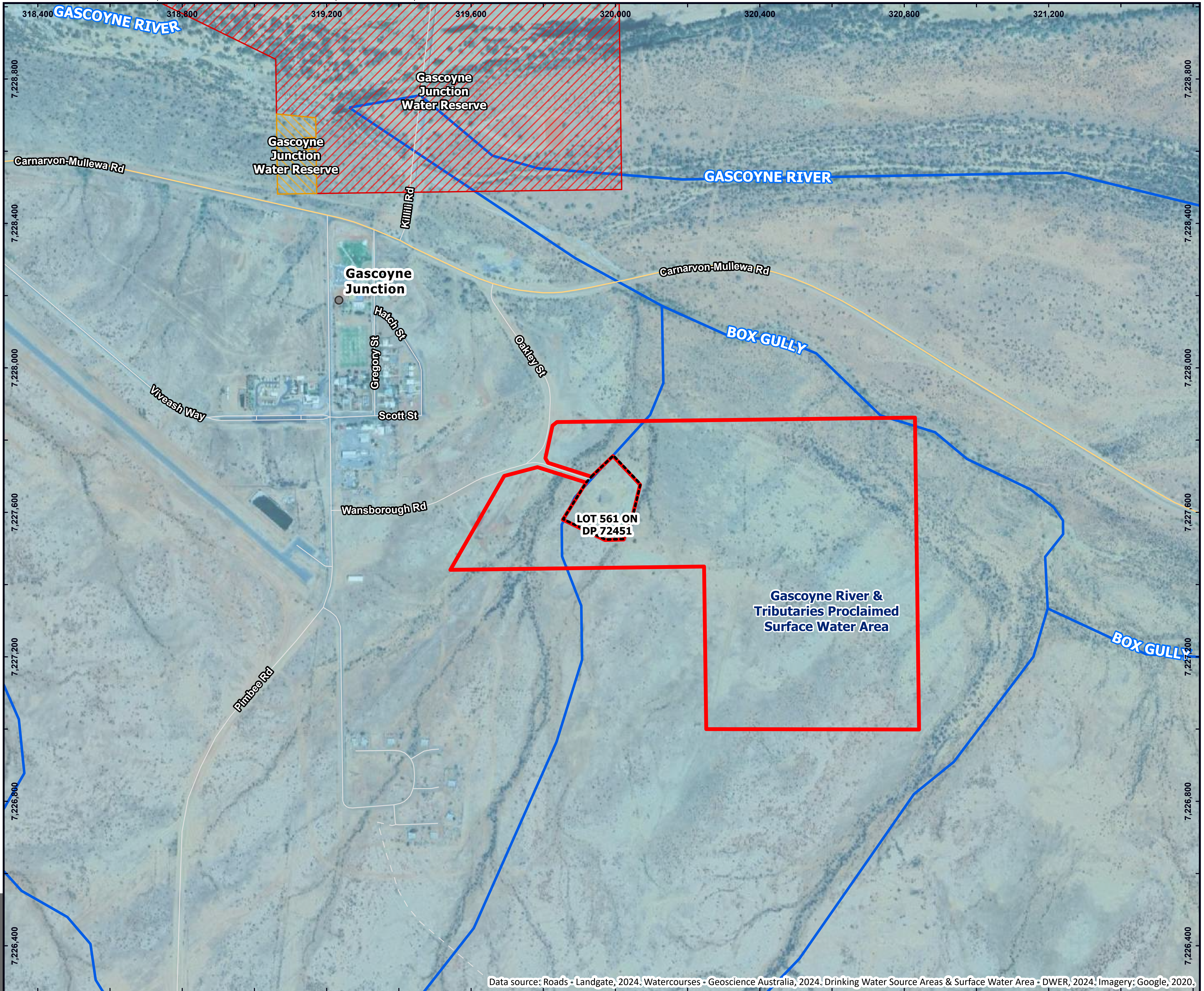


Data source: Roads - Landgate, 2024. Watercourses - Geoscience Australia, 2024. Drinking Water Source Areas & Surface Water Area - DWER, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Hydrography

- Minor Watercourse
- Surface Water Area

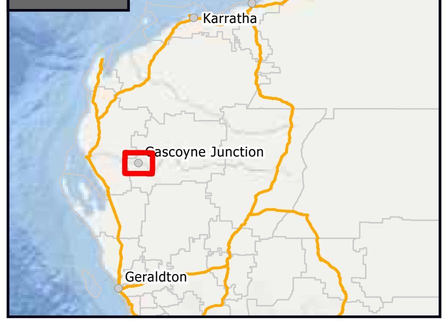
Public Drinking Water Source Areas

- Protection Area - P1
- Protection Area - P2

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



0 200 400 600 800 1,000 km

HYDROLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 05

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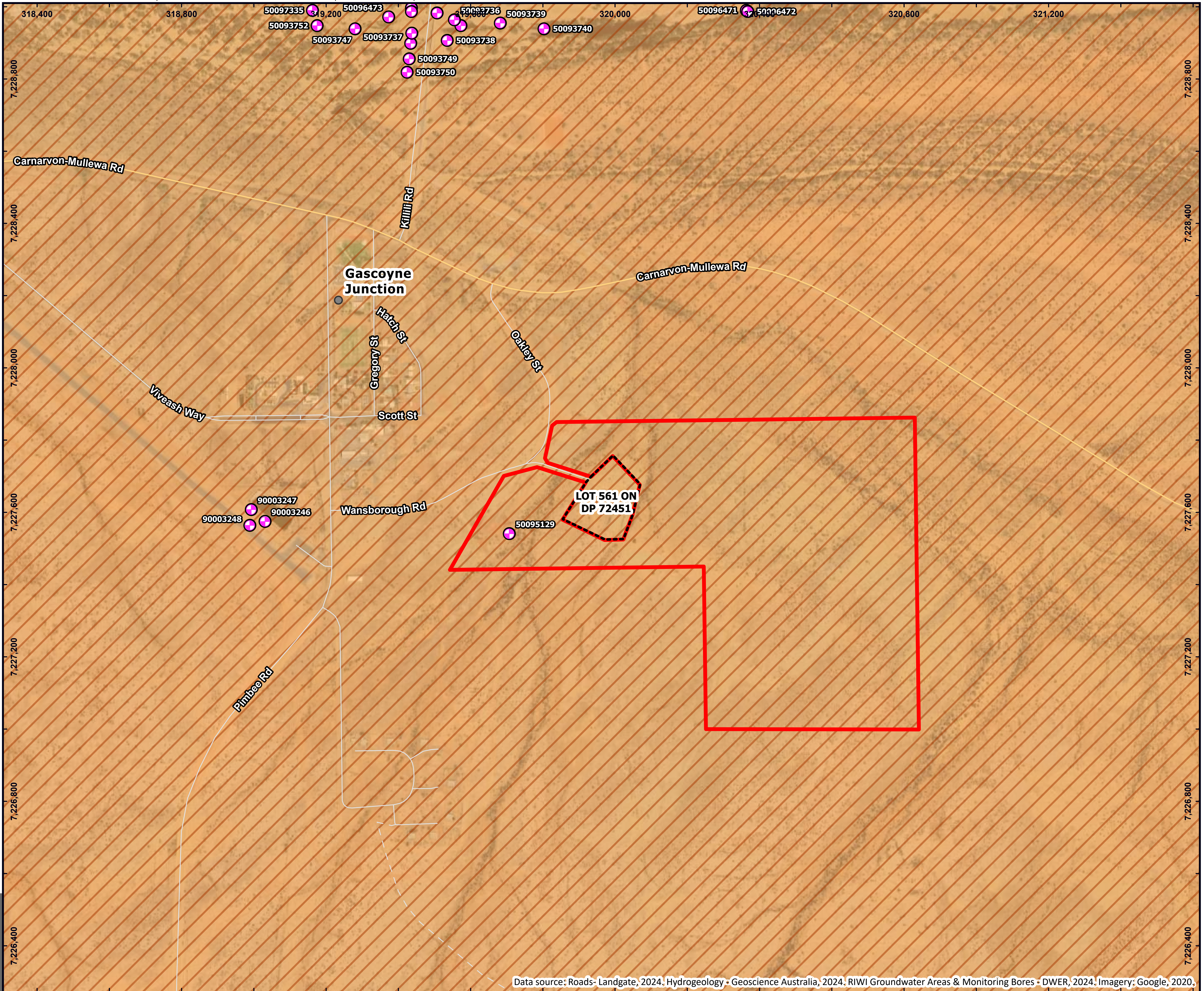


Data source: Roads- Landgate, 2024. Hydrogeology - Geoscience Australia, 2024. RIWI Groundwater Areas & Monitoring Bores - DWER, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Hydrogeology

- Gascoyne Proclaimed Groundwater Area
- Porous, extensive highly productive aquifers

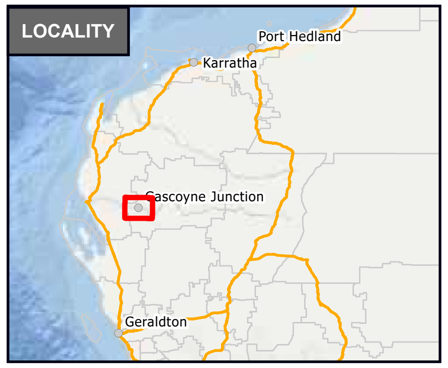
Groundwater Monitoring Bores

- Unknown Status

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



0 200 400 600 800 1,000 km

HYDROGEOLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 06

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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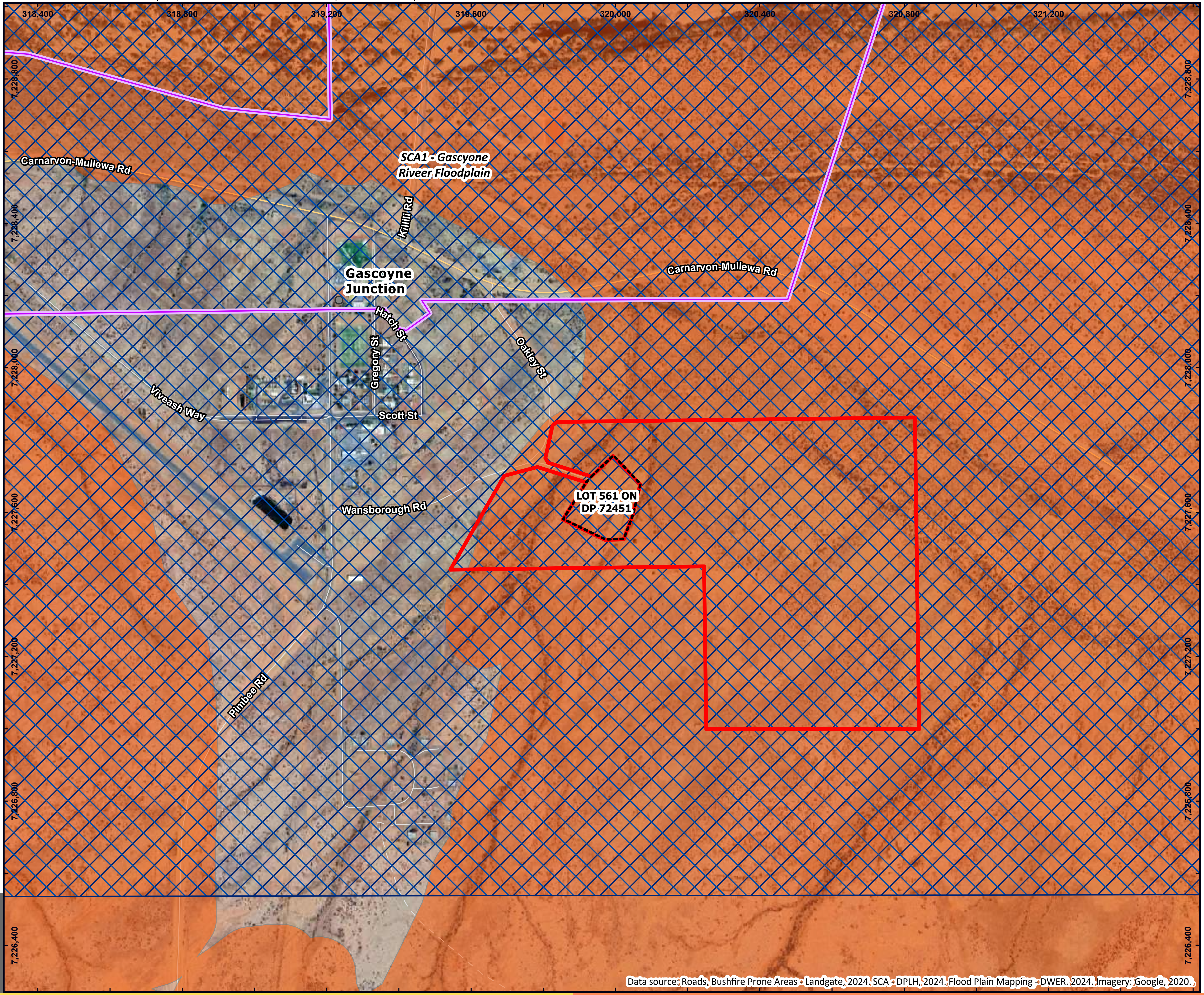


Data source: Roads, Bushfire Prone Areas - Landgate, 2024. SCA - DPLH, 2024. Flood Plain Mapping - DWER. 2024. Imagery: Google, 2020.

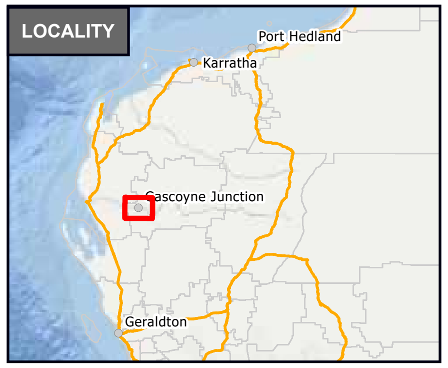
LEGEND

- Proposed Boundary Expansion
- Special Control Areas
- Lot 561 on Plan 72451
- 1 in 100 1 AEP Floodplain Development Control Area
- Bushfire Prone Areas

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



DISASTER MAPPING

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	13/12/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 07

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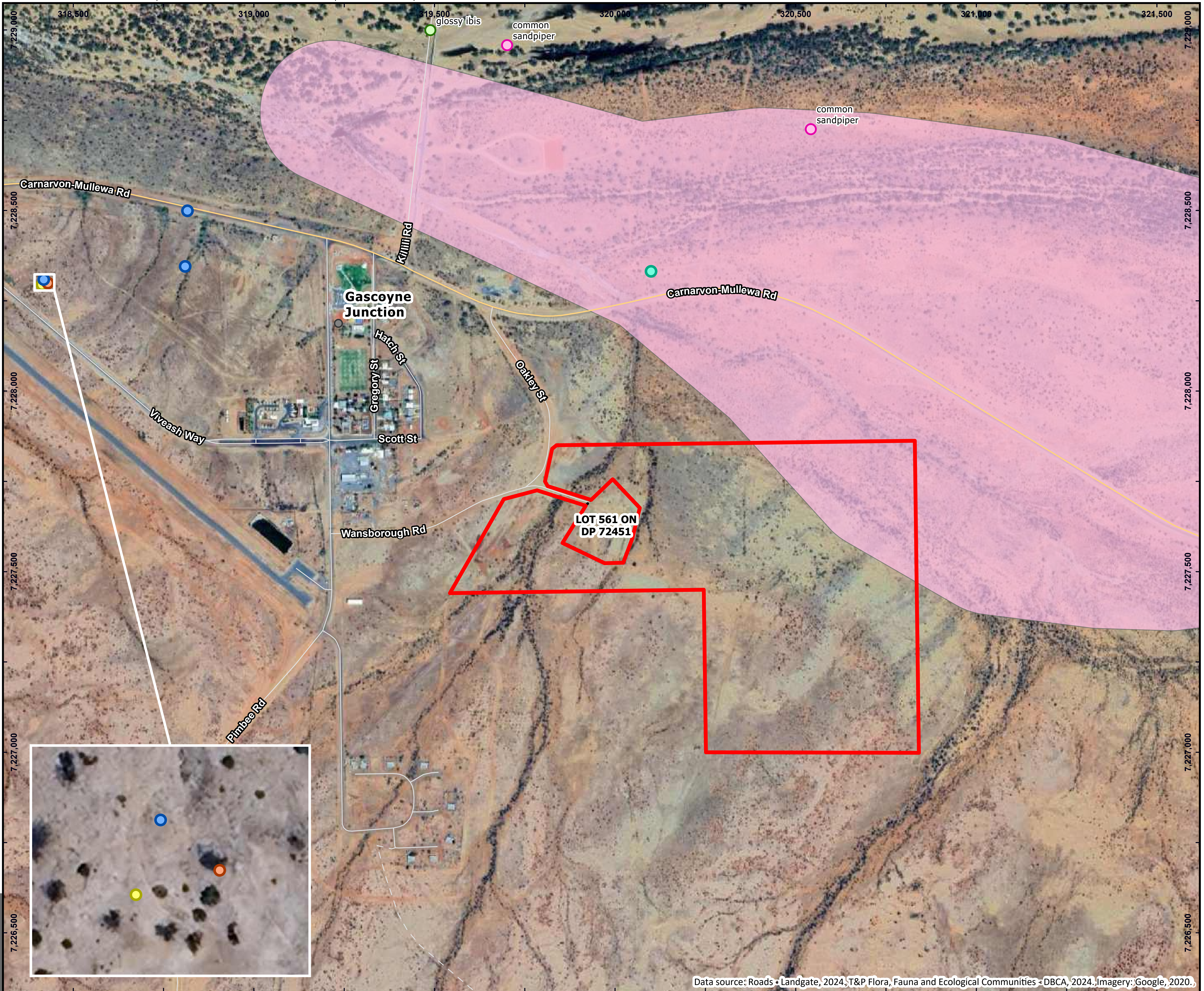


Data source: Roads - Landgate, 2024, T&P Flora, Fauna and Ecological Communities - DBCA, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Threatened & Priority Flora

Priority 1

- Rhodanthe ascendens

Priority 2

- Bergia auriculata

Priority 3

- Abutilon sp. Pritzelianum (S. van Leeuwen 5095)
- 3: Grevillea subterlineata

Threatened & Priority Fauna

Migratory Species

- common sandpiper
- glossy ibis

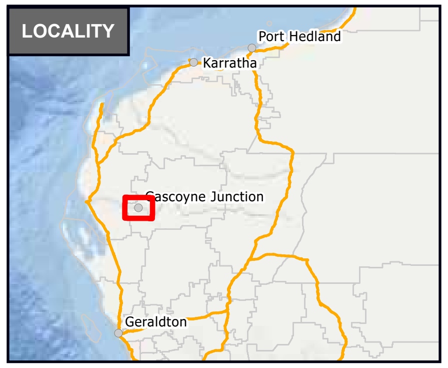
Priority Ecological Communities

- Jingle Land System

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



0 200 400 600 800 1,000 km

THREATENED & PRIORITY FLORA, FAUNA AND ECOLOGICAL COMMUNITIES

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	B Roelofse	Date:	8/11/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 08

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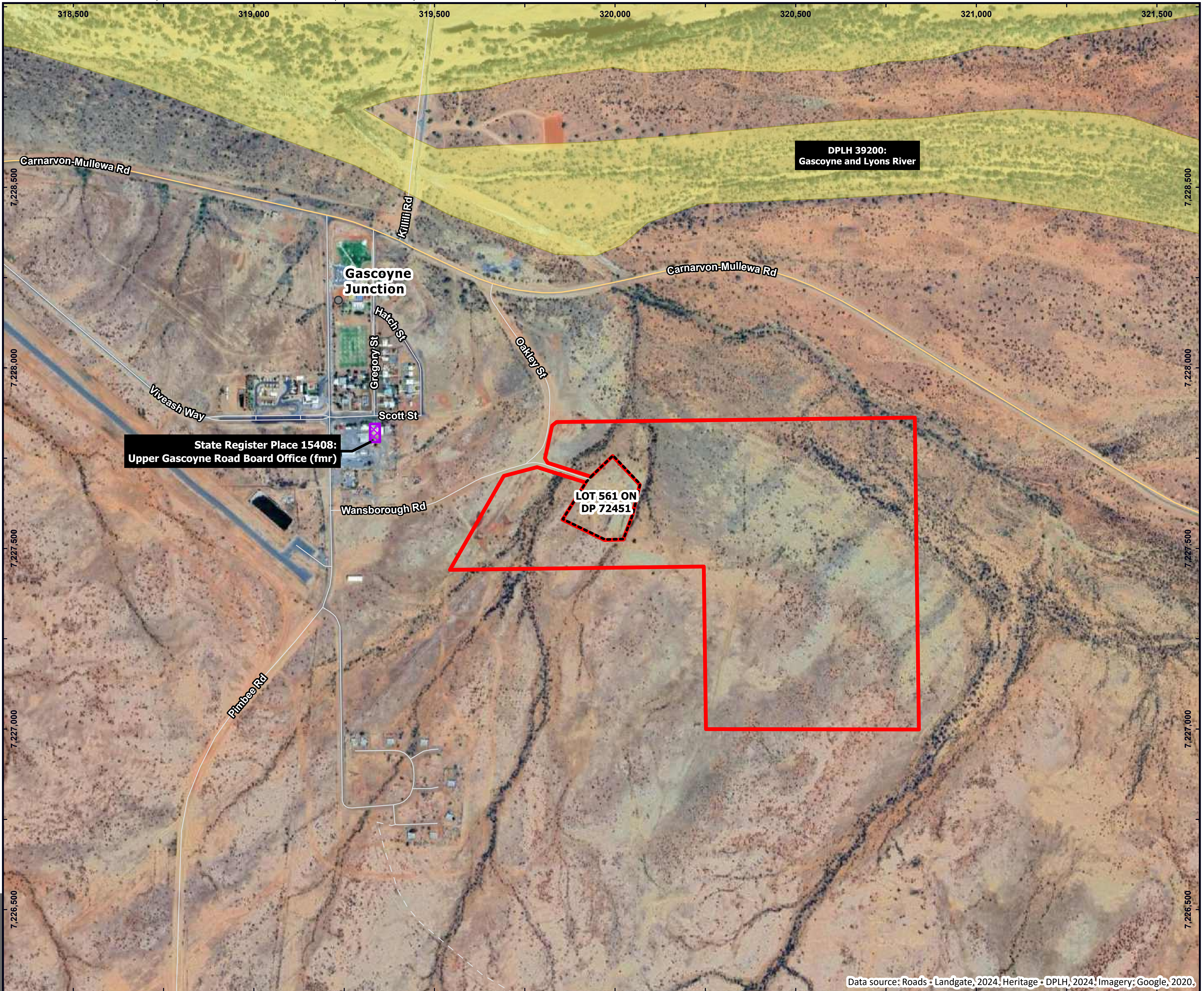


LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Aboriginal Heritage

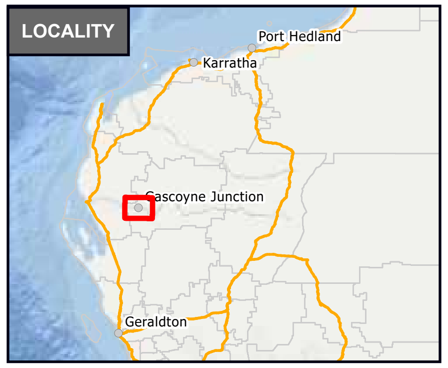
- Registered Aboriginal Heritage Place

European / Local Heritage

- Heritage Council WA State Register

Western Australian Roads

- Main Road
- Minor Road
- Other



HERITAGE

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	13/12/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 09

APPENDIX B
Drawings

Drawing W-000: Cover Sheet

Drawing W-100: Existing Site Layout and Topography

Drawing W-101: Proposed Site Layout

Drawing W-102: Proposed Community Recycling Centre Layout

Drawing W-103: Proposed Surface Water Management System

Drawing W-104: Proposed Rehabilitation Profile

Drawing W-105: Proposed Liquid Waste Facility

Drawing W-106: Proposed Putrescible Landfill Details

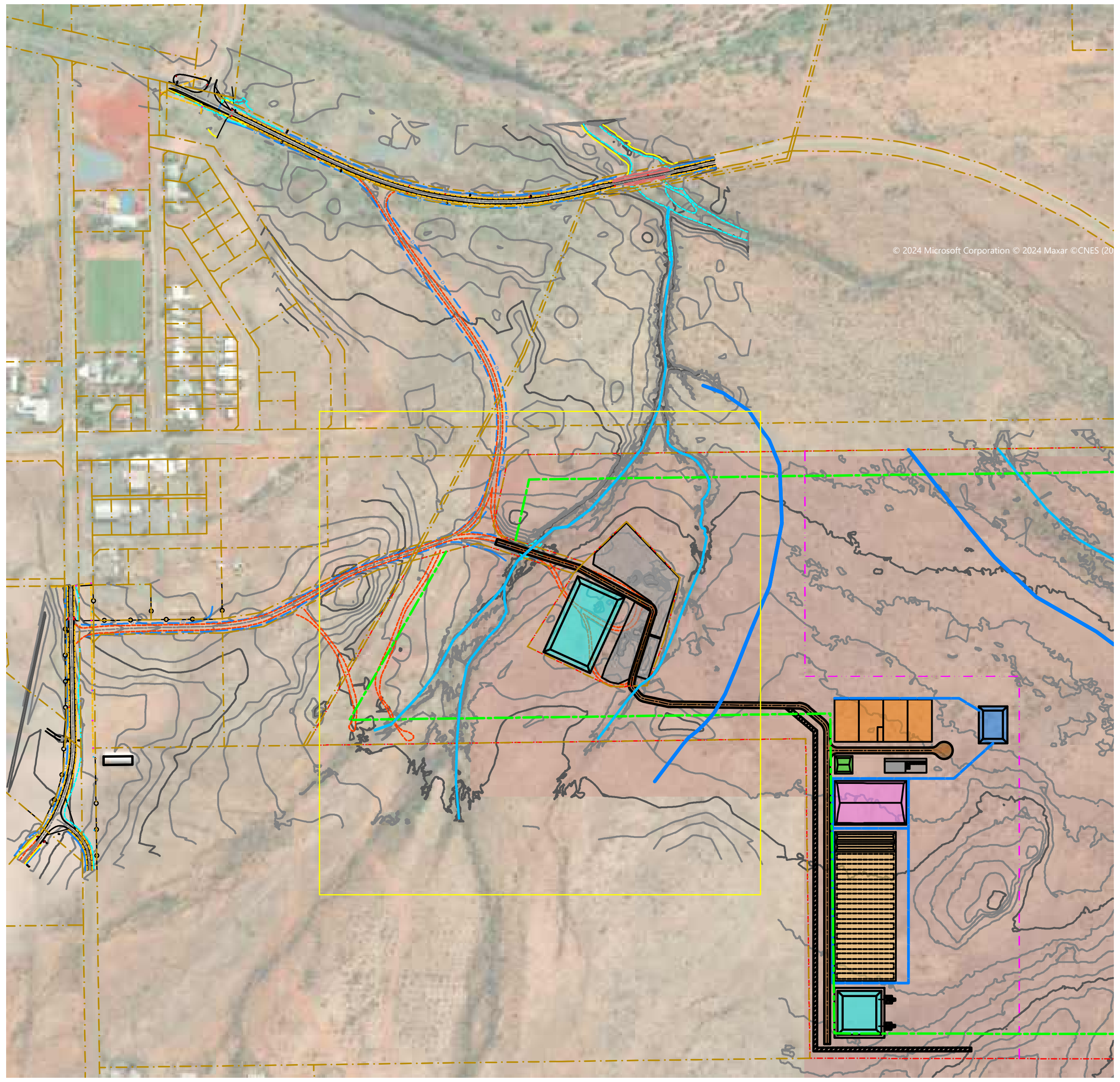
Drawing W-107: Inert Landfill and Asbestos Details

Drawing W-301: Typical Surface Water System Details

Drawing W-302: Typical Liquid Waste Facility Details

Drawing W-400: Combined Site Constraints

UPPER GASCOYNE LANDFILL DEVELOPMENT



LOCALITY PLAN
SCALE: N.T.S

Sheet List Table	
Sheet Number	Sheet Title
W-000	Cover Sheet
W-100	Existing Site Layout and Topography
W-101	Proposed Site Layout
W-102	Proposed Community Recycling Centre Layout
W-103	Proposed Surface Water Management System
W-104	Proposed Rehabilitation Profile
W-106	Proposed Putrescible Landfill Details
W-107	Inert Landfill and Asbestos Details
W-301	Typical Surface Water System Details
W-302	Typical Liquid Waste Facility Details
W-400	Combined Site Constraints

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SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: COVER SHEET

Scale: AS SHOWN @ A3 Date: 05.11.2024
Drawn: JS Checked: AB Approved:
Job No: TW24019 Drg. No: W-000 Rev: A
Filename: TW24019.DWG

FILENAME: \\SERVER\TALIS\SECTIONS\WASTE\PROJECTS\TW2024\TW24019 - UPPER GASCOYNE LANDFILL DEVELOPMENT\DRAWINGS\1_DRAWINGS\TW24019.DWG

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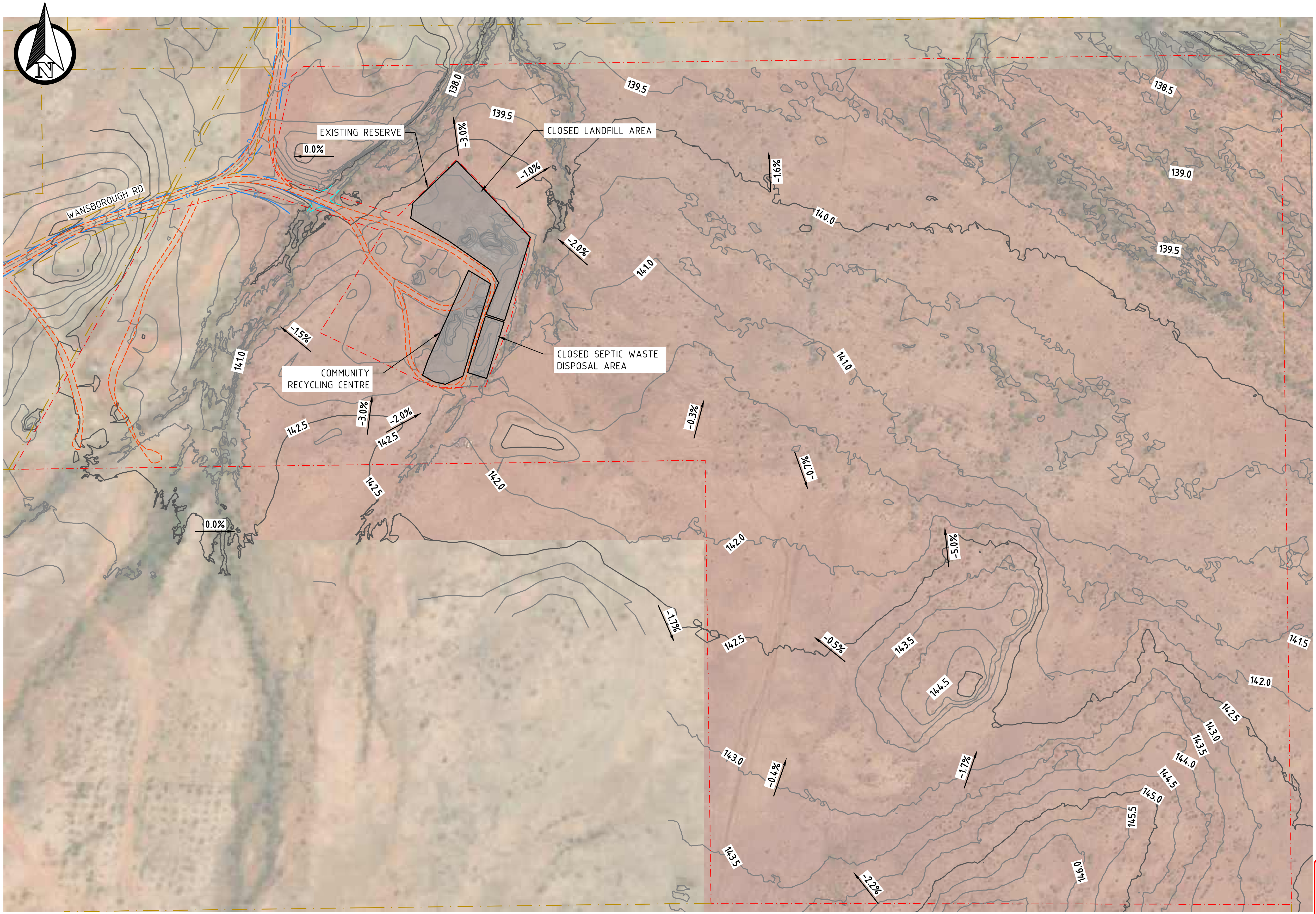

LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE

PRELIMINARY ONLY
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80m 0m 80m 160m
1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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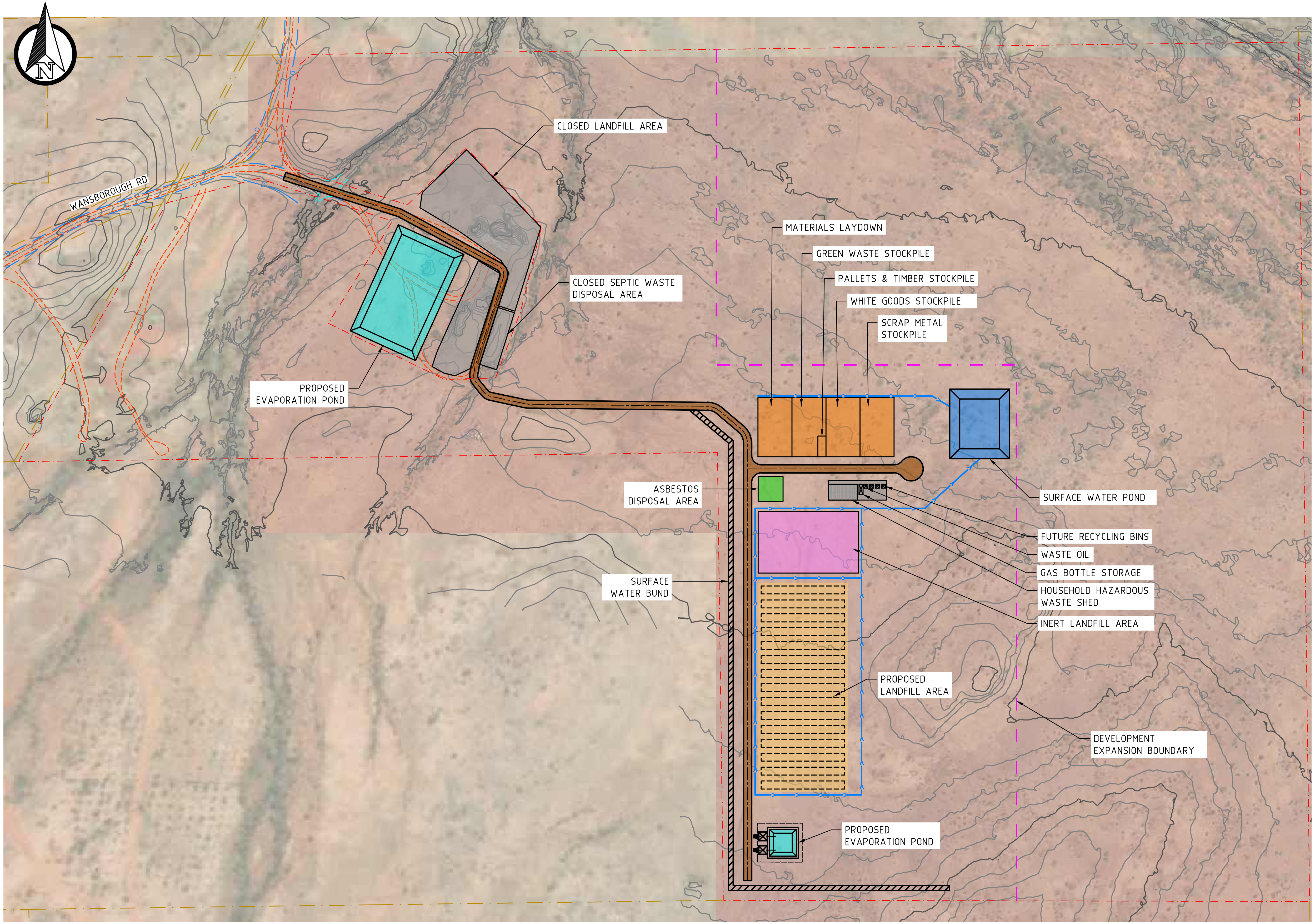
A	12.04.2024	VS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: EXISTING SITE LAYOUT AND TOPOGRAPHY

Scale: 1:4000 @ A3	Date: 12.04.2024	
Drawn: VS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-100	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

PRELIMINARY ONLY
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80m 0m 80m 160m
1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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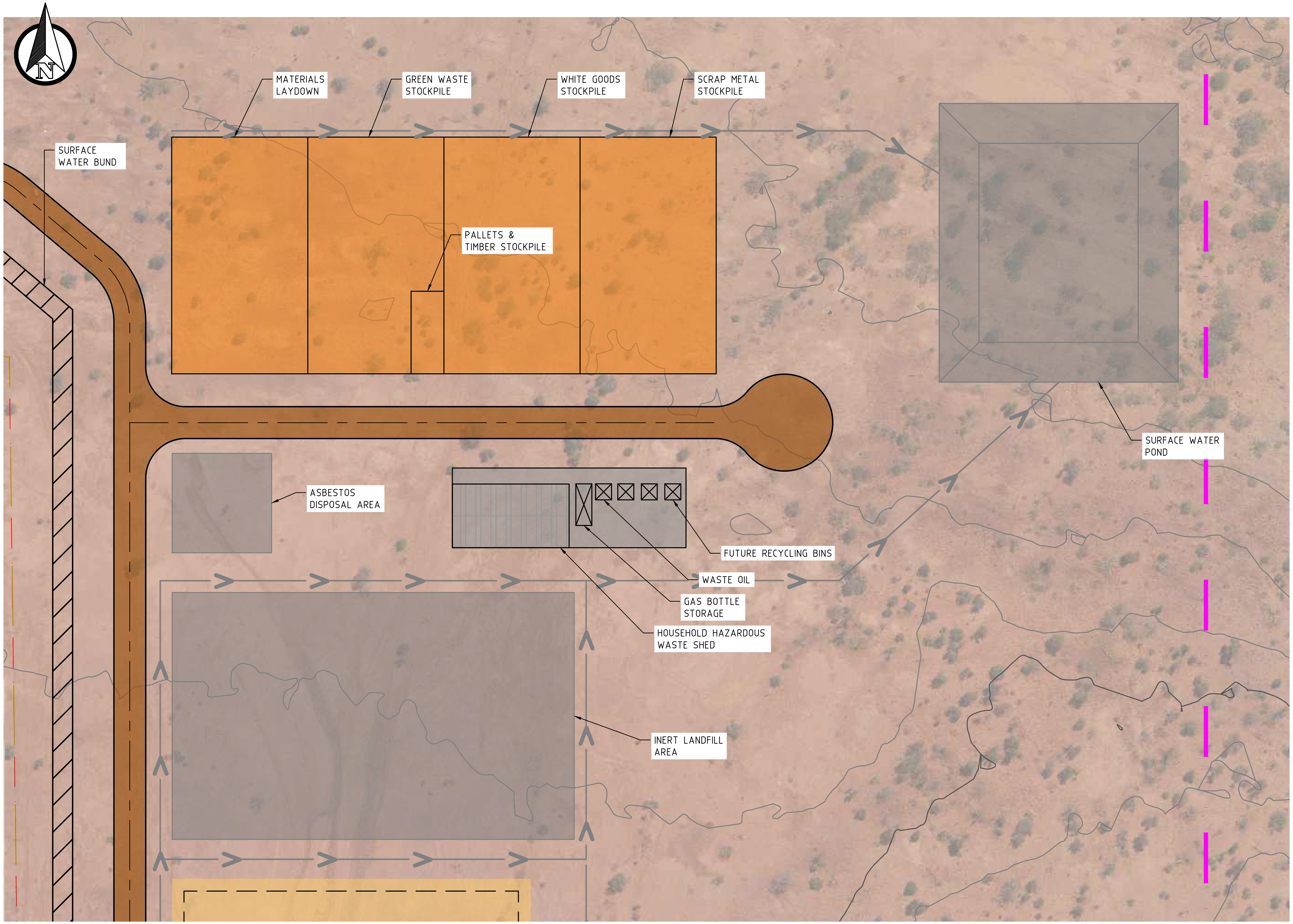
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED SITE LAYOUT

Scale: 1:4000 @ A3	Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-101	Rev: A
Filename: TW24019.DWG		



LEGEND:

- CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED UNSEALED ROAD
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

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20m 0m 20m 40m
1:1000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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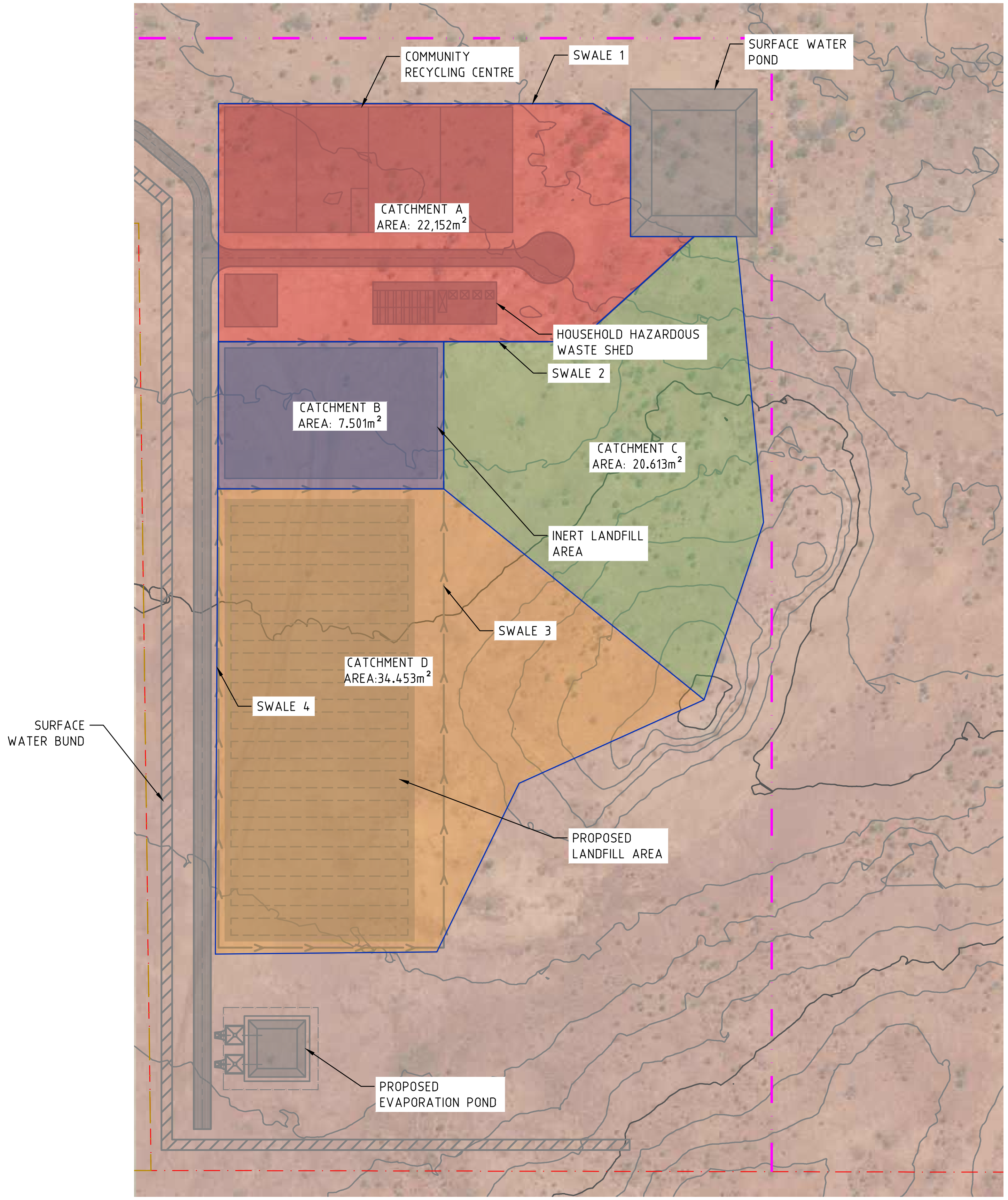
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED COMMUNITY RECYCLING CENTRE LAYOUT

Scale: 1:1000 @ A3	Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-102	Rev: A
Filename: TW24019.DWG		



LEGEND:

- CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- SWALE
- SURFACE WATER POND
- SURFACE WATER CATCHMENT A
- SURFACE WATER CATCHMENT B
- SURFACE WATER CATCHMENT C
- SURFACE WATER CATCHMENT D
- DEVELOPMENT EXPANSION BOUNDARY

PRELIMINARY ONLY
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50m 0m 50m 100m

1:2500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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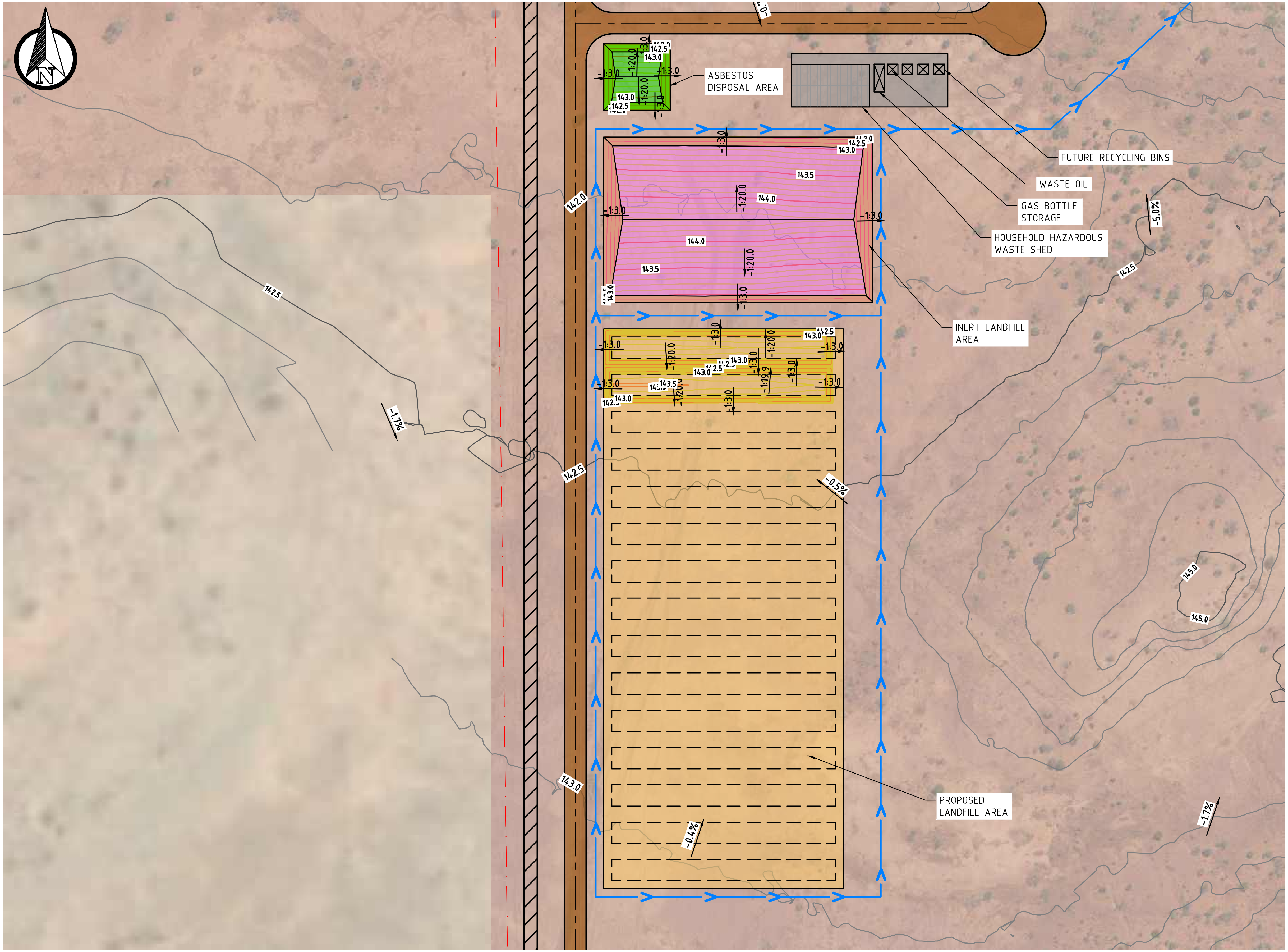
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED SURFACE WATER MANAGEMENT SYSTEM

Scale: 1:2500 @ A3	Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-103	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

PRELIMINARY ONLY
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30m 0m 30m 60m
1:1500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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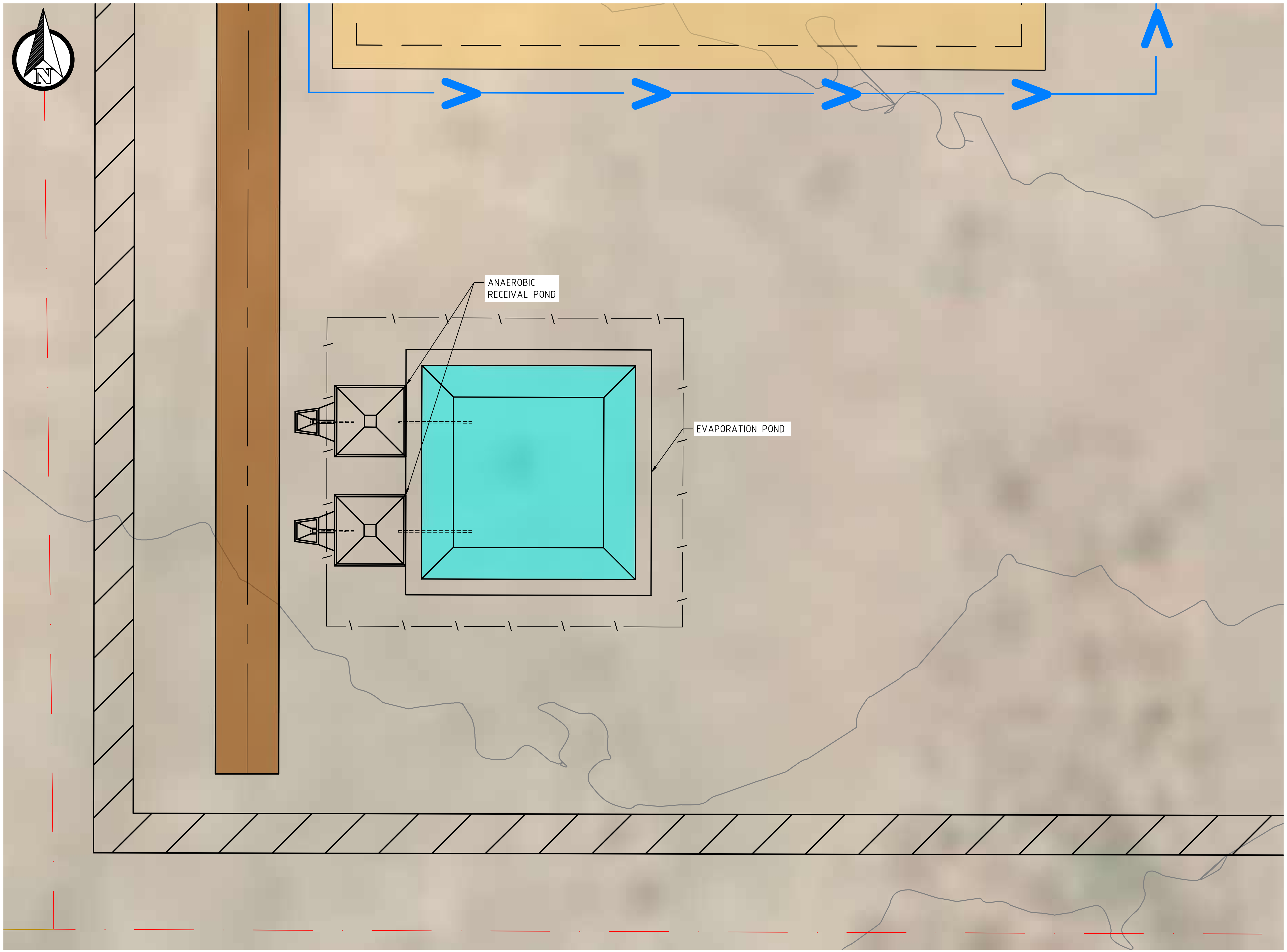
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED REHABILITATION PROFILE

Scale: 1:1500 @ A3	Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-104	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND
- NEW FENCE

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

10m 0m 10m 20m
1:500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	10.12.2024	JS	AB	PRELIMINARY ISSUE	

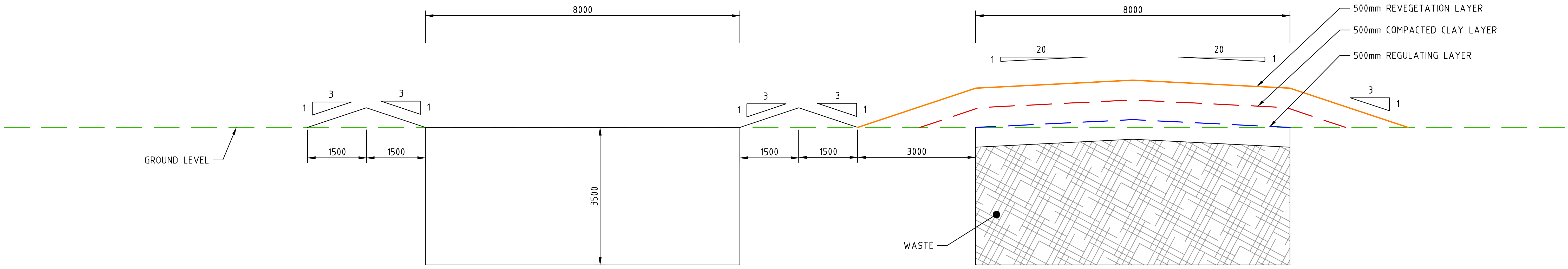
Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED LIQUID WASTE FACILITY

Scale: 1:500 @ A3	Date: 10.12.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-105	Rev: A
Filename: TW24019.DWG		

Printed by Juliana Da Silva on 14.11.2024 02:22 PM

FILENAME: \\SERVER\TALIS\SECTIONS\WASTE\PROJECTS\TW2024\TW24019 - UPPER GASCOYNE LANDFILL DEVELOPMENT\DRAWINGS\1_DRAWINGS\TW24019.DWG



ACTIVE LANDFILL TRENCH N-S

SCALE: 1:100

CAPPED LANDFILL TRENCH N-S

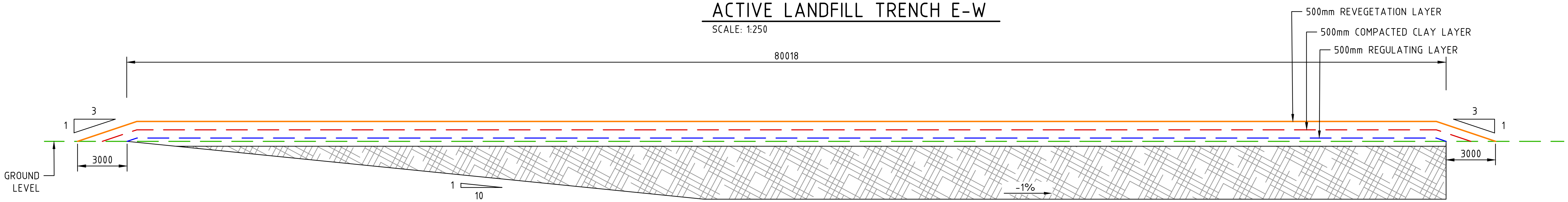
SCALE: 1:100

2.0m 0m 2.0m 4.0m

1:100 @ A3

ACTIVE LANDFILL TRENCH E-W

SCALE: 1:250



CAPPED LANDFILL TRENCH E-W

SCALE: 1:250

PRELIMINARY ONLY

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5m 0m 5m 10m

1:250 @ A3

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Client: Shire of UPPER GASCOYNE

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No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED PUTRESCIBLE LANDFILL DETAILS

Scale: AS SHOWN @ A3	Date: 05.11.2024		
Drawn: YJ	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-106	Rev: A	
Filename: TW24019.DWG			

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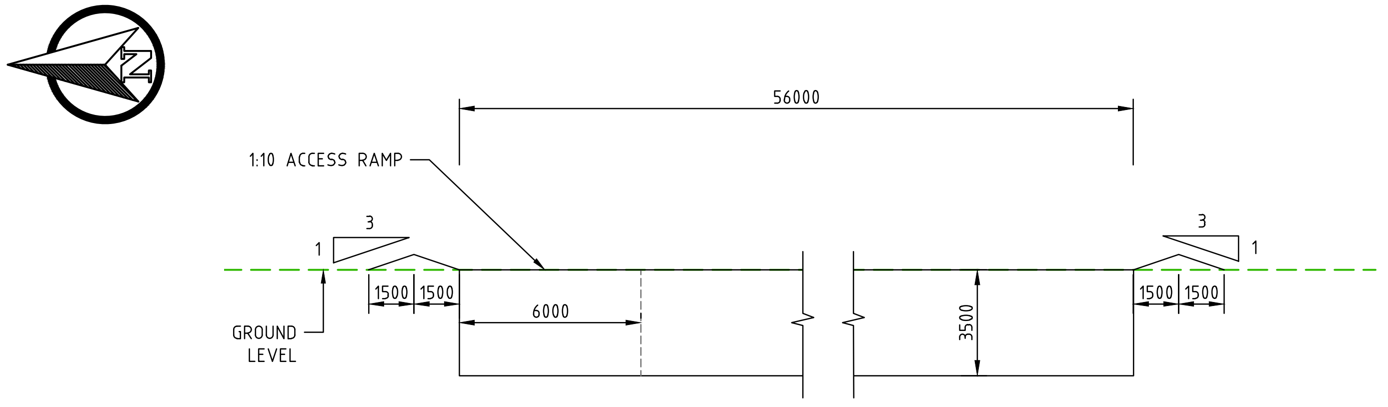
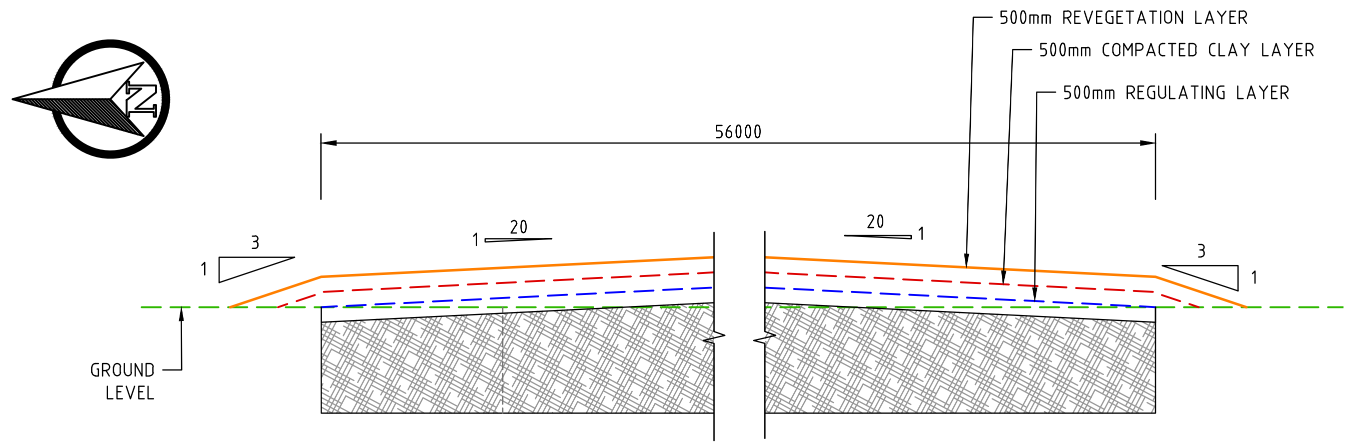


ACTIVE INERT LANDFILL TRENCH N-S
SCALE: 1:250



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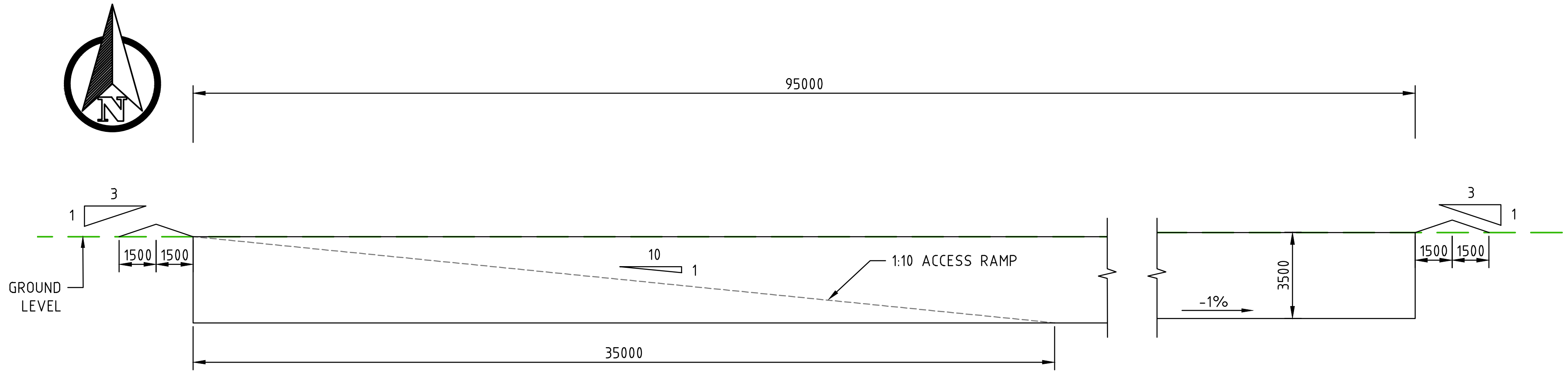
SCALE: 1:250



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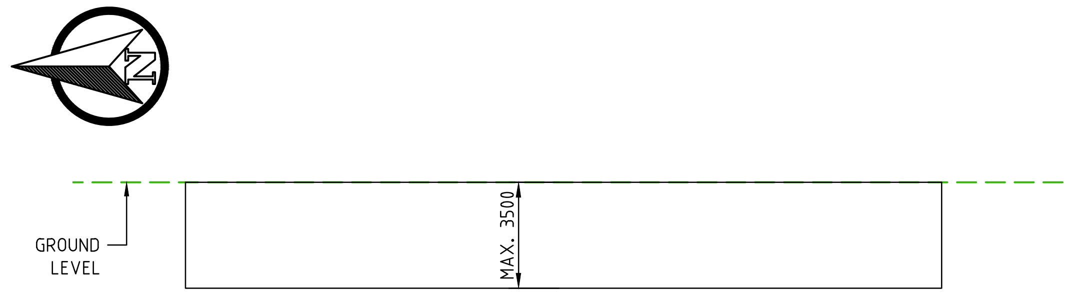
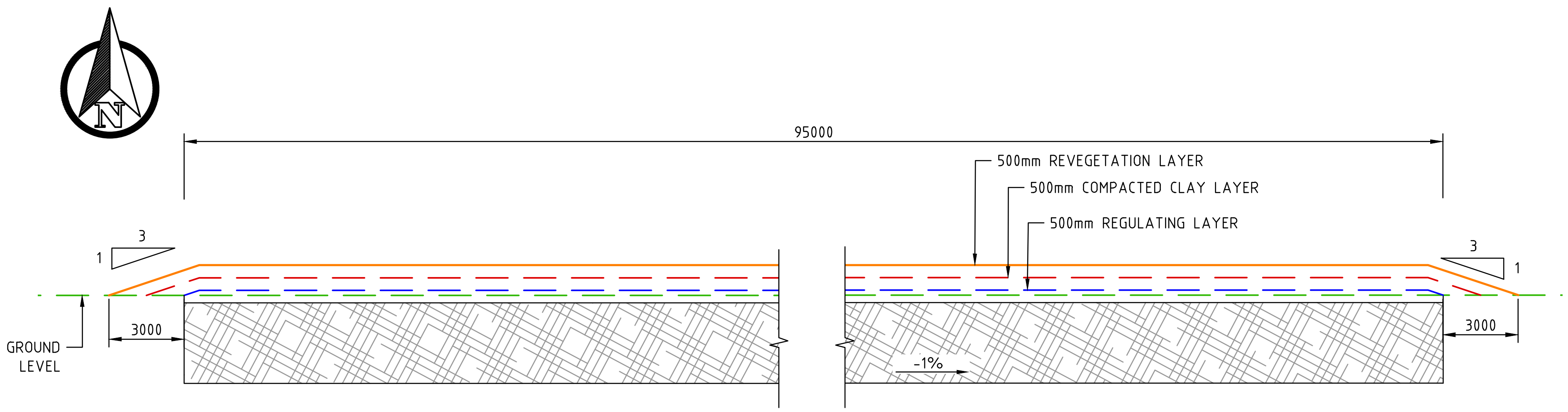


TYPICAL ASBESTOS DETAILS
SCALE: 1:250



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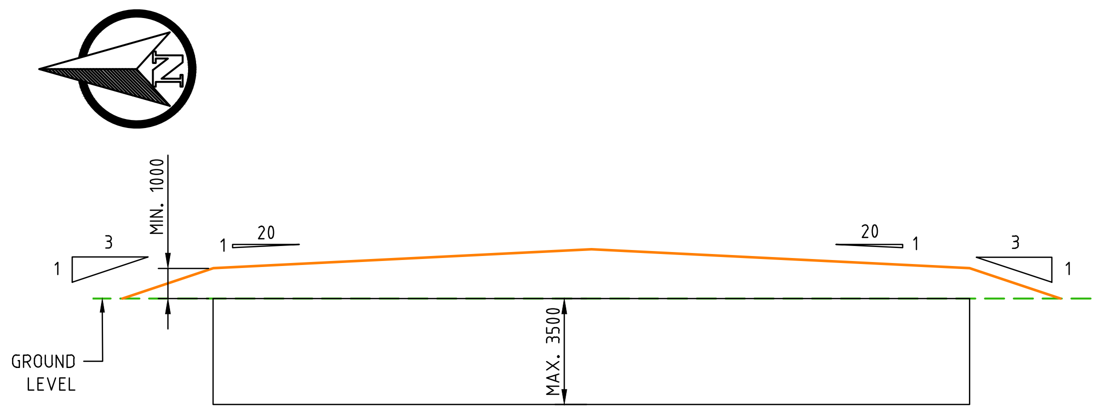
SCALE: 1:250



ASBESTOS CAPPING DETAILS
SCALE: 1:250

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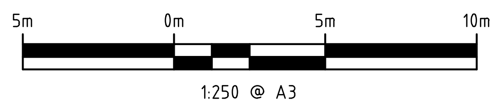

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A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: INERT LANDFILL AND ASBESTOS DETAILS

Scale: AS SHOWN @ A3	Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-107	Rev: A
Filename: TW24019.DWG		

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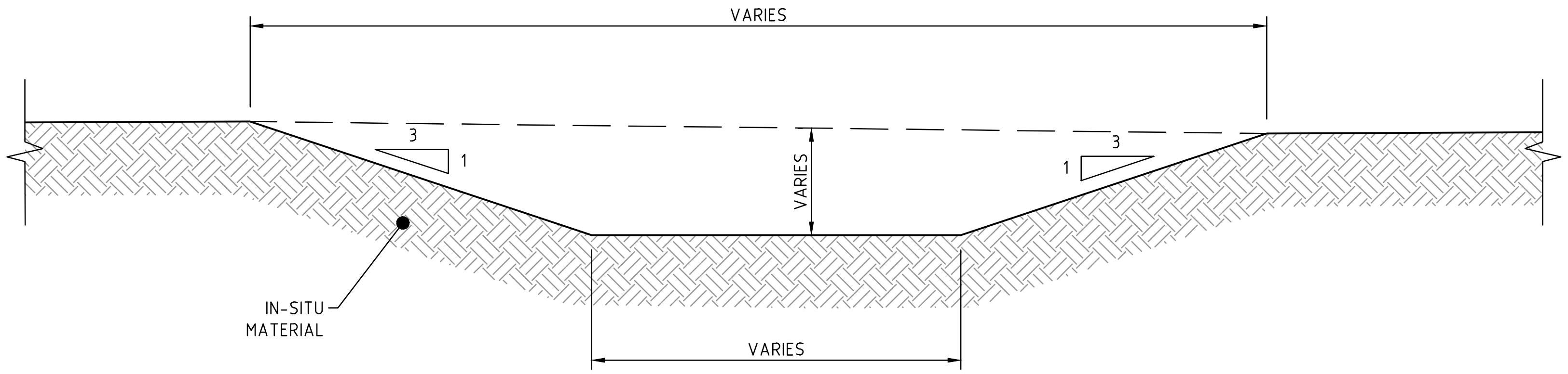
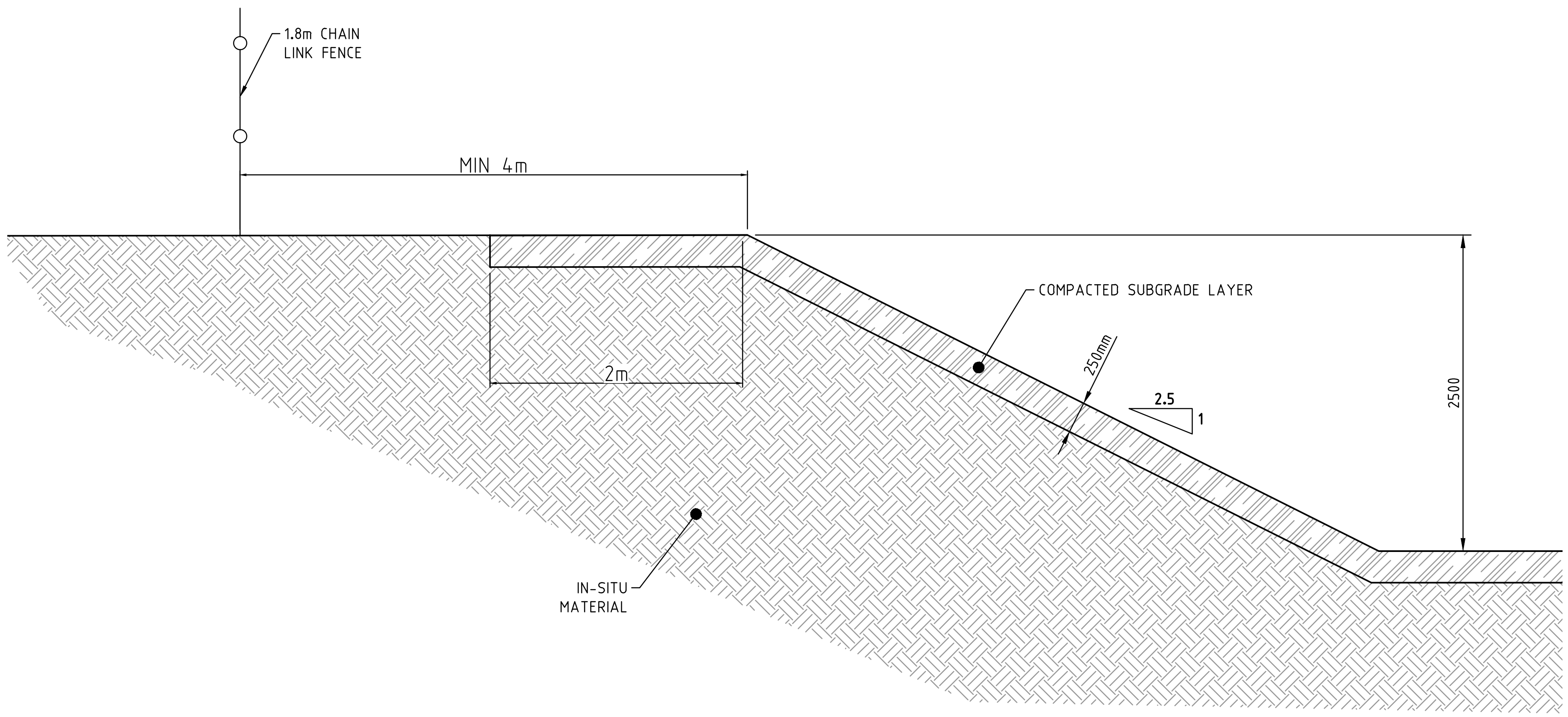


TYPICAL DETAIL - DRAINAGE SWALE

SCALE: 1:50



TYPICAL SECTION - SURFACE WATER POND

SCALE: 1:50

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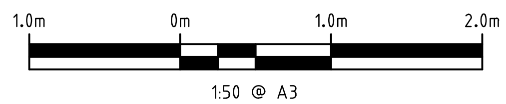

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

FILENAME: \\SERVER\TALIS\SECTIONS\WASTE\PROJECTS\TW2024\TW24019 - UPPER GASCOYNE LANDFILL DEVELOPMENT\DRAWINGS\1_DRAWINGS\TW24019.DWG

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A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: TYPICAL SURFACE WATER SYSTEM DETAILS

Scale: 1:50 @ A3	Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-301	Rev: A
Filename: TW24019.DWG		

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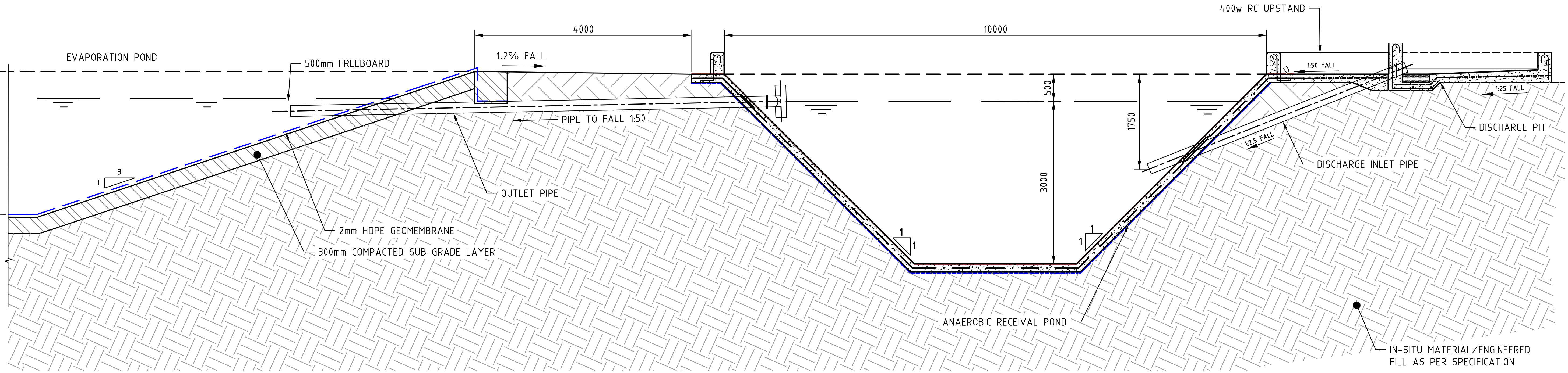
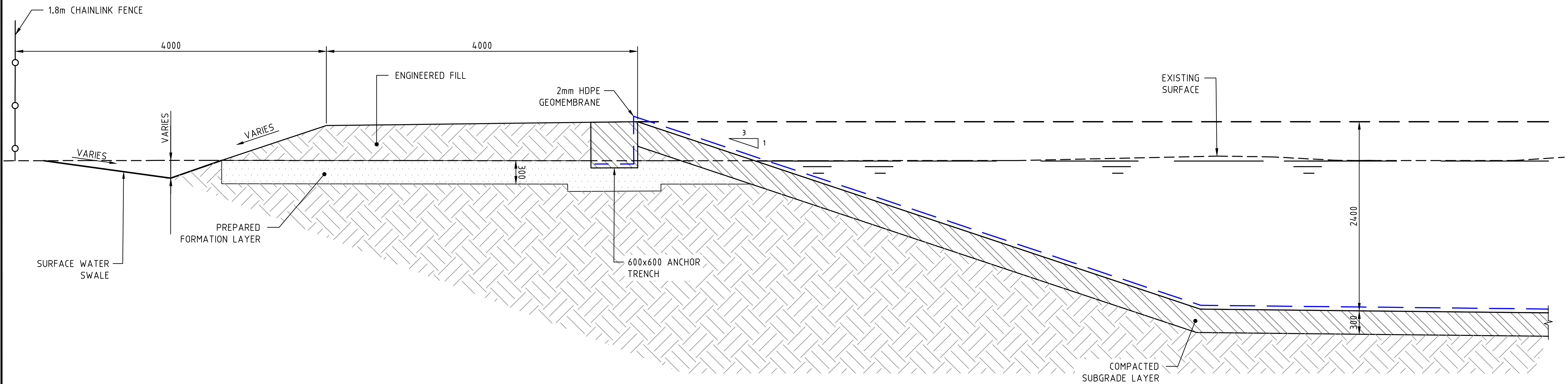


EVAPORATION POND CROSS-SECTION

SCALE: 1:75

1.5m 0m 1.5m 3.0m

1:75 @ A3



TYPICAL DETAIL - POND EMBANKMENT

SCALE: 1:50

1.0m 0m 1.0m 2.0m

1:50 @ A3

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SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

FILENAME: \\SERVER\TALIS\SECTIONS\WASTE\PROJECTS\TW2024\TW24019 - UPPER GASCOYNE LANDFILL DEVELOPMENT\DRAWINGS\1_DRAWINGS\TW24019.DWG

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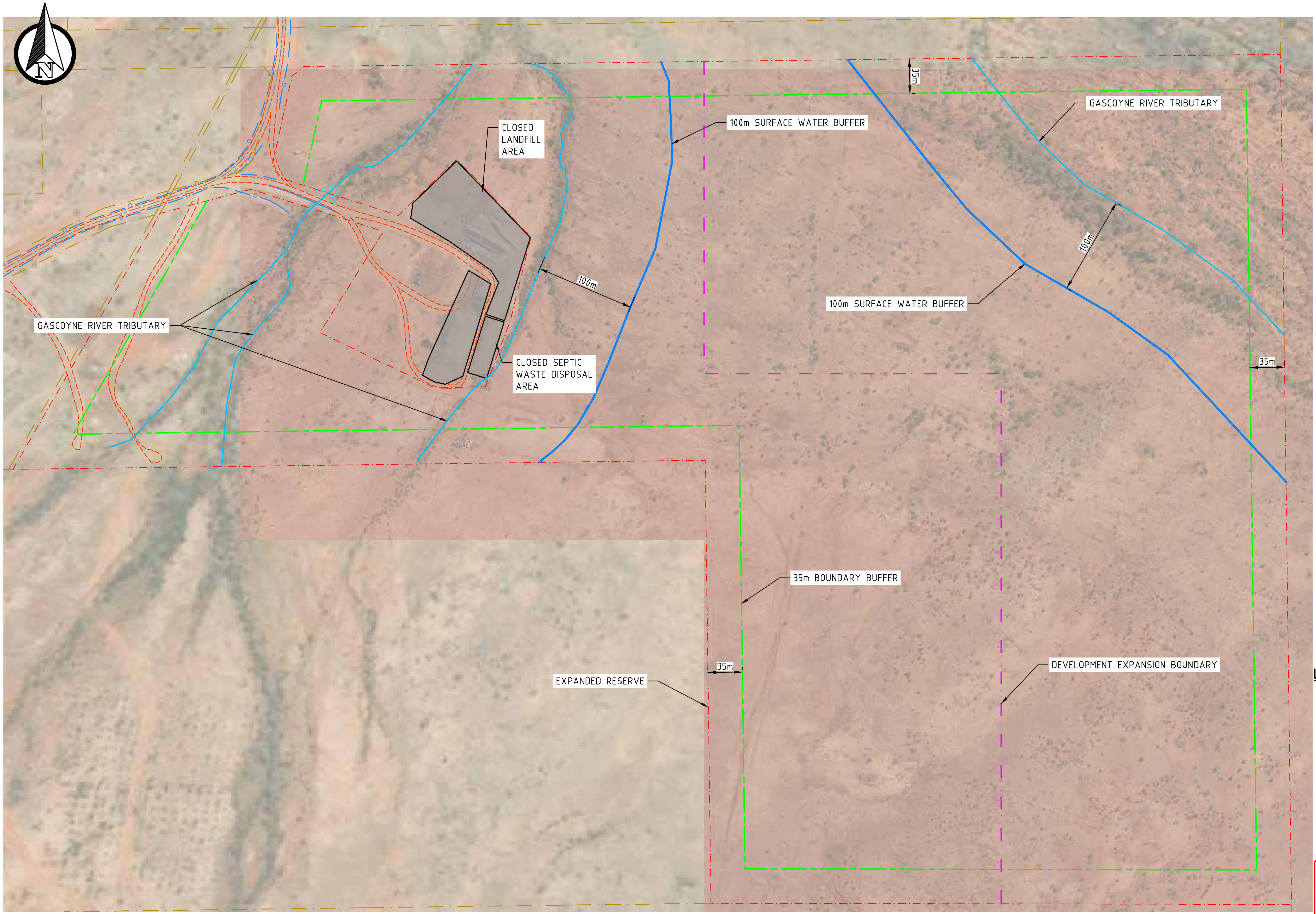
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: TYPICAL LIQUID WASTE FACILITY DETAILS

Scale: AS SHOWN @ A3	Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-302	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- DEVELOPMENT EXPANSION BOUNDARY
- 35m BOUNDARY BUFFER
- GASCOYNE RIVER TRIBUTARY
- 100m SURFACE WATER BUFFER

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80m 0m 80m 160m

1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	18.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: COMBINED SITE CONSTRAINTS

Scale: 1:4000 @ A3 Date: 18.11.2024
Drawn: JS Checked: AB Approved:
Job No: TW24019 Drg. No: W-400 Rev: A
Filename: TW24019.DWG

FILENAME: \\SERVER\TALIS\SECTIONS\WASTE\PROJECTS\TW2024\TW24019 - UPPER GASCOYNE LANDFILL DEVELOPMENT\DRAWINGS\1_DRAWINGS\TW24019.DWG
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APPENDIX C
Waste Projections and Void Space Modelling

Table 1.1 - Upper Gascoyne Waste Management Facility Serviced Population

Year	Population	Annual Growth Rate	Source
2024	40	Shire Repr.	Shire rep.
2039	72	4.00%	4 person/household * 8

Table 1.2 - Serviced Population Data Gascoyne

Year	Population	Growth Rate	Source
2024	40		Shire rep.
2025	42	4.0%	
2026	43	4.0%	
2027	45	4.0%	
2028	47	4.0%	
2029	49	4.0%	
2030	51	4.0%	
2031	53	4.0%	
2032	55	4.0%	
2033	57	4.0%	
2034		4.0%	
2035	0	4.0%	
2036	0	4.0%	
2037	0	4.0%	
2038	0	4.0%	
2039	0	0.0%	Assumed that population
2040	0	0.0%	
2041	0	0.0%	
2042	0	0.0%	
2043	0	0.0%	
2044	0	0.0%	
2045	0	0.0%	
2046	0	0.0%	
2047	0	0.0%	
2048	0	0.0%	
2049	0	0.0%	
2050	0	0.0%	
2051	0	0.0%	
2052	0	0.0%	
2053	0	0.0%	
2054	0	0.0%	
2055	0	0.0%	
Average Growth Rate		**1.9%**	

NOTES:

The Shire has indicated that the Site currently serves 40 people, and anticipates an additional 8 houses to be constructed within the town between 2024 and 2039. Assuming that each household will have an average of 4 residents, this increases the number of people the Site services to 72 people by 2040.

The per capita waste generation rate was calculated by using the current population and an estimated annual waste acceptance tonnage. Generation rate was then used to calculate the airspace consumption. The waste compaction factor was estimated to be 0.35 based on the availability of plant equipment on Site. The volume of cover soils used has been estimated to be 50%, based on the volume of waste accepted and the frequency that waste must be covered.

The airspace consumption rate was applied to the estimated population to provide the estimated landfill airspace volume consumed per year. Using an estimated trench lifespan of 2 years, the required cell capacity was calculated and landfill trenches sized to meet this capacity.

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Table 1.3 - Generation Estimates

Scenario		Unit	Source
Estimated Annual Acceptance	80.00	Tonnes/year	Shire Repr.
Estimated currently serviced population	40	units	Shire Repr.
Estimate Waste Generation per Capita	2.00	Tonnes/year	
Waste Compaction Factor	0.35	Tonnes/m^3	Est.
Cover Soil	50%	% of total Void	Est.
Airspace consumption per Capita (inc cover soils)	11.43	m^3/year	

Table 1.4 - Landfill Facility Sizing Factors

Aspect		Unit	Source
Sizing Criteria			
Approximate Trenches Lifespan	2.00	years	BPEM Guidance
Landfill Lifespan	30.00	years	
Number of Trenches Required	15.0	unit	
Total Fill (2025-55)	5,030	m^3	
Required Trench Capacity	**335**	**m^3**	
Trench Dimensions			
Length	84	m	
Base Length [inc. 1:10 access ramp]	49	m	
Width	8.00	m	
Base Width	8	m	Allows collectin vehicle access
Depth	3.5	m	Assumes groundwater exceeds 7.5mbgl
Slope (1:V)	0		
Approximate Trench Capacity	**1,526**	**m^3**	
Supporting Infrastructure Dimensions			
Capping final height	1	m	
Landfill bund width	3		
Capping Width Required (1:3)	3	m	
Facility Dimensions			
Landfill Facility Length (E-W)	90	m	
Landfill Facility Width (N-S)	210	m	
Landfill Facility Area	18,900	m^2	

Table 1.5 - Landfill Fill Rate Estimates

Year	Estimated Population	Estimated Generation Tonnes/year	Airspace Consumption Rate m^3/year
2024	40	80	457
2025	42	83	475
2026	43	87	494
2027	45	90	514
2028	47	94	535
2029	49	97	556
2030	51	101	578
2031	53	105	601
2032	55	109	625
2033	57	114	650
2034	0	0	0
2035	0	0	0
2036	0	0	0
2037	0	0	0
2038	0	0	0
2039	0	0	0
2040	0	0	0
2041	0	0	0
2042	0	0	0
2043	0	0	0
2044	0	0	0
2045	0	0	0
2046	0	0	0
2047	0	0	0
2048	0	0	0
2049	0	0	0
2050	0	0	0
2051	0	0	0
2052	0	0	0
2053	0	0	0
2054	0	0	0
2055	0	0	0
Total (2025-2055)		**880**	**5,030**

Table 2.1 - Generation Estimates

Scenario		Unit	Source
Estimated Required Facility Area	6500	m^2	Previous operations
Waste Compaction Factor	1.00	Tonnes/m^3	Estimate
Cover Soil	0%	% of total Void	Estimate

Table 2.2 - Inert Landfill Sizing Factors

Scenario		Unit	Source
Sizing Criteria			
Landfill Lifespan	30.00	years	
Number of Cells Required	1.0	unit	
Cell Dimensions			
Length	95	m	
Base Length [inc. 1:10 access ramp]	60	m	
Width	56	m	
Base Width	56	m	
Depth	3.5	m	Assumes groundwater exceeds 7.5mbgl
Slope (1:V)	0		DMIRS *Excavation Code of Practice*
Approximate Cell Capacity		**m^3**	
Supporting Infrastructure Dimensions			
Capping final height	1	m	
Landfill bund width	3		
Capping Width Required (1:3)	3	m	Based on 1:5 slope from edge of waste
Facility Dimensions			
Landfill Facility Length (E-W)	101	m	
Landfill Facility Width (N-S)	62	m	
Landfill Facility Area	6,262	m^2	

Table 3.1 - Void Space Modelling

Stage	Available Void Space (m^3)	Net Void Space ex. Cover Soils (m^3)	Landfill Capaity (years)
Putrescible Landfill (1)	1,526	763	2
Putrescible Landfill (15)	22,890	11,445	30
Inert Landfill	0	0	30
Total	24,416	12,208	30

Table 3.2 - Material Balance

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Total Material Requirement (m^3)	Net Balance
Putrescible Landfill (1)	1,526	763	1,008	1,771	-245
Putrescible Landfill Facility	22,890	11,445	15,120	26,565	-3,675
Inert Landfill Facility	0	0	9,393	9,393	-9,393
Surface Water Pond	1,877	0	0	0	1,877
Total	24,767	11,445	24,513	35,958	-11,191

APPENDIX D

Surface Water Modelling

Table 1.1: Site Details

Site Location:	Upper Gascoyne
Latitutde:	-25.05607
Longitude:	115.21589

Notes:
Data from BOM's IFDs (2016):
http://www.bom.gov.au/water
/designRainfalls/revised-ifd/

Table 1.2 Rainfall AEP

Annual Exceedance Probability		Rainfall (mm)							
Duration		63.2%	50.0%	20.0%	10.0%	5.0%	2.0%	1.0%	4.00%
Hours	BoM	1:1	1:2	1:5	1:10	1:20	1:50	1:100	1:25
0.02	**1 min**	1.18	1.42	2.23	2.85	3.52	4.52	5.38	3.687
0.03	**2 min**	1.94	2.34	3.69	4.71	5.8	7.34	8.62	6.057
0.05	**3 min**	2.72	3.27	5.15	6.58	8.1	10.3	12.1	8.467
0.07	**4 min**	3.44	4.13	6.5	8.3	10.2	13	15.4	10.67
0.08	**5 min**	4.1	4.91	7.73	9.88	12.2	15.6	18.5	12.77
0.17	**10 min**	6.65	7.95	12.5	16	19.8	25.4	30.3	20.73
0.25	**15 min**	8.42	10.1	15.8	20.2	25.1	32.3	38.4	26.3
0.33	**20 min**	9.75	11.7	18.3	23.5	29.1	37.4	44.5	30.48
0.42	**25 min**	10.8	12.9	20.3	26	32.3	41.5	49.4	33.83
0.50	**30 min**	11.7	14	22	28.2	34.9	44.9	53.4	36.57
0.75	**45 min**	13.7	16.4	25.9	33.1	41	52.6	62.6	42.93
1.00	**1 hour**	15.1	18.2	28.7	36.8	45.5	58.4	69.4	47.65
1.50	**1.5 hour**	17.3	20.8	32.9	42.2	52.3	67.1	79.7	54.77
2.00	**2 hour**	18.9	22.8	36.1	46.4	57.5	73.9	87.9	60.23
3.00	**3 hour**	21.4	25.8	41	52.8	65.6	84.6	101	68.77
4.50	**4.5 hour**	24.2	29.1	46.5	60	74.8	97	116	78.5
6.00	**6 hour**	26.3	31.7	50.7	65.7	82.2	107	129	86.33
9.00	**9 hour**	29.5	35.6	57.2	74.5	93.7	123	149	98.58
12.00	**12 hour**	31.8	38.4	62.1	81.3	103	135	164	108.3
18.00	**18 hour**	35.2	42.5	69.3	91.2	116	154	187	122.3
24.00	**24 hour**	37.4	45.3	74.3	98.2	126	167	204	132.8
30.00	**30 hour**	39	47.3	78	104	133	176	215	140.2
36.00	**36 hour**	40.3	48.9	80.9	108	138	184	224	145.7
48.00	**48 hour**	42	51.1	85.1	114	147	194	237	154.8
72.00	**72 hour**	44	53.8	90.2	121	156	205	249	164.2
96.00	**96 hour**	45.3	55.5	93.1	124	160	210	253	168.3
120.00	**120 hour**	46.4	56.9	95.2	127	162	212	255	170.3
144.00	**144 hour**	47.5	58.2	97	128	163	213	255	171.3
168.00	**168 hour**	48.6	59.5	98.5	130	164	213	255	172.2

Table 1.3 IFD Coefficients

	AEP Coefficients (Coefficients Tab)						
	63%	50%	20%	10%	5%	2%	1%
	1:1	1:2	1:5	1:10	1:20	1:50	1:100
C_0	1.686E-01	3.482E-01	8.002E-01	1.047E+00	1.260E+00	1.509E+00	1.682E+00
C_1	5.523E-01	5.738E-01	5.936E-01	5.858E-01	5.696E-01	5.159E-01	4.720E-01
C_2	3.371E-01	3.113E-01	2.858E-01	2.933E-01	3.107E-01	3.750E-01	4.275E-01
C_3	-1.701E-01	-1.590E-01	-1.472E-01	-1.496E-01	-1.561E-01	-1.840E-01	-2.068E-01
C_4	3.254E-02	3.036E-02	2.785E-02	2.811E-02	2.915E-02	3.470E-02	3.922E-02
C_5	-2.846E-03	-2.644E-03	-2.389E-03	-2.385E-03	-2.450E-03	-2.957E-03	-3.371E-03
C_6	9.404E-05	8.698E-05	7.702E-05	7.576E-05	7.675E-05	9.403E-05	1.081E-04

Table 2.1 Catchment Summary

Catchments	Area (m^2)	Catchment Surface	Comments	Runoff Coefficient	1:20 Year Runoff
Catchment A	22,647	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	1,427
Catchment B	10,930	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	689
Catchment C	17,535	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	1,105
Catchment D	34,220	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	2,156
Catchment E				0	0
Catchment F				0	0
Catchment G				0	0
Catchment H				0	0
Catchment I				0	0
Catchment J				0	0
Catchment K				0	0
Catchment L				0	0
Catchment M				0	0
Catchment N				0	0
Catchment O				0	0
Catchment P				0	0

Total Area (m^2)	85,332	Composite Runoff Coefficient	0.500

Table 2.2 Surface Water Movement Summary

Aspect		Catchment A	Catchment B	Catchment C	Catchment D
Swale Surface Water Movement	1st Swale	Swale 1	Swale 2	Swale 2	Swale 3
	2nd Swale				Swale 4
	3rd Swale				Swale 2
	4th Swale				
	5th Swale				
	6th Swale				
Overland Flow (over waste mass)	Flow Length (m)	220	183	176	250
	ΔRL (mAHD)	3	2	7	6
	Slope	0.014	0.011	0.040	0.024
	Surface Material	Smooth bare soil	Smooth bare soil	Smooth bare soil	Smooth bare soil
	Kerby's Roughness Factor	0.10	0.10	0.10	0.10
	Time of Conc., Tc-o	16.735	16.176	11.725	15.554

NOTES:
Slope = ΔRL/ΔFlow Length
Tc-o = K*((L*N)^0.467)*(S^-0.235)
K=constant; =1.44 for SI   L=flow length (m)   N=Kerby's roughness   S = Slope

Table 4.1 Swale Design Characteristics and Modelling Results

Aspect	Swale 1	Swale 2	Swale 3	Swale 4
Swale Flow Timing				
Flow Length (m)	211	315	395	323
ΔRL (mAHD)	1	1	1.5	1.5
Slope	0.005	0.003	0.004	0.005
Swale Material	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean
Manning's Coefficient	0.022	0.022	0.022	0.022
Time of Conc., Tc-h	9.432	14.982	16.646	13.194
Combined Flows				
Min. Total Concentration Time, Tc (min)	26.17	26.71	32.20	28.75
Intensity for Min. Tc (mm/hr)	115.52	114.19	102.43	109.47
Flow Rate for Min. Tc (m^3/hr)	1,308	3,579	1,753	1,873
Peak Flow Rate for Min. Tc (m^3/hr)	1,308	3,579	1,753	1,873
Comments				
Swale Geometry	**1**	**2**	**3**	**4**
Swale Bottom Width (m)	1	1	1	1
Depth of Flow w/o Freeboard (m)	0.5	0.5	0.5	0.5
LHS Slope (1:H)	3	3	3	3
RHS Slope (1:H)	3	3	3	3
Freeboard (m)	0.5	0.5	0.5	0.5
Freeboard included?	YES	YES	YES	YES
Top width, T (m)	7	7	7	7
Design Depth inc. Freeboard (m)	1	1	1	1
Swale Area, As (m^2)	4.000	4.000	4.000	4.000
Wetted Perimeter, Pw (m)	7.32	7.32	7.32	7.32
Hydraulic Radius, Rh (m)	0.55	0.55	0.55	0.55
Hydraulic Depth, Dh (m)	0.57	0.57	0.57	0.57
Flow				
Manning's coefficient, n	0.022	0.022	0.022	0.022
Maximum Velocity, V (m/s)	2.09	1.71	1.87	2.07
Minimum Flow, Q (m^3/s)	8.36	6.84	7.49	8.28
Minimum Flow, Q (m^3/h)	30,106	24,640	26,949	29,801
Factor of Safety	**23.02**	**6.88**	**15.38**	**15.91**
Froude Number, Fr	0.88	0.72	0.79	0.87
Nature of Flow	**Subcritical**	**Subcritical**	**Subcritical**	**Subcritical**
Reynolds Number, Re (channel)	638,915	522,912	571,914	632,453
Flow Type	**Turbulent**	**Turbulent**	**Turbulent**	**Turbulent**

Table 4.2 Swale Design Event & IFD Coefficients

Design Period	1:100
C_0	1.6820911
C_1	0.47203836
C_2	0.42746368
C_3	-0.20680352
C_4	0.039223228
C_5	-0.003370929
C_6	0.000108108

Table 3.1 Pond Design Events

Minimum Design Event	
Design Period	1:20
Storm Duration	24 hour
Total Rainfall (mm)	126
Maximum Design Event	
Design Period	1:50
Storm Duration	24 hour
Total Rainfall (mm)	167

NOTES:
Volume of Pond:
$V=(h/6)*((LxW)+((W+W_b)*(L+L_b))+(L_b*W_b))$

Table 3.2 SW Movement into Ponds

	Pond 1
Catchment A	YES
Catchment B	YES
Catchment C	YES
Catchment D	YES
Catchment E	
Catchment F	
Catchment G	
Catchment H	
Catchment I	
Catchment J	
Catchment K	
Catchment L	
Catchment M	
Catchment N	
Catchment O	
Catchment P	

Table 3.3 Pond Design Details

Aspect	Pond 1
W (m)	60
L (m)	70
h (m)	2.5
Side Slope (1:V)	2.5
Freeboard (m)	0.3
Base Width (m)	47.5
Base Length (m)	57.5
Operational Width (m)	58.5
Operational Length (m)	68.5
Pond Catchment Area (m^2)	4,200
Operational Capacity (m^3)	7,368
Total Capacity (m^3)	8,599

Table 3.4 Pond Capacity Checks

Aspect	Pond 1
Catchment Area (m^2)	85,332
Runoff Coefficient	0.50
Minimum Storage Requirement (m^3)	5,905
Storage Check	PASS
Maximum Storage Requirement (m^3)	7,827
Storage Check	PASS

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Talis Consultants

Head Office
Level 1, 604 Newcastle Street,
Leederville
Western Australia 6007

PO Box 454,
Leederville
Western Australia 6903

NSW Office
5/62 North Street, Nowra
New South Wales, 2541

PO Box 1189, Nowra
New South Wales, 2541

P: 1300 251 070
E: info@talisconsultants.com.au